FOOD
PRODUCTS

SHERMAN

REVISED
EDITION

MACMILLAN

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Anna E. Boller

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FOOD PRODUCTS

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PREFACE TO FIRST EDITION

Both food legislation and the scientific investigation of certain important aspects of the composition and value of food have undergone an exceptionally rapid development during the past few years. In this volume it is sought to incorporate in the subject matter of a general study of foods the results of these recent advances which heretofore have been too widely scattered to be readily accessible.

The general plan is to devote a chapter to each important type of food covering (1) an account of its production and preparation for market with such brief statistical data as will indicate the relative economic importance of the industry, (2) the proximate composition and general food value, (3) questions of sanitation, inspection, and standards of purity, (4) special characteristics of composition, digestibility, nutritive value, and place in the diet. The study of milk affords opportunity for the correlation of all these aspects and may therefore serve to set standards for the study of the other types of food. Since a detailed discussion of each aspect under every article of food would have made the present volume too large for its main purpose, it has seemed best to distribute the emphasis differently in different chapters according to the nature of the food and the state of development of the industry. Lists of references appended to the different chapters will facilitate the extension of the work covered by the text along either chemical, economic, sanitary, or nutritional lines.

To add to the usefulness of the book for reference the tables of composition of foods have been made as complete as is practicable and a considerable compilation of data relating to food legislation and inspection has also been included in the appendix.

The author would here make grateful acknowledgment to the authorities whose lectures and reports have been freely quoted in describing the different food industries, and to many friends for helpful suggestions. Special thanks are due to his colleague Mr. A. W. Thomas and his former students Miss Lucy H. Gillett and Miss Ethel Ronzone each of whom has critically examined the entire work either in manuscript or in proof. Corrections or suggestions from others who may use the book will be appreciated.

H. C. S.

JULY, 1914.

PREFACE TO SECOND EDITION

In rewriting this book in the light of ten years' experience in its use in other classrooms as well as that of the author, the text has been clarified wherever possible and new material has been incorporated in every chapter in order to bring the subject matter up to date. Several chapters have been completely rewritten and a new chapter has been added, dealing with the economic relationships of food products, with practical suggestions for household food budgets. Certain rearrangements have been made in the interest of convenience in teaching; but the general sequence of topics followed in the first edition remains unchanged, since in the actual development of the subject matter this sequence has been found to involve a minimum of reference to explanations not yet reached. In the judgment of the writer, this sequence permits the most satisfactory development of the economic phases of the subject, while avoiding the common danger of misleading the student by classifications which over-emphasize a single aspect of a food material. Each chapter is, however, sufficiently complete in itself, so that the order of topics can readily be altered by the teacher who desires.

Special attention has been given to the incorporation of the advances of the past ten years with adequate emphasis and yet in such a way as to avoid giving exaggerated impressions. To this end the first chapter is rewritten and enlarged to include a brief sketch of the newer view-points regarding food values; and throughout the book the vitamin content of foods is given its proper place together with calories, proteins, and mineral elements in the discussion of food values. The newer knowledge of food values supplements the older, but does not supplant it.

In order to put the user of the book in touch with the recent advances in all phases of our knowledge of food products without making the descriptive text unduly voluminous, many of the publications of the past ten years which are chiefly significant as extending our descriptive knowledge or as developing certain topics more fully than is feasible in a book of this size, are included by title in the lists of references at the ends of the chapters, so that by selection from these the teacher may develop the course, or the individual reader may extend his reading, as fully and in such directions as may be desired in each case.

As in the preparation of the first edition, the writer has profited greatly by both the writings and the oral suggestions of many colleagues and other friends. His special indebtedness to those who assisted in the original work as noted in the preface to the first edition, and to Dr. M. L. Caldwell for collaboration in the present revision, is gratefully acknowledged.

H. C. S.

May, 1924.

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FOOD PRODUCTS

CHAPTER I

THE PRINCIPAL CONSTITUENTS AND FUNCTIONS OF FOOD

Foods and Food Values

THROUGH the food the body obtains the substances which enter into its structure, which yield energy for its activities, and which regulate the processes essential to life and health.

Most articles of food contain *water*, as shown by the fact that they lose weight on drying. The dry residue consists mainly of combustible matters (organic substances), but when these are burned, there usually remains more or less *ash* (a mixture of inorganic or mineral substances).

The combustible portion of the food may comprise a variety of organic compounds, but in the great majority of staple foods most of the organic matter is found to be comprised within three groups of substances — *the carbohydrates* (such as the starches and sugars), *the fats* (such as those of butter, olive oil, corn oil, lard, and meat fat), and *the proteins* (such as the albumin of egg, the curd of milk or cheese, the muscle fiber of meat, the gluten of flour or bread).

In most cases if the percentages of proteins, fats, carbohydrates, mineral matters, and water in a food be determined accurately, it will be found that these groups of substances make up nearly the entire weight of the food. For many purposes it is sufficient to analyze foods as if they consisted entirely of these five parts, ignoring the minor constituents and letting them be included in the estimated percentage of protein, of fat, or of carbohydrate, whichever they most resemble. Such an analysis will include with the proteins any other substances containing nitrogen which may be present in the food; with the fats will be included any other substances which are dissolved from the dried food by ether, such as the resinous or waxy material which serves to waterproof the surfaces of many fruits and vegetables, and many of the natural coloring matters which occur in small quantities in such foods as green vegetables and tomatoes; and with the carbohydrates will be included the fruit acids and any other undetermined organic substances which are not counted with the proteins or the fats.

Such a partial analysis of a food can easily be criticized; yet it often serves very important purposes. Thus with a knowledge of the digestibility of the food it enables us to compute its value as a source of energy in nutrition, this energy value or fuel value being usually expressed in terms of Calories per gram or of Calories per pound of the food.

Many foods also furnish us one or more of a group of very important organic substances now commonly called *the vitamins*. These are present in such small quantities as not to be shown by chemical analysis, but at least three of them (generally known as vitamins A, B, and C) are absolutely essential to normal human nutrition and are therefore very important factors in food values.

By means of feeding experiments with laboratory animals the relative values of different foods as sources of a particular vitamin can be compared, and we shall take account of such comparisons of vitamin values in our consideration of the different types of food products in subsequent chapters of this book.

Laboratory feeding experiments often serve also to demonstrate other differences in food value such as the differing efficiencies of certain proteins in nutrition; and they show us more conclusively than we can expect to find in any other way how different articles and combinations of food compare in all-round adequacy for the support of nutrition. This is usually tested by means of experiments which include a comparison of the effects of the foods upon the growth of young animals, as in the case illustrated in the accompanying photograph (Fig. 1).

The weight curves of the two rats photographed in Fig. 1, and of three others of the same litter which were differently fed, are shown in Fig. 2. The results of such feeding experiments, most often presented in the form of weight charts, have played

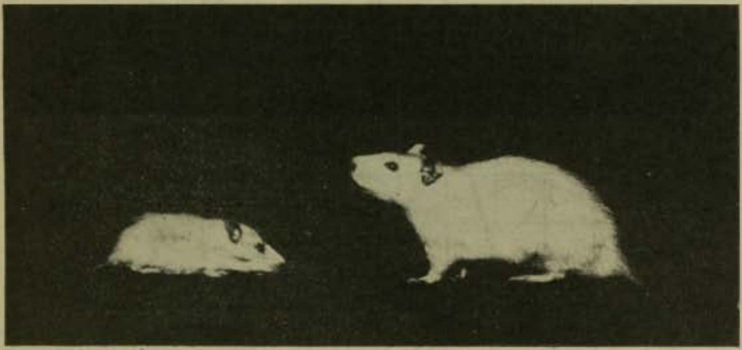


FIG. 1. — Contrasting effects of equally simplified food supplies. These two rats were twin sisters and at weaning time were of equal size and equally healthy and vigorous. One was then fed with bread and apple, the other with bread and milk. The latter had grown to five times the weight of the former by the time this photograph was taken. (By permission of the *Journal of Biological Chemistry*.)

a large part in the development of the newer knowledge of food values. Figures 1 and 2 show the high food value of a diet of bread and milk as compared with bread alone, bread and meat, or bread and apple. The bread consumed by all the rats was identical; the meat fed No. 45 and the apple fed No. 53 were of as good quality as was the milk fed No. 54. Each of the foods was " pure " in the usual sense and good of its kind. Rat No. 53, although retarded in growth and as can be judged from Fig. 1 somewhat enfeebled by malnutrition, cannot be considered as having been injured by the apple of her diet, for at the time the photograph was taken she had already outlived her litter mates who received bread alone or bread and meat. The apple had supplemented the bread to the extent of prolonging

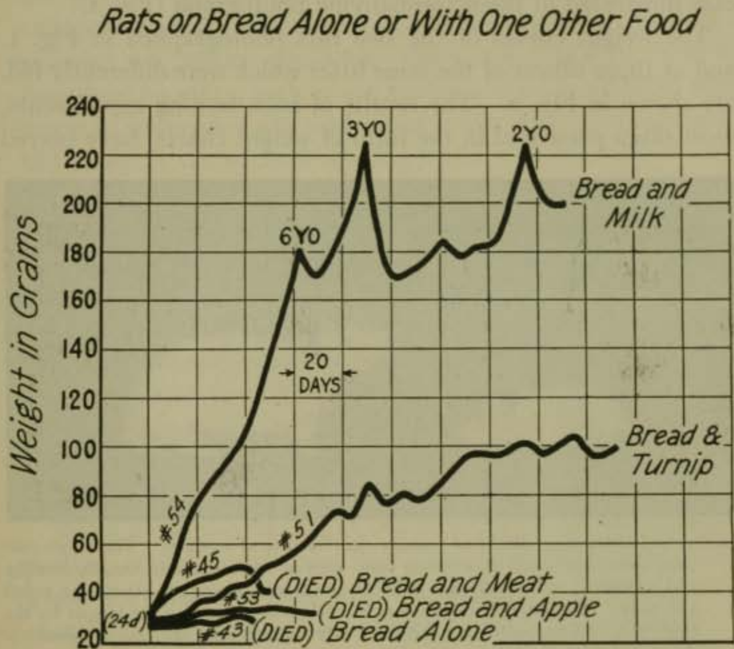


FIG. 2.—Growth curves of rats of the same litter placed at weaning time upon diets consisting of bread alone or with one other food. Rat No. 43 fed bread alone did not grow and lived only six weeks. Rat No. 45 fed bread and meat grew for a time but then failed and lived only a little longer than the one on bread alone. Rat No. 53 fed bread and apple did not grow but lived much longer. Rat No. 54 fed bread and milk grew at a fully normal rate. Nos. 53 and 54, photographed together after two months on their respective diets, are the two rats shown in Fig. 1. (By permission of the *Journal of Biological Chemistry*.)

life but not of supporting growth. The difference in size, development, and vigor of the twin sisters shown in Fig. 1 is attributable entirely to the superior food value of the milk.

In the case of the stunted rat here shown, as in most cases of human malnutrition, the fault of the diet was partly in its vitamin content and partly in other respects. Both the older and the newer knowledge of food values must be taken into account if the varied supply of food products which the modern market affords is to be used to full advantage. We must know the composition of our foods in terms of the familiar chemical elements and compounds, their fuel values in terms of Calories, and also their values as sources of the vitamins.

The Composition of Food Materials

If we consider the composition of food materials first in terms of the chemical elements and then in terms of compounds, we find that the plant and animal tissues which we use as food are composed mainly of the same twelve chemical elements which chiefly compose the tissues of the body; namely, carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, chlorine, sodium, potassium, calcium, magnesium, and iron. Iodine, and probably fluorine, silicon, and manganese, are also essential to the body and so must be supplied by the food (or by food and drinking water together); but the amounts of these latter elements are so small that they are usually scarcely measurable by the ordinary methods of food analysis.

While the ash of foods is composed of relatively simple inorganic (mineral) compounds such as the chlorides, phosphates, sulphates, and carbonates of sodium, potassium, calcium, magnesium, and iron, it does not follow that these elements exist in the form of the same inorganic compounds in the food. In many cases the inorganic compounds found in the ash are to a large extent formed during the burning of the food, the base-forming elements having existed in combination with organic acids or with proteins, while the acid radicles may also have existed in organic combination or may have been formed by the oxidation of the sulphur, phosphorus, or carbon of the organic matter.

The principal chemical elements of foods and the most important kinds of compounds in which they are found may therefore be summarized as follows:

Hydrogen Oxygen	forming Water.
Carbon Hydrogen Oxygen	forming Carbohydrates, Fats (and sometimes Organic Acids).
Carbon Hydrogen Oxygen Nitrogen Sulphur Phosphorus (sometimes) Iron (sometimes)	forming Proteins.
Sulphur Phosphorus Chlorine Sodium Potassium Calcium Magnesium Iron	forming Ash Constituents which exist partly as mineral salts and partly in combination with carbohydrates, fats, proteins, and other organic compounds.

The *ultimate composition* of a food is its composition as expressed in terms of the chemical elements into which it might ultimately be resolved, — carbon, hydrogen, oxygen, nitrogen, sulphur, etc.

The *proximate composition* is the composition in terms of the compounds actually present — proteins, fats, carbohydrates, mineral salts, water. These five groups of compounds have sometimes been called the "proximate principles" of food, or the "five food principles." As a precaution against ambiguity this use of the term "principles" is now generally avoided, but there is frequent occasion to use the terms "ultimate" and "proximate" in speaking of the composition and analysis of foods, and it is well to keep the exact chemical significances of these terms in mind. The word "proximate" must not be confused with "approximate."

Food materials and foodstuffs. The term "food materials" is synonymous with the expression "articles of foods." Thus bread, meat, eggs, milk, are spoken of as food materials. The term "foodstuffs" as a scientific term, and as it will be used in this work, means the stuffs that foods are made of, or, in the terms which we have been using, the substances of which the food materials are composed. Thus, the proteins, fats, and carbohydrates and the various organic and inorganic compounds of phosphorus, potassium, iron, etc., which occur in food materials are foodstuffs.

The chemistry and nutritive significance of the foodstuffs, both organic and inorganic, have been discussed by the writer in another volume (*Chemistry of Food and Nutrition*, *Revised Edition*) and cannot be considered here in any detail. A brief summary of some of the facts having most relation to what follows in later chapters may, however, be advantageous at this point.

Carbohydrates

The carbohydrates include the simple sugars and all the substances which can be split (by hydrolysis) into simple sugars. The simple sugars, having only one sugar radicle in the molecule, are called "monosaccharides." Sugars whose molecules contain two sugar radicles, and from each molecule of which two molecules of monosaccharide can be obtained by hydrolysis, are called disaccharides. Substances like starch and dextrin which can be hydrolyzed to simple sugars but which are of high molecular weight, each molecule containing many monosaccharide radicles, are called polysaccharides.

The classification which follows includes only a few of the most important carbohydrates. Fuller information may be obtained from the books listed at the end of this chapter.

Monosaccharides
- Glucose (dextrose, grape sugar, starch sugar)
- Fructose (levulose, fruit sugar)
- Galactose

Disaccharides
- Sucrose (cane sugar, saccharose)
- Lactose (milk sugar)
- Maltose (malt sugar)

Polysaccharides
- Starch
- Dextrin
- Glycogen
- Inulin
- Cellulose
- Hemicelluloses

Glucose is widely distributed in nature, occurring abundantly in many fruits and plant juices, often mixed with other sugars. Since most of the other carbohydrates yield glucose when split by the digestive ferments the total amount of glucose which is absorbed into the body is much larger than that of any other sugar. Normal blood always contains glucose (usually about 0.1 per cent) which is constantly being burned to yield energy to the body. Any surplus of glucose absorbed from the digestive tract is normally stored in the body in the form of glycogen which later is converted back into glucose as needed to replace that which has been burned. Commercially glucose is made by hydrolysis of starch as explained in Chapter VIII.

Fructose occurs with glucose in plant juices and especially in fruits and honey. It is formed along with an equal weight of glucose when cane sugar is hydrolyzed; hence its occurrence in molasses and sirups as well as honey. (See Chapter XI.)

When cane sugar is eaten, it is not absorbed as such, but is changed into equal parts of glucose and fructose in digestion. The fructose absorbed into the body serves the same purposes as glucose and like glucose may be changed into glycogen for storage. Glucose and fructose are the only monosaccharides which occur as such in foods, at least in any important quantity.

Galactose does not occur free in nature or in commercial food products, but as a product of digestion of milk sugar it is of some importance in nutrition. It is utilized like glucose in the body.

Sucrose occurs commonly in the vegetable kingdom, being found in considerable quantity in many familiar fruits and vegetables. Usually these sweet fruits and plant juices contain glucose and fructose along with the sucrose, and also other substances which make it difficult to separate the sucrose in crystalline form. The juices of the sugar cane, the sugar beet, and to a less extent certain maple and palm trees, contain enough sucrose and little enough of other substances to make it practicable to manufacture sugar from them commercially. (See Chapter XI.) On hydrolysis a molecule of sucrose yields one molecule each of glucose and fructose. The process is often called "inversion" and the product "invert sugar." When eaten, sucrose is digested into glucose and fructose, the nutritive functions of which have been mentioned above.

Lactose occurs in milk and is made commercially from the whey of milk used in the manufacture of cheese or casein. In the body lactose is digested into equal parts of glucose and galactose, the nutritive functions of which have been noted above. Lactose has special interest for the student of nutrition for at least two reasons. It is not found in the blood or body tissues generally, but is evidently formed only in the mammary gland for secretion in the milk, which suggests its especial importance in the nourishment of the young. It also appears to be unique among the sugars in its property of favoring the development of the most desirable species of bacteria in the intestine. See brief discussions in Chapters III and IV and sources of fuller information among the references at the end of the latter chapter.

Maltose occurs in malted or germinated grains, in malt extracts, etc., but the amount of maltose eaten as such is not likely to be large. It is formed in quantity by the digestion of starch by the saliva or the pancreatic juice. Maltose, however, whether eaten or formed in the course of digestion, is not absorbed as such to any important extent, but is split by a digestive ferment of the intestinal juice, each molecule of maltose yielding two molecules of glucose.

Starch is the chief form in which most plants store their reserve supply of carbohydrate material. It constitutes over one half of the solid matter of the cereal grains and an even larger proportion of the total solids of some other starchy foods such as potatoes, bananas, and chestnuts. In the processes of digestion, starch (especially when it has been cooked) is changed to maltose and the latter (as stated above) into glucose. In addition to the direct use of starchy materials as food, much starch is separated on an industrial scale (Chapter VIII) and used as such or as a source of dextrin, maltose, commercial glucose, or fermentation products.

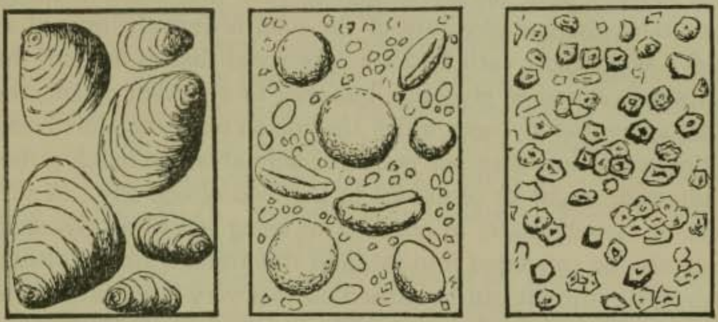
Raw starch is easily seen under the microscope to consist of distinct granules, the size and shape of which differ greatly in the starches formed in different types of plants. Figure 3 represents starch granules from potato, wheat, and corn (maize), all magnified in the same proportion.

Dextrins are formed from starch by the action of ferments, acids, or heat. Although usually represented by the same empirical formula as starch, the dextrins appear in general as intermediary products in the hydrolysis of starch to maltose or glucose; hence no further discussion is required here.

Glycogen is the chief reserve form of carbohydrate in animals as starch is in plants. For this reason and because of its physical properties and its chemical relationship to maltose and glucose, it is often called "animal starch." It is stored principally in the liver and to a small extent in the muscles.

Inulin is a substance, found in a few vegetables, which on hydrolysis yields fructose. It is of little practical importance as food.

Cellulose is familiar as a woody or fibrous material occurring in the cell walls of all vegetable tissues. It yields glucose on hydrolysis, but is not digested to a sufficient extent to make it



Potato starch. Wheat starch. Corn starch.

FIG. 3. — Starch granules magnified 300 diameters.

of much nutritive value to man, though it is often of value in giving proper bulk to the diet.

Hemicelluloses are substances which botanically seem to resemble cellulose in belonging to the walls rather than to the contents of plant cells. Chemically they resemble starch in being rather easily hydrolyzed by acids, but differ from it in that they often yield sugars other than glucose. Thus in any given plant tissue the material called hemicellulose may consist chiefly of galactan yielding galactose, mannan yielding mannose, or pentosan yielding one or both of the pentose sugars xylose and arabinose. These hemicelluloses do not appear to be digested by any of our digestive juices and are therefore presumably of little practical importance as food.

Carbohydrates in nutrition. From what has been said above it will be clear that the various digestible carbohydrates of the food, having been split by the digestive ferments to monosaccharides, are absorbed into the blood. Any surplus is stored temporarily in the form of glycogen, chiefly in the liver, though to some extent in the muscles. The glucose which circulates in the blood is burned in the muscles and other active tissues as fuel, the burned glucose being constantly replaced by new glucose derived from the stored glycogen, so that under ordinary conditions the carbohydrate of the food is entirely burned as fuel. When more carbohydrate is received than is burned, the surplus is stored as glycogen, but only to a limited extent, the total amount of glycogen which the human body can store being estimated at less than one pound or only about as much carbohydrate as might be contained in the food of one day. A surplus of carbohydrate, in addition to being stored as glycogen, may also be converted into fat, and this transformation of carbohydrate into fat can be carried on to a very large extent and with almost no loss of energy. The energy value to the body of average carbohydrate in the food is 4.0 Calories per gram, or 1814 Calories per pound.

Organic Acids

Some foods contain considerable quantities of organic acids or their salts. Oranges and lemons, for instance, are rich in citric acid; grapes contain potassium acid tartrate; apples and other fruits contain malic acid; and many fruits contain succinic acid. Fermented foods may contain appreciable quantities of lactic acid as in sauerkraut and sour milk, buttermilk, etc., or acetic acid as in vinegar. A few foods contain oxalic acid or oxalates, but these are probably of little if any food value and may be injurious.

With the exception of oxalic acid, these organic acids appear normally to be burned in the body, and doubtless their energy is used in practically the same way as the energy of the carbohydrates. The fuel values of some of these acids have been determined as follows: acetic acid. 3.5 Calories per gram; citric acid, 2.5 Calories per gram; lactic acid, 3.7

Calories per gram; succinic acid, 3.0 Calories per gram; tartaric acid, 1.7 Calories per gram. While these values are somewhat lower than those of the carbohydrates, it is not uncommon in reckoning the fuel value of a food to count the organic acid as carbohydrate, especially as in routine analyses the acids are often not sought nor are the carbohydrates determined directly, but all of the material not found to be moisture, protein, fat, or ash is often considered to be carbohydrate for the purposes of ordinary estimations of food values.

Fats

The fats are all glycerides; that is, substances consisting of combinations of glycerol (commercially called "glycerin") with fatty acids. Many of these fatty acids belong chemically to the same series with acetic acid. The chief members of this series occurring naturally in fats are butyric acid, $C_4H_8O_2$; caproic acid, $C_6H_{12}O_2$; caprylic acid, $C_8H_{16}O_2$; capric acid, $C_{10}H_{20}O_2$; lauric acid, $C_{12}H_{24}O_2$; myristic acid, $C_{14}H_{28}O_2$; palmitic acid, $C_{16}H_{32}O_2$; stearic acid, $C_{18}H_{36}O_2$.

Butyric acid is a liquid which mixes in all proportions with water, alcohol, and ether, can be boiled without decomposition, and is readily volatile in steam.

With increasing molecular weight, the acids of this series regularly show increasing boiling or melting points, decreasing solubility, and become less volatile. Those up to capric acid are liquids at ordinary temperatures; those above are solids. The higher the molecular weight, the harder the solid. Stearic acid is a hard paraffin-like crystalline solid insoluble in water and only moderately soluble in alcohol and ether.

The properties of the fats themselves depend upon and run parallel with those of the fatty acids.

In addition to the fatty acids of the series to which acetic, butyric, and stearic acids belong, all of which are saturated compounds, there are several unsaturated fatty acids, capable of combining chemically with hydrogen, oxygen, or halogens by direct addition. The most important of these contain eighteen carbon atoms to the molecule and therefore resemble stearic acid in molecular size.

The most important of these unsaturated fatty acids are: oleic acid, $C_{18}H_{34}O_2$; linoleic acid, $C_{18}H_{32}O_2$; linolenic acid, $C_{18}H_{30}O_2$. All of these acids and their glycerides are liquid at ordinary temperatures. Commercial fats consisting mainly of the glycerides of these acids are therefore liquids and are usually called oils. The chief chemical difference between olive oil and lard is that the former contains more *olein* (glyceride of oleic acid) and the latter more of *palmitin* and *stearin* (glycerides of palmitic and stearic acids). Olein or *linolein* (glyceride of linoleic acid) may be converted into stearin by direct chemical union with hydrogen, and this is now done on a commercial scale for the hardening of fatty oils so as to give them the consistency of lard (Chapter X).

The body fat of man and of the animals commonly used as food consists of glycerides of palmitic, stearic, and oleic acids. Since palmitin and stearin are solids, while olein is a liquid, the hardness or softness of these fats is principally due to the proportion of olein which they contain. Butter fat contains all of the fatty acids listed above in the series from butyric to stearic acid and is distinguished from the other food fats principally by this fact. Olive oil consists chiefly of palmitin, stearin, and olein, but contains much more olein and much less stearin than the ordinary solid fats. In cottonseed oil, sesame oil, and other seed oils used as food, the quantities of palmitin and stearin are still smaller and, in addition to large quantities of olein, considerable quantities of linolein and in some cases even linolenin may occur.

"Simple" and "mixed" glycerides. For convenience we speak as though the oleic acid radicles in a fat were present simply in the form of olein; the stearic in the form of stearin; the palmitic as palmitin; etc. As a matter of fact this may be true, and glycerides which contain only one kind of fatty acid radicle in the molecule like simple olein, stearin, or palmitin are called "simple glycerides"; and it may also be true that two or more kinds of fatty acid may combine with the same molecule of glycerol forming what is called a "mixed glyceride." "Mixed glyceride" is thus used as a technical term to mean something more than merely a mixture of glycerides. If one molecule of glycerol be combined with one molecule each of oleic, stearic, and palmitic acids, the resulting mixed glyceride, oleo-stearo-palmitin, is different from a mere mixture of simple olein, palmitin, and stearin. Ordinary natural and commercial fats are mixtures of both simple and mixed glycerides.

Fats in foods and nutrition. In food analysis, fat is usually determined by extraction with ether. All ether-soluble substances are therefore likely to be counted as fat. In this way some small quantities of materials of less food value are likely to be counted along with the fat of the food. A more serious source of misunderstanding arises from the fact that some food fats are important sources of fat-soluble vitamin while others are not. As will be shown more fully in Chapter X, the familiar edible fats and oils of commerce are rather similar in their chemical composition and digestibility and therefore in their *fuel value;* but they are very different in their *food value* because of the great differences in their fat-soluble vitamin content.

The fat of the food after digestion and absorption is again found in the blood in the form of glycerides or neutral fat which disappears partly by being burned in the muscles and other active tissues where it is used as fuel for the same purposes as carbohydrate; and if in excess of the fuel requirements of the body, the fat obtained from the food may also be stored in the tissues. The body fat obtained thus directly from the food may show somewhat different characters from the fat which has been formed in the body from carbohydrate, but its nutritive relations appear to be exactly the same. In either case, the fat thus stored in the body may be drawn upon for use as fuel at any future time when the energy requirements of the body demand it.

The energy value to the body of average food fat is 9.0 Calories per gram, or 4082 Calories per pound.

Proteins (Nitrogen Compounds)

Among the nitrogenous constituents of foods, the proteins usually so far predominate that the term "protein" is often used as practically synonymous with the nitrogen compounds of food materials. For this reason, and because the great majority of proteins contain from 15 to 18 per cent, averaging about 16 per cent, of nitrogen, the protein content of food materials is usually estimated by determining nitrogen and multiplying the percentage of nitrogen found by 6.25.

The proteins are very complex substances and in no case is the chemical constitution of a natural protein fully and exactly known. It has, however, been determined that the typical proteins are essentially anhydrides of amino acids. Thus the relation of the protein molecule to the amino acids, from which it is derived and into which it can be resolved, is analogous to the relation of starch to glucose. There is, however, this striking difference: that the molecules of monosaccharide derived from the complete hydrolysis of the starch are all alike (glucose), whereas the complete hydrolysis of a protein always yields several different amino acids, usually from twelve to fifteen.

The names[1] of the amino acids commonly met as products of hydrolysis of proteins are: glycine (glycocoll), alanine, serine, valine, leucine, proline, phenylalanine, tyrosine, aspartic acid,

[1] The names of the amino acids are sometimes spelled without the final *e*; for example, glycine as glycin, alanine as alanin. The names of *proteins* should always be spelled *without* the final *e* to distinguish them from amino acids and some other groups of nitrogen compounds; thus always gelatin (never gelatine).

glutamic (glutaminic) acid, lysine, arginine, histidine, tryptophane, cystine. The strict chemical names and structural formulæ of these amino acids are given in Chapter III of *Chemistry of Food and Nutrition, Revised Edition.*

Classification of the proteins. There has been considerable confusion in the classification and terminology of the proteins, and even in the publications of the present day, the same terms may sometimes be found employed with different meanings by different writers. The classification now generally approved is as follows:

I. Simple proteins. Protein substances which yield only amino acids or their derivatives on hydrolysis.

(*a*) *Albumins.* Simple proteins soluble in pure water and coagulable by heat. Examples: egg albumin, lact-albumin (milk), serum albumin (blood), leucosin (wheat), legumelin (peas).

(*b*) *Globulins.* Simple proteins insoluble in pure water, but soluble in neutral salt solutions. Examples: muscle globulin, serum globulin (blood), edestin (wheat, hemp seed, and other seeds), phaseolin (beans), legumin (beans and peas), vignin (cow peas), tuberin (potato), amandin (almonds), excelsin (Brazil nuts).

(*c*) *Glutelins.* Simple proteins insoluble in all neutral solvents, but readily soluble in very dilute acids and alkalies. The best known and most important member of this group is the glutenin of wheat.

(*d*) *Alcohol-soluble proteins.* Simple proteins soluble in relatively strong alcohol (70–80 per cent) but insoluble in water, absolute alcohol, and other neutral solvents. Examples: gliadin (wheat), zein (corn), hordein (barley).

(*e*) *Albuminoids.* These are the simple proteins characteristic of the skeletal structures of animals (for which reason they are also called scleroproteins) and also of the external protective tissues such as the skin, hair, etc. None of these proteins is commonly used for food in the natural state, but collagen when boiled with water yields gelatin so that these two are of considerable importance in food chemistry.

(*f*) *Histons.* Soluble in water, and insoluble in very dilute ammonia, and in the absence of ammonium salts insoluble even in an excess of ammonia; yield precipitates with solutions of other proteins and a coagulum on heating which is easily soluble in very dilute acids. On hydrolysis they yield several amino acids, among which the basic ones predominate. The only members of this group which have any considerable importance as food are the thymus histon and the globin derived from the hemoglobin of the blood.

(*g*) *Protamins.* These are simpler substances than the preceding groups, are soluble in water, uncoagulable by heat, possess strong basic properties, and on hydrolysis yield a few amino acids, among which the basic amino acids greatly predominate. While basic amino acids are important in nutrition, the protamins themselves are of practically no importance as food.

II. Conjugated proteins. Substances which contain the protein molecule united to some other molecule or molecules otherwise than as a salt.

(*a*) *Nucleoproteins.* Compounds of one or more protein molecules with nucleic acid. Examples of the nucleic acids thus found united with proteins are thymo-nucleic acid (thymus gland), tritico-nucleic acid (wheat germ).

(*b*) *Glycoproteins.* Compounds of the protein molecule with a substance or substances containing a carbohydrate group other than a nucleic acid. Example: mucins.

(*c*) *Phosphoproteins.* Compounds in which the phosphorus is in organic union with the protein molecule otherwise than in a nucleic acid or lecithin. Examples: caseinogen (milk), ovovitellin (egg yolk).

(*d*) *Hemoglobins.* Compounds of the protein molecule with hematin or some similar substance. Example: hemoglobin of blood. (The redness of meat is due chiefly to the hemoglobin of the blood which the meat still retains.)

(*e*) *Lecithoproteins.* Compounds of the protein molecule with lecithins or related substances.

III. Derived proteins.

1. *Primary protein derivatives.* Derivatives of the protein molecule apparently formed through hydrolytic changes which involve only slight alterations of the protein molecule.

(*a*) *Proteans.* Insoluble products which apparently result from the incipient action of water, very dilute acids, or enzymes. Examples: casein (curdled milk), fibrin (coagulated blood).

(*b*) *Metaproteins.* Products of the further action of acids and alkalies whereby the molecule is sufficiently altered to form proteins soluble in very weak acids and alkalies, but insoluble in neutral solvents. This group includes the substances which have been called "acid proteins," "acid albumins," "syntonin," "alkali proteins," "alkali albumins," and "albuminates."

(*c*) *Coagulated proteins.* Insoluble products which result from (1) the action of heat on protein solutions, or (2) the action of alcohol on the protein. Example: cooked egg albumin, or egg albumin precipitated by means of alcohol.

2. *Secondary protein derivatives.* Products of the further hydrolytic cleavage of the protein molecule.

(*a*) *Proteoses.* Soluble in water, not coagulable by heat, precipitated by saturating their solutions with ammonium sulphate or zinc sulphate. The products commercially known as "peptones" consist largely of proteoses.

(*b*) *Peptones.* Soluble in water, not coagulable by heat, and not precipitated by saturating their solutions with ammonium sulphate or zinc sulphate. These represent a further stage of cleavage than the proteoses.

(*c*) *Peptids.* Definitely characterized combinations of two or more amino acids. An anhydride of two amino acid radicles is called a "di-peptid"; one having three amino acid radicles, a

" tri-peptid "; etc. Peptids result from the further hydrolytic cleavage of the peptones. Many peptids have also been made in the laboratory by the linking together of amino acids.

Substances simpler than the peptones but containing several amino acid radicles are often called " polypeptids."

Proteins in nutrition.[1] The digestion products of protein absorbed from the digestive tract into the blood stream are rapidly distributed through the body and taken up by the muscles and other tissues. A part of the nitrogenous material thus received may be utilized for the growth or " repair " (" upkeep " is perhaps a preferable term) of tissue material; the remainder is split, the nitrogen being eliminated chiefly as urea and the non-nitrogenous residue being either burned as fuel or converted into carbohydrate or fat.

It should be kept in mind that in the full-grown, well-nourished organism, no increase of protein tissue ordinarily occurs; hence all the protein received from the food is burned as fuel, whether it first serves for the repair or upkeep of the body tissue or not. The exact nature of the " repair " process in the tissues is not fully known. It is also uncertain to what extent the food must supply the exact amount of each individual amino acid which is to enter into the constitution of the body proteins. It is certain that the body can make glycine (glycocoll), while it cannot make cystine or tryptophane (certainly at least not at a sufficient rate to meet its needs). Hence the protein of the food need not contain glycine radicles but must contain cystine and tryptophane radicles if it is to serve fully the nutritive requirements of the body. It is now believed that lysine cannot be made in the animal body, though the full-grown animal can maintain itself for a long time with only very small amounts of lysine. The evidence in regard to the ability of the body to make certain other amino acids is less clear. Probably either

[1] For fuller discussion see *Chemistry of Food and Nutrition, Revised Edition*, Chapters III, V, VIII.

arginine or histidine or both and either tyrosine or phenylalanine must be supplied by the food protein.

The energy value to the body of average food protein is 4.0 Calories per gram, or 1814 Calories per pound.

Ash Constituents

Sulphur compounds. Sulphur occurs in the food, as it does in the body, chiefly as a constituent of proteins. Since sulphur is essential to the constitution of the body proteins, it is obviously important that sufficient of this element shall be supplied by the food; but all food proteins contain sulphur, and though the percentages of sulphur in individual proteins show considerable differences, the different proteins of the same food material usually tend to balance each other in this respect so that the sulphur content of the total protein (or the ratio of sulphur to nitrogen) is about the same for most staple foods as for the body.

Hence it is believed that under ordinary conditions food which supplies adequate protein will thereby supply adequate sulphur, so that usually sulphur need not be considered as a separate factor in determining food values, but may be regarded as sufficiently provided for when the protein requirement is covered.

When the digestion products of the food proteins are burned in the body, the greater part of the sulphur is oxidized to sulphuric acid and excreted as sulphates.

Phosphorus compounds. Phosphorus compounds are essential to all the tissues of the body, and it is important that they be adequately supplied by the food.

The various articles of food differ greatly in phosphorus content, nor does the amount of phosphorus run even approximately parallel with the protein content (as does the sulphur). Hence the phosphorus compounds of food materials should be carefully considered in forming judgments of nutritive values.

The phosphorus compounds of foods may be grouped into four general classes, one inorganic and three organic: (1) inorganic phosphates; (2) phosphorized proteins, including the phosphoproteins such as casein and the nucleoproteins characteristic of cell nuclei; (3) phosphorized fats or phospholipins, such as egg lecithin; (4) combinations of phosphoric acid with carbohydrates or with closely related substances such as inosite. This last group includes phytin and the related compounds.

All three groups of organic phosphorus compounds are more or less completely oxidized in the body, the phosphorus being finally excreted almost entirely in the form of phosphate. The phosphates of the food while entering and leaving the body in essentially the same form are nevertheless utilized in some very important nutritive functions such as furnishing material for bone structure and facilitating the maintenance of the normal neutrality or slight alkalescence of the blood and the body tissues. (The normal condition of the blood and tissues is described either as neutral or as slightly alkaline, according to the definition of neutrality used.)

Chlorides. Sodium chloride (common salt) is an essential and a prominent constituent of the blood and other body fluids. Carnivorous animals, eating the blood as well as the flesh of their prey, obtain in this way sufficient salt for their needs along with their organic foodstuffs; man and the herbivora take salt in addition to that naturally contained in their food. Salt is now such a cheap and popular condiment that it is commonly added to the food in quantities which make the natural chloride content of the food a matter of no practical consequence.

While sodium chloride enters and leaves the body in the same form, it performs important functions. From it the hydrochloric acid of the gastric juice is made and chiefly to it the normal solvent power and osmotic pressure of the blood and other body fluids are due. The nature of these functions makes plain the imperative need for salt, but also suggests that too much may be objectionable. The quantities of salt now commonly eaten seem larger than necessary; whether larger than desirable is still an open question.

Sodium, potassium, calcium, and magnesium. Sodium occurs in the food chiefly in the form of sodium chloride; potassium chiefly as phosphate, as salts of organic acids, and perhaps in other organic combinations. The quantity of sodium present naturally in foods is usually not of great significance because of the large amounts added in the form of common salt used as a condiment. Potassium is particularly abundant in many of the vegetables. To a certain extent sodium and potassium appear to act antagonistically in the body, so that the large quantity of potassium taken in when such vegetables are eaten freely must be balanced by the taking of common salt.

There must also be maintained in the body a proper balance between sodium and calcium. For example, the rhythmical contraction and relaxation of heart muscle which constitutes the normal beating of the heart is dependent upon this muscle being bathed by a fluid containing the proper concentration and quantitative proportions of sodium and calcium.

In other directions there appear to be somewhat analogous balancings of calcium and magnesium, and of calcium and phosphorus.

Since these elements are not only not interchangeable but are in some respects mutually antagonistic, it is evident that each must be supplied in sufficient quantity to permit the proper performance of its specific functions. In the case of sodium, the liberal use of salt as a condiment insures a more than ample supply. Potassium and magnesium appear to be sufficiently abundant in most staple foods so that it is not usually necessary to specifically consider these elements in estimates of food values. Calcium is not always sufficiently abundant even when the food is freely chosen; hence the richness of a food in calcium is a factor affecting its nutritive value. American dietaries are probably more often deficient in calcium than in any other chemical element. Milk and many vegetables are relatively rich in calcium, and for this reason as well as others they are deserving of a more prominent place in our dietaries.

Iron. Iron occurs in the food almost entirely in organic form as a constituent of certain proteins. The simpler forms, chiefly inorganic, in which iron is given medicinally may or may not have the same nutritive effect as the food iron.

The greater part of the iron in the body exists as an essential constituent of the hemoglobin of the blood, the remainder being chiefly in the chromatin substances of the cells. There is no considerable reserve store of inactive iron in the body corresponding to the stores of phosphorus and calcium in the bones. Hence if the food fails to furnish as much iron as is expended in the nutritive processes and excreted by the body, there must soon result a diminution of hemoglobin, which if allowed to continue is marked by a greater or less degree of anæmia. Thus although only small amounts of iron are contained in the food or involved in the nutritive processes, its function as a building material for the red blood cells is conspicuously important. Iron salts and other simple compounds of iron have long been used medicinally in the treatment of anæmia and are undoubtedly often helpful, but very extensive investigation leaves it still an open question whether hemoglobin is made from these forms as advantageously as from the iron-protein compounds of the food. Perhaps there are organic groups in these latter compounds which play a part in hemoglobin formation as well as the iron itself.

For the present at least it seems much better to look to the food and not to medicines or mineral waters for the supply of iron needed in normal nutrition and since freely chosen food does not always furnish enough iron to meet satisfactorily the requirements of the body, it follows that the iron content is a factor of some importance in the consideration of food values.

The Vitamins as Factors in Food Values

Hopkins of Cambridge University was the first to make clear that normal nutrition requires something more than proteins, fats, carbohydrates, and compounds of the mineral elements. He showed that even small amounts of milk (fresh or dried, or of the alcohol-soluble organic material of milk[1]) exert a very marked influence upon the growth of young animals kept on a diet of artificially purified food materials, however carefully the purified food substances were chosen to include the right kinds and amounts of proteins and of all the mineral elements required for growth.

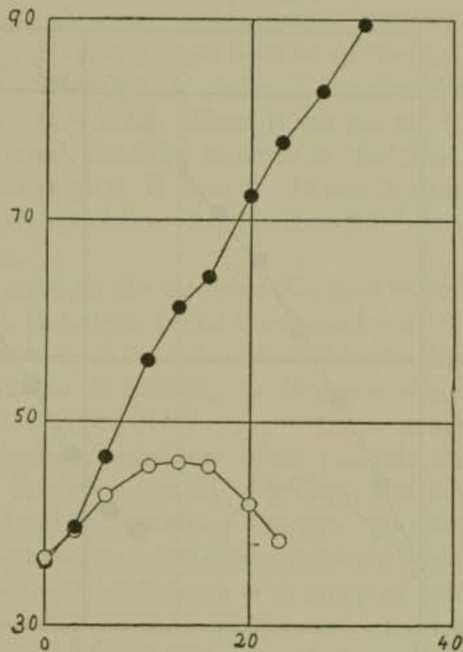


FIG. 4. — Growth curves of rats. Lower curve six rats on artificial diet alone. Upper curve six similar rats receiving in addition 2 cc. of milk each per day. Abscissæ time in days; ordinates average weight in grams. (Courtesy of Dr. F. Gowland Hopkins.)

Some of Hopkins's results are shown in the accompanying cuts. Figure 4 shows the growth curves of rats with and without a small amount of milk when the rest of the diet was of artificially purified food. Figure 5 shows the results of a similar experiment in which on the eighteenth day the milk was transferred

[1] The good results obtained by Hopkins with an alcohol-extract of dry milk are attributable to the fact that alcohol dissolves both the fat-soluble and the water-soluble vitamins.

from one set of rats to the other. Note in both cases the failure of growth on the diet of artificially purified foodstuffs alone and the rapid growth when milk was fed.

The previously unknown organic substances essential to normal nutrition whose existence was thus demonstrated by

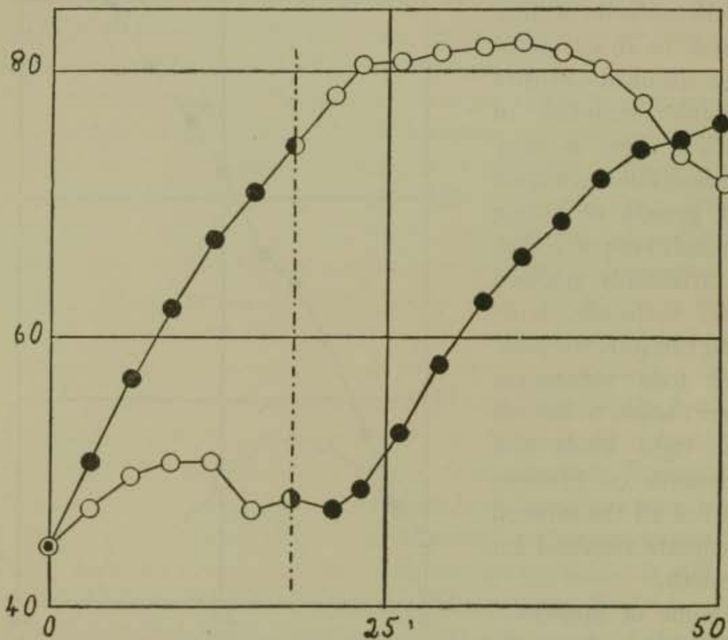


FIG. 5. — Growth curves of rats. Lower curve (up to 18th day) represents rats on purified food; upper curve similar rats having 3 cc. milk each per day in addition to this food. On the 18th day, marked by the vertical dotted line, the milk was transferred from one set to the other. Abscissæ time in days; ordinates average weight in grams. (Courtesy of Dr. F. Gowland Hopkins.)

Hopkins are now known as the vitamins. While much that we should like to know about the vitamins is still obscure, and much that has been written about them is confusing, it can be said that all students of the subject now recognize the existence of at least three kinds of vitamins and understand in essentially the same way the terms vitamin A, vitamin B, and vitamin C. Probably not all the effects which are attributed to vitamins are due to only three chemical substances. There are already reasons for believing that the effects which have been attributed to " vitamin A " are to be separated and assigned to two or three different substances. A similar subdivision of " vitamin B " appears also to be in progress, and we need be neither surprised nor disconcerted if the scientific study of the vitamins should result in further subdivisions. Most, if not all, of our present needs may be served, however, in terms of the threefold classification into vitamins A, B, and C. It will be convenient to consider the water-soluble vitamins B and C before the fat-soluble vitamin A.

Vitamin B is defined both as the water-soluble growth-promoting substance which McCollum called " water-soluble B " and as the antineuritic substance (so-called because it prevents the neuritis or nerve disease of beriberi), to designate which Funk coined the term " vitamine." To most writers, it has seemed probable that the same substance which prevents the neuritis, functions also in the promotion of growth, and has other functions in normal nutrition as well. The term " vitamin B " stands for the food factor which meets these nutritional needs, whether it be a single chemical substance or a group of substances. It appears to be important to appetite and digestion and to bear some relation to general nutrition as well, for it seems that in order to maintain the best condition of nutrition it is necessary to supply the body with more vitamin B than is needed to prevent beriberi, and probably more than is needed to sustain normal growth. Once the matter is understood, however, it is relatively easy to provide an abundance of vitamin B in the dietary because of its wide natural distribution among food products. Milk, eggs, and nearly all parts of plants in their natural state contain vitamin B in liberal amount. Vitamin B also as the most stable of the three vitamins is the least likely to be destroyed by heat or by oxidation; but being readily soluble in water, much of it may be lost if one rejects the watery portions of canned vegetables or the waters in which vegetables have been cooked.

Vitamin C is called the "antiscorbutic" vitamin because it prevents scurvy, just as vitamin B prevents the neuritis of beriberi.

There is strong evidence that vitamin C not only prevents scurvy but plays an important part in normal nutrition as well, and that our food must furnish us much more vitamin C than is needed for protection from scurvy, if we are to enjoy a full measure of good health and vigor. Hess has pointed out the frequency among young children of cases in which irritability, lack of stamina, and retardation of growth can be cured by the simple addition of more antiscorbutic food to the diet, showing that the diet had been too poor in vitamin C even though no distinct symptoms of scurvy had appeared. Undoubtedly many adult dietaries also are capable of improvement by being made richer in vitamin C; for vitamin C is less widely distributed in food materials than is vitamin B, and being a less stable substance it is more likely to be destroyed in the preservation or the cooking of the food. We shall find, however, that some foods are rich sources of vitamin C and retain this property well, even when heated or stored. This is true of oranges and lemons and their properly preserved juices, and also of ordinary canned tomatoes. Cabbage and onion eaten raw are also rich sources of vitamin C. Apples, bananas, potatoes, and milk contain it in less concentration, but are important sources because of the quantities in which they may be eaten. In some of the subsequent chapters we shall have occasion to consider more fully the occurrence and properties of vitamin C because of its importance as a factor in the nutritive values of certain foods.

Vitamin A may not bear the direct controlling relation to any specific disease that vitamin B does to beriberi or vitamin C to scurvy; but, of the three, vitamin A is probably the most important to health in America because so many of our staple foods are poor in vitamin A and because a diet poor in this vitamin seems so plainly to lower the general stamina of the body and so greatly to increase its susceptibility to several different infectious diseases. Vitamin A is therefore to be regarded as an important factor in food values.

That certain foods contain a fat-soluble substance of fundamental importance to nutrition was discovered in 1913, independently by McCollum and Davis at the University of Wisconsin and Osborne and Mendel at New Haven, through feeding experiments in which it was found that, with all other conditions the same, young animals would grow normally or fail to grow, depending upon whether the fat in their food mixture was butterfat or lard.

When growth ceases for lack of vitamin A, there also results a greatly increased susceptibility to infection. This seems to be due to a weakening of the membranes in many parts of the body, with the result that the eyes, the air passages and lungs, the skin and the bladder, and even the ear passages and frontal sinus often become affected. Hence it appears that diet poor in vitamin A leads to increased prevalence of disease due to various infections. When the diet furnishes barely enough vitamin A to permit growth and the maintenance of apparently normal health, more is really needed for full vigor, but the nature of this need is apt to go unrecognized. In experiments with laboratory animals the greater vigor conferred by a richer supply of vitamin A becomes very strikingly manifest when animals alike except for the amount of this vitamin in their diet are tested for health and vigor by subjecting them to the added nutritional demands of reproduction and the suckling of young. An individual may appear to thrive on a diet relatively poor in vitamin A, but the results are always deleterious to the offspring (if any are produced) and almost always the individuals which have appeared to bear such a diet well in early life are found to break down in middle life or to become prematurely old.

Vitamin A differs strikingly from vitamins B and C in that it can be stored in relatively large amounts in the body for future use. The liver appears to be especially adapted to the storage of vitamin A; but it has also been found that the lung tissue is richer in vitamin A when the food has furnished it more abundantly. Thus a diet poor in vitamin A leads to a lower proportion of this vitamin in lung tissue, and lung tissue thus depleted becomes more susceptible to infection. These facts strongly suggest that vitamin A here plays the part of an important constituent of the tissue.

All three of the vitamins plainly have important functions in regulating certain conditions in the body, and it here appears that vitamin A may be important as a tissue-building material as well. Hence vitamin values as well as the older aspects of food values will enter into our studies of food products in the chapters which follow.

Summary of the Functions of Food

Much the largest part of the total solids of the food is burned in the body and yields energy for the support of its activities. Even during growth most of the fat and carbohydrate and the greater part of the protein is so used.

Part of the protein of the food is used as a source of body protein, or, as it is often expressed, is used to build tissue. Several elements not contained in most proteins are also essential to the tissues of the body and these are derived from the so-called ash constituents of the food. The calcium and phosphorus of the bones, the potassium and phosphorus of the soft tissues, the iron of the red blood cells are just as necessary "building materials" as are the proteins, though the amounts required are much smaller.

Upon the presence in the body of salts derived from the food, either directly or as the result of its oxidation in the tissues, depend such important properties and processes as the solvent power and osmotic pressure of the body fluids, the elasticity of the muscles, the maintenance of the normal reaction of the blood and tissues, and in recent years it has been strikingly shown that many body processes are dependent upon vitamins as well.

Many functions which might be mentioned as primarily dependent upon water, salts, and vitamins are hardly suggested by the phrase "tissue building," since they have to do not so much with the actual construction or repair of the tissues as with the regulation of the processes on which the nutrition of the body depends.

It may therefore be said that the functions of food are

(1) to yield energy,

(2) to build tissue,

(3) to regulate body processes.

It is not to be inferred that any given food substance can be assigned once for all to some one of these three general functions. Thus the protein digestion products may serve both to build tissue and to yield energy; phosphates may serve both to build tissue and to assist in regulating the neutrality of the blood and tissues.

Since the same kind of foodstuff may function in more than one way and since more than one kind of foodstuff may contribute to the meeting of certain of the nutritive requirements — proteins, fats, and carbohydrates all serving as sources of energy, for example — there is often wide scope for the exercise of knowledge and judgment in the choice of articles of food to meet the needs of nutrition.

The food as a whole must furnish:

1. Enough of the digestible organic foodstuffs to supply the body's needs for energy, usually measured in terms of Calories.

2. Enough protein of suitable sorts to meet all needs for essential amino acids.

3. Adequate amounts and proper proportions of the mineral elements or ash constituents of the food.

4. Enough of each of at least three kinds of vitamins.

Modern commerce offers us a bewildering array of articles of food ranging from those which contribute to only one of the nutritive needs to those which supply them all. Only by applying a fairly comprehensive knowledge of food products may one hope to be able to make such use of what the market offers as to provide the most satisfactory food supply to the best advantage of health and purse. Any adequate conception of food study must consider the contribution which food makes both to the immediate satisfaction and to the ultimate health of the consumer; it should also hold in due regard the conservation both of the financial resources of the individual and the food resources of the community or of the race as a whole.

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CHAPTER II

THE FOOD INDUSTRY AND ITS CONTROL

The purpose of this chapter is to consider briefly the economic status of the food industry as a whole, the importance of food as a factor in the cost of living, the reasons for legal control of the food industry in behalf of the consuming public, the chief features of the food laws and the methods and standards which have been adopted for their enforcement, and the marked tendency to standardization and scientific control on the part of trade organizations within the food industries themselves.

The individual foods and food industries discussed in subsequent chapters can be studied with most interest against a background of general survey of the food industry as a whole, of the principles underlying our food laws and standards, of the extent to which such laws can and cannot insure the nutritive value of the food, and of the general safety and wholesomeness from the sanitary standpoint of the foods now offered to the consumer.

Some Economic Features of the Food Supply

More than half the total value of natural products of the United States is represented by the food products, whose annual value is about twice that of all other farm products and over twice that of the combined products of the mines and forests.

The products of the mines and forests may be subjected to more elaborate processes of manufacture and so may be increased in value in greater ratio before reaching the consumer than are the food products; but even so we find from the census returns that in value of finished as well as of natural products the food industries lead all others. Among the manufactures, as classified by the United States Census, the greatest is that of slaughtering and meat packing. The annual product of the meat-packing establishments exceeds in value that of the foundries and machine shops. The product of the flour and grist mills is about equal in value to that of either the rolling mills, the lumber mills, or the cotton mills of the country.

The enormous size to which many of the food manufacturing establishments have grown during recent years (as for example a sugar refinery turning out daily from 1,000,000 to 3,000,000 pounds of sugar, or a butter factory producing 25,000 pounds of butter per day) makes it possible to effect great economies or make great advances, through what are apparently quite modest improvements in process or product. Hence the food industries are rapidly being brought under scientific control for the sake of economy in processes, improvement of staple products, and advantageous utilization of by-products.

A recent official report of the Bureau of Chemistry quotes United States Census Statistics for 1919 as showing 67,453 establishments engaged in the manufacture of food products with an output valued at $13,391,914,000 for the year. The fraction of this output which consists of by-products other than foods is more than offset by the great volume of nonmanufactured foods, such as milk, eggs, fresh fruits and vegetables, fresh fish, and the like. A part of the output of food products is of course exported.

With the food industries tending more and more to become highly centralized commercial enterprises and with a decreasing percentage of the people in position to produce any considerable fraction of their own food, it is natural that consumers have sought to safeguard their food supply through legislation, and this not only as a health measure but as an economic measure as well.

"Half the struggle of life is a struggle for food" in the sense that a majority of the world's people must spend as much of their time or their earnings in providing themselves with adequate food as with all other necessities combined. A family in comfortable circumstances may spend as much for rent and (too often perhaps) as much for clothing as for food; but the food is more nearly a fixed requirement than are the other items of the cost of living, so that as we pass to the larger numbers of families who must live on smaller incomes we find that while expenditures for food are less than in well-to-do families of the same size, yet in general it is not feasible to diminish the expenditure for food in the same ratio that the income is diminished, so that the smaller the income the larger the proportion of it that goes for food[1] until in the typical family of a laboring man or clerk practically half the entire income is often spent for food and must be if the health and efficiency of the family are to be maintained. Or as one writer puts it: "The less the worker gains the more he must invest in food, renouncing of necessity all other desires."

Naturally, therefore, consumers must have an intense interest in their food supply. But with the development of modern industry population has concentrated in cities and towns to such an extent that the majority of people have ceased to produce any appreciable part of their own food or even to obtain it from their immediate neighbors. Most people must buy practically all of their food, and the food is brought from greater and greater distances and distributed under conditions which make it increasingly difficult for the consumer to exercise any direct individual control over the methods by which his food is produced and handled. When the majority of the people in any community find themselves in this position, they naturally

[1] Andrews's *Economics of the Household* (1923) contains an excellent compilation and discussion of studies of the cost of living and the distribution of the income at different economic levels, including both the classical and the most recent data.

tend to substitute for the individual control which is no longer feasible a collective control of their food supplies through legislation and official inspection.

Principles of Food Legislation and Inspection

In the United States the legal regulation of the food industry is accomplished partly through the Federal Government by virtue of its constitutional power to regulate commerce with foreign nations and among the several states; and partly through the police power inherent in the state (and often delegated in large measure to the city) to pass such laws and provide such regulations as are necessary to protect its citizens in their rights as to health, morals, and property.

Many communities had laws or ordinances for the prevention of milk adulteration long before making any attempt at general regulation of the entire food supply.

General food legislation was enacted and systematic inspection of food of all kinds was begun in Massachusetts about forty years ago. Legislation of this character spread gradually, and in 1905 about half of the states had general food laws. The national law for prevention of adulteration or misbranding of foods or drugs was passed in 1906, and went into effect January 1, 1907. This stimulated further state legislation, with the result that now nearly every state has a general food law and is making an attempt at its enforcement.

Thus the people, while no longer able to produce their own food or buy it of neighbors who have produced it under known conditions, may still through legislation seek to insure that the food they buy shall be:

(1) What it purports to be, in kind and amount;
(2) Free from deterioration or unwholesome additions;
(3) Possessed of full nutritive value.

Most of our food laws take the form of prescribing what the food shall not be rather than what it shall be, and these prohibitions are usually classified under the two heads of **adulteration** and **misbranding**.

Anything which makes a food unwholesome or lowers its nutritive value is usually considered *adulteration;* while to offer a food under false or misleading claims as to its source, kind, quality, or amount is usually called *misbranding*.

In view of the diversity of methods used in handling different kinds of foods, and the constant changing of methods to keep abreast of scientific developments and economic conditions, it is plain that there will often be room for difference of opinion as to whether a given trade practice shall or shall not be held to be either adulteration or misbranding.

The attempt to settle such questions in advance by writing detailed specifications into the law itself may defeat its own purpose, since in general the more specific the wording of the law, the more literally (and hence narrowly) it must be construed. Thus in the Pennsylvania Food Act of May 13, 1909, the addition of alum to food is prohibited; but it was held by the courts that the word "alum" as used in the law means only potassium aluminum sulphate and not sodium aluminum sulphate nor simple sulphate of aluminum. The latter, being cheaper, are commonly used in the making of "alum" baking powders and for preserving the crispness of pickles, and the introduction of aluminum into the food in these two ways is therefore allowed to continue, although it was for the express purpose of preventing this that the word "alum" was included in the list of forbidden substances in the law.

The Federal Food Law

The Federal Food and Drugs Act of June 30, 1906, commonly known as "The Pure Food Law," and on which subsequent legislation by most of the states has been largely based, defines the main types of adulteration and misbranding, but, except in the case of confectionery and of habit-forming drugs, does not name the specific substances which are to be prohibited or restricted in use, nor does the law itself contain standards of composition for foods.

According to this law *a food is deemed adulterated:*

(1) If any substance has been mixed or packed with it so as to reduce or lower or injuriously affect its quality or strength.

(2) If any substance has been substituted, wholly or in part.

(3) If any valuable constituent has been wholly or in part abstracted.

(4) If it be mixed, colored, coated, powdered, or stained in a manner whereby damage or inferiority is concealed.

(5) If it contain any added poisonous or other added deleterious ingredient which may render it injurious to health.

(6) If it consists in whole or in part of a filthy, decomposed, or putrid animal or vegetable substance, or any portion of an animal unfit for food, or if it be the product of a diseased animal, or one that has died otherwise than by slaughter.

And a food is deemed to be misbranded:

(1) If it be an imitation of or offered for sale under the distinctive name of another article.

(2) If it be labeled or branded so as to deceive or mislead the purchaser, or purport to be a foreign product when not so, or if the contents shall have been substituted in whole or in part, or if it fail to bear a statement on the label of the quantity or proportion of any narcotic or habit-forming drug which it contains.

(3) If, when sold in package form, it fails to bear a correct statement of weight, measure, or numerical count of its contents; provision being made for reasonable variations and for certain exemptions.

(4) If the package containing it or its label shall bear any statement, design, or device which is false or misleading in any particular.

The exact wording of the definitions, and the corresponding definitions of adulteration and misbranding as applied to confectionery and drugs, may be seen by consulting the text of the law, which is given in full in the Appendix at the back of this book (Appendix A).

Notes on the Federal Law and the Rules and Regulations for its Enforcement

Since in the chapters which follow there may be frequent occasion to refer to decisions which have been rendered or standards which have been established under the National law, it will be advantageous at this point to refer to some of its more prominent features and to the provisions for its interpretation and enforcement.

Scope of the law. The direct objective of the law is the prevention of interstate or foreign commerce in adulterated or misbranded foods (and drugs). On account of the limitations placed by the Constitution upon Federal legislation of this sort the law can *directly prohibit the manufacture* of adulterated or misbranded food only in the District of Columbia, or the Territories. *Indirectly*, however, the manufacture of such food on a large scale anywhere in the country can be made difficult if not impracticable through the control of interstate and foreign commerce. Food manufactured and sold exclusively within the borders of any one state is subject only to state or municipal control, but any lot or package of food which passes from one state to another is subject to the provisions of the National law. Moreover, in all such interstate transactions in food products both the consignor and the consignee are liable unless one of them assumes complete liability under the provisions of the law. Often a shipment of food is seized and the prosecution is brought against the goods, the interested parties being given opportunity to appear as claimants and answer the charge of adulteration or misbranding.

Rules and Regulations. The law makes it the duty of the Secretary of the Treasury, the Secretary of Agriculture, and the

Secretary of Commerce to formulate uniform Rules and Regulations for the carrying out of its provisions. As already mentioned, most of the provisions and definitions in the law are general in character. It therefore became necessary for the three Secretaries, in drawing up Rules and Regulations, not only to provide a plan for the collection and examination of samples but also to interpret many of the definitions of adulteration and misbranding.

The Rules and Regulations adopted by the Secretaries are given either in full or in abstract at the back of this book (Appendix A).

These Rules and Regulations are of course subject to review by the courts and they do not have the force and effect of law except in so far as they interpret the law correctly. They are, however, of great importance as constituting the working basis for the enforcement of the law and are frequently quoted.

Food Inspection Decisions. The actual administration of the law and of the Rules and Regulations is the duty of the Secretary of Agriculture. Notwithstanding the adoption of the Rules and Regulations, several questions of interpretation requiring decision by the administrative officers have arisen.

These decisions are published from the Office of the Secretary, United States Department of Agriculture, in a series of numbered leaflets called Food Inspection Decisions (F. I. D.).

A few of these decisions have been signed by the three Secretaries and are practically amendments of the Rules and Regulations. In most cases, however, the "decisions" are simply declarations of the attitude of the Department of Agriculture.

Such decisions of administrative officers must not be confused with the decisions reached by the courts. The latter are found under Notices of Judgment (see below).

Many of the Food Inspection Decisions will be quoted in later chapters in the discussion of the particular types of food to which they relate. Those of more general scope will be found at the back of this book (Appendix A).

Collection of samples. Samples are collected only by authorized agents of the Department of Agriculture or by some health, food, or drug officer commissioned by the Secretary of Agriculture for this purpose. The collectors must purchase representative samples. Samples purchased in bulk are divided into three parts; when in the original unbroken packages three such packages are usually taken. One of the three samples is delivered to the chemist or examiner and two are held under seal by the Secretary of Agriculture, who, upon request, will deliver one of such samples to the party or parties interested.

Examinations or analyses of samples are made in the laboratories of the Bureau of Chemistry of the Department of Agriculture or under its direction and supervision. Unless otherwise directed by the Secretary of Agriculture, foods are analyzed by the methods of the Association of Official Agricultural Chemists, and drugs by the methods of the United States Pharmacopœia.

Standards of purity. The Pharmacopœia gives standards of purity for drugs along with the methods of analysis. The methods of analysis of the Association of Official Agricultural Chemists do not provide corresponding standards, but the Department of Agriculture has from time to time published definitions and standards "as a guide for the officials of this department in enforcing the Food and Drugs Act." The standards current at time of writing (1923) are published as Circular 136, Office of the Secretary, United States Department of Agriculture, and in supplementary Food Inspection Decisions.

The present practice of the Department of Agriculture is to publish for the guidance of its officials the definitions and standards adopted from time to time by the Joint Committee on Definitions and Standards, composed of representatives of the United States Department of Agriculture, the Association of

American Dairy, Food, and Drug Officials, and the Association of Official Agricultural Chemists.

The food officials of the different states are also apt to govern their decisions by these standards unless some other standard is provided for by state law.

These standards, therefore, carry considerable weight and will be considered in connection with the discussions of the composition of food materials in the chapters which follow. They are variously designated as " United States Standards," " Government Standards," " Federal Standards," " Department of Agriculture Standards," or " A. O. A. C. Standards." The latter term was originally the more accurate since these standards for foods, while often cited in Federal prosecutions, are not established by law nor referred to in the Rules and Regulations, but originally represented the action only of the Association of Official Agricultural Chemists (A. O. A. C.). Since the establishment of the Joint Standards Committee on which the Department of Agriculture is officially represented, and the official publication of the standards by the Secretary of Agriculture for the guidance of officials of that Department in enforcing the Federal law, the familiar designation United States Standard or Federal Standard appears to be justified.

In connection with the enforcement of the Federal law and of the laws of many of the states, the strict legal status of these standards is only that of expert testimony, but their actual weight is much greater than that of the testimony of an individual expert. In some states these or similar standards have been written into the law itself and it has been proposed that the Federal law be amended to include such standards.

The present tendency, however, seems to be away from the incorporation of " numerical standards " or limits of composition of foods into the text of the law or even of the regulations.

With or without the guidance of quantitative standards of composition, the Bureau of Chemistry examines each sample submitted by the official inspectors and reports to the Department of Agriculture as to whether or not such sample is adulterated or misbranded.

Hearings. When the examination or analysis indicates that a sample is adulterated or misbranded within the meaning of the law, notice is sent to the party or parties responsible for the food and opportunity is given for a hearing. These hearings are confined to questions of fact (as distinguished from questions of law). The interested parties may appear in person or by attorney and may submit evidence to show any fault or error in the findings of the analyst or examiner.

Prosecutions. If, after a hearing, it appears that a violation of the law has been committed, the Secretary of Agriculture reports the case to the Department of Justice for prosecution, and action is brought by the proper United States attorney, the cases being tried in the Federal courts.

Notices of Judgment. After a judgment of the court has been rendered, the findings are published in such form as the Secretary of Agriculture may direct. These notices are numbered in series and designated as Notices of Judgment (N. J.). Up to the beginning of January, 1924, when the law had been seventeen years in effect, there had been issued from the Office of the Secretary of Agriculture 11,750 such Notices of Judgment. Of these cases more than nine tenths had been decided favorably to the Government. If an appeal is taken from the judgment of the court before the publication of the Notice of Judgment, notice of the appeal must accompany the publication.

Definitions of adulteration and misbranding. The types of adulteration and misbranding recognized by the law were summarized above and their exact definition may be seen from the text of the law. Some types of adulteration and misbranding can be demonstrated directly, while others are detected through the fact that analysis shows the article to be of inferior composition. The latter cases require the acceptance of some standard for comparison. For this purpose the standards of the Association of Official Agricultural Chemists, already referred to, have generally been upheld by the courts.

The clause which declares a food adulterated if it contains any added poisonous or other added deleterious ingredient which may render such article injurious to health has given rise to more discussion than any other part of the law. It had become a custom of the trade to use in the preparation of food a number of substances which had been found helpful in securing the desired color or keeping qualities of the foods, but whose wholesomeness had sometimes been questioned.

Congress declined to include in the food law any specific authorization or prohibition of any particular substance so used, leaving this to be covered by the rules and regulations which the three Secretaries were directed to prepare, and appropriating money to the Department of Agriculture for investigations as to the wholesomeness of these substances.

The original Rules and Regulations contained the provision that: "The Secretary of Agriculture shall determine from time to time, in accordance with the authority conferred by the agricultural appropriation act, Public 382, approved June 30, 1906, the principles which shall guide the use of colors, preservatives, and other substances added to foods; and when concurred in by the Secretary of the Treasury and the Secretary of Commerce, the principles so established shall become a part of these regulations."

Regarding the wholesomeness of colors, it is the practice to permit the use of any natural vegetable or animal color which is not known to be impure or injurious, but to be much more stringent with respect to the use of artificial (synthetic) colors. Only about a dozen artificial colors have so far been authorized, and of these the purity of each batch must be attested before it can legally be used.

Whether the presence of an authorized color must be declared upon the label will depend upon the nature of the food. Any coloring which is intended to mislead is illegal and in most other cases the fact that the food has been artificially colored must be plainly stated.

Under these regulations many manufacturers who formerly used artificial coloring have ceased to do so. Thus one of the good effects of the law is that it results in foods being marketed in more nearly their normal appearance.

The establishment of principles to guide the use of preservatives has presented greater difficulty than in the case of colors, partly for the obvious reason that the preservation of food is necessary while the coloring of food is not. It is true that by drying, by heating and canning, and to a certain extent by refrigeration, foods may be preserved from the season of abundance to the season of scarcity without the addition of any preservative substance, but restriction to these methods of preservation would often be unnecessarily burdensome and costly and would in many cases involve a loss of the flavor for which the food is chiefly prized. The prohibition of all preservative substances would be as unsatisfactory to the consumer as to the producer and has never been seriously contemplated. What has sometimes been attempted is to divide all preservative substances into two classes, those in one class to be freely permitted and those in the other class to be strictly forbidden. The fact that the law defines food in such a way as to include condiments has been construed as tacitly authorizing the unlimited use of such preservatives as have condimental properties (like salt, sugar, vinegar, and woodsmoke) and the question of wholesomeness has as yet been officially raised only with respect to the noncondimental preservatives such as saltpeter, sodium benzoate, salicylic acid, and sulphur dioxide.

To assist the Secretary of Agriculture in determining the wholesomeness of certain of the preservative substances used, a Referee Board of Consulting Scientific Experts consisting of five prominent scientists, not otherwise connected with the Government service, was appointed and served for a number of years. In general such Rules and Regulations governing the use of preservatives as have been formulated by the three Secretaries have been based on the findings of the Bureau of Chemistry or of the Referee Board or have been made tentatively pending investigation. The regulations at present (1924) in force are given in the Appendix. As might be anticipated, when the different (noncondimental) preservative substances are treated each on its own merits, the regulations deemed necessary are not the same in all cases. Regarding the four substances just mentioned the present Federal regulations are essentially as follows: Saltpeter may be used without restriction; sodium benzoate may be used with no restriction except that the presence and true amount must be stated on the label; salicylic acid is forbidden; sulphur dioxide may be used only in those foods in which its use was already common and only in limited amounts.

Guaranty. In order to secure justice in the fixing of responsibility, the law provides that the manufacturer or wholesaler may assume liability for his products so that he and not the retail dealer shall be held responsible in case of adulteration or misbranding. Formerly this was done by filing with the Government a general guaranty which was recorded under a Serial Number. Each package then bore a label showing the serial number and name and address of the party responsible for the guaranty. This guaranty was simply to fix responsibility and to protect the retail dealer. It afforded no additional protection to the consumer and added nothing to the penalty in case the food was found to be adulterated or misbranded. This, however, was not always understood, many purchasers supposing that they derived some additional protection from such guaranty. Hence a revised regulation, effective May 1, 1916, abolished the issuing of serial numbers and forbade their use or the printing of the "guaranty legend" on the labels.

Under the present regulation the guaranty should be incorporated in or attached to the bill of sale, invoice, or bill of lading, and should not appear on the labels or packages.

Imported foods. The law provides for the inspection of imported foods while still in the hands of the customs officers or under bond. This greatly facilitates the prevention of importation of adulterated food, and it is believed that comparatively little adulterated food is now imported. Adulterated food bearing labels indicating a foreign origin may be found in the American market but is likely to have been prepared in this country.

State and Municipal Food Control

Since the Federal authorities cannot inspect or control any food which is produced and consumed in the same state, it is evident that each of the forty-eight states must have adequate legislation and inspection if its citizens are to obtain the full benefit of the pure food movement. In order fully to realize the importance of state and municipal control, one must remember that some of the foods most readily subjected to fraudulent adulteration (*e.g.*, milk) and some of those most subject to dangerous contamination (*e.g.*, meats and shellfish) are largely handled by producers and dealers who do a local business and so do not come under the authority of the Federal Government. Slaughtering and meat packing is now a highly centralized industry and is regulated both by the Food and Drugs Act and by a special Meat Inspection Law (see Chapter VI and Appendix B), yet about half the meat consumed in the United States is slaughtered in local establishments which are never visited by the Federal inspectors because they do no interstate business.

The rural population and the residents of small towns, who together make up about one half the people of the United States, derive relatively little *direct* benefit from the Federal law. *Indirectly* they benefit in proportion as the Federal legislation and inspection serves to stimulate and standardize that of the states. At the present time most of the states have on their statute books food laws which are modeled more or less directly after the Federal law and which are satisfactory in so far as sufficient funds are appropriated to make possible their enforcement.

State laws may be more stringent in some respects than those of the Federal Government. Thus several states limit the time that food may be held in cold storage; the Sanitary Code of New York State makes it unlawful for any person "affected with any communicable disease to handle food or food products in any manner whatever," and several other states have laws or regulations of similar import.

The responsibility of the enforcement of state food laws is lodged sometimes with health officers, sometimes with the commissioner of agriculture, sometimes with a food commissioner independent of either the Department of Agriculture or of Health. Not infrequently the office of "dairy and food commissioner" has developed through the fact that legal regulation of the milk supply and dairy industry antedated general food legislation. Whatever the organization, it is important that the enforcement of the state food laws be in the hands of permanent officials, scientifically trained, gifted with good judgment and administrative capacity, and entirely independent of politics.

State legislation and inspection may be supplemented by municipal ordinances enforced by distinct corps of officers. In New York City, for example, the board of health has the power to enact a sanitary code which becomes law on publication without requiring the approval of any other body or official. This code contains general rules for food control; and additional rules and regulations to govern certain industries are also promulgated by the board and thus become part of, and have the legal force of, the code. The board of health has the power to control any food industry by requiring that it be carried on only under permits granted by the board. So long as no charge is made for these permits the board may revoke them at any time without resorting to the courts. Violations of the sanitary code may be punished either by criminal prosecution or civil suit. The policy has been to bring criminal prosecution in all cases of actual adulteration.

Recent Developments in Food Control

Official grades and standards, market news, and shipping-point inspection. The standards established for the enforcement of the Food and Drugs Act are essentially official definitions with or without numerical limits of composition for guidance in determining adulteration. They can therefore define only that minimum of quality or food value which permits of the article being considered free from adulteration. In addition to such minimum standards there is much advantage in the grading and standardizing of foods according to degree of excellence. For some foods trade practices have done this to a greater or less extent, and in the case of milk a group of authorities from different parts of the country have voluntarily agreed upon standards for grades "A" and "B," as will be described in Chapter III.

The Federal Government has also undertaken a comprehensive program of standardization of important farm products.

The United States Grain-Standards Act authorizes the Secretary of Agriculture to investigate the handling and grading of grain, establish official standards, license grain inspectors, and otherwise administer its provisions. All shipments by grade in interstate or foreign commerce must either be inspected by a licensed inspector at the point of shipment, during transit, or at the point of delivery, or, if there are no inspection facilities available, may be marketed uninspected but subject to the right of either party to the transaction to refer any dispute as to the grade to the Secretary of Agriculture for his determination. An appeal to the Secretary may also be taken as to the true grade of grain which has been inspected. The findings of the Secretary in cases of dispute and appeals are made prima facie evidence in court proceedings.

The certifying of an official grade on shipments subject to Federal supervision is restricted to inspectors holding Federal licenses. These licenses are to be issued to persons authorized to inspect and grade grain under state laws, or may be issued to any competent and disinterested person, and may be suspended or revoked for cause. A complete system of records and reports is required of inspectors, and penalties are provided for false grading, interference with officials, and other violations of the act.

The legislation is designed to facilitate the use of more uniform grades in handling grain, thus simplifying the relations between the producer, dealer, and consumer. Since the final decision as to the grade of a shipment rests with the Department, it is also expected that the grower may more readily obtain higher returns for a product of superior merit, thus supplying him with a financial incentive to improve its quality.

Similar grading of other products is also contemplated or in progress. In his report for the year ending 1922, the Secretary of Agriculture writes:

"The necessity for establishing grades and standards for farm products of all kinds becomes increasingly evident. Clearly defined and generally accepted grades not only prevent innumerable irritations, annoyances, and abuses but help the farmer to produce to better purpose and with fuller understanding of market needs. In the case of many farm products acceptable and fairly well understood grades already have been established, such, for example, as the grain and cotton grades. For some time studies have been in progress with the hope of perfecting market classes and grades for livestock and dressed meats. This work has been carried on in connection with the market-reporting service, the tentative grades being used as the basis for the market reports. Numerous conferences have been held with producers and members of the trade, and recommendations and suggestions have been invited, so that when standards are adopted they will be suited to trade conditions. Illustrated bulletins describing the various classes and grades and defining terms are now in course of preparation. Manuscript for a bulletin on 'Market Classes and Grades of Dressed Beef' is in the hands of the printer. Similar bulletins will be submitted soon dealing with grades of cattle, hogs, veal, lamb and mutton, and pork carcasses, and cuts and miscellaneous meat products.

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"Up to the present time grades have been formulated and recommended for 14 of the more important fruits and vegetables. These grades have been brought to the attention of growers and dealers through demonstration work done in coöperation with State representatives and with organizations of growers. Assistance also is given to States in preparing and revising grades for a large number of products.

"Tentative standards have been prepared for eggs, and attention is being given to the preparation of standards for live and dressed poultry.

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"The demand for Federal inspection of farm products at points of shipment becomes more insistent. Applications for such inspection already have been received from at least 20 states. . . . Some extensions of the market news service have been made through coöperative agreement with the states, whereby the latter pay the expenses involved. Insistent demands have come for a considerable extension of this service but have been denied because of lack of funds. It has been possible, however, to disseminate market information much more widely than heretofore through the use of the radio stations of the Post Office and Navy Departments.

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"The volume of business handled by the office of Federal grain supervision during the past year surpassed by far that handled in any previous year. . . . In addition to the handling of appeals on complaint of parties to commercial transactions, supervisors work in close contact with licensed inspectors, aiding them in inspection problems, and in applying the standards. A total of 175,896 supervision samples were handled during the year to check the work of the inspectors in order to secure correct and uniform application of the Federal standards."

Coöperation within the food industries. Many of the food industries are now strongly organized with associations, institutes, or councils representing the producers of a given type of food and working for the improvement and standardization of practice within the industry as well as to bring its products favorably and intelligently to the attention of the consuming public. The scientific work of such organizations is apparently only in its infancy, yet already important researches both in sanitary and in nutrition problems have been undertaken by them either in laboratories of their own or through grants for the support of research upon specified problems in universities or in special research laboratories.

Trend of interest in food problems through sanitation toward nutrition. To summarize recent progress it may be said that not only is the general food supply now efficiently policed from the sanitary standpoint, but to an even greater extent has the safety of our food been enhanced by the application of sanitary science in and by the food industries, largely under the constructive guidance of the United States Department of Agriculture and the state agricultural colleges and experiment stations on the one hand and the health authorities of our states and cities on the other. So effectively has the science of sanitation been applied in the production, handling, and inspection of food in recent years that in general the consumer may now safely assume that food products offered for sale will not contain anything directly deleterious to health.

At the same time that the development of sanitary science and of food legislation and inspection have largely relieved us from anxiety as to the safety of our food supply, the growth of our knowledge of nutrition has made it quite plain that a freely chosen food supply, adequate both to please the palate and to satisfy hunger, does not always meet all nutritive requirements so as to insure the full measure of health which each of us ought to enjoy. Thus the center of gravity of the problem of the relation of food to health has shifted from sanitation to nutrition.

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CHAPTER III

MILK

MILK is the one article of diet whose sole function in nature is to serve as food. It is also the one food for which there seems to be no satisfactory substitute. Each species of mammal produces a milk especially adapted to the nutritive requirements of its own young, but it was early learned that the milk of other species is also an excellent food for man, and several different species are used for dairy purposes in various parts of the world. In general only cows' milk is of much commercial importance, and the statements which follow refer always to cows' milk unless otherwise explained.

It is estimated by the United States Department of Agriculture (*Yearbook* for 1922, page 291) that 98,862,276,000 pounds of milk were produced in this country in 1921 and that 45.66 per cent of this was used for household purposes, chiefly for direct consumption as milk or cream; while 47.03 per cent was used in the manufacture of butter, cheese, condensed and evaporated milk, and ice cream; and 7.31 per cent was either fed to calves, lost or wasted, or devoted to unspecified uses. The present chapter will be devoted to milk as such, its products being treated in subsequent chapters.

The Department of Agriculture estimates the farm value of dairy products produced in the United States in 1921 at $2,410,000,000. The proportionate valuation of the milk consumed as such would be about $1,100,000,000, so that the milk industry is one of the few whose annual product reaches a value of a billion dollars a year.

The real importance of the milk industry to the community is much greater than can be expressed in terms of money value, because of the supreme importance to public health of an adequate milk supply. It has long been recognized that milk occupies a unique place in the dietaries of most children and many invalids, while at the same time the fluidity and opacity of milk offer unusual opportunity for adulteration unless the supply is properly safeguarded. It is largely for these reasons that in many states laws designed to protect the milk supply antedated general food legislation. It is perhaps less commonly realized that not only the quality but also the quantity of the milk supply is an extremely important factor in public health, partly because the reduction of infant mortality depends upon the abundance as well as the excellence of the milk available for infant feeding, and also because a liberal consumption of milk, even by healthy adults, tends to a higher degree of health and vigor and greater ability to resist disease. Thus not only is a good milk supply directly essential to public health, but confidence in the milk supply leads to better health by inducing a more liberal use of milk.

In the present chapter the production and handling of milk will first be outlined, then its composition and standards of purity will be discussed, and finally its nutritive value, pecuniary economy, and place in the diet will be considered.

Production and Handling of Milk

The cows. A milch cow should produce an average of over two gallons of milk per day for eight months of each year with a smaller yield for about two months longer, making a total of at least 600 gallons or 5000 pounds of milk for the year.

Many high-grade cows produce three or four times this quantity, and more than one cow has produced over 30,000 pounds of milk in a year; but the average for all the milch cows in the United States at the present time is only about 4000 pounds per year (United States Department of Agriculture, *Yearbook* for 1922). In Great Britain and in Denmark the average production of milk per cow is half as large again as in the United States, and in the Netherlands it is about twice as large. The production of milk in the United States can be greatly increased without increasing the number of dairy cattle.

Increased yield of milk per cow may be obtained both by breeding and selection and by superior care and feeding. According to official estimates the annual yield of milk per cow in Denmark, where the dairy industry is well developed and highly systematized, was increased from 4480 pounds in 1898 to 4884 pounds in 1901, 5335 pounds in 1904, and 5874 pounds in 1908.

Since the fat of the milk is commercially its most valuable constituent, the productiveness of a milch cow is perhaps as often expressed in terms of fat or butter yield as in terms of weight of milk. Those races of cattle which have been developed with special reference to milk or butter production are called the dairy breeds, and those which are chiefly useful for meat production are known as beef breeds. An investigation in Wisconsin [1] showed a higher food consumption on the part of the more productive dairy cows, but the value of the milk produced increased much more rapidly than the cost of feed, so that the more productive cows proved very much more profitable.

The United States Department of Agriculture reports that cows averaging a production of 400 pounds of butter fat per year showed over twice the profit, after deducting cost of feed, as was shown by cows producing only half as much milk and butter; and states that "all studies that have been made of dairy cattle indicate that where other things are equal the economical producers are always comparatively high producers."

[1] Studies in Dairy Production, based on the Records Secured in the Wisconsin Dairy Cow Competition, 1909–1911. Wisconsin Agricultural Experiment Station, Research Bulletin 26 (October, 1912).

The same authority summarizes as follows the characteristics of the dairy cow as a producer of human food:

"The dairy cow economically converts pasture grasses, dry and succulent roughage, and the by-products of many different kinds of grain into milk, that most excellent food for man. The dairy cow does well when a large proportion of her ration comes from these products. Only through the agency of animals can roughage be converted into human food. The great purpose of agricultural production is an adequate food supply. For feed eaten the dairy cow returns more than three times as much digestible protein as the steer and more than twice as much energy in edible products."[1]

Good health of the cow is of great importance and should be insured by systematic veterinary inspection. Annual or semi-annual testing with tuberculin, with elimination or segregation of all cows which show any indication of tuberculosis, serves to protect the herd from the ravages of the disease as well as to remove one source of possible danger to the consumer of the milk. Dairy farmers can now arrange with the United States Department of Agriculture to have their herds tested and "accredited" by the Federal authorities.

It is important also that the cows be kept clean, and especially that the udder and adjacent parts of the body be thoroughly clean at the time of milking.

The stable should be free from contaminating surroundings, well drained, well lighted and ventilated, as clean and comfortable as possible. It should be used for no other purpose than the keeping of cows, and if there is a loft overhead, the ceiling should be tight to prevent the falling of dust. The feeding of the cows should be so planned that there will be no dust from hay or other feed in the air of the stable at milking time. The floor should be tight, constructed preferably of cement, and properly guttered; walls and ceiling should be whitewashed twice a year.

[1] *Yearbook* of the United States Department of Agriculture, for 1922, pages 281–282.

The milk house should be separate from the stable and so located as to be free from dust and odors. It should be used for no other purpose and should be light, clean, and well screened.

All utensils which come in contact with the milk should be of metal with smoothly soldered joints. In addition to being thoroughly washed the utensils should be sterilized by means of steam or boiling water and then kept either closed or inverted in a clean place free from dust until used. By furnishing the farmers with sterilized utensils for each milking and insisting upon the use of covered milking pails, Dr. North greatly reduced the numbers of bacteria shown by the milk.

Milking is performed sometimes by machine, sometimes by hand. Cleanliness of the milker and his clothing are essential to cleanliness of the milk. On well-conducted milk farms the milker puts on a special washable suit for milking and washes and dries his hands immediately before commencing to milk each cow. The cows having previously been cleaned, the udders and flanks should be wiped with a moist cloth preparatory to milking. As a further precaution against the falling of dust and bacteria into the milk a covered or hooded milking pail should be used.

Machines by means of which one man may milk several cows at a time are now on the market. These have the advantage of reducing the number of employees required in milking and diminishing the opportunities for contamination of the milk through contact with the air of the stable or the hands of the milker; among the disadvantages are the cost of the equipment necessary for machine milking and the care needed in preventing the rubber parts of the mechanism from becoming a breeding place for bacteria. In 1912, an extended study at the New York State Agricultural Experiment Station[1] led to the conclusion that machine milking compared favorably with ordinary hand milking in its effect upon the milk flow and upon the germ con-

[1] Bulletin No. 353, November, 1912.

tent of the milk; and that machine milking had proven practicable. Labor conditions have led to a rather rapid increase of machine milking during the past few years.

Handling the milk. The milk is removed from the stable to the milk room as quickly as possible and (after clarifying or straining through sterile cotton or cloth if deemed necessary) is promptly cooled to prevent the growth and multiplication of such bacteria as it may contain. The multiplication of bacteria in milk does not begin as soon as the milk is drawn, but is preceded by a short period in which there is an apparent decrease in the number of bacteria. This is attributed to a "bactericidal property" of freshly drawn milk. The importance of early and thorough cooling was well shown in an experiment by Conn, in which it was found that the multiplication of bacteria in 24 hours in milk kept at 50° F. (10° C.) was only fivefold, while at 70° F. (21° C.) it was seven hundred and fifty fold.

Usually the milk is first poured into a mixing tank, then run over a metal cooler, and the cold milk filled into cans or bottles and kept cold both in storage and during transportation. In many localities it is required by law that milk be held at a temperature not above 50° or 55° F. until delivered to the consumer. Preferably the milk is bottled in the country, the bottles packed in cracked ice and kept so until delivered to the consumer.

General sanitation. In recent years much attention has been given to improvements in the sanitary conditions surrounding the production and handling of milk, largely because it is realized that contaminated milk may undergo such deterioration as to become unwholesome, or may be the means of transmitting specific infectious diseases. As an aid to dairy farmers the Dairy Division of the United States Department of Agriculture has published for free distribution Dairy Suggestions with Special Reference to Sanitation, which are printed on cloth in poster form suitable for posting in barns and milk rooms. The rules for the production and handling of certified milk, which may be taken as representing ideal conditions, are given in full at the back of this book (Appendix C).

As an example of the influence of sanitary precautions upon the keeping qualities of milk, it may be noted that three American dairy farms exhibited raw milk at the Paris Exposition of 1900, one of them sending weekly shipments throughout the summer, each of which was kept on exhibition in the raw state without spoilage until the next shipment arrived. It was difficult to convince the jury of European experts of the fact that "cleanliness and cold" were the only preservatives needed to accomplish the keeping of raw milk in a fresh, sweet condition for two to four weeks in midsummer.

Score cards are largely used in connection with the sanitary inspection of dairy farms. Their primary purpose is said to be educational, but the scores shown are sometimes used also as a factor in the grading of the milk which the farm produces. Some sanitarians believe that milk should be graded chiefly according to the sanitary score of the producing farm; others that the chief basis for judgment should be the bacteriological examination of milk as it is offered for sale.

In its Bulletin 642, the United States Department of Agriculture emphasizes the following as "the four essentials in the production of milk of low bacterial content": (1) Use of "small-top" or "covered" milking pails; (2) Sterilization of utensils; (3) Careful cleaning of cows; (4) Keeping milk cold. By observance of these four precautions it is believed that "the average dairyman on the average farm without expensive barns and equipment" can produce milk of high sanitary quality.

Certified milk. This term is properly applied only to milk produced under sanitary conditions of exceptional excellence, by the most painstaking methods and under the constant supervision and inspection of a Medical Milk Commission. It is understood as meaning that the milk is certified as to its quality and wholesomeness by a properly constituted medical milk commission. The medical profession was led to engage in the certification of milk in order that there might be made available for infant feeding at least a limited supply of milk of exceptional excellence which should be as nearly as possible absolutely safe. The requirements placed upon the producer and handler are such as to make the cost of certified milk about twice that of ordinarily good bottled milk. Although less than 1 per cent of the market milk of commerce is of this grade, the certified milk movement has had great influence in improving dairy practice and raising the sanitary quality of the general milk supply. The detailed requirements for the production and handling of certified milk are given in Appendix C at the back of this book.

The North system of sanitary milk production differs from the system in which certified milk is produced in that much of the responsibility which the certified milk system imposes upon the farmer is by the North system transferred to the receiving station. The farmer must keep only healthy cows and must clean them before milking, and the milk must be drawn by a clean milker into covered pails, transferred without straining to the milk cans and kept in ice water until sent to the receiving station. At the receiving station all pails and cans are thoroughly washed, sterilized with live steam, dried with a blast of hot air, covered and delivered back to the farmer, who must keep them unopened until the next milking time. Other features of the North system are daily laboratory tests of each farmer's milk at the receiving station and payment according to the quality of the milk as shown by these tests.

Pasteurization of milk by heating it to a temperature of 60° to 63° C. (140° to 145° F.) and holding at this temperature for 20 to 30 minutes serves to destroy any bacteria of diseases regarded as transmissible by milk. The use of higher temperatures in order to shorten the time required for pasteurization is often permitted, but seems undesirable because higher heating kills an undue proportion of the lactic acid bacteria while the spores of certain bacteria which decompose the proteins of the milk are not destroyed and, if the milk be kept too long, may render it unwholesome before it becomes sour. As a precaution against subsequent contamination it is desirable that the milk be pasteurized in the sealed bottles in which it is to be delivered to the consumer, or that it be filled into sterilized bottles while still hot. There is a growing tendency on the part of public health authorities to require the pasteurization of all market milk which is not obtained under good sanitary conditions from tuberculin-tested cows.

General Composition of Milk

The qualitative composition was concisely stated by Richmond as follows: "It is essentially an aqueous solution of milk sugar, albumin, and certain salts, holding in suspension globules of fat, and in a state of semi-solution, casein [1] together with

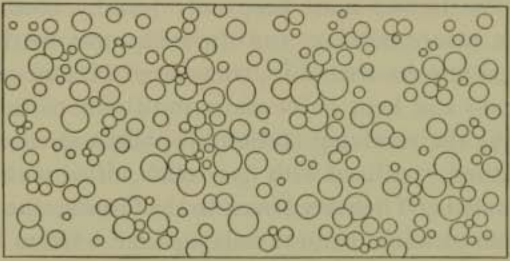

FIG. 6. — Fat globules in milk magnified 300 diameters.

mineral matter. Small quantities of other substances are also found." Books on colloid chemistry may be consulted for fuller descriptions in more technical terms of the state of dispersion of the proteins, particularly caseinogen, in milk. Under the microscope the fat globules are readily seen floating in the fluid portion or serum of the milk. (See Fig. 6.) These globules

[1] For this protein as it exists in milk the term "caseinogen" is perhaps preferable, the term "casein" being more strictly applicable to the coagulated protein as it exists in curd or cheese.

vary considerably in size from an average of about 0.0025 millimeter or 0.0001 inch in diameter. A single drop of milk contains many millions of these fat globules.

The yellowish tint of milk is due to a small quantity of coloring matter contained in the fat, and its opacity in part to the fat and in part to other constituents, particularly the caseinogen and the calcium phosphate. The reaction of fresh cows' milk is practically neutral to litmus and slightly acid to phenolphthalein, due chiefly to the presence of phosphates and carbonic acid.

Colostrum, the fluid secreted from the mammary glands for a short time after giving birth to the young, is different from milk in composition and physiological properties. Under the microscope colostrum shows characteristic corpuscles in addition to the fat globules seen in milk.

The quantitative composition of milk varies with a number of conditions, the most prominent of which are the breed and the individual characteristics of the cow. It is difficult to make fair comparisons of breeds because there may be within the same breed different strains or families which differ markedly in the composition of their milk. The following figures obtained by averaging the results of independent breed tests made at the Agricultural Experiment Stations of New York and New Jersey are believed to be fairly representative (Table 1).

TABLE 1. COMPOSITION OF MILK OF DIFFERENT BREEDS OF CATTLE

BREED	TOTAL SOLIDS	FAT	SOLIDS-NOT-FAT
	Per cent	*Per cent*	*Per cent*
Jersey	14.87	5.19	9.68
Guernsey . . .	14.69	5.16	9.53
Durham . . .	13.38	4.05	9.33
Ayrshire . . .	12.73	3.64	9.09
Holstein . . .	11.96	3.43	8.53

Among the conditions other than breed and individuality which may influence the composition of cows' milk may be mentioned advancement in lactation, the season of the year, feeding and care, time and completeness of milking.

After a cow has been three or four months in lactation there is usually a decrease in the milk yield and a gradual increase in the richness of the milk as the period of lactation advances. At the end of the lactation period when the cow is "going dry" there is sometimes a marked increase in the richness of the milk, but the quantity produced at such times is usually too small to exert much influence on the average composition of the mixed milk of the herd.

Other conditions being the same, the milk of well-kept cows is usually richer in winter than in summer, in cooler than in warmer weather, and on rich, dry food than on pasture, except that on first admitting the cows to pasture in spring or early summer a richer milk may be obtained for a short time.

Doubtless reasonably good feeding and care are necessary to secure from each cow as rich a milk as she is normally capable of producing, and there are indications that by changes of food, liberal feeding with special foods or perhaps other special treatment, a cow may be made to produce for a time a milk above her normal standard of richness. In general practice, however, the dairy farmer depends upon breeding and selection to secure milk of high richness and expects the return for liberal feeding and exceptional care to take the form of an increased yield of milk rather than a permanent change in its composition.

In general a longer interval of time between milkings results in a slightly decreased fat content. This is often the cause of a fairly constant difference of 0.25 to 0.50 per cent of fat in the morning and afternoon milk of the same herd.

All statements regarding the composition of cows' milk ordinarily refer to the product of complete milking. In partial or fractional milking the first portions drawn are much poorer in fat content than the average, and the last portions, or "strippings," are much richer.

The extreme variations in composition of milk from cows apparently normal have been compiled by the writer elsewhere.[1] Since market milk is nearly always the mixed product of many cows and often of many herds, a knowledge of these extremes is for practical purposes much less significant than is a knowledge of the usual variations. Table 2 includes a statement of (1) the variations which may be considered not unusual, (2) an estimate of average composition based on all available data, (3) a convenient approximation to the estimated average, which is sufficiently accurate for most purposes and is generally used in statements of the food value of milk.

TABLE 2. COMPOSITION OF MILK; USUAL LIMITS AND AVERAGE

CONSTITUENT	USUAL LIMITS OF VARIATION	ESTIMATED AVERAGE	CONVENIENT APPROXIMATION
	Per cent	*Per cent*	*Per cent*
Fat	3. –6.	4.00	4.0
Protein	3.0 –4.0	3.33	3.3
Carbohydrate .	4.6 –5.0	4.85	5.0
Ash	0.70–0.78	0.72	0.7
Solids-not-fat . .	8.5 –9.5	8.90	9.0

It will be noted that the fat is much the most variable constituent and that the protein varies about one third as much as the fat. In general, the variations in the protein content are in the same direction as the fat. Thus genuine milk with 3 per cent fat averages about 3 per cent protein; with 4 per cent fat about 3.33 per cent protein; with 5 per cent fat about 3.66 per cent protein; with 6 per cent fat about 4 per cent protein. Such differences in fat and protein content are usually accompanied by very little variation in the percentages of milk sugar and ash.

[1] *Methods of Organic Analysis, Revised Edition*, page 351.

Another way of expressing the relationship of the constituents is that the proteins usually constitute about one fourth of the total solids, the remainder of the fluctuation in total solids being almost entirely due to the fat.[1]

Such statements as the above express average relationships. It is not to be expected that they will hold true for every sample. Marked departure from these relationships is, however, an occasion for suspicion when observed in market milk, because such milk is nearly always the mixed product of an entire herd (often of several herds) and is therefore not normally subject to such fluctuations in composition as is the milk of individual cows.

Another fact worthy of note is that very rarely if ever are minimum or maximum percentages of all constituents found in any one sample of genuine milk. For this reason the figures for usual limits of variation in solids-not-fat in the above table do not exactly coincide with the summation of the corresponding data for proteins, carbohydrates, and ash.

In many cases it is convenient to consider the solids of milk simply in terms of fat and of solids-not-fat. In fact this is usually considered sufficient in the formulation of legal standards of composition, as will be seen below.

Adulteration and Inspection

Adulteration of milk is now doubtless much less common than formerly; but the possibility remains that milk may sometimes be deliberately adulterated, and also that it may become an adulterated product (within the legal meaning of the term) through accidental contamination or deterioration.

The principal forms of deliberate adulteration to which milk is subjected are watering, skimming, the addition of preservatives, and attempts to conceal inferiority by the use of artificial color or thickening agents, and by the addition of sodium bicarbonate to disguise the fact that the milk has begun to sour.

[1] For further data see *Methods of Organic Analysis, Revised Edition*, pages 349–352.

In most localities all these practices are made illegal either by specific prohibition or by some general provision that milk to which anything has been added or from which anything has been abstracted shall be deemed adulterated.

Watering is, of course, the simplest form of adulteration and is objectionable both as a fraud and as a possible source of contamination. In most localities the watering of milk is much less common now than formerly.

Skimming, by which is meant either the removal of a part of the cream or the addition of skimmed or partially skimmed milk, is probably more common than watering. As the same farmer often sells both milk and cream, the temptation to remove a part of the cream before selling the milk (especially if the milk originally contains considerably more fat than the law requires) is obvious. The fact that some state standards require a high content of solids-not-fat and a relatively low fat content constitutes an incentive to partial skimming.

Artificial color is occasionally (probably but rarely now) added to restore the yellow tint of milk which has been partially skimmed or to make a milk which is naturally of poor quality appear richer than it is.

Addition of preservatives is not as common now as formerly, at least in cities having systematic milk inspection. The preservatives chiefly used are formaldehyde and boric acid or borax. At present these preservatives appear to be less commonly sold by dairy supply houses, and their use is largely restricted to small towns having no milk inspection. In such towns, however, it should not be difficult for the consumer to know the source of the milk which he buys and to accept only the product of reliable producers and dealers.

Contaminated or deteriorated milk can be treated as adulterated under that clause of the Food and Drugs Act which declares a food to be adulterated if it consists in whole or in part of "a filthy, decomposed or putrid animal or vegetable substance."

As will be evident from the section which follows, the sanitary quality as well as the chemical composition of milk is now regarded as a proper matter for standardization.

The conduct of inspection. Practices differ greatly in regard to milk inspection. Municipal authorities usually have wide discretion in the matter, under their general "police powers," and city ordinances often go much farther than state legislation in attempts to control the milk supply. City boards of health often have inspectors in the country to visit farms and receiving stations as well as in the city to inspect the milk as it comes to market and as it is offered for sale. The sanitary conditions of production and handling reported by the country inspectors may be made the basis of renewal or revocation of the permit to sell milk in the city or of the classification or designation under which it may be sold. The city inspectors seek to detect or prevent unsanitary practices in the city and the sale of milk which has been skimmed or watered or is otherwise adulterated or deteriorated.

Thermometer and lactometer tests. As preliminary tests the city milk inspector often takes the temperature of the milk and its reading on the *lactometer*, which is merely a hydrometer so constructed as to cover a sufficient range and density to include all qualities of milk. Milk showing too high a temperature is sometimes destroyed forthwith. In other cases the high temperature is construed simply as requiring a laboratory examination for bacteria. A low lactometer reading is not sufficient in itself to condemn milk, but aids the inspector to judge whether further examination is necessary.

The lactometer may be graduated to read specific gravity or on an arbitrary scale. The New York Board of Health lactometer has an arbitrary scale of which the zero point coincides with a specific gravity of 1.000 and the 100 point with a specific gravity of 1.029. Figure 7 shows the different lactometer scales side by side. Whole milk normally has a specific gravity of 1.029 to

1.035; usually 1.030 to 1.033, and should therefore read more than 100 on the New York Board of Health lactometer. The specific gravity or lactometer reading of milk is lowered either by addition of water or addition of cream; but milk which is naturally rich in fat, being usually rich in protein also, ordinarily has a higher specific gravity or lactometer reading than the average. If in addition to the lactometer reading the viscosity and opacity of the milk be observed by carefully watching the lactometer bulb on lifting it out of the milk, it is possible for an experienced inspector to form a fairly reliable impression as to whether the milk is open to suspicion and should be sampled for laboratory analysis.

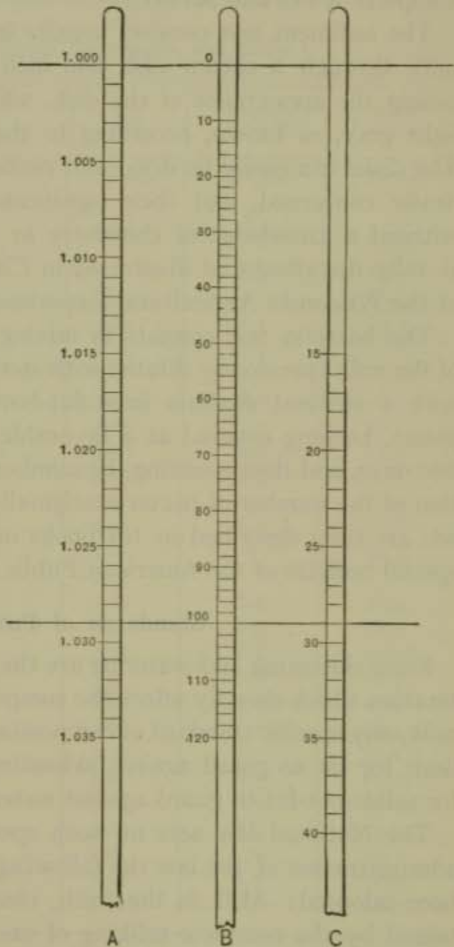

Fig. 7. — Lactometer scales: *A*, hydrometer; *B*, New York City Board of Health lactometer; *C*, Quevenne lactometer. (From Wing's *Milk and its Products*.)

Chemical analysis when made for purposes of inspection consists usually in determining the percentages of fat and of total solids or solids-not-fat and testing for preservatives. (See *Methods of Organic Analysis*, Revised Edition, Chapters XVII and XVIII.)

The sediment test consists usually in straining a pint of the milk through a cotton disk one inch in diameter and then noting the appearance of the disk, which may be pure white, light gray, or brown, according to the cleanness of the milk. The disks can easily be dried and mailed to the farmer or milk dealer concerned, and their significance may be appreciated without a knowledge of chemistry or bacteriology. This test is fully described and illustrated in Circular of Information 41 of the Wisconsin Agricultural Experiment Station.

The bacteria test consists in mixing a known small volume of the milk (previously diluted with sterilized water if necessary) with a nutrient medium in a flat-bottomed glass dish (Petri plate), keeping covered at a favorable temperature for one or two days, and then counting the number of colonies as an indication of the number of bacteria originally present. These methods are fully described in textbooks of bacteriology, and in a special bulletin of the American Public Health Association.

Standards of Purity

Since skimming and watering are the two chief forms of adulteration which directly affect the composition and food value of milk, any specific standard of composition should set a minimum limit for fat to guard against skimming, and a minimum limit for solids-not-fat to guard against watering.

The National law sets no such specific standards. In the administration of the law the following standard definition has been adopted: Milk is the fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving.

Most of the state laws definitely prescribe that all milk offered for sale shall contain not less than certain percentages of fat and of total solids or solids-not-fat.

The principal state standards are shown in Table 3.

TABLE 3. STATE STANDARDS FOR MILK [1]

STATE	FAT	SOLIDS-NOT-FAT	TOTAL SOLIDS
	Per cent	*Per cent*	*Per cent*
Alabama			
Arizona	3.25	8.5	——
Arkansas			——
California	3.0	8.5	11.5
Colorado	3.0	——	——
Connecticut	3.25	8.5	11.75
Delaware	3.25	8.5	——
District of Columbia	3.5	9.0	12.5
Florida	3.25	8.5	11.75
Georgia	3.25	8.5	11.75
Hawaii	3.0	8.5	11.5
Idaho	(3.25)[2]	(8.5)[2]	——
Illinois	3.0	8.5	11.5
Indiana	3.25	8.5	——
Iowa	3.0	——	11.5
Kansas	3.25		
Kentucky	3.25	8.5	12.0
Louisiana	3.5	8.5	12.0
Maine	3.25	8.5	11.75
Maryland	3.5	——	12.5
Massachusetts	3.35	——	12.0
Michigan	3.0	——	12.5
Minnesota	3.25	——	13.0
Mississippi	3.0	8.5	11.75
Missouri	3.25	8.5	11.75
Montana	3.25	8.5	11.75
Nebraska	3.0	——	——
Nevada	3.25	8.5	11.75
New Hampshire	3.35	——	11.85

[1] Data obtained in part directly from state food officials and in part from the Dairy Division of the United States Department of Agriculture.

[2] Law provides that state inspection shall follow Federal Standards which when last declared in numerical form called for not less than 3.25 per cent fat and not less than 8.5 per cent solids-not-fat.

TABLE 3. STATE STANDARDS FOR MILK — Continued

State	Fat	Solids-not-fat	Total Solids
	Per cent	*Per cent*	*Per cent*
New Jersey	3.0	——	11.5
New Mexico			
New York	3.0	——	11.5
North Carolina	3.25	8.5	11.75
North Dakota	3.0	9.0	12.0
Ohio	3.0	——	12.0
Oklahoma	3.5	8.5	12.0
Oregon	3.2	8.5	11.7
Pennsylvania	3.25	——	12.0
Philippine Islands	3.25	8.5	11.75
Porto Rico	——	——	——
Rhode Island	2.5	——	12.0
South Carolina	3.0	8.5	11.5
South Dakota	3.5	8.5	11.75
Tennessee	3.5	8.5	——
Texas	(3.25)[1]	(8.5)[1]	——
Utah	3.2	8.8	12.0
Vermont	——	8.5	11.75
Virginia	3.25	8.5	11.75
Washington	3.25	8.5	——
West Virginia	3.0	8.5	11.5
Wisconsin	3.0	8.5	——
Wyoming	3.25	8.5	——

It will be seen that there is considerable diversity of standards among the states. Since the fat content of milk is so variable, some difference of opinion as to the proper legal minimum of fat is readily understood, but there is no justification in the natural composition of milk for setting a low standard for fat and at the same time a high standard for solids-not-fat, or total solids, as is still done in some states. The explanation for such disproportionate standards is to be found in the fact

[1] Law provides that state inspection shall follow Federal Standards which when last declared in numerical form called for not less than 3.25 per cent fat and not less than 8.5 per cent solids-not-fat.

that methods of milk analysis formerly used tended to underestimate the fat and overestimate the other solids.

The Commission on Milk Standards appointed with a view to securing uniformity of requirement among the different states and cities of the United States has recommended the general adoption of the standard calling for not less than 3.25 per cent of milk fat and not less than 8.5 per cent of milk solids-not-fat, as previously proposed by the Association of Official Agricultural Chemists.

The Commission also recommended the adoption by communities of regulations providing for the sale of milk on a basis of guaranteed composition. The advantage of such a system is apparent from the fact that any single legal minimum must necessarily be set considerably below the average in order to provide for natural variations in composition. Average milk and milk considerably below the average are thus equally legal, though of different value. It would obviously be fairer both to producer and to consumer if all milk could be sold on the basis of its true value.

In addition to standards of chemical composition several communities have adopted sanitary or bacteriological standards. Thus milk which contains visible dirt or more than a certain number of bacteria may be forbidden sale, or (as in the case of New York City) a maximum temperature may be prescribed on the ground that in warm milk bacteria multiply so rapidly as to make it a " decomposed substance " if not an actual menace to health. Until recent years such sanitary and bacteriological standards as existed varied much with the locality and were generally regarded as more or less tentative; but such standards are now becoming stabilized and are playing an important part in the steady improvement of the sanitary quality of the milk supply. The reader can doubtless ascertain the current standards of his own locality by inquiring of the city health department or the state food commissioner.

Classification Recommended by Commission on Milk Standards

GRADE A

Raw milk. Milk of this class shall come from cows free from disease as determined by tuberculin tests and physical examinations by a qualified veterinarian, and shall be produced and handled by employees free from disease as determined by medical inspection of a qualified physician, under sanitary conditions such that the bacteria count shall not exceed 100,000 per cubic centimeter at the time of delivery to the consumer. It is recommended that dairies from which this supply is obtained shall score at least 80 on the United States Bureau of Animal Industry score card.

Pasteurized milk. Milk of this class shall come from cows free from disease as determined by physical examinations by a qualified veterinarian and shall be produced and handled under sanitary conditions such that the bacteria count at no time exceeds 200,000 per cubic centimeter. All milk of this class shall be pasteurized under official supervision, and the bacteria count shall not exceed 10,000 per cubic centimeter at the time of delivery to the consumer. It is recommended that dairies from which this supply is obtained should score 65 on the United States Bureau of Animal Industry score card.

(*Note.* The above represents only the minimum standards under which milk may be classified in grade A. The commission recognizes, however, that there are grades of milk which are produced under unusually good conditions, in especially sanitary dairies, many of which are operated under the supervision of medical associations. Such milks clearly stand at the head of this grade.)

GRADE B

Milk of this class shall come from cows free from disease as determined by physical examinations, of which one each year shall be by a qualified veterinarian, and shall be produced and handled under sanitary conditions such that the bacteria count at no time exceeds 1,000,000 per cubic centimeter. All milk of this class shall be pasteurized under official supervision, and the bacteria count shall not exceed 50,000 per cubic centimeter when delivered to the consumer.

It is recommended that dairies producing grade B milk should be scored and that the health departments or the controlling departments, whatever they may be, strive to bring these scores up as rapidly as possible.

GRADE C

Milk of this class shall come from cows free from disease as determined by physical examinations and shall include all milk that is produced under conditions such that the bacteria count is in excess of 1,000,000 per cubic centimeter.

All milk of this class shall be pasteurized, or heated to a higher temperature, and shall contain less than 50,000 bacteria per cubic centimeter when delivered to the customer. It is recommended that this milk be used for cooking or manufacturing purposes only.

Whenever any large city or community finds it necessary, on account of the length of haul or other peculiar conditions, to allow the sale of grade C milk, its sale shall be surrounded by safeguards such as to insure the restriction of its use to cooking and manufacturing purposes.

The above recommendations have been indorsed by the American Public Health Association, the American Medical Association, and the Conference of State and Provincial Boards of Health of North America. They have formed the basis for the regulations of many cities, though modifications of detail are naturally often introduced to meet local conditions.

Detailed Composition

The proteins of milk. From three fourths to four fifths of the nitrogenous matter of cows' milk consists of caseinogen (casein, calcium-casein), while most of the remainder is in the form of lactalbumin; other proteins have been found in very small amounts, among these lactoglobulin has long been known and an alcohol-soluble protein has recently been described by Osborne and Wakeman, who suggest that milk may also contain extremely small quantities of proteoses.

Caseinogen or casein is the best known of the phosphoproteins. Lactalbumin contains no phosphorus but is richer in sulphur than is casein. The elementary composition of these two proteins is shown in Table 4, while in Table 5 are given the amounts of the different amino acids obtained from the hydrolysis of each.

By comparison with the corresponding data given in later chapters it will be seen that the yields of several of the more complex amino acids such as tryptophane, tyrosine, and lysine are distinctly higher from the milk proteins than from food proteins in general; while the amino acids lacking or present only in small quantity in milk proteins are, in most cases, those of which the body may readily derive abundant supplies from other sources. (See also the sections on nutritive value and place in the diet in this and succeeding chapters.)

TABLE 4. ELEMENTARY COMPOSITION OF CASEIN AND LACTALBUMIN

	CASEIN	LACTALBUMIN
	Per cent	*Per cent*
Carbon	53.13	52.19
Hydrogen	7.06	7.18
Oxygen	22.37	23.13
Nitrogen	15.78	15.77
Sulphur	0.80	1.73
Phosphorus	0.86	0.00

TABLE 5. AMINO ACIDS FROM MILK PROTEINS[1]

	CASEIN	LACTALBUMIN
	Per cent	*Per cent*
Glycine	0.5	0.4
Alanine	1.5	2.5
Valine	7.2	3.3
Leucine	10.5	14.0
Proline	8.0	4.0
Aspartic acid	4.1	9.3
Glutamic acid	21.0	12.9
Hydroxyglutamic acid	10.5	10.0
Phenylalanine	3.2	2.4
Tyrosine	6.5	4.9
Serine	0.5	1.8
Oxyproline	0.2	——
Histidine	2.5	2.6
Arginine	4.8	3.5
Lysine	7.6	9.9
Tryptophane	1.5	3.0
Cystine	0.3	1.7
Ammonia	1.6	1.3

[1] In general the highest yield of each amino acid is given since it is known that the methods used tend to give results below the truth.

To separate all the amino acids which a protein yields and determine the amount of each one as shown in Table 5 requires a large quantity of purified material and the devotion of an enormous amount of time to most difficult and intricate research methods. With much smaller quantities of purified material and a more moderate expenditure of time and labor a partial knowledge of the "amino-acid make-up" of a protein may be obtained by the method of examination devised by Dr. D. D. Van Slyke. This Van Slyke method determines how the total nitrogen of the protein is divided among eight fractions or forms of combination, four of which are individual amino acids of much importance in nutrition and therefore very significant in our judgment of food values. The results of such an examination of casein and lactalbumin are shown in Table 6.

TABLE 6. DISTRIBUTION OF THE NITROGEN OF MILK PROTEINS AMONG THE FORMS DETERMINABLE BY THE VAN SLYKE METHOD (EXPRESSED AS PERCENTAGE OF THE TOTAL NITROGEN OF THE PROTEIN)

	Casein	Lactalbumin
	Per cent	*Per cent*
Amide nitrogen	10.27	8.57
Arginine nitrogen	7.41	7.20
Cystine nitrogen	0.27	1.30
Histidine nitrogen	6.21	4.57
Lysine nitrogen	10.30	12.24
Monoamino nitrogen	55.81	62.00
Non-amino nitrogen	7.13	2.00
Humin nitrogen	1.28	2.32

It is to be remembered that data of the two kinds illustrated by Tables 5 and 6 cannot be compared directly because expressed on different bases: in the one case as weight of amino acid obtained from one hundred parts by weight of protein, in the other as the percentage of the total nitrogen which is found to exist in a particular form. Also the nature of the methods is such that data such as those in Table 6 regularly show a summation of approximately 100 per cent, while those of the sort shown in Table 5 always fall considerably short because a part of each amino acid is unavoidably lost in the process of their separation and determination. It is certainly largely and probably chiefly because of the unavoidable underestimation of each known amino acid that the summation in all analyses of this kind fall so far short of showing 100 per cent. The deficit does not prove the presence of amino acid radicles of other kinds, though it is still possible that some such may be present.

On whichever basis the amino-acid make-up of the milk proteins is expressed, it is plainly apparent that the proteins of milk are richer than those of most other foods in the amino-acid lysine which is important in growth. Such quantitative estimations as are available show the milk proteins to be also relatively rich in tryptophane, which is extremely important both for growth and maintenance and which is furnished in only small amounts, if at all, by some of the other important food proteins. This richness in lysine and tryptophane has important bearings upon the place of milk in the diet, as have also the richness of milk in calcium and in fat-soluble vitamin.

The fat of milk is characterized both by its physical form and by its chemical composition. As shown above (Fig. 6) it exists in the form of small droplets floating in the " serum " of the milk and tending to rise to the surface and form a cream layer when the milk is allowed to stand. This makes of milk an emulsion varying in physical property with the percentage of fat and the size of the fat globules. The so-called " homogenizing " machines are devices for breaking up the fat globules into particles of small and more uniform size with the object of getting the fat into such a finely divided and highly dispersed form that it will remain uniformly distributed through the milk on standing. Milk or cream which has been thus treated is said to be " homogenized," though it is, of course, still a heterogeneous system in the scientific sense.

Chemically milk fat is characterized by its relatively high content of butyric acid, and relatively low content of stearic acid. The percentages of the different fatty acids found by Browne in butter fat are shown in Table 7.

TABLE 7. PERCENTAGES OF DIFFERENT FATTY ACIDS OBTAINED FROM BUTTER FAT BY BROWNE

NAME OF FATTY ACID	BUTTER FAT
Butyric	5.45
Caproic	2.09
Caprylic	0.49
Capric	0.32
Lauric	2.57
Myristic	9.89
Palmitic	38.61
Stearic	1.83
Oleic	32.50
Dihydroxystearic	1.00
Total	94.75

Butter fat, like most other food fats, contains considerable quantities of palmitic and oleic acids, but it differs in containing very little stearic acid, and notable quantities of butyric and caproic acid, of which other food fats contain very little. The fact that butter contains more of these fatty acids of low molecular weight (which are liquids) and less stearic acid (which is solid) makes milk fat softer than most food fats, and this softness together with its emulsified form both help to give it its high digestibility.

For convenience we have here spoken of fatty acids as contained in the fat. It is not implied that the fatty acids exist in the free state, nor even necessarily in the form of their simple glycerides. Doubtless both simple and mixed glycerides are present. It is believed that practically all of the butyric acid in butter fat exists in the form of mixed glycerides.

The most important difference between milk fat and most other fats as food lies not in the triglycerides, which, chemically, constitute the fat itself, but rather in the fact that milk fat is rich in fat-soluble vitamin.

The yellowish color of milk is due to a small amount of the natural coloring matter, lactochrome, dissolved chiefly though not entirely in the fat of the milk, and which is derived from the pigments of the green plant tissues consumed by the cow (Palmer).

Milk sugar, lactose, is the only known carbohydrate of milk. It is formed in the mammary gland, doubtless from glucose brought by the blood. While the proteins exist in milk in the form of colloidal dispersion, the fat in the form of distinct droplets easily visible under the microscope, the milk sugar is in true solution. It is to the milk sugar and the soluble salts of milk that its osmotic properties are due. Investigation has shown that the mammary gland secretes milk always of a very uniform osmotic pressure. Usually this means that the percentages of lactose and soluble salts in milk remain nearly constant even when the percentages of other constituents vary. Occasionally the percentage of lactose falls considerably below the normal average, and in such cases the percentage of salt in the milk rises sufficiently to keep the osmotic pressure at the normal figure. Since, weight for weight, the osmotic pressure of salt is much higher than of sugar, a sample of milk of the sort just mentioned will have an abnormally low percentage of solids-not-fat, but since its osmotic pressure and therefore its freezing point remains normal, a determination of the freezing point will show that the milk is not watered. Conversely, watered milk always shows a different freezing point from genuine milk, even though the latter varies in chemical composition. For this reason the **determination of the freezing point** is frequently included in the analytical examination of milk for the purpose of determining whether or not it has been watered.

Citric acid occurs normally in milk to the extent of about 0.2 per cent. In the ordinary routine analysis, or in statements of composition based on such analyses, the citric acid is usually counted as carbohydrate.

The ash constituents of milk include all the so-called inorganic elements necessary to the normal nutrition of man. Some of these exist in the milk as salts, some as constituents of the organic matter, some in both forms.

Sulphur, of which milk contains about 0.03 per cent, exists almost entirely as a constituent of the milk proteins.

Phosphorus constitutes about 0.10 per cent of the fresh weight of milk (equivalent to 0.23 per cent phosphoric acid) and is present in at least four forms. About 65 per cent of the phosphorus of milk is in the form of phosphate in the sense that it is precipitable by phosphate reagents, but to what extent this is free phosphate and to what extent loosely combined with organic matter has not been determined; about 25 per cent exists as an essential organic constituent of the casein (the latter containing 0.8 to 0.9 per cent of phosphorus after having been purified by dissolving and reprecipitating until ash free); about 10 per cent in the form of phosphatids (the so-called phosphorized fats, including lecithin) and other organic compounds. References to the recent work of Osborne and Wakeman upon the phosphatids of milk will be found at the end of the chapter.

Chlorine exists in milk in the form of sodium chloride, possibly in part also as potassium chloride.

The base-forming elements, sodium, potassium, calcium, and magnesium, are present in milk in slightly greater amounts than would be necessary to neutralize the acids obtainable from the sulphur, phosphorus, and chlorine present, and in distinct excess over what would be required to combine with the ready-formed acid radicles. This surplus of base is combined in part with the casein and in part with citric acid, a small quantity of which is a normal constituent of milk and is counted with the carbohydrates in the usual proximate analysis. The percentages of these elements, calculated as oxides, in average cows' milk are as follows: calcium oxide, 0.168 per cent; magnesium oxide, 0.019 per cent; potassium oxide, 0.171 per cent; sodium oxide, 0.068 per cent.

Noticeable here are the high calcium content as compared with other foods and the richness of milk in calcium and potassium as compared with magnesium and sodium. In these respects the composition of milk ash resembles that of the ash of the animal body.

The iron of milk is small in amount (about 0.0002 per cent) but of high food value. It will be considered in the section on the nutritive value of milk and the place of milk in the diet.

Since iodine is now known to be essential to normal nutrition and since animals have grown normally and even reproduced themselves when kept from weaning time upon exclusive milk diet, we must conclude that milk contains some compound of iodine, although the amount is too small for satisfactory determination by present analytical methods.

Table 8 summarizes the mineral elements or ash constituents of milk, calculated in terms of the element and not of its oxide.

Table 8. Mineral Elements of Cows' Milk

Element	In Fresh Milk	In Dried Milk	In Milk Ash
	Per cent	*Per cent*	*Per cent*
Calcium	0.120	0.92	17.
Magnesium	0.012	0.09	1.7
Potassium	0.143	1.10	20.
Sodium	0.051	0.39	7.
Phosphorus	0.093	0.71	13.
Chlorine	0.106	0.82	15.
Sulphur	0.034	0.26	4.8
Iron	0.0002	0.0015	0.03
Iodine	?	?	?

The reader will notice that in Table 8 and the preceding text the amounts of certain elements are calculated sometimes as the oxide and sometimes as the element itself. Neither form of statement implies anything as to the actual form of chemical combination in which the element is present in the food. Both are merely modes of reckoning the results of quantitative determinations, usually of the total amount of the element present in the food in any form. Both will be met in current literature, and the reader should be prepared to interpret the data correctly in whichever form they are found. The writer considers it preferable to reckon in terms of the element itself wherever practicable.

The vitamin content of milk. Milk contains all three of the vitamins A, B, and C in amounts varying somewhat with the food of the cow and with some other conditions, but probably on the whole in rather more constant proportions than is generally supposed.

The growth of experimental rats receiving limited amounts of milk as sole sources of vitamins A or B indicates that, compared on the basis of food solids or calories, milk contains about 3 times the concentration of vitamin B and about 15 times the concentration of vitamin A that the diet as a whole must contain to be adequate for the support of normal growth. The results of tests made with the ordinary market milk of New York City at different times of the year have not shown any marked seasonal differences.

Milk may be regarded as regularly constituting an excellent source of vitamin A and a good source of vitamin B. The amount of vitamin C in milk is more variable than its vitamin A or B content.

So far as we know, vitamins are not formed in the animal body, and so the vitamins found in milk are to be regarded as derived from the food of the cow. Experimentally it has been shown that the vitamin value of milk may be much reduced by keeping the cow on vitamin-poor food. But such are not the rations of modern dairy practice, and cows so badly fed cannot be very common. Moreover, such a cow gives so little milk that the product of such cows can seldom have an appreciable influence upon the character of the mixed milk which reaches the consumer. Another influence tending to relative stability of the vitamin content of milk, at least in the case of vitamin A, is the fact that on diet rich in this factor (as is that of nearly all cows during the season of green pasture) the body stores up considerable quantities of vitamin A, which are then available for secretion in the milk when at any future time the vitamin A value of the food intake may be diminished.

In the case of vitamin C the differences in concentration in different samples of milk are doubtless larger, for the food may be poor in vitamin C without apparently injuring the health of the cow or seriously diminishing her productiveness. It has been estimated that summer milk produced on fresh pasture may contain three to five times as much vitamin C as winter milk produced by cows which have been for months on dry feed.

Nutritive Value and Place in the Diet

Average milk with 4 per cent fat furnishes about 314 Calories per pound or 675 Calories per quart. Milk naturally so poor as to contain only 3 per cent fat would furnish 268 Calories per pound; natural milk with 5 per cent fat would furnish 360, and that with 6 per cent fat, 407 Calories per pound. In any of these cases from 18 to 20 per cent of the Calories would be furnished by protein.

The quantitative relations between protein content and fat content or fuel value are readily altered by separating the "top milk" or cream from the "skim milk." Milk skimmed so as to contain only 1 per cent fat would yield about 200 Calories per pound, and protein would furnish approximately one third of the Calories; while a thin cream obtained from the same milk and containing 10 per cent fat would yield about 550 Calories per pound, of which only one tenth of the Calories would be furnished by protein.

Even from the standpoint of gross proximate composition and fuel value milk is a fairly economical food, especially when compared with other foods of animal origin, a quart of milk being approximately equivalent to a pound of steak[1] or to eight or nine eggs.

Such a comparison, however, fails to do justice to the true nutritive value of milk, which is largely due to the peculiar nature of its constituents and to its vitamin content.

The carbohydrate of milk (lactose) is already in solution, and like other sugars does not require the action of the salivary or pancreatic juice, but only that of the intestinal juice, for its digestion. It has the advantage over sucrose and glucose of being less susceptible to fermentation and less liable to irritate the stomach. Moreover lactose has the very important dietary property of favoring the development of the *Bacillus acidophilus* in the intestine, thus making for good intestinal hygiene through the multiplication of the "friendly germs" and the suppression of the highly objectionable but all too common putrefactive bacteria of the intestine.

The fat of milk is already emulsified and so is more readily available to the body than the fats of other common foods except eggs. The fact that milk fat is fluid at body temperature also aids its digestibility. Whether the presence of glycerides of the volatile acids is of any special advantage aside from flavor is not clear.

The proteins of milk are of high nutritive value. When milk

[1] That the standard tables of analyses give an exaggerated impression of the fuel value of meats, especially beef, is explained in Chapter VI preceding Table 16. In that table it will be seen that sirloin steak as purchased is given a fuel value of 960 Calories per pound, but this includes all the fat originally belonging with the cut, and two thirds of the Calories come from the fat. If, as is often the case, the butcher and consumer remove one half or more of the fat originally present, then the steak as actually eaten furnishes not over 640 Calories for each pound of material purchased.

is taken under normal conditions (even in relatively large quantity and in connection with only a small amount of bread or other solid food), about 97 to 98 per cent of the milk protein is digested and absorbed. Numerous recent digestion and metabolism experiments indicate that under normal conditions it is among the most completely digested and absorbed of all the food proteins.

Not only do the milk proteins show a high coefficient of digestibility, but metabolism experiments and clinical observations show that milk furnishes a form of protein food particularly adapted to bring about a storage of protein in the body. This observed superiority of milk proteins has now been explained in terms of their chemical structure or amino-acid make-up.

If the data of Table 6 be compared with the corresponding data for proteins of other foods, as given in later chapters, it will be seen that the milk proteins are relatively rich in the amino-acid radicles of more complex structure, which apparently are not readily formed in the body, notably in tryptophane and lysine, which are known to play an especially important part in nutrition and growth. Not only does this give milk proteins high nutritive value in themselves; but, what is also of the highest importance from the standpoint of food economics, it makes milk a most effective protein supplement to bread, oatmeal, hominy, and other grain products, since the milk proteins are rich in the particular amino acids in which the grain proteins tend to be poor. Together with this important property the milk proteins have the unique advantage of being taken in admixture with milk sugar, which, as explained above, tends to protect them from putrefactive decomposition in the intestine.

The ash constituents of milk constitute an important factor in its nutritive value since they furnish all the inorganic elements needed in nutrition and in exceptionally favorable proportions. In many experiments by Osborne and Mendel and by McCollum and his associates, the growth and health of laboratory animals kept on restricted diets have been very greatly improved by adding to the rations such salt mixtures as would give to the total inorganic content of the ration the composition of milk ash. Often such improvement in the mineral content of the diet makes all the difference between complete success and total failure. While such laboratory experiments professedly make use of somewhat extreme conditions, there is no doubt that many human dietaries depend for the adequacy of their mineral elements upon the milk which the dietaries contain, and that thus the ash constituents of milk are important not only for their property of being adequate in the absence of all other ash constituents, as in the experiments just cited, but also in their bearing upon the adequacy of the phosphorus, calcium, and iron supply in a mixed diet.

Phosphorus compounds are present in milk in relative abundance and in a variety of forms. Calcium is present in still greater relative abundance. Milk contains slightly more calcium, volume for volume, than does limewater. As a rule the calcium content of the diet depends mainly upon the amount of milk consumed. In family dietaries where ordinary quantities of milk are used, the milk is apt to furnish over one half of the total calcium of the diet. Without milk it is unlikely that the diet will be as rich in calcium as is desirable either for the child or for the adult, and with the limited amounts of milk used by so many American families the dietary is probably more often deficient in calcium than in any other chemical element. This is a strong reason for a more liberal use of milk as a food.

Iron is present in milk in only small quantity, but evidently in a form exceptionally favorable for assimilation. Notwithstanding the low iron content, a diet of milk and white bread appears to be adequate for the maintenance of iron equilibrium in man, whereas white bread alone in larger quantity or a diet of bread and iron-free protein is much less efficient.

So far as our present knowledge indicates, this favorable influence of milk upon the iron metabolism, in spite of the small amount of iron which it contains, would seem to be due in part to the form in which the iron is present and in part to the fact that it is associated with a large amount of calcium which in some way appears to be favorable to the economy of iron in the organism. Possibly another reason for the high nutritive efficiency of milk iron may be found in the fact that the milk furnishes along with its iron certain organic radicles, which, whether as building material for the construction of hemoglobin or as growth- and health-promoting vitamin, or both, directly contribute to the efficiency of those constructive nutritional processes in which the iron is particularly concerned.

The vitamin content of milk is also a very important factor in its nutritive value. As a brief generalization the statement of Rosenau that "milk is rich in all three of the known vitamins" may be accepted, though we have seen that its vitamin C content is variable. Mendel in his address to the World's Dairy Congress (1923) emphasized the fact that milk contains important amounts of all three vitamins A, B, and C, and that while each one of these may be found in other foods as well, there are few if any other foods which furnish all these vitamins in such well-balanced proportions as does milk.

As McCollum has so often emphasized, and so strikingly demonstrated in his work with experimental animals, a liberal consumption of milk is the most important and effective way in which to protect against the very real danger that the dietary may otherwise fall below the optimum in calcium and in fat-soluble vitamin.

As much of our present knowledge regarding the nutritive value of milk is the result of the researches of the past few years it is important to inquire whether this knowledge is yet reflected to an adequate extent in the place actually occupied by milk in the average American dietary at the present time.

According to recent estimates of the United States Department of Agriculture (*Yearbook* for 1922), the average consumption of milk by the people of the United States is a little over one third of a quart per capita per day, which of course includes the milk used in cooking as well as that consumed in fluid form. To this is added the cream from one sixth of a pint of milk per capita per day. On the assumption that the consumption is larger in the country than in the cities, it is estimated that the general average reaches the equivalent of about one pint of milk (or milk and cream) per capita per day.

Data gathered by Dr. Haven Emerson from statistics of city health departments indicate that a large proportion of American cities receive less than one half pint of milk per capita per day.

In view of our present knowledge of the great importance of a liberal consumption of milk, supplies of less than one pint per capita per day must be regarded as certainly too low for the making of satisfactory dietaries. A pint of milk per capita per day may be taken as representing what the general public accepts at the present time as an adequate community supply; but this does not fully reflect the newer knowledge of nutrition. McCollum advocates the general adoption of a dietary standard calling for a quart of milk per capita per day. Taking into account the many and important factors which increase the value of milk as a food above that indicated by the usual statement of composition and fuel value, and also the fact that it requires no preparation and has no waste, it may well be regarded as true economy to use as much as a quart of milk per person per day when the cost of the dietary does not have to be limited with great stringency, or in any case in which the milk does not cost more than twice as much per 100 Calories as the average of the food eaten.

"A quart of milk a day for every child" is a good rule easy to remember; and to this we may well add "and at least a pint for every adult." In no case need all the milk be consumed as such; much (or in extreme cases all) of it may be used in or on solid food or concealed in cooking.

Especially in the feeding of children should milk be used freely, because of its unique value as a tissue-building and growth-promoting food.

In view of the fact that most physicians and dietitians recommend a quart of milk a day for children's dietaries, whereas some believe that a smaller amount may do as well, and because of the question as to the age at which the importance of milk in the diet begins to diminish, the New York Association for Improving the Condition of the Poor recently carried out in coöperation with Columbia University an extended series of experiments upon children from 3 years to over 13 years of age to determine what quantity of milk per day, taken as part of a normal diet, would induce the best storage of calcium and phosphorus in the growing body and therefore presumably the best development of bones and teeth. It was found that at all ages studied, extending from 3 to over 13 years inclusive, the child must be fed a full quart of milk per day in order to insure the best growth and development. As pointed out editorially in the Journal of the American Medical Association in the discussion of these results: "The dietary rule of a quart of milk each day for every child is much more than a precept based on individual opinions or drawn by analogy from the results of feeding experiments with lower animals; it now rests on scientific evidence obtained by extensive and intensive experiments directly upon the children themselves."

The experiments just cited emphasize the importance of continuing the allowance of a quart of milk a day up to at least the age of 13 to 14 years. It is hardly practicable to carry the same method of experiment much farther into normal human life; but it is possible to determine by means of studies with laboratory animals of rapid development like the rat, the effect of different levels of milk consumption upon adult health when all other conditions of life are kept strictly uniform. This has been studied in the writer's laboratory through several generations of experimental animals with results which show plainly that, starting with a dietary already adequate according to current standards, an increase in the proportion of milk up to approximately the equivalent of a quart of milk per day for every person greatly favors the growth and development throughout youth and confers improved health and vigor throughout adult life, actually postponing old age in the same individuals in which it has induced better growth and earlier maturity.

In no other way can the food habits now prevailing, especially in the cities, be so certainly and economically improved as by a more liberal use of good milk.

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[1] The first group (I) contains books (and a few of the more comprehensive bulletins) arranged alphabetically by authors. The second group (II) contains contributions to scientific journals and other periodicals, reports, bulletins, etc., arranged chronologically. Similar lists will be found at the end of each of the chapters which follow.

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CHAPTER IV

MILK PRODUCTS OTHER THAN BUTTER

The dairy farming "belt" of the United States extends from Vermont and Massachusetts southward and westward including New York, Pennsylvania, Ohio, Indiana, Illinois, southern Michigan, Iowa, Wisconsin, and Minnesota. Many other states have very considerable numbers of dairy cattle, and each of the Pacific coast states has certain areas which are largely devoted to dairy farming. Outside of the "dairy belt" and the limited dairy districts of California, Oregon, and Washington dairy cattle are numerous in total numbers but not sufficiently concentrated to support much large-scale manufacture of milk products. Texas and Missouri each has a larger number of dairy cattle than has Vermont; but Vermont has a larger number of cows per farm than has any other state and supports intensive commercial dairying as Texas and Missouri do not. (See Fig. 8, from *Yearbook* of the United States Department of Agriculture for 1922.)

To only a limited extent as yet do we find dairy farming developed at great distances from centers of population for the exclusive purpose of supporting the manufacture of milk products. More commonly the manufacture of these products begins in (or on the margin of) the market milk region, using the seasonal surplus of the market milk farms and thus resulting in a gradual intensification and extension of the original "dairy belt."

According to official estimates of the United States Department of Agriculture (*Yearbook* for 1922) about 46 billion pounds of milk per year are used in the United States for manufacture

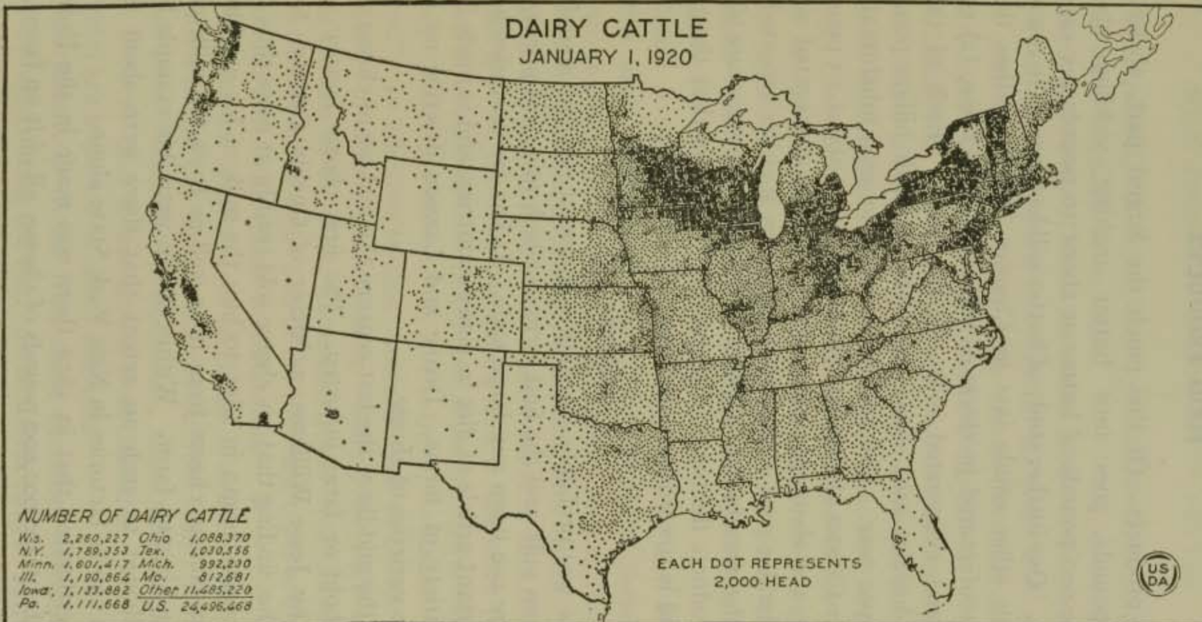

FIG. 8. — Distribution of dairy cattle in the United States in 1920. Each dot represents 2000 dairy cattle. United States Department of Agriculture *Yearbook* for 1922.

of milk products. Of this much the largest part, about 35 billion pounds, goes into butter making, yielding about 1,700,000,000 pounds of butter or about 16 pounds per capita per year. Our further study of butter will be taken up in connection with other edible fats in Chapter X. The other three chief manufactured products of milk are: (1) cheese, (2) condensed and evaporated milk, (3) ice cream. Each of these three industries uses about three and one half billion pounds of milk per year. This makes annually for each inhabitant of the United States about 2 gallons of ice cream, about 3.5 pounds of cheese, and about 14 pounds of condensed or evaporated milk. A considerable part of the latter, however, is either exported or used in the manufacture of other foods. The manufacture of all these products fluctuates with market conditions, but the general trend is toward increased production.

Cheese

Cheese was probably the first commercial product manufactured from milk and the first form in which milk was preserved for future use upon any large scale. It has for centuries been an important article of diet in many countries, and is made in a great variety of forms. Doane and Lawson describe no less than 350 varieties of cheese.

Until the middle of the last century the making of cheese was a household or farm industry. The first cheese factory was started by Jesse Williams, a farmer of Oneida County, New York, who, finding that his cheese sold readily at more than the average price, began in 1851 to buy the milk of his neighbors and manufacture cheese from it as well as from the milk produced on his own farm. Within fifteen years his example had been followed to such an extent that there were about five hundred cheese factories in New York State alone.

It is estimated that in 1850 there was made in the United States about 100,000,000 pounds of cheese, all of it on farms or in the household; in 1920, about 350,000,000 pounds, of which 98 per cent was made in factories.

About two thirds of this cheese was made in Wisconsin, the larger part of the remainder in New York, while small amounts were contributed by several other states, including (quite recently) some of the mountain sections of the South.

Including that imported, the total cheese consumption in the United States is only $3\frac{1}{2}$ to 4 pounds per person per year, a low figure in comparison with the amounts of meat and butter consumed. During the past few years the United States Department of Agriculture has given considerable attention to the cheese industry and to the use of cheese as a food, and it is probable that this will result in a larger per capita consumption of cheese for the country as a whole.

Cheese is roughly divided into two main types: the hard cheeses such as Cheddar, Edam, Emmental (or Swiss), Parmesan, and Roquefort; and the soft cheeses such as Brie, Camembert, Gorgonzola, Limburg, Neufchâtel, and Stilton.

Much the largest part of the cheese made in this country is of the type of the Cheddar cheese and is therefore properly known as American Cheddar cheese, although frequently called simply "American cheese" or, in the trade, "standard factory cheese." In addition to this standard type of cheese smaller quantities of other types are made. Some New York factories make cheeses of the Brie, Camembert, and Neufchâtel types, while cheeses of the Swiss and of the Limburg types are made in Wisconsin and Swiss cheese in California.

The principal importations of cheese into the United States are of Parmesan and Gorgonzola cheese from Italy; Emmental cheese from Switzerland; Roquefort, Camembert, and Brie, from France; and Edam cheese from Holland. Many other varieties are imported in small amounts.

Exportations of cheese from these countries were naturally much reduced during the war. In fact from 1915 to 1918 America exported more cheese than it imported. Since the war, both imports and exports have been small, the American market being supplied essentially by cheeses of American manufacture, among which those of the Cheddar type predominate, while other types are growing in importance as the methods of making them are improved.

Manufacture of American Cheddar Cheese

This process is divided into several fairly distinct steps as follows: (1) inspection of milk, (2) ripening of milk, (3) addition of color — when color is used, (4) coagulating the milk, (5) cutting the curd, (6) stirring and heating the curd, (7) removing whey, (8) cheddaring the curd, (9) milling the curd, (10) salting and pressing the curd, (11) ripening or curing the cheese.

Inspection of milk. Each can of milk received for cheese making should be examined for acidity, dirt, and abnormal flavors (odor or taste). Sometimes a rapid examination by the senses of sight and smell is deemed sufficient; sometimes a roughly quantitative determination of the acidity is made. When the cheese maker is troubled with abnormal fermentation or defective curd, it may be necessary for him to make a test of each farmer's milk to determine the nature of the fermentation which it shows and of the curd which it yields, in order that the particular milk which is responsible for the trouble may be located and excluded.

Ripening of milk. This consists in keeping the milk at about 86° F. (30° C.) until the desired amount of lactic acid has formed. "Starters," consisting of commercial cultures of lactic acid bacteria or of milk in active lactic acid fermentation, are sometimes added to facilitate the ripening process. The lactic acid is important in its influence on the operations of cheese making, and its presence also tends to repress abnormal fermentations. The proper degree of ripeness is judged either by titrating for acidity or by testing a portion of the milk with rennet to see whether it coagulates as readily as is desired. Acidity equivalent to 0.20 per cent of lactic acid usually marks the completion of the ripening process.

Addition of color. When coloring matter is used in cheese making, it should be added to the ripened milk just before coagulating it with rennet.

Coagulating the milk. Rennet is the most useful reagent for the precipitation of the curd, that prepared from the calves' stomachs being most highly prized for cheese making. Rennet is now prepared on a large scale and is purchased from the makers for use in the cheese industry. The quality of the rennet is very important, as an inferior grade gives a bad taste to the cheese. The amount of rennet to be added depends, of course, upon the strength of the preparation, but should be sufficient so that when mixed with the milk and kept at 84°–86° F. the milk will be curdled in 15 to 20 minutes if it is to be used for a quick-curing cheese, and in 30 to 40 minutes for a slow-curing cheese. The rennet extracts commonly used are added in the proportion of from 2 to 5 ounces per 1000 pounds of milk. Before adding, the extract should be diluted with 40 times its volume of water at a temperature of 85°–90° F. so as to prevent the production of a lumpy curd. Previous to adding the rennet the milk is thoroughly stirred in order to distribute the fat evenly, and the rennet is added evenly and slowly with constant stirring, which is continued for several minutes. After this, the milk is stirred gently near the surface to prevent separation of cream. All stirring is stopped as soon as (or before) coagulation begins, and the milk is then left covered and undisturbed while the coagulation gradually continues until the whole mass forms one coherent curd and is ready for cutting.

Cutting the curd. In order that the whey may be separated it is necessary that the curd be cut into pieces; the smaller the pieces of curd, the more rapidly will the whey escape. As soon as the curd is formed it tends to contract and force out a portion of the whey. By cutting the curd the surface from which the whey can exude is increased and so the separation of the whey from the curd goes on much more rapidly. The time for cutting the curd is important and is determined by the skill and experience of the cheese maker. If the curd is cut when it is too soft, there may be a large loss of fat, with a resulting decrease in the yield and quality of the cheese. If the curd is allowed to become too hard before cutting, the whey is removed with greater difficulty; and if incompletely removed, a cheese of low quality results. The cutting is accomplished by drawing specially devised cutting knives through the mass of curd, both horizontally and vertically, so as to cut it into cubes of one quarter to one half inch size.

Stirring and heating the curd. As soon as the curd is cut, the whey begins to separate, and the mass of cut curd is then kept in gentle motion by stirring, taking care to avoid breaking the cubes. This results in the separation of a clear whey, free from fat or small particles of curd. The curd contracts and hardens during this process and soon reaches a condition in which the surfaces do not readily adhere. During this process of separation of the whey, the temperature is raised to about 90° F. and finally toward the last to about 98° F.

Removing the whey. The precipitated curd is left in contact with the whey for some time, during which time there is some action of the acid of the whey upon the protein of the curd, which is allowed to continue until a small mass of the curd, which has been squeezed in the hand to remove the whey and then pressed against a bar of iron heated a little below redness, will leave adhering to the iron fine, silky threads, the length of which indicates roughly the extent to which the desired combination of acid and protein has taken place. Usually the curd is separated when the hot iron test shows strings about one eighth of an inch long; but other tests are also used to aid in judging when the whey should be removed. The whey is run off gradually while the stirring of the curd is continued.

Cheddaring the curd. Most of the whey having run off, the cubes of curd are left piled in the bottom of the vat until they mat or pack together, which process is technically known as "cheddaring." Sometimes the "cheddaring" is accomplished in a special apparatus called the "curd sink." When the cheddaring of the curd is complete, it is cut into blocks, 6 to 12 inches in each dimension, which are turned in the vat in order to facilitate the further removal of whey, and are then carefully placed, one over the other, until they form a large mass. The process of solidifying or "cheddaring" has two results: first, the more complete removal of the whey, and second, the formation of a characteristic texture in the curd which becomes less rubber-like and more velvety and forms strings of an inch or more in length when tested with the hot iron. During the cheddaring a considerable increase of acidity occurs, the last of the whey which drains from the piled curd showing usually an acidity equal to 0.6 to 0.9 per cent of lactic acid.

Milling the curd. The milling process consists in cutting the lumps of curd into small pieces of uniform size in order that it may be salted more evenly and handled more readily when it is placed in hoops for pressing. This is done by means of curd mills designed to avoid as far as possible the loss of fat which would result from crushing or squeezing the curd.

Salting and pressing. Salt is added chiefly for flavoring, but also it aids in removing the whey, it hardens the curd, it checks the further formation of lactic acid, and it helps to prevent the development of undesirable fermentation. Excessive salting is, however, injurious. Usually from 1 to 3 pounds of salt are added to the curd obtained from 1000 pounds of milk. After filling the curd into the mold it is pressed in the proper form by a uniform pressure which is continued for 24 to 48 hours. Usually a light pressure is applied at first and gradually increased during about an hour, when the cheese is removed, trimmed, turned, wrapped in cloth, and replaced for the final pressing.

Ripening or curing the cheese. When taken from the press, cheese is said to be unripe, green, or uncured. It must be stored for weeks or months to become properly ripened. The higher the temperature to which cheese is exposed in ripening, the more rapid the process will be, but this is attained usually at the expense of the quality of the cheese. For the best results, the ripening is conducted at a temperature not above 55° F. and requires a comparatively long time. During the ripening the cheese undergoes some loss of weight by evaporation of moisture, but the chief object of the ripening process is to secure certain changes in texture and flavor which depend essentially upon a gradual hydrolysis of the cheese protein, the changes being very similar to those which take place in digestion.

The increase of soluble proteins, and of the products of further cleavage, which takes place at the expense of the insoluble protein of the original curd, is shown in Table 9, which is condensed from data given by Van Slyke and Publow.[1]

TABLE 9. DEVELOPMENT OF PROTEIN CLEAVAGE PRODUCTS IN CHEESE

Age of Cheese	Nitrogen, Expressed as Percentage of the Total Nitrogen of the Cheese, in the Form of:				
	Soluble Proteins and Derivatives	Proteoses	Peptones	Amino-acids	Ammonia
Months	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1½	21.44	3.15	3.84	9.88	1.56
3	30.98	4.56	4.65	14.36	2.45
6	36.15	4.92	4.22	19.96	3.52
9	43.45	4.59	3.56	26.53	4.74
12	44.75	4.16	3.95	28.38	5.41
18	47.25	3.88	2.57	30.46	6.62

[1] *The Science and Practice of Cheese Making*, page 337.

The changes which take place in the cheese protein during the ripening process are doubtless due to a combination of factors. Van Slyke holds that (1) the lactic acid, (2) the rennet enzyme, (3) the milk enzyme (galactase), (4) microörganisms, chiefly bacteria, all play important parts in the ripening process. The exact part played by each of these factors is still a subject of investigation.

Other Varieties of Cheese

Since about three fourths of all the cheese used in the United States is of the Cheddar type, only that type can be considered at all fully here. Most of the following statements regarding a few other varieties of cheese are abbreviated from the descriptions given by Doane and Lawson.[1]

Brie. This is a soft rennet cheese made from cows' milk. The cheese varies in size and also in quality, depending on whether whole or partly skimmed milk is used. The method of manufacture closely resembles that of Camembert.

This cheese has been made in France for several centuries. Mention was made of it as early as 1407. It is made throughout France, but more extensively in the Department of Seine et Marne, in which it doubtless originated. More or less successful imitations of this cheese are made in other countries. It was estimated that 7,000,000 pounds of Brie cheese were sold in Paris during 1900. The export trade is also very important.

Camembert. This is a soft rennet cheese made from cows' milk. A typical cheese is about $4\frac{1}{4}$ inches in diameter and $1\frac{1}{4}$ inches thick and is usually found on the market in this country wrapped in paper and inclosed in a wooden box of the same shape. The cheese usually has a rind about one eighth of an inch in thickness which is composed of molds and dried cheese. The interior is yellowish in color, and waxy, creamy, or almost fluid in consistency, depending largely upon the degree of ripeness.

[1] *Varieties of Cheese: Descriptions and Analyses*. United States Department of Agriculture, Bureau of Animal Industry, Bulletin 105.

Camembert cheese is said to have originated in 1791 in the locality from which it derives its name in the Department of Orne, in the northwestern part of France. The industry extended soon into Calvados, and these two departments are still the principal seat of the industry. Very successful cheeses of this type have been made at the Storrs Agricultural Experiment Station in Connecticut.

Cheshire. This cheese is one of the oldest and most popular of the English varieties. It is a rennet cheese made from unskimmed cows' milk, and is named for Chester County, England, where it is largely produced. It is made in cylindrical shape from 14 to 16 inches in diameter, and weighs 50 to 70 pounds. In making this cheese sufficient annatto is used to give the product a very high color.

Cheshire-Stilton. This is a combination of the Cheshire and Stilton varieties of cheese in which the general characteristics of size and shape and manufacture of the Cheshire are retained, and a growth of the mold peculiar to Stilton is secured. The mold is propagated by keeping out each day a portion of curd and mixing it with some older curd in which the mold is growing well.

Edam. This is a hard rennet cheese produced in Holland; it is also known as Katzenkopf, Tete de Maure, and Manbollen. The best of the product is made of unskimmed cows' milk, but much of it at the present time is made from milk which has had at least one half of the fat removed. The cheeses are round and are colored deep red on the surface or wrapped in tinfoil.

When the cheese is one month old, it is washed in water at 70° F. for twenty minutes and then placed in the sun to dry, after which it is rubbed with linseed oil. Before shipping the cheese is colored, usually red, but for some markets it is colored yellow with annatto. This coloring is done with a watery solution of litmus and Berlin red, or with carmine. A considerable quantity of this cheese is imported into the United States. At the present time some Edam cheeses are inclosed in air-tight tins for export.

Emmental. This is a hard rennet cheese made from unskimmed cows' milk, and has a mild, somewhat sweetish flavor. It is characterized by holes or eyes which develop to about the size of a half inch in typical cheeses and are situated from 1 to 3 inches apart

Emmental cheese is a very old variety. In the middle of the fifteenth century a cheese probably of this type was manufactured in the Canton of Emmental. In the middle of the seventeenth century the industry was well developed and Emmental cheese as we now know it was being exported. In 1722 its manufacture under the name of Gruyère is recorded in France, two coöperative societies having been organized for this purpose.

Emmental cheese is now manufactured in every civilized country. In the United States its manufacture has recently received an important impetus through the discovery in the Dairy Division of the United States Department of Agriculture, of the organisms responsible for the particular combination of flavor and texture desired.

Gorgonzola. This variety, known also as Stracchino di Gorgonzola, is a rennet Italian cheese made from whole cows' milk. The name is taken from the village of Gorgonzola, near Milan; but very little of this cheese is now made in that immediate locality. The interior of the cheese is mottled or veined with a penicillium much like Roquefort, and for this reason the cheese has been grouped with Roquefort and Stilton varieties. As seen upon the markets in this country, the surface of the cheese is covered with a thin coat resembling clay, said to be prepared by mixing barite or gypsum, lard or tallow, and coloring matter. The cheeses are cylindrical in shape, being about 12 inches in diameter and 6 inches in height, and as marketed are wrapped in paper and packed with straw in wicker baskets.

The manufacture of Gorgonzola cheese is an important industry in Lombardy, where formerly it was carried on principally during the months of September and October, but with the establishment of curing cellars in the Alps, especially near Lecco, the manufacture is no longer confined to this season.

At an early stage in the process of ripening the cheese is usually punched with an instrument about 6 inches long, tapering from a sharp point to a diameter of about one eighth inch at the base. About 150 holes are made in each cheese. This favors the development of the penicillium throughout the interior of the cheese. Well-made cheese may be kept for a year or longer. In the region where made, much of the cheese is consumed while in a fresh condition.

Gruyère. This name is applied to Emmental cheese manufactured in France, the name originating from the Swiss village of Gruyère. The cheese was first mentioned in 1722, when two societies were reported to have been organized for its manufacture. The Gruyère cheese is made in three different qualities — whole milk, partly skimmed, and skimmed. It is usually made from partly skimmed milk, and this is supposed to distinguish it from Emmental, which is supposed to be made from whole milk. The manufacture of Gruyère cheese is an extensive industry in France, about 50,000,000 pounds having been manufactured annually the latter part of the last century.

Limburg. This is a soft rennet cheese made from cows' milk which may contain all of the fat or be partly or entirely skimmed. The best Limburg is undoubtedly made from whole milk. This cheese has a very strong and characteristic odor and taste. The cheese is about 6 by 6 by 3 inches and weighs about 2 pounds.

Limburg cheese originated in the province of Luttich, Belgium, in the neighborhood of Hervé, and was marketed in Limburg, Belgium. Its manufacture has spread to Germany and Austria, where it is very popular, and to the United States, where large quantities are made, mostly in New York and Wisconsin.

According to Doane and Lawson no Limburg is imported into this country at the present time, this type of cheese being made so cheaply and of such good quality in this country that the foreign make has been crowded out of the market.

Neufchâtel. This is a soft rennet cheese made extensively in the Department of Seine-Inférieure, France, from cows' milk, either whole or skimmed.

The milk, preferably fresh, is set at 85° F. with only so much rennet as is necessary to secure the desired coagulation in twenty-four hours in summer and from thirty-six to forty-eight hours in winter. The curd is then inclosed in cheesecloth and drained for twelve hours, after which it is subjected to pressure for another period of twelve hours. It is then thoroughly kneaded by hand, or in the larger factories by means of a curd mill, and pressed into tin cylinders about 2 inches in diameter and 3 inches high. The cheeses are removed soon from the molds, salted, and replaced. After draining for twenty-four hours they are transferred to the so-called "drying room," where they become covered with white and later with blue molds. They are then taken to the curing cellar, where the ripening process is continued for three to four weeks. The appearance of red spots on the surface is taken as an indication that the ripening has progressed far enough. The cheeses are then wrapped in tin foil and marketed.

Parmesan. This name is in common use outside of Italy for the cheese made and known in that country for centuries as Grana, the term "grana" or "granona" referring to the granular appearance of the cheese when broken, as is necessary on account of the hardness of the cheese, which makes cutting practically impossible. There are two quite distinct varieties of Parmesan cheese, one made in Lombardy and the other in Emilia, the centers of production being separated by the River Po. Parma, situated in Emilia, has long been an important commercial center for both varieties, and to this fact the name

Parmesan is due. The use of the term "Parmesan," however, is sometimes restricted to the cheese made in Lombardy, the term "Reggian" being used to designate that made in Emilia.

The Lombardy cheese made from April to September is known locally as Sorte Maggenga and that from October to March as Sorte Vermenga. The Reggian cheese is made only in summer.

Parmesan cheese when well made may be broken and grated easily and may be kept for an indefinite number of years. It is grated and used largely for soups and with macaroni. A considerable quantity of this cheese is imported into this country and sells for a high price.

Pineapple. This cheese, which is said to have had its origin in Litchfield County, Conn., about 1845, is so named from the fruit which the cheese is made to resemble in shape. It is a hard rennet cheese made from whole cows' milk. The cheese is quite hard and is rather highly colored. The early process of manufacture is the same as with Cheddar, except that it is made much harder. The curd is pressed in the desired shape in various sizes up to 6 pounds in weight. After pressing, the cheese is dipped for a few minutes in water at 120° F. and is then put in a net for twenty-four hours, which gives it the diamond-shaped corrugations on the surface. It requires several months to ripen, and during this time the surface is rubbed with oil, which makes it very smooth and hard.

Roquefort. This is a hard rennet cheese made from the milk of sheep. There are, however, numerous imitations or varieties closely resembling Roquefort, such as Gex and Septmoncel, made from cows' milk. One of the most striking characteristics of this cheese is the mottled or marbled appearance of the interior, due to the development of a penicillium, which is the principal ripening agent. The manufacture of Roquefort cheese has been carried on in the southeastern part of France for at least two centuries. The industry is particularly important in the Department of Avekron, in which is situated the village of Roquefort, from which the cheese derives its name. It is also made in Corsica. Imitations of Roquefort cheese are made in various countries.

Formerly the manufacture of the cheese was carried on by the shepherds themselves, but in recent years centralized factories have been established and much of the milk is collected and there made into cheese. The cheese is then taken to the caves. These are for the most part natural caverns which exist in large numbers in the region of Roquefort and the air circulates freely through them. Recently, artificial caves have been constructed and used. When the cheeses reach the caves, they are salted, which serves to check the growth of the mold on the surface. One or two days later they are rubbed vigorously with cloth and are afterwards subjected to thorough scraping with knives, a process formerly done by hand, but now much more satisfactorily and economically by machinery. The salting, scraping, or brushing seems to check the development of mold on the surface. In order to favor the growth of mold in the interior, the cheese is pierced by machinery with 60 to 100 small steel needles, which process permits the free access of air. The cheese may be sold after thirty to forty days or may remain in the caves as long as five months, depending upon the degree of ripening desired. The cheese loses during ripening by scraping and evaporation as much as 25 per cent of the original weight. The weight when ripened is about 4½ to 5 pounds.

Stilton. This is a hard rennet cheese, the best of which is made from cows' milk to which a portion of cream has been added. It was first made near the village of Stilton, Huntingdonshire, England, about the middle of the eighteenth century. It is now made principally in Leicestershire and West Rutlandshire, though its manufacture has extended to other parts of England. Its manufacture has been tried, though without success, in the United States. The cheese is about 7 inches in diameter and 9 inches high, and weighs 12 to 15 pounds. It has a very characteristic wrinkled or ridged skin or rind, which is likely caused by the drying of molds and bacteria on the surface. When cut it shows blue or green portions of mold, which give its characteristic piquant flavor. The cheese belongs to the same group as the Roquefort of France and the Gorgonzola of Italy.

Relation of Microörganisms to Cheese Making

That there should be hundreds of varieties of cheese all made from milk, rennet, and salt, but each having a characteristic flavor, is chiefly due to the differences in the microörganisms which take part in the ripening of the different varieties.

As a rule in the hard cheeses the ripening agents are distributed throughout the cheese mass at the beginning of the ripening process and therefore act in a more or less uniform way throughout the cheese, whatever its size; while in the soft cheeses the ripening process is largely due to organisms growing on the surface and producing products which only gradually penetrate the cheese mass, so that it is practically necessary that these cheeses be made in small sizes.

It will be recalled from the above description of Cheddar cheese making that lactic acid bacteria are active in the ripening of the milk before curdling, in the whey and curd during the cheese making process, and in the ripening cheese. According to Hastings[1] the maximum number of bacteria is found when the cheese is one to five days old and may be as high as 1,500,000,000 per gram of moist cheese. While no one species is considered entirely responsible for this lactic acid fermentation, it is essential that the desirable types producing a clean lactic acid fermentation without gas production shall predominate over the undesirable gas-producing types.

During the ripening process the number of active lactic acid bacteria becomes considerably reduced, and it is believed that the substances liberated in disintegration of these bacteria may

[1] Marshall's *Microbiology*, page 354.

play a part in the development of the characteristic flavor. Recently Hucker has reinvestigated the subject. From 39 samples of commercial American Cheddar cheeses he obtained 265 species of bacteria and yeasts, the majority of which, however, came from cheeses of relatively poor quality and are therefore not essential to (and probably do not contribute to) the normal characteristics of this type of cheese. In the better samples of Cheddar cheese he found the predominant organisms to be *Streptococcus lactis* and the group known as lactobacilli.

The Swiss (Emmental) type of cheese differs from Cheddar cheese in that the lactic acid fermentation is much less pronounced during the process of making the cheese, while the fermentation during the ripening process is of a somewhat different type and gives rise to a different flavor. Lactic acid bacteria produce lactic acid or lactates, which in turn are attacked by organisms of a different type with the production of carbon dioxide, to which the characteristic holes or "eyes" are due. Recently it has been shown that the organism essential to the production of the characteristic eyes and flavor belongs to the group of propionic acid-producing bacteria. This organism has been designated as *Bact. acidi-propionici* (*d*).[1]

Roquefort cheese owes its mottled appearance and much at least of its characteristic flavor to the growth of a mold, *Penicillium roqueforti* (Thom), which is introduced by sprinkling the curd with crumbs of bread on which this mold has grown. The growth of the mold in the cheese is favored by punching holes to admit the air.

Gorgonzola and Stilton cheeses resemble Roquefort and are supposed to contain either the same mold or a related type, *Penicillium glaucum*.

Camembert cheese owes its characteristic flavor and consistency chiefly to the growth of two molds, *Oidium* (*Oöspora*) *lactis*, which covers the cheese during the first few days of ripening,

[1] J. M. Sherman, *Journal of Bacteriology*, Vol. 6, page 379 (1921).

and *Penicillium camemberti*, which appears later. These molds utilize organic acids as food, thus reducing the acidity of the cheese, while they produce proteolytic (protein-digesting) enzymes which gradually penetrate and soften the cheese. The reduction of acidity, however, also renders the cheese more susceptible to attack by putrefactive bacteria, which, if allowed to multiply in the cheese, will soon change its flavor. The manufacture of Camembert cheese is particularly difficult because the development of the desired consistency and flavor depends upon such a close control of conditions as will maintain a delicate balance in the development of the different organisms involved.

Brie also owes its flavor and consistency to molds, while the red coloration of the surface is attributed to a bacillus.

Limburg cheese is characteristic of the type in which development of putrefactive bacteria is allowed to continue to a considerable extent with a corresponding development of putrefactive odor.

These statements regarding the rôle of microörganisms in cheese ripening are based largely upon Buchanan's *Bacteriology* and Marshall's *Microbiology*, which works, as well as the more special papers listed in the bibliography at the end of this chapter, may be consulted for more detailed discussions.

Commercial Quality

The commercial quality of cheese depends upon the flavor, texture, body, color, and "appearance." By flavor is meant the quality which is perceptible to the taste and smell. "Texture" refers chiefly to compactness or appearance of solidity. "Body" means the consistency or firmness as revealed by pressing a piece of the cheese between finger and thumb. Color should be uniform whether the cheese is artificially colored or not. "Appearance" as the term is here used applies to the exterior finish of the cheese and its package.

The technical terms used in describing these qualities, together with other practices relating to the commercial grading and scoring of cheese, are described and explained in Van Slyke and Publow's *Science and Practice of Cheese Making*, Chapter VIII.

The following are typical scales of points used in judging and scoring cheese:

	Export Cheese	Home-trade Cheese
Flavor	45	50
Texture	15	25
Body	15	
Color	15	15
Appearance	10	10

Composition, Adulteration, Standards of Purity

Qualitative composition. As is readily seen from its method of manufacture, cheese contains the casein and fat of the milk and so much of the whey as does not drain out of the curd. The retention of portions of whey will of course keep in the cheese appreciable but small amounts of lactalbumin, of the soluble salts of the milk, and of milk sugar or the lactic acid resulting from its fermentation.

Quantitative composition. The composition of the milk and the details of manipulation in the manufacture of the cheese naturally influence the composition of the product. In a series of analyses covering 156 samples of green cheese of the Cheddar type made in various factories in New York State in 1892–1893, Van Slyke found: moisture, 32.7 to 43.9 per cent; fat, 30.0 to 36.8 per cent; protein, 20.8 to 26.1 per cent. Samples from more widely scattered sources would doubtless show greater variation. The approximate average composition of the principal types of cheese is shown in Table 10.

Except that the soft cheeses like Brie, Camembert, and Neufchâtel are wetter and the hard pineapple cheese is drier, it will be seen that the different varieties do not differ greatly from an average composition of about one third water, one third fat, and one fourth protein. These statements, of course, relate to whole-milk cheese.

The fat of cheese, while not so perfectly emulsified as it originally existed in the milk, is still in a finely divided state and should be quite uniformly distributed throughout the cheese-mass. Chemically it has the composition of milk fat or butter fat and shows but little change as the result of the ripening process.

TABLE 10. APPROXIMATE AVERAGE COMPOSITION OF DIFFERENT TYPES OF CHEESE[1]

VARIETY	WATER	FAT	PROTEIN (N×6.25)	SALT, MILK SUGAR, LACTIC ACID, AND ASH
	Per cent	*Per cent*	*Per cent*	*Per cent*
Brie	50.	28.	18.	4.
Camembert	45.	30.	20.	5.
Cheddar	35.	34.	25.	6.
Edam	33.	29.	29.	9.
Emmental	34.	31.	30.	5.
Limburg	35.	30.	29.	6.
Neufchâtel	50.	27.	18.	5.
Parmesan	35.	21.	36.	8.
Pineapple	24.	38.	30.	8.
Roquefort	35.	32.	25.	8.
Stilton	33.	37.	25.	5.

The protein of cheese consists chiefly of the more or less digested casein (though to a small extent of the albumin also) of the milk. It has already been shown in the paragraph on the ripening process that much of the casein is digested, not only into a soluble protein, but to proteoses, peptones, and even amino acids and ammonia. Of the successive analyses shown in

[1] Based on analyses given in Bulletin 105, Bureau of Animal Industry, United States Department of Agriculture.

Table 9, the one made when the cheese was six months old most nearly represents the stage of digestion at which it is ordinarily sold and eaten.

The ash of cheese varies greatly in composition according as much or little salt has been added during manufacture. It is always high in calcium, phosphorus, and sulphur, and fairly high in iron, these elements of the milk being largely constituents of the curd; while the potassium, sodium, and chlorine of the milk are largely removed in the whey, but the sodium and chlorine are later more than restored in the added salt.

Adulteration and misbranding. The chief forms of adulteration and misbranding of cheese are deficiency (or substitution) of fat, excess of moisture, and misuse of geographical names. Cheese made from milk which has been wholly or partially skimmed is known as "skimmed milk cheese" or "skim cheese." This is a wholesome and nutritious food, but less palatable and of much less fuel value than whole-milk cheese. Unless its sale is carefully regulated it is apt to be substituted to a greater or less extent for whole-milk cheese, at least in retail trade, which is considered serious both as an imposition upon the consumer and as an injury to the cheese trade. Van Slyke and Publow point out that skim-milk cheese is not only deficient in fat but must also contain an excess of water in order to be salable, since a skim-milk cheese with only the same amount of water as a whole-milk cheese would be too hard and tough to be acceptable, and that because of this high moisture content it does not possess the keeping qualities of whole-milk cheese. They suggest that the sale of skim-milk cheese should be prohibited in the interest of the cheese industry. In many localities the restrictions placed upon skimmed milk cheese are in fact so stringent that it is practically driven out of the market.

Cheese made from skimmed milk and added fat is called "filled cheese." The trade in this cheese is also subjected to restrictions which are very nearly prohibitive. The United

States cheese law requires that filled cheese shall be packed only in wooden containers which must be very conspicuously branded with the words "filled cheese" in several places, and retailers must sell only from these original packages and must deliver each portion of such cheese sold in a marked and branded package.[1]

Sometimes the cheese curd is soaked in cold water before the final draining, salting, and pressing. This practice was declared fraudulent by the Board of Food and Drug Inspection (Food Inspection Decision 97) on the ground that it introduces an undue amount of water into the cheese and also gives it a soft texture and an appearance of superior quality which deceives the purchaser as to its real nature. The board further stated that such cheese is of inferior quality in that it develops less of the desirable cheese flavor and that it deteriorates during the curing process, and therefore ruled that such cheese may not enter interstate commerce unless under some such name as "soaked curd cheese."

Standards of purity. The following definitions and standards for cheeses were adopted by the Joint Committee on Definitions and Standards, September 6, 1919, were approved by the Association of American Dairy, Food, and Drug Officials, September 10, 1919, and by the Association of Official Agricultural Chemists, November 19, 1919; and were published by the United States Department of Agriculture, March 3, 1921, as a guide for the officials of the department in enforcing the Food and Drugs Act.

1. *Cheese* is the sound product made from curd obtained from the whole, partly skimmed, or skimmed milk of cows, or from the milk of other animals, with or without added cream, by coagulating the casein with rennet, lactic acid, or other suitable enzyme or acid, and with or without further treatment of the separated curd by heat or pressure, or by means of ripening ferments, special molds, or seasoning.

[1] Wing's *Milk and Its Products.*

By act of Congress, approved June 6, 1896, cheese may also contain added coloring matter.

In the United States, the name "cheese," unqualified, is understood to mean Cheddar cheese, American cheese, American Cheddar cheese.

2. *Whole-milk cheese* is cheese made from whole milk.

3. *Partly skimmed milk cheese* is cheese made from partly skimmed milk.

4. *Skimmed milk cheese* is cheese made from skimmed milk.

WHOLE-MILK CHEESES

5. *Cheddar cheese, American cheese, American Cheddar cheese,* is the cheese made by the Cheddar process, from heated and pressed curd obtained by the action of rennet on whole milk. It contains not more than thirty-nine per cent (39%) of water, and, in the water-free substance, not less than fifty per cent (50%) of milk fat.

6. *Stirred curd cheese, sweet curd cheese,* is the cheese made by a modified Cheddar process, from curd obtained by the action of rennet on whole milk. The special treatment of the curd, after the removal of the whey, yields a cheese of more open, granular texture than Cheddar cheese. It contains, in the water-free substance, not less than fifty per cent (50%) of milk fat.

7. *Pineapple cheese* is the cheese made by the pineapple Cheddar cheese process, from pressed curd obtained by the action of rennet on whole milk. The curd is formed into a shape resembling a pineapple, with characteristic surface corrugations, and during the ripening period the cheese is thoroughly coated and rubbed with a suitable oil, with or without shellac. It contains, in the water-free substance, not less than fifty per cent (50%) of milk fat.

8. *Limburger cheese* is the cheese made by the Limburger process, from unpressed curd obtained by the action of rennet on whole milk. The curd is ripened in a damp atmosphere by special fermentation. It contains, in the water-free substance, not less than fifty per cent (50%) of milk fat.

9. *Brick cheese* is the quick-ripened cheese made by the brick cheese process, from pressed curd obtained by the action of rennet on whole milk. It contains, in the water-free substance, not less than fifty per cent (50%) of milk fat.

10. *Stilton cheese* is the cheese made by the Stilton process, from unpressed curd obtained by the action of rennet on whole milk, with or without added cream. During the ripening process a special blue-green mold develops, and the cheese thus acquires a marbled or mottled appearance in section.

11. *Gouda cheese* is the cheese made by the Gouda process, from heated and pressed curd obtained by the action of rennet on whole milk. The rind is colored with saffron. It contains, in the water-free substance, not less than forty-five per cent (45%) of milk fat.

12. *Neufchâtel cheese* is the cheese made by the Neufchâtel process from unheated curd obtained by the combined action of lactic fermentation and rennet on whole milk. The curd, drained by gravity and light pressure, is kneaded or worked into a butter-like consistence and pressed into forms for immediate consumption or for ripening. It contains, in the water-free substance, not less than fifty per cent (50%) of milk fat.

13. *Cream cheese* is the unripened cheese made by the Neufchâtel process from whole milk enriched with cream. It contains, in the water-free substance, not less than sixty-five per cent (65%) of milk fat.

14. *Roquefort cheese* is the cheese made by the Roquefort process from unheated, unpressed curd obtained by the action of rennet on the whole milk of sheep, with or without the addition of a small proportion of the milk of goats. The curd is inoculated with a special mold (*Penicillium Roqueforti*) and ripens with the growth of the mold. The fully ripened cheese is friable and has a mottled or marbled appearance in section.

15. *Gorgonzola cheese* is the cheese made by the Gorgonzola process from curd obtained by the action of rennet on whole milk. The cheese ripens in a cool, moist atmosphere with the development of a blue-green mold and thus acquires a mottled or marbled appearance in section.

WHOLE-MILK OR PARTLY SKIMMED MILK CHEESES

16. *Edam cheese* is the cheese made by the Edam process from heated and pressed curd obtained by the action of rennet on whole milk or on partly skimmed milk. It is commonly made in spherical form and coated with a suitable oil and a harmless red coloring matter.

17. *Emmenthaler cheese*, *Swiss cheese*, is the cheese made by the Emmenthaler process from heated and pressed curd obtained by the action of rennet on whole milk or on partly skimmed milk, and is ripened by special gas-producing bacteria, causing characteristic "eyes" or holes. The cheese is also known in the United States as "Schweitzer." It contains, in the water-free substance, not less than forty-five per cent (45%) of milk fat.

18. *Camembert cheese* is the cheese made by the Camembert process from unheated, unpressed curd obtained by the action of rennet on whole milk or on slightly skimmed milk, and ripens with the growth of a special mold (*Penicillium Camemberti*) on the outer surface. It contains, in the water-free substance, not less than forty-five per cent (45%) of milk fat.

19. *Brie cheese* is the cheese made by the Brie process from unheated, unpressed curd obtained by the action of rennet on whole milk, on milk with added cream, or on slightly skimmed milk, and ripens with the growth of a special mold on the outer surface.

20. *Parmesan cheese* is the cheese made by the Parmesan process from heated and hard-pressed curd obtained by the action of rennet on partly skimmed milk. The cheese, during the long ripening process, is coated with a suitable oil.

SKIMMED MILK CHEESES

21. *Cottage cheese, Schmierkäse*, is the unripened cheese made from unheated (or scalded) curd obtained by the action of lactic fermentation or lactic acid or rennet, or by any combination of these agents, on skimmed milk, with or without the addition of buttermilk. The drained curd is sometimes mixed with cream, salted, and sometimes otherwise seasoned.

WHEY CHEESES

22. *Whey cheese* (so-called) is produced by various processes from the constituents of whey. There are a number of varieties, each of which bears a distinctive name, according to the nature of the process by which it has been produced, as, for example, "Ricotta," "Zieger," "Primost," "Mysost."

Nutritive Value and Place in the Diet

A pound of cheese represents the casein and fat of a gallon of average milk. The high nutritive value of casein has been explained in the preceding chapter. Cheese is thus a concentrated and economical food, especially when compared with other foods of animal origin.

Generally speaking cheese sells at no higher price per pound than the ordinary cuts of meat, while it is considerably richer in both proteins and fat.

While fluctuations in price and in the proportions of fat and bone in the meats make exact comparisons impracticable except for individual cases, yet it is a fair general estimate that a given amount of money spent for American cheese at ordinary prices will buy about twice as much food value as it would if spent for meat. In most localities cheese gives a greater return in food value for the money expended than other staple foods of animal origin, but in some places milk may be obtained at such prices as to make it a cheaper food than cheese.

Cheese is very rich, not only in protein and fat, but also in calcium and phosphorus, since these elements in milk are largely in combination in or with the casein and so are concentrated with the casein in the process of cheese making. The iron-protein compounds of the milk are also retained in the cheese.

As would be expected in view of the fact that it contains the fat of the milk, ordinary cheese is found by experiment to be rich in fat-soluble vitamin. Quantitative measurements of the vitamin value of cheese are not yet available at time of writing (1923).

Digestibility of cheese. The discomfort which sometimes follows the eating of cheese may be due in part to irritation of the stomach by the volatile acids and some of the protein cleavage products developed during the ripening, but is doubtless very largely attributable to the unsuitable way in which cheese is often eaten — as at hours other than meal times or at the end of a meal already sufficient. When given a rational place in the meal, and thoroughly chewed, cheese is usually well digested. In a large number of digestion experiments carried out by the United States Department of Agriculture, it was found that on an average about 95 per cent of the protein and over 95 per cent of the fat of the cheese were digested and absorbed.[1] Hence so far as the coefficients of digestibility are concerned the various kinds of cheese tested were found to compare favorably with the average food of an ordinary mixed diet. Even when fed in relatively large quantity, the cheese did not, in these experiments, cause constipation " or other physiological disturbances."

The general belief that cheese is difficult of digestion is attributed by Langworthy to its being digested to a less extent in the stomach than many other foods, the digestion of the cheese taking place chiefly in the intestine. In order to determine whether the digestion of cheese requires a greater expenditure of energy than the digestion of meat, Langworthy measured accurately by means of the respiration calorimeter the energy

[1] *Yearbook* of the United States Department of Agriculture, 1910, page 366.

metabolism of the same man after eating a meal consisting chiefly of beef and again under circumstances otherwise the same after eating a meal containing instead of the beef a corresponding amount of cheese. The results differed by only 2 Calories per hour, which is about the margin which must be allowed for experimental error in such measurements. Langworthy therefore concludes that "it seems fair to believe that there was practically no difference between the cheese and the meat with respect to ease of digestion, at least in such quantities as are commonly eaten."

Place of cheese in the diet. Langworthy records a case of a young man who "for the sake of such considerations as ease of preparation and relative economy" lived for over two years on a diet of cheese, bread, and fruit. The man enjoyed good health and did not tire of his diet. A quantitative record covering a part of the time indicated that the man was accustomed to consume slightly over one half pound of cheese, one pound of whole wheat bread, and two pounds of fresh fruit per day.

The amounts of cheese eaten by the various men who took part in the experiments of the United States Department of Agriculture were usually from one third to one half pound per day. These quantities were taken with relish and were well digested even though the men as a rule had previously not been accustomed to eat any considerable quantity of cheese.

The bulletins of the United States Department of Agriculture contain many specific suggestions for the use of cheese in a variety of ways.

As already suggested cheese should be eaten with intelligence to avoid danger of irritation of the stomach, and a warning may also be added against eating large quantities at a time of cheese which has been so highly ripened as to contain a considerable percentage of ammonia. With these precautions cheese may well be used as a regular staple article of food, interchangeably with such foods as meats and fish. As the food value and digestibility of cheese become better known it should come to occupy a much more prominent place in the typical dietary than it does at present.

Fermented Milks; B. Acidophilus; Lactose Lemonade

We have seen that the making of cheese is a very old method of preserving milk for future use as food. Another old method, yielding a product less permanent than cheese, but more permanent than fresh milk, is to allow the milk to undergo fermentation of such a character that the fermentation products are not unwholesome or unpleasant for human consumption, yet serve as preservatives to prevent undesirable types of decomposition.

The fermentation product chiefly depended upon in such cases is lactic acid, although in certain types alcoholic fermentation may also be prominent. Fermented milks have long been a prominent article of diet in Southern Russia, Turkey, Bulgaria, and neighboring countries, and in recent years various products of this type such as kumiss, kefir, yogurt, and fermented milks sold under proprietary names have come into increasing use in Western Europe and in America.

Buttermilk is a food of the same type, and until recently the demand for fermented milk in this country was readily met by the sale of a part of this by-product of butter making. As the manufacture of butter and the handling of market milk and cream grew to be separate industries, dealers in milk and cream sometimes met the demand for buttermilk by fermenting the skim milk which remains as a by-product of the cream trade. Such fermented skim milk is, of course, not literally buttermilk, although it may be indistinguishable in composition and properties and equal in food value.

On the other hand, the products made by fermenting whole milk are of considerably greater food value because of their higher fat content.

It is, however, not simply because of the amounts of nutrients which they contain that these fermented milks have attracted special attention in recent years, but because of belief that the finely coagulated casein of these preparations is more easily digested than the curds which are formed in the stomach after drinking ordinary milk, and especially because of the possible therapeutic or prophylactic value of the lactic acid or lactic-acid bacteria which they contain.

In some cases it is possible that the fermentation products (lactic acid, alcohol, carbonic acid) may have a slight stimulating or tonic action in the digestive tract; otherwise any increased digestibility of the fermented milk is due not so much to changes in the chemical nature of the milk constituents as to the fact that the casein is furnished in a precipitated and finely divided condition. The fermentation does not involve any material digestive cleavage of the casein such as occurs in the ripening of cheese. The fat is almost unchanged and only a part of the milk sugar is converted into organic acids, alcohol, and carbonic acid. In certain disorders of the stomach in which there is much difficulty in retaining food, it has frequently been found possible to use one or another of the fermented milks with good results. Ever since the studies of Metchnikoff and his associates at the Pasteur Institute in Paris, there has also been much interest in fermented milks as a possible means of preventing or controlling excessive intestinal putrefaction. It is for this purpose that cultures supposed to give a purer lactic acid fermentation than that of buttermilk have been introduced. In buttermilk or in ordinary milk which has been allowed to sour freely, there is usually developed only about 1 per cent of lactic acid; but certain selected species of lactic acid bacteria, notably *B. bulgaricus*, may carry the fermentation to such a point that the milk may contain 2 per cent of lactic acid or even more.

Some representative analyses of fermented milks are given in Table 11.

TABLE 11. ANALYSES OF SOME FERMENTED MILKS

	BUTTERMILK (LARSEN AND WHITE)	KUMISS OR KEFIR (HAMMARSTEN)		
		2 days old	4 days old	6 days old
	Per cent	*Per cent*	*Per cent*	*Per cent*
Water	90.39	88.12	88.79	89.00
Fat	0.50	3.62	3.63	3.63
Protein	3.60	3.03	3.07	3.07
Milk sugar . .	4.06	3.70	2.24	1.67
Lactic acid . .	0.80	0.66	0.83	0.90
Alcohol		0.23	0.81	1.10
Ash	0.75	0.64	0.63	0.63

The use of fermented milk to combat excessive intestinal putrefaction is based on the belief that the putrefactive bacteria, which so often predominate, can be largely displaced by acid-forming bacteria taken in sufficient abundance in some form of fermented milk, especially if with the cultures of the desired acid-forming bacteria liberal quantities of milk sugar (lactose) are taken. Of the different kinds of acid-forming bacteria which have been tried, the species known as *Bacillus acidophilus* seems best adapted to establish and maintain itself in the human intestine.

Rettger and his coworkers at Yale have shown by extensive investigations that the intestinal conditions can often be very greatly improved by the taking of milk cultures of *Bacillus acidophilus*. *Bacillus acidophilus* milks are now available commercially and at least two such preparations, one made from skimmed and one from whole milk, have been accepted by the Council on Pharmacy and Chemistry of the American Medical Association. Since the "implantation" of the acid-forming bacteria in the intestine is most likely to be successful if considerable quantities of lactose (milk sugar) are given along with the bacterial cultures, lactose is often stirred into the *B. acidophilus* milk before drinking it. This diminishes the sour taste of the preparation as well as increasing its effectiveness. Since under ordinary conditions the intestine nearly always contains some bacteria of the *Bacillus acidophilus* type, the taking of liberal amounts of lactose, even without the milk cultures of the organism, may be more or less effective in bringing about a predominance of the acid-forming over the putrefactive types of bacteria. Hence a liberal consumption of lactose lemonade or of orange juice sweetened with lactose (milk sugar) is often helpful in improving intestinal hygiene, whether *Bacillus acidophilus* milk is taken at the same time or not. Liberal amounts both of the milk culture of *B. acidophilus* and of lactose in some form are thought usually to give better results than either alone.

For a fuller account of the bacteriology involved the reader should consult Rettger and Cheplin's *Treatise on the Transformation of the Intestinal Flora with Special Reference to the Implantation of Bacillus Acidophilus* (Yale University Press); and for practical dietary discussion of the feeding of acidophilus cultures and lactose, Rose's *Feeding the Family* (*Revised Edition*) (The Macmillan Company).

Condensed and Evaporated Milks

By evaporating a large proportion of the water from milk, the keeping property is much improved and the labor and expense of subsequent handling and transportation of the product are further reduced through the saving in bulk and weight. Sugar is often added as a preservative. Condensed milk, whether sweetened or unsweetened, may be marketed in bottles like ordinary milk, in which case it is intended for use within a very few days, or it may be sealed in tin cans for indefinite keeping like other canned foods. Marketing in cans is now much the more common.

The condensed milk industry began with the granting of a patent for "concentrating sweet milk by evaporation in vacuo" to Gail Borden, Jr., in 1856. In 1880 the total production

(United States Census) in the United States was 13,033,267 pounds; in 1890, 37,926,821 pounds; in 1900, 186,921,787 pounds; in 1909, 494,796,544 pounds; in 1920, 1,578,015,000 pounds.

The production of condensed milk has varied considerably in recent years. The reasons for this are apparent in the great demand for condensed milk for export to Europe during the war, the violent fluctuations in sugar prices near the end of the war, and the decreased purchasing power of the European peoples since the war. Allowing for the fluctuations due to abnormal conditions, the condensing of milk may be said to be a steadily growing industry.

In the industry the term " condensed milk " means the product which has been condensed and canned with the least possible heat treatment and with added sugar to assist in its preservation, while " evaporated milk " means the product of condensation and canning without addition of sugar but with a much more rigorous heat treatment than the (sweetened) condensed milk receives. The popular names " sweetened condensed " and " unsweetened condensed " are synonymous respectively with the trade names " condensed " and " evaporated."

Condensed (sweetened) milk is manufactured by very carefully regulated processes briefly outlined as follows: Fresh cows' milk is heated to 160° to 180° F. to expel the dissolved gases and then run into vacuum pans, about 16 pounds of sugar per 100 pounds of fresh milk is added, and the mixture evaporated in vacuo at a temperature of 130° to 150° F. until the desired concentration is reached, usually until one pound of the final product represents about $2\frac{1}{4}$ to $2\frac{1}{2}$ pounds of fresh milk. This final product is of semiliquid consistency with a specific gravity of about 1.29 and averages about 30 per cent water, 30 per cent milk solids, and 40 per cent cane sugar.

The products of individual manufacturers may vary considerably from this average, but the minimum percentages of milk solids and milk fat are safeguarded by the official standards given below.

Evaporated (unsweetened condensed) milk is prepared in much the same manner as just described for condensed milk except that no sugar is added and the evaporated milk after being run into the cans is sterilized by heating to temperatures much higher than are employed at any stage in the preparation of condensed milk. Heating at from 226° F. to 240° F. for from 30 to 60 minutes is said to be common in the sterilization of evaporated milk. This necessarily gives the product more or less of a cooked taste. Its specific gravity is usually about 1.065.

Standards of composition for condensed and evaporated milks. The following definition and standard was adopted by the Joint Committee on Definitions and Standards, June 21, 1922, and was approved by the Association of American Dairy, Food, and Drug Officials, October 5, 1922, and by the Association of Official Agricultural Chemists, November 17, 1922, and adopted December 18, 1922, by the United States Department of Agriculture as a guide for officials of the department in enforcing the Food and Drugs Act.

Condensed milk, evaporated milk, concentrated milk, is the product resulting from the evaporation of a considerable portion of the water from milk, or from milk with adjustment, if necessary, of the ratio of fat to nonfat solids by the addition or by the abstraction of cream. It contains, all tolerances being allowed for, not less than seven and eight tenths per cent (7.8%) of milk fat, nor less than twenty-five and five tenths per cent (25.5%) of total milk solids; provided, however, that the sum of the percentages of milk fat and total milk solids be not less than thirty-three and seven tenths (33.7).

It will be noted that notwithstanding the added sugar in condensed milk this has the same percentage standard for milk fat and for milk solids as has evaporated milk; also that the sum of the percentages of milk fat and total milk solids is set a little higher than the sum of the separate minima for milk fat and for milk solids. This latter provision has the effect of permitting a slightly lesser degree of concentration of solids in those samples having more than the minimum of fat, a provision for legitimate variation which is considered important on technical grounds and which is entirely consistent with the maintenance of the full food value of the product.

Nutritive value and place in the diet. All the general considerations regarding the nutritive value of milk and its place in the diet apply also to condensed and evaporated milks since these are essentially milk in a more concentrated form, with or without sugar added to permit of the preservation of the product with a minimum of heating. Whether condensed and evaporated milks can be sold at prices making them more economical to the consumer than an equivalent amount of fresh milk of corresponding sanitary quality must depend upon local conditions. In close proximity to a good fresh milk supply this should naturally be cheaper, while the canned milk may readily be cheaper in markets more remote from milk farms. Where the fresh milk supply is not of good sanitary quality or not uniform, the uniformity of canned milk is a point in its favor. Commercial considerations insure that the manufacturers of each brand of condensed or evaporated milk will keep it as uniform as possible in all respects; and in the case of condensed milk which is canned without heat sterilization very great care is exercised both in the selection and sanitary control of the milk to be condensed and in the regulation of every step in the process.

Naturally a question has arisen as to the value of canned milks as sources of vitamins. It is hardly possible as yet to discuss this question in precise quantitative terms; but from such experiments as have been made directly with condensed and evaporated milks and from our present knowledge of the relative stability of the different vitamins toward heat, it seems altogether probable that vitamins A and B are well preserved in both condensed and evaporated milk, while with vitamin C the question is probably not to be answered quite so simply.

Hess and also Hume have reported experiments in which sweetened condensed milk showed such good antiscorbutic value as to suggest little if any destruction of vitamin C in the condensing process or the subsequent storage in the can. Alonzo Taylor (quoted by Rosenau, Boston Medical and Surgical Journal, May 5, 1921) reports that in the war zone scurvy was both prevented and cured by condensed milk. He gives 8 ounces of condensed milk per day as the amount furnishing sufficient vitamin C for a child. Hess emphasizes in this connection the fact of the handling of the condensed milk under vacuum which thus protects it from oxidation, which is known to be destructive to vitamin C. Although similarly protected from oxidation (unsweetened) evaporated milk showed in the experiments of Hart, Steenbock, and Smith no evidence of appreciable antiscorbutic value, indicating destruction of most of the vitamin C of the original milk. This difference may be due to the use of higher heat in the preparation of the evaporated than of the condensed milk and especially to the heat sterilization which is applied to the unsweetened and not to the sweetened product.

Since the vitamin C content of cows' milk varies with the feed of the cow, this may also have been a factor in the experiments just mentioned.

As a factor of safety in view of the variations in the vitamin C content of milk, it is now recommended that all artificially fed infants be given regularly small quantities of orange juice or some other antiscorbutic food. If this is done, anxiety regarding the relative amounts of vitamin C in the different forms of milk may be avoided.

Dried or Powdered Milk

Several processes have been invented for bringing milk into the form of dry flakes or a dry powder. The advantages of this are of course the great saving in weight and the fact that the dried milk is even less subject to contamination or deterioration than evaporated or condensed milk. Among the devices for drying milk on a commercial scale are: (1) passing the milk in thin layers over heated surfaces preferably in vacuo, (2) blowing air through layers of partially evaporated milk on perforated drying cylinders or web belts, (3) spraying partially evaporated milk into warm dry air. The latter process as described by Merrill[1] is in outline as follows:

Fresh whole milk is partially evaporated in a vacuum pan with precautions to prevent any of the albumin from coagulating on the walls of the chamber. The milk, still in a fluid condition, is then drawn from the vacuum pan and sprayed into a current of hot air. The remaining moisture is thus instantly evaporated and the particles of milk solids fall like snow. This milk powder is said to contain less than 2 per cent moisture and to consist of particles from $\frac{1}{2000}$ to $\frac{1}{10000}$ inch in diameter, in which the fat, sugar, and albumin of the milk exist in a dry state, chemically unchanged.

A modification of this process consists in spraying the milk with a swirling motion with the idea that the fat globules will be coated with layers of dried protein and carbohydrate, and the fat thus protected from exposure to oxidation, which is believed to be the chief factor in rancidity.

The corresponding advantage claimed for drum drying is that the period of heating is reduced to a minimum and that when the process is carried out under vacuum, the opportunity for oxidative changes (whether in the fat or in the vitamins) is practically excluded.

As the different mechanical processes for the drying of milk are still undergoing investigation and improvement, it seems unwise to attempt to pass upon the relative merits of different processes.

[1] *Journal of Industrial and Engineering Chemistry*, August, 1909.

Dried milk has been more cordially received than most new food products. As yet it is not largely sold at retail, probably because the manufacturers find such a ready wholesale market in the baking, confectionery, and ice-cream industries. It is, however, very generally believed that dried milk will play an increasing part in the food supply. At the request of the American Public Health Association, its Committee on Nutritional Problems prepared in 1921 a special report upon dried milks, from which the following extracts may be quoted:

In order that the seasonal surplus of milk produced in the present market milk areas may be conserved for human consumption, and that as it becomes necessary milk may be brought economically from greater distances, it seems both inevitable and desirable that the preservation of milk by condensing, evaporating, or drying should be much more fully developed, and that such preserved forms of milk (either as such or after being "remade" to the composition of fresh milk) shall play an increasingly important rôle in the food supply of the future. . . .

Probably the three most important points to be considered are: (*a*) the sanitary aspects of the milk-drying industry, (*b*) the nutritive value of dried milk and its products, (*c*) the possible effects of a dry milk industry upon the dairy industry and milk supply as a whole.

The cleanliness of a dry milk product will obviously depend in large measure upon the cleanliness of the milk which was dried; and sanitary conditions in the factory and the details of method employed will largely influence the opportunities for recontamination of the dry product during handling and packing. Milk-drying establishments should naturally be subject to the same inspection as other food factories with reference to the sanitary aspects both of the materials and the methods which they employ. On the other hand, the ordinary processes of commercial drying are more efficient even than pasteurization in destroying the bacteria originally present in the milk, and the product is no longer in danger of secondary decompositions and is no more subject to secondary contamination than any other dried food. . . .

The nutritive value of dry milk and its products has been the subject of extended study and report under the auspices of the Local Government Board of Great Britain and has likewise been treated in several publications of the United States Public Health Service. Some of us have been privileged also to see a report upon the use of dried milks as human food prepared by

Dr. E. V. McCollum for the International Health Commission, and have been connected with laboratory investigations in which dried milks have constituted the chief part of experimental diets.

The evidence which has come to us from these different sources is quite consistent, and plainly places dried milk with pasteurized milk as regards the various factors of food value. In both cases the only significant change which occurs as the result of the heat treatment with its attendant manipulations, if properly conducted, is a diminution of the antiscorbutic vitamin. This has already been recognized as a possible result of pasteurization, and it is now a generally accepted practice to give orange juice or some other suitable antiscorbutic to all infants artificially fed on any other than fresh *raw* milk. The orange or tomato juice thus given primarily as an antiscorbutic is undoubtedly beneficial in other aspects of nutrition as well, and with this addition to the diet it becomes unnecessary to debate further as to the extent to which the antiscorbutic vitamin present in the milk is diminished in the drying process or whether there is greater destruction when the drying is accomplished by one mechanical process than by another. The original vitamin content of the milk, its freshness when dried, and the manner in which the drying process and the subsequent handling of the product is conducted are all factors of possibly equal importance with the mechanical principle on which the drying process is based. It is important also to remember that the processes for drying milk are still undergoing development and modification. In our opinion, it would be a mistake to prejudice the development of the industry at this early stage by any expression of preference as between the different drying processes, based merely upon consideration of the antiscorbutic vitamin. We think it much better to recommend that an antiscorbutic be given in all cases in which dependence is placed upon either pasteurized or dried milk by whatever process prepared. In fact, in view of the dependence of the antiscorbutic value of milk upon the diet of the cow (or of the mother), it may be advisable that all children receive an antiscorbutic.

Aside from the question of antiscorbutic vitamin, which easily can, and in our opinion always should, be provided from other sources, we believe that milk dried by any of the modern methods properly conducted is the equivalent of the fresh milk from which it was prepared.

The British report above referred to states explicitly "that cow's milk, during the process of desiccation, loses none of the characters which are necessary for the support of normal growth in infants." The United States Public Health Service also reports highly favorable results from the use of dry milk products in infant feeding. McCollum records most excellent results from the addition of dried milk as sole milk supply to the dietary of an institutional group of children, and many experiments could be cited in which dried milk as a sole food has supported good health and normal growth in the rat for periods much longer than would correspond to infancy and early childhood in the human subject.

We believe there is ample evidence to support the position taken by the Commission on Milk Standards that there is no occasion for prejudice or discrimination against dried milk as compared with pasteurized milk even as concerns the most delicate factors of nutritive value.

Since the best standards of nutrition and health require not only the conservation of our present milk supply but its increase, in order that the per capita consumption of milk may grow with the knowledge of the food value of milk and its proper place in the diet, it is important that the drying of milk be considered also from the standpoint of the effect of this industry upon the dairy industry and milk supply as a whole.

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The opinion is widely held and in our judgment well founded, that the dry milk industry will not seriously compete with or in any way injure the fluid milk industry as it now exists, but, rather, will supplement it and make possible the good use of its seasonal surplus; that with increasing recognition by consumers of the great importance of milk as food for adults as well as for children, dried milk will come to be largely used in cookery without diminishing the consumption of milk in fluid form; that the drying of milk both as a means of preservation and of greatly reducing transportation costs will permit the extension of the milk industry into regions too distant from large markets to ship milk in fluid form; that because of this extension of the source of supply, the greater consumption of milk in its different forms should not necessarily result in higher prices; that the drying of milk will greatly facilitate the production and handling of milk in the South where lack of natural ice so greatly hampers the fluid milk industry and where an increased use of milk in the diet is so urgently needed and will doubtless do more than anything else toward the lowering of the infant death rate and the suppression of pellagra among adults.

The manufacture of dry milk grew rapidly during the war. The production in the United States in 1920 was estimated at over ten million pounds. Most of this was skim-milk powder or flakes because legal restrictions hamper the sale of skim milk as such to the consumer, while, on the other hand, it is more easily dried than whole milk and yields a product which is more readily kept, the fat of the whole-milk powder being liable to become rancid on storage unless kept under special precautions.

Cream and Skimmed Milk

Cream may be obtained from milk either by gravity or by centrifugal force. The prevailing method at present is by means of centrifugal separators in which the milk flows continuously into a rotating bowl containing thin metal plates which separate the milk into inclined sheets in which by centrifugal force the heavier "skim" milk is thrown toward the outer rim [1] and the lighter fat globules are forced toward the center. Thus while the separator is in operation a continuous stream of cream and another of skimmed milk are obtained from the inner and outer layers respectively of the rotated bowl of milk. In order that the skimmed milk shall not be thrown out of the machine with too great force, the tubes which receive it from the outer portion of the bowl are carried back toward the center of the bowl, where they discharge into an outlet pipe. The size of the skim milk outlet may be made to bear any desired relation to the size of inlet, size of bowl, and speed of rotation, and thus any desired proportion of the whole milk may be drawn off as skimmed milk while the remainder is forced to the center of the bowl and discharged through the cream outlet.

If the skimmed milk outlet is set to discharge only one half of the milk entering the bowl, the other half must discharge through the cream pipe and a large volume of very thin cream having only twice the fat content of the original milk will be obtained.

If the skimmed milk tube be set to take nine tenths of the amount of milk which flows in, a small amount of rich cream having about ten times the fat content of the original milk will result.

To a considerable extent these proportions and the resulting

[1] Suspended solids heavier than the skim milk are forced against the outer wall and result in a deposit of "separator slime."

amount and richness of the cream may be controlled by regulating the rate of inflow of milk without changing the size of the discharge pipes or the rate of running the machine. Thus, as illustrated by Wing: "If the milk is turned into the bowl at such a rate that 0.8 escapes through the skimmed milk outlet we shall have 0.8 skimmed milk and 0.2 cream. If now we reduce the rate of inflow by 0.1, we shall get just as much skimmed milk as before, but only half as much cream; or if the inflow is increased by 0.1 we shall get the same amount of skimmed milk and one and one half times as much cream." In the first case, we should get from 100 pounds of milk with 4 per cent fat, 80 pounds of skimmed milk with, say, 0.1 per cent of fat, and 20 pounds of cream with 19.6 per cent fat; in the second case from 90 pounds of the same milk, 10 pounds of cream with 35.2 per cent fat; in the third case from 110 pounds of the same milk, 30 pounds of cream with 14.4 per cent of fat. This assumes that the completeness of the separation will be the same, which should be true so long as the separator is run within the range of its capacity. McKay and Larsen state that in skimming milk for butter making, separators are usually run to yield cream with 25 per cent to 50 per cent fat, but that most separators will do good skimming even up to a cream of 60 per cent fat content. When the separator is well managed, the skim milk does not contain over 0.1 per cent fat.

Since cream is an artificial product of such variable composition, it is obvious that any standard which may be set for the fat content of cream must necessarily be rather arbitrary. The standards which have been adopted appear to have been based largely on the fat content of the cream formerly obtained by the gravity process.

The standard recommended by the Association of Official Agricultural Chemists requires not less than 18 per cent of milk fat; and this has been adopted by a large proportion of the states. A few states have other standards.

The full definitions and standards adopted in 1919 by the United States Department of Agriculture as a guide for the officials of the department in enforcing the Food and Drugs Act are as follows:

1. *Cream, sweet cream*, is that portion of milk, rich in milk fat, which rises to the surface of milk on standing, or is separated from it by centrifugal force. It is fresh and clean. It contains not less than eighteen per cent (18.0%) of milk fat and not more than two tenths per cent (0.2%) of acid-reacting substances, calculated in terms of lactic acid.

2. *Whipping cream* is cream which contains not less than thirty per cent (30.0%) of milk fat.

3. *Homogenized cream* is cream that has been mechanically treated in such a manner as to alter its physical properties, with particular reference to the conditions and appearance of the fat globules.

4. *Evaporated cream, clotted cream*, is cream from which a considerable portion of water has been evaporated.

Market cream is apt to be at least half a day older than the corresponding grade of market milk and almost invariably has a higher bacteria content.

The Commission on Milk Standards recommends that cream be classified on the same plan as milk except for the number of bacteria permitted, which may be five times the number permitted in the corresponding grade of milk.

The Commission recommended that all cream be sold either on a guaranteed fat content or with a minimum standard of 18 per cent milk fat; also that cream should contain no constituent foreign to normal milk.

Nutritive value of cream. This will depend upon the composition and nutritive value of the milk from which the cream is taken and the extent to which the fat globules of the milk are concentrated in the cream, which latter factor, as explained above, is controllable within wide limits now that centrifugal separators are so commonly used. If the milk contains 3.6 per cent by weight of fat globules and 96.4 per cent by weight of serum, then a cream made from it to contain 18 per cent fat will have 82 per cent serum, and will therefore contain, weight for weight, about five times as much of the fat globules as did the original milk, and about five sixths as much of everything which the milk contains outside its fat globules.

The fat-soluble vitamin is concentrated in the cream in nearly but not quite the same ratio as the fat itself. The high growth-promoting value of skimmed milk was until very recently interpreted to mean that it contained about half as much vitamin A as whole milk; but this now appears to have been an overestimate.

According to the most recent work thoroughly skimmed milk shows only about one tenth as much vitamin A as whole milk. Hence it follows that by far the largest part of the vitamin A of milk is in the fat globules and will be concentrated with the fat globules in the cream when this is removed either by gravity or by centrifugal force.

Ice Cream and Related Products

The ice-cream trade has grown enormously in recent years and appears to be still increasing. Creameries which are favorably located find it often much more profitable to convert their cream into ice cream than into butter.

The term "ice cream" is commonly applied to a variety of products, including what would more accurately be called frozen custards and water ices. There is not yet a consensus of opinion among food control authorities as to whether the wider application of the term "ice cream" is justified by common usage or whether the narrower and more literal usage should be insisted upon.

The Federal standards are as follows:

Ice cream is a frozen product made from cream and sugar, with or without a natural flavoring, and contains not less than 14 per cent of milk fat.

Fruit ice cream is a frozen product made from cream, sugar, and sound, clean, mature fruits, and contains not less than 12 per cent of milk fat.

Nut ice cream is a frozen product made from cream, sugar, and sound, non-rancid nuts and contains not less than 12 per cent of milk fat.

These standards would make ice cream a fat-rich food which many health authorities do not deem desirable, some holding that since it is so largely consumed between meals or at the end of a meal already sufficiently abundant, it should better remain, as custom had so largely made it, a frozen beverage rather than a fat-rich food.

The above standards have therefore been adopted by some of the states, but are far from being generally recognized. Probably the standard of 8 per cent milk-fat recommended by the Commission on Milk Standards is more commonly accepted than is the Federal standard of 14 per cent. The composition and food value of ice cream must therefore be expected to vary widely in different localities.

Frozen products made from fermented milk, sugar, eggs, and fruit, fruit juices, or other flavoring have been described under the general name of "lacto."

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CHAPTER V

EGGS

Doubtless eggs of various kinds were among the very earliest of human foods. At the present time only the eggs of hens, ducks, geese, guinea fowl, and turkeys are commonly used for food; and of these, hens' eggs are so much more abundant than all others that, unless otherwise explained, all statements made here may be understood as referring to hens' eggs.

Production

The production of eggs is widely distributed. It is estimated that about nine tenths of all farms in the United States keep chickens and produce eggs. It will be seen from Fig. 9 that in poultry culture there is less tendency toward concentration in particular regions than is the case with many other food industries.

It is difficult to measure the egg production of the country, because eggs are so largely consumed by the producer or sold at retail without going through trade channels from which accurate statistics can be obtained. The United States Census Bureau estimates the egg industry at seventeen and one half dozen eggs per capita per year, *i.e.* an average of 210 eggs per year or 4 eggs per week for each person in the United States.

Pennington and Pierce, writing in 1910,[1] reported that only the states of Ohio, Indiana, Illinois, Iowa, Minnesota, Nebraska, Kansas, Missouri, Texas, Tennessee, and Kentucky produce more eggs than are consumed within their own borders, and this

[1] United States Department of Agriculture, *Yearbook* for 1910.

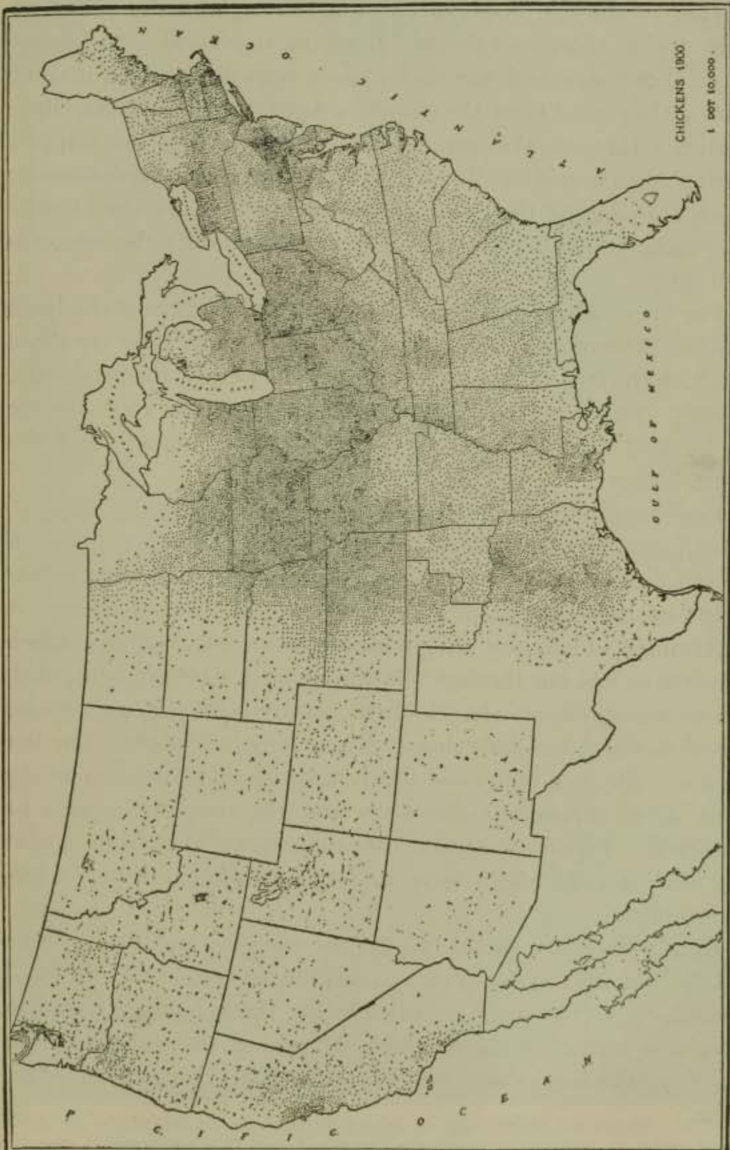

FIG. 9. — Distribution of chickens in the United States according to the census of 1900. Reproduced by permission from Taylor's *Prices of Farm Products* (Bulletin 209 of the Wisconsin Agricultural Experiment Station).

surplus production does not continue throughout the year, but only during those months which are most favorable to laying. From Tennessee and Kentucky most eggs are sent to market during the period from December to April; from southern Ohio, southern Kansas, Missouri, and Texas many eggs are shipped during March and April; in the later spring northern Kansas, Iowa, Illinois, and the Central States generally show their heaviest production, while for Michigan and Minnesota the season is still later.

For the country as a whole as judged by the data of the large markets, the months of March, April, May, and June are those in which the largest number of eggs are shipped by the producers. During these months many eggs are placed in cold storage to be sold later when the supply is less abundant and the price higher.

Eggs are graded in the market chiefly according to freshness, cleanliness, size, cracks, and color. Freshness in this connection means the firmness and state of preservation of the egg rather than the mere length of time since laying. This freshness is determined chiefly by the process known as candling, which consists in looking through the egg against a bright light, such as an incandescent electric light, surrounded by an opaque shield in which is a hole shaped like an egg but slightly smaller in size. The egg is pressed firmly against this hole, and as the light shines through it, the white and the air-chamber may be observed. Figure 10 shows the appearance of a fresh, sound egg and of eggs which have undergone different types of deterioration.

Eggs sufficiently sound to pass the candling test may still be subdivided into many grades according to age, color, size, and cleanliness. It is these qualities rather than chemical composition and nutritive value which determine the very different prices at which eggs are sold in the same market and at the same time.

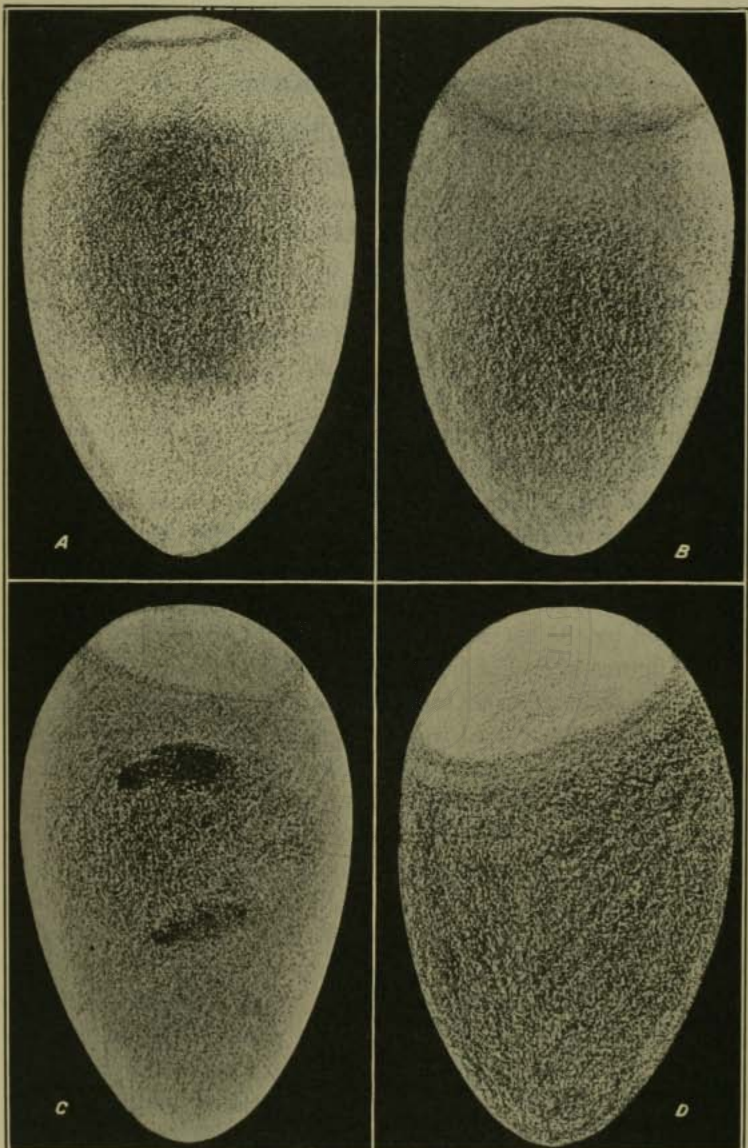

FIG. 10. — Appearance of different grades of eggs before the candle. *A*, fresh egg; *B*, shrunken (old) egg; *C*, "spot" egg (fungous growth); *D*, rotten egg.

Chemical Composition

Since the price of eggs is determined entirely by considerations other than chemical composition, and eggs are never produced primarily for industrial uses in which the components are separated from each other, there has been no economic reason for the study of the causes and extent of variations in composition, and our information on these points is very meager as compared, for example, with the corresponding data for milk. Differences in composition seem usually due to different proportions of white and yolk. According to Langworthy the proportion of yolk (and therefore of fat) is greatest in the eggs of those breeds which are best adapted to fattening. Other things being alike the edible portion of white-shelled and dark-shelled eggs shows essentially the same composition and nutritive value.

The average composition of eggs of different kinds, as given by Langworthy, is shown in Table 12, the fuel values being recalculated by the use of the now accepted factors.

The figures given for hens' eggs in this table are the average of 60 American analyses compiled by Atwater and Bryant,[1] in which the protein varied from 11.6 to 16.0 per cent and the fat from 8.6 to 15.1 per cent. The estimated averages of European writers fall well within these limits, but are apt to be somewhat higher in fat than the American average as given above. Thus the estimate of König, which is widely quoted, allows 12.55 per cent protein and 12.11 per cent fat.

Speaking in round numbers, we may say that the edible portion of the egg contains 72 to 75 per cent of water, about 1 per cent of ash, 12 to 14 per cent protein, 10 to 12 per cent fat; or about three fourths water, one eighth protein, and one eighth fat. Of the edible portion the yolk constitutes (by weight) a little over one third and the white a little under two thirds; and these are of very different composition. The white is about

[1] United States Department of Agriculture, Office of Experiment Stations, Bulletin 28.

TABLE 12. AVERAGE COMPOSITION OF EGGS (LANGWORTHY)

DESCRIPTION	REFUSE (SHELL)	WATER	PROTEIN	FAT	ASH	FUEL VALUE PER POUND
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Calories*
Hen:						
Whole egg as purchased .	11.2	65.5	11.9	9.3	0.9	596
Whole egg, edible portion .		73.7	13.4	10.5	1.0	672
White		86.2	12.3	0.2	0.6	231
Yolk		49.5	15.7	33.3	1.1	1643
White-shelled eggs as purchased	10.7	65.6	11.8	10.8	0.6	655
Brown-shelled eggs as purchased	10.9	64.8	11.9	11.2	0.7	675
Duck:						
Whole egg as purchased . .	13.7	60.8	12.1	12.5	0.8	730
Whole egg, edible portion .		70.5	13.3	14.5	1.0	835
White		87.0	11.1	0.03	0.8	203
Yolk		45.8	16.8	36.2	1.2	1683
Goose:						
Whole egg as purchased .	14.2	59.7	12.9	12.3	0.9	737
Whole egg, edible portion .		69.5	13.8	14.4	1.0	829
White		86.3	11.6	0.02	0.8	211
Yolk		44.1	17.3	36.2	1.3	1793
Turkey:						
Whole egg as purchased .	13.8	63.5	12.2	9.7	0.8	618
Whole egg, edible portion .		73.7	13.4	11.2	0.9	700
White		86.7	11.5	0.03	0.8	210
Yolk		48.3	17.4	32.9	1.2	1660
Guinea fowl:						
Whole egg as purchased .	16.9	60.5	11.9	9.9	0.8	620
Whole egg, edible portion .		72.8	13.5	12.0	0.9	735
White		86.6	11.6	0.03	0.8	212
Yolk		49.7	16.7	31.8	1.2	1598
Plover:						
Whole egg as purchased .	9.6	67.3	9.7	10.6	0.9	609
Whole egg, edible portion .		74.4	10.7	11.7	1.0	662
Fresh-water turtle eggs . .		65.0	18.1	11.1	2.9	772
Sea-turtle eggs		76.4	18.8	9.8	0.4	742
Salted duck eggs		68.0	12.0	9.2	4.0	594

seven eighths water and one eighth protein (chiefly albumin) with a small amount of ash, consisting mainly of common salt with smaller amounts of potassium salts. The yolk is about one half water, one third fat, and one sixth protein with more ash than the white, including relatively large amounts of phosphorus, calcium, and iron in organic combination. Thus the yolk is a much more concentrated food material than the white, containing in a given weight about seven times as much energy, as well as larger amounts of protein and of the chief ash constituents. The vitamins of the egg are also contained chiefly in the yolk.

The nature of the nutrients in eggs is of almost as much interest and importance as their amount. The fact that when an egg is kept at a proper temperature for about three weeks without the addition of anything from without, it produces a chick so well developed as to begin at once to walk and to eat the same food as the adult, suggests that the egg must contain substances which are very efficient as sources both of the energy and the materials for growth and development.

The fat of egg is practically all in the yolk, and like milk fat it exists in a finely emulsified condition, so that it is capable of digestion in the stomach, as well as in the intestine. Volhard has reported an experiment in which 78 per cent of the fat of egg yolk was digested in the stomach. A large proportion of the egg fat, probably at least one fourth, consists of phosphorized fats (lecithins together with closely related substances, such as kephalins). Egg lecithin is usually taken as typical of the "phosphorized fats," "phospholipines," or "phosphatids." It has the chemical structure of a fat in which one of the fatty acid radicles is replaced by a radicle of phosphoric acid in combination with a nitrogenous organic base (choline). The typical lecithin molecule thus contains one atom each of phosphorus and nitrogen; that described by Hoppe-Seyler had the composition $C_{44}H_{90}NPO_9$.

Recent investigations, especially those of McCollum and his associates at the Wisconsin Agricultural Experiment Station, appear to demonstrate that the nature of the fatty acids in both the ordinary fat and the phosphorized fat of the egg is influenced by the food of the hen. This is consistent with earlier observations relating to the influence of the food upon butter fat and upon the fat of the adipose tissues.

Dissolved in the fat of the egg yolk is a yellow coloring matter to which the name "lutein" has been given. Recently Palmer has shown this to be the same substance as the yellow plant pigment called carotin.

The proteins of egg are of much interest, and those of the yolk and of the white are quite different in their properties. The fact that egg white contains so little of any other substances than proteins and water makes it easy to observe the behavior of the proteins. Egg white is therefore largely used as a material with which to demonstrate the properties of proteins — particularly of the albumins, since ovalbumin is the chief protein of the egg white. According to Osborne and Campbell [1] egg white also contains small quantities of three other proteins called conalbumin, ovomucin, and ovomucoid. The chemical constitution of these minor proteins has not been studied. Ovalbumin has been purified in quantity by Osborne, Jones, and Leavenworth, and studied with reference to the amino acids yielded on hydrolysis; the results, together with those for ovovitellin, are shown below.

Ovovitellin is the chief protein of the egg yolk. It is believed to exist largely in chemical combination with lecithin.[2] When freed from lecithin, it has nearly the composition of casein, as shown by the following analyses, due chiefly to the work of Osborne.

[1] See references at the end of the chapter.

[2] Those who desire a fuller account of the chemistry of the egg proteins should consult the original papers of Osborne and Campbell. (See references at end of chapter.)

	Carbon	Hydrogen	Nitrogen	Oxygen	Sulphur	Phosphorus
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Casein	53.13	7.06	15.78	22.37	0.80	0.86
Ovovitellin	51.56	7.12	16.23	23.24	1.03	0.82

Casein and ovovitellin are regarded as the two typical phosphoproteins.

The percentages of the various amino acids obtained on hydrolysis of ovalbumin and ovovitellin, by Osborne and his associates, were as given below (Table 13).

A comparison with the corresponding data given in Chapter III (Table 5) shows that ovovitellin resembles casein in the amino acid radicles which it contains as well as in its elementary composition.

Table 13. Percentages of Amino Acids from Egg Proteins

	Ovalbumin	Ovovitellin
Glycine[1]	0.00	0.00
Alanine	2.22	0.75
Valine	2.50	1.87
Leucine	10.71	9.87
Proline	3.56	4.18
Phenylalanine	5.07	2.54
Aspartic acid	2.20	2.13
Glutamic acid[2]	9.10	12.95
Serine	?	?
Tyrosine	1.77	3.37
Cystine	?	?
Histidine	1.71	1.90
Arginine	4.91	7.46
Lysine	3.76	4.81
Tryptophan	1.11	1.74
Ammonia	1.34	1.25

[1] Also called glycocoll. [2] Also called glutaminic acid.

TABLE 14. COMPARISON OF WHITE AND YOLK OF EGG [1]

Constituent		White	Yolk
Water	*Per cent*	86.2	49.5
Protein	*Per cent*	12.3	15.7
Fat	*Per cent*	0.2	33.3
Ash	*Per cent*	0.6	1.1
Calcium	*Per cent*	0.01	0.14
Magnesium	*Per cent*	0.01	0.01
Potassium	*Per cent*	0.16	0.11
Sodium	*Per cent*	0.16	0.07
Phosphorus	*Per cent*	0.01	0.43
Chlorine	*Per cent*	0.15	0.1
Sulphur	*Per cent*	0.196	0.157
Iron	*Per cent*	0.0001	0.0085
Weight per average egg	*Grams*	33.	17.
Weight per average egg	*Ounces*	1.2	0.6
Fuel value per average egg	*Calories*	17.	60.

The ash constituents of the egg are, like the proteins, evidently well adapted to serve as material for the formation of body tissue. This may be inferred from the function of eggs in nature and from the success attending the use of eggs in diets designed especially for tissue building, and has also been demonstrated experimentally in laboratory feeding experiments. It will be seen from the accompanying tables that the egg is rich in all those elements which enter largely into the construction of muscle, bone, and blood; also that these are very unequally distributed between the white and the yolk.

The yolk is very much richer than the white in the calcium, phosphorus, and iron compounds which (for reasons explained in Chapter I) are especially significant in human nutrition.

The phosphorus of the egg, and especially of the yolk, is present chiefly as phosphoproteins and phosphorized fats

[1] The occasional small discrepancies between the data for the entire egg and the sum of the data for white and yolk are due to the fact that the two sets of analyses did not cover exactly the same samples.

("phosphatids," "phospholipines"). The occurrence of phosphorus in this form was formerly believed to have special significance in nutrition. Since recent experiments have shown that these compounds are not strictly necessary, the animal body being able to build them from mineral phosphates, we do not now lay so much emphasis upon the form of organic combination of the phosphorus, but we still recognize that the forms in which it is offered in milk and eggs are preëminently adapted to the requirements of the growing body.

TABLE 15. NUTRIENTS IN EGGS AS PURCHASED AND EDIBLE PORTION

CONSTITUENT		ENTIRE EGG AS PURCHASED	ENTIRE EDIBLE PORTION
Shell	*Per cent*	11.2	——
Water	*Per cent*	65.5	73.7
Protein	*Per cent*	11.9	13.4
Fat	*Per cent*	9.3	10.5
Ash	*Per cent*	0.9	1.0
Calcium	*Per cent*	0.06	0.07
Magnesium	*Per cent*	0.01	0.01
Potassium	*Per cent*	0.12	0.13
Sodium	*Per cent*	0.14	0.15
Phosphorus	*Per cent*	0.14	0.15
Chlorine	*Per cent*	0.09	0.10
Sulphur	*Per cent*	0.17	0.19
Iron	*Per cent*	0.0027	0.003
Weight of 100-Calorie portion	*Grams*	76.	68.
Weight of 100-Calorie portion	*Ounces*	2.7	2.4
Fuel value per pound	*Calories*	596.	672.
Weight per average egg	*Grams*	56.	50.
Weight per average egg	*Ounces*	2.	1.8
Fuel value per average egg	*Calories*	74.	74.

The iron of the egg yolk is also present in organic combination, chiefly, if not entirely, as a constituent of protein. Bunge separated from egg yolk a protein substance having the composition:

	Per cent
Carbon	42.11
Hydrogen	6.08
Nitrogen	14.73
Sulphur	0.55
Phosphorus	5.19
Iron	0.29
Oxygen	31.05

This appeared to be the substance which during incubation is changed into hemoglobin, and for this reason Bunge named it *hematogen*. This is believed to be typical of the iron-protein compounds of the food. The richness of the egg yolk in this food iron should therefore be recognized as adding much to the food value of the egg.

The calcium compounds of the egg have been less studied than the iron and phosphorus compounds, perhaps because the utilization of calcium in the body seems to be less dependent upon the form in which it exists in the food than in the case of iron and phosphorus. It is certain that the calcium of the egg is well utilized, and the relative richness of egg yolk in calcium as compared with the poverty of meats and breadstuffs in this element constitutes another important factor in the resemblance between eggs and milk as food.

The sulphur content of eggs is high — higher even than would be anticipated from the protein content, since the chief protein of the white of egg (ovalbumin) is particularly rich in sulphur. This abundance of sulphur probably has its function as a source of supply for the sulphur-rich substances of the skin, claws, and feathers of the chick. From the standpoint of human nutrition, such a high sulphur content is not altogether an advantage, since it results in a considerable preponderance of the acid-forming elements over the base-forming elements of the egg. This makes the egg an "acid-forming" food. In this respect the egg is similar to meat and unsimilar to milk. In other respects, notwithstanding the fact that milk contains about 5 per cent of carbohydrate and eggs almost none,[1] there is an essential similarity between milk and eggs in those features of their chemical nature which are most directly connected with their food value.

Vitamins. Eggs, and more especially egg yolks, are good sources of vitamins A and B. Weight for weight, eggs have probably ten times as much vitamin A and twice as much vitamin B as fresh milk; but it must be remembered in this connection that the weight of milk which can wisely be taken daily is many times greater than the weight of eggs. Practically all of the vitamin A and doubtless most of the vitamin B of the egg is in the yolk. The amount of vitamin C in eggs is probably not large, and neither its quantitative measurement nor its distribution between white and yolk appears yet to have been studied. To these should probably now be added an "antirachitic vitamin", present in egg yolk as well as in cod liver oil, milk, and butter.

Nutritive Value and Place in the Diet

That the egg is a food of high nutritive value will have been inferred from the above discussion of its chemical composition and the nature of the nutrients which it contains.

The digestibility of eggs has been studied experimentally, but not in such detail as with some other articles of food. The results indicate that egg protein is digested and absorbed to practically the same extent as milk or meat protein, about 97 to 98 per cent; and that the fat of egg is digested about as thoroughly as milk fat and rather more thoroughly than meat fat. It is probable that eggs "soft cooked" at a temperature below that of boiling water are the most readily and rapidly digested, but the ultimate thoroughness of digestion does not seem to be greatly influenced by the method of cooking. Thorough mastication is naturally most important in the case of eggs which have

[1] It is estimated that hens' eggs contain 0.25 to 0.5 per cent of glycogen, which, however, is not shown in the usual analyses.

been "hard boiled" or cooked at a higher temperature. Recent work on the digestibility of raw egg white by Rose and MacLeod showed that it is well utilized by the human subject, the coefficient of digestibility for raw egg white being 80 as compared with 86 for cooked egg white. The absorption varies with the method of preparation, being less for raw egg whites taken "clear" than when beaten until light.

Nutritive value. There can be no doubt that the nutrients of the egg when absorbed from the digestive tract are of exceptional value in the nutrition of the body tissues. The richness of eggs in protein and fat and in compounds of phosphorus and iron, all in forms especially adapted for conversion into body tissue, make the food value much greater than a comparison based simply on amounts of protein and energy would indicate.

Eggs as we eat them are relatively rich in all substances required for growth except calcium and vitamin C. The low calcium content of the edible portion of the egg is balanced so far as the natural function of the egg is concerned by the abundance of calcium in the shell, much of which is assimilated by the developing chick.

McCollum [1] has reported growth approximating the normal rate and successful reproduction in rats fed exclusively on boiled egg yolk; but elsewhere he states: [2] "Later studies have convinced us that while egg yolk contains all the organic complexes essential for nutrition, egg yolk as the sole food does not form a very satisfactory diet when gauged by the amount of reproduction secured or by the longevity of the animals so fed."

McCollum, Simmonds, and Parsons find [3] that, "The best proteins for the support of growth in the rat are those of milk and eggs." While their statement is based upon experiments

[1] *American Journal of Physiology*, Vol. 25, page 120.
[2] *Journal of Biological Chemistry*, Vol. 28, page 212.
[3] *Journal of Biological Chemistry*, Vol. 37, page 156.

with rats, there seems no reason to doubt that the same will hold true in human nutrition.

Hess has shown that the feeding of one egg yolk daily is an effective means of preventing rickets and this has been confirmed by Casparis, Shipley, and Kramer.

Eggs are more nearly interchangeable with milk in nutritive value than is any other food. They rank with milk as a source of vitamins and they are richer than milk in iron, but not so rich in calcium. On account of this richness in iron and the fact that egg yolk is a good source of the rickets-preventing substance, eggs are among the first foods to be added to the milk diet of the young child, and if circumstances should arise in which no form of milk enters into the child's diet, the egg will come nearer furnishing a satisfactory substitute than will any other food. Normally, however, eggs should only supplement the milk of children's dietaries and should not be allowed to displace the milk to any appreciable extent. Since, as noted above, the white of egg is better adapted to the nutrition of the chick than of the child, it is often best to give the child the yolk of the egg without the white.

For much the same reasons that it is adapted to the needs of the growing organism, the egg is also a very valuable food for adults who need to be "built up"; hence eggs are usually prominent in well-arranged dietaries for undernourished anemic people and especially for tuberculosis patients.

In addition to their well-known high nutritive value, eggs are popular for other reasons. They are easily cooked in a variety of ways and by their admixture it becomes possible to make many modifications in the texture, flavor, and appearance of other food materials. Doubtless it is largely because the egg facilitates so many things in cookery which would otherwise be difficult or impracticable, that the demand for eggs keeps the price almost always higher than their food value, for general use, would seem to warrant. We have seen, however, that the real food value of eggs is much greater than a mere statement of the protein and fat content and energy value would indicate. When all the factors of food value are taken into account, eggs are apt to be more economical than meat though not so economical as milk.

Trade Practices in the Egg Industry

The great value of eggs as food, the importance of keeping them in the best possible condition until consumed, and the desirability of preserving a considerable proportion of the eggs produced in time of abundance in order that undue scarcity at the time of minimum production may be avoided, make the trade practices in the egg industry a matter of large public importance.

For the individual consumer who wishes to preserve eggs when cheap, for use in time of scarcity, the best method is probably to keep the eggs immersed in a solution of water glass (sodium silicate) in a cool place. The water glass is usually purchased in the form of a concentrated (sirupy) solution of the sodium silicate which is diluted ten times its volume by addition of pure water. According to Bartlett, the diluted solution should not be strongly alkaline, and should have a specific gravity of about 1.045, in which case fresh eggs readily sink and remain submerged. The silicate seals the pores of the eggshell and so prevents the entrance of organisms and greatly retards the passage of gases, so that oxygen is practically excluded. If the silicate is of the right composition and the eggs are kept completely submerged in a cool place, the eggs should remain without apparent change in weight, composition, or flavor for many months, provided the eggs are clean, sound, and fresh when placed in the solution. Unless the consumer knows the origin of the eggs and is sure of their freshness at the start, the attempt to preserve cheap eggs by household methods is apt to result in disappointment.

Whether they are to be used as soon as they reach the market, or preserved on a small scale in the household or on a large scale in cold-storage warehouses, it is in any case highly important that eggs be promptly and properly collected and handled so as to reach the consumer or the storage warehouse in good condition.

At the present time the consumer, living in a large city, is offered eggs of all degrees of freshness, from those which are guaranteed to have been laid within 24 hours of delivery to those which have been weeks in the hands of farmers and country merchants and perhaps after that several months in cold storage.

Naturally the poultryman who makes eggs his chief crop is likely to market them much more systematically than is the general farmer who produces only a few more eggs than he uses. If a local egg dealer visits the farms frequently, he may be able to get the eggs to a refrigerated warehouse while still fresh, and if subsequent shipment is in refrigerator cars and storage always at low temperatures, the eggs may travel hundreds of miles and remain weeks or months in the hands of dealers without serious deterioration. At present, however, the bulk of the eggs going into wholesale trade is not so well handled.

Pennington and Pierce estimate that there is a total loss of 7.8 per cent of the eggs marketed, as a result of improper handling, and of course this must be accompanied by a great decline in value of a large proportion of the eggs not totally lost. Irregular gathering of eggs on the farm and storage at too high a temperature result in much deterioration. There is also apt to be delay and exposure to too high a temperature in the shipment of the eggs from the small dealer to the large packer, since eggs in " less than car lots " (technically known as " l. c. l.'s ") are apt to be handled as ordinary local freight.

When the eggs reach the packer, they are cooled and candled. On the basis of their appearance on candling, they are classified as " fresh," " weak," " spots," and "rotten" (see Fig. 10), and sometimes still other categories. The marketable eggs are graded according to size, cleanliness, and to some extent freshness. The eggs are then packed in cases or crates, usually holding thirty dozen each, and shipped to a commission man at the market center, from whom they pass to the wholesaler or jobber, and finally (perhaps after being kept in a cold-storage warehouse) to the retailer.

Some of the methods which are being employed for the improvement of conditions in the general egg trade are: better care of eggs on the farm and prompt delivery to egg dealers who will purchase for cash and base the price upon the quality of the eggs, so that the farmer who uses good methods will profit accordingly; early cooling and consistent maintenance of low temperature somewhat as in the marketing of milk; reduction or elimination of middlemen, even to the extent of direct contracts between the farmer and consumer for regular shipments either in dozens by parcel post or in crates by express. For the latter purpose crates holding 15 dozen (half the usual commercial size) are now being made.

When direct contracts between producer and consumer are not practicable, it has been found that the losses and deterioration involved in the old methods may be largely eliminated by making use of the facilities of the dairy industry for the prompt marketing of the farmers' eggs. Such marketing of eggs "through the creamery" has been described by Slocum in Farmers' Bulletin 445, United States Department of Agriculture.

The publication of this account by the United States Department of Agriculture in 1910 gave an impetus to this method of marketing eggs and it is said to be extending rapidly.

Special attention to the handling of eggs is not a new project. In Denmark a farmers' coöperative egg export association was organized in 1895 to better the market for Danish eggs by guaranteeing that eggs delivered under the association's trade-mark are strictly fresh and clean. This association handled in 1909 over 9,000,000 pounds of eggs. In Canada both the Dominion government and the Quebec government have taken up the matter and are doing what they can to forward similar coöperative work. In Australia one state has a system by which twenty-one associations of farmers each maintains a center at which a Secretary receives, tests, and grades the eggs, pays cash for them at the current market rate, and sends them to the government cold stores, receiving one cent per dozen eggs for his services. The government does the marketing and at the end of each quarter any profits are divided among those who supply the eggs (Powell). For several years the United States Department of Agriculture has been working through both the Bureau of Animal Industry and the Bureau of Chemistry for the improvement of the egg trade and now through the newly established Bureau of Agricultural Economics will doubtless be able to contribute still more toward the solution of the problems of this industry.

The following is quoted from Bulletin 248 of the Connecticut Agricultural Experiment Station, being the report of the State of Connecticut on Food Products and Drugs for 1922 — Part II, pages 394 to 396:

"The characteristics of a fresh egg have been defined by various authorities from which the following may be cited:[1]

CHARACTERISTICS OF A FRESH EGG

Before the Candle

Air space: Not enlarged; less than three fourths inch in diameter.

White: Firm and clear.

Yolk: Dimly seen through the white as a shadowy object indistinct in outline. The chick spot is not visible.

Distinguishing characteristics: No shrinkage and general firm condition of white and yolk. Edible.

[1] United States Department of Agriculture, Bulletin 565, p. 13 (1918).

Out of Shell

White: Firm and thick; opalescent; reflects the light.

Yolk: Spherical and firm; chick spot small with no sign of hatching. Color is uniform for the entire yolk, but varies in color from light yellow to deep orange, and is occasionally olive green.

Distinguishing characteristics: General firm condition of white and yolk. White, opalescent.

"The characteristics of a fresh egg have been further defined in more general terms as follows:[1]

"Its white is capable of whipping well; in cooking it can be satisfactorily poached or soft boiled, it has not absorbed foreign disagreeable odors, its embryo shall not have developed appreciably. The yolk should be fairly stiff and well rounded, the white should not be watery and the chalaza should be well defined."

"Opposed to eggs of this quality are those which are recognized as stale or shrunken, yet edible, the characteristics of which have been defined as follows:[2]

CHARACTERISTICS OF AN EGG WHICH IS NOT FRESH

Before the Candle

Air space: Enlarged; the lower wall may be movable in outline.

White: Thin and clear.

Yolk: Definite in outline; sometimes weak, and may occasionally have dark mottled areas.

Distinguishing characteristics: Enlarged air cell and increased contrast between white and yolk as compared with a fresh egg. Edible.

Out of Shell

White: Thin, no opalescence, does not reflect the light as much as does a fresh egg.

Yolk: Flattened, and occasionally may have light, mottled areas.

Distinguishing characteristics: Thin white and flattened yolk.

[1] Pennsylvania Department of Agriculture, Bureau of Foods, 17, p. 44 (1919).
[2] United States Department of Agriculture, Bulletin 565, p. 13 (1918).

"Other types of eggs which are not fresh, but still edible, are hatch-spot eggs, weak eggs, and eggs with movable air space. The numerous types of inedible eggs need not be enumerated here.

"Laws regulating the distribution and sale of eggs aim to insure that the consumer obtains good, edible eggs always, and fresh eggs if the extra price of such is paid. If, however, the consumer's understanding of a fresh egg be one that is but two or three days old then he seldom gets what he expects. If he accepts fresh eggs to be those possessing the characteristics here defined for fresh eggs, he obtains such eggs much more frequently. Whatever his idea of fresh may be, it can be positively stated that the elapsed time since an egg was laid is not the determining factor in establishing its freshness; the conditions of holding are all-important. As to how old an egg may be and still retain the characteristics of a fresh egg it is pertinent to quote the following:[1]

"An egg laid in March or April and kept under proper conditions will retain the characteristics which distinguish a fresh egg for from three to four weeks. In warmer weather this time would necessarily have to be reduced, and an egg laid in very hot weather and possibly allowed to remain in the nest for twenty-four hours or more, has lost these characteristics to such an extent that it is not as good as an April egg kept for a month under favorable conditions, and it should not be offered for sale nor be permitted to be sold as and for a fresh egg.

"Nor can an egg which is allowed to remain exposed to ordinary atmospheric conditions in a retail store for several days or a week in warm weather be expected to retain the characteristics which are expected of a fresh egg."

"Thus it would appear that when eggs are sold under the description fresh, they should conform to the characteristics of fresh eggs and our examinations have been made upon this hypothesis.

"For many of the abuses which occur in connection with the sale of so-called fresh eggs the consumer himself is largely responsible by reason of his prejudice against cold storage eggs.

[1] Pennsylvania Department of Agriculture, Bureau of Foods, 17, page 44 (1919).

No matter what the season of the year may be he insists that the eggs he buys shall be *fresh*, and the retailer finds it necessary to incorporate the word *fresh* somewhere in the legend under which he offers eggs for sale in order to sell them at all. If he goes further and increases the price a few cents per dozen his sales are further facilitated, because the average purchaser is very suspicious of cheap eggs. We do not defend this practice on the part of the retailer, but the consumer's share in the responsibility for it is obvious.

"In the last ten years great progress has been made in methods of production, handling, transportation, and storage through the efforts of federal and state authorities in egg producing centers which furnish the bulk of eggs which are placed in cold storage. The object of all this study which has been given to the egg problem is to insure that good, edible eggs shall be obtained in the season of shortage. It is chiefly his traditional prejudice against this cold-storage product which prevents the consumer from availing himself of the full benefit of these improved conditions."

Cold Storage and its Regulation

The cold-storage industry as now understood is a relatively recent development. While statistics of the industry in its earlier stages are not available, it is generally accepted that only since about 1893 have the quantities of food materials placed in cold storage been large enough to have an appreciable effect upon market conditions.

It should be kept in mind that statements regarding the quantity of food "put in cold storage" do not include food kept cold while in preparation or transportation or while in the hands of the retailer, but refer, as a rule, specifically to the business conducted by cold-storage warehousemen who rent space for the storage of food, which the owners wish to withhold from the market for a longer or shorter time. It is obvious that the owner's chief object in thus withholding his goods from the market is to await an increase of price; it should be equally plain that the owner cannot wish to hold the food so long as to have it lose value through deterioration. Hence the influence of cold storage in the food industry is more largely economic than hygienic, though occasionally there may be cases in which food becomes unwholesome in cold storage, either through being stored too long, or under improper conditions, or because the food was not suitable for storage in the first place.

Of the total egg production of the United States it is estimated that about one seventh (13.5 to 15 per cent) are placed in cold storage in the sense explained above, *i.e.* are sent to storage warehouses to await higher prices instead of being sent directly to the retail trade. Referring to the estimates of egg production quoted earlier in this chapter, it will be seen how great is the quantity represented by one seventh of this total. The cold-storage warehouses are apt to be located in close proximity to some large market. On the occasion of an official investigation by a committee of the State Legislature it was reported that hundreds of millions of eggs were found in the cold-storage warehouses of Hudson County, New Jersey, awaiting a rise of price in New York City.

That egg production is much larger and prices much lower in spring and early summer than in autumn and winter is a well-recognized condition which recurs regularly year after year. The supply of eggs received by a large city is more nearly in proportion to the surplus production than to the actual production of the large areas from which the supply comes.

While the price of storage eggs is always below that of fresh eggs, it usually reaches a point sufficiently above the prices ruling in spring to yield a profit to the owner after paying the warehouse charges, and insurance, and allowing for interest on the money value of the eggs. It is of course in anticipation of this profit that eggs are placed in storage at the time of greatest abundance in the spring and early summer.

According to statistics of the United States Department of Agriculture four fifths (79.4 per cent) of all the eggs placed in cold storage are stored during April, May, and June. In the Chicago market, where large quantities of eggs are received from the Southwest as well as from the surrounding country, storage begins in March and (normally) nearly all the eggs stored are placed in storage during a period of four months. The

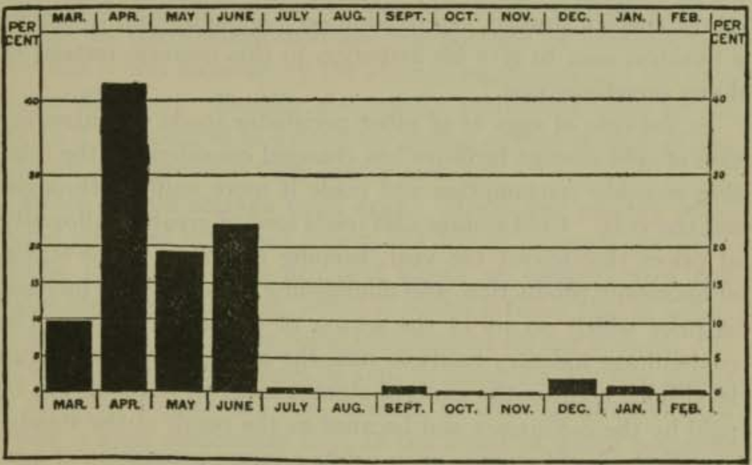

FIG. 11. — Relative quantities of eggs put in cold storage each month (by a Chicago firm). Reproduced by permission from Taylor's *Prices of Farm Products* (Bulletin 209 of the Wisconsin Agricultural Experiment Station)

relative quantities of eggs put into storage each month for a year by one Chicago firm are shown in Fig. 11.

Since midsummer eggs do not keep well, few eggs are placed in storage in July and August even though the price may continue low.

Of the eggs placed in storage it appears from the statistics of the United States Department of Agriculture that only 22.6 per cent are taken out within 4 months of receipt, but that 75.8 per cent are taken out within 7 months, and 99.9 per cent within

10 months. Thus it appears that more than three fourths of all the eggs which are stored remain in storage over 4 months, but practically none remain in storage longer than 10 months. The average length of storage of eggs was found to be 5.9 months. The total cost of storage was estimated at 0.57 cent per dozen per month or 3.5 cents per dozen for the average length of storage. In general the stored eggs must sell, as Professor Taylor has pointed out, at a sufficient advance on their original price to pay all the costs of storage, and in addition " enough profit to induce a business man to give his attention to this business instead of doing something else."

In the case of eggs as of other perishable foods the introduction of cold-storage facilities has changed considerably the relative monthly consumption and made it more uniform throughout the year. Cold storage also tends toward greater uniformity of prices throughout the year, keeping up prices in the season of maximum production, and diminishing somewhat the increase of price which occurs at the season of natural scarcity. The cold-storage industry tends to raise the average or annual price level both because the costs of storage must in the long run be paid by the consumers and because as the result of the steadying effect of cold storage upon prices a larger proportion of consumers now use eggs throughout the year, so that there is a much larger volume of business during the season of high prices. So far as this last factor is concerned it may fairly be considered that the standard of living is raised with the cost.

The conclusion drawn from the statistical investigation conducted by the United States Department of Agriculture (1909–1911) was that there is no just ground for complaint against the men who keep foods in cold storage except in so far as they sometimes speculate. Since the power to withhold goods from the market obviously constitutes a temptation to try to raise prices by creating an artificial scarcity (or exaggerating a scarcity which already exists), it was recommended that storage warehouses be required to make monthly reports to the government and that official estimates of the quantities of foods in storage be made public each month somewhat as in the case of the government crop reports.

This is now largely accomplished and about half of the states also have laws directly regulating the operations of cold-storage warehouses. These laws usually require that such warehouses and their records shall be open at all times to inspection and that any food placed in cold storage for 30 days or more shall be labeled as cold-storage food and the package be branded with the date it was received by the storage warehouse and the date it was delivered. Usually also special permission must be obtained if it is desired to extend the period of cold storage of any food for a longer time than twelve months.

Effect of cold storage upon eggs. Meats and poultry when stored are often kept hard frozen, but this of course is not practicable for eggs. Eggs are best stored at temperatures just above their freezing point, which of course is below that of water. From 29° to 32° F. is the usual temperature for egg storage. At such temperatures the eggs, if kept in moist air, become musty or moldy. To prevent this, the air in well-regulated storage rooms is kept moderately dry, as the result of which moisture evaporates through the shell and the contents of the egg shrink, the size of the air chamber becoming larger. This condition is detected by candling, as already explained. Other results of long storage are an increased tendency of the egg albumen to adhere to the shell membrane, and sometimes a slight crystallization of certain of the components of the egg. One of the earliest prosecutions by the Government after the Food and Drugs Act became effective in 1907 was against a dealer in Washington, D. C., for selling eggs "misbranded in that they were sold as strictly fresh when not so," the evidence against the eggs being "that the albumen clung to the shell membrane, that the air chamber was greatly enlarged, and that minute rosette crystals were found in the albumen and larger rosette crystals in the yolk."

During storage the white of egg loses moisture not only by evaporation through the shell, but also by an osmotic transfer of water from the white to the yolk. Greenlee[1] has studied this point quantitatively and proposed a formula by means of which the length of time an egg had been in storage could be judged from the water content of the white if the temperature and humidity of the storage room were known.

As a result of the transfer of water from the white to the yolk of the egg, the latter expands somewhat and the membrane which separates the yolk from the white is stretched and weakened and may break and permit a spreading of the yolk into the white, especially if the egg is carelessly handled.

These results of storage may interfere seriously with the appearance and behavior of the eggs when boiled or poached, and eggs showing these properties are rated considerably below fresh eggs in market value, but it should be noted that none of these effects is indicative of decomposition or unwholesomeness or indeed of anything but purely physical changes.

That slight chemical changes may occur during the time that eggs are ordinarily held in storage seems probable in view of the somewhat different flavor and strength of white in fresh and storage eggs. Normally the change in flavor is no different from that which takes place in a much shorter time when the eggs are kept under household conditions. Just why the white of the storage egg shows somewhat less strength than that of the fresh egg is not entirely clear, but may be due to slight self-digestion ("autolysis") such as occurs in animal organs and tissues generally when removed from the body and protected from the action of microörganisms.

The slight changes in flavor and in behavior on cooking and the fact that storage eggs are sometimes fraudulently sold as

[1] *Journal of the American Chemical Society*, Vol. 34, page 539.

fresh in the retail trade are sufficient to explain the prejudice against cold-storage eggs which exists among many if not most consumers. But these properties should not be confused with those which are indicative of decomposition and unwholesomeness. As regards wholesomeness, there is no presumption against the cold-storage egg as such. In general, storage eggs may be regarded as less desirable than those which are in reality "strictly fresh," but superior to many of the so-called "fresh" eggs which have not had the benefit of refrigeration.

Many species of organisms, both bacteria and molds, have been found in decaying eggs. In general the spoilage which takes place rapidly at high temperatures is apt to be due chiefly to bacteria, while the mustiness which develops slowly at low temperatures is often due more largely to molds. An initial infection with bacteria may occur while the egg is still within the oviduct of the hen; or organisms may gain entrance after the egg is laid, especially if it be allowed to lie in an unclean nest. The properties of the white and yolk with reference to bacterial growth are summarized by Buchanan as follows:[1] Egg white has been shown to possess distinct antiseptic properties. Many species of bacteria are quickly destroyed when mixed with it. This is not true of the yolk, for this is a favorable growth medium for many species of bacteria. It is not probable that this bactericidal property of egg white persists indefinitely, but it is doubtless responsible for the fact that the egg keeps as well as it does.

Certain types of spoilage are due to developing embryos and are therefore avoided in the case of infertile eggs.

Frozen and Dried Eggs

Freezing and drying are the two general methods of preserving eggs when removed from their shells. Pennington and also Stiles and Bates, of the United States Department of Agricul-

[1] *Bacteriology*, page 508.

ture, have made special investigations of frozen and dried eggs and the following is based chiefly on their findings. Since the centers of egg production and egg consumption are now so widely separated, it is believed that, properly conducted, the freezing and drying of eggs is an industry which is economically desirable, especially so long as the prevalent methods of handling bring to the dealers in the producing sections great numbers of eggs which are wholesome but not available for long hauls. Another important consideration is that frozen eggs can be stored at very much lower temperatures than can eggs in the shell.

As Pennington points out, the handling of eggs which have been removed from their shells is somewhat analogous to the handling of milk and, like the milk industry, should be characterized by the most scrupulous cleanliness throughout. As in the case of milk, the sources of contamination are best demonstrated by bacteriological methods and can in the main be eliminated by the adoption of such precautions as a knowledge of sanitation would suggest — cleanliness of surroundings and workers, frequent cleansing and drying of the fingers, use of appliances and containers which have been sterilized by means of live steam, prompt freezing or drying of the egg after removal from the shell, etc. A complicating factor in this industry is that eggs do not come directly from the farm to the breaking establishment and even though the eggs be sorted by candling before going to the breakers, some of the eggs which have passed the candler prove to be distinctly bad when broken. In legitimate establishments, such an egg is rejected and the receptacle into which it was broken as well as the fingers of the breaker are rinsed before being used again. Mere rinsing, however, is not sufficient to prevent the contamination of the next egg, since large numbers of bacteria from the bad egg remain in the receptacle even though it looks and smells clean. Pennington recommends that all the fittings of the room in which eggs are broken and all the appliances and receptacles used be of metal or other nonporous material adapted to easy and thorough cleaning and steam sterilization. Each egg should be cracked on a steel blade and broken into a smooth, clear glass cup. When a bad egg is encountered, the blade on which, and the cup into which, it was broken are at once replaced and sent away to be thoroughly washed and steam sterilized. It is further recommended that all eggs received by the breaking establishment be first chilled below 40° F. for 24 hours, then candled and broken in cooled rooms and the liquid egg, while still cold (preferably below 45° F.), sent in its final container to a quick freezer.

Stiles and Bates described, in Bulletin 158 of the Bureau of Chemistry, United States Department of Agriculture, the processes of freezing and drying eggs as they found them in 1911. Since that time the egg-drying industry has been largely transferred to China, where eggs are cheaper than in this country, but the freezing of eggs has grown to considerable proportions.

Redfield states that over 19,000,000 pounds of frozen eggs were held in storage in the United States on January 1, 192c (United States Department of Agriculture, Bulletin 846).

Stiles and Bates as the result of a large number of experiments to determine the bacterial content of frozen and dried products from eggs of different grades when made and stored under known conditions reached the following conclusions:

(1) Under normal conditions, strictly fresh eggs contain few if any bacteria, and no appreciable numbers of *B. coli* in 1 cc. quantities.

(2) Frozen egg products prepared in the laboratory in Washington from second-grade eggs comprising "undersized," "cracks," "dirties," and "weak eggs" generally show a total bacterial content of less than 1,000,000 organisms per gram, while dried eggs prepared from the same grades usually contain a total bacterial content of less than 4,000,000 organisms per gram, both kinds containing but a very small number of *B. coli;*

from a bacteriological standpoint they are considered an edible product.

(3) Frozen products made from "light spots," "heavy spots," "blood rings," and "rots" show bacterial counts generally ranging from about 1,000,000 to 1,000,000,000, while dried eggs made from the same grades usually contain from 4,000,000 to more than 1,000,000,000 organisms per gram with a relatively high proportion of *B. coli* and *streptococci* in both the frozen and dried material, indicating an unwholesome article, unfit for food, and only useful for tanning leathers, or for other technical purposes.

It should be noted, however, that testimony offered in the Federal courts, in a case in which condemnation of a shipment of frozen eggs was contested by the owner, tended to show that market eggs such as are accepted without question as food may contain many more bacteria, both in total numbers and of the *B. coli* type, than would be expected from the results found in the Government laboratories.

The frozen eggs in question contained large numbers of bacteria, a considerable proportion of which were of the *B. coli* type. The eggs, however, showed no taint in taste or odor and no bad effects when eaten. The ammonia content, which was held to be the best chemical evidence of decomposition, was about the same as in ordinary market eggs, *viz.*, about 3 parts in 100,000.

The Federal court decided in favor of the egg company, holding that the Government had not shown the eggs to be filthy, decomposed, putrid, or unfit for human food.

Chinese Pidan — Fermented Preserved Egg

As Blunt and Wang have pointed out, the Chinese and other Oriental peoples preserve eggs, not necessarily to keep them unchanged, but to make various new products — a process analogous to the production of cheese from milk. They describe the manufacture of one of these products — pidan, from ducks' eggs, on a factory scale, as follows: To an infusion of $1\frac{1}{3}$ pounds of strong black tea are stirred in successively 9 pounds of lime, $4\frac{1}{2}$ pounds of common salt, and about 1 bushel of freshly burned wood ashes. This pasty mixture is put away to cool overnight. Next day, 1,000 ducks' eggs of the best quality are cleaned and one by one carefully and evenly covered with the mixture, and stored away for 5 months. Then they are covered further with rice hulls, and so with a coating fully $\frac{1}{4}$ inch thick are ready for the market. They improve on further keeping, however, for at first they have a strong taste of lime which gradually disappears. The eggs are eaten without cooking. The following changes were found by these authors to take place during the formation of pidan from fresh ducks' eggs: "(1) Water in large quantities has been transferred from the white to the yolk, and water has been lost from the white to the outside. (2) The ash and the alkalinity of ash have increased in a way similar to that of other eggs preserved in alkali. (3) The ether extract has decreased and its acidity is high. (4) Both total and lecithin phosphorus have decreased. (5) The non-coagulable nitrogen has increased and also the ammoniacal nitrogen, the latter to an extraordinary degree, and the amino nitrogen is high. From these changes the conclusion is drawn that decomposition of the egg protein and of the phospholipoids has taken place. The production of pidan from the fresh eggs is probably brought about through the agency of the alkali, bacteria, and enzymes."[1]

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CHAPTER VI

MEATS AND MEAT PRODUCTS

As rated by the Bureau of the Census according to money value of annual product, the industry of slaughtering and meat packing is the largest manufacturing industry of the United States. Many animals are also slaughtered for food on farms and in local butcher shops not classed as manufacturing establishments. The United States Department estimates the farm value of cattle slaughtered yearly at about one billion dollars, and that of swine at somewhat more than a billion dollars; and since it is also estimated that the farm value averages about fifty-three per cent of what the consumer pays, it follows that the retail meat bill of the United States must be between \$3,500,000,000 and \$4,000,000,000 per year. This is about one third of the total expenditure for food and a larger amount than is spent for food of any other one type.

The meat-packing industry as we now understand it began about fifty years ago, with establishments for the curing and packing of pork at Cincinnati, which was then the center of the corn belt. The close connection between corn growing and swine raising is illustrated by a comparison of Figs. 12 and 13.

With the development of railroad transportation, and the westward extension of the corn belt, the center of the pork-packing industry moved to Chicago; and with the introduction of refrigerator cars, slaughter of beef for transportation in cold storage has grown to a business of great magnitude.

Beef

Slaughterhouse methods. The animals are driven up an incline to the upper stories of the packing houses so that after slaughter the carcasses may be run from place to place by gravity. A few beeves at a time are let into the slaughter pen, where each is killed by a blow with a sledge-hammer. The floor of the pen then drops like an elevator, the beeves are rolled out upon the cement floor of the slaughterhouse, and the slaughter pen is raised into position again. The dead animal is at once strung up by the hind feet and, hanging head downward from a wheel on a track which runs from room to room, is bled, dressed, skinned, and the carcass divided in half without the necessity of any lifting or the use of power to transport it.

The animal is bled by cutting the carotid artery, the blood being collected by itself and for the most part dried for fertilizer, though a part of it may find its way into food products. In Europe blood sausage is a common article of food; here it is not generally popular, but a small amount of blood is sold at a large profit in dried or condensed form in patent foods. Commercial albumen may also be made from this blood.

Next the stomach and intestines are removed, the fat which adheres to them serving for the preparation of oleo oil or tallow, their contents going into the cheaper grades of tankage, their muscular walls after thorough cleaning being available for food as "tripe." The lining of the stomach, particularly of calves, may be used as a source of rennet.

Then the hide, horns, and hoofs are removed and worked for oil, gelatin, glue, leather, hair, and horn, the trimmings going into the tankage for fertilizer.

Finally the carcass is split down the backbone and the halves sent to the refrigerating room to be thoroughly chilled.

Although not more than twenty minutes may elapse between the felling of the animal and the arrival of the dressed sides at

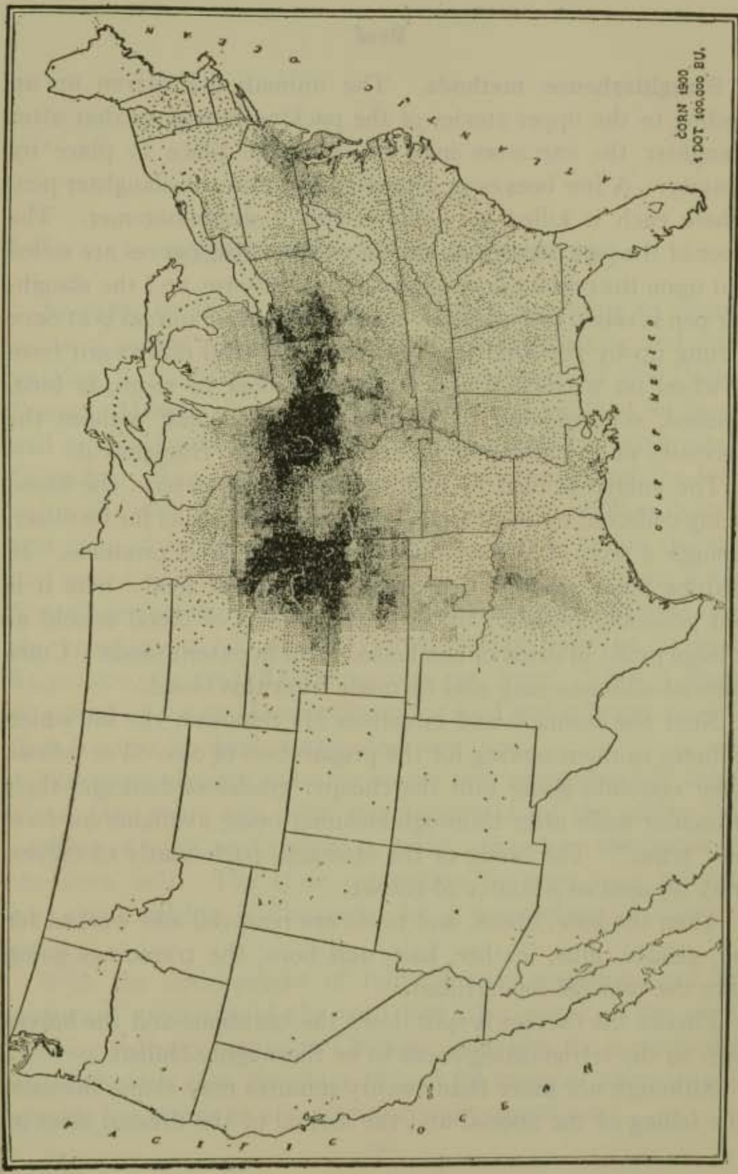


FIG. 12. — Production of corn in the United States in 1900. Reproduced by permission from Taylor's *Prices of Farm Products* (Bulletin 209 of the Wisconsin Agricultural Experiment Station).

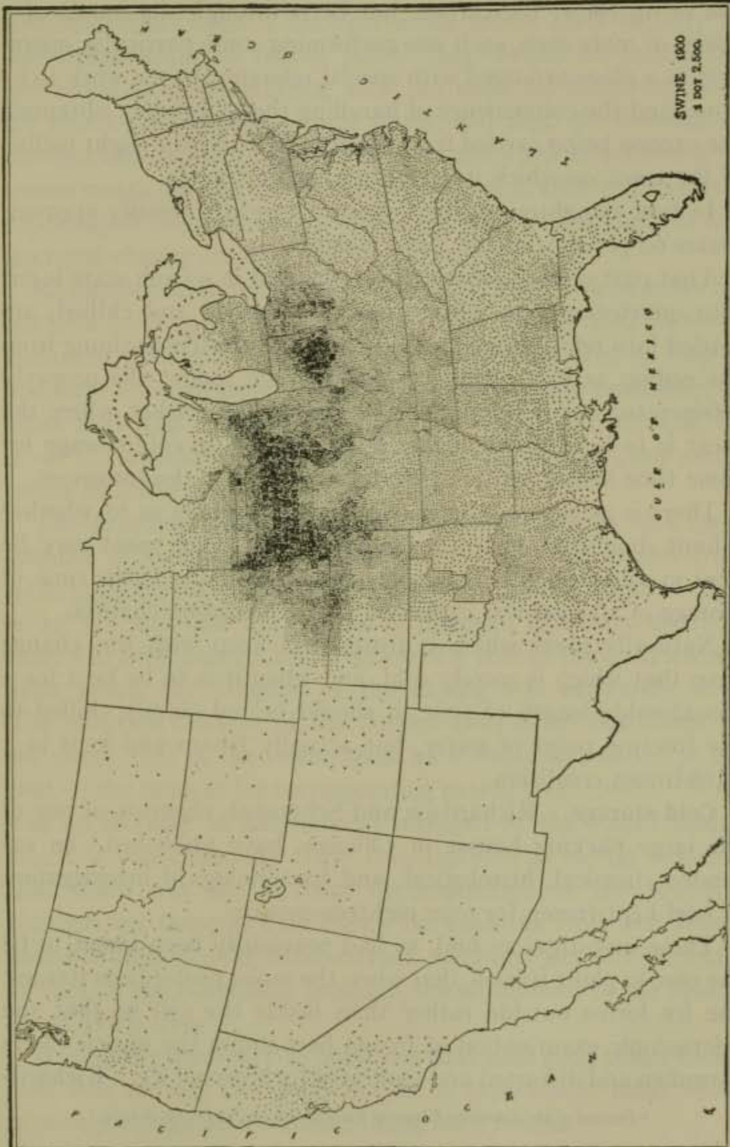


FIG. 13. — Production of swine in the United States in 1900. Reproduced by permission from Taylor's *Prices of Farm Products* (Bulletin 209 of the Wisconsin Agricultural Experiment Station).

the refrigerator, the carcass has been through the hands of a dozen or more men, each one performing some particular operation in a place arranged with special reference to the work to be done, and the convenience of handling the by-product obtained, the carcass being carried from place to place by the slight incline of the track on which its overhead trolley travels.

In beef slaughtering, the "dressed weight" usually approximates 60 per cent of the "live weight."

That part of the beef which is to be sold in a fresh state is cut into quarters which, when properly trimmed and chilled, are loaded into refrigerator cars in which the quarters are hung from the ceiling as in an ordinary cold-storage room; the properly refrigerated car is shipped under seal to the market where the meat is to be retailed. Here it may remain in cold storage for some time longer before being actually sold to the consumer.

There is as yet no general consensus of opinion as to whether a limit should be set to the length of time which meat may be kept in cold storage. That some states set limits to the time of storage of all food was explained in the preceding chapter.

Naturally meat which is frozen will keep with less change than that which is merely cold, and when it is to be kept for a considerable length of time, it should be not simply chilled to the freezing point of water, but actually frozen and kept in a hard-frozen condition.

Cold storage. Richardson and Scherubel, chemists of one of the large packing houses in Chicago, have published[1] an extended chemical, histological, and bacteriological investigation of beef kept frozen for over eighteen months.

These investigators find, as had previously been found to be the case in plant tissues, that when the moist protoplasm freezes, the ice forms outside rather than inside the cell so that the microscopic examination of frozen beef shows the muscle fibers shrunken and distorted and separated by layers of ice. Richard-

[1] *Journal of the American Chemical Society*, Vol. 30, pages 1515–1564.

son holds that even if bacteria could retain their activity at the temperature of frozen meat, they would be practically prevented from penetrating into the meat by these layers of ice which separate the muscle fibers, and that the histological changes which have sometimes been reported as occurring in frozen meats may be due to the mere physical effects of freezing, especially if followed by too rapid thawing, rather than to any bacterial change or other deterioration.

Richardson and Scherubel's examinations of frozen meat for bacteria both by direct microscopic and by cultural methods indicated that beef which had been kept frozen even so long as 600 days was free from bacteria at a depth of one centimeter or more from the surface. On the other hand, in meat kept at 2°–4° C. bacteria had penetrated to a depth of about one centimeter in thirty days.

The principal result shown by chemical analysis of a large number of samples of beef which had been kept frozen from 33 to 554 days (in a room whose temperature varied from − 9° to − 12° C.) was that the exterior of the meat dried to a depth of from 2 to 4 millimeters in the course of a year in the open freezer, after which the progress of the drying was extremely slow. The moisture content of the portion thus dried was about 30 per cent; that of the frozen meat as a whole was about 76 per cent — the same as for corresponding cuts of fresh meat. There was no increase of ammoniacal nitrogen in the stored meats, which is considered by these investigators as strong evidence that there was no bacterial decomposition of the proteins. Neither was there any difference between the fresh and frozen meats as regards cold water extract, total nitrogen of cold water extract, or the coagulable proteins, the albumoses, or the nitrogenous extractives.

It is hardly necessary to point out that such good preservation over long periods of time is not to be expected of meat which is merely refrigerated without being hard frozen.

Other methods of preservation. Aside from cold storage, the principal means of preserving meats are drying, canning, and the application of preservative substances.

Drying is, when applicable, a very effective method and has been long used. In some climates it is only necessary to cut the meat into strips and hang it out of doors. The "jerked beef" of the West was prepared in this way, and a mixture of dried lean meat with fat known as "pemmican" is concentrated food largely used by explorers. Dried meat is, however, by most people considered less attractive than fresh meat, and as a commercial process, the drying is slow and troublesome.

Canned meat is now put up in large quantities. Often all of the meat of the fore quarter and the cheaper cuts of the hind quarter are canned. There is a tendency to use the leaner carcasses for canning, both because the fat beeves can be sold at better prices in the fresh state and because the leaner meats are more attractive than the fat meats when canned.

Sometimes the beef is cured with salt, and usually also a little saltpeter, and then canned and sold as "canned corned beef." When preserved by canning alone without salting the product is sometimes called "canned roast beef" and sometimes simply "canned beef." The following is an outline of the latter process.

The meat selected for canning is cut into pieces usually one to four pounds each, depending upon the size of cans to be filled. It is then parboiled by putting into a tank with water and cooking with steam. Or the meat may be parboiled in larger pieces, then trimmed free from gristle and superfluous fat, and cut by machinery into approximately uniform pieces of a size proportioned to the size of the cans.

The parboiling causes a shrinkage of the meat so that (while being cooked in water) its water content is diminished.

That part of the fat which is cooked out of the meat rises to the top and is skimmed off; the extractives, the salts, and the very small amounts of protein which are extracted remain in solution in the water in which the meat is cooked, which thus becomes of value for the making of soup stock and meat extract.

Wiley estimated that this cooking extracts a little over one part in one hundred of the protein of the meat, about one third of the "extractives," and up to one half of the salts.

After the parboiled meat has been packed in the cans, enough of the "soup liquor," made by concentrating the water in which the meat was cooked, is added to fill the spaces between the pieces and to restore so far as is practicable the flavoring constituents lost in parboiling. This added "soup liquor" may also contain salt, sugar, or molasses as a flavoring.

In canning tongue and in other cases in which the form of the product is to be preserved, the cans are filled by hand. In the case of corned beef and potted or deviled meat, the cans are filled by means of the "stuffing machine," which presses into the can approximately the required amount of meat, the weight being tested and adjusted as each can leaves the machine. The cap of the can is then soldered on by means of the "capping machine," which leaves the can completely sealed except for the small vent hole in the top. The cans are then tested for leaks and any leaks found are repaired by hand.

The cans are then sent to vacuum machines by means of which the air is exhausted from within the can and the vent holes sealed while the can is in the vacuum chamber. From the vacuum machines the cans are run out on tables and again inspected to make sure that they are free from leaks.[1]

The cans are now ready for "processing," which simply means the heating of the can and contents to a sufficient temperature to insure its keeping. The temperature and time of heating depend chiefly upon the size of the cans, but also to some extent upon other conditions. Probably the most usual temperature is between 225° and 250° F. (107°–121° C.), which is usually

[1] Any can found leaky at this point is repaired by hand, the vent reopened, and the can returned to the vacuum machine.

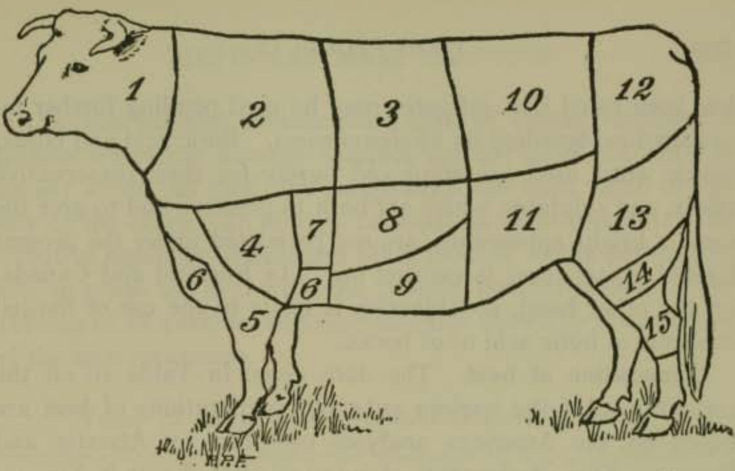
attained by the use of superheated steam in large iron or steel boilers or "retorts." Sometimes an oil bath is employed as a means of maintaining the high temperature. In case the nature of the product makes it desirable to avoid a temperature above boiling, the processing may be accomplished by placing the cans for a sufficient length of time in large open kettles or tanks of water which are kept at the boiling point by means of steam coils.

As the cans come hot from processing, the ends are slightly bulged outward owing to the expansion of the contents by the heating. They are now subjected to a cold spray until the contents are thoroughly chilled, when the ends of the can should be slightly concave and should remain so until the can is opened for use.

Finally the cans are washed in alkali to remove any grease, then in water, dried, painted, and labeled. Many establishments maintain warm "test rooms" at a temperature of 100°–110° F. to which is sent a sample batch of each "run" of canned meats to make sure that no cans prove defective when kept for several days at this high temperature.

A sound can should have slightly concave ends and should give only a dull sound when struck on the top or bottom; a can which shows bulging ends and emits a hollow or drum-like sound when struck on the top or bottom is likely to be leaky, or improperly packed, or to contain material which has undergone decomposition with production of gas.

Application of preservative substances is another common and important method of preserving meats. The substances which have been used to any considerable extent for this purpose are salt, saltpeter, boric acid or borates, sulphites, vinegar, wood smoke, and sugar. Salt, sugar, vinegar, and wood smoke are condimental as well as preservative in their properties, and there is no restriction upon their use. Saltpeter in addition to its preservative action has the property of maintaining or even intensifying the red color of beef. Under the present laws it



1. Neck.
2. Chuck.
3. Ribs.
4. Shoulder clod.
5. Fore shank.
6. Brisket.
7. Cross ribs.
8. Plate.
9. Navel.
10. Loin.
11. Flank.
12. Rump.
13. Round.
14. Second cut round.
15. Hind shank.

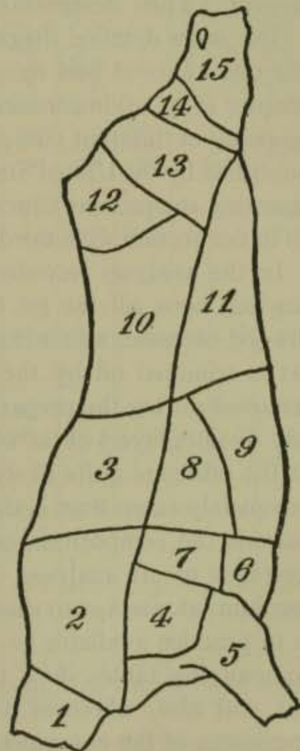


FIG. 14. — Cuts of beef. (Atwater and Bryant.) U. S. Department of Agriculture.

has been ruled that saltpeter may be used pending further investigation regarding its wholesomeness. Boric acid and borax, which when used are employed purely for their preservative effect, and sulphites, which act both to preserve and to give the meat a bright appearance, are not permitted under the present United States meat inspection law. In England and Canada, on the other hand, no objection is made to the use of limited amounts of boric acid or of borax.

Composition of beef. The data given in Table 16 on the composition of the various cuts and preparations of beef are based on the American analyses complied by Atwater and Bryant. Their designation of cuts was that shown in Fig. 14.

The more detailed diagram of Hall and Emmett showing all the retail cuts of beef recognized by them is given later in this chapter (Fig. 19) in connection with the discussion of the relative economy of different cuts; and a still different diagram recently published by the United States Department of Agriculture as representing the present Chicago system of cutting is given as Fig. 18 in connection with the discussion of Federal standardization.

In the analyses recorded by Atwater and Bryant and summarized here, all the fat found on the respective parts of the dressed carcasses was included, whereas in practice much of this fat is trimmed off by the retail butcher, usually still more is removed during the preparation of the meat in the kitchen, and any distinct layers of fat which remain on the meat when served at the table are quite likely to be left uneaten — or at least less completely eaten than is the lean portion of the beef. For these reasons the composition of the various cuts, as shown by the averages of all analyses, or analyses of samples classified as medium fat, are apt to show a very much higher fuel value than is in practice available to the consumer of the meat. The accompanying tables show the averages of all analyses for each cut and also, wherever available, average analyses for those specimens of the cut which were described as lean or very lean.

The lean samples contain more than an average amount of protein while the average samples contain more fat than is usually eaten, so that each exaggerates the food value in one way or the other. In dietary calculations or in comparing the nutritive economy of beef and other foods it might perhaps be wise to credit the beef with the protein content shown by the average of all analyses and the fuel value shown by the analyses of the lean specimens.

TABLE 16. AVERAGE COMPOSITION OF CUTS OF BEEF[1]

Description	Number of Analyses	Refuse	Water	Protein: N × 6.25	Protein: By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
BEEF, FRESH		Per cent	Per cent	Per cent	Per cent	Per cent		Per cent	Cal.
Brisket, medium fat:									
Edible portion	3	—	54.6	15.8	*16.0*	28.5	—	.9	1450
As purchased	3	23.3	41.6	12.0	*12.2*	22.3	—	.6	1130
Chuck, including shoulder, very lean:									
Edible portion	1	—	73.8	22.3	*21.3*	3.9	—	1.0	564
As purchased	1	18.4	60.2	18.2	*17.4*	3.2	—	.8	461
Chuck, including shoulder, lean:									
Edible portion	2	—	71.3	20.2	*19.5*	8.2	—	1.0	702
As purchased	2	19.5	57.4	16.3	*15.7*	6.6	—	.8	565
Chuck, including shoulder, all analyses:									
Edible portion	13	—	65.0	19.2	*18.7*	15.4	—	.9	978
As purchased	12	17.3	54.0	15.8	*15.5*	12.5	—	.7	797
Chuck rib, very lean:									
Edible portion	1	—	75.8	22.2	*21.7*	1.4	—	1.1	460
As purchased	1	16.7	63.1	18.6	*18.1*	1.2	—	.9	387
Chuck rib, lean:									
Edible portion	11	—	71.3	19.5	*19.4*	8.3	—	1.0	693
As purchased	11	22.7	55.1	15.1	*15.0*	6.4	—	.8	535

[1] Based on Atwater and Bryant's *Composition of American Food Materials*. Bulletin 28 (Revised). Office of Experiment Stations, U. S. Department of Agriculture.

TABLE 16. AVERAGE COMPOSITION OF CUTS OF BEEF — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN N × 6.25	PROTEIN By difference	FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
BEEF, FRESH		Per cent	Per cent	Per cent	Per cent	Per cent		Per cent	Cal.
Chuck rib, all analyses:									
Edible portion	21	—	66.8	19.0	*18.8*	13.4	—	1.0	892
As purchased	21	19.1	53.8	15.3	*15.2*	11.1	—	.8	730
Flank, very lean:									
Edible portion	3	—	70.7	25.9	*24.8*	3.3	—	1.2	605
As purchased	3	3.5	68.2	24.9	*23.9*	3.3	—	1.1	587
Flank, lean:									
Edible portion	3	—	67.8	20.8	*19.9*	11.3	—	1.0	840
As purchased	3	1.4	66.9	20.5	*19.7*	11.0	—	1.0	821
Flank, all analyses:									
Edible portion	16	—	59.3	19.6	*18.7*	21.1	—	.9	1217
As purchased	16	5.5	56.1	18.6	*17.7*	19.9	—	.8	1148
Loin, very lean:									
Edible portion	3	—	70.8	24.6	*24.2*	3.7	—	1.3	593
As purchased	3	23.0	54.6	18.8	*18.5*	3.0	—	.9	463
Loin, lean:									
Edible portion	12	—	67.0	19.7	*19.3*	12.7	—	1.0	877
As purchased	11	13.1	58.2	17.1	*16.7*	11.1	—	.9	764
Loin, all analyses:									
Edible portion	56	—	61.3	19.0	*18.6*	19.1	—	1.0	1125
As purchased	55	13.3	52.9	16.4	*16.0*	16.9	—	.9	988
Loin, boneless strip:[1]	6	—	66.3	17.8	*16.2*	16.7	—	.8	1002
Loin, sirloin butt:[1]	6	—	62.5	19.7	*18.9*	17.7	—	.9	1080
Loin, porterhouse steak:[1]									
Edible portion	7	—	60.0	21.9	*18.6*	20.4	—	1.0	1230
As purchased	7	12.7	52.4	19.1	*16.2*	17.9	—	.8	1075
Loin, sirloin steak:[1]									
Edible portion	21	—	61.9	18.9	*18.6*	18.5	—	1.0	1100
As purchased	21	12.8	54.0	16.5	*16.2*	16.1	—	.9	960
Loin, tenderloin	6	—	59.2	16.2	*15.6*	24.4	—	.8	1290
Navel, very lean:									
Edible portion	1	—	68.6	30.7	*29.4*	.6	—	1.4	582
As purchased	1	2.9	66.6	29.8	*28.5*	.6	—	1.4	565

[1] All loin parts are included under analysis of "loin."

TABLE 16. AVERAGE COMPOSITION OF CUTS OF BEEF — Continued

Description	Number of Analyses	Refuse	Water	Protein		Fat	Carbohydrates	Ash	Fuel Value per Pound
				N × 6.25	By difference				
BEEF, FRESH		*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*		*Per cent*	*Cal.*
Neck, lean:									
Edible portion	2	—	70.1	21.4	*20.5*	8.4	—	1.0	731
As purchased	2	29.5	49.5	15.1	*14.4*	5.9	—	.7	515
Neck, all analyses:									
Edible portion	15	—	66.3	20.7	*20.0*	12.7	—	1.0	894
As purchased	15	31.2	45.3	14.2	*13.6*	9.2	—	.7	633
Plate, very lean:									
Edible portion	3	—	69.1	22.8	*22.1*	7.7	—	1.1	728
As purchased	3	37.4	43.0	13.6	*13.2*	5.7	—	.7	479
Plate, lean:									
Edible portion	3	—	65.9	15.6	*14.6*	18.8	—	.7	1051
As purchased	3	17.3	54.4	13.0	*12.2*	15.5	—	.6	869
Plate, all analyses:									
Edible portion	17	—	56.3	16.8	*16.0*	26.9	—	.8	1390
As purchased	17	19.8	44.4	13.1	*12.5*	22.7	—	.6	1165
Ribs, very lean:									
Edible portion	4	—	70.9	25.0	*24.4*	3.5	—	1.2	597
As purchased	4	23.3	54.2	19.4	*18.9*	2.7	—	.9	462
Ribs, lean:									
Edible portion	6	—	67.9	19.6	*19.1*	12.0	—	1.0	845
As purchased	6	22.6	52.6	15.2	*14.8*	9.3	—	.7	654
Ribs, all analyses:									
Edible portion	35	—	57.0	17.8	*17.5*	24.6	—	.9	1338
As purchased	34	20.1	45.3	14.4	*13.9*	20.0	—	.7	1078
Rib rolls, lean, as purchased	3	—	69.0	20.2	*19.5*	10.5	—	1.0	795
Rib rolls, all analyses, as purchased	11	—	64.8	19.4	*18.8*	15.5	—	.9	985
Rib trimmings, all analyses, as purchased . . .	11	34.1	35.7	11.0	*10.5*	19.2	—	.5	984
Ribs, cross, very lean:									
Edible portion	1	—	65.8	18.0	*18.4*	14.9	—	.9	935
As purchased	1	12.8	57.4	15.6	*16.1*	13.0	—	.7	814
Ribs, cross, all analyses:									
Edible portion	2	—	54.9	15.9	*16.1*	28.2	—	.8	1440
As purchased	2	12.5	48.0	13.8	*14.0*	24.8	—	.7	1260

TABLE 16. AVERAGE COMPOSITION OF CUTS OF BEEF — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN N × 6.25	PROTEIN By difference	FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
BEEF, FRESH		*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*		*Per cent*	*Cal.*
Round, very lean:									
Edible portion	6	—	73.6	22.6	*22.3*	2.8	—	1.3	525
As purchased	6	10.6	65.9	20.2	*19.9*	2.4	—	1.2	464
Round, lean:									
Edible portion	31	—	70.0	21.3	*21.0*	7.9	—	1.1	709
As purchased	29	8.1	64.4	19.5	*19.2*	7.3	—	1.0	652
Round, all analyses:									
Edible portion	62	—	67.8	20.9	*20.5*	10.6	—	1.1	812
As purchased	54	8.5	62.5	19.2	*18.8*	9.2	—	1.0	724
Round, second cut:									
Edible portion	2	—	69.8	20.4	*20.5*	8.6	—	1.1	721
As purchased	2	19.5	56.2	16.4	*16.5*	6.9	—	.9	580
Rump, very lean:									
Edible portion	4	—	71.2	23.0	*22.5*	5.1	—	1.2	626
As purchased	4	14.3	60.9	19.5	*19.1*	4.6	—	1.1	542
Rump, lean:									
Edible portion	4	—	65.7	20.9	*19.6*	13.7	—	1.0	938
As purchased	3	14.0	56.6	19.1	*17.5*	11.0	—	.9	796
Shank, fore, all analyses:									
Edible portion	15	—	70.3	21.4	*20.7*	8.1	—	.9	719
As purchased	15	38.3	43.2	13.2	*12.7*	5.2	—	.6	452
Shank, hind, all analyses:									
Edible portion	14	—	69.6	21.7	*20.7*	8.7	—	1.0	749
As purchased	14	55.4	31.0	9.7	*9.3*	3.9	—	.4	335
Shoulder and clod, very lean:									
Edible portion	4	—	76.1	21.3	*21.5*	1.3	—	1.1	440
As purchased	4	23.3	58.3	16.3	*16.5*	1.0	—	.9	337
Shoulder and clod, lean:									
Edible portion	5	—	73.1	20.4	*20.4*	5.4	—	1.1	591
As purchased	4	18.8	59.4	16.4	*16.5*	4.4	—	.9	477
Shoulder and clod, all analyses:									
Edible portion	28	—	68.9	20.0	*19.7*	10.3	—	1.1	784
As purchased	23	17.4	57.0	16.5	*16.3*	8.4	—	.9	643

TABLE 16. AVERAGE COMPOSITION OF CUTS OF BEEF — Continued

Description	Number of Analyses	Refuse	Water	Protein N × 6.25	Protein By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
BEEF, FRESH		Per cent	Per cent	Per cent	Per cent	Per cent		Per cent	Cal.
Fore quarter, very lean:									
Edible portion	2	—	74.1	22.1	*21.3*	3.6	—	1.0	548
As purchased	2	30.3	51.5	15.4	*14.8*	2.7	—	.7	390
Fore quarter, lean:									
Edible portion	4	—	68.6	18.9	*18.4*	12.2	—	.8	841
As purchased	4	22.3	53.3	14.7	*14.3*	9.5	—	.6	655
Fore quarter, all analyses:									
Edible portion	18	—	62.5	18.3	*17.7*	18.9	—	.9	1100
As purchased	18	20.6	49.5	14.4	*14.1*	15.1	—	.7	878
Hind quarter, very lean:									
Edible portion	2	—	72.0	24.0	*23.3*	3.5	—	1.2	578
As purchased	2	21.0	56.9	19.0	*18.4*	2.8	—	.9	459
Hind quarter, lean:									
Edible portion	4	—	66.3	20.0	*19.3*	13.4	—	1.0	910
As purchased	4	16.6	55.3	16.7	*16.1*	11.2	—	.8	760
Hind quarter, all analyses:									
Edible portion	18	—	62.2	19.3	*18.6*	18.3	—	.9	1100
As purchased	18	16.3	52.0	16.1	*15.5*	15.4	—	.8	921
Sides, very lean:									
Edible portion	2	—	73.1	23.0	*22.3*	3.5	—	1.1	560
As purchased	2	26.0	54.0	17.0	*16.5*	2.7	—	.8	419
Sides, lean:									
Edible portion	4	—	67.2	19.3	*18.7*	13.2	—	.9	890
As purchased	4	19.5	54.1	15.5	*15.1*	10.6	—	.7	714
Sides, all analyses:									
Edible portion	18	—	62.2	18.8	*18.1*	18.8	—	.9	1110
As purchased	18	18.6	50.5	15.2	*14.7*	15.5	—	.7	909
Miscellaneous cuts, free from all visible fat	11	—	73.8	22.4	*22.1*	2.9	—	1.2	525
Clear fat	7	—	13.4	4.1	*4.1*	82.1	—	.4	3425
Soup stock	1	—	89.1	—	*5.8*	1.5	—	3.6	166
BEEF ORGANS									
Brain, edible portion	1	—	80.6	8.8	*9.0*	9.3	—	1.1	540
Heart, edible portion	2	—	62.6	16.0	*16.0*	20.4	—	1.0	1125

TABLE 16. AVERAGE COMPOSITION OF CUTS OF BEEF — Continued

Description	Number of Analyses	Refuse	Water	Protein N × 6.25	Protein By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
BEEF ORGANS		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Kidney, as purchased	1	19.9	63.1	13.7	—	1.9	.4	1.0	333
Beef liver, as purchased	1	7.3	65.6	20.2	—	3.1	2.5	1.3	539
Lungs, as purchased	1	—	79.7	16.4	*16.1*	3.2	—	1.0	438
Marrow, as purchased	1	—	3.3	2.2	*2.6*	92.8	—	1.3	3830
Sweetbreads, as purchased	1	—	70.9	16.8	*15.4*	12.1	—	1.6	800
Suet, as purchased	9	—	13.7	4.7	*4.2*	81.8	—	.3	3420
Tongue:									
Edible portion	3	—	70.8	18.9	*19.0*	9.2	—	1.0	719
As purchased	3	26.5	51.8	14.1	*14.2*	6.7	—	.8	530
BEEF, COOKED									
Round steak, fat partly removed	18	—	63.0	27.6	*27.5*	7.7	—	1.8	815
Sirloin steak, baked	1	—	63.7	23.9	*24.7*	10.2	—	1.4	850
Loin steak, tenderloin, broiled, edible portion	6	—	54.8	23.5	*23.6*	20.4	—	1.2	1260
Sandwich meat	3	—	58.3	28.0	*27.9*	11.0	—	2.8	958
BEEF, CANNED									
Chili-con-carne	1	—	75.4	13.3	—	4.6	4.0	2.7	502
Collops, minced	1	—	72.3	17.8	—	6.8	1.1	1.9	611
Corned beef	15	—	51.8	26.3	*25.5*	18.7	—	4.0	1240
Dried beef	2	—	44.8	39.2	*38.6*	5.4	—	11.2	932
Kidneys, stewed	2	—	71.9	18.4	—	5.1	2.1	2.5	570
Luncheon beef	1	—	52.9	27.6	*26.4*	15.9	—	4.8	1150
Roast beef	4	—	58.9	25.9	*25.0*	14.8	—	1.3	1070
Rump steak	1	—	56.3	24.3	*23.5*	18.7	—	1.5	1200
Sweetbreads	1	—	69.0	20.2	*19.5*	9.5	—	2.0	755
Tongue, ground	6	—	49.9	21.4	*21.0*	25.1	—	4.0	1410
Tongue, whole	5	—	51.3	19.5	*21.5*	23.2	—	4.0	1300
Tripe	2	—	74.6	16.8	*16.4*	8.5	—	.5	652
BEEF, CORNED AND PICKLED									
Corned beef, all analyses:									
Edible portion	10	—	53.6	15.6	*15.3*	26.2	—	4.9	1350
As purchased	10	8.4	49.2	14.3	*14.0*	23.8	—	4.6	1230

TABLE 16. AVERAGE COMPOSITION OF CUTS OF BEEF — Continued

Description	Number of Analyses	Refuse	Water	Protein: N × 6.25	Protein: By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
BEEF, CORNED AND PICKLED		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Spiced beef, rolled . . .	1	—	30.0	12.0	*11.8*	51.4	—	6.8	2320
Tongues, pickled:									
Edible portion	2	—	62.3	12.8	*12.5*	20.5	—	4.7	1070
As purchased	2	6.0	58.9	11.9	*11.6*	19.2	—	4.3	1000
Tripe	4	—	86.5	11.7	*11.8*	1.2	.2	.3	265
BEEF, DRIED, ETC.									
Dried, salted, and smoked:									
Edible portion	7	—	54.3	30.0	*30.1*	6.5	—	9.1	810
As purchased	2	4.7	53.7	26.4	*25.8*	6.9	—	8.9	761

Veal

Veal is the meat of calves which under the United States Meat Inspection Regulations must be not less than three weeks old at the time of slaughter.[1] Meat of calves less than three weeks old is popularly known as "bob veal."

As a food veal is generally regarded in this country with less favor than beef, and with greater suspicion the younger the animal. Thus Gilman Thompson writes: "Veal, especially when obtained from animals killed too young, is usually tough, pale, dry, and indigestible." According to Friedenwald and Rührah: "Veal is tough and indigestible, especially when obtained from animals that are killed too young. It differs considerably in flavor from beef, and contains more gelatin than the latter. As in many persons veal has a tendency to

[1] In Europe no objection is raised to the use of veal from younger calves. Edelmann states that in Germany calves are commonly slaughtered at from three days to three weeks of age.

produce indigestion, it is to be avoided in all cases of digestive debility."

The experiments conducted in the Bureau of Animal Industry of the United States Department of Agriculture by Berg indicate no significant difference in digestibility between mature beef and immature veal.

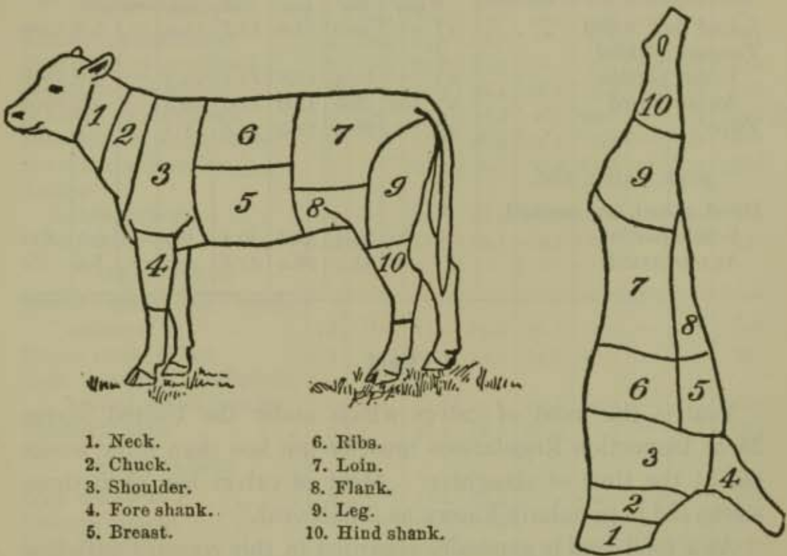


FIG. 15. — Cuts of veal. (Atwater and Bryant.) U. S. Department of Agriculture.

The method of cutting up a side of veal is quite different from that followed in the case of beef. The cuts recognized in the tables of Atwater and Bryant are shown in Fig. 15.

The average composition of the various cuts of veal, based on the results of American analyses compiled by Atwater and Bryant, is given in Table 17.

TABLE 17. AVERAGE COMPOSITION OF CUTS OF VEAL

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN N × 6.25	PROTEIN By difference	FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Breast, very lean:									
Edible portion	1	—	73.2	23.1	*23.1*	2.5	—	1.2	522
As purchased	1	46.8	38.9	12.3	*12.3*	1.3	—	.7	276
Breast, lean:									
Edible portion	3	—	70.3	21.2	*20.7*	8.0	—	1.0	711
As purchased	3	23.4	54.0	15.7	*16.1*	6.2	—	.7	538
Breast, all analyses:									
Edible portion	8	—	68.2	20.3	*19.8*	11.0	—	1.0	817
As purchased	8	24.5	51.3	15.3	*14.8*	8.6	—	.8	629
Chuck, lean:									
Edible portion	1	—	76.3	—	*20.6*	1.9	—	1.2	451
As purchased	1	19.0	61.8	—	*16.7*	1.6	—	.9	368
Chuck, all analyses:									
Edible portion	7	—	73.8	19.7	*19.4*	5.8	—	1.0	595
As purchased	7	19.0	59.8	16.0	*15.7*	4.7	—	.8	483
Flank, all analyses, as purchased	6	—	66.9	20.1	*19.4*	12.7	—	1.0	884
Leg, lean:									
Edible portion	9	—	73.5	21.3	*21.2*	4.1	—	1.2	554
As purchased	9	9.1	66.8	19.4	*19.3*	3.7	—	1.1	503
Leg, all analyses:									
Edible portion	19	—	71.7	20.7	*20.5*	6.7	—	1.1	649
As purchased	18	11.7	63.4	18.3	*18.1*	5.8	—	1.0	569
Leg, cutlets:									
Edible portion	3	—	70.7	20.3	*20.5*	7.7	—	1.1	683
As purchased	3	3.4	68.3	20.1	*19.8*	7.5	—	1.0	671
Loin, lean:									
Edible portion . . .	5	—	73.3	20.4	*19.9*	5.6	—	1.2	599
As purchased	5	22.0	57.1	15.9	*15.6*	4.4	—	.9	468
Loin, all analyses:									
Edible portion	13	—	69.5	19.9	*19.4*	10.0	—	1.1	770
As purchased . .	13	18.9	56.3	16.1	*15.7*	8.2	—	.9	627
Neck:									
Edible portion	6	—	72.6	20.3	*19.5*	6.9	—	1.0	650
As purchased	6	31.5	49.9	13.9	*13.3*	4.6	—	.7	440

TABLE 17. AVERAGE COMPOSITION OF CUTS OF VEAL — Continued

Description	Number of Analyses	Refuse	Water	Protein N × 6.25	Protein By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Rib, medium fat:									
Edible portion	9	—	72.7	20.7	*20.1*	6.1	—	1.1	625
As purchased	9	25.3	54.3	15.5	*15.0*	4.6	—	.8	469
Rib, all analyses:									
Edible portion	12	—	69.8	20.2	*19.7*	9.4	—	1.1	750
As purchased	12	25.0	52.3	15.2	*14.8*	7.1	—	.8	566
Rump:									
Edible portion	1	—	62.6	19.8	*20.1*	16.2	—	1.1	1020
As purchased	1	30.2	43.7	13.8	*14.0*	11.3	—	.8	712
Shank, fore:									
Edible portion	6	—	74.0	20.7	*19.8*	5.2	—	1.0	588
As purchased	6	40.4	44.1	12.2	*11.8*	3.1	—	.6	347
Shank, hind, medium fat:									
Edible portion	6	—	74.5	20.7	*19.9*	4.6	—	1.0	563
As purchased	6	62.7	27.8	7.7	*7.4*	1.7	—	.4	209
Shoulder, lean:									
Edible portion	2	—	73.4	20.7	*20.7*	4.6	—	1.3	563
As purchased	2	18.3	59.9	16.9	*16.9*	3.9	—	1.0	466
Fore quarter:									
Edible portion	6	—	71.7	20.0	*19.4*	8.0	—	.9	690
As purchased	6	24.5	54.2	15.1	*14.6*	6.0	—	.7	519
Hind quarter:									
Edible portion	6	—	70.9	20.7	*19.8*	8.3	—	1.0	715
As purchased	6	20.7	56.2	16.2	*15.7*	6.6	—	.8	565
Side, with kidney, fat, and tallow:									
Edible portion	6	—	71.3	20.2	*19.6*	8.1	—	1.0	698
As purchased	6	22.6	55.2	15.6	*15.1*	6.3	—	.8	540
VEAL ORGANS									
Heart, as purchased . .	1	—	73.2	16.8	*16.2*	9.6	—	1.0	697
Kidneys, as purchased . .	2	—	75.8	16.9	*16.5*	6.4	—	1.3	568
Liver, as purchased . . .	2	—	73.0	19.0	*20.4*	5.3	—	1.3	561
Lungs, as purchased . . .	1	—	76.8	17.1	*17.1*	5.0	—	1.1	514

Mutton and Lamb

Sheep and lambs are slaughtered by bleeding and then dressed in much the same manner as cattle. The dressed weight is usually 45 to 50 per cent of the live weight.

According to Atwater and Bryant the cuts in a side of mutton or lamb number but six, three in each quarter. The "loin"

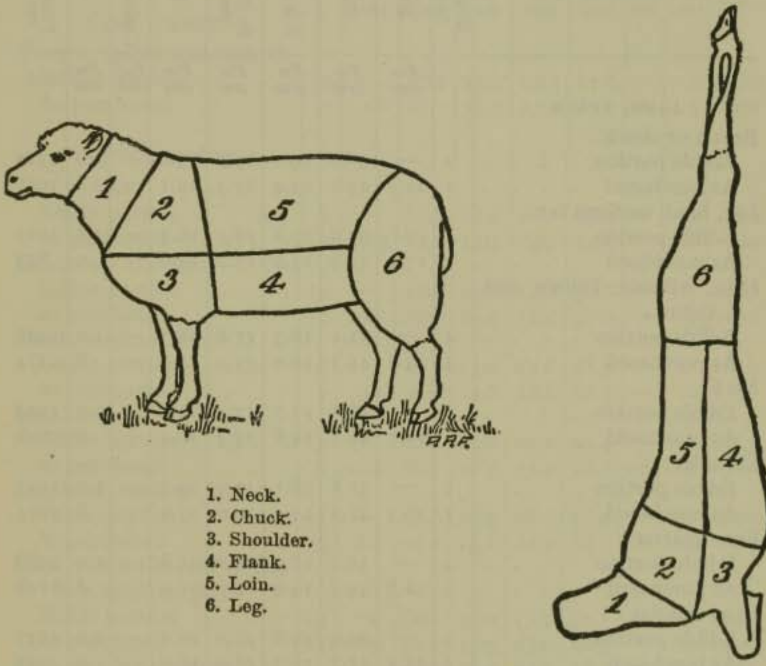


FIG. 16. — Cuts of lamb and mutton. (Atwater and Bryant.) U. S. Department of Agriculture.

extends forward to the shoulder blades and the "flank" is made to include all the under side of the animal. (See Fig. 16.)

The term "chops" is used to designate portions of either the loin, ribs, chuck, or shoulder which are cut or "chopped" by the butcher into pieces suitable for broiling or frying.

The following table (Table 18) gives the composition of cuts of mutton and lamb according to Atwater and Bryant.

TABLE 18. AVERAGE COMPOSITION OF LAMB AND MUTTON

Description	Number of Analyses	Refuse	Water	Protein N × 6.25	Protein By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
LAMB, FRESH									
Breast or chuck:									
Edible portion	1	—	56.2	19.1	*19.2*	23.6	—	1.0	1310
As purchased	1	19.1	45.5	15.4	*15.5*	19.1	—	.8	1057
Leg, hind, medium fat:									
Edible portion	2	—	63.9	19.2	*18.5*	16.5	—	1.1	1022
As purchased	2	17.4	52.9	15.9	*15.2*	13.6	—	.9	844
Loin, without kidney and tallow:									
Edible portion	4	—	53.1	18.7	*17.6*	28.3	—	1.0	1495
As purchased	4	14.8	45.3	16.0	*15.0*	24.1	—	.8	1274
Neck:									
Edible portion	1	—	56.7	17.7	*17.5*	24.8	—	1.0	1334
As purchased	1	17.7	46.7	14.6	*14.4*	20.4	—	.8	1098
Shoulder:									
Edible portion	1	—	51.8	18.1	*17.5*	29.7	—	1.0	1541
As purchased	1	20.3	41.3	14.4	*14.0*	23.6	—	.8	1225
Fore quarter:									
Edible portion	1	—	55.1	18.3	*18.1*	25.8	—	1.0	1386
As purchased	1	18.8	44.7	14.9	*14.7*	21.0	—	.8	1128
Hind quarter:									
Edible portion	1	—	60.9	19.6	*19.0*	19.1	—	1.0	1137
As purchased	1	15.7	51.3	16.5	*16.0*	16.1	—	.9	957
Side, without tallow:									
Edible portion	3	—	58.2	17.6	*17.6*	23.1	—	1.1	1263
As purchased	3	19.3	47.0	14.1	*14.2*	18.7	—	.8	1020
LAMB, COOKED									
Chops, broiled:									
Edible portion	4	—	47.6	21.7	*21.2*	29.9	—	1.3	1615
As purchased	1	13.5	40.1	18.4	*18.5*	26.7	—	1.2	1425
Leg, roast	1	—	67.1	19.7	*19.4*	12.7	—	.8	876

TABLE 18. AVERAGE COMPOSITION OF LAMB AND MUTTON — Continued

Description	Number of Analyses	Refuse	Water	Protein		Fat	Carbohydrates	Ash	Fuel Value per Pound
				N × 6.25	By difference				
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cal.*
LAMB, CANNED									
Tongue, spiced and cooked:									
Edible portion	1	—	67.4	13.9	*14.3*	17.8	—	.5	980
As purchased	1	2.6	65.7	13.5	*13.9*	17.3	—	.5	951
MUTTON, FRESH									
Chuck, lean:									
Edible portion	1	—	64.7	17.8	*18.1*	16.3	—	.9	989
As purchased	1	19.5	52.1	14.3	*14.5*	13.1	—	.8	794
Chuck, all analyses:									
Edible portion	10	—	48.2	14.6	*14.2*	36.8	—	.8	1767
As purchased	10	19.4	38.5	11.7	*11.4*	30.0	—	.7	1437
Flank, medium fat:									
Edible portion	8	—	46.2	15.2	*14.8*	38.3	—	.7	1839
As purchased	2	9.9	39.0	13.8	*13.6*	36.9	—	.6	1757
Leg, hind, lean:									
Edible portion	3	—	67.4	19.8	*19.1*	12.4	—	1.1	865
As purchased	3	16.8	56.1	16.5	*15.9*	10.3	—	.9	720
Leg, hind, medium fat:									
Edible portion	11	—	62.8	18.5	*18.2*	18.0	—	1.0	1070
As purchased	11	18.4	51.2	15.1	*14.9*	14.7	—	.8	874
Loin, without kidney or tallow, medium fat:									
Edible portion	13	—	50.2	16.0	*15.9*	33.1	—	.8	1642
As purchased	12	16.0	42.0	13.5	*13.0*	28.3	—	.7	1400
Loin, free fat removed . .	1	—	56.5	23.7	*23.9*	18.5	—	1.1	1185
Neck, medium fat:									
Edible portion	10	—	58.1	16.9	*16.3*	24.6	—	1.0	1311
As purchased	10	27.4	42.1	12.3	*11.9*	17.9	—	.7	954
Shoulder, lean:									
Edible portion	1	—	67.2	19.5	*18.9*	12.9	—	1.0	905
As purchased	1	25.3	50.2	14.6	*14.2*	9.6	—	.7	675
Shoulder, medium fat:									
Edible portion	7	—	61.9	17.7	*17.3*	19.9	—	.9	1133
As purchased	7	22.5	47.9	13.7	*13.4*	15.5	—	.7	881

TABLE 18. AVERAGE COMPOSITION OF LAMB AND MUTTON — Continued

Description	Number of Analyses	Refuse	Water	Protein N × 6.25	Protein By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
Fore quarter:									
Edible portion	10	—	52.9	15.6	*15.3*	30.9	—	.9	1545
As purchased	10	21.2	41.6	12.3	*12.0*	24.5	—	.7	1224
Hind quarter:									
Edible portion	10	—	54.8	16.7	*16.3*	28.1	—	.8	1451
As purchased	10	17.2	45.4	13.8	*13.5*	23.2	—	.7	1198
Side, including tallow:									
Edible portion	25	—	54.2	16.3	*16.0*	28.9	—	.9	1475
As purchased	25	18.1	45.4	13.0	*12.7*	23.1	—	.7	1180
MUTTON, COOKED									
Mutton, leg roast, edible portion	2	—	50.9	25.0	*25.3*	22.6	—	1.2	1377
MUTTON, ORGANS									
Heart, as purchased . . .	2	—	69.5	16.9	*17.0*	12.6	—	.9	821
Kidneys, as purchased . .	1	—	78.7	16.5	*16.8*	3.2	—	1.3	430
Liver, as purchased . . .	2	—	61.2	23.1	—	9.0	5.0	1.7	878
Lungs, as purchased . . .	2	—	75.9	20.2	*20.1*	2.8	—	1.2	481
MUTTON, CANNED									
Corned	1	—	45.8	28.8	*27.2*	22.8	—	4.2	1454
Tongue	1	—	47.6	24.4	*23.6*	24.0	—	4.8	1423

Pork

The slaughtering and packing of pork is carried on largely in the same establishments with the beef-packing industry, but the processes are quite different. The hog is killed by bleeding and then scalded by dropping into a tank of hot water from which the carcass is drawn up through a tower in which mechanical scrapers remove the bristles, thence through the hands of successive workmen who dress and trim the carcass, split it in half, and send the halves to the refrigerating room. This entire process is completed in about 12 minutes, the carcasses following each other over the same track with almost incredible rapidity, sometimes as many as 400 hogs per hour.

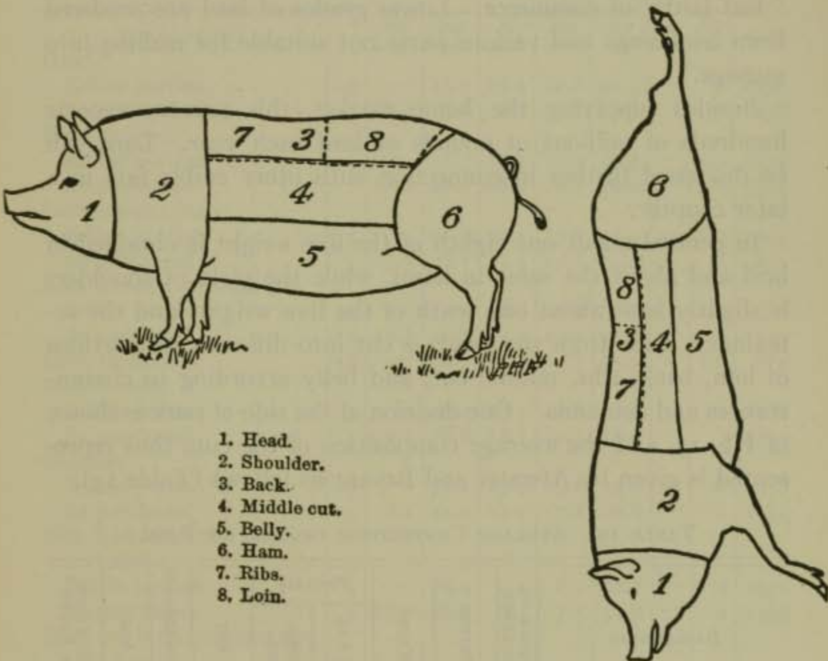


Fig. 17.—Cuts of pork. (Atwater and Bryant.) U. S. Department of Agriculture.

The by-products of slaughter are utilized according to the same general principles as in the beef industry, but with many differences in detail which need not be considered here.

Hogs are dressed without removal of the heads, and being fatter than cattle show a larger yield of dressed weight — usually 75 to 85 per cent of the live weight.

After having hung a couple of days in the chilling room the sides of pork are taken out, cut into the usual market pieces, a part sent to the refrigerator cars to be marketed fresh, and a much larger part, generally about nine tenths of the whole, is cured in various ways, chiefly by salting or smoking or both.

The fat from the abdominal cavity of the hog furnishes the "leaf lard" of commerce. Lower grades of lard are rendered from trimmings and various parts not suitable for making into sausage.

Besides supplying the home market, this country exports hundreds of millions of pounds of lard each year. Lard will be discussed further in connection with other edible fats in a later chapter.

In general about one eighth of the live weight is obtained in lard and about the same in hams, while the yield of shoulders is slightly less (about one tenth of the live weight) and the remainder, aside from the head, is cut into different proportions of loin, back, ribs, middle cut, and belly according to circumstances and demands. One division of the side of pork is shown in Fig. 17, and the average composition of the cuts thus represented is given by Atwater and Bryant as follows (Table 19).

TABLE 19. AVERAGE COMPOSITION OF CUTS OF PORK

Description	Number of Analyses	Refuse	Water	Protein		Fat	Carbohydrates	Ash	Fuel Value per Pound
				N × 6.25	By difference				
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cal.*
PORK, FRESH									
Ham, fresh, lean:									
Edible portion . . .	2	—	60.0	25.0	*24.3*	14.4	—	1.3	1042
As purchased . . .	2	.9	59.4	24.8	*24.2*	14.2	—	1.3	1030
Ham, fresh, medium fat:									
Edible portion . . .	10	—	53.9	15.3	*16.4*	28.9	—	.8	1457
As purchased . . .	10	10.7	48.0	13.5	*14.6*	25.9	—	.8	1302

TABLE 19. AVERAGE COMPOSITION OF CUTS OF PORK — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN N × 6.25	PROTEIN By difference	FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
PORK, FRESH									
Head:									
Edible portion	3	—	45.3	13.4	*12.7*	41.3	—	.7	1930
As purchased	3	68.4	13.8	4.1	*3.8*	13.8	—	.2	638
Head cheese:									
Edible portion	3	—	43.3	19.5	*16.9*	33.8	—	3.3	1734
As purchased	1	12.1	42.3	18.9	*18.6*	24.0	—	3.0	1323
Loin (chops), lean:									
Edible portion	1	—	60.3	20.3	*19.7*	19.0	—	1.0	1144
As purchased	1	23.5	46.1	15.5	*15.1*	14.5	—	.8	873
Loin (chops), medium fat:									
Edible portion	19	—	52.0	16.6	*16.9*	30.1	—	1.0	1530
As purchased	19	19.7	41.8	13.4	*13.5*	24.2	—	.8	1230
Loin, tenderloin	11	—	66.5	18.9	*19.5*	13.0	—	1.0	874
Middle cuts:									
Edible portion	3	—	48.2	15.7	*14.8*	36.3	—	.7	1768
As purchased	3	19.7	38.6	12.7	*12.1*	28.9	—	.7	1391
Shoulder:									
Edible portion	19	—	51.2	13.3	*13.8*	34.2	—	.8	1638
As purchased	19	12.4	44.9	12.0	*12.2*	29.8	—	.7	1435
Side, lard and other fat included:									
Edible portion	3	—	29.4	9.4	*8.5*	61.7	—	.4	2691
As purchased	3	11.2	26.1	8.3	*7.5*	54.8	—	.4	2388
Side, not including lard and kidney:									
Edible portion	11	—	34.4	9.1	*9.8*	55.3	—	.5	2424
As purchased	11	11.5	30.4	8.0	*8.6*	49.0	—	.5	2147
Clear backs:									
Edible portion	8	—	25.1	6.4	*6.9*	67.6	—	.4	2878
As purchased	8	5.7	23.7	6.0	*6.4*	63.8	—	.4	2715
Clear bellies:									
Edible portion	8	—	31.4	6.9	*7.8*	60.4	—	.4	2592
As purchased	8	6.2	29.5	6.5	*7.3*	56.6	—	.4	2429
PORK ORGANS, ETC.									
Brains, as purchased . . .	1	—	75.8	11.7	*12.3*	10.3	—	1.6	633

TABLE 19. AVERAGE COMPOSITION OF CUTS OF PORK — Continued

Description	Number of Analyses	Refuse	Water	Protein N × 6.25	Protein By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cal.
PORK ORGANS, ETC.									
Heart, as purchased	1	—	75.6	17.1	*17.1*	6.3	—	1.0	568
Kidneys, as purchased	2	—	77.8	15.5	—	4.8	0.7	1.2	490
Liver, as purchased	1	—	71.4	21.3	—	4.5	1.4	1.4	596
Lungs, as purchased	1	—	83.3	11.9	*11.8*	4.0	—	.9	379
Marrow, as purchased	6	—	14.6	2.3	*4.2*	81.2	—	?	3357
PORK, PICKLED, SALTED, AND SMOKED									
Ham, smoked, lean:									
Edible portion	3	—	53.5	19.8	*20.2*	20.8	—	5.5	1207
As purchased	3	11.5	47.2	17.5	*17.9*	18.5	—	4.9	1073
Ham, smoked, medium fat:									
Edible portion	14	—	40.3	16.3	*16.1*	38.8	—	4.8	1880
As purchased	14	13.6	34.8	14.2	*14.0*	33.4	—	4.2	1621
Ham, luncheon, cooked:									
Edible portion	2	—	49.2	22.5	*24.0*	21.0	—	5.8	1266
As purchased	2	2.1	48.1	22.1	*23.5*	20.6	—	5.7	1243
Shoulder, smoked, medium fat:									
Edible portion	3	—	45.0	15.9	*15.8*	32.5	—	6.7	1615
As purchased	3	18.2	36.8	13.0	*12.9*	26.6	—	5.5	1322
Pigs' tongues, pickled:									
Edible portion	2	—	58.6	17.7	*18.0*	19.8	—	3.6	1130
As purchased	2	3.2	56.8	17.1	*17.5*	19.1	—	3.4	1090
Pigs' feet, pickled:									
Edible portion	2	—	68.2	16.3	*16.1*	14.8	—	.9	900
As purchased	2	35.5	44.6	10.2	*10.0*	9.3	—	.6	565
Dry-salted backs:									
Edible portion	2	—	17.3	7.7	*7.2*	72.7	—	2.8	3110
As purchased	2	8.1	15.9	7.1	*6.5*	66.8	—	2.7	2858
Dry-salted bellies:									
Edible portion	2	—	17.7	8.4	*6.7*	72.2	—	3.4	3100
As purchased	2	8.2	16.2	7.7	*6.2*	66.2	—	3.2	2842

TABLE 19. AVERAGE COMPOSITION OF CUTS OF PORK — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN N × 6.25	PROTEIN By difference	FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cal.*
PORK, PICKLED, SALTED, AND SMOKED									
Salt pork, clear fat	7	—	7.9	1.9	*2.0*	86.2	—	3.9	3575
Bacon, smoked, all analyses:									
Edible portion	19	—	20.2	10.5	*9.9*	64.8	—	5.1	2836
As purchased	19	8.7	18.4	9.5	*9.0*	59.4	—	4.5	2597
Ham, deviled	6	—	44.1	19.0	*18.5*	34.1	—	3.3	1738
SAUSAGE									
Arles:									
Edible portion	1	—	17.2	26.8	*24.9*	50.6	—	7.3	2554
As purchased	1	5.2	16.3	25.4	*23.6*	48.0	—	6.9	2422
Bologna:									
Edible portion	8	—	60.0	18.7	*18.4*	17.6	.3	3.7	1063
As purchased	4	3.3	55.2	18.2	*18.0*	19.7	—	3.8	1134
Frankfort	8	—	57.2	19.6	*19.7*	18.6	1.1	3.4	1034
Pork, as purchased	11	—	39.8	13.0	*12.7*	44.2	1.1	2.2	2052
Pork and beef chopped together, as purchased	1	—	55.4	19.4	*19.5*	24.1	—	1.0	1327
Summer:									
Edible portion	3	—	23.2	26.0	*24.6*	44.5	—	7.7	2289
As purchased	2	7.0	20.9	24.5	*23.0*	42.1	—	7.0	2163

Legislation and Inspection

Since meats vary so greatly in fat content it is impracticable to set standards for percentages of nutrients. Moreover, as ordinarily sold by the butcher there is little chance for any such robbing of nutrients as is involved in the skimming and watering of milk. Standards of quantitative composition have therefore not been adopted for meat itself, although there are such standards for certain manufactured products of meat as will be seen later.

Standards for meat itself relate chiefly to the healthfulness of the animals from which obtained and the sanitary conditions in which the meat is handled. These are matters of great importance. In the preface to their translation of Edelmann's *Textbook of Meat Hygiene*, Mohler and Eichhorn of the United States Bureau of Animal Industry write: "Of the various classes of foods, meat is one of the most important, and it is certainly the one most subject to conditions rendering it unwholesome or even dangerous."

Not only are certain diseases of animals communicable to man through eating of the flesh, but also there is always danger through lack of cleanliness in the slaughter house, exposure to dust or flies, handling by men who are "carriers" of disease germs, or by other accident, that meat may be infected with organisms such as the *Bacillus enteritidis*, which according to Buchanan multiply in the meat, producing poisonous products which are not destroyed by cooking, and which are now considered to be the commonest cause of food poisoning, including what is ordinarily called ptomaine poisoning.

The flesh may become infected with *Bacillus enteritidis* either before or after the slaughter of the animal. Veterinary inspection seeks to exclude animals thus infected as well as those diseased in other ways. To prevent the infection of the meat during slaughter house operations and subsequent handling requires strict sanitation.

Experiments cited by Buchanan[1] have shown that when *Bacillus enteritidis* is placed upon the surface of fresh meat, it rapidly penetrates to the interior of the tissues even when the meat is stored at a relatively low temperature.

Since this organism may occur in the intestinal contents and feces of even healthy animals it is plain that every precaution should be used to see not only that the animal is not diseased but also that fecal material is never allowed to come in contact

[1] *Household Bacteriology*, pages 386–389.

with the healthy tissues. This means the rigid exclusion of flies and a high degree of cleanliness in all the operations.

Veterinary and sanitary inspection and control of slaughter houses and meat-packing establishments is therefore extremely important. For the establishments which send products into interstate or foreign commerce, this is provided by the United States Department of Agriculture under the meat inspection law of 1906. Official records show that a total of over 55,000,000 cattle, sheep, goats, and swine are thus inspected annually. There are, however, about as many more which are slaughtered for food in establishments doing business entirely within one state and which therefore do not come under the jurisdiction of the national authorities. Thus there is urgent need of adequate state and municipal inspection to supplement the Federal inspection in order to insure the wholesomeness of all meat sold to consumers.

Only the provisions of the Federal inspection can be discussed here.

Federal meat inspection. In an amendment to the law making appropriation for the United States Department of Agriculture (Public Number 382, approved June 30, 1906) Congress authorized the Secretary of Agriculture to provide for inspection of all packing houses whose products enter into interstate or foreign commerce, to inspect all animals before and after slaughter and condemn all carcasses or parts thereof found unfit for food. It was provided that inspectors shall have access to all parts of the packing houses at all times of the day and night to examine all meat food products prepared " and said inspectors shall label, mark, stamp, or tag as ' Inspected and Condemned ' all such products found unsound, unhealthful, and unwholesome, or which contain dyes, chemicals, preservatives, or ingredients which render such meat food products unsound, unhealthful, unwholesome, or unfit for human food: *Provided*, that subject to the rules and regulations of the Secretary of Agriculture, the provisions hereof in regard to preservatives shall not apply to meat food products for export to any foreign country and which are prepared or packed according to the specifications or directions of the foreign purchaser, when no substance is used in the preparation or packing thereof in conflict with the laws of the foreign country to which said article is to be exported." Meats from healthy animals prepared in sanitary establishments in accordance with all requirements are labeled "Inspected and Passed," and *only meat products so labeled are allowed in interstate or foreign commerce.* The penalties provided for violation of this meat inspection law are more severe than those for violation of the general food law, and the sum appropriated for the work of meat inspection ($3,000,000 a year) is much greater than has yet been provided for the enforcement of the Food and Drugs Act.

The Secretary of Agriculture is authorized to furnish "certificates of exemption" to farmers and retail butchers, who are exempted under the law. The regulations governing the meat inspection of the United States Department of Agriculture are published in Order No. 211 of the Bureau of Animal Industry of the Department, to which Bureau is delegated the conduct of this work. Among these regulations are detailed requirements as to sanitary arrangements in slaughter and packing houses, and the sanitary conduct of all the operations; also explicit provision as to what diseases (and in what degrees) shall cause a carcass to be condemned, what may be passed, and what intermediate grades may be rendered for lard or tallow but not used for meat. Condemned meats are treated with such colors as would prevent their sale for food, and as soon as possible are placed in rendering tanks and "a sufficient force of steam is turned into the tank and maintained a sufficient length of time effectually to render the contents unfit for any edible product." The regulation regarding preservative substances and colors provides that common salt, sugar, wood smoke, vinegar, pure spices, and saltpeter may be added. Sodium benzoate may be used when its presence and amount are shown on the label. Only such coloring matters as may be designated by the Secretary of Agriculture as being harmless may be used and these only in such manner as the Secretary of Agriculture may designate.

The full text of the meat inspection law and some of the regulations for its enforcement, especially those which are in the nature of requirements as to sanitation, and the sanitary handling of meats and other slaughter house products intended for food will be found in the Appendix.

The need of adequate State and city meat inspection to supplement the work of the Federal authorities has already been mentioned. This is important both to secure proper conditions in local slaughter houses and to insure proper handling of the meat in wholesale and retail markets and shops. The flesh of a healthy animal should be practically sterile at slaughter, and we have seen above that in good meat kept frozen the multiplication and penetration of bacteria is slow; but in an investigation by Weinzirl and Newton, the bacteria content of Hamburg steak as sold was found to range from 269,000 to 525,000,000 bacteria per gram, about half the samples examined showing over 10,000,000. Plainly consumers should demand a more careful handling of meat products.

Aside from the question of the sanitary character of the meat supply which is of very real importance to health, the trade also recognizes differences in "quality" or grade depending upon the texture and palatability of the meat which are considerably influenced by the age, nutritive condition, and other characteristics of the animal. These differences are of no particular significance to the food value or wholesomeness of the meat, but since the market price depends largely upon them, they are of considerable commercial importance and differences of usage regarding such commercial classification and grading tends to demoralize the meat industry.

The United States Department of Agriculture has endeavored to assist in solving this problem by adopting a standard set of **classes and grades for cattle and calves** and formulating simple and easily understood definitions for each.

Cattle and calves for slaughter have been divided into seven classes: Steers, baby beef, heifers, cows, stags, bulls, and veal calves. Some of these are still further divided into subclasses on weight, such as heavyweights, mediumweights, and lightweights.

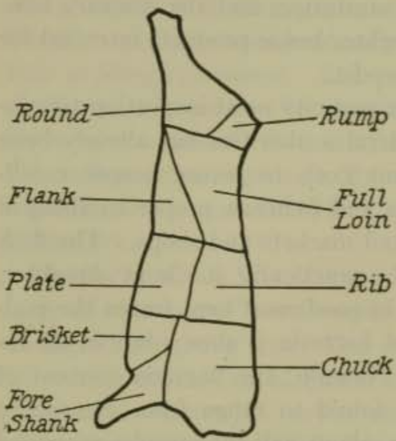


Fig. 18. — Wholesale Cuts of Beef according to the Chicago System of Cutting. United States Department of Agriculture, Yearbook for 1921, page 308.

Having grouped the animals in these seven classes, such grouping being based largely on sex and age, each class is further subdivided into grades. Although the number of grades varies somewhat between classes, the more important grades are: Prime, choice, good, medium, and common.

As there is even more confusion in the minds of most people regarding the various classes and grades of dressed meats than of live animals, a similar classification of dressed beef and veal has been made. These grades of the dressed meat correspond with those of the live animals. In other words, a "choice" steer must produce "choice" beef and a "common" steer, "common" beef.

As a basis of understanding the classes and grades of beef, an idea of the important wholesale and retail cuts, their location in the carcass, and the percentage of the total weight of the "side" which each cut comprises, is necessary. (See Fig. 18.) Methods of cutting up a beef carcass vary in different parts of the country, and it is obvious that the number of pounds in the different cuts and the percentage of the carcass weight represented by a given cut will depend upon the method of cutting adopted. The Chicago system of cutting (Fig. 18) is said to be more extensively used than any other. Table 20 shows the result of a cutting test made in Washington, D. C., late in 1921.

TABLE 20. THE WEIGHTS OF THE WHOLESALE AND RETAIL CUTS OF AN OPEN SIDE OF BEEF WEIGHING 291 POUNDS[1]

	POUNDS		POUNDS
Round and Rump (62 pounds):		Chuck (58 pounds):	
Top round steak	12	Chuck roast	32
Bottom round steak	11	Cross rib roast	11
Round roast	$2\frac{3}{4}$	Boneless neck	9
Rump roast	$12\frac{1}{4}$	Fat	$1\frac{1}{2}$
Shank meat	$9\frac{3}{4}$	Bones	$4\frac{1}{2}$
Soup bones	$5\frac{1}{2}$	Flank ($9\frac{1}{2}$ pounds):	
Fat	$1\frac{1}{4}$	Flank steak	$1\frac{1}{2}$
Bones	$7\frac{1}{2}$	Lean trimmings	$3\frac{1}{2}$
Full loin (65 pounds):		Fat	$4\frac{1}{2}$
Sirloin	22	Plate ($20\frac{1}{4}$ pounds):	
Porterhouse steak	$17\frac{1}{2}$	Stewing beef	20
Tip steak	$5\frac{3}{4}$	Lean trimmings	$\frac{1}{4}$
Tip roast	$5\frac{1}{4}$	Brisket ($21\frac{3}{4}$ pounds):	
Hanging tenderloin	2	Sticking piece	$4\frac{1}{4}$
Kidney	1	Stewing beef	$16\frac{1}{4}$
Suet	$9\frac{1}{2}$	Fat	$1\frac{1}{4}$
Fat	1	Fore shank ($22\frac{3}{4}$ lbs.):	
Bones	1	Shoulder clod	$9\frac{3}{4}$
Rib (30 pounds):		Shank meat	5
Rib roast	29	Soup bones	4
Bones	1	Bones	4

Standards of Purity

The following are quoted from the *Standards of Purity for Food Products*, published by the United States Department of Agriculture as Circular 136, Office of the Secretary, June, 1919.

[1] Loss in making wholesale cuts $1\frac{3}{4}$ pounds, due largely to the fact that in weighing the cuts one fourth pound was the smallest unit considered.

a. Meats

1. **Meat, flesh,** is any clean, sound, dressed, and properly prepared edible part of animals in good health at the time of slaughter, and if it bears a name descriptive of its kind, composition, or origin, it corresponds thereto. The term "animals," as herein used, includes not only mammals, but fish, fowl, crustaceans, mollusks, and all other animals used as food.

2. **Fresh meat** is meat from animals recently slaughtered and properly cooled until delivered to the consumer.

3. **Cold-storage meat** is meat from animals recently slaughtered and preserved by refrigeration until delivered to the consumer.[1]

4. **Salted, pickled,** and **smoked meats** are unmixed meats preserved by salt, sugar, vinegar, spices, or smoke, singly or in combination, whether in bulk or in suitable containers.[2]

b. Manufactured Meats

1. **Manufactured meats** are meats not included in paragraphs 2, 3, and 4, whether simple or mixed, whole or comminuted, in bulk or in suitable containers,[2] with or without the addition of salt, sugar, vinegar, spices, smoke, oils, or rendered fat. If they bear names descriptive of kind, composition, or origin, they correspond thereto, and when bearing such descriptive names, if force or flavoring meats are used, the kind and quantity thereof are made known.

c. Meat Extracts, Meat Peptones, Etc.

(Schedule in preparation.)

d. Lard

1. **Lard** is the rendered fresh fat from hogs in good health at the time of slaughter, is clean, free from rancidity, and contains, necessarily incorporated in the process of rendering, not more than one per cent (1%) of substances, other than fatty acids and fat.

[1] The establishment of proper periods of time for cold storage is reserved for future consideration, when the investigations on this subject, authorized by Congress, are completed.

[2] Suitable containers for keeping moist food products, such as sirups, honeys, condensed milk, soups, meat extracts, meats, manufactured meats, and undried fruits and vegetables, and wrappers in contact with food products contain on their surfaces, in contact with the food product, no lead, antimony, arsenic, zinc or copper, or any compounds thereof, or any other poisonous or injurious substance. If the containers are made of tin plate they are outside soldered and the plate in no place contains less than one hundred and thirteen (113) milligrams of tin on a piece five (5) centimeters square or one and eight tenths (1.8) grains on a piece two (2) inches square. The inner coating of the containers is free from pin holes, blisters, and cracks. If the tin plate is lacquered, the lacquer completely covers the tinned surface within the container, and yields to the contents of the container no lead, antimony, arsenic, zinc or copper, or any compounds thereof, or any other poisonous or injurious substance.

2. **Leaf lard** is lard rendered at moderately high temperatures from the internal fat of the abdomen of the hog, excluding that adherent to the intestines, and has an iodin number not greater than sixty (60).

3. **Neutral lard** is lard rendered at low temperatures.

Meat Extracts and Related Products

Beef extract was highly recommended by Liebig, who at one time supposed it to be of great nutritive value because it contained much nitrogen in a form readily absorbed from the digestive tract.

Later he realized that this was an error and said that the extract " does not give us strength but makes us aware of our strength." In other words he realized that the effect of the meat extract is that of a stimulant rather than a food.

Manufacturers of beef extract still frequently apply the term " Liebig's extract " to their product.

In South America, especially before the country was thickly settled and before facilities for transportation of meat for long distances under refrigeration had been introduced, large factories for the manufacture of beef extract were established and droves of cattle were slaughtered for their hides and the extract obtained from their flesh, the rest of the flesh being merely a by-product.

Beef is now shipped in large quantities from South America; but large quantities of beef extract are still made in South America and it is also of considerable importance as one of the numerous secondary products of the beef-packing industry in the United States.

Pieces of meat removed in trimming quarters and sides for market, as well as cuts for which there is less market demand, are cut small and put in water in a closed digester (generally with the addition of salt) and heated under pressure of $1\frac{1}{2}$ atmospheres of steam for several hours until the extraction is judged to be complete, then allowed to cool, the fat removed from the surface, and the liquid strained to remove the solid pieces.

The aqueous solution thus obtained may be used either for soup stock or for making beef extract. In the latter case the liquid is concentrated in a partial vacuum to the consistency of a pasty solid or of a viscous liquid.

About 35 pounds of meat are supposed to yield 1 pound of concentrated extract which on dilution makes about 7 gallons of beef tea.

Creatin has usually been considered the characteristic nitrogen compound of meat extract. Purin bases are, however, also present and may have greater physiological significance. Potassium phosphate is the principal salt (unless extra sodium chloride has been added) and this doubtless plays a part in the stimulating effects of the extract. The acidity of the extract is usually attributed to lactic acid.

Yeast extracts and perhaps other plant extracts are coming into increasing use as substitutes for or adulterants of meat extracts. Plant extract is distinguished from meat extract by the absence of creatin and creatinin. In a recent examination of "bouillon cubes" as sold in the United States, Cook finds large quantities of salt and a considerable substitution of plant extract for meat extract. The results of Cook's analyses are shown in Table 21 on opposite page.

While regarded as adulterants when found in meat extracts, plant extracts may prove to be important food adjuncts on account of their vitamins. It remains to be seen what the ultimate status of plant extract will be.

Nutritive Value of Meats and Meat Products

Although meats differ greatly in the nutrients which they contain, these differences are due in the main to simple variations in fatness. The protoplasm of the muscle cells consists mainly of proteins swollen and partially dissolved in 3 to 4 times their weight of water, in which are small amounts of other organic compounds and about 1 per cent of ash. The fat of meat is usually deposited partly in the cells, but more largely in the connective tissue between the cells, where it often forms layers of considerable thickness. Since fat neither dissolves in nor absorbs water, it is evident that the deposition of fat either in or between the muscle cells does not alter the composition of the actual protoplasm.

TABLE 21. THE COMPOSITION OF COMMERCIAL BOUILLON CUBES (COOK)

CUBE No.[1]	SOURCE OF MANUFACTURE	SALT	WATER AND FAT	APPROXIMATE AMOUNT OF MEAT EXTRACT PRESENT	APPROXIMATE AMOUNT OF PLANT EXTRACT PRESENT
		Per cent	*Per cent*	*Per cent*	*Per cent*
1	United States	62	5.25	28	4.75
2	Germany	65	9	23	3
3	United States	65	8	18	9
4	United States	67.5	5	17.8	9.7
5	United States	59.2	7	17.8	16
6	United States	49.25	5.75	15.33	29.66
7	United States	53	4.1	14.6	28.3
8	Germany	72	5.5	14	8.5
9	United States	72.5	8.5	8.33	10.92
10	United States	72	8.5	8.17	11.33

When an animal is killed, the muscular protoplasm coagulates (rigor mortis), but without essential change in the amount or distribution of moisture, protein, or fat. A piece of meat may therefore be regarded as mainly a mixture of fat and coagulated protoplasm, the latter being chiefly composed of protein with 3 to 4 times its weight of water. We should therefore expect the *fat-free substance* of fresh meat to contain from 20 to 25 per cent of protein regardless of the amount of fat which is or was present.

In the following table are given the average proximate composition and the percentage of protein in the fat-free substance

[1] Cubes arranged in table in order of content of meat extract.

of the entire edible portion of different meats and fish. The data are taken from the tables of analyses in Bulletin 28, Office of Experiment Stations, the figures for proteins being the mean between those given in the bulletin as "protein by difference" and that obtained by multiplying the percentage of nitrogen by 6.25.

TABLE 22. SHOWING RELATION OF WATER, PROTEIN, AND FAT IN MEATS (AND FISH)

KIND OF MEAT OR FISH	WATER	PROTEIN	FAT	ASH	PROTEIN IN FAT-FREE
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Beef (fat)	59.7	17.75	22.0	0.9	22.8
Beef (lean)	67.2	19.0	13.2	0.9	21.9
Veal	71.3	19.9	8.1	1.0	21.7
Mutton	53.6	16.0	29.8	0.8	22.8
Lamb	58.2	17.6	23.1	1.1	22.9
Pork	34.4	9.5	55.3	0.5	21.3
Fowls	63.7	19.2	16.3	1.0	22.9
Bass	77.7	18.45	2.8	1.2	19.0
Blackfish	79.1	18.6	1.3	1.1	18.8
Halibut	75.4	18.5	5.2	1.0	19.5
Salmon	64.6	21.6	12.8	1.4	26.6
Shad	70.6	18.7	9.5	1.3	20.7
Trout (lake)	70.8	17.75	10.3	1.2	19.8

In some species the water content of the tissues changes markedly with age, but among the meats which play any important part in the diet high fat content is associated with decreased percentages of both water and protein, the ratio of water to protein, or the percentage of protein in the fat-free substance, being nearly the same for the different species, the young and mature of the same species, and the different degrees of fatness. This, of course, does not mean that all cuts of meat free from visible fat are of the same composition, for the manner in which the fat is deposited in the muscles differs somewhat with the species. Beef fat is mainly in distinct layers which can be mechanically separated from the lean, while in pork and some other meats, the fat exists largely as minute layers invisible to the naked eye, surrounding the individual muscle fibers and not separable by ordinary mechanical means.

Among the fish, the differences in the protein content of the fat-free substance are larger, and the protein content appears not to be diminished in those cases in which the fat content is higher. In general the muscular protoplasm of the fatter kinds of fish is about as rich in protein as the protoplasm of meats, while among the leaner kinds of fish the muscular protoplasm is more watery.

The fuel value of meat or fish is very directly dependent upon its fatness; a gram of clear fat has a fuel value of about 9 Calories, whereas a gram of clear lean containing about one fourth gram protein has a fuel value of but 1 Calorie.

The amount of *glycogen* present in muscular tissue as usually marketed is too small to be of significance in determining the food value. Some kinds of meats tend to be richer in glycogen than others, horse-flesh than beef for example.

The *fats* vary somewhat in composition both as between different species and different organs of the same species, but, so far as is known these variations in the composition of the fat are of little nutritive significance.

Protein. As between muscle protein and gelatin, there are pronounced differences. It has long been known that gelatin alone cannot meet the entire protein requirement of the animal body. Since the development of methods for the isolation of individual amino acids from the products of hydrolysis of proteins, this deficiency in food value of gelatin has been correlated with the absence of certain amino-acid radicles, conspicuously tryptophane.

The amounts of amino acids thus far isolated from beef protein and from gelatin are compared in Table 23.

TABLE 23. AMINO ACIDS FROM BEEF AND GELATIN

	BEEF PROTEIN	GELATIN[1]
	Per cent	*Per cent*
Glycine	2.06	25.5
Alanine	3.72	8.7
Valine	0.81	——
Leucine	11.65	7.1
Proline	5.82	9.5
Hydroxyproline	——	14.1
Phenylalanine	3.15	1.4
Aspartic acid	4.51	3.4
Glutamic acid	15.49	5.8
Serine	——	0.4
Tyrosine	2.20	0.01
Arginine	7.47	8.2
Histidine	1.76	0.9
Lysine	7.59	5.9
Ammonia	1.07	0.4
Tryptophane	present	absent
Summation	67.30	91.31

Opinions vary as to whether there are significant differences in the *extractives* of different kinds of meats. Hutchison and Gautier hold that there are no well-marked differences, while Wiley reports comparative analyses of light and dark meat of fowls according to which the dark meat is much richer in "meat bases" than the light.

Among the extractives, creatin is most conspicuous, constituting about 0.25 per cent of the fresh weight of lean meat and being ordinarily the most abundant organic substance of meat extract. It is probable, however, that the properties of meat extract are due less to the creatin than to the purins and potassium salts.

[1] The figures here given for gelatin are those published by Dakin in 1920.

Purins exist in meat both "free" (as in the form of hypoxanthin, adenin, guanin) and "bound" as constituents of the nucleoproteins. Hall has determined the amounts of nitrogen existing as free and as bound purin in some different meats with the results shown in Table 24.

TABLE 24. PURINS IN DIFFERENT MEATS (HALL)

	Nitrogen in Form of		
	"Free" purins	"Bound" purins	Total purins
	Per cent	*Per cent*	*Per cent*
Beef	0.0460	0.0070	0.053
Veal	0.0430	0.0100	0.053
Ham	0.0398	0.0064	0.046
Chicken	0.0348	0.0147	0.049
Codfish	0.0299	0.0106	0.040
Liver	0.0330	0.0790	0.112
Sweetbread	0.0420	0.3510	0.393

It will be seen that the amount of purin nitrogen is about the same for the muscular flesh of the different kinds, even including fish, but is much higher in the liver and sweetbread on account of the relatively large amount of nucleoproteins in the highly nucleated secreting cells of these organs.

Ash constituents of meats. Clear lean meat consisting essentially of muscle tissue contains about 1 per cent of ash; clear fat has hardly any. The proportion of total ash or of any given ash constituent is therefore largely dependent upon the fatness of the meat and runs more or less parallel with the percentage of protein present. While the ash constituents of the muscle tissue probably differ somewhat with different species and with the same species at different ages, yet recent analyses indicate that such differences are much smaller than the usually quoted data would indicate. After study of all the data at present available, it seems best not to assume any distinct and constant differences in the ash constituents of the lean tissue of different animals, but to estimate that the ash constituents of meats in general will be proportional to the protein content. Average meat is calculated to contain *per 100 grams of protein* about as follows: calcium, 0.05 gram; magnesium, 0.12 gram; potassium, 1.2 grams; sodium, 0.3 gram; phosphorus, 1.0 gram; chlorine, 0.2 gram; sulphur, 0.9 gram; iron, 0.015 gram.

In all meats there is a decided excess of the acid-forming over the base-forming elements. For equal degrees of fatness, the different kinds of meat appear to be practically alike in this respect.

Digestibility of meat. Meat protein is usually digested quite rapidly and shows a high percentage of absorption from the digestive tract, the average "coefficient of digestibility" being about the same for the protein of meat, milk, and eggs, viz., 97 to 98 per cent. The extractives of meat probably aid to some extent the digestion of the proteins by stimulating the flow of gastric juice. In a series of seven experiments in which extracted beef constituted a large part of the diet, the average coefficient of digestibility of the meat protein was 92 per cent. This decreased digestibility may have been due in part to the rather large amount of meat eaten (300 grams per day), but was probably at least in part attributable to the withdrawal of the extractives.

Mendel and Fine have reported [1] a series of digestion experiments with dogs in which the utilization of the protein of extracted meat fiber ranged from 89.3 to 91.3 per cent, while that of fresh meat was 93.7 to 94.5 per cent, leading them to the conclusion that the utilization of the nitrogen (protein) of the extractive-free meat powder "is distinctly, although slightly, lower than that of fresh meat."

The digestibility of the fat of meat is influenced by the amount

[1] *Journal of Biological Chemistry*, Vol. 11, pages 5–9.

eaten and its mechanical condition, whether in large or small masses. In favorable circumstances 95 per cent or more of the fat of meat is digested and utilized.

The relative digestibility of meats as the term is used popularly, and in medical writings, is apt to refer to the length of time that the meat remains in the stomach. Penzolt experimented by feeding different articles of food and after different intervals withdrawing the stomach contents by means of a stomach-tube. From the results of such experiments he constructed a table indicating the time which must elapse after taking a stated amount of a given food until it has entirely left the stomach. These results are widely quoted, especially in books on dietetics.

The length of time which meat remains in the stomach may vary considerably, depending upon such factors as the fat content, method of cooking, thoroughness of mastication, etc., but the ultimate utilization, at least by healthy persons, is much more nearly alike.

In a recent discussion of the extended series of experiments made under the auspices of the United States Department of Agriculture, Langworthy states: "There was nothing in the results of the experiments to indicate that any one variety of meat or any one cut of meat has any very great advantage over others in this respect."

Grindley found that differences in the rate of gastric digestion as between meats cooked in different ways, could be detected in artificial digestion experiments when the experiments were of sufficiently short duration, but practically disappeared in artificial experiments of longer duration, and in the coefficients of digestibility obtained in actual experiments with healthy men.

Blunt and Mallon report that the coefficient of digestibility of both slightly cooked and much cooked bacon fat was found to average 96.7 per cent, approximately the same as for other soft fats; and also that the protein of bacon is as well digested as that of other meats.

Vitamins. Ordinary meats are poor in all three of the vitamins. Meats are somewhat variable in their vitamin A content, depending upon proportion of fat, rate of fattening, and food of the animal. As regards vitamin B, Osborne and Mendel found the amount in beef so small as to be practically negligible; while Hoagland reports that there is somewhat more of vitamin B in pork. The amounts of vitamin C in muscle meats are negligible. Liver contains more of all three vitamins than does muscle; but liver can never constitute a large fraction of the meat supply. It is, however, worth while to realize that the nutritive value of liver is higher than that of ordinary meats because of its vitamin content; and to see that liver is fully utilized as human food.

Food value of meat broths and extracts. The extractives of meat are stimulating, and for this reason may be useful additions to the dietary, but they have almost no food value. The creatin and purins of meat extracts may be oxidized to some extent in the body, but the energy derived from this source is negligible.

Meat broths may be so prepared as to contain some of the coagulable protein as well as the extractives, but Grindley in a long series of experiments never succeeded in obtaining more than 13 per cent of the true protein of the meat in the broth, and in the average obtained only 7 per cent, so that it is evident that at best the broths must be of but limited food value and that the residual meat, even though tasteless, still retains by far the greatest part of the food value.

Some so-called meat extracts partake more or less of the nature of condensed broths, containing coagulated protein with the extractives, some contain proteoses or peptone, and some are enriched with dried and ground meat. Preparations of condensed meat juice and some consisting essentially of condensed blood are also commercially available. Many of these products are described by Hutchison in his *Food and Dietetics*, and by Bigelow and Cook in Bulletin 114 of the Bureau of Chemistry, United States Department of Agriculture.

Food value of gelatin. It has already been pointed out that gelatin alone cannot maintain protein equilibrium in nutrition. It is, however, not simply a "protein-sparer" as it was formerly called. Gelatin is a true protein, but not "complete" as a protein food, the "incompleteness" of food value being doubtless due to the absence of certain amino-acid radicles, conspicuously tryptophane, in the gelatin molecule. If one were to depend very largely upon gelatin as food, it would be important that some other proteins, such as those of milk, rich in the particular amino acids which gelatin lacks, should also be represented in the diet.

Relative Economy of Different Cuts of Meat

It is hardly possible to generalize in regard to the relative economy of the meats of different species, because of the wide variations of price in different localities, and because of the different significance of lean and fat meats as food.

It is, however, instructive to consider the relative economy of different cuts from the same animal, especially in the case of beef. This has been studied in some detail by Hall and Emmett,[1] an abstract of whose data and discussion follows:

In the experiments at the Illinois station, three each of choice and prime steers from the university herd were slaughtered and determinations made of (1) the relative proportions of lean, visible fat and bone in each of the retail and wholesale cuts of beef; (2) the chemical composition and nutritive value of the boneless meat of the various wholesale cuts; and (3) the net cost to the consumer of the lean, the gross meat, and the food nutrients in each cut at current market prices.

The relative cost of the lean and of the total meat in the straight wholesale cuts at market prices is shown in Table 25.

[1] Illinois Agricultural Experiment Station, Bulletin 158.

TABLE 25. COST OF LEAN AND OF TOTAL MEAT IN THE STRAIGHT WHOLESALE CUTS AT [PRE-WAR] MARKET PRICES

STRAIGHT WHOLESALE CUTS	WHOLESALE PRICE PER POUND OF CUT	COST PER POUND OF LEAN IN CUT	COST PER POUND OF TOTAL MEAT IN CUT
	Cents	*Cents*	*Cents*
Loin	18.5	31.6	20.5
Rib	15.0	27.1	17.5
Round	11.5	17.8	13.9
Chuck	9.5	13.7	10.8
Plate	8.0	15.8	8.7
Flank	8.0	22.0	8.0
Fore shank	5.0	10.5	8.4

The net cost per pound of lean is, in general, greatest in the cuts which command the highest prices, and *vice versa*. The flank is an exception to this rule, and the chuck is more economical in this respect than the plate. Referring to the last column, it is also observed that the more expensive the cut, the greater the cost per pound of visible fat and lean combined, the flank being the only exception. From these figures it is apparent that food values of beef cuts do not correspond to their wholesale market prices, and that the cheaper cuts are by far the most economical sources of both lean and fat meat. On the whole, the different cuts vary more widely in net cost of food ingredients than in market price per pound of gross meat. The following discussion tends to confirm these statements.

The manner of cutting and the location of the different retail cuts are shown in Fig. 19.

Retail Cuts

Loin cuts. Loin steaks averaged 59 per cent lean, 32 per cent visible fat, and 9 per cent bone. Sirloin steaks in general contained a greater proportion of lean and smaller proportion of fat than porterhouse and club steaks.

Rib cuts. Rib roasts contained, on the average, 55 per cent lean, 30 per cent visible fat, and 15 per cent bone. The greatest percentage of lean was found in the sixth rib roast, and the smallest in the eleventh and twelfth rib cut.

Round cuts. The various cuts made from the round averaged 65 per cent lean, 18 per cent visible fat, and 17 per cent bone. Round steaks contained 74 to 84 per cent lean, the rump roast 49 per cent, round pot roast 85 per cent,

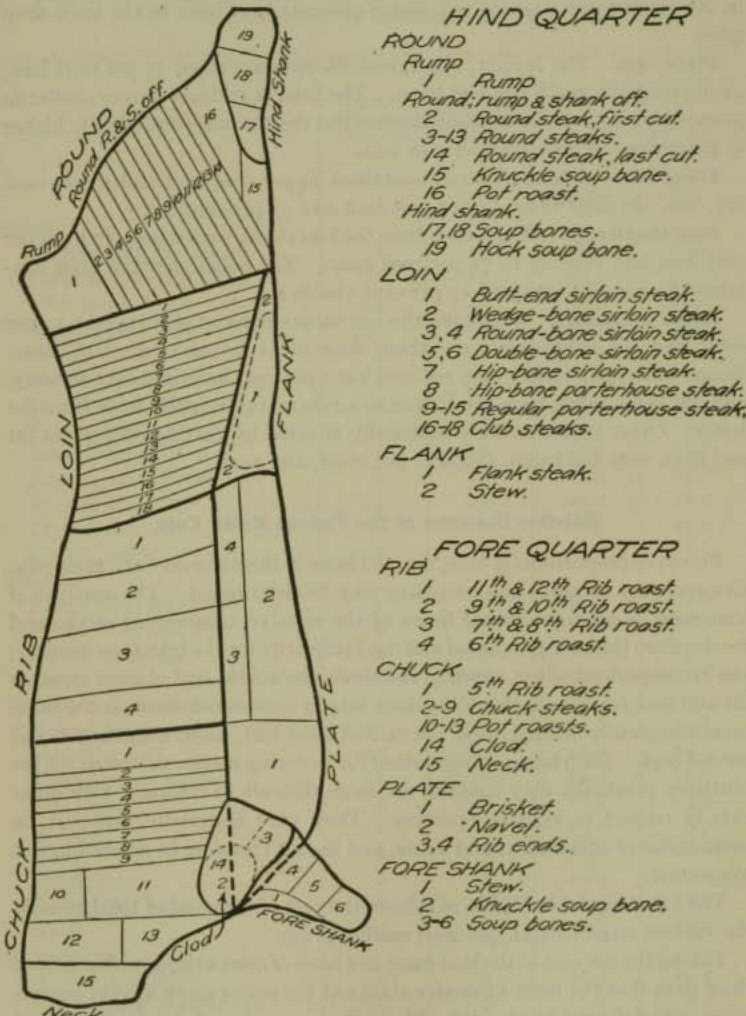


FIG. 19. — Retail cuts of beef. (Hall and Emmett.) Courtesy of Illinois Experiment Station and United States Department of Agriculture.

and soup bones 8 to 66 per cent. The maximum percentage of fat was found in the rump roast, and the maximum percentage of bone in the hock soup bone.

Plate cuts. The brisket, navel, and rib ends averaged 51 per cent lean, 41 per cent fat, and 8 per cent bone. The brisket and navel were similar in proportions of the different constituents, but the rib ends were slightly higher in percentage of bone and lower in lean.

Flank cuts. The flank steak contained 83 per cent lean and 16 per cent fat; and the flank stew, 64 per cent lean and 35 per cent fat.

Fore shank cuts. Soup bones from the fore shank varied from 17 to 69 per cent lean and from 25 to 75 per cent bone. The boneless shank stew contained 83 per cent lean and 17 per cent visible fat.

Retail trimmings. Trimming the loin steaks reduced their weight 12 per cent, and the trimmings were about four fifths fat and one fifth bone. Round and chuck steaks were reduced but 5 per cent in weight by trimming, only fat being taken from the former as a rule and principally bone from the latter. Other cuts that were materially affected by cutting off surplus fat and bone were the rump, shoulder pot roast, and neck.

Relative Economy of the Various Retail Cuts

From the proportions of lean, fat, and bone in the different cuts, their relative economy at retail market prices may be determined. The net cost of lean meat is an approximate index of the relative economy of steaks and roasts, since they are purchased and used primarily for the lean they contain; but in comparing boiling, stewing, and similar meats the cost of gross meat, or fat and lean combined, should be more largely considered, because the fat is more completely utilized, as in the case of meat loaf, hash, Hamburger, and corned beef. Soup bones, being valued for flavoring matter as well as for the nutritive substance they contain, are more difficult to compare with other cuts in respect to relative economy. They vary materially, however, in proportions of edible meat and waste, and should therefore be studied in this connection.

The following table (Table 26) shows the cost of lean and of total meat in the various retail cuts at [pre-war] market prices.

Taking the net cost of the lean meat as a basis of comparison, we learn from these data that the most expensive steaks at the prices given are the porterhouse cuts, followed by the club, sirloin, flank, round, and chuck steaks. Of the different roasts, the first-cut prime ribs are the most costly in terms of lean meat, and the rump roast is the most economical. The various boiling and stewing pieces furnish lean meat more economically at market prices

TABLE 26. COST OF LEAN AND OF TOTAL MEAT IN THE VARIOUS RETAIL CUTS AT MARKET PRICES

RETAIL CUTS	DIAGRAM NUMBER (FIG. 9)	RETAIL PRICE PER POUND OF CUT	COST PER POUND OF LEAN MEAT IN CUT	COST PER POUND OF LEAN AND FAT MEAT IN CUT
		Cents	*Cents*	*Cents*
Steaks:				
Porterhouse, hip bone	8	25	38.6	28.9
Porterhouse, regular	10	25	40.2	27.2
Club steak	18	20	32.1	22.6
Sirloin, butt end	1	20	25.3	20.6
Sirloin, round bone	3	20	28.3	21.1
Sirloin, double bone	5	20	28.7	22.7
Sirloin, hip bone	7	20	32.3	24.2
Flank steak	1	16	19.3	16.0
Round, first cut	2	15	17.0	15.3
Round, middle cut	6	15	17.3	15.6
Round, last cut	14	15	19.3	16.0
Chuck, first cut	2	12	18.3	14.1
Chuck, last cut	9	12	15.7	13.1
Roasts:				
Prime ribs, first cut	1	20	40.5	22.9
Prime ribs, last cut	4	16	26.1	18.8
Chuck, fifth rib	1	15	22.8	17.3
Rump	1	12	19.4	12.8
Boiling and stewing pieces:				
Round pot roast	16	10	11.6	10.1
Shoulder clod	14	10	12.3	10.5
Shoulder pot roast	11	10	14.3	11.6
Rib ends	3	8	16.2	9.2
Brisket	1	8	15.0	8.7
Navel	2	7	12.8	7.7
Flank stew	2	7	10.9	7.1
Fore shank stew	1	7	8.5	7.0
Neck	15	6	8.5	7.0
Soup bones:				
Round, knuckle	2	5	26.3	12.5
Hind shank, middle cut	18	5	7.5	6.3
Hind shank, hock	19	5	62.5	26.6
Fore shank, knuckle	2	5	17.2	12.5
Fore shank, middle cut	4	5	12.5	9.4
Fore shank, end	6	5	28.8	20.9

than either the roasts or steaks, the rib ends and brisket being the dearer cuts of this class, while the neck and shank stews are relatively cheapest. Several of the soup bones are very economical sources of lean meat, particularly the middle cuts of both shanks, and only one of them is extremely expensive even on this basis. In general the wide variation between the various cuts in net cost of lean is remarkable, ranging from 7.5 cents in one of the soup bones to 40.5 cents in a prime rib roast, and up to 62.5 cents in the hock soup bone, the latter, however, being used primarily for its flavoring substance rather than for lean meat. It will be observed, also, that the market prices of the cheaper cuts correspond much more closely to their net cost of lean meat than is true of the higher-priced steaks and roasts.

The net cost per pound of gross meat, or lean and fat combined, varies much less as between the different cuts than does the net cost per pound of lean, because the proportions of total meat are more nearly uniform than the percentages of lean. The various steaks and roasts rank in substantially the same order as to relative economy on this basis as on the basis of lean meat. The rib roasts, however, are considerably more economical as compared with the porterhouse and sirloin steaks when all the edible meat is considered. The rump shows a very low cost per pound of edible meat, due to the large proportion of fat it contains; and a still further difference is noticed in the case of the rib ends, brisket, navel, flank, neck, and several of the soup-bone cuts. The stewing meats are generally the most economical sources of edible meat at these prices, while porterhouse steaks are the most expensive.

On the whole, the data clearly show that the cheaper cuts of beef are by far the most economical sources both of lean and of total edible meat, including fat and lean. . . . No correlation exists between market prices and the proportion of flavoring substances contained in various portions of the carcass, and cooking tests indicate that the proportion of waste and shrinkage is not necessarily greater in the cheaper than in the more expensive cuts. It is evident, therefore, that retail prices of beef cuts are determined chiefly by considerations other than their food value such as tenderness, grain, color, general appearance, and convenience of cooking. . . . To such an extreme has this condition developed that a portion of the carcass (loins and ribs), forming only about one fourth of its weight, represents nearly one half of its retail cost. In view of the large place which meat occupies in the American diet, amounting to nearly one third of the average expenditure for all food, the importance of an intelligent understanding of the subject on the part of the consumer is readily apparent.

Not only are the foregoing statements true of meat producers and consumers as individuals, but it is highly essential to the entire beef-cattle industry, on the one hand, and the economic welfare of the beef-eating public, on the other, that a more intelligent understanding of the different cuts of meat be acquired by consumers generally. An increased demand for those portions of the carcass which are now difficult for the butcher to dispose of would contribute largely toward a more stable condition of the trade and thus enable the producer to operate with greater confidence and economy. At the same time it would effect a tremendous saving to the consumer. . . . There seems to be no relation between the market prices and the percentages of fat, protein, extractives, and ash. The cheaper cuts appear to be as valuable and in some cases actually more so than the higher priced cuts from the standpoint of protein and of energy. These statements do not take into account the factors of tenderness nor the influence the degree of fatness may have upon the palatability of cooked meat. In purchasing meat for protein primarily, the neck, shanks, and clod are the most economical cuts; the plate, chuck, flank, and round follow; with the rump, rib, and loin as the most expensive. From the standpoint of fuel value, the flank, plate, neck, and shank cuts are the cheapest, while the rib, loin, and round are the most expensive. Considering both factors, protein and fuel value, and along with these the adaptability of the meat for general use, the clod, chuck, and plate are the most economical cuts at the retail prices given.

Place of Meat in the Diet

Authorities seem to agree in the estimate that in the United States about one third of the total expenditure for food materials is for meat.

Roberts of the United States Department of Agriculture, using data from the census of 1900, estimated the yearly per capita consumption of meat in this and other countries as follows:

	Pounds
United States	178
Great Britain and Ireland	122
Germany	99
France	80
Sweden and Norway	62
Denmark	76
Belgium	70

These figures doubtless give a better general view of the place of meat in the normal dietaries of the countries named than would the most recent data which must necessarily reflect the abnormal conditions resulting from the World War.

That the usual per capita consumption of meat in the United States is almost half as high again as in the United Kingdom and fully twice as high as on the continent of Europe is perhaps not generally known, and is certainly a very significant fact worthy of more attention than it has yet received.

What are the reasons for the exceptionally high rate of meat consumption in America, and is this departure from the practice of the older countries an improvement?

The flavor of meat is well liked by most people, its extractives certainly stimulate the flow of the digestive juices and probably have some stimulating action upon the body generally. Meat is a food quickly cooked and (in general) readily digested, and tradition associates meat-eating with muscular stamina, vigor, and initiative, with success in the chase in earlier days and in more recent generations with success and prosperity generally. With this attitude toward meat as a food, Europeans coming to America and finding here a more abundant supply of meat than that to which they had been accustomed, have naturally made meat a larger part of their diet than it was or is in the countries from which they came.

Is it probable that the eating of such a large amount of meat is physiologically advantageous?

For people whose occupations are largely sedentary or at any rate do not involve much vigorous muscular exercise, a too liberal use of meat may bring on uric acid disorders or may result in excessive intestinal putrefaction. The purin substances which give rise to uric acid in the body are much more abundant in meats than in other staple foods, and it seems also well established that meat proteins are more susceptible to putrefaction in the intestine, giving rise to absorption of putrefactive products which are more or less injurious ("autointoxication") than are the proteins of most other foods. Thus the two chief objections to a high-protein diet are more applicable to meat than to most other high-protein foods.

Another fact which we should not emphasize unduly but which should perhaps be borne in mind is that the meats contain a large excess of acid-forming over base-forming elements. In a mixed diet containing a limited amount of meat this is easily offset by foods in which the base-forming elements predominate, but when the amount of meat eaten is too large, there may result an excessive preponderance of acid-forming elements in the diet as a whole. This subject, as well as that of intestinal putrefaction, will be referred to again in the discussion of the place of vegetables in the diet (Chapter IX).

Since meat is strikingly poor in calcium, it does not serve adequately to balance a diet consisting largely of bread or other cereal products. It is of interest to note that vitamins furnished by the food consumed by cattle are stored to a limited extent in animal tissue, but are transferred in abundance to the milk. Our present knowledge of nutrition strongly emphasizes the importance of mineral elements and vitamins, thus suggesting a shifting of the emphasis from meat to milk in the diet.

A moderate amount of meat in the dietary may be useful in stimulating the appetite with the result that more food in the form of milk, vegetables, and fruit is consumed. Such favorable reaction would only be possible where meat does not constitute so large a proportion of the diet as to displace other foods.

Meat proteins effectively supplement the proteins of grains in nutrition, but it must be remembered in this connection that this supplementing value of the meats is practically confined to the protein factor alone, for meats show about the same deficiencies as do the grains in their mineral and vitamin content. Hence so far as protein alone is concerned meats supplement grains almost as efficiently as eggs and eggs almost as efficiently as milk; but in supplementing the grains and breadstuffs in an all-round way milk is much superior to eggs and eggs are much superior to meat. In fact from a broad standpoint one cannot properly speak of meats as supplementing breadstuffs to any important degree since their supplementing value is practically limited to the protein factor which is usually much less in need of supplementing than are the mineral elements and vitamins.

It is difficult to balance the advantages and disadvantages of meat as a food in such a way as to reach a confident conclusion as to just how prominent a place it should have in the diet, both because so many factors enter into the problem and because so many of those who have studied the subject and published their conclusions appear to have been more or less influenced by controversial bias engendered by the vegetarian propaganda. The following quotation from Tigerstedt represents an opinion which seems neither radical nor reactionary.

" From a purely physiological point of view, we can find no reason why a healthy man should forego the use of so excellent an article of food, considered with respect to its content of protein and fat, or its eminent adaptability, as we know meat to be. But in so stating, I do not wish to be understood as saying that one should eat any quantity of meat he pleases, or should cover too much of his requirements with meat. In too large quantities the extractive substances found in meat may possibly produce disorders of one kind or another in the body. The metabolism might also take an abnormal or unfavorable form, if the fluids of the body were flooded with too much protein." This moderate and conservative warning against too free a use of meat as food was written, it is important to remember, in a Scandinavian textbook and was therefore addressed to those whose average rate of meat consumption was less than half as much as ours.

While the consideration of the place of meat in the diet from the physiological standpoint alone is subject to considerable difference of opinion, the economic aspect of the matter is much clearer. In any country in which frontier conditions no longer predominate, meat is of necessity an expensive food.

In general the protein and energy values of the total meat yielded by an animal represent only about one tenth of the total protein and energy values of the food which the animal has consumed, for only a fraction of the nutrients of the food is converted into, and retained as, body material by the animal, and scarcely half the total body weight of the animal is utilized as food for man. It is evident, therefore, that the meat will be a much more costly food than, for instance, the grain which if not fed to the animal might have been utilized directly as human food.

Had the grain been used directly as human food probably about eight tenths of it would have been digested and utilized; had it been fed to dairy cattle the average return in protein and energy values would average about three to four times as much as is obtained from animals fed for slaughter. Moreover milk has a high vitamin value and a well-balanced mineral content, whereas meat has a low vitamin value and a poorly balanced mineral content. It is true that much meat is produced from grass and " roughages " not directly available for human food; but in general any feed-stuffs which can be turned into meat can also be turned into milk. For these reasons meat can practically never be economical as compared with milk, bread, and most other staple foods.

A recent investigation at Columbia University of the data of over 200 American dietary studies, about half of which had been made by the United States Department of Agriculture and about half under independent auspices, has shown in a very convincing way the actual practical influence upon the food value of the dietary of a greater or less prominence of meat. When the dietaries (each representing the freely chosen food of a family or larger group for a period of a week or more) were arranged in three groups according to increasing prominence of expenditure for meats in the total expenditure for food it was found that in Group I about one sixth of the total expenditure for food was for meats; in Group II, about one third; in Group III, nearly one half. The level of total expenditure for food per man per day was fortunately the same in all three groups, thus permitting direct comparison of the food values obtained for the expenditure. It was found that increasing prominence of meat meant diminishing returns in calories and calcium without any compensating increase in the returns in protein, phosphorus, and iron; for while meat contains a higher percentage of protein than the average of other foods the meat is so much more costly that it furnishes no larger amount of protein for a given expenditure than do other foods which furnish much larger amounts of energy value, of calcium, and of the vitamins.

The dietaries in which meat was less prominent were both more adequate and better balanced in food value.

On the whole, it seems reasonable to conclude that a reduction of our meat consumption to something like half the present amount (*i.e.* to about what had, before the war, been reached through the longer experience of the European nations) is desirable on both economic and physiological grounds.

When one sixth instead of one third of the total expenditure for food is for meats, the dietary is usually both more economical and better balanced.

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CHAPTER VII

POULTRY, GAME, FISH, AND SHELLFISH

POULTRY, game, fish, and shellfish belong in their essential characteristics with the meat foods discussed in the last chapter. They are treated separately here, not so much in deference to the traditional distinction between flesh, fish, and fowl as because the products now to be considered are usually not classed as belonging to the slaughter-house industry and do not come under the provisions of the meat-inspection law.

Poultry

In a freshly killed bird the feet feel moist, soft, and limber, the eyes are bright and full. As it becomes stale, the eyes shrink and the feet dry and harden. The flesh should be neither flabby nor stiff, but should give evenly when pressed by the finger.

One of the commonest ways of testing the age of dressed poultry is to take the end of the breast bone farthest from the head between thumb and finger and attempt to bend it to one side. In a very young bird, a "broiler," it will be easily bent, in a bird a year old it will be brittle, and in an old bird, tough and hard to bend or break. In a young bird the feet are soft and smooth, becoming hard and rough as the bird grows older.

Much of the poultry now offered for sale is produced hundreds of miles from its market. The transportation of live poultry presents numerous problems, most of which lie outside the scope of this book. The shipping and handling of poultry killed at a distance from market involves obvious possibilities of deterioration. That such deterioration may be avoided, the methods of dressing poultry and of maintaining efficient refrigeration in transit and while awaiting sale have been studied in some detail by the United States Department of Agriculture and discussed in a series of bulletins and other articles, the titles of which may be found at the end of this chapter.

The practice recommended by Pennington is to bring the fowl into good condition by feeding clean grain mixed with buttermilk for from seven to fourteen days, then starve them for 24 hours in order that the intestinal tract may be as nearly empty as possible, and kill by cutting the jugular vein; then that part of the brain which controls the muscles holding the feathers in place is destroyed by a thrust of the knife, and the feathers are so loosened that they are easily pulled out. The cutting of the blood vessels in the proper way permits the blood to drain out of the carcass almost completely and the keeping quality is thus improved. After removal of feathers, and without removal of the entrails, the fowls should be hung by the feet on racks made entirely of metal and chilled by placing in rooms in which a temperature of about 32° F. is constantly maintained by means of mechanical refrigeration. Below 30° F. the flesh would become "frosted"; above 35° F. deterioration proceeds too rapidly to permit of long hauls to distant markets and the subsequent delays involved in the usual routine of city marketing. At 32° F. the time required for chilling is usually about 24 hours. The carcasses are then graded and packed, preferable in boxes holding 12 fowls each. The boxes should be lined with parchment paper and sometimes each fowl is wrapped separately. Separate cartons are sometimes used for extra high grade poultry. The packed poultry is shipped in refrigerator cars, either chilled or hard frozen. A refrigerator car as ordinarily loaded in the West contains 20,000 pounds of poultry. Bunkers filled with ice and salt maintain the low temperature of the car and its contents during transit.

Chemical analyses indicate that even when well handled and dry packed, the condition of dressed poultry after transportation varies appreciably with the differences in car temperatures ordinarily met. The best evidence of this is found in the development of ammonia as indicated in Fig. 20, which shows the percentages of ammoniacal nitrogen in the flesh of fowls otherwise comparable which had been transported at different

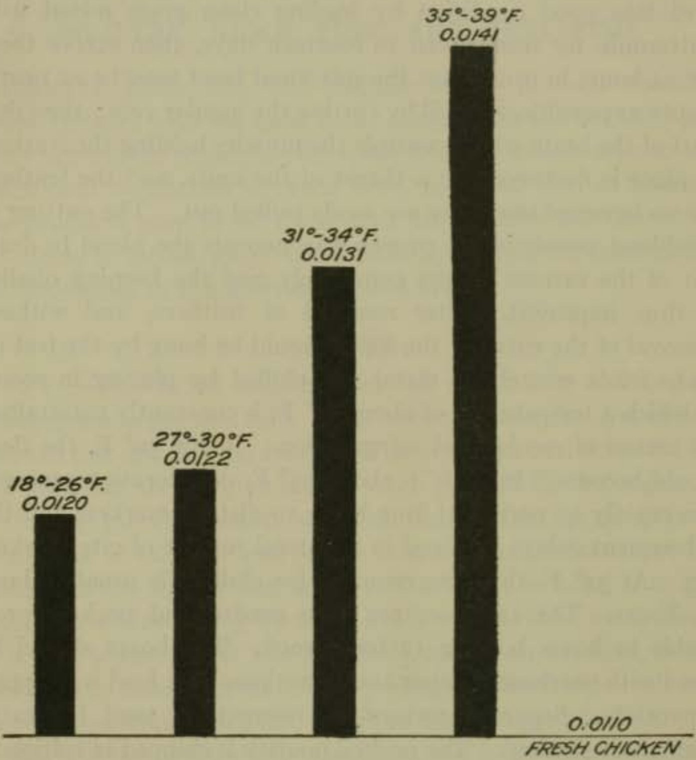

FIG. 20. — Deterioration of poultry in transit at different temperatures. U. S. Department of Agriculture.

temperatures. The difference thus shown at the end of the railroad haul tends to continue and become greater throughout the period that the fowls remain at the wholesale commission house or in the hands of the retailer, as is shown in Fig. 21, which, like Fig. 20, is taken from the bulletin by Pennington, Greenlee, *et al.*

Preservation is of course much more perfect when the fowls are kept hard frozen and delivered to the consumer without thawing. The common practice of thawing frozen poultry before exposing it for sale is objectionable in that it introduces an

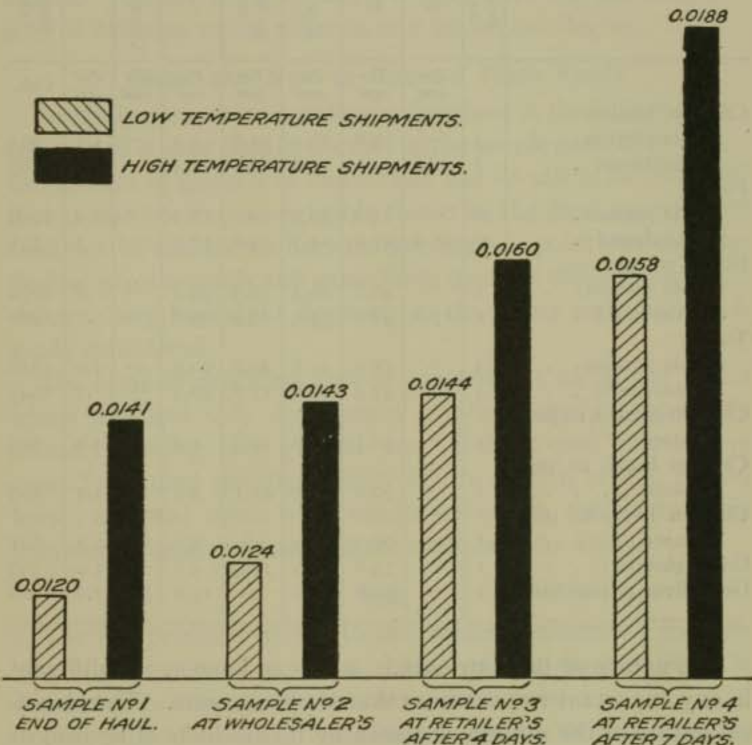

FIG. 21. — Deterioration of poultry during marketing period as affected by temperature. U. S. Department of Agriculture.

opportunity for deterioration which is quite unnecessary, and would be avoided if consumers would learn to demand that the poultry be delivered to them in a solidly frozen condition.

The general composition of poultry is shown in the following table based on the data compiled by Atwater and Bryant.

TABLE 27. AVERAGE COMPOSITION OF POULTRY

Description	Number of Analyses	Refuse	Water	Protein N × 6.25	Protein By difference	Fat	Carbohydrates	Ash	Fuel Value per pound
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
Chicken, broilers:									
Edible portion . . .	3	—	74.8	21.5	*21.6*	2.5	—	1.1	492
As purchased . . .	3	41.6	43.7	12.8	*12.6*	1.4	—	.7	289
Fowls:									
Edible portion . . .	26	—	63.7	19.3	*19.0*	16.3	—	1.0	1016
As purchased . . .	26	25.9	47.1	13.7	*14.0*	12.3	—	.7	751
Goose, young:									
Edible portion . . .	1	—	46.7	16.3	*16.3*	36.2	—	.8	1774
As purchased . . .	1	17.6	38.5	13.4	*13.4*	29.8	—	.7	1460
Turkey:									
Edible portion . . .	3	—	55.5	21.1	*20.6*	22.9	—	1.0	1318
As purchased . . .	3	22.7	42.4	16.1	*15.7*	18.4	—	.8	1043
Chicken gizzard, as purchased	1	—	72.5	24.7	*24.7*	1.4	—	1.4	505
Chicken heart, as purchased	1	—	72.0	20.7	*21.1*	5.5	—	1.4	600
Chicken liver, as purchased	1	—	69.3	22.4	—	4.2	2.4	1.7	621
Goose gizzard	1	—	73.8	19.6	*19.4*	5.8	—	1.0	593
Goose liver, as purchased	1	—	62.6	16.6	—	15.9	3.7	1.2	1018

The nature of the nutrients is, so far as known, not different in any important respect from that of other meats. The chemical nature of the protein as shown by its products of hydrolysis has been studied in comparison with the flesh of widely different species by Osborne, whose results are tabulated farther on in this chapter (Table 32).

The light meat, such as breast, is composed of more tender fibers less firmly held together by connective tissue than is the dark meat, such as the leg muscle. Usually also the light meat contains less fat. For both these reasons it is apt to be somewhat more rapidly digested, at least in the stomach, and is therefore preferable for people having weak digestion. The impression that light meat furnishes less of the substances which give rise to uric acid in the body does not seem to have been confirmed. Neither have we any evidence that the ash constituents of different meats differ in any important degree.

Game and New or Unusual Flesh Foods

Formerly game was exceedingly abundant in the United States and played a large part in the diet of the people generally. Now the amount of game is so diminished and its sale is so restricted that it has become a negligible factor in the food supply, and need not be considered here further than to point out that the flesh of game animals and game birds does not differ in nutritive value to any important degree from the meats and poultry already considered.

The same is doubtless true of most if not all of the meats which are used only occasionally in this country or are only recently coming into general use. Holmes and Deuel have recently studied the digestibility of the protein of kid, rabbit, horse, and seal meats with results essentially similar to those previously found for meats of the more familiar kinds.

Fish

The fish products of the United States constitute a food resource of growing commercial value and one which is likely to command increasing attention from consumers.

Fish to be sold " fresh " may be sent directly to market or may be kept in cold storage either chilled to ice temperature or hard frozen. Experiments begun by C. S. Smith and continued by Perlzweig and Gies indicate that fresh fish may be preserved frozen, by the best cold-storage processes, for at least two years without undergoing any important change.

The analyses made by Atwater of the commercially important kinds of fresh fish are shown in Table 28.

TABLE 28. AVERAGE COMPOSITION OF FISH

Description	Number of Analyses	Refuse	Water	Protein N × 6.25	Protein By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
FISH, FRESH									
Alewife, whole:									
Edible portion	2	—	74.4	19.4	*19.2*	4.9	—	1.5	552
As purchased	2	49.5	37.6	9.8	*9.7*	2.4	—	.8	276
Bass, black, whole:									
Edible portion	2	—	76.7	20.6	*20.4*	1.7	—	1.2	448
As purchased	2	54.8	34.6	9.3	*9.3*	.8	—	.5	201
Bass, red, whole:									
Edible portion	1	—	81.6	16.9	*16.7*	.5	—	1.2	327
As purchased	1	63.5	29.8	6.2	*6.1*	.2	—	.4	121
Bass, sea, whole:									
Edible portion	1	—	79.3	19.8	*18.8*	.5	—	1.4	380
As purchased	1	56.1	34.8	8.7	*8.3*	.2	—	.6	166
Bass, striped, whole, edible portion	6	—	77.7	18.6	*18.3*	2.8	—	1.2	452
Bass, striped, entrails removed, as purchased .	1	51.2	37.4	8.8	*8.7*	2.2	—	.5	249
Blackfish, whole:									
Edible portion	4	—	79.1	18.7	*18.5*	1.3	—	1.1	393
As purchased	2	60.2	31.4	7.4	*7.3*	.7	—	.4	163
Blackfish, entrails removed, as purchased	2	55.7	35.0	8.4	*8.3*	.5	—	.5	173
Bluefish, entrails removed:									
Edible portion	1	—	78.5	19.4	*19.0*	1.2	—	1.3	401
As purchased	1	48.6	40.3	10.0	*9.8*	.6	—	.7	206
Buffalo fish, entrails removed:									
Edible portion	1	—	78.6	18.0	*17.9*	2.3	—	1.2	430
As purchased	1	52.5	37.3	8.5	*8.5*	1.1	—	.6	205
Butter-fish, whole:									
Edible portion	1	—	70.0	18.0	*17.8*	11.0	—	1.2	776
As purchased	1	42.8	40.1	10.3	*10.2*	6.3	—	.6	444
Catfish:									
Edible portion	1	—	64.1	14.4	*14.4*	20.6	—	.9	1102
As purchased	1	19.4	51.7	11.6	*11.6*	16.6	—	.7	888

TABLE 28. AVERAGE COMPOSITION OF FISH — Continued

Description	Number of Analyses	Refuse	Water	Protein N × 6.25	Protein By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
FISH, FRESH									
Cod, dressed, as purchased	3	29.9	58.5	11.1	*10.6*	.2	—	.8	210
Cod, sections, edible portion	3	—	82.5	16.7	*16.3*	.3	—	.9	315
Cod, steaks:									
Edible portion	1	—	79.7	18.7	*18.6*	.5	—	1.2	370
As purchased	1	9.2	72.4	17.0	*16.9*	.5	—	1.0	329
Cusk, entrails removed:									
Edible portion	1	—	82.0	17.0	*16.9*	.2	—	.9	317
As purchased	1	40.3	49.0	10.1	*10.1*	.1	—	.5	188
Eels, salt water, head, skin, and entrails removed:									
Edible portion	2	—	71.6	18.6	*18.3*	9.1	—	1.0	709
As purchased	2	20.2	57.2	14.8	*14.6*	7.2	—	.8	562
Flounder, whole:									
Edible portion	3	—	84.2	14.2	*13.9*	.6	—	1.3	282
As purchased	2	61.5	32.6	5.4	*5.1*	.3	—	.5	110
Flounder, entrails removed, as purchased . . .	1	57.0	35.8	6.4	*6.3*	.3	—	.6	128
Haddock, entrails removed:									
Edible portion	4	—	81.7	17.2	*16.8*	.3	—	1.2	324
As purchased	4	51.0	40.0	8.4	*8.2*	.2	—	.6	160
Hake, entrails removed:									
Edible portion	1	—	83.1	15.4	*15.2*	.7	—	1.0	308
As purchased	1	52.5	39.5	7.3	*7.2*	.3	—	.5	145
Halibut, steaks or sections:									
Edible portion	3	—	75.4	18.6	*18.4*	5.2	—	1.0	550
As purchased	3	17.7	61.9	15.3	*15.1*	4.4	—	.9	457
Herring, whole:									
Edible portion	2	—	72.5	19.5	*18.9*	7.1	—	1.5	644
As purchased	2	42.6	41.7	11.2	*10.9*	3.9	—	.9	362
Mackerel, whole:									
Edible portion	6	—	73.4	18.7	*18.3*	7.1	—	1.2	629
As purchased	5	44.7	40.4	10.2	*10.0*	4.2	—	.7	356
Mackerel, entrails removed, as purchased	1	40.7	43.7	11.6	*11.4*	3.5	—	.7	353

TABLE 28. AVERAGE COMPOSITION OF FISH — Continued

Description	Number of Analyses	Refuse	Water	Protein N × 6.25	Protein By difference	Fat	Carbohydrates	Ash	Fuel Value per Pound
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
FISH, FRESH									
Mullet, whole:									
Edible portion	1	—	74.9	19.5	*19.3*	4.6	—	1.2	542
As purchased	1	57.9	31.5	8.2	*8.1*	2.0	—	.5	230
Muskellunge, whole:									
Edible portion	1	—	76.3	20.2	*19.6*	2.5	—	1.6	469
As purchased	1	49.2	38.7	10.2	*10.0*	1.3	—	.8	238
Perch, white, whole, edible portion	2	—	75.7	19.3	*19.1*	4.0	—	1.2	514
Perch, yellow, whole:									
Edible portion	2	—	79.3	18.7	*18.7*	.8	—	1.2	372
As purchased	1	62.7	30.0	6.6	*6.7*	.2	—	.4	127
Perch, yellow, dressed, as purchased	1	35.1	50.7	12.8	*12.6*	.7	—	.9	261
Pickerel, pike, whole:									
Edible portion	3	—	79.8	18.7	*18.6*	.5	—	1.1	360
As purchased	2	47.1	42.2	9.9	*9.9*	.2	—	.6	188
Pickerel, pike, entrails removed, as purchased .	1	42.7	45.7	10.7	*10.7*	.3	—	.6	206
Pollock, dressed:									
Edible portion	1	—	76.0	21.6	*21.7*	.8	—	1.5	425
As purchased	1	28.5	54.3	15.4	*15.5*	.6	—	1.1	304
Porgy, whole:									
Edible portion	3	—	75.0	18.6	*18.5*	5.1	—	1.4	546
As purchased	3	60.0	29.9	7.4	*7.4*	2.1	—	.6	220
Salmon, whole:									
Edible portion	6	—	64.6	22.0	*21.2*	12.8	—	1.4	922
As purchased	4	34.9	40.9	15.3	*14.4*	8.9	—	.9	642
Salmon, entrails removed, as purchased:		29.5	48.1	13.8	*13.5*	8.1	—	.8	582
Shad, whole:									
Edible portion	7	—	70.6	18.8	*18.6*	9.5	—	1.3	727
As purchased	7	50.1	35.2	9.4	*9.2*	4.8	—	.7	367
Shad roe, as purchased . .	1	—	71.2	20.9	—	3.8	2.6	1.5	582
Sheepshead, edible portion	2	—	75.6	20.1	*19.5*	3.7	—	1.2	516

TABLE 28. AVERAGE COMPOSITION OF FISH — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N × 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
FISH, FRESH									
Sheepshead, entrails removed, as purchased	1	56.6	31.2	9.0	*8.8*	2.9	—	.5	282
Smelt, whole:									
Edible portion	2	—	79.2	17.6	*17.3*	1.8	—	1.7	393
As purchased	2	41.9	46.1	10.1	*10.0*	1.0	—	1.0	224
Spanish mackerel, whole:									
Edible portion	1	—	68.1	21.5	*21.0*	9.4	—	1.5	774
As purchased	1	34.6	44.5	14.1	*13.7*	6.2	—	1.0	509
Sturgeon, anterior sections:									
Edible portion	1	—	78.7	18.1	*18.0*	1.9	—	1.4	406
As purchased	1	14.4	67.4	15.1	*15.4*	1.6	—	1.2	339
Tomcod, whole:									
Edible portion	1	—	81.5	17.2	*17.1*	.4	—	1.0	328
As purchased	1	59.9	32.7	6.9	*6.8*	.2	—	.4	133
Trout, brook, whole:									
Edible portion	3	—	77.8	19.2	*18.9*	2.1	—	1.2	434
As purchased	3	48.1	40.4	9.9	*9.8*	1.1	—	.6	225
Trout, salmon or lake:									
Edible portion	2	—	70.8	17.8	*17.7*	10.3	—	1.2	743
As purchased	2	48.5	36.6	9.1	*9.2*	5.1	—	6	373
Turbot:									
Edible portion	1	—	71.4	14.8	*12.9*	14.4	—	1.3	857
As purchased	1	47.7	37.3	7.7	*6.8*	7.5	—	.7	446
Weakfish, whole:									
Edible portion	1	—	79.0	17.8	*17.4*	2.4	—	1.2	421
As purchased	1	51.9	38.0	8.6	*8.4*	1.1	—	.6	201
Whitefish, whole:									
Edible portion	1	—	69.8	22.9	*22.1*	6.5	—	1.6	680
As purchased	1	53.5	32.5	10.6	*10.3*	3.0	—	.7	315
AMPHIBIA									
Frogs' legs:									
Edible portion	2	—	83.7	15.5	*15.1*	.2	—	1.0	289
As purchased	2	32.0	56.9	10.5	*10.3*	.1	—	.7	194

TABLE 29. PERCENTAGE COMPOSITION OF EDIBLE PART OF FISH. FRESH BASIS. (CLARK AND ALMY)

COMMON NAME OF FISH	WHEN CAUGHT	SOLIDS	FAT	ASH	NITROGEN				
					Total	Cold Water Soluble	Coagulable	Hot Water Soluble	Ammonia
	1915	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Blackfish	June 16	20.0	0.15	1.40	2.93	0.874	0.532	0.241	0.0172
Bonita	June 12	26.66	1.46	1.71	3.82	1.030	0.389	0.088	0.0251
Cod	Nov. 24	18.65	0.09	1.23	2.95	0.950	0.530	0.330	0.0170
Herring	June 12	22.90	2.41	1.66	3.03	1.028	0.516	0.234	0.0177
Kingfish	May 4	24.60	5.24	1.39	2.83	0.838	0.425	0.172	0.0162
Ling	Nov. 18	18.30	0.12	1.15	2.69	1.030	0.650	0.240	0.0180
Porgy	May 14	23.39	2.59	1.37	3.02	1.001	0.620	0.221	0.0165
Tilefish	Dec. 17	19.66	0.51	1.35	2.80	0.770	0.380	0.220	0.0130
Silver hake	May 26	18.86	1.41	1.22	2.60	1.025	0.638	0.211	0.0140
Bluefish	May 7	23.83	1.54	1.16	3.36	0.760	0.320	0.071	0.0185
Bluefish	Sept. 28	29.04	8.10	1.11	3.26	0.730	0.360	0.085	0.0180
Butterfish	May 19	25.66	5.96	1.49	2.89	0.862	0.498	0.020	0.0162
Butterfish	Oct. 12	30.01	13.52	1.40	2.92	0.850	0.430	0.021	0.0180
Carp sucker	May 29	22.80	2.10	1.20	2.98	1.151	0.787	0.206	0.0154
Carp sucker	Oct. 20	24.79	4.17	1.20	3.19	1.078	0.748	0.210	0.0170
Croaker	Apr. 10	20.77	1.25	1.18	2.85	0.813	0.447	0.141	0.0140
Croaker	Sept. 8	24.26	3.23	1.37	——	0.880	0.410	0.130	0.0230
Flounder	Apr. 19	17.54	0.20	1.17	2.56	0.888	0.477	0.117	0.0143
Flounder	Sept. 22	21.59	0.37	1.34	2.54	0.740	0.330	0.200	0.0190
Haddock	Apr. 2	18.32	0.15	1.11	2.33	0.748	0.343	0.147	0.0220
Haddock	Aug. 31	20.83	0.09	1.01	2.59	0.800	0.520	0.150	0.0220
Striped bass	Apr. 16	25.70	3.58	1.26	3.21	1.153	0.719	0.102	0.0170
Striped bass	Oct. 16	19.83	2.98	1.26	3.07	1.050	0.650	——	0.0166
Sea bass	May 12	22.02	1.61	1.23	2.98	0.967	0.532	0.106	0.0159
Sea bass	Sept. 14	19.44	1.60	1.09	——	0.970	0.700	——	0.0220
Spanish mackerel	June 4	33.01	12.59	1.20	3.13	0.846	0.458	0.055	0.0185
Spanish mackerel	Oct. 26	35.70	16.24	1.11	3.09	0.890	0.570	0.102	0.0240
Weakfish	May 1	21.41	2.34	1.25	2.83	1.118	0.851	0.203	0.0134
Weakfish	Sept. 25	19.35	0.52	1.20	——	0.820	0.500	0.290	0.0150
Shad (Male)	Apr. 2	35.32	14.43	1.34	3.18	1.112	0.621	0.074	0.0160
Shad (Female)	Apr. 13	34.17	13.93	1.40	3.00	1.147	0.685	0.063	0.0182
Shad (Female)	May 22	26.00	5.87	1.29	2.91	0.980	0.549	0.058	0.0191
Shad (Female) spent	June 19	23.38	2.95	1.53	2.98	0.975	0.549	0.182	0.0178

Clark and Almy (1918) made a series of analyses of fish obtained from Philadelphia fish dealers, giving particular attention to the forms of nitrogen present (see discussion of ammonia or ammoniacal nitrogen in poultry above) and to the influence of season upon the fat content of the fish. Since protein is computed from nitrogen content by means of a factor which Clark and Almy did not consider sufficiently well established for fish protein, they did not include a statement of the protein content in their table of analyses (Table 29). The reader may easily compute the percentage of protein as ordinarily computed for foods, by multiplying the percentage of total nitrogen by 6.25.

Clark and Almy lay considerable emphasis on the variations of fat content of fish with season of the year as found in their analyses, which show a considerably increased fat content in the summer and autumn.

Dill (1921), on the other hand, has analyzed large numbers of Pacific coast fishes and finds that, with some exceptions, the mackerel and mackerel-like fishes have an increasing fat content through the summer and early fall; but that in general the variations in composition of fishes "are frequently erratic and cannot be ascribed to known factors."

Daughters (1918) has studied the Pacific coast eulachon, which in his analysis showed 13.18 per cent protein and 11.21 per cent of fat in the edible portion. He concludes that "in food value the eulachon is equal to the salmon. It contains a higher percentage of fat than the salmon and in flavor is considered superior." For methods of dressing, cooking, and preserving the eulachon he refers to United States Bureau of Fisheries, Economic Circular 33 (1917).

Preserved Fish

Many kinds of fish are preserved in large quantities by drying, salting, smoking, canning, or by combinations of these processes. As illustrative of these industries the preparation of salt codfish, canned salmon, and sardines in oil will be outlined.

Preparation of salt cod. This is a New England industry centering at Gloucester, Mass. The annual product (including cusk, haddock, hake, and pollock which are caught and handled with the cod) is estimated to represent a catch of about 225,000,000 pounds. In a bulletin of the Bureau of Chemistry, United States Department of Agriculture, Bitting describes the process as follows:

The cod are separated into three classes, snappers, medium and large, according to their size. All codfish less than 16 inches from the curve of the nape to the hollow of the tail are designated as snappers; those more than 16 but under 22 inches are called medium, and those above 22 inches are rated as large. The codfish generally run — snappers 4 per cent, medium 41 per cent, and large 55 per cent. The cusk and hake are generally divided into two sizes, the snappers under 19 inches and the large above that. Each class is weighed and kept separate, being examined for any evidence of spoilage as they are pitched out. . . .

The curing of salt fish depends upon drying, and this is accomplished in three ways — by the use of salt, by pressure, and by exposure to the air, either in the open air or in a drier. In this country all three agents are employed, as it is not possible to dry the fish in the air alone, as is done in certain parts of Norway.

Salt acts as a drier as well as a preservative, as it abstracts moisture wherever it comes in contact with the tissue, whether this be in the kench in the boat or in the butt at the factory. In the strictly full-pickle fish (that is, fresh fish placed in the butt) the maximum effect of drying by means of salt is accomplished. All the water abstracted in making pickle is so much drying. Kenching and air drying are necessary to complete the operation, though the amount of water abstracted by the latter operations is not so great as is generally supposed. In the "kench cure" there is a combination of salting and pressure. . . .

A very large proportion of the fish is cured by a combination of these two processes, being salted and kenched on board the boat and the work completed in pickle at the factory. One of the advantages of the pickle cure is that the fish can be handled at all seasons and at such a rate as the trade may demand. For the slack-salted fish the salt is used as a preservative and the drying is accomplished by pressure and in the air. This can be done only when the weather is favorable.

The more fully the drying is done by salt or by pressure, the less time is required on the flakes. Those dried for domestic consumption are not nearly so dry as those packed for export trade. In the former class the moisture content is usually between 43 and 51 per cent, while in the latter it is between 28 and 35 per cent. . . .

The fish are dried on flakes and the drying yard is known as the flake yard. The flake consists of a lattice bed about 8 feet wide, 30 inches high, and as long as the requirements may demand. The lattice used on this bed is made of triangular strips 1 inch on the base, and these are placed about 3 inches apart. The fish therefore rest upon a sharp edge about every 4 inches. This is for the purpose of giving the maximum circulation of air about the fish. One double-deck flake yard was seen, the space between decks being 18 inches.

At regular intervals along the flakes, crosspieces are provided over which to stretch a canvas to protect the fish from sunburn during hot weather. Boxes or coops are also provided to cover the fish during rains and at night.

The fish are spread out carefully on the flakes with the face side up, and the drying is continued as long as may be necessary for the particular grade of fish. The full-pickle fish are dried for the shortest period, as they cannot be skinned readily if too dry, and, furthermore, the trade seems to desire fish which are moist and not too hard, and these retain practically 50 per cent of their water. If the sun is fairly warm and there is a good breeze, the drying can be accomplished in about ten hours as the minimum time, but this may be greatly increased with unfavorable weather conditions. Only one drying is usual for the full-cured fish.

The slack-salted fish are generally dried for two days, kenched for two or three days to "sweat" them, then placed on the flakes again for one day. Porto Rican or hard-dried fish are dried for three days, "sweated" for two days, and then again dried for two days. The object of the "sweating" is to bring the moisture out of the interior of the fish. The drying on the flakes removes the moisture from the surface and crystallizes the salt, but to get the moisture out of the center of the meat the fish must be piled in the kench, where the dry salt takes up some of the remaining moisture, so that the second drying on the flakes has a greater effect. The full-pickle fish lose about 9 per cent of their weight in drying on the flakes. When cured, they retain about 50 per cent of their moisture, the slack-salted retain 35 to 40 per cent, and the hard-dried from 25 to 30 per cent.

The fish are taken to the skinning department according to the orders to be filled. If the fish are to be put up as "absolutely boneless," then the fins are pulled out and the skin pulled off. The skin is started at the napes and pulled in toward the middle of the back and then pulled toward the tail. If the fish has been properly cured, the skin can be stripped off clean without tearing the flesh. If it has been sunburned, the skin will not hang together well. After the back has been skinned the fish is turned over and the dark lining membrane of the napes is stripped forward so that the whole fish is clean. The remaining portion of the backbone is cut out and the fish is passed to the bone pickers, who remove with forceps the ribs and any pieces of bone left in the body. If the fish are to be packed as so-called "boneless," then the fins are only cut off and the thick part of the backbone cut out closely, the small pieces of the fins, ribs, and backbone being allowed to remain. The term "boneless" as used in the trade is hardly appropriate and should be changed for one more nearly descriptive of the real conditions.

From bone picking to cutting is a short step. The table at which this is done is made of boards with openings between them at regular intervals. The fish are laid on the cutting table so that the best parts come between the openings. A half dozen pieces or more may be stretched out at a time across these openings, then a long-bladed knife is swept through them and they are ready to be packed into fish cakes, etc. A trough or miter box is also used for securing the same result.

The pieces of fish are passed to girls, who sort them and weigh out exactly a pound or two pounds, whatever the cake or package is to be. Two good slices are selected to make the outside of the packages, and short or narrow strips to make up the middle part. . . . The mold is pressed tightly by foot power, held for a few seconds, and a twine string tied securely around near each end. . . . The package is completed by wrapping first in paraffined paper and then in the labeled wrapper.

Preparation of canned salmon. The salmon of the North Pacific coast has now become one of the most important fishery products. It is said that in the Northwest the catching and packing of salmon is an enterprise second only to the lumber industry in size. The output in 1911 amounted to 290,000,000 cans. The canned salmon put up in this region is used throughout America and also to a considerable extent abroad. The outline of the industry which follows is based upon a paper by Loomis of the Bureau of Chemistry, United States Department of Agriculture, presented at the Eighth International Congress of Applied Chemistry.

There are five principal varieties of salmon packed along the Pacific coast, each of which is known by several names, depending upon the locality in which it is caught. The fish with reddest flesh and most oil are usually preferred by consumers, the following being the commonly accepted order of preference: (1) Red salmon, sockeye, or blueback; (2) chinook, king or spring salmon; (3) medium red salmon, coho, or silverside; (4) humpback or pink salmon; (5) chum or dog salmon.

The salmon spend most of their lives in the sea but spawn in the fresh water of the rivers. They are caught in seines and traps of various forms, placed along the shores of the mainland or islands at points which the large schools of fish pass on their way from the ocean to the rivers. As many as 50,000 salmon are sometimes taken in a trap at once. The sockeye salmon weighs usually from 5 to 10 pounds, while the other varieties are larger, the chinook being largest and averaging about 30 pounds.

At the cannery the fish are unloaded and carried by conveyor to a machine which removes the heads, tails, fins, and entrails. The fish are then cleaned, washed, and sliced transversely into pieces of the right size to fit the cans. Salt is first placed in the cans, then the sections of salmon are packed in, the can covers put on, and the whole heated in a steam retort for one half hour, sealed while hot, tested for leaks, heated again at 240° F. to sterilize the contents, and the cans finally retested, cleaned, lacquered, and labeled. The details vary somewhat, depending upon whether a soldered can or a so-called sanitary can is used.

The salmon canning industry is regulated by the Bureau of Chemistry under the Food and Drugs Act and by the Bureau of Fisheries under the provisions of the Alaska Fisheries Law. Loomis finds that the methods in use are generally adapted to the production of a fresh, clean, and high-grade product and that there is little if any attempt at misbranding, the cans being generally labeled to show the variety of salmon contained in them.

The sardine industry. The fish packed in France under the name sardine is the *Clupea pilchardus;* while the Maine sardine is the *Clupea harengus*. In the opinion of the Bureau of Fisheries and of the United States Department of Agriculture the name sardine is equally applicable to either species. Sardines need not therefore be labeled to show their origin, but of course must not "purport to be a foreign product when not so." Also if packed in any other than olive oil, the fact must be stated. French sardines are usually packed with much care in olive oil and sold at a high price. Maine sardines are usually handled rapidly in large quantities, packed in cottonseed oil and sold at such low prices as to make them an economical food. The following outline of the industry as carried on in Maine is taken from reports made by Buswell to the Maine Experiment Station in 1911, and by Hanson to the Eighth International Congress of Applied Chemistry in 1912.

Sardines are canned in about fifty-five factories along the Maine coast, the total annual output being between 125,000,000 and 200,000,000 cans valued at from $5,000,000 to $7,000,000 according to the season.

The fish are trapped in weirs and are taken by seining the weir shortly before low tide. As many as three hundred hogsheads of herring have been caught in a single weir at one time.

At the factory they are scooped into tubs with scoop nets or shovels, and hoisted to the sluicing troughs, which run on an incline either through a separator to the pickle tanks or directly to the tanks without separating. The separator is a simple device for separating those to be packed in oil — 3 to 7 inches in length — from the larger ones which are to be packed in mustard sauce. It consists of an inclined revolving drum made up of hoops of steel pipe placed closer together at the upper than at the lower end. As the fish are sluiced through the separator the smaller ones drop through the openings at the upper end while those larger pass on to the lower end. From the separator the fish fall into sluices which convey them to the pickle tanks. The lower end of these sluices is made of coarse wire netting which allows the water to drain off and prevents the dilution of the pickle.

The pickle tanks are of wood and hold about three hogsheads. They are filled about one third full with a 90 to 95 per cent saturated salt solution. This solution is strong enough to float the fish. If it becomes so weak — due to the loss of the salt taken up by the fish — that the fish sink, it is considered a sign that they are beginning to take up water, which is most undesirable. The length of time the fish are left in the pickle is variable, but the most common practice is to leave the fish in the pickle from one and one half to three hours. The object of the pickling is to toughen the fish and give flavor. Fat fish take the salt much less readily than do lean fish, hence require a longer time in the pickle.

From the pickle room the fish are sluiced or carried in baskets to the flaking room where they are laid in rows on wire trays or flakes. This is usually done by machine, but sometimes by hand. The flaking machine when properly operated does the work much faster than it can be done by hand.

The flakes of fish are next placed in racks running on rollers and these are pushed into the steam boxes where they are cooked with live steam for from 8 to 15 minutes. The object of steaming is to cook the fish. A well-cooked fish should not show blood along the backbone.

After steaming the fish are dried, either in air driers or in ovens. The air driers are in general of two types: First, a long low-ceiling room with a large fan at one end which blows heated air over the racks of fish; second, a circular chamber with a fan in the center. From the first type the dried fish are taken out by a door at the fan end of the drier while at the same time wet fish are being put in at the opposite end. Two or three hours are required for drying. In the second type the floor of the chamber revolves slowly so that as they pass a certain point the racks of dry fish are taken off and wet fish put on.

There are two types of ovens, the older or reel oven and the track oven. The reel oven is of brick having a large reel revolving over a hard coal fire. As the pans which hang from the arms of the reel come to the front of the oven the flakes of dried fish are taken off and wet fish put on. The time of one revolution varies with the heat of the fire and the size of the fish, but as a rule about 20 minutes are required to dry the fish thoroughly. The other type of oven has steel tracks arranged so that the racks of flakes can be pushed in over the fire; 15 to 30 minutes are required to dry the fish in this kind of an oven.

The dried fish are next distributed to the packing tables, where they are beheaded with shears and packed in tin boxes, holding 4 or 11 ounces of fish. In general the small fish are packed in oil in the 4-ounce boxes, the larger fish in mustard sauce in 11-ounce boxes. Fish of intermediate size are brought to the proper length for the smaller boxes by cutting off the anterior portions. (These anterior sections, which of course are just as good as the part used for canning, furnish the material for the manufacture of "deviled sardine.")

The cans then go to the sealing machine, where the covers are sealed on, after which they are "bathed." The bath is a rectangular steel tank about three and one half feet deep, filled with water and heated by a perforated steam coil in the bottom. The object of "bathing" is to sterilize the contents of the can and to soften the bones. To accomplish this the four ounce cans are bathed from one and one quarter to two hours, and the eleven ounce cans from one and one half to three hours. Long bathing tends to "chowder" the fish.

The sardines packed in oil in the four-ounce cans are called by the trade "quarter oils." A few are packed in mustard sauce in the same size cans and these are called "quarter mustards." Most of the fish packed in mustard sauce, however, are packed in the 11 ounce size and these are called "three-quarter mustards."

Composition of preserved fish. The results of American analyses of canned, dried, salted, and smoked fish as compiled by Atwater and Bryant are as follows:

TABLE 30. COMPOSITION OF PRESERVED FISH

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN		FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
				N × 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
FISH, PRESERVED AND CANNED									
Cod, salt, "boneless," as purchased	1	1.6	54.8	27.7	*28.6*	.3	—	14.7	515
Haddock, smoked:									
Edible portion . . .	1	—	72.5	23.3	*23.7*	.2	—	3.6	431
As purchased . . .	1	32.2	49.2	15.8	*16.1*	.1	—	2.4	291
Halibut, smoked:									
Edible portion . . .	2	—	49.4	20.7	*20.6*	15.0	—	[1]15.0	988
As purchased . . .	2	27.0	46.0	19.3	*19.1*	14.0	—	13.9	922
Herring, smoked:									
Edible portion . . .	1	—	34.6	36.9	*36.4*	15.8	—	[2]13.2	1315
As purchased . . .	1	44.4	19.2	20.5	*20.2*	8.8	—	7.4	731

[1] One sample contained 12.1 per cent common salt.
[2] Contained 11.7 per cent common salt.

TABLE 30. COMPOSITION OF PRESERVED FISH — Continued

Description	Number of Analyses	Refuse	Water	Protein		Fat	Carbohydrates	Ash	Fuel Value per Pound
				N × 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
FISH, PRESERVED AND CANNED									
Mackerel, salt, entrails removed:									
Edible portion . . .	1	—	42.2	21.1	*22.0*	22.6	—	[1] 13.2	1305
As purchased . . .	1	22.9	32.5	16.3	*17.0*	17.4	—	10.2	1005
Mackerel, salt, canned, as purchased . . .	1	—	68.2	19.6	*19.9*	8.7	—	3.2	711
Mackerel, salt, canned in oil:									
Edible portion . . .	1	—	58.3	25.4	*23.5*	14.1	—	4.1	1037
As purchased . . .	1	[2] 31.5	39.9	17.4	*16.1*	9.7	—	2.8	722
Mackerel, salt, dressed:									
Edible portion . . .	2	—	43.4	17.3	*17.3*	26.4	—	[3] 12.9	1392
As purchased . . .	2	19.7	34.8	13.9	*13.9*	21.2	—	10.4	1118
Pilchard in tomatoes, canned, Russia, as purchased	1	—	52.7	27.9	*27.5*	15.8	—	4.0	1152
Salmon, canned:									
Edible portion . . .	7	—	63.5	21.8	*21.8*	12.1	—	2.6	889
As purchased . . .	3	14.2	56.8	19.5	*19.5*	7.5	—	2.0	660
Sardines, canned:									
Edible portion . . .	2	—	52.3	23.0	*22.4*	19.7	—	5.6	1221
As purchased . . .	1	[2] 5.0	53.6	23.7	*24.0*	12.1	—	5.3	924
Sturgeon, dried, Russia:									
Edible portion . . .	1	—	50.6	31.8	*32.2*	9.6	—	7.6	969
As purchased . . .	1	12.7	44.1	27.8	*28.1*	8.4	—	6.7	848
Sturgeon, caviare, pressed, Russian, as purchased	1	—	38.1	30.0	—	19.7	7.6	4.6	1487
Tunny, as purchased .	1	—	72.7	21.7	*21.5*	4.1	—	1.7	560
Tunny, canned in oil, Russia:									
Edible portion . . .	1	—	51.3	23 8	—	20.0	0.6	4.3	1260
As purchased . . .	1	16.7	42.7	20.3	—	16.7	—	3.6	1400

[1] Contained 9.2 per cent common salt. [2] Refuse, oil.
[3] Contained 10.4 per cent common salt.

Shellfish

The principal shellfish used for food are divisible into two classes: (1) mollusks, including oysters, clams, mussels, and scallops; (2) crustaceans, including lobsters, crabs, shrimps, and crawfish.

Of all these the oyster is by far the most important as a factor in the general food supply.

It is estimated that the oyster crop of the United States (representing about two thirds of the world's supply) approximates 25,000,000 bushels annually, valued at about $20,000,000. The total amount paid at retail would of course be much larger. The shores of Long Island and of Chesapeake Bay produce oysters abundantly. According to statistics collected by Stiles, the chief oyster-producing states are, in order of rank: New York, Virginia, Connecticut, Maryland, New Jersey, Rhode Island, Louisiana, Mississippi. A considerable proportion of the oyster crop, perhaps one fifth, is preserved by canning. The oyster-canning industry grew up around Baltimore, but is now carried on to an even larger extent in some of the more southern states, where there are areas well suited to oyster culture but not readily accessible to the large markets.

Although still classified with the fisheries, the oyster industry is rapidly becoming a kind of farming. Submerged lands suitable for oyster culture are either owned or rented from the state, and many people devote themselves exclusively to the care of these oyster farms, which in some cases are natural oyster beds which have been conserved and in other cases are the result of artificial planting. The oyster reproduces by eggs which on hatching yield free-swimming larvæ, but when about two weeks old the young oysters have secreted shells of sufficient weight to cause them to sink and they then "set" on any object with which they come in contact, and thereafter are stationary. By the end of the first season the young oyster is from one to two

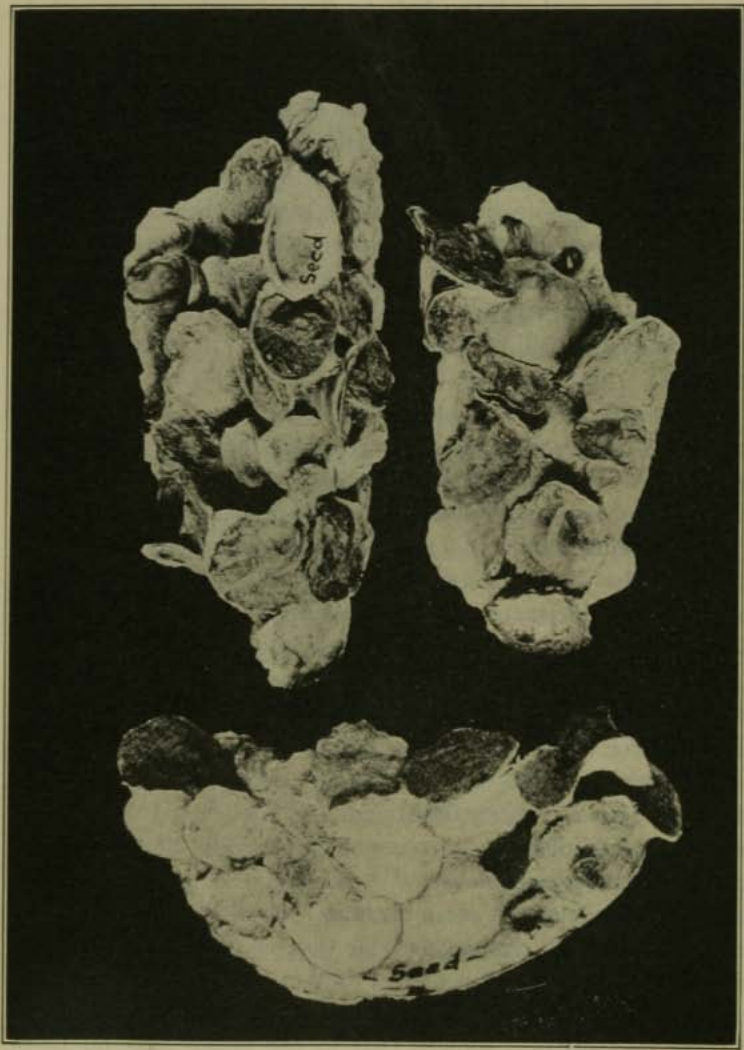

FIG. 22. — Seed oysters.

centimeters, or about one half to three fourths of an inch in diameter and at this stage in their development are often sold as "seed oysters" (Fig. 22) to be replanted in other beds. This transplanting of oysters is a matter of growing importance and appears to make possible a great development of the industry, since there are large areas on both the Atlantic and Pacific coasts, as well as in other countries, where the conditions are unfavorable for spawning but entirely suitable for the raising of transplanted oysters. The rate of growth of the oyster is dependent upon its environment, but in general it is expected that the oysters will be marketed when from three to five years old.

It is partly for the sanitary protection of the shellfish grounds of the estuaries and inland waters that the state and federal governments are now taking steps to prevent or regulate the discharge of raw sewage into rivers and harbors.

The feeding habits of oysters, clams, and mussels make it probable that they will contain considerable numbers of bacteria of the types characteristic of the waters in which they live. Hence when these shellfish are taken from (or have been kept in) sewage-polluted waters, they may easily contain bacteria of the intestinal types and thus may become carriers of typhoid fever as well as less serious intestinal disorders. This was first clearly demonstrated by Conn, in the investigation of an epidemic of typhoid among the students of Wesleyan University in 1894. The epidemic was confined to members of the various college fraternities which had held banquets in their several houses, but all on the same evening. Each of these banquets had included raw oysters and all the oysters came from one dealer and had been "floated" or "fattened" at the mouth of a stream. This stream was found to be highly polluted, and further investigation showed that in one house near by there were two cases of typhoid the discharges of which passed through the house drain into the stream without disinfection. There was left no room for doubt that the typhoid bacteria passed from the patients in the house near the stream to the oysters and so to the students at the banquet. In 1902 there occurred simultaneous outbreaks of typhoid fever at Winchester and at Southampton, England, which were traced to contaminated oysters from a common source. In 1912 two epidemics of typhoid and other intestinal disorders were clearly traced by Stiles [1] to oysters obtained from a dealer who was accustomed to store his shellfish in water which on investigation was found to be contaminated. As Prescott and Winslow point out: [2] "It should be noted that it is unfortunately not only raw shellfish which are responsible for the spread of disease. Most of the processes of cooking to which these foods are subjected are insufficient to destroy pathogenic germs." These authors quote results showing that, with steamed clams, the bacteria present could not be destroyed except by a temperature high enough and prolonged enough to ruin the clams for eating and that oyster stew, fried oysters, and fancy roast oysters may still contain active bacteria of the types indicative of sewage pollution. Clams in chowder, on the other hand, were found to be practically sterilized.

When shellfish are carelessly opened and handled, they may receive additional contamination in the process. Stiles, in 1911, found enormously greater numbers of bacteria in the "shucked" than in the corresponding "shell" oysters.

Gorham [3] has found that oysters taken from the same beds show much less contamination in winter than in summer. He believes that during the cold weather the oysters assume a condition of rest or hibernation, during which the process of feeding is suspended. In such a condition no organisms would be taken in from the outside water and those within the oyster are grad-

[1] See references at the end of the chapter.
[2] *Elements of Water Bacteriology* (3d ed.), page 248.
[3] See references at end of the chapter.

ually destroyed. These observations upon seasonal variations were made with oysters taken from Narragansett Bay; whether the same holds true in the warmer waters farther south does not appear to have been determined. It would seem only a reasonable precaution not to eat shellfish taken from contaminated waters at any season of the year; at least not until after such thorough cooking as to insure the death of any bacteria present.

Oysters are often kept for a time after gathering, on rafts constructed with false bottoms where they remain immersed in the water. This is called "floating." Except where the practice is forbidden by law, it is common for the dealers to "float" oysters in waters of a less salt content than that in which they were grown, with the result that the fresher water enters the oyster, increasing its plumpness and weight and giving it a whiter appearance. If the water in which the oysters are floated is less pure than that in which they were grown, the danger of disease bacteria in the oyster is of course increased, and *vice versa*. How long it would be necessary to float polluted oysters in pure water in order to make them safe cannot be stated with any degree of certainty at the present time.

The composition of the principal shellfish used for food is shown in Table 31, in which the percentages of nutrients are those given by Atwater and Bryant and the fuel values are recalculated as explained in earlier chapters.

Another shellfish used somewhat for food, especially upon the Pacific coast, is the abalone, the flesh of which is marketed fresh, canned, and dried. Fresh or canned flesh of the abalone contains about 22 per cent of protein; dried abalone meat, about 36 per cent. According to data quoted by Langworthy the fat content is negligible, but the fresh flesh of the abalone contains, like that of clams and oysters, about three per cent of carbohydrate, doubtless chiefly glycogen.

TABLE 31. AVERAGE COMPOSITION OF SHELLFISH

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN N × 6.25	PROTEIN By difference	FAT	CARBOHYDRATES	ASH	FUEL VALUE PER POUND
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
SHELLFISH, ETC., FRESH									
Clams, long, in shell:									
Edible portion . . .	4	—	85.8	8.6	—	1.0	2.0	2.6	233
As purchased	4	41.9	49.9	5.0	—	.6	1.1	1.5	135
Clams, round, in shell:									
Edible portion . . .	1	—	86.2	6.5	—	.4	4.2	2.7	210
As purchased	1	67.5	28.0	2.1	—	.1	1.4	.9	68
Clams, round, removed from shell, as purchased .	1	—	80.8	10.6	—	1.1	5.2	2.3	332
Crabs, hardshell, whole:									
Edible portion . . .	1	—	77.1	16.6	—	2.0	1.2	3.1	405
As purchased	1	52.4	36.7	7.9	—	.9	.6	1.5	191
Crayfish, abdomen, whole:									
Edible portion . . .	1	—	81.2	16.0	—	.5	1.0	1.3	329
As purchased	1	86.6	10.9	2.1	—	.1	.1	.2	44
Lobster, whole:									
Edible portion . . .	5	—	79.2	16.4	—	1.8	.4	2.2	379
As purchased	5	61.7	30.7	5.9	—	.7	.2	.8	139
Mussels, in shell:									
Edible portion . . .	1	—	84.2	8.7	—	1.1	4.1	1.9	277
As purchased	1	46.7	44.9	4.6	—	.6	2.2	1.0	148
Oysters, in shell:									
Edible portion . . .	34	—	86.9	6.2	—	1.2	3.7	2.0	228
As purchased	34	81.4	16.1	1.2	—	.2	.7	.4	43
Oysters, solids, as purchased	9	—	88.3	6.0	—	1.3	3.3	1.1	222
Scallops, as purchased . .	2	—	80.3	14.8	—	.1	3.4	1.4	334
Terrapin:									
Edible portion . .	1	—	74.5	21.2	*21.0*	3.5	—	1.0	528
As purchased	1	75.4	18.3	5.2	*5.2*	.9	—	.2	131
Turtle, green, whole:									
Edible portion . . .	1	—	79.8	19.8	*18.5*	.5	—	1.2	380
As purchased	1	76.0	19.2	4.7	*4.4*	.1	—	.3	89

TABLE 31. AVERAGE COMPOSITION OF SHELLFISH — Continued

Description	Number of Analyses	Refuse	Water	Protein		Fat	Carbohydrates	Ash	Fuel Value per Pound
				N × 6.25	By difference				
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
SHELLFISH, ETC., CANNED									
Clams, long, as purchased	1	—	84.5	9.0	—	1.3	2.9	2.3	269
Clams, round, as purchased	1	—	82.9	10.5	—	.8	3.0	2.8	277
Crabs, as purchased . . .	2	—	80.0	15.8	—	1.5	.7	2.0	360
Lobster, as purchased . .	2	—	77.8	18.1	—	1.1	.5	2.5	382
Oysters, as purchased . .	4	—	83.4	8.8	—	2.4	3.9	1.5	328
Shrimp, as purchased . .	1	—	70.8	25.4	—	1.0	.2	2.6	505

Ash constituents of oysters. The fact that the oyster secretes such a large amount of calcium in its shell suggests that the edible portion may be relatively rich in calcium as compared with other flesh foods, which, as we have seen, are strikingly poor in this element.

According to Albu and Neuberg the edible portion of the oyster is strikingly rich in calcium, but an analysis in the writer's laboratory yielded:

	Per cent
Calcium	0.04
Magnesium	0.05
Potassium	0.05
Sodium	0.44
Phosphorus	0.16
Chlorine	0.67
Sulphur	0.18

This analysis shows a calcium content somewhat above that of meat but much below that of milk, and a preponderance of acid-forming elements as great as that found in lean meats.

Comparison of Poultry, Fish, and Shellfish with Other Flesh Foods

Attention has been called to the similarity of all these flesh foods and to the fact that the differences in general composition are chiefly attributable to varying fat content.

That there is also a general similarity in the structure of the proteins of shellfish, fish, and fowl and of ordinary meat protein such as beef is shown by the following table based on the work of Osborne:

TABLE 32. PERCENTAGES OF AMINO ACIDS FROM THE FLESH OF WIDELY DIFFERENT SPECIES

	SCALLOPS	HALIBUT	CHICKEN	BEEF
Glycine	0.00	0.00	0.68	2.06
Alanine	——	——	2.28	3.72
Valine	——	0.79	——	0.81
Leucine	8.78	10.33	11.19	11.65
Proline	2.28	3.17	4.74	5.82
Phenylalanine	4.90	3.04	3.53	3.15
Aspartic acid	3.47	2.73	3.21	4.51
Glutamic acid	14.88	10.13	16.48	15.49
Tyrosine	1.95	2.39	2.16	2.20
Arginine	7.38	6.34	6.50	7.47
Histidine	2.02	2.55	2.47	1.76
Lysine	5.77	7.45	7.24	7.59
Ammonia	1.08	1.33	1.67	1.07
Tryptophane	present	present	present	present
Summation	52.51	50.25	62.15	67.30

The digestibility of poultry and fish has been studied quantitatively by Milner and by Holmes in experiments in which the total percentages of net absorption from the digestive tract (coefficients of digestibility) were determined for protein and fat with the following results:

TABLE 33. DIGESTIBILITY OF POULTRY AND FISH. (MILNER AND HOLMES)

Source of Protein and Fat	Experimenter	Protein Digested	Fat Digested
		Per cent	*Per cent*
Chicken	Milner	96.7	97.1
Duck	Milner	94.6	97.3
Codfish	Milner	95.9	97.4
Salmon	Milner	96.2	97.0
Salmon	Holmes	93.2	93.7
Mackerel	Holmes	93.1	95.2
Butterfish	Holmes	91.9	86.4
Grayfish	Holmes	92.8	94.3

The digestibility as thus determined is seen to be approximately equal to that of meats and appreciably higher than that of average mixed diet.

While these coefficients represent digestibility in the only sense in which it can be measured quantitatively, it is well known that the term digestibility is also used to indicate the relative ease and comfort with which foods are digested and the readiness with which gastric digestion is completed as evidenced by the time elapsing between the eating of the food and its entire passage from the stomach into the intestine. In these respects oysters, lean fish, and chicken are held to be even more digestible than lean beef, while fat fish, duck, goose, lobsters, and crabs are held to be of about the same order of digestibility with ham and pork. (See, for instance, the Table of Comparative Digestibility in Gilman Thompson's *Practical Dietetics*.)

Place in the diet. From most standpoints poultry, fish, and shellfish may be regarded as interchangeable with the ordinary meats. As in the case of meats, their chief nutritional significance is as sources of protein. Drummond has found fish proteins to resemble meat proteins in efficiency for the support of growth. Furthermore poultry, game, fish, and shellfish all show about the same mineral deficiencies as do the meats and grains. There are some indications that fish have a better vitamin A content than ordinary meats.

The comparative economy of these different types of flesh food varies widely with locality and season. While game has become so scarce and costly as to be no longer an important factor in the food supply, the prices of poultry, fish, and shellfish appear at present to be rising less rapidly on the whole than the price of beef. The breaking up of the great cattle ranges into small cultivated farms naturally tends toward a relative (perhaps not absolute) decrease in beef production and an increase (both absolute and relative) in poultry culture. Oyster culture is becoming systematized so that, while oysters will doubtless remain an expensive food, the supply will probably increase. The fishery industries are also capable of great development both by improved methods of handling the species now regarded as important and by utilizing as food the flesh of species which in the past have been neglected. Thus it is said that a few years ago sturgeon was so little prized as food that much of it was used as fertilizer, while now smoked sturgeon is in good demand; and that still more recently the garfish, formerly regarded merely as a pest, has begun to find a market as a food fish.

Since in the nature of the case the meat production of the country cannot be greatly increased except at the cost of a restricted output of other farm crops, we may anticipate a constantly increasing tendency towards better conservation and more economical utilization of the fishery products as food.

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CHAPTER VIII

GRAIN PRODUCTS

In nearly every part of the world some form of breadstuff or other food made from grain is found to be the largest single item, not as to cost but as source of energy, in the food supply — in this sense the staff of life. This is because grain crops are easily grown and, once the seeds are fully matured, they are easily stored and can be kept a long time with little danger of loss from spoilage; and by processes which need not be elaborate or expensive the grains can be brought into the form of palatable, wholesome, and economical food.

According to the estimates of Alsberg and of Cooper and Spillman an average day's labor of a farmer devoted to wheat growing by American methods produces enough protein and calories of human food to maintain a man for a year.

Osborne and Mendel quote from Hopkins: "Circumstances have to be very exceptional indeed when the growing of cereals does not yield an energy supply for the worker at less cost and with less relative effort than any other method of food production. Economic and social factors usually tend to make bread by far the most convenient form in which the cereals can reach the individual consumer. The nations of the West have acquired the habit of demanding a well-piled loaf, and for this the special properties of wheat gluten seem necessary. Hence the reliance on wheat in the West."

If, however, we consider the world as a whole, rice far surpasses wheat in popularity and in the contribution which it makes to the feeding of the human race. It is estimated that for half of the world's people rice is the main article of food. In tropical Oriental countries it takes a larger place in the dietary than is occupied in the temperate zone of the Western world by wheat, rye, barley, and potatoes combined. From the standpoint of world production and consumption, therefore, rice unquestionably takes the first place among the grains.

As a bread grain, wheat is usually preferred, with rye second in favor, and barley third.

Maize and oats are important both as human food and in the feeding of farm animals.

Buckwheat, millet, and the grain sorghums (kafirs, durra) are also of considerable importance.

Rice (*Oryza sativa*)

If the population of the entire globe be considered, rice is the most used as human food of all the grains, since it enters so largely into the dietary of the people of India, China, Japan, and other Oriental countries.

In the United States rice plays the part only of a minor cereal, but its cultivation is increasing, especially in Louisiana and Texas. Smaller areas are devoted to rice culture in the South Atlantic States and in California.

Rice has been commonly marketed in this country either (1) unhulled, *i.e.* with the chaffy husk still covering the kernel; (2) "cured," freed from husk but not from bran; (3) polished (white). The following comparative analyses (Table 34) of rice in these three conditions are from Bulletin 13, Bureau of Chemistry, United States Department of Agriculture, except the figures for phosphorus, which have been added by the author.

It will be seen that the "polishing" of the rice kernel removes only about one eighth of its weight but more than half of its ash constituents. The ash in both cases is composed chiefly of phosphates, about one half of the weight of ash being P_2O_5.

TABLE 34. ANALYSES OF RICE

	UNHULLED RICE	"CURED" RICE	POLISHED RICE
Weight of 100 kernels . . *Grams*	2.929	2.466	2.132
Moisture . . . . . . *Per cent*	10.28	11.88	12.34
Protein . . . . *Per cent*	7.95	8.02	7.18
Fat . . . . *Per cent*	1.65	1.96	0.26
Fiber . . . . *Per cent*	10.42	0.93	0.40
Carbohydrates other than fiber . . . . *Per cent*	65.60	76.05	79.36
Ash . . . . *Per cent*	4.09	1.15	0.46
Phosphorus calc. as P_2O_5 . *Per cent*		0.65	0.20

It has been known for some time, especially in Japan and the Philippines, that a diet consisting chiefly of polished rice is likely to result in the disease *beriberi*, and by careful observation and experiment it was decided that rice which had been polished so as to contain less than 0.40 per cent of P_2O_5 was unsafe for use as the chief article of food, as rice often is used in those countries. The frequency with which beriberi follows a deficient diet, such as one consisting mainly of highly polished rice, and the certainty with which it can be prevented by simply substituting unpolished (also called "cured") rice, shows plainly that the removal of the outer portions of the rice kernel as in the "polishing" process results in a deficiency of some substance or substances which occur in that part of the grain and which are important for the maintenance of health. Beriberi is therefore considered typical of the "deficiency diseases." The limit to which rice may be "refined" without becoming markedly deficient has been determined in terms of its phosphorus content, and it is altogether probable that a diet of polished rice taken in sufficient quantity to furnish all the energy required in nutrition would fail to furnish an adequate supply of phosphorus. Experiments have shown, however, that so far as beriberi is concerned, the deficiency of the polished rice is due more particularly to the removal of vitamin B. In rice there is a high concentration of vitamin B in the embryo, a lower concentration in the bran, and little if any in the pure endosperm. The milling of rice is likely to lower greatly its antineuritic value through a loss of the embryo but rice which is not too highly milled still has some antineuritic value. In pure white polished rice, however, the vitamin content is so far reduced that it is a disputed point whether such rice contains any vitamin B whatever. It is also practically devoid of vitamins A and C. The use of a less highly refined product known as brown or cured rice is desirable, especially when rice constitutes a large proportion of the diet.

Partly as a result of the interest aroused by the rather striking demonstration in the Philippines of the impoverishment of rice by the complete removal of the outer layers to make a white product, "cured" or "brown" rice is now being introduced in the grocery trade.

Wheat

Wheat is the typical bread-making grain and the one most used for human food in the United States, in English-speaking countries generally, and in probably the greater part of Europe. The different cultivated varieties of wheat all belong to the same genus (*Triticum*), but not all to one species. The wheat most commonly grown in America is *Triticum vulgare*, and probably the next most important from our standpoint is *Triticum durum*, which is valuable because of its ability to resist drouth and also because of yielding a flour suited to the manufacture of macaroni. Wheat is often classified as "hard" or "soft," as "spring" or "winter" wheat, and also according to the locality in which it is grown.

Winter wheat is sown in the autumn in regions where the winter is not severe, and matures early in the summer. Spring wheat, which is grown mainly in the Northwestern states, including Minnesota and the Dakotas, and in Canada, is sown in the spring and matures in the late summer. There are many varieties of both classes, and the composition and properties vary with variety and environment. As a rule, winter wheats are softer and somewhat more starchy; the spring wheats harder and slightly richer in protein. In general a rather hard wheat of more than average protein content is preferred for the manufacture of bread flour, but the wheats with most protein do not necessarily make the best flour, since the bread-making quality depends upon the nature and quantitative relationship of the proteins and not simply on the amount present.

In bulk and value of crop, wheat ranks second to corn in production in the United States, but in quantity sold from the farms and sent into commerce it ranks first among the grains.

The structure of the wheat kernel is doubtless already familiar to most readers of this book. We shall therefore not repeat the description here, and it must be understood that this paragraph is not intended as an adequate description but only as a reminder of a few of the points which are to be kept in mind when considering the production and composition of the mill products. It should also be clearly understood that Fig. 23, representing some features in the structure of the wheat kernel, is only a diagram to illustrate these few points and is not intended as a complete picture. The bran, which is actually composed of several layers, is shown at *a*. The square cells of the aleurone layer are shown at *b*, while *c* represents the endosperm made up chiefly of "starch cells" which, however, always contain protein as well as starch. The germ or embryo, *d*, is shown at one end of the longitudinal section, but does not appear in the transverse section, since the germ does not extend to the middle of the kernel. The deep crease extending from end to end of the wheat kernel increases the surface considerably so that the percentage of bran and of aleurone layer is larger than would otherwise be the case. It is estimated that the bran proper (including epidermis, epicarp, endocarp, and testa) constitutes about 5 per cent, the aleurone layer about 8 per cent, the germ with its membrane about 5 per cent, and the "starch cells" about 82 per cent of the entire grain. The "bran" obtained in milling may contain not only the bran proper, but also the germ and more or less of the aleurone layer, depending upon the processes employed. The flour obtained in ordinary milling contains more

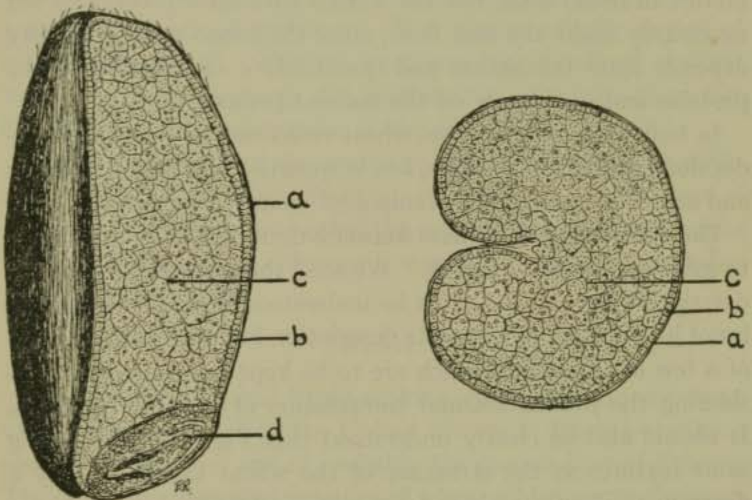

FIG. 23. — Diagram of grain of wheat, longitudinal and transverse sections. *a*, bran; *b*, aleurone layer; *c*, starch cells of endosperm; *d*, germ.

or less of the aleurone layer, which is rich in protein and in phosphorus compounds, and most of the "starch cells" of the original kernel. From the relative proportions in which these exist in the grain it is evident that much the larger part of ordinary white flour must consist of these starch cells, and their general nature should therefore be kept in mind. Each cell contains hundreds of starch granules of various sizes embedded in a network of protoplasmic material composed essentially of protein matter, in this case chiefly gliadin and glutenin, the proteins which together form the characteristic gluten of wheat flour. The accompanying diagrams (Fig. 24) published by the United States Department of Agriculture illustrate respectively the protoplasmic structure or protein components of the cell and the starch granules which are found deposited in it. A view through *both* of these diagrams would represent the structure and composition of the "starch cell" as a whole. It should be clear that

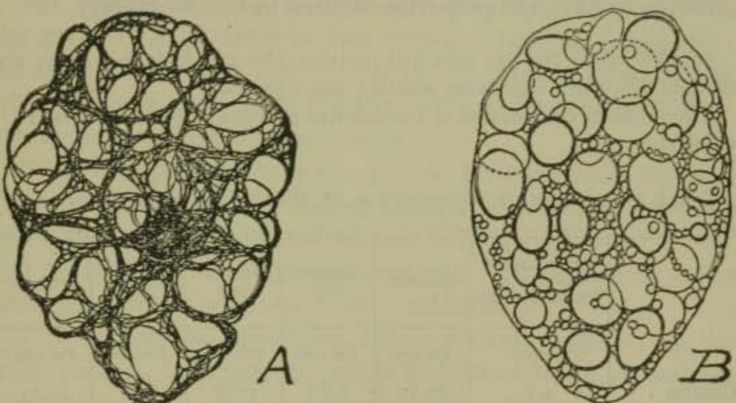

FIG. 24. — Diagram of "starch cells" or "flour cells" of wheat. *A*, showing network of protein; *B*, showing starch granules.

even the whitest and most starchy part of the wheat kernel contains a significant amount of protein.

The granules of wheat starch vary greatly in size — in fact, this is one of the properties by which wheat flour is identified under the microscope. That the average size is quite small may be appreciated from the fact that a kernel of wheat weighing less than 0.04 gram is estimated to contain from 10,000,000 to 20,000,000 starch granules.

The wheat proteins have been extensively investigated, especially by Osborne.[1] Gliadin and glutenin together form

[1] Osborne, *The Proteins of the Wheat Kernel.* Publication No. 84, Carnegie Institution of Washington.

wheat gluten and constitute about nine tenths of the protein matter of the grain. In the whole kernel these two proteins are present in about equal proportions, but in wheat flour there is more gliadin than glutenin. Gliadin is the best known of the alcohol-soluble proteins, and glutenin of the glutelins. In a general way it may be said that gliadin gives tenacity and elasticity to the gluten, while glutenin gives it strength, and that the two proteins must be present in proper proportions if the gluten is to have the properties desired in bread-making.

In addition to the two principal proteins, Osborne finds in wheat: an albumin, leucosin; a globulin, edestin; and a proteose.

The ultimate composition of the ash-free proteins is given by Osborne[1] as follows:

TABLE 35. ULTIMATE COMPOSITION OF WHEAT PROTEINS (OSBORNE)

	Approximate Amount in Wheat Kernel	Carbon	Hydrogen	Nitrogen	Sulphur	Oxygen
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Gliadin . .	4.5	52.72	6.86	17.66	1.03	21.73
Glutenin .	4.0	52.34	6.83	17.49	1.08	22.26
Globulin .	0.6	51.03	6.85	18.39	0.69	23.04
Leucosin .	0.4	53.02	6.84	16.80	1.28	22.06
Proteose—*a*.	0.2	49.94	6.80	17.08	1.24	24.94
Proteose—*b*.	0.2	48.99	6.85	16.89	1.10	26.17

The proteose (which like the albumin and the globulin is chiefly found in the germ) appeared to be a mixture of two substances, *a* and *b*, the first of which was precipitated when its solution was saturated with sodium chloride while the second was not.

It will be seen that all of the wheat proteins contain more than 16 per cent of nitrogen, so that if the percentage of nitrogen in wheat products is multiplied by 6.25, a result higher than the actual amount of protein is obtained. As a whole the wheat proteins contain about 17.55 per cent of nitrogen so

[1] Osborne has also investigated the amino acids obtained by hydrolysis of gliadin, glutenin, and leucosin with the results shown in comparison with other grain proteins beyond.

that the factor for converting nitrogen to proteins should be about 5.7 if the true weight of proteins and of carbohydrates by difference is sought, and this factor as well as the factor 6.25 is frequently used. For most of the purposes of food chemistry and nutrition, however, the term "protein" as used in proximate analyses and dietary calculations is understood to mean the product obtained by multiplying the weight or percentage of nitrogen by the factor 6.25, which should therefore be uniformly used in such cases.

Flour and Bread

The making of flour has gradually developed from crushing the grain by hand between two stones to the highly elaborate mechanical processes now in use in the large milling centers where a single mill often requires acres of floor space and an enormous investment in machinery.

For a long period wheat was ground between millstones and the product sifted. The coarser material was sold as bran, the white material which passed the finer bolting cloth was "flour," and the material of intermediate size and color containing many small particles of bran was called "middlings."

That process has now been almost entirely replaced by the roller process, in which the wheat instead of being ground between stones is crushed between steel rolls. This process gives a somewhat more complete separation of the starchy endosperm from the bran and so yields a somewhat larger proportion of white flour than did the older process. In the roller process as now commonly carried out, about 72 per cent of the weight of cleaned wheat is obtained as white flour and the remainder is sold chiefly for stock feeding under such names as "wheat offals," "bran," and "shorts." Under this process the term "middlings" is applied to the material yielded by that part of the endosperm which is relatively rich in protein and therefore not so quickly nor so finely pulverized as the more starchy portion but which is only yellowish, not brown in color, and quite distinct from the bran. Thus "middlings," as the term is now used, is considered by the miller a desirable constituent of flour, since it does not materially affect the color and, on account of its high gluten content, it enhances the bread-making quality.

It seems unnecessary to take space here for more than a brief outline of the roller process, especially since detailed and illustrated descriptions are so readily obtainable from some of the large millers.

Wheat which has been screened and cleaned is first passed between a pair of corrugated rollers, known as the " first break," where the kernel is flattened and somewhat crushed and a small amount of flour known as the " break " or " first break " flour is separated by means of sieves while the main portion is conveyed to the " second break " where the kernels are more completely flattened and granular flour particles are partially separated from the bran. The material passes over several pairs of rollers or breaks, each succeeding pair being set a little nearer together. This is called the " gradual reduction process," and effects a more complete separation of the flour and bran than was possible in the older processes in which the wheat was ground fine in one operation. The effect of passing through these rollers is to pulverize the inner floury part of the wheat grain, to flatten the bran (and germ), and to break up the intermediate portion into what is called " middlings." The flour is obtained by sifting, the bran and dust are separated from the middlings by means of coarser sieves, aspirators, and other devices, and the purified middlings are then passed between smooth rolls, where they are reduced to the desired degree of fineness, or, as it is sometimes expressed, where the granulation is completed.

The best grades of patent flour are not made entirely smooth and homogeneous, but are rather made to have a characteristic feel, which is due to the granulated middlings which these flours contain. A flour which has no granular feeling is not usually considered of the highest grade, but is generally rated as a soft wheat flour of poorer gluten. On the other hand, the flour should not be too coarsely granulated, and the miller in order to obtain the desired product must be careful in blending the powdered flour obtained from earlier breaks with the granular flour obtained from the middlings.

The flour from the middlings finally passes through silk bolting cloths of 100 mesh or finer, the dust and particles of débris having been removed at various points in the milling process.

In some large mills in order to secure a better granulation and more complete removal of the offals the grain passes through so many rollers and sieves that 40 or more different streams of flour are obtained from the same lot of wheat. Many of these streams are then usually brought together to produce the finished flour of the ordinary commercial grades. The break flours are those obtained from the earlier crushings of the wheat and consist mainly of the innermost powdery portion of the grain, while the patent flours contain more of the harder portion known as the middlings, but no absolute definition of the term "patent flour" can be given because of differences in usage in different parts of the country. Generally the first and second patent flours are spoken of as "high grade," which term may also include what is called "standard patent flour" or "straight grade flour"; or the "straight grade" may be divided between the high grade and low grade classes. To the low grade flour belong what are called the "second clear" and the "red dog." About 72 per cent of the clean wheat is recovered in the higher grades of flour and about 2 or 3 per cent as merchantable white flour of lower grade. The higher grades are characterized by a lighter color, more elastic gluten, better granulation, and a smaller number of débris particles. The low grade flours contain a somewhat higher percentage of protein but are not as valuable for bread-making purposes because the gluten is less elastic.

Technical terms of the flour trade are sometimes confusing. Thus "95 per cent patent" means that 95 per cent of the total flour (not of total grain) is included in the patent, while an "85 per cent patent" is a higher grade of flour which constitutes only 85 per cent of the total flour obtained in the given process.

The composition of the mill products of wheat may vary both with the wheat and with the details of the process. The following analyses (Table 36) are for products all milled by the modern roller process from the same lot of Minnesota hard spring wheat and are therefore strictly comparable with each other. The differences of composition are therefore properly attributable to the separations effected by the milling process alone.

TABLE 36. ANALYSES OF WHEAT AND THE PRODUCTS OF ROLLER MILLING (United States Department of Agriculture)

MILLING PRODUCT	WATER	PROTEIN (N×5.7)	FAT	CARBOHYDRATES	ASH
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
First patent flour	10.55	11.08	1.15	76.85	0.37
Second patent flour	10.49	11.14	1.20	76.75	0.42
First clear-grade flour	10.13	13.74	2.20	73.13	0.80
Straight or standard-patent flour	10.54	11.99	1.61	75.36	0.50
Second clear-grade flour	10.08	15.03	3.77	69.37	1.75
"Red dog" flour	9.17	18.98	7.00	61.37	3.48
Shorts	8.73	14.87	6.37	65.47	4.56
Bran	9.99	14.02	4.39	65.54	6.06
Entire-wheat flour	10.81	12.26	2.24	73.67	1.02
Graham flour	8.61	12.65	2.44	74.58	1.72
Wheat ground in laboratory	8.50	12.65	2.36	74.69	1.80
Germ	8.73	27.24	11.23	48.09	4.71

These analyses show a gradual increase in the protein content[1] from first patent to "red dog" flour, but the "red dog" flour, while containing the most protein, is the poorest grade of flour

[1] Note that in the above table the percentage of protein is that of nitrogen multiplied by 5.7 for the reason explained above (page 299). Increasing the protein figures in the above table by one tenth gives essentially the results which would be obtained by the use of the more common factor 6.25.

from the standpoint of the baker, and in the milling of wheat it often is allowed to remain with offals and sold for cattle food. It will also be seen that the percentage of ash is lowest in those flours which are commercially rated as of highest grade and increases as we go down the list to the lower commercial grades of flour. Patent flour rarely contains more than 0.55 per cent ash and usually contains less than 0.5 per cent.

Snyder points out, however, that noticeable variations occur in the amount of mineral matter or ash in different wheats. It may also be pointed out that the ash constituents of wheat are many of them of distinct nutritive value, so that it is only from a commercial and not from a nutritive standpoint that we would classify a flour as low grade because it has a relatively high ash content.

Another study of the mill products of wheat made by Teller at the Arkansas Experiment Station, 1894 to 1898,[1] included a milling experiment in which the principal products of a long process (7 break) roller mill were analyzed with the following results:

TABLE 37. PERCENTAGE COMPOSITION OF MILL PRODUCTS OF WHEAT (TELLER)

	Patent Flour	Straight Flour	Low Grade Flour	Ship Stuff	Bran	Whole Wheat	Pure Germ
Water	13.75	13.90	13.22	12.25	12.85	13.90	6.80
Ash	0.33	0.47	0.90	3.12	5.80	2.15	4.65
Crude fiber	0.17	0.26	0.74	3.55	6.14	2.17	1.60
Fat	1.05	1.25	1.70	4.80	5.20	2.15	14.38
Protein (N × 5.7)[2]	9.69	10.37	12.88	16.36	15.56	12.31	36.00
Carbohydrates	75.01	73.75	70.56	59.02	54.45	63.32	36.55
Total nitrogen	1.70	1.82	2.26	2.87	2.73	2.16	6.34

[1] Bulletins 42 and 53, Arkansas Experiment Station (Fayetteville, Ark.).
[2] For explanation of this factor for estimating protein from nitrogen see page 298.

In this investigation Teller also determined the amount of each of four different forms of nitrogen compounds in each of the main mill products, with the results shown in Table 38.

It will be seen that the higher commercial grades of flour, that is, those most prized for bread-making, show the largest proportion of gliadin whether this be reckoned in percentage of the gluten or of the total proteins present. The quality of making an elastic dough capable of large expansion in the bread-making process depends upon both the amount and the nature of the gluten. In order to make a large light loaf of bread, the flour should have a fairly high gluten content, and its gluten should contain a high proportion of gliadin.

TABLE 38. DISTRIBUTION OF NITROGEN IN MILL PRODUCTS (TELLER)

	Different Forms of Nitrogen in Percentage of Total				Percentage of Gliadin in the Gluten
	Gliadin Nitrogen	Glutenin Nitrogen	Edestin and Leucosin Nitrogen	Amid Nitrogen	
Patent flour . . .	64.2	27.7	6.4	1.7	69.9
Straight flour . .	54.0	37.4	7.0	1.6	59.1
Low grade flour . .	50.5	37.7	9.5	2.3	57.3
Ship stuff	46.2	36.6	13.0	4.2	55.8
Bran	23.5	50.0	17.8	8.5	31.9
Sifted dust . . .	11.8	61.7	11.8	14.7	16.1

Analyses of flours with reference to their bread-making value often include determination of total nitrogen and of the "*gliadin number*" which shows what percentage of the total protein is in the form of gliadin.

Absorption, expansion, and baking tests may also be required in an examination of flour as to its bread-making qualities. Directions for making such tests may be found in Leach's *Food Inspection and Analysis.*

The making of bread, always prominent among household pursuits, is now also a large commercial industry. Bread and other bakery products made in the United States in bakeries large enough to be classified as manufacturing establishments are included in the Census of Manufactures, the current data of which at any given time may be obtained from the Bureau of the Census at Washington, D. C.

The following definitions and standards for breads were adopted by the Joint Committee on Definitions and Standards, September 28, 1922; were approved by the Association of American Dairy, Food and Drug Officials, October 5, 1922, and by the Association of Official Agricultural Chemists, November 17, 1922; and adopted December 18, 1922, by the United States Department of Agriculture as a guide in enforcing the Food and Drugs Act:

Bread is the sound product made by baking a dough consisting of a leavened or unleavened mixture of ground grain and / or other clean, sound, edible farinaceous substance, with potable water, and with or without the addition of other edible substances.

In the United States the name " bread," unqualified, is understood to mean wheat bread, white bread.

Wheat Bread Dough, White Bread Dough, is the dough consisting of a leavened and kneaded mixture of flour, potable water, edible fat or oil, sugar and / or other fermentable carbohydrate substance, salt, and yeast, with or without the addition of milk or a milk product, of diastatic and / or proteolytic ferments, and of such limited amounts of unobjectionable salts as serve solely as yeast nutrients,[1] and with or without the replacement of not more than three per cent (3%) of the flour ingredient by some other edible farinaceous substance.

Wheat Bread, White Bread, is the bread obtained by baking

[1] The propriety of the use of minute amounts of oxidizing agents as enzyme activators is reserved for future consideration and without prejudice.

Wheat Bread Dough in the form of a loaf or of rolls or other units smaller than a loaf. It contains, one hour or more after baking, not more than thirty-eight per cent (38%) of moisture, as determined upon the entire loaf or other unit.

Milk Bread is the bread obtained by baking a Wheat Bread Dough in which not less than one third ($\frac{1}{3}$) of the water ingredient has been replaced by milk or the constituents of milk solids in proportions normal for whole milk. It conforms to the moisture limitation for Wheat Bread.

Rye Bread is the bread obtained by baking a dough which differs from Wheat Bread Dough in that not less than one third ($\frac{1}{3}$) of the flour ingredient has been replaced by rye flour. It conforms to the moisture limitation for Wheat Bread.

Raisin Bread is the bread obtained by baking Wheat Bread Dough, to which have been added sound raisins in quantity equivalent to at least three (3) ounces for each pound of the baked product and which may contain proportions of sweetening and shortening ingredients greater than those commonly used in Wheat Bread Dough.

Brown Bread, Boston Brown Bread, is a bread made from rye and corn meals, with or without flour, whole-wheat flour, and/or rye flour, with molasses, and in which chemical leavening agents, with or without sour milk, are commonly used instead of yeast.

In some localities the name "brown bread" is used to designate a bread obtained by baking a dough which differs from Wheat Bread Dough in that a portion of the flour ingredient has been replaced by whole-wheat flour.

In recent years much careful study has been devoted to the making and judging of bread. A description of bread-making processes would lead beyond the scope of this work, but the qualities by which the product is judged may be concisely indicated by reproducing here the following:

Score Card Devised by Miss Bevier[1]

General Appearance	20
Size (5)	
Shape (5)	
Crust (10)	
Color	
Character	
Depth	
Flavor	35
Odor	
Taste	
Lightness	15
Crumb	30
Character (20)	
Coarse — fine (Texture)	
Tough — tender (Texture)	
Moist — dry (Texture)	
Elastic or not (Texture)	
Color (5)	
Grain — Distribution of gas (5)	
Total	100

Leavening agents. Compressed yeast is commonly used for leavening bread dough and the production of such yeast is now an important industry.

Yeast for use in baking is separated from the wort by skimming, washed with water, freed from impurities by washing through sieves or by settling, pressed in bags in hydraulic presses, cut into cakes, wrapped in tin foil, and kept cold until distributed for use.

Such yeast should be used fresh, and when fresh "should have a creamy white color, uniform throughout, and should possess a fine even texture; it should be moist without being slimy. It should quickly melt in the mouth without an acid taste. Its odor is characteristic and should be somewhat suggestive of the apple. It should never be 'cheesy,' such an

[1] University of Illinois Bulletin, Vol. 10, No. 25 (March, 1913).

odor indicating incipient decomposition, as does a dark or streaked color" (Leach).

The addition of starch to yeast before pressing has been commonly practiced and justified on the ground that the starch acts as a drier, producing a yeast more easily mixed with the flour, beside making the yeast keep better, especially in warm weather. Compressed yeast has commonly contained from 5 to 50 per cent starch, although 20 per cent has been suggested (Jago) as a limit above which the starch should be considered an adulterant.

Improved methods of manufacture yield a yeast comparatively free from slime, capable of being pressed into cakes without the use of starch, and recently the Board of Food and Drug Inspection has ruled that compressed yeast should not contain starch unless so labeled.

Baking powders are used when it is desired to leaven the dough more quickly than it can be done by fermentation. Those in common use all depend upon the liberation of carbon dioxide by the action of tartaric acid or acid tartrate, acid phosphate, or alum upon sodium bicarbonate.

With *tartaric acid* the reaction is as follows:

$$H_2C_4H_4O_6 + 2\ NaHCO_3 \longrightarrow Na_2C_4H_4O_6 + 2\ CO_2 + 2\ H_2O$$

and with *cream of tartar* (acid potassium tartrate):

$$HKC_4H_4O_6 + NaHCO_3 \longrightarrow NaKC_4H_4O_6 + CO_2 + H_2O$$

In *phosphate powders* the acid component is calcium acid phosphate and the reaction is:

$$CaH_4(PO_4)_2 + 2\ NaHCO_3 \longrightarrow CaHPO_4 + Na_2HPO_4 + 2\ CO_2 + H_2O$$

The calcium acid phosphate is made by acting upon rock phosphate (tricalcium phosphate) with sulphuric acid. This reaction produces also calcium sulphate, which may or may not be left in the acid phosphate when the latter is made into baking powder.

Alum powders react in the manner indicated by the following:

$$NaAl(SO_4)_2 + 3\ NaHCO_3 \longrightarrow 2\ Na_2SO_4 + Al(OH)_3 + 3\ CO_2$$

Formerly potassium and ammonium alums were used interchangeably according to price; now calcined sodium alum is said to be commonly used.

Mixed baking powders having more than one component which reacts with the bicarbonate are sometimes used. Thus with an alum and phosphate powder both the prompt action of the acid phosphate and the more continued evolution of gas due to the slow action of the alum may be obtained.

Rye (*Secale cereale*)

Rye is more hardy than wheat and so in northern Europe is more commonly used than wheat as a bread-making material. The United States produces less than one twentieth as much rye as wheat. The mean composition of 20 samples of rye (18 of which were grown in the United States) analyzed at the World's Fair at Chicago in 1893 was as follows:

Weight of 100 kernels	*Grams*	2.516
Moisture	*Per cent*	10.77
Protein	*Per cent*	12.26
Fat	*Per cent*	1.58
Fiber	*Per cent*	2.08
Carbohydrates, other than fiber	*Per cent*	71.42
Ash	*Per cent*	1.92

In bread-making qualities rye approaches wheat more nearly than does any other grain.

Osborne has investigated the proteins of rye and reports that they are similar to, but not identical with, those of wheat.

Barley

The cultivated barleys belong to two or three different species of the genus *Hordeum*.

The grain is about as large as wheat, one hundred kernels weighing about 4 grams. As human food it appears in this country chiefly in the form of "pearled barley," used mainly in soups, and "patent barley flour" for infant feeding. In making pearled barley the germ and most of the bran is removed without grinding the remainder of the grain. "Patent" barley flour is a finely ground product representing the grain from which the outer layers have been removed more completely than in making pearled barley, but perhaps not so completely as in making "patent" flour from wheat. The following are comparative analyses of barley (the entire kernel), pearled barley, and patent barley flour (Table 39).

Table 39. Composition of Barley and Barley Flour

	Barley (Entire Grain)	Pearled Barley	"Patent" Barley Flour
Moisture . . . . *Per cent*	11.9	11.3	10.3
Protein (nitrogen × 6.25) . . *Per cent*	10.5	8.5	8.0
Fat (ether extract) . . . . *Per cent*	2.2	1.1	1.7
Carbohydrates (by difference) *Per cent*	72.8	77.8	79.35
Fuel value, Calories per pound . . .	1610.	1615.	1650.
Weight of 100 Calorie portion,			
in grams	28.	28.	28.
in ounces	1.0	1.0	1.0
Total ash . . . . *Per cent*	2.6	1.3	0.65
Phosphorus (calc. as P_2O_5) . *Per cent*	0.95	0.46	0.30
Iron (calc. as Fe) . . . . . *Per cent*	0.004	0.0013	0.0010

The student should notice in what respects the mill products differ from the original grain, and compare the corresponding data for other grain products.

Osborne found in barley an alcohol-soluble protein, different from that of wheat or of rye, to which he gave the name "hordein." The products of hydrolysis and the ultimate composition of hordein are given in comparison with some other grain proteins beyond. The albumin, the globulin, and the proteose extracted from barley were judged by Osborne to be probably identical with the corresponding proteins found in wheat and rye.

Barley which has begun to sprout (called malted barley or simply " malt ") is rich in an enzyme which digests starch with production of maltose. Enzymes which digest starch are called *amylases*, commonly also " diastases." The characteristic enzyme of malted barley is commonly called malt diastase. On account of its high " diastatic power," due to abundance of this enzyme, barley malt is largely used in the fermentation industries as a means of digesting the starch (of the barley itself and often also of other grains) into fermentable sugar.

Oats

Oats belong to different species of the genus *Avena*, the kind commonly cultivated being *Avena sativa*. Oat culture is widely distributed over Europe and America, and the grain very generally used both as human food and for feeding farm animals.

The husk of the oat adheres closely to the grain and is not usually removed before sending the grain to market. The following analyses of oats with and without the husks and of oatmeal as ordinarily ground are from bulletins of the United States Department of Agriculture.

TABLE 40. ANALYSES OF OATS AND OAT PRODUCTS

	OATS ENTIRE KERNEL WITH HUSK	OATS KERNEL WITHOUT HUSK	OATMEAL	ROLLED OATS
	Per cent	*Per cent*	*Per cent*	*Per cent*
Moisture	10.06	6.93	7.3	7.7
Protein	12.15	14.31	16.1	16.7
Fat	4.33	8.14	7.2	7.3
Fiber	12.07	1.38	0.9	1.3
Carbohydrates, other than fiber	57.93	67.09	67.5	66.2
Ash	3.46	2.15	1.9	2.1

It is evident from these averages that in general oatmeal and rolled oats have about the same composition and represent nearly the whole of the oat kernel. In the making of these products the chaffy husk is of course eliminated and with it is usually removed a portion of the skin of the kernel, and sometimes the tips of the kernels are also scoured off, but the greater part of the germ and a considerable part of the outer layers of the kernel remain in the product offered for sale. Oatmeal and rolled oats are therefore relatively rich in fat as well as in protein, and are somewhat more concentrated foods, both from the standpoint of energy value and protein content, than are the other staple grain products.

The proteins of oats have proven particularly difficult to purify and have therefore not yet been studied so thoroughly as have some of the other grain proteins.

Farther on in this chapter the nutritive value of oat products and their place in the diet will be considered in connection with the same characteristics of other grain products.

Maize or Indian Corn (*Zea mays*)

Maize or Indian corn (commonly called "corn" in the United States, though the word corn in English literature usually refers to the wheat plant) is a native American plant and has long been (economically) the most important single crop raised in the United States. The area annually planted to maize in this country is said to be nearly equal to the entire area of France or Germany. A normal crop is estimated by the United States Department of Agriculture at about 3,000,000,000 bushels. The relative distribution of corn culture throughout the United States is shown in Fig. 12 (Chapter VI).

Of the total corn crop from 85 to 90 per cent is fed on farms and only 10 to 15 per cent comes to market.

It will be seen that in the corn crop there is an enormous reserve supply of material suitable for human food. To any extent that the demand for corn meal makes it more profitable for the farmer to sell his corn to the miller than to use it in raising and fattening farm animals, the supply of corn meal can be increased up to about ten times the amount now milled without necessarily increasing the amount of land devoted to corn raising. To use for human food a large proportion of the corn now fed to farm animals, would of course diminish somewhat the amount of meat produced, but as was pointed out in Chapter V one can never recover in the edible flesh of the carcass more than a small fraction of the protein and energy which was required for the growth and fattening of the animal.

The following approximate analyses (Table 41) indicate the more significant differences in composition between (1) the kernel as a whole, (2) the "old process" corn meal made by grinding the entire kernel and sifting out only the larger particles of bran, (3) the "new process" corn meal in the making of which the bran is more completely removed and the germ is also rejected.

TABLE 41. ANALYSES OF CORN AND CORN MEAL

	CORN (ENTIRE KERNEL)	OLD PROCESS CORN MEAL	NEW PROCESS CORN MEAL
	Per cent	*Per cent*	*Per cent*
Moisture	10.7	11.6	12.0
Protein (nitrogen × 6.25)	10.0	9.0	7.8
Fat	4.3	4.3	1.3
Carbohydrate (other than fiber)	71.8	72.5	78.5
Fiber	1.7	1.5	0.8
Ash	1.5	1.3	0.6
Phosphorus (calc. as P_2O_5)	0.7	0.7	0.22

To meet the requirements of the standards proposed by the Association of Official Agricultural Chemists, corn meal must contain not more than 14 per cent of moisture, not less than 1.12 per cent of nitrogen, and not more than 1.6 per cent of ash.

The establishment of official grades and standards for corn will permit grits, corn meal, and corn flour to have a moisture content of from $12\frac{1}{2}$ to $13\frac{1}{2}$ per cent. Fat content may range from $1\frac{1}{2}$ to $2\frac{1}{2}$ per cent, instead of being limited to $1\frac{1}{2}$ per cent. In any case the sum total of the moisture and fat content must not exceed 15 per cent.

Standard bolted and plain or water ground common corn meal, when shipped in interstate traffic, must not contain more than 12 per cent of moisture.

The composition of the corn kernel can be altered by breeding and selection. Hopkins and Smith of Illinois Agricultural Experiment Station starting with corn containing 10.92 per cent protein and 4.70 per cent fat have by breeding and selection through ten years (ten generations of the corn plant) produced a " high protein " strain with 14.26 per cent protein and a " low protein " strain with 8.64 per cent of protein; also a " high fat " strain with 7.37 per cent, and a " low fat " strain with 2.66 per cent of fat.

Osborne finds that corn contains an albumin, at least three globulins, a proteose similar to that in wheat, an alcohol-soluble protein (different from those of other grains) to which the name zein has been given, and an insoluble glutelin. The zein and glutelin are included in the discussion of chemical structure and food value of grain proteins beyond.

A maize kernel of the varieties chiefly cultivated in the United States has about ten times the weight of a kernel of wheat. Like the latter it has a fibrous outer skin beneath which is a layer rich in protein and phosphorus compounds which is often called the gluten layer; within these outer layers lie the germ, constituting about one tenth, and the endosperm, which makes up between eight tenths and nine tenths of the entire kernel.

The bran obtained in the ordinary grinding of corn includes along with the fibrous hull a considerable proportion of the so-called gluten layer. When the corn kernel is soaked to loosen the skin, the latter may be removed alone, leaving the starchy and the "glutenous" parts of the endosperm together. Wagner gives the following analyses of the skin, the germ, and the endosperm as thus separated (Table 42).

TABLE 42. COMPOSITION OF CORN KERNEL AND ITS PARTS (WAGNER)

PART	PROPORTION OF THE WHOLE	PROTEIN	FAT	CARBOHYDRATE OTHER THAN FIBER	FIBER	ASH
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Original kernel	100.0	12.6	4.3	79.4	2.0	1.7
Skin	5.5	6.6	1.6	74.1	16.4	1.3
Germ . . .	10.2	21.7	29.6	34.7	2.9	11.1
Endosperm .	84.3	12.2	1.5	85.0	0.6	0.7

We have spoken of the hull as fibrous covering, yet the above analysis indicates that the fiber constitutes only about one fifth of the total carbohydrate of the hull. This is partly because only the fiber sufficiently resistant to remain after successive boiling with acid and alkali is reported as "fiber" in the analysis, while all the material (other than protein, fat, and ash) which is dissolved by the acid or the alkali is reported as "carbohydrate other than fiber" or as "nitrogen-free extract." The latter therefore includes not only the starch, but also the pentosans and much of the so-called lignin or lignone substances, which in their chemical nature are not strictly carbohydrate but which are usually grouped with the carbohydrates because of their close association with cellulose. The material designated in the table as carbohydrate other than fiber is therefore quite different for different parts of the kernel: in the hull it is chiefly pentosan; in the endosperm, chiefly starch; in the germ there is much less starch and an appreciable amount of sugar.

The chief differences in composition among the different parts of the corn kernel may be summarized as follows: The hulls contain much fiber and wood gum (pentosans) and relatively little starch, protein, or fat; the endosperm is rich in starch, low in fiber, relatively poor in fat and ash, and has about the same percentage of protein as the entire kernel; the germ contains little starch, but is rich in fat, protein, and ash. The fat is liquid at ordinary temperatures and therefore usually referred to as oil. It is classed as a "semi-drying" oil, being intermediate in properties between olive oil and linseed oil. The chemical nature and nutritive value of the proteins and ash constituents will be discussed along with those of wheat farther on in this chapter.

The industrial process of separating and refining the chief components of corn will now be described in brief outline.

Manufacture of Starch and Other Products from Corn

The corn is first cleaned and sent to steeping tanks, where it is soaked (steeped) for about 2 days in warm water to which has been added a small amount of sulphurous acid to prevent putrefaction and assist in the loosening of the hull.

This steeping causes the corn to swell, and brings about a softening of the endosperm which facilitates the subsequent separation of the germ.

The steeped grain is then coarsely ground in mills so arranged as to disintegrate the kernel without breaking the germ. The type known as the Foos or Fuss mill, in which the grain is torn to pieces by passing between parallel studded plates which revolve in opposite directions, is generally used.

The ground mass is then run into the "separators," which are long tanks or vats containing a mixture of starch and water of a density of 8° Baumé (1.06 specific gravity). The germs, on account of the oil which they contain, float on this liquid, while the hulls and starch granules tend to settle to the bottom. The separation is a continuous process, the ground mass being introduced at one end of the tank while at the other end the germs float off at the top and the other constituents are drawn off from the bottom.

The germs are repeatedly washed with water to remove any adhering starch, then dried in revolving steam driers and the oil extracted by pressure.

Corn oil seems to have established itself as a satisfactory product for which there will be an ever increasing demand as a substitute for the more expensive oils. In 1918, 111,000,000 pounds of corn oil were produced, of which about 70 per cent was refined for edible purposes. The corn oil when refined and deodorized is a pale straw color with a slightly characteristic taste.

The crude oil is used in making soaps and soap powders, in the tanning industry, in paint and putty, and in the manufacture of rubber substitutes and water-proofing and insulating materials. Oil cake, as the mass remaining after pressing the dried germs for oil is called, contains still a considerable amount of fat and is very rich in protein. At present this oil cake is used in stock-feeding. In view of the high food value of the germ and the fact that it constitutes about one tenth of the entire grain, it seems unfortunate that it enters so little into human consumption.

The coarsely ground mass drawn off from the bottoms of the separator tanks as described above, and which represents all of the corn except the germ and the water-soluble substances, is reground in burr-stone mills (" Buhr " mills) and the semi-liquid mass passed over " shakers." These are mechanically shaken sieves of bolting cloth of about 200 mesh which sift out the particles of hull while the starch granules and most of the protein pass through. The hulls are sprayed with water while on the sieves and are usually reground and the process repeated two or three times to complete the removal of the starch from the particles of hull.

The liquid which has passed through the " shakers," and which contains practically all of the starch and most of the protein of the corn, is known as the raw starch liquor. This is adjusted to a density of 4° to 5° Baumé (1.03 to 1.045 specific gravity) and then passed into very long flat-bottomed tanks known as "runs" or "tables." These are almost level, being usually 100 to 120 feet long and inclined only about 4 inches. As the raw starch liquor flows slowly down the run, the starch granules settle out gradually, and in rolling along the bottom before finally coming to rest they tend to rub each other free from adherent protein. The length and inclination of the "runs" and the concentration of the raw starch liquor are so adjusted that nearly all of the starch settles before reaching the lower end of the run, while most of the protein remains suspended in the water which flows out and which is known as the "gluten liquor." The solids of this "gluten liquor" are recovered in the gluten feed.

When the "gluten liquor" has been drained off from the "run," the starch which has settled is found in a very compact deposit which may be dug out in blocks like stiff wet clay. As taken from the "tables" or "runs" it is known as "green starch." This may be utilized directly for the manufacture of glucose or corn sirup. To refine the "green starch" for eating or for industrial use it is stirred with water and again sent over the "run," or washed more quickly by decantation, according to the degree to which the starch is to be freed from protein; or in preparation for certain purposes it may be washed with dilute alkali. The latter is more effective in removing the protein than is water alone, but the subsequent removal of the alkali from the starch is difficult. Being used for many industrial purposes as well as for food, starch and dextrin are prepared in a variety of forms the description of which does not come within the scope of this book.

For the manufacture of commercial glucose, the "green starch" is stirred with water to make a suspension of a density of about 20° to 22° Baumé (1.16 to 1.18 specific gravity), to which is added hydrochloric acid in such proportion as to make about 0.1 per cent of actual acid in the entire mixture. This mixture is treated with superheated steam in strong metal cylinders called converters. The converters now in use are six feet in diameter and may be as much as twenty feet high. By running in superheated steam up to a pressure of 35 pounds per square inch, the hydrolysis of the starch is greatly accelerated and is brought to the desired point in a few minutes. The pressure is then released and the acid neutralized with sodium carbonate. The neutral solution is then filtered clear, concentrated by evaporation, decolorized by running through bone-black filters like those used in the refining of cane sugar (Chapter XI), and finally evaporated further to a viscous sirup containing 80 per cent or more of solids.

The average composition of this sirup according to Wagner is:

	Per cent
Water	19.0
Glucose (dextrose)	38.5
Dextrin	42.0
Ash	0.5

In this case it is assumed that glucose (dextrose) is the only reducing sugar present. According to Rolfe and Defren, however, there would be present at the stage of hydrolysis reached in this process a considerable amount of maltose, so that the actual percentage of glucose would be less than that given by Wagner. In any case it will be seen that considerably less than half of the carbohydrate material is actually in the form of glucose. This product is called "commercial glucose" or "corn sirup"; to call it simply glucose is obviously inaccurate and contrary to the regulation that a food product which is a mixture must not be sold under the name of a single constituent.

The manufacture of purified corn starch and of corn sirup or commercial glucose are usually carried on in the same factories. Both industries have developed rapidly in recent years.

Millets and Grain Sorghums

The name "millet" (from *mille*, thousand, referring to the large number of seeds borne by one plant) has been applied to several kinds of food grains, some of which belong to different and not closely related species. *Panicum miliaceum* (German *Hirse*) is the common millet of Europe and probably still the most common in this country.

It is very widely cultivated in Europe, Asia, northern Africa, and to a less extent in the Americas. While largely used and highly prized as a feed for farm animals and poultry (a Russian peasant expression for contentment is "as happy as a millet-fed hen"), millet is also a valuable food for man. It is perhaps most often milled to the form of groats, and large quantities of millet groats are used as human food in Russia cooked with water, or with fat, or combined, in the various ways in which rice is combined, with meats and vegetables.

Australian millet, Polish millet, and Guinea grass are other species of the same genus. Less closely related are Egyptian millet or pearl millet (widely cultivated in the near and far East and popular as a breakfast food with Americans there), and Indian millet or *durra*.

McCollum reported millet seed richer in vitamin A than are other seeds. Steenbock, Sell, and Jones, however, find that millets are not uniformly rich in this vitamin; "some contain barely enough to give evidence of its presence" while other varieties contain somewhat more than most seeds. These investigators do not consider it warrantable to assume that millets occupy a unique position among the grains with respect to their content of the fat-soluble vitamin. A large variety of grain sorghum, extensively grown in northern China, is sometimes called Manchurian millet. Its native name is kao-liang. In the region from Peking northward nearly to Harbin one passes through miles of unbroken fields of kao-liang, as of wheat or maize on the American prairies. It grows to a height of 10 to 12 feet, bearing a large cluster of seeds at the top.

The grain sorghums are able to thrive with relatively little moisture, and several varieties of them are now being tested in the dry-farming of some of our western states. While not of great economic importance in this country at present (1923), they may easily become so if dry-farming extends. Probably most of the products made from corn (maize) could be made from the seeds of the grain sorghum if future economic conditions should render this profitable.

Buckwheat

Buckwheat, the seed of *Fagopyrum esculentum*, is not a cereal (since the plant which bears it does not belong to the true grasses), but for practical discussion is usually grouped with the cereal grains. Although more popular as a food in the United States than in most other countries, the amount grown is small as compared with other grains.

The buckwheat kernel is about as large as that of wheat or barley and is characterized by its different shape and higher proportion of fiber due to its thick protective covering. The latter is rejected in milling the grain, so that the "fine" buckwheat flour has, like "fine" wheat flour, only a negligible amount of fiber — about one half of one per cent.

Typical American analyses of buckwheat and buckwheat flour are as follows (Table 43):

Table 43. Composition of Buckwheat and Buckwheat Flour

	Buckwheat (Entire Grain)	Buckwheat Flour
	Per cent	*Per cent*
Moisture	12.3	11.9
Protein (nitrogen × 6.25)	10.7	8.7
Fat	2.0	1.6
Carbohydrates (other than fiber)	62.8	76.2
Fiber	10.7	0.6
Ash	1.8	1.0

In order to comply with the standard of the Association of Official Agricultural Chemists, buckwheat flour must contain not more than 12 per cent moisture, not less than 1.28 per cent nitrogen, and not more than 1.75 per cent of ash.

Breakfast Cereals

The great variety of forms in which the grains are prepared as breakfast foods and the extravagant claims which have sometimes been made by the manufacturers have directed so much attention to these products that it is now generally understood that they resemble closely the staple grain products in composition and nutritive value.

For detailed discussion of these products with analyses of the different brands, the reader is referred to the following publications:

Atwater. Digestibility of Cereal Breakfast Foods. Storrs (Conn.) Agricultural Experiment Station, 16th Annual Report, pages 180–209 (1904).

Harcourt. Breakfast Foods; Their Chemical Composition, Digestibility and Cost. Journal of the Society of Chemical Industry, Vol. 26, pages 240–243, and Ontario Department of Agriculture, Bulletin 162 (1907).

Woods and Snyder. Cereal Breakfast Foods. U. S. Department of Agriculture, Farmers' Bulletin 249.

See also the general references at the end of the chapter.

Composition of Grain and Bakery Products

The composition of most of the grains and of several of their mill products have been given in the preceding sections of this chapter. The table which follows contains a compilation of analyses of raw and cooked grain products, taken chiefly from Atwater and Bryant and arranged according to their classification.

TABLE 44. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN ANALYSES)

Description	Number of Analyses	Water	Protein (N × 6.25)	Fat	Total Carbohydrates (including Fiber)	Fiber (Number of Determinations in Parentheses)	Ash	Fuel Value per Pound
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
FLOUR, MEALS, ETC.								
Barley meal and flour	3	11.9	10.5	2.2	72.8	(3) *6.5*	2.6	1603
Barley, pearled	3	11.5	8.5	1.1	77.8	(1) *.3*	1.1	1615
Buckwheat flour	17	13.6	6.4	1.2	77.9	(8) *.4*	.9	1577
Buckwheat preparations, self-raising	14	11.6	8.2	1.2	73.4	(1) *.4*	5.6	1530
Corn meal, granular	19	12.5	9.2	1.9	75.4	(1) *1.0*	1.0	1620
Pop corn	2	4.3	10.7	5.0	78.7	*1.4*	1.3	1826
Corn preparations:								
Cerealine	5	10.3	9.6	1.1	78.3	(4) *.4*	.7	1640
Hominy	17	11.8	8.3	.6	79.0	(12) *.9*	.3	1608
Hominy, cooked	1	79.3	2.2	.2	17.8	——	.5	371
Parched	2	5.2	11.5	8.4	72.3	——	2.6	1865
Kafir corn	1	16.8	6.6	3.8	70.6	*1.1*	2.2	1557
Oatmeal	16	7.3	16.1	7.2	67.5	(9) *.9*	1.9	1811
Oatmeal, boiled	1	84.5	2.8	.5	11.5	——	.7	280
Oatmeal gruel	2	91.6	1.2	.4	6.3	——	.5	152
Oatmeal water	2	96.0	.7	.1	2.9	——	.3	69
Rice	21	12.3	8.0	.3	79.0	(13) *.2*	.4	1591
Rice, boiled	3	72.5	2.8	.1	24.4	——	.2	498
Rice, flaked	2	9.5	7.9	.4	81.9	*.2*	.3	1647
Rye flour	8	12.9	6.8	.9	78.7	(4) *.4*	.7	1588
Rye meal	1	11.4	13.6	2.0	71.5	*1.8*	1.5	1626
Wheat flour, California fine	3	13.8	7.9	1.4	76.4	——	.5	1585
Wheat flour, entire wheat	9	11.4	13.8	1.9	71.9	(3) *.9*	1.0	1630
Wheat flour, Graham	13	11.3	13.3	2.2	71.4	(3) *1.9*	1.8	1628
Wheat flour, prepared (self-raising)	29	10.8	10.2	1.2	73.0	(3) *.4*	4.8	1560
Wheat flour, patent roller process, bakers' grade	14	11.9	13.3	1.5	72.7	(6) *.7*	.6	1623
Wheat flour, patent roller process, family and straight grade	28	12.8	10.8	1.1	74.8	(6) *.2*	.5	1600

TABLE 44. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN ANALYSES) — Continued

DESCRIPTION	NUMBER OF ANALYSES	WATER	PROTEIN (N × 6.25)	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
FLOUR, MEALS, ETC.								
Wheat flour, patent roller process, grade not indicated	111	11.5	11.4	1.0	75.6	(15) *.2*	.5	1620
Wheat flour, patent roller process, high grade	57	12.4	11.2	1.0	74.9	(14) *.2*	.5	1603
Average of all analyses of high and medium grades and grade not indicated	210	12.0	11.4	1.0	75.1	(41) *.3*	.5	1610
Wheat flour, patent roller process, low grade	13	12.0	14.0	1.9	71.2	(7) *.8*	.9	1625
Wheat breakfast foods:[1]								
Cracked and crushed	11	10.1	11.1	1.7	75.5	(7) *1.7*	1.6	1635
Farina	9	10.9	11.0	1.4	76.3	(7) *.4*	.4	1640
Flaked	7	8.7	13.4	1.4	74.3	*1.8*	2.2	1648
Parched and toasted	6	8.6	13.6	2.4	74.5	*.8*	.9	1696
Shredded	6	8.1	10.5	1.4	77.9	(3) *1.7*	2.1	1660
Wheat preparations:								
Macaroni	11	10.3	13.4	.9	74.1	——	1.3	1625
Noodles	2	10.7	11.7	1.0	75.6	*.4*	1.0	1625
Spaghetti	3	10.6	12.1	.4	76.3	(2) *.4*	.6	1620
Vermicelli	15	11.0	10.9	2.0	72.0	——	4.1	1587
BREAD, CRACKERS, PASTRY, ETC.								
Bread, corn (johnnycake)	5	38.9	7.9	4.7	46.3	——	2.2	1175
Bread, rye	21	35.7	9.0	.6	53.2	(9) *.5*	1.5	1153
Bread, rye and wheat	1	35.3	11.9	.3	51.5	——	1.0	1163

[1] The different groups of wheat breakfast foods contain various brands, which have been arranged as far as possible according to similarity in method of preparation. The varieties under each group differ only slightly from the average in percentage composition.

TABLE 44. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN ANALYSES) — Continued

Description	Number of Analyses	Water	Protein (N × 6.25)	Fat	Total Carbohydrates (including Fiber)	Fiber (Number of Determinations in Parentheses)	Ash	Fuel Value per Pound
BREAD, CRACKERS, PASTRY, ETC.		*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
Bread, etc., wheat:								
Buns, cinnamon, as purchased	1	23.6	9.4	7.2	59.1	——	.7	1537
Buns, currant, as purchased	1	27.5	6.7	7.6	57.6	*1.1*	.6	1488
Buns, hot cross, as purchased	1	36.7	7.9	4.8	49.7	——	.9	1242
Buns, sugar, as purchased	3	29.6	8.1	6.9	54.2	(1) *.3*	1.2	1413
Graham bread, as purchased	27	35.7	8.9	1.8	52.1	(11) *1.1*	1.5	1189
Biscuit, homemade, as purchased	3	32.9	8.7	2.6	55.3	(2) *.7*	.5	1268
Biscuit, Maryland, as purchased	2	24.6	8.4	5.6	60.1	*1.3*	1.3	1470
Rolls, French, as purchased	2	32.0	8.5	2.5	55.7	*.6*	1.3	1267
Rolls, plain, as purchased	5	25.2	9.7	4.2	59.9	(2) *.3*	1.0	1435
Rolls, Vienna, as purchased	1	31.7	8.5	2.2	56.5	*.4*	1.1	1270
Rolls, water, as purchased	2	32.6	9.0	3.0	54.2	——	1.2	1268
Rolls, all analyses, as purchased	20	29.2	8.9	4.1	56.7	(12) *.6*	1.1	1357
Toasted bread, as purchased	5	24.0	11.5	1.6	61.2	——	1.7	1385
White bread, cheap grade	6	33.2	10.9	1.3	53.6	——	1.0	1224
White bread, homemade	38	35.0	9.1	1.6	53.3	(2) *.2*	1.0	1198
White bread, milk, as purchased	8	36.5	9.6	1.4	51.1	——	1.4	1160
White bread, New England, as purchased	7	36.6	9.1	1.2	52.1	——	1.0	1160
White bread, Quaker, as purchased	4	35.8	8.3	1.1	53.7	(3) *.3*	1.1	1170
White bread, Vienna, as purchased	25	34.2	9.4	1.2	54.1	(9) *.5*	1.1	1200

TABLE 44. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN ANALYSES) — Continued

DESCRIPTION	NUMBER OF ANALYSES	WATER	PROTEIN (N × 6.25)	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
BREAD, CRACKERS, PASTRY, ETC.		*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
White bread, all analyses, as purchased, average[1] .	198	35.3	9.2	1.3	53.1	(27) *.5*	1.1	1182
Whole wheat bread, as purchased	12	38.4	9.7	.9	49.7	(1) *1.2*	1.3	1113
Zwieback, as purchased .	4	5.8	9.8	9.9	73.5	——	1.0	1915
Crackers, Boston (split) crackers, as purchased .	2	7.5	11.0	8.5	71.1	(1) *.8*	1.9	1837
Butter crackers	3	7.2	9.6	10.1	71.6	(2) *.4*	1.5	1885
Cream crackers	9	6.8	9.7	12.1	69.7	(5) *.6*	1.7	1935
Egg crackers	2	5.8	12.6	14.0	66.6	*.4*	1.0	2008
Flatbread	3	9.8	14.9	.5	73.6	——	1.2	1625
Graham crackers . . .	4	5.4	10.0	9.4	73.8	(2) *1.5*	1.4	1904
Oatmeal crackers . . .	2	6.3	11.8	11.1	69.0	(1) *1.9*	1.8	1920
Oyster crackers	7	4.8	11.3	10.5	70.5	(1) *.2*	2.9	1914
Pilot bread	3	8.7	11.1	5.0	74.2	(2) *.3*	1.0	1752
Pretzels	2	9.6	9.7	3.9	72.8	(2) *.5*	4.0	1657
Saltines	2	5.6	10.6	12.7	68.5	*.5*	2.6	1952
Soda crackers	5	5.9	9.8	9.1	73.1	(1) *.3*	2.1	1875
Water crackers	6	6.4	11.7	5.0	75.7	*.4*	1.2	1790
All analyses	71	6.8	10.7	8.8	71.9	(45) *.5*	1.8	1847

[1] Analyses of similar bread made from different grades of flour, from high to low grade:

	WATER	PROTEIN	FAT	CARBOHYDRATES	FIBER	ASH	FUEL VALUE PER POUND
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
White bread from high-grade patent flour	32.9	8.7	1.4	56.5	——	0.5	1235
White bread from regular patent flour	34.1	9.0	1.3	54.9	——	.7	1212
White bread from baker's flour . .	39.1	10.6	1.2	48.3	——	.9	1117
White bread from low-grade flour . .	40.7	12.6	1.1	44.3	——	1.3	1078

TABLE 44. AVERAGE COMPOSITION OF GRAIN PRODUCTS (AMERICAN ANALYSES) — Continued

DESCRIPTION	NUMBER OF ANALYSES	WATER	PROTEIN (N × 6.25)	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
BREAD, CRACKERS, PASTRY, ETC.		*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
Cake:								
Coffee cake	5	21.3	7.1	7.5	63.2	(4) .4	.9	1583
Cup cake	2	15.6	5.9	9.0	68.5	(1) .3	1.0	1716
Frosted cake	7	18.2	5.9	9.0	64.8	——	2.1	1650
Fruit cake	4	17.3	5.9	10.9	64.1	——	1.8	1715
Gingerbread	2	18.8	5.8	9.0	63.5	(1) .9	2.9	1625
Sponge cake	3	15.3	6.3	10.7	65.9	——	1.8	1748
All analyses, except fruit	27	19.9	6.3	9.0	63.3	(7) .4	1.5	1630
Cookies	20	8.1	7.0	9.7	73.7	.5	1.5	1860
Doughnuts	9	18.3	6.7	21.0	53.1	(2) .7	.9	1942
Fig biscuits or bars	1	17.9	4.6	6.6	69.8	1.7	1.1	1620
Ginger snaps	7	6.3	6.5	8.6	76.0	(5) .7	2.6	1848
Lady fingers	3	15.0	8.8	5.0	70.6	(2) .2	.6	1643
Macaroons	4	12.3	6.5	15.2	65.2	1.1	.8	1921
Pie, apple	4	42.5	3.1	9.8	42.8	——	1.8	1233
Pie, cream	3	32.0	4.4	11.4	51.2	——	1.0	1465
Pie, custard	1	62.4	4.2	6.3	26.1	——	1.0	800
Pie, lemon	1	47.4	3.6	10.1	37.4	——	1.5	1157
Pie, mince	3	41.3	5.8	12.3	38.1	——	2.5	1298
Pie, raisin	1	37.0	3.0	11.3	47.2	——	1.5	1373
Pie, squash	1	64.2	4.4	8.4	21.7	——	1.3	817
Pudding, Indian meal	1	60.7	5.5	4.8	27.5	——	1.5	795
Pudding, rice custard	1	59.4	4.0	4.6	31.4	——	.6	830
Pudding, tapioca	3	64.5	3.3	3.2	28.2	——	.8	702
Wafers, miscellaneous	5	6.6	8.7	8.6	74.5	.4	1.6	1860
Wafers, vanilla	6	6.7	6.6	14.0	71.6	(5) .3	1.1	1990

The moisture content of grain products is subject to considerable variation. Bailey finds moisture in flour in equilibrium with air to vary from about 5.25 per cent when the air showed 30 per cent relative humidity to 15 per cent when the relative humidity of the air was 80 per cent.

Nutritive Value of Grain Products and Their Economy as Food

The quantitative composition of the grains and of the chief food products made from them has already been given. The grains themselves, their chief mill products, and the dry cereal preparations made from them show considerable similarity in the general features of their chemical composition, and they vary but little from an average fuel value of about 1650 Calories per pound. The 100-Calorie portion of all these (dry) products is very nearly one ounce (varying only from 25 grams for oatmeal to 29 grams for rice). The cooked products naturally show greater differences, chiefly because of the presence of added water or fat.

The chemical nature and nutritive value of the carbohydrates (chiefly starch in all of the grains) and of the fat do not offer any problem requiring further discussion.

The chemical structure of the proteins of the cereal grains has been investigated with great thoroughness by Osborne, from whose results are taken the percentages of amino acids obtained on hydrolysis of these proteins as shown in Table 45.

That glycine is absent in some cases is, as has been seen in earlier chapters, a matter of no consequence so far as food value is concerned. When, however, we find little or no lysine, as in gliadin, hordein, and zein, or find tryptophane absent as in zein, we are confronted with a deficiency which affects seriously the nutritive value.

TABLE 45. AMINO ACIDS FROM PROTEINS OF GRAINS (OSBORNE)

	HORDEIN (BARLEY)	ZEIN (CORN)	GLUTELIN (CORN)	PROLAMIN (RYE)	GLIADIN (WHEAT)	GLUTENIN (WHEAT)	LEUCOSIN (WHEAT)	EDESTIN (HEMP)[1]
Glycine	0	0	0.25	0.13	0	0.89	0.94	3.80
Alanine	0.43	9.79	?	1.33	2.00	4.65	4.45	3.60
Valine	0.13	1.88	?	——	3.34	0.24	0.18	6.20
Leucine	5.67	19.55	6.22	6.30	6.62	5.95	11.34	14.50
Proline	13.73	9.04	4.99	9.82	13.22	4.23	3.18	1.70
Phenylalanine	5.03	6.55	1.74	2.70	2.35	1.97	3.83	2.40
Aspartic acid	?	1.71	0.63	0.25	0.58	0.91	3.35	4.50
Glutamic acid	43.20	26.17	12.72	38.05	43.66	23.42	6.73	14.50
Serine	?	1.02	?	0.06	0.13	0.74	——	0.33
Tyrosine	1.67	3.55	3.78	1.19	1.20	4.25	3.34	2.13
Cystine	1.00	——	——	——	0.45	0.02	——	1.00
Lysine	1.00	0	2.93	——	0.92	1.92	2.75	1.65
Histidine	1.28	0.82	3.00	0.39	0.61	1.76	2.83	2.19
Arginine	2.16	1.55	7.06	2.22	3.16	4.72	5.94	14.17
Ammonia	4.84	3.64	2.12	5.11	5.22	4.01	1.41	2.28
Tryptophane	Present	Absent	Present	Present	1.05	1.80	Present	1.50
Summation	78.17	85.27	45.44	67.55	82.69	59.68	50.32	76.95

Osborne and Mendel have used these proteins largely in their feeding experiments with isolated food substances and have found: (1) that when zein (lacking tryptophane) is the only protein of the diet, it does not suffice for the needs either of a growing or a full-grown animal; (2) that when hordein or gliadin (containing tryptophane but very little lysine) is the sole protein fed, full-grown animals can be maintained, but young animals cannot grow.

That these deficiencies in food value are actually due to the lack of the amino acids named has been shown by experiments in which the simple addition of the amino acid to the dietary was found to correct the deficiency.

This successful correlation of the chemical structure and nutritive function of the proteins is an accomplishment of the greatest importance to the scientific development of food chemistry.

[1]Edestin occurs also in wheat.

It does not follow, however, from the fact that gliadin, hordein, or zein is inadequate as a sole protein food, that wheat, barley, maize, or their mill products would be correspondingly inadequate even if fed alone. Each of these grains (and of the staple mill products made from them) contains a mixture of proteins, and the other proteins with which gliadin, hordein, and zein are always mixed in wheat, barley, and maize do not show these same peculiarities of chemical structure, so that we have no reason to fear that either lysine or tryptophane would ever be wholly lacking in any staple food product made from grain. Thus glutenin, which is always present in wheat flour, has been shown to be adequate for both maintenance and growth even when it was the only protein in the diet. It is, however, only reasonable to expect that the mixture of proteins found in corn meal or even wheat flour will be of somewhat less value in nutrition than an equal weight of the mixture of proteins which we find in milk, eggs, or meat.

Fortunately the proteins of milk are relatively rich in those amino-acid radicles in which the grains are poor. Osborne and Mendel have found that their animals are not only maintained in health and vigor, but also make a normal rate of growth when three fourths of their protein is zein and one fourth is lactalbumin. If bread be made with milk instead of water, or if breakfast cereal or even corn meal mush be eaten with cream or milk, the protein of the combination may have fully as high a value in nutrition as the average protein of ordinary mixed diet.

In connection with wheat-saving by substitution of other cereals during the war, the question of the equivalence of the different food-grains and particularly of corn with wheat in nutrition became a matter of some importance.

The investigations of McCollum, in which laboratory animals have been kept on restricted diets often for a lifetime, and in several cases for more than one generation, seem well calculated to bring to light any differences in the more obscure factors of food value or in general wholesomeness of the two grains, if any such differences exist. In summaries of the results of an extended series of such experiments, McCollum repeatedly has stated that wheat and maize are very similar in their dietary properties. If this seems surprising in view of the well-known inadequacy of zein when fed as the sole protein of the diet, it should be recalled that Osborne and Mendel, to whom our knowledge of the nature of this deficiency of zein is so largely due, have demonstrated also that the other important protein of corn, maize glutelin, is adequate to meet all protein requirements and maintain a normal rate of growth when fed as the sole protein of the diet. They have also shown that zein, while inadequate alone, may yet take the major part in meeting protein requirements either of maintenance or of growth, when it is supplemented by a much smaller amount of milk protein.

As the result of their further studies with rats, Osborne and Mendel have also found the proteins of barley, oats, rye, and wheat to be about equally efficient in promoting and supporting growth.

Wheat, maize, and oat proteins all showed essentially the same efficiency in human nutrition experiments carried on in the writer's laboratory.

The evidence at present available makes it appear probable that there is this slight difference, that in wheat and oats the first limiting amino acid is probably lysine, while in maize tryptophane is probably the first and lysine the second limiting amino acid.

Experiments by Osborne and Mendel have shown that the proteins of entire wheat have a much higher nutritive efficiency than an equal weight of the proteins of patent flour.

Kramer and St. John have found that the heating involved in toasting bread does not lower the nutritive efficiency of its protein.

The digestibility of the grain proteins when fed free is probably not inferior to that of animal protein. It is evidently very largely because of the associated substances, such as cell walls which still inclose the grain proteins to a certain extent in ordinary mill products, that the coefficient of digestibility of the protein of bread, for example, is lower than that of an average mixed diet. Partly for the same and partly for other reasons, it was anticipated that the coefficient of digestibility of whole grain products might be somewhat lower than that of the finer products representing only the inner portion of the kernel.

This question was of particular interest as affecting the comparative food values of patent, "entire wheat," and Graham flours and the breads made from them. The average results of a long series of digestion experiments carried out under the auspices of the United States Department of Agriculture were as shown in Table 46.

TABLE 46. DIGESTIBILITY OF BREADS MADE FROM DIFFERENT FLOURS

	Coefficient of Digestibility of	
	Protein	Carbohydrate
	Per cent	*Per cent*
Standard patent flour	88.6	97.7
"Entire wheat" flour	82.0	93.5
Graham flour	74.9	89.2

The lower coefficients of digestibility of the "entire wheat" and Graham flours almost exactly offset their higher protein contents, so that it may be said that the amount of protein digested and absorbed from a pound of one of these or from a pound of patent flour is practically the same. The amount of available energy is also about the same in either case. However, as Woods and Merrill have pointed out, it does not follow that a larger amount of digestible nutrients may not be obtained from a given amount of wheat when milled as Graham flour or as entire wheat flour than when ground for patent flour, because 100 pounds of cleaned and screened wheat will yield 100 pounds of Graham flour, or about 85 pounds of " entire wheat " flour, but only about 70 pounds of patent flour. It follows that if milled on an equally large scale, *i.e.* if there were an equally large demand, Graham and " entire wheat " flours could be sold at a lower price than patent flour, but at present they usually cost as much, or in some cases even more.

Regarding the coarser and finer flours simply as sources of protein and energy, they are so nearly equal both in digestible nutrients and (at present, to the individual consumer) in pecuniary economy [1] that they may be regarded as substantially equivalent and interchangeable. They are, however, quite different as sources of mineral elements and vitamin B and somewhat different in their effect upon the digestive tract.

The coarser wheat products stimulate peristalsis more than do the fine flour products, an effect which is desirable in some persons and undesirable in others. This property of the whole wheat products is often attributed to mechanical irritation, but cannot be due entirely to this, because " bran mash " is used as a laxative with horses whose other food (hay, for example) would certainly furnish more mechanical stimulation than the bran. The wheat kernel contains two distinct substances reported as having laxative effects which are largely rejected in the preparation of fine flour. These are the oil of the germ and the phytin (one of the phosphorus compounds) which is especially abundant in the bran. It is probable that in man the stimulation of peristalsis by whole wheat products is due in part to direct mild laxative action by one or both of these constituents, and in part also to the mechanical effect of the fibrous particles.

[1] This, of course, does not apply to certain proprietary "whole wheat" products sold at high prices.

The ash constituents of the grains are largely concentrated in the germs and outer layers. This has been pointed out with respect to barley, maize, and rice earlier in the chapter. We shall therefore consider wheat chiefly at this point. Bran yields 10 to 20 times as much ash as patent flour. Comparing the patent flour with the whole wheat, the discrepancy is still large, the wheat containing 3 to 5 times as much of iron, of phosphorus, of calcium, or of total ash as the fine flour made from it. Thus three fourths of the ash constituents of the wheat kernel are lost to man in the process of manufacturing the wheat into white flour. Doubtless the loss in digestion is somewhat greater for the coarser than for the finer products in the case of the ash constituents as of the proteins, but there is no reason to suppose that the loss in digestion would in any case approach the loss involved in the ordinary milling process. The body probably absorbs from a pound of genuine whole wheat bread at least twice as much phosphorus, iron, and calcium compounds as from a pound of white bread. No adequate experiments upon this point appear to have been made with man,[1] but Bunge[2] has tested the value of the ash constituents of the bran for growing rats.

Eight young rats of the same litter and approximately the same size at the beginning of the experiment were divided into two groups of four each. One group was fed on white bread which contained 0.0015 per cent iron, 0.032 per cent calcium, and 0.12 per cent phosphorus; the other group on whole wheat bread which contained 0.0055 per cent iron, 0.055 per cent calcium, and 0.39 per cent phosphorus. The rats receiving the whole wheat bread grew much better than those fed on white bread, and were found to contain at the end of the experiment both a larger amount and a higher percentage of hemoglobin. It was clear that the ash constituents of the outer layers of the

[1] The ordinary digestion experiments taken alone are useless if not positively misleading for this purpose because of the excretion in the feces of ash constituents which have been absorbed and utilized in the body.

[2] *Zeitschrift für physiologische Chemie*, Vol. 25, page 36 (1898).

grain were utilized for the production of bone, muscle, and blood, and that the rats receiving the whole wheat bread were much better nourished than those which were fed on white bread, though all had appeared equally well nourished at the beginning of the experiment.

The vitamin values of grain products are similar when similarly prepared, but vary greatly with preparation in some respects.

Vitamin A occurs in the whole grains, but in quantities too small to make them satisfactory sources of this vitamin in the nutrition of man or most other animals. What vitamin A the grains contain is chiefly in the embryo or germ, so that the ordinary (degerminated) mill products are apt to be practically devoid of vitamin A.

Vitamin B occurs in the whole grains in relatively liberal amounts. From the experiments of Osborne and Mendel, McCollum, Steenbock, Johns, and others it appears that a ground whole grain such as wheat, maize, or barley, fed in the proportion of 15 to 25 per cent of the total weight of food consumed, will furnish an amount of vitamin B adequate for normal nutrition, thus indicating that the whole grains are four to seven times as rich in vitamin B as the diet as a whole needs to be.

The ordinary mature, dry grains and their mill products are all practically devoid of vitamin C. This vitamin is, however, formed in these as well as other seeds when they are germinated. Hence in the absence of other antiscorbutic foods, carefully germinated grains can be fed for the prevention of scurvy.

Whole grain *versus* highly milled products and the supplementing of grain products by milk. Osborne and Mendel have described experiments in which whole wheat served as the sole source of vitamin B and protein, the diet consisting of whole wheat 92 per cent, salt mixture 3 per cent, and butter fat 5 per cent. This diet, fed to young rats, supported normal growth and reproduction although its protein content was only 10 per cent. Adult rats were well maintained, in Osborne and Mendel's experiments, on a diet in which the sole protein was that of whole wheat and its proportion only 7 per cent of the weight, or 5 to 6 per cent of the total calories, of the food mixture.

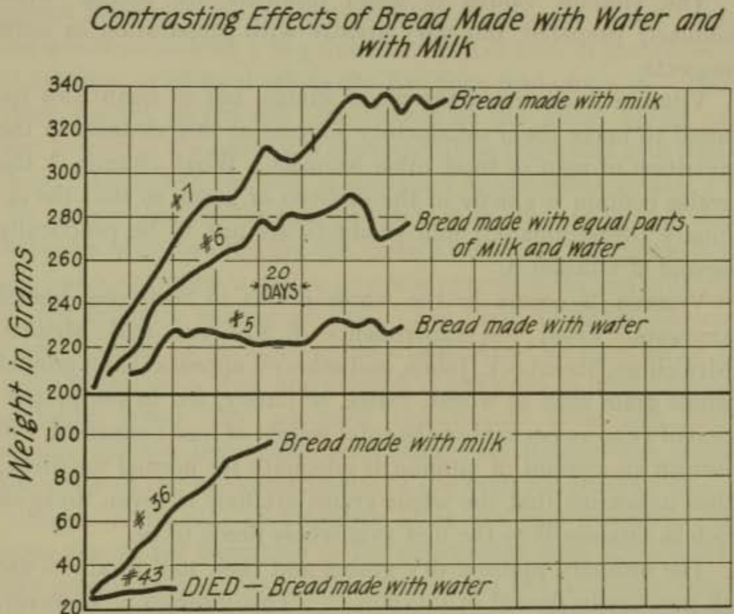

FIG. 25. — Weight curves showing marked difference in nutritive value of bread made with and without milk. (By permission of the *Journal of Biological Chemistry*.)

Patent flour shows a much lower vitamin content than whole wheat and also a less efficient protein mixture. Its proteins are very efficiently supplemented by those of milk. Even a small proportion of milk constituents, such as is introduced by the use of milk in place of water in bread-making, has a marked influence on the nutritive value of bread, as may be seen in Fig. 25. The results are, however, progressively better with increasing proportions of milk in the diet up to at least one third of the total solids of the food (Fig. 26).

"With milk constituting one-third of the total solids of the food intake, almost equally good growth resulted whether the remainder of the diet were whole wheat or patent flour, and even when these were replaced by starch, the result was not very strikingly different. But when the proportion of milk was decreased so that milk solids constituted one sixth of the total dry weight of food, the superiority of whole wheat to patent flour

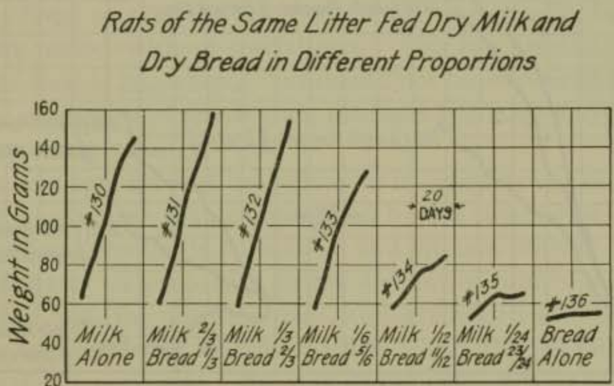

FIG. 26. — Growth curves of rats receiving different mixtures of dried whole milk and dried white bread. (By permission of the *Journal of Biological Chemistry*.)

and of patent flour to starch both became strikingly apparent." Compare the curves on the left with those on the right of Fig. 27 (Sherman and Smith, *The Vitamins*).

The whole grain has also been found markedly superior to patent flour for the support of reproduction and lactation in laboratory animals. A mixture of five parts by weight of ground whole wheat and one part of whole milk powder supported normal growth and successful reproduction and rearing of young by rats, while a corresponding mixture of patent flour and whole milk powder, while giving fairly comparable results in growth, was not adequate to the support of normal reproduction and successful suckling of the young (Sherman, Rouse, Allen and Woods, 1921).

The superior food value of the whole grains over the products representing the endosperm only is due to several factors.

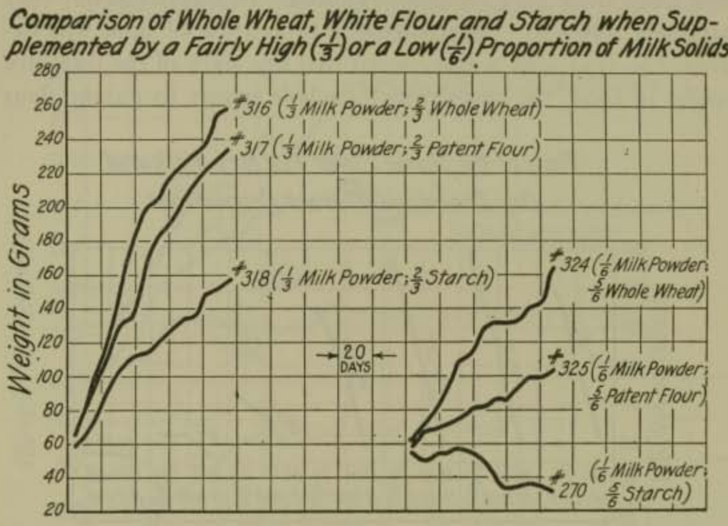

FIG. 27. — Showing that with a liberal proportion of milk in the food mixture the difference in nutritive value between whole wheat and patent flour appears small but that, as shown by a comparison at the right of the chart, as the grain product becomes more prominent in the diet the superiority of the whole wheat over the patent flour and of the patent flour over the starch becomes more marked.

Osborne and Mendel found that the proteins of wheat embryo were more efficient in nutrition, and that those of the endosperm (patent flour) were less efficient than those of the entire wheat grain. The proteins both of the bran and of the germ are quite efficient in supplementing the proteins of the endosperm. When the superiority of the mineral and vitamin contents of the germ and outer layers of the grain are also remembered, it is plain that even though whole grain products are somewhat less completely digested, they are certainly far superior to the highly milled products in nutritive value if the latter term be used in as broad a sense as we should now use it to take account of mineral elements and vitamins as well as protein and calories. Recent work also indicates that the difference in digestibility between properly prepared " whole wheat " bread and that made from patent flour is less than was formerly supposed. Probably for much the same reasons that they are more efficient in nutrition, whole wheat products when not properly kept are more susceptible to the ravages of insects and microörganisms than is patent flour, so that the latter can much more readily be kept for long periods without special care. This is a practical point of considerable importance, but should not be over-emphasized, for the marketing of whole grain products is a large and apparently growing industry.

" It now appears that the difference in completeness of digestion is much more than compensated by the superiority of the whole wheat product in its mineral and vitamin content and in the nature of its proteins. In the amount of protein actually absorbed from the digestive tract, and in energy value, the difference between equal weights of whole wheat and patent flours is practically negligible. But a bushel of grain will make many more pounds of the actual, or even of the so-called, whole wheat flour than of patent flour, so that, even from the standpoint of protein and energy, the best economy demands the milling of as high a percentage as seems practicable of the whole wheat kernel into human food, and from the vitamin standpoint this is also true and in much more striking degree. The parts of the grains now commonly rejected in milling them for human food are, of course, by no means entirely lost since their value in stock feeding is well known; but to the extent that it may be found wise to increase the fraction of the wheat, rice, or maize kernel devoted to human consumption there is no doubt that a true gain in efficient utilization of food resources will result because other and cheaper farm products which are not available for human food can be used in the feeding of animals."[1]

Some writers and teachers treat the losses incurred in the ordinary milling processes as a matter of indifference or even object to any serious discussion of the problem, calling it a "fad" on the ground that with the mixed dietary prevalent in the United States there is no danger of "deficiency disease" from any mode of milling the grains. This is probably true as regards the pronounced diseases such as beriberi, but it is also true that many American family dietaries show little margin of safety as regards iron, phosphorus, and calcium,[2] which makes it only reasonable that we should wish to include in the products used for human food as much as is practicable of those parts of the grain which are rich in these elements.

A paper by Steenbock, Kent, and Gross (Journal of Biological Chemistry, Vol. 35, pages 61–74) on the dietary qualities of barley may be cited as presenting a very complete investigation of a typical grain as food, the investigation being carried out by means of the rat-feeding method.

Pecuniary economy. The grain products, including flour, bread, corn meal, and oatmeal, constitute the most economical of the general groups of foods.

A pound of bread or 12 ounces of flour, corn meal, or oatmeal is equal in fuel value to 5 or 6 ounces of butter or fat bacon, 1 to 2 pounds steak, 2 to 3 pounds halibut or other lean fish.

In an extended series of dietary studies made at the State University of Maine, the grain products, while costing only 17 per cent of the total expenditure for food, furnished 40 per cent of the fuel value, 25 per cent of the protein, and 18 per cent of the phosphorus.

In the general average of 224 typical American dietaries, grain

[1] Sherman and Smith, *The Vitamins*.

[2] Bulletins 185 and 227, Office of Experiment Stations, United States Department of Agriculture.

products represented 18 per cent of the total cost of food and furnished 38 per cent of the calories, 37 per cent of the protein, 30 per cent of the phosphorus, 16 per cent of the calcium, and 26 per cent of the iron.

As a rule a free use of bread and other grain products together with an adequate amount of milk makes for both an economical and a well-balanced dietary.

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CHAPTER IX

VEGETABLES, FRUITS, AND NUTS

SINCE it is difficult to draw any logical line of demarkation between vegetables, fruits, and nuts, because of the many important characteristics common to articles belonging to more than one of these categories, they will here be discussed in one chapter. The number of fruits and vegetables used as food being so large and so likely to grow, it would seem impracticable to attempt to treat them all in the same way in this chapter. What is attempted, therefore, is (1) to discuss adequately a few which are both typical and of large practical importance, (2) to mention briefly as many other important and interesting members of the group as can be included without making the chapter too much like a catalogue, and (3) to include at the end of the chapter references to discussions which will put the reader in touch with as much additional literature on fruits and vegetables as may be desired.

Among fruits and vegetables there are wide differences in protein content and in energy values but practically all are important sources of mineral elements or vitamins or both. In fact the chief nutritional significance of the fruits and vegetables as a group now appears to be in their mineral and vitamin content.

Vegetables

Of the food materials commonly known as vegetables, some are leaves, some flowers or fruits, some seeds, some stems, bulbs, tubers, or roots.

Leaf Vegetables

Leaf vegetables include representatives of several botanical groups, different kinds of leaves being preferred in different countries. In America and Europe, cabbage, lettuce, spinach, chard, and beet greens are the leaves most used as food; in the Orient a much wider variety of leaves is commonly eaten, among which one of the most popular in parts of China is young tender clover.

Green leaves may be ranked next to milk, butter, and egg yolks as sources of vitamin A. It is in green leaves that vitamin A is formed, and in general they contain a higher concentration of this vitamin than is contained in any other part of the plant. From the leaves more or less of the vitamin A passes to the other parts of the plant, where in general it is found in higher concentration in the actively functioning parts, such as the embryos of seeds and the tips of growing shoots, than in storage organs such as the endosperms of seeds and fleshy roots or tubers. It is chiefly to McCollum that we are indebted for this general view of the relation between the functional activity of the parts of plants and their richness in vitamin A. Steenbock, on the other hand, has pointed out that the storage organs of some plants contain more vitamin A than others and that a high concentration of this vitamin often accompanies a high concentration of yellow or green coloring matter. While there are exceptions to both "rules," these suggestions of McCollum and of Steenbock are useful in helping one to remember the vegetables which may be expected to be rich in vitamin A. Among leaves, the thinner and greener the leaf the richer it is apt to be in vitamin A. Spinach is the richest in vitamin A of the leaves thus far studied, containing (notwithstanding its high water content) about as much of this vitamin as an equal weight of butter or of egg yolk. It has been found in the case of cabbage, and is doubtless true of lettuce also, that the loose green leaves are relatively rich and the inner white leaves are relatively poor in vitamin A. In fact the most careful quantitative comparisons yet made have shown white cabbage to contain only about as much vitamin A as an equal weight of white potato while spinach showed at least fifty times as much. Head lettuce showed an intermediate amount. Green string beans (young seed pods) showed at least as much

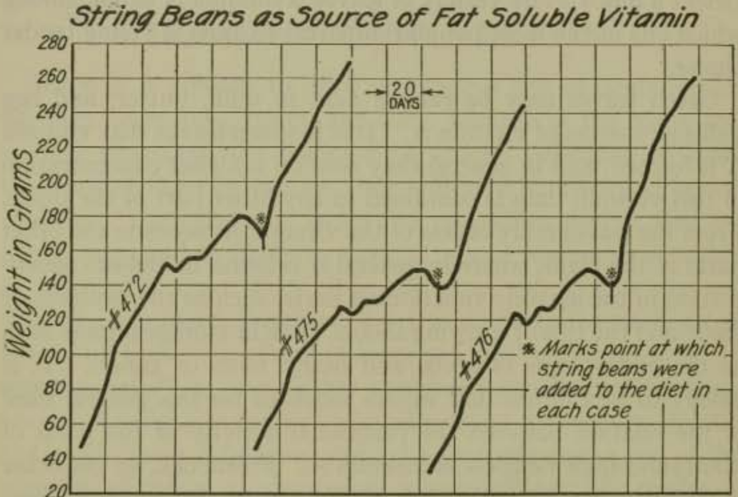

FIG. 28. — String beans as source of vitamin A. Weight curves of three rats which at first were fed a diet deficient in vitamin A. All grew well for some time by virtue of the vitamin A which they had previously stored, but finally began to weaken and lose weight and all developed the characteristic eye disease due to lack of vitamin A. Upon adding string beans to the diet the eye trouble soon disappeared and the animals all quickly recovered in weight and strength and again grew at a rapid rate showing that the string beans furnished liberal amounts of vitamin A.

vitamin A as head lettuce and several times more than the inner leaves of new raw cabbage. As regards vitamin A, therefore, the emphasis should be placed upon *green* rather than merely upon *leaf*, vegetables. (See Fig. 28.)

Probably all the leaf vegetables when raw are fairly rich in vitamins B and C. Raw cabbage and raw spinach rank with orange and lemon juice and with tomatoes among the richest sources of vitamin C. In the case of vitamin B there have been fewer attempts at strictly quantitative comparison, but the available evidence warrants the belief that the leaf vegetables as well as most other vegetables contain vitamin B in relative abundance.

So far as can be judged from the few experiments thus far recorded, neither the vitamin A nor the vitamin B of vegetables is destroyed to any serious degree by ordinary cooking. In the case of vitamin C, however, the losses in cooking are very different for different vegetables. Tomatoes retain their high antiscorbutic value when cooked or canned, while in cabbage this value is very greatly diminished. Thus in the experiments of Eddy and his co-workers cabbage was found to lose from 90 to 95 per cent of its vitamin C (antiscorbutic value) when cooked either by the pressure cooker or by the open-kettle method.

Flowers and Fruits as Vegetables

Cauliflower is the only important example of a flower used as a vegetable; but several important vegetables including tomatoes, pumpkins, squashes, and cucumbers are botanically fruits. Of these, **tomatoes** occupy much the largest place in the American food supply, and the popularity of the tomato, fresh and canned, is fully justified by our present knowledge of food values, for the tomato is rich in all three vitamins and retains them well when cooked and canned. Over 200,000,000 cans of tomatoes are put up commercially each year in the United States besides the large quantities that are canned in the household for home use. The natural acidity of the tomato makes it possible to sterilize it in canning with greater certainty and at a lower temperature than in the case of most other foods. While the canning of tomatoes is a very important industry, it is so simple, the results are so certain, and the product is so nearly uniform and so universally familiar that no description of the industry seems necessary here.

Weight for weight tomatoes, raw or canned, rank with lettuce and green string beans as sources of vitamins A and B, and with oranges and lemons as sources of vitamin C.

Seed Vegetables

The plants whose seeds are commonly classed as vegetables belong chiefly to the Leguminosæ, or pulse family. Such seeds include the various kinds of beans, peas, and lentils and are known collectively as legumes or pulses. Seeds of the Graminaceæ, or grass family, which includes the common cereals, and which have been studied under the general name of "grains" in the preceding chapter, are sometimes grouped with the vegetables. Thus sweet corn is commonly classed as a vegetable, and rice, though handled as a grain crop commercially, is sometimes given the place of a vegetable on the table.

Beans and peas are commonly marketed as food both in the green condition (fresh or canned) and in the dry state, the dry legumes being sometimes classed as "grains." The Census Bureau reports the production of dry edible beans, but fresh legumes do not appear separately in the census reports. Hence we have no statistical data as to the extent to which the green and dry legumes together enter into the food supply of the country as a whole. From the data of about 400 studies of families and other groups of people, Langworthy estimated that they supply 3.3 per cent of the protein, 0.2 per cent of the fat, and 2.0 per cent of the carbohydrate in the average American dietary.

On account of the recent growth of the pea-canning industry, it seems likely that the legumes may now be playing a larger part in the food supply than at the time of the observations upon which Langworthy's estimates are based.

The present methods of canning peas were fully described by Bitting in Bulletin 125, of the Bureau of Chemistry, United States Department of Agriculture, from which the following paragraphs are taken. (Note that this description, quoted from a bulletin published several years ago, takes no account of the vitamins. The student may find it a useful exercise to annotate the description and discussion from the point of view of the probable variations in vitamin content among peas and the influence of each step in the canning process upon each of the vitamins which the green peas may be presumed to contain.)

Pea Canning as Described by Bitting

Pea canning is one of the most important lines of the canning industry, being third in order of output, tomatoes and corn being, respectively, first and second, although peas are second in point of value. The pea pack for 1907 is estimated at 6,505,961 cases, valued at $14,650,000.

The first labor-saving device of importance in pea canning was the podding machine invented by Madame Faure in France in 1883. The invention was practically duplicated in this country in 1889. The American podding machine was improved, and in 1893 it was patented as a vining machine. The whole pea-canning industry was changed by this invention. Practically all of the peas canned in this country are passed through these vining machines, so that their use has virtually changed the growing of peas in small patches — market-garden fashion, with hundreds of persons going over the vines and picking the pods — to the cultivating of large fields which are cut by a machine. The viner occupies the same relation to hand picking in the pea-canning industry that the thrashing machine does to the flail in the thrashing of wheat.

The first operation through which the peas pass after leaving the viner is that of washing. This is accomplished in what is known as the squirrel cage, which is a wire cylinder about 3 feet in diameter and 12 feet long. The cylinder is set on a slight incline so that when the peas are admitted at one end they will tend to roll to the other as the cylinder revolves. On the inside is a perforated pipe that sprays a stream of water upon the peas, which insures their being well washed provided the spray has some force. When the weather is very warm and the peas accumulate more rapidly than they can be passed through the filler, it may be necessary to wash the shelled peas in cold water every few hours in order to prevent fermentation.

After the peas pass through the washer, they should be graded according to the degree of maturity or hardness. This is accomplished by passing them through tanks containing salt solutions of different densities. It has been found that the young tender peas will float in a salt solution somewhat heavier than water and those more mature will sink, while the very mature peas will sink in a heavy salt solution. Peas, therefore, may be sorted very readily into different grades according to their density by using different strengths of salt water. In practice three grades have been made. The first grade consists of all peas which will float in a solution having a specific gravity of 1.040. The second grade consists of those peas which will sink in a solution of this density but which will float in a solution having a specific gravity of 1.070. The third grade consists of the peas which will sink in the latter solution.

Grading. The grading of peas for quality is as sharp and clear as that for size. The lightest weight peas are the finest, being even in quality, succulent, and tender. The heaviest peas are the poorest, being uneven in quality, hard, overripe, and of bad color. The middle-weight peas are good, but harder than the first grade, of darker color, and not so uniform. These differences are most apparent before the canning is done, though they are readily distinguishable in the can, and also show on chemical examination.

A chemical examination of peas graded for quality as well as for size gave results as shown in the table on page 363.

The table shows more total solids and higher protein and starch content in the third-grade goods. This might be expected, as the third grade represents the more mature product. If canned peas were purchased for their nutritive properties only, then the third grade would be the preferable one to buy, but they are usually selected for their delicacy and flavor, which are found in the highest degree in the youngest and tenderest peas, or the first grade.

The grading for size is a very simple matter. The peas are passed over sieves, or into a revolving cylinder having four sections with perforations of different sizes. The perforations in the first sieve or section measure nine thirty-seconds of an inch in diameter. The peas which pass through this size opening are known as No. 1, or "petits pois." The next size of perforation is ten thirty-seconds of an inch in diameter, and the peas passing through are known as No. 2, "extra sifted," or "extra fins." The third size of perforation is eleven thirty-seconds of an inch, and the peas which pass through are known as No. 3, "sifted," or "fins." The last size is twelve thirty-seconds of an inch, and the peas which pass through are known as No. 4, or "early June" peas. The peas which are too large to pass through this sieve go over the end and are known as No. 5, or "marrowfats." Some packers add one more sieve for late peas, with perforations thirteen thirty-seconds of an inch in diameter for the No. 5, and those which pass over this sieve are called No. 6, or "telephone peas." The sizes of these perforations are standard and in general use. Some packers have attempted to make sizes of their own by reaming out the holes, while others do not use all four sieves, but group two sizes together; and some peas are ungraded.

TABLE 47. CHEMICAL EXAMINATION OF PEAS GRADED FOR SIZE AND QUALITY

[Analyses made in the Division of Foods, Bureau of Chemistry.]

GRADE	TOTAL SOLIDS	ASH	PROTEIN	FIBER	PENTOSANS	STARCH	SUCROSE	REDUCING SUGAR	UNDETERMINED
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Petits pois:									
First . .	14.23	1.03	3.44	1.68	0.75	5.57	0.72	0.00	1.04
Second .	18.80	1.78	4.19	1.84	.92	8.53	.93	.00	.61
Third .	18.04	1.82	4.41	2.28	.94	8.53	.81	.00	.35
Sifted:									
First . .	22.06	1.36	5.31	2.21	.96	10.23	.98	.00	1.01
Second .	24.32	1.04	5.69	2.05	1.01	11.52	.57	.00	2.44
Third .	27.74	1.37	5.63	2.18	1.50	13.52	.48	.00	3.06
Marrowfat:									
First . .	22.22	1.02	5.13	2.18	.98	10.48	.94	.00	1.49
Second .	24.10	1.30	6.69	2.55	1.55	8.77	.63	.00	2.60
Third .	27.15	2.03	5.94	2.00	1.27	12.90	.36	.00	2.63

After the peas have been graded into sizes they are usually run in thin layers over slowly moving belts, so that pieces of foreign material, broken, fully matured, and defective peas may be seen easily and removed. Low-grade peas are not so carefully picked over.

Blanching. There are two objects in blanching peas: (1) To remove the mucous substance from the outside and a part of the green coloring matter, so as to have a clear liquor in the can; and (2) to drive water into the peas, so that all will be tender.

In the young, juicy pea, the water content is at its maximum, so that the cleaning of the surface is all that is necessary. The time required for blanching is from one-half to one minute for No. 1 and No. 2, or "petits pois" and "extra sifted"; one and a half minutes for No. 3, or "sifted"; two minutes for No. 4, or "early June"; and two and one half minutes for No. 5, or "marrowfat" peas. To get the best results, peas which are very old and hard will need a blanch approximately five times as long as young peas of the corresponding grade, while those in the intermediate stages will require a blanch proportional to their development.

It is evident, therefore, that among peas that are good, but ungraded as to quality, there will be a greater or less number which will be hard because of

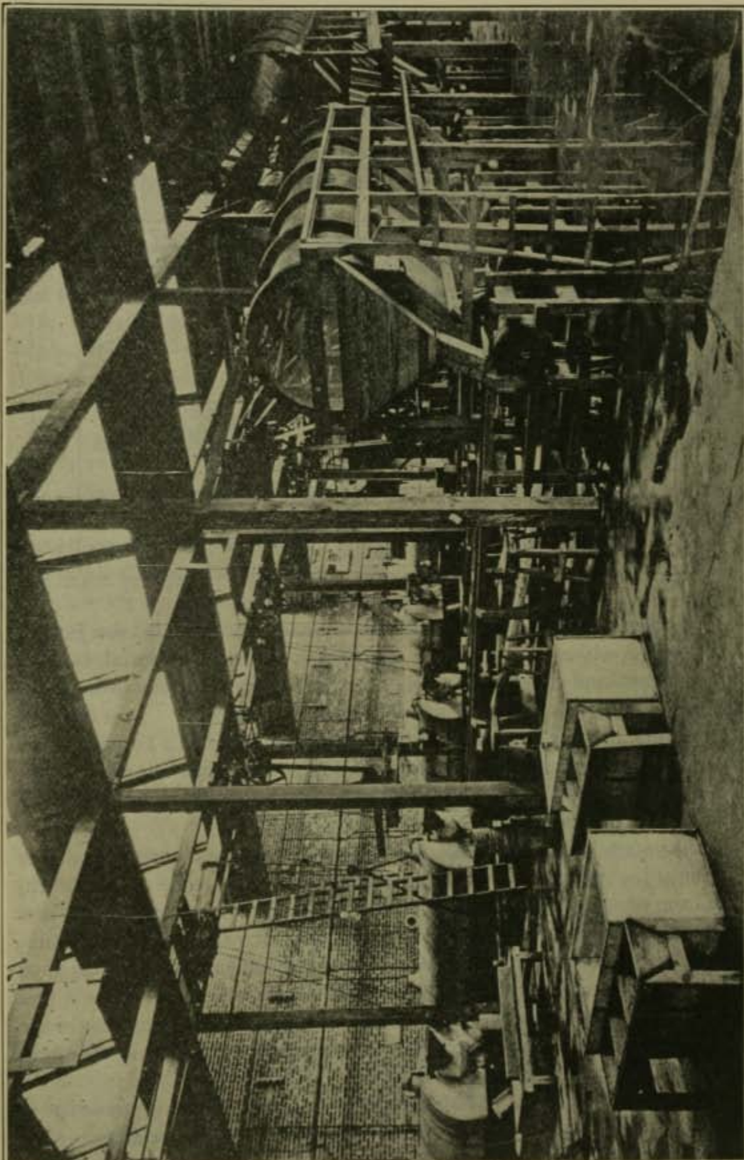

FIG. 29. — Pea cannery. Cylindrical sieves may be seen at the right; blanching tanks at the left. (U. S. Department of Agriculture.)

under blanching, and some above size because of swelling during the blanching and after processing. There is no part of the work of canning peas which requires so much judgment as that of blanching if the best quality of goods is to be obtained.

When the peas leave the blancher, they are sometimes washed, and this is desirable in order to insure a clear liquor, especially if the peas have been blanched in wire baskets suspended in a tank of water.

The peas are filled into the cans by special machines, although in very small factories this may be done by hand. The modern machines do the work with a fair degree of accuracy, insuring a uniform quantity in each can, then adding liquor to fill, so that the caps will just go on.

A can is said to be well filled when the contents are within three eighths inch of the cap and the peas are just covered with liquor. Peas of excellent quality when covered to too great a depth with liquor deteriorate in appearance as can be determined by inserting a spoon and raising the peas gently but without appreciably disturbing the liquor. On the other hand, if there is not sufficient liquor to cover the peas, they are not generally attractive, and if very short of liquor, they become pasty. It is important, therefore, to use just enough liquor to cover the peas.

The No. 2 can generally used is popularly supposed to mean a 2-pound can, and is often so billed and referred to in market reports, but it does not hold 2 pounds and should be given its proper designation. The average fill of a can is such that after processing there will be 14 ounces of peas (400 grams) and 7¼ ounces (200 grams) of liquor. The can weighs 100 grams, making a total of 700 grams or 25 ounces. Any very marked deviation from these figures in the direction of reducing the proportion of peas would evidently be an adulteration with water, while any considerable increase in the proportion of peas would result in dryness. Cans containing only 11 or 12 ounces of peas are evidently short weight, though a customer cannot reasonably demand more than 15 ounces as a maximum and expect a good appearance.

A can of marrowfat or telephone peas will not weigh as much by about three fourths ounce (20 grams) as a can of the smaller-sized peas if the fill be the same. The " sifted " pea, or No. 3 size, is the heaviest in the commercial grading. The " extra sifted " and the " petits pois " are the most expensive to the canner, and the tendency is to cut slightly in the weight, usually about three fourths of an ounce, although it is not uncommon to get cans from 1½ to 2 ounces short on peas and correspondingly overweight on liquor.

The liquor used on peas is usually composed of water, salt, and sugar. At one time saccharin was used by many packers instead of sugar, but this practice has been almost entirely discontinued. The proportion of salt and sugar used varies greatly with the different packers. The lowest amounts given were 2 pounds of salt and 2 pounds of sugar to 100 gallons of water. The largest quantities used were 40 pounds of sugar and 16 pounds of salt per 100 gallons, while the average seems to be about 10 pounds of salt and 10 of sugar per 100 gallons of water. There is undoubtedly a tendency to reduce the amount of sugar used, and a few canners have left out both salt and sugar in some lots of peas to determine whether there is a market for an unseasoned product. The heavy sirups are used in the fancy and extra fancy brands of goods, the amount of sugar added to the sirup being often the only difference between the " superlatively good " and the " best." A fairly sweet sirup is sometimes used to give a weak, insipid, sugarless pea some semblance of quality, also to make the smooth pea as sweet as the sweet wrinkled variety. Analyses of 35 brands of peas purchased in the open market show the sugar content of the liquor to vary between 0.46 and 4.17 per cent, the average being 2.62 per cent. More sugar is found in eastern than in western packed peas, and in the domestic than in the foreign peas.

After being filled the can is passed through the wiping machine, the cap is put on and soldered in the automatic capper, the tipping follows, and then comes the final inspection in the water bath for leaks. At one factory the cans were passed through an exhauster for the double purpose of heating them uniformly and of driving off a certain characteristic odor which is objectionable.

Peas are processed in retorts under pressure, or in a solution of a calcium salt, in order to secure a temperature above that of boiling water. The time and temperature necessary to sterilize peas cannot be given with certainty because of the variation in factory practice and conditions which must be taken into account. If all factories handled their material promptly after being cut in the field, allowed no delays, such as standing on wagons or in piles to ferment, washed the peas well as soon as thrashed, graded them equally well, blanched them according to their needs, siruped and filled the cans the same, tipped the cans at the same temperature, and brought them to the process tank under like conditions, it would be possible to develop a process which might be safe for nearly all localities. Such ideal conditions are not to be found in practice, and hence it is that one factory will employ a a process of 240° F. for twenty minutes and do it successfully, while another must double the time before being reasonably successful in preventing spoilage. The effect of long processing is to cause a gradual decrease in the amount of free liquor in the can and to cause the peas to become sticky and adherent. This effect is shown in the following table:

TABLE 48. EFFECT OF VARIATION IN TIME OF PROCESSING ON LIQUOR CONTENT OF CAN

Grade of Peas	Grams of Liquor in Cans Processed for					
	20 Minutes	25 Minutes	30 Minutes	35 Minutes	50 Minutes	55 Minutes
Marrowfat . . .	215	212	190	165	70	60
Sifted	155	140	125	115	90	85
Petits pois . . .	155	150	125	115	60	50

The peas were sufficiently cooked in twenty-five minutes, and at each succeeding step they became thicker and stickier.

Examination of commercial canned peas. Peas were purchased from 15 groceries, representing 135 brands, 125 of which were of domestic production and 10 were imported. With the exception of 5 brands, the domestic peas were put up in standard No. 2 cans. The average weight of a can of peas was found to be 705 grams (25.2 ounces); the can, 103 grams (3.66 ounces); the peas, after the liquor was allowed to drain through a sieve for one minute, 394 grams (14 ounces); and the liquor, 208 grams (7.5 ounces). The variation in the total weight was between 650 and 735 grams; the can between 95 and 110 grams; the peas between 301 and 605 grams; and the liquor between 0 and 300 grams.

In the experimental work it was determined that a well-filled can should have 400 grams of peas and 200 grams of liquor, and the average for the commercial brands is essentially the same. When a can contains less than 385 grams, it is usually a slack fill, unless it contains marrowfat or telephone peas; if it contains more than 415 grams, the peas will be overcrowded or the liquor will be poor.

Spoilage. The spoilage in canned peas may be classified under three heads: (1) That due to leaks in the can; (2) to insufficient processing; and (3) to spoilage prior to the canning.

The spoilage due to leaks is largely a matter of carelessness in inspection.

Goods spoiled owing to insufficient processing are generally classed as "swells" and "sours." Formerly spoilage of this character was a serious matter, but the discovery of the cause and the means of prevention has decreased the loss from this source. At first No. 2 cans were boiled in open kettles from one to three hours, and the losses were not considered large, although the percentage would probably be considered high at this time.

Later the processing was done in a retort at a higher temperature than that of boiling water, in order to reduce the time.

The spoilage occurring before the peas enter the can is due to allowing them to stand in piles, on the wagons or after thrashing, until they heat and start fermentation. If the peas are kept moving from the vine to the can, the spoilage from this source is very small.

Composition of legumes. The legumes are characterized by high protein content, as will readily be seen from the table beyond, where these and other vegetables are arranged alphabetically.

It will be seen that beans, lentils, and peas are not only richer in protein than other vegetables, but when dry they show higher percentages of protein than does fresh or canned meat. Since the dry legumes contain also considerable amounts of carbohydrate and small amounts of fat, they are in general of higher fuel value than meats. Those meats which are fat enough to equal the dry legumes in energy value are considerably below them in protein content. The amino acid make-up of several legume proteins is shown in Table 49. It should be especially noted, however, that in these cases no attempt was made to estimate the cystine content. Recent experiments by Johns and Jones indicate that the nutritive values of legume proteins may in some cases be restricted by their low cystine content; but that this may be readily supplied from other sources.

With the possible exception of a lower cystine content as mentioned above, the legume proteins show a general similarity in their amino acid make-up to the proteins of meats and fish.

Legumes also furnish important quantities of iron, phosphorus, and, to a less conspicuous degree, calcium. Notwithstanding the high protein content, the base-forming elements predominate. Vitamin values will depend upon maturity and freshness, but in general legumes may be expected to be good sources of at least the B vitamin.

TABLE 49. AMINO ACIDS FROM PROTEINS OF LEGUMES (OSBORNE)

	PHASEOLIN (Bean)	VIGNIN (Cowpea)	LEGUMIN (Pea)	VICILIN (Pea)	LEGUMELIN (Pea)
Glycine	0.55	0.00	0.38	0.00	0.50
Alanine	1.80	0.97	2.08	0.50	0.92
Valine	1.04	0.34	—	0.15	0.69
Leucine	9.65	7.82	8.00	9.38	9.63
Proline	2.77	5.25	3.22	4.06	3.96
Phenylalanine	3.25	5.27	3.75	3.82	4.79
Aspartic acid	5.24	3.97	5.30	5.30	4.11
Glutamic acid	14.54	16.89	16.97	21.34	12.96
Serine	0.38	—	0.53	—	—
Tyrosine	2.84	2.26	1.55	2.38	1.56
Arginine	4.87	7.20	11.71	8.91	5.45
Histidine	2.62	3.08	1.69	2.17	2.27
Lysine	4.58	4.28	4.98	5.40	3.03
Ammonia	2.06	2.32	2.05	2.03	1.26
Tryptophane	present	present	present	present	present
Summation	56.19	59.65	62.21	65.44	51.13

Digestibility. Legumes in the green state seem to be more readily digested than dried legumes. The latter have been staple articles of diet since ancient times, but have almost always been considered more or less difficult of digestion. This impression is based more upon consciousness of the digestive process than upon measurements of actual losses in digestion, since the latter have been made only in recent years and show that the losses are not so large as might be supposed. Only the more recent experiments will be cited here.

Snyder, feeding a porridge made from dried peas as the principal part of a simple mixed diet, found the coefficient of digestibility for the peas alone: protein, 80 per cent, and carbohydrates, 96 per cent, — the amount of fat in the peas being too small for an accurate measurement of its digestibility.

Woods and Mansfield, in an experiment in which baked beans furnished about one fourth of the total protein, estimated the coefficient of digestibility of the protein of the beans at 78 per cent.

Wait, in a very extended series of digestion experiments,[1] in which legumes were fed as a prominent constituent of simple mixed diets, found the following coefficients of digestibility for the legumes:

TABLE 50. DIGESTIBILITY OF LEGUMES (WAIT)

	PROTEIN	CARBOHYDRATE
	Per cent	*Per cent*
Kidney beans	77	94
White beans	78	96
Cowpeas, "whippoorwill"	70	87
Cowpeas, "clay"	74	88
Cowpeas, "lady"	83	95

The comparatively low digestibility of protein is not entirely a matter of the nature of the protein itself, but is at least partly due to the associated substances, for when the isolated protein is fed, a much higher coefficient is obtained.

Thus in a Japanese experiment cited by Oshima[2] in which a soy-bean preparation consisting chiefly of the bean protein was fed, the coefficient of digestibility for the protein was 96 per cent, and Salkowski found a coefficient of 94 per cent for the isolated protein of the horse bean.

Mendel and Fine,[3] feeding a man with a simple mixed diet of which 90 per cent of the protein was in the form of a commercial soy-bean meal "which betrayed no cellular structure under the microscope," found a coefficient of digestibility of 85.3 for the protein of the diet as against 87.9 and 88.0 for mixed diets in which the protein was furnished chiefly by meat and eggs.

Peas greened with copper. Canned peas, particularly those prepared in France for export to England and to the United

[1] United States Department of Agriculture, Office of Experiment Stations, Bulletin 187.
[2] Ibid., 159.
[3] *Journal of Biological Chemistry*, Vol. 10, pages 435–438.

States, had to a large extent been treated with small quantities of copper salts to preserve or intensify their green color; but under the Food and Drugs Act, the question of the wholesomeness of vegetables thus greened with copper was raised and was referred to the Referee Board of Consulting Scientific Experts for investigation, with the result that the importation of such coppered vegetables has been forbidden.

Stems, Bulbs, Roots, and Tubers

Among edible stems are asparagus and celery; among bulbs, artichokes, leeks, and onions; among roots, carrots, parsnips, sweet potatoes, and turnips; among tubers the ordinary white potato.

Asparagus is now largely canned and thus made available at all times of the year. Its nature and the place which custom gives it in the preparation of salads, suggest its value as a source of vitamins but this does not seem yet to have been very fully investigated.

Celery is increasing in importance with improved facilities for transportation and marketing. Its *green* leaves are rich in vitamin A, but the blanched leaves and stems contain relatively little. The latter are, however, of some importance as sources of vitamin B.

Onions are good sources of vitamin C, especially when eaten raw. The report of the British Committee ranks raw onions with oranges, lemons, tomatoes, and raw cabbage in richness in vitamin C. Osborne and Mendel rank onions with about the same vegetables and fruits as sources of vitamin B. The vitamin A content of onions appears to be low.

Among the roots and tubers, potatoes play by far the largest part in the American food supply. The average consumption of potatoes in the United States is about four bushels per capita per year. McCollum attributes the popularity of the potato to the fact that it has no pronounced characteristic flavor.

The potato is a native of America, said to have been first found in Chili, and it was not commonly cultivated in Europe until the eighteenth century.

At present potatoes are raised in large quantities in Europe both for food, for industrial purposes such as starch, glucose, and alcohol manufacture, and for stock-feeding. Estimates of per capita consumption of potatoes as human food in European countries are not at hand.

For description of the potato industry, the reader must be referred to books on agriculture and horticulture, to "The Potato Industry of Colorado," published as Bulletin 158 of the Agricultural Experiment Station, Fort Collins, Colorado, and to the chapter by Appleman in Caldwell and Slosson's *Science Remaking the World*.

Composition of potatoes. The averages of American analyses are tabulated with those of other vegetables beyond (Table 51). In round numbers the potato contains 2 to 2.5 per cent of protein; 18 to 20 per cent of carbohydrates, chiefly starch; almost no fat; about 1 per cent of ash; and 75 to 79 per cent of water. Or, in still simpler terms, about three fourths of the potato is water, and of the solids there is about eight times as much starch as protein, a little fiber, a very little fat, and an amount of ash which is relatively large in comparison with most other foods.

Digestion experiments with potatoes fed in considerable quantity to healthy men have been reported by Rubner, by Snyder, and by Bryant and Milner, who found respectively 68, 72, and 73 per cent of the protein and 92, 93, and 99 per cent of the carbohydrate utilized. Thus the fuel value of the potato is as well utilized as that of most foods, and at least 70 per cent of the protein is digested and absorbed. Rose and Cooper have shown that potato protein is of high nutritive value.

Structure of the potato. Since the potato tuber is in reality a thickened stem, it can be seen to consist of fairly definite anatomical parts. The following description is taken essentially from Langworthy, Farmers' Bulletin 295 of the United States Department of Agriculture:

The outer skin of the tuber consists of a thin, grayish brown, corkish substance and corresponds roughly to the bark of an

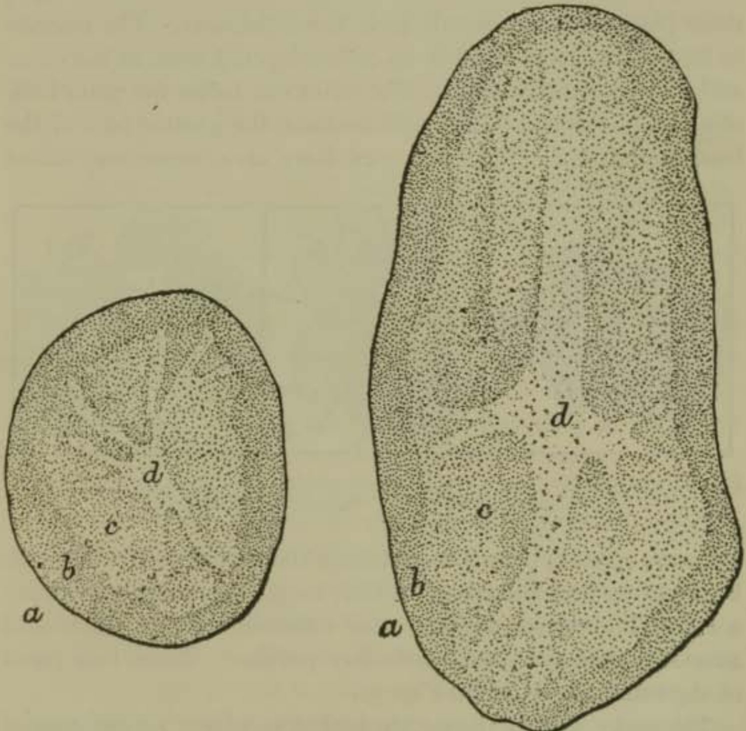

FIG. 30. — Transverse and longitudinal sections of the potato: *a*, skin; *b*, cortical layer; *c*, outer medullary layer; *d*, inner medullary layer. (U. S. Department of Agriculture.)

overground stem. If a crosswise section of a raw potato is held up to the light, three distinct parts besides the skin may be seen. The outermost one is known as the cortical layer and may be from 0.12 to 0.5 inch in thickness. This layer is slightly colored, the tint varying with the kind, and turns green if exposed to the light for some time, thus showing its relation to the tender green layer beneath the bark of overground stems. It is denser than the other parts of the potato and contains many fibrovascular bundles, especially on the inner edge, where a marked ring of them plainly separates this layer from the next. The interior or flesh of the tuber is made up of two layers known as the outer and inner medullary areas. The outer one forms the main bulk of a well-developed potato and contains the greater part of the food ingredients. The inner medullary area, sometimes called

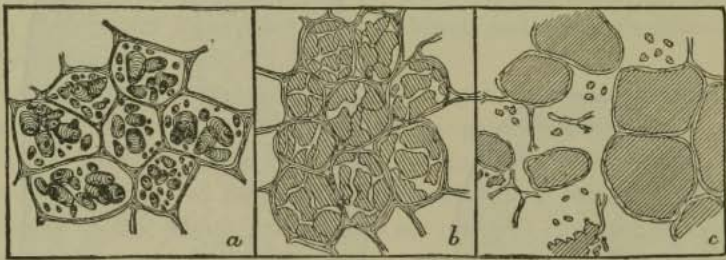

FIG. 31. — Changes of potato starch cells in cooking: *a*, raw; *b*, partially cooked; *c*, thoroughly cooked. (U. S. Department of Agriculture.)

the core, appears in a cross section of the tuber to spread irregular arms up into the outer, so that its outline roughly suggests a star. It contains slightly more cellulose and less water and nutrients than the outer medullary portion. These four parts of the tuber are shown in Fig. 30.

The corky skin of the potato makes up about 2.5 per cent of the whole, and the cortical layer 8.5 per cent, leaving 89 per cent for the medullary areas. . . .

As in all other plant forms, the framework of the tuber is made up of cellulose. Cellulose forms the walls of a network of cells, which in turn form the body of the tuber. These cells vary in shape and size in different sections of the tuber according to the part they play in its life. In the flesh they serve mainly for storage, and in them lie the starch grains. (See Fig. 31.)

In young tubers there is a larger proportion of sugars and less starch than when they have become mature. As the tuber lies in the ground the starch content increases. When it begins to sprout, however, part of the starch is converted by a ferment in the tuber into soluble glucose. Thus, young or early potatoes and old ones both have a smaller proportion of starch and more soluble sugars than well-grown but still fresh tubers. The effect of cooking on the mechanical condition of the potato cells is shown in Fig. 31.

The figures show the great changes in the mechanical condition of the potato flesh under the influence of heat, the broken cell walls and the increased bulk of the starch grains being particularly noticeable.

The **sweet potato** plant (*Ipomœa batata* or *Batatas edulis*) is not closely related to the white potato, botanically, but in composition and use as food the two are much alike, the sweet potato having in general about the same nutrients as the white potato and in addition from 5 to 8 per cent of sugar.

Recently the canning of sweet potatoes has developed into an important industry, and has made these vegetables available as a staple food throughout the year.

Among other roots, the **carrot** is of special interest because it is relatively rich in vitamin A in addition to containing considerable amounts of vitamins B and C. The root of the **beet** is apparently not so rich in vitamins as that of the carrot, but the good practise of eating the leaves and stems of young beets along with the roots adds much to the nutritive importance of beets as a garden vegetable. **Turnips** are also a root crop of very considerable importance as food.

Composition of Vegetables

The average composition of practically all vegetables used for food to any important extent in the United States is shown in the following table, which is based chiefly on analyses compiled by Atwater and Bryant, and published by the United States Department of Agriculture:

TABLE 51. AVERAGE COMPOSITION OF AMERICAN VEGETABLES[1]

Description	Number of Analyses	Refuse	Water	Protein	Fat	Total Carbohydrates (including Fiber)	Fiber (Number of Determinations in Parentheses)	Ash	Fuel Value per Pound
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
Artichokes	2	—	79.5	2.6	.2	16.7	*.8*	1.0	358
Asparagus, fresh	3	—	94.0	1.8	.2	3.3	*.8*	.7	101
Asparagus, cooked	1	—	91.6	2.1	3.3	2.2	—	.8	213
Beans, butter, green:									
Edible portion	1	—	58.9	9.4	.6	29.1	—	2.0	723
As purchased	1	50.0	29.4	4.7	.3	14.6	—	1.0	361
Beans, dried	11	—	12.6	22.5	1.8	59.6	(4)*4.4*	3.5	1564
Beans, frijoles (New Mexico)	4	—	7.5	21.9	1.3	65.1	—	4.2	1633
Beans, Lima, dried	4	—	10.4	18.1	1.5	65.9	—	4.1	1586
Beans, Lima, fresh:									
Edible portion	1	—	68.5	7.1	.7	22.0	*1.7*	1.7	557
As purchased	—	55.0	30.8	3.2	.3	9.9	*.8*	.8	250
Beans, mesquite, dry	1	—	4.8	12.2	2.5	77.1	—	3.4	1723
Beans, string, cooked:									
Edible portion	1	—	95.3	.8	1.1	1.9	—	.9	94
Beans, string, fresh:									
Edible portion	5	—	89.2	2.3	.3	7.4	(2)*1.9*	.8	189
As purchased	—	7.0	83.0	2.1	.3	6.9	*1.8*	.7	176

[1] Such vegetables as potatoes, squash, beets, etc., have a certain amount of inedible material, skin, seeds, etc. The amount varies with the method of preparing the vegetables, and cannot be accurately estimated. The figures given for refuse of vegetables, fruits, etc., are assumed to represent approximately the amount of refuse in these foods as ordinarily prepared.

TABLE 51. AVERAGE COMPOSITION OF AMERICAN VEGETABLES — Continued

Description	Number of Analyses	Refuse	Water	Protein	Fat	Total Carbohydrates (including Fiber)	Fiber (Number of Determinations in Parentheses)	Ash	Fuel Value per Pound
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
Beets, cooked	1	—	88.6	2.3	.1	7.4	—	1.6	180
Beets, fresh:									
Edible portion	24	—	87.5	1.6	.1	9.7	(18) *.9*	1.1	209
As purchased	—	20.0	70.0	1.3	.1	7.7	—	.9	167
Cabbage:									
Edible portion	16	—	91.5	1.6	.3	5.6	(8) *1.1*	1.0	143
As purchased	—	15.0	77.7	1.4	.2	4.8	—	.9	121
Cabbage, curly	1	—	87.3	4.1	.6	6.2	—	1.8	211
Cabbage sprouts:									
Edible portion	1	—	88.2	4.7	1.1	4.3	—	1.7	208
As purchased	1	61.8	33.7	1.8	.4	1.7	—	.6	79
Carrots, fresh:									
Edible portion	18	—	88.2	1.1	.4	9.3	(15) *1.1*	1.0	205
As purchased	—	20.0	70.6	.9	.2	7.4	—	.9	159
Carrots, evaporated	1	—	3.5	7.7	3.6	80.3	—	4.9	1743
Cauliflower	2	—	92.3	1.8	.5	4.7	(1) *1.0*	.7	138
Celery:									
Edible portion	5	—	94.5	1.1	.1	3.3	—	1.0	84
As purchased	—	20.0	75.6	.9	.1	2.6	—	.8	68
Chard	2	—	89.6	3.2	.6	5.0	—	1.6	173
Collards:									
Edible portion	2	—	87.1	4.5	.6	6.3	—	1.5	220
Corn, green:									
Edible portion	3	—	75.4	3.1	1.1	19.7	(1) *.5*	.7	459
As purchased	—	61.0	29.4	1.2	.4	7.7	—	.3	178
Cucumbers:									
Edible portion	4	—	95.4	.8	.2	3.1	(2) *.7*	.5	79
As purchased	—	15.0	81.1	.7	.2	2.6	—	.4	68
Eggplant, edible portion	1	—	92.9	1.2	.3	5.1	*.8*	.5	127
Greens, beet, cooked	1	—	89.5	2.2	3.4	3.2	—	1.7	237
Greens, dandelion, as purchased	1	—	81.4	2.4	1.0	10.6	—	4.6	277
Greens, turnip-salad	2	—	86.7	4.2	.6	6.3	—	2.2	215
Kohl-rabi, edible portion	2	—	91.1	2.0	.1	5.5	*1.3*	1.3	146

TABLE 51. AVERAGE COMPOSITION OF AMERICAN VEGETABLES — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
Leeks:									
Edible portion . .	1	—	91.8	1.2	.5	5.8	——	.7	147
As purchased . . .	1	15.0	78.0	1.0	.4	5.0	*.6*	.6	125
Lentils, dried . . .	3	—	8.4	25.7	1.0	59.2	——	5.7	1581
Lettuce:									
Edible portion . . .	8	—	94.7	1.2	.3	2.9	(7) *.7*	.9	87
As purchased . . .	—	15.0	80.5	1.0	.2	2.5	——	.8	72
Mushrooms	11	—	88.1	3.5	.4	6.8	(8) *.8*	1.2	203
Okra:									
Edible portion . .	2	—	90.2	1.6	.2	7.4	(1) *3.4*	.6	172
As purchased . . .	—	12.5	78.9	1.4	.2	6.5	——	.5	152
Onions, fresh:									
Edible portion . . .	15	—	87.6	1.6	.3	9.9	(7) *.8*	.6	220
As purchased . . .	—	10.0	78.9	1.4	.3	8.9	——	.5	200
Onions, cooked . . .	1	—	91.2	1.2	1.8	4.9	——	.9	184
Onions, green (New Mexico):									
Edible portion . . .	2	—	87.1	1.0	.1	11.2	——	.6	225
As purchased . . .	—	51.0	42.6	.5	.1	5.5	——	.3	113
Parsnips:									
Edible portion . .	3	—	83.0	1.6	.5	13.5	(1) *2.5*	1.4	294
As purchased . . .	—	20.0	66.4	1.3	.4	10.8	——	1.1	236
Peas, dried	8	—	9.5	24.6	1.0	62.0	(2) *4.5*	2.9	1612
Peas, green:									
Edible portion . .	5	—	74.6	7.0	.5	16.9	(1) *1.7*	1.0	454
As purchased . . .	—	45.0	40.8	3.6	.2	9.8	——	.6	251
Peas, green, cooked .	1	—	73.8	6.7	3.4	14.6	——	1.5	525
Peas, sugar, green . .	1	—	81.8	3.4	.4	13.7	*1.6*	.7	327
Cowpeas, dried . . .	13	—	13.0	21.4	1.4	60.8	*4.1*	3.4	1550
Cowpeas, green, edible portion	1	—	65.9	9.4	.6	22.7	——	1.4	603
Potatoes, raw or fresh:									
Edible portion . .	136	—	78.3	2.2	.1	18.4	(53) *.4*	1.0	378
As purchased . . .	—	20.0	62.6	1.8	.1	14.7	——	.8	302

TABLE 51. AVERAGE COMPOSITION OF AMERICAN VEGETABLES — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
Potatoes, evaporated	3	—	7.1	8.5	.4	80.9	—	3.1	1638
Potatoes, cooked, boiled	11	—	75.5	2.5	.1	20.9	(1) *.6*	1.0	429
Potatoes, cooked, chips	2	—	2.2	6.8	39.8	46.7	—	4.5	2598
Potatoes, cooked, mashed, and creamed	4	—	75.1	2.6	3.0	17.8	—	1.5	493
Potatoes, sweet, raw, or fresh:									
Edible portion	95	—	69.0	1.8	.7	27.4	(88) *1.3*	1.1	558
As purchased	—	20.0	55.2	1.4	.6	21.9	—	.9	447
Potatoes, sweet, cooked	1	—	51.9	3.0	2.1	42.1	—	.9	903
Pumpkins:									
Edible portion	3	—	93.1	1.0	.1	5.2	*1.2*	.6	117
As purchased	—	50.0	46.5	.5	.1	2.6	—	.3	59
Radishes:									
Edible portion	4	—	91.8	1.3	.1	5.8	(2) *.7*	1.0	133
As purchased	—	30.0	64.3	.9	.1	4.0	—	.7	91
Rhubarb:									
Edible portion	2	—	94.4	.6	.7	3.6	(1) *1.1*	.7	105
As purchased	—	40.0	56.6	.4	.4	2.2	—	.4	63
Rutabagas:									
Edible portion	5	—	88.9	1.3	.2	8.5	*1.2*	1.1	186
As purchased	—	30.0	62.2	.9	.1	6.0	—	.8	129
Sauerkraut	2	—	88.8	1.7	.5	3.8	—	5.2	120
Spinach, fresh	3	—	92.3	2.1	.3	3.2	*.9*	2.1	109
Spinach, cooked	1	—	89.8	2.1	4.1	2.6	—	1.4	252
Squash:									
Edible portion	10	—	88.3	1.4	.5	9.0	(5) *.8*	.8	209
As purchased	—	50.0	44.2	.7	.2	4.5	—	.4	103
Tomatoes, fresh	27	—	94.3	.9	.4	3.9	(22) *.6*	.5	104
Tomatoes, dried	1	—	7.3	12.9	8.1	62.3	—	9.4	1695
Turnips:									
Edible portion	19	—	89.6	1.3	.2	8.1	(9) *1.3*	.8	178
As purchased	—	30.0	62.7	.9	.1	5.7	—	.6	124

TABLE 51. AVERAGE COMPOSITION OF AMERICAN VEGETABLES — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
VEGETABLES, CANNED									
Artichokes	3	—	92.5	.8	—	5.0	*.6*	1.7	105
Asparagus	14	—	94.4	1.5	.1	2.8	*.5*	1.2	82
Beans, baked	21	—	68.9	6.9	2.5	19.6	(12)*2.5*	2.1	583
Beans, string	29	—	93.7	1.1	.1	3.8	(18) *.5*	1.3	93
Beans, little green . .	1	—	93.8	1.2	.1	3.4	*.6*	1.5	87
Beans, wax	1	—	94.6	1.0	.1	3.1	*.6*	1.2	78
Beans, haricots verts .	7	—	95.2	1.1	.1	2.5	*.5*	1.1	69
Beans, haricots flageolets	3	—	81.6	4.6	.1	12.5	*1.0*	1.2	314
Beans, Lima	16	—	79.5	4.0	.3	14.6	(15)*1.2*	1.6	350
Beans, red kidney, shelled	1	—	72.7	7.0	.2	18.5	*1.2*	1.6	471
Brussels sprouts, as purchased	1	—	93.7	1.5	.1	3.4	*.5*	1.3	93
Corn, green [1]	52	—	76.1	2.8	1.2	19.0	(43) *.8*	.9	445
Corn and tomatoes . .	2	—	87.6	1.6	.4	9.6	*.5*	.8	220
Macedoine (mixed vegetables) . . .	5	—	93.1	1.4	—	4.5	*.6*	1.0	107
Okra [2]	4	—	94.4	.7	.1	3.6	*.7*	1.2	82
Peas, green [3]	88	—	85.3	3.6	.2	9.8	(83)*1.2*	1.1	251
Potatoes, sweet . . .	2	—	55.2	1.9	.4	41.4	(1) *.8*	1.1	802
Pumpkins	7	—	91.6	.8	.2	6.7	(5)*1.1*	.7	144
Squash	5	—	87.6	.9	.5	10.5	(2) *.7*	.5	227
Succotash	12	—	75.9	3.6	1.0	18.6	(10) *.9*	.9	444
Tomatoes [4]	19	—	94.0	1.2	.2	4.0	(11) *.5*	.6	103
PICKLES, CONDIMENTS, ETC.									
Catsup, tomato . . .	2	—	82.8	1.5	.2	12.3	—	3.2	259
Horseradish	2	—	86.4	1.4	.2	10.5	—	1.5	224

[1] Thirty-two samples contained an average of 0.4 per cent NaCl.
[2] Three samples contained an average of 1.1 per cent NaCl.
[3] Eighty samples contained an average of 0.7 per cent NaCl.
[4] Seven samples contained an average 0.1 per cent NaCl.

TABLE 51. AVERAGE COMPOSITION OF AMERICAN VEGETABLES — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
PICKLES, CONDIMENTS, ETC.		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
Olives, green:									
Edible portion . . .	1	—	58.0	1.1	27.6	11.6	——	1.7	1357
As purchased . . .	1	27.0	42.3	.8	20.2	8.5	——	1.2	994
Olives, ripe:									
Edible portion . . .	1	—	64.7	1.7	25.9	4.3	——	3.4	1166
As purchased . . .	1	19.0	52.4	1.4	21.0	3.5	——	2.7	947
Peppers (paprica), green, dried	1	—	5.0	15.5	8.5	63.0	——	8.0	1771
Peppers, red chili . .	5	—	5.3	9.4	7.7	70.0	——	7.6	1756
Pickles, cucumber . .	3	—	92.9	.5	.3	2.7	——	3.6	66
Pickles, mixed, as purchased	1	—	93.8	1.1	.4	4.0	——	.7	109

The nutritive economy of vegetables and their place in the diet is discussed in connection with fruits and nuts further on in this chapter.

Fruits and Nuts

Of the "small fruits" grown in the United States, strawberries represent over half the total acreage and about three fourths of the total value; next in order of value of product among the small fruits follow raspberries, blackberries (and dewberries), currants, gooseberries, and cranberries.

Among the orchard fruits, apples are much the most important, being about three fifths of the total. Peaches and nectarines rank next, followed by plums and prunes, pears, cherries, and apricots and quinces, in the order named. From 150,000,000 to 175,000,000 bushels of apples are produced in the United States each year.

Among the citrus fruits, oranges lead; then follow lemons and grapefruit (pomeloes). The production of grapefruit has shown a rapid increase since 1900. The production of the other citrus fruits, limes, tangerines, mandarins, and kumquats is so far below that of oranges, lemons, and grapefruit as to play no significant part in the fruit supply.

FIG. 32. — Production of fruits and nuts in the United States. (Census of 1910.)

Olive culture in the United States is practically confined to California and Arizona. The crop of 1909, 16,405,000 pounds, was more than three times as great as that of 1899.

The widely varying extent to which the different states contribute to the fruit and nut supply is shown by Fig. 32.

The growing, packing, and ordinary handling of fruits is discussed in works on horticulture and need not be taken up here.

There are, however, certain modern practices in the fruit industry which may be worthy of note because of their influence in systematizing the fruit supply, particularly in facilitating the marketing of California fruit in the eastern cities. The following notes on this industry are based on the account given in Powell's *Coöperation in Agriculture:*

California oranges and lemons are handled differently from any other American fruit. They are staple products ripening less quickly than most fruits, and the distribution and marketing have been reduced to a systematic basis. The crop now amounts to about 50,000 carloads, or 20,000,000 boxes, a year. This is the product of more than 12,000 growers, about three fourths of whom are organized into coöperative associations, sixty-five per cent of which are federated into the California Fruit-growers' Exchange. These associations build packing-houses in which the fruit of the members is assembled, graded, packed, and made ready for shipment, these operations being usually done at cost prorated on the number of boxes shipped by each grower. On the average one packing-house suffices for about 500 acres of orange or lemon groves. Many of the associations pick the fruit, and some of them prune and fumigate the trees for the members. The associations have brands for each grade of fruit, and when a carload is ready for shipment, it is marketed in coöperation with the district exchange of which the association is a member through the agents and facilities provided by the central exchange. The local associations have (1913) formed seventeen district exchanges. Among other functions, it is the duty of the district exchange to act as the business medium between the local associations and the central exchange, to order cars and see that they are placed by the railroads at the various packing-houses, to keep records, and to distribute to the local associations the information gathered by the central exchange. The function of this central exchange is to furnish marketing facilities for the district exchanges and associations at a *pro rata* share of the cost. The exchange maintains its own agents in the principal markets in the United States and Canada, supervises these agents, gathers daily information through them of conditions in each market, and furnishes this information daily in bulletin form to the associations. The central exchange also performs other functions for the protection of its members and the extension of the industry, but makes no attempt to regulate shipments or to influence prices. Each shipper has entire control of its own shipments, reserving the right of free competition with all other shippers even within the same organization, and the agent in the market acts directly under the order of the shipper. There is no uniformity of price among the different brands, each brand selling on its own merits. This system is the result of twenty years' development and has been a large factor in changing the status of the orange from a luxury to a staple article of diet.

Formerly about $1,000,000 worth of oranges and lemons were lost yearly by decay during shipment to market from California. This loss has been practically eliminated by improved methods of picking and handling the fruit. At the same time the introduction of "pre-cooling" makes it possible to market a fruit which is of superior quality through having come more nearly to maturity before picking.

The fruit is cooled to 35° F. before shipping, loaded in cars having bunkers filled with ice, and shipped thus without re-icing to any part of the United States. The cold storage plants operated in connection with the pre-cooling system make possible also a better classification of the fruit in shipment from the larger accumulation of packed fruit in the storage rooms.

The production of dried fruits is a very large industry in California, where many thousands of tons of peaches, apricots, prunes, and raisins are dried annually.

During most of the year California dried fruit is much cheaper (in proportion to the solids contained), even in the eastern markets, than is the corresponding fresh fruit of near-by origin. Much is also exported to European countries and sold at prices within reach of those who cannot afford to buy their native fresh fruits. Since it was found that the sunshine and dry air of California make out-door drying on a large scale practicable, the drying of fruit has become a "primary industry" and not simply a means of utilizing a surplus crop. Large orchards are planted specifically for the production of fruit for drying, and very large amounts of capital (aggregating millions of dollars) are invested in drying establishments. It is claimed that the fruit which is to be dried is as carefully chosen and handled with as much care in every way as that which is sold fresh or canned. The fruit is graded so that all the fruit on a drying tray shall be approximately the same size. The freshly cut fruit is placed on trays and the trays placed in large boxes or small houses under which sulphur is burned. This treatment of the fruit with sulphur dioxide (called sulphuring) prevents darkening and fermentation during the subsequent air-drying and, as at present conducted, is said also to protect the fruit from insects. It is also claimed that the sulphured fruit dries more rapidly than the untreated. For these reasons it is feasible to dry larger pieces when the sulphuring process is used.

Sulphuring also permits the marketing of dried fruits with a higher moisture content, which, of course, means that the consumer pays for the extra water at the price of dried fruit. Partly for this economic reason and partly on account of the fear that sulphurous acid may sometimes accumulate in the fruit to an extent not entirely negligible from the health standpoint, the conditions under which sulphuring should be practiced and permitted are still regarded as matter for final determination.

After the fruit is sufficiently dried it is piled in houses or placed in boxes or bins, where it goes through a "sweating" process during which it must be frequently turned. When danger of further sweating is past, the fruit is packed in boxes of which one standard size is 6 × 9 × 15 inches holding 25 pounds of the dried fruit. This description applies, with varying details, to the drying of peaches, apricots, nectarines, apples, and pears. Of these, peaches and apricots are dried in largest quantity.

Prunes are handled somewhat differently, since they are not cut before drying. In fact the usual definition of a prune is a plum of such character as to permit of being dried on the pit without fermentation. As a rule the prunes are dipped for about a minute in boiling lye to thin and crack the skin, then washed to remove the lye and dried in the sun. To insure a sterile surface they may be dipped after drying into a boiling solution of prune juice, glycerin, or salt. Prunes are graded as to size before they are packed, the different grades being designated as 30's to 40's, 50's to 60's, 90's to 100's, etc., the figures indicating the approximate number of fruits in a pound. When computed on the basis of cost per pound of pulp the 70's to 80's are usually the cheapest source of prune pulp.

Raisins are also dried by special processes; and these differ too much according to locality and conditions to permit of a concise general description.

Methods of "dehydration" (mechanical drying) have been so materially improved that it is now contended by operators of modern dehydraters that properly dehydrated fruits are equal or superior to the sun-dried fruits. Certain advantages are claimed for dehydrated fruit over sun-dried, namely (1) that dehydrated fruits when cooked more nearly resemble fresh fruit in color and flavor, (2) that dehydrated fruits are produced under more sanitary conditions, (3) that dehydration permits more exact control of quality and yield. However successful dehydration may become, much California fruit will doubtless continue to be sun-dried because of the reputation which has been established for the quality of sun-dried fruits.

The production of dried fruits in California has increased rapidly during the last decade. The total output rose from 185,000 tons in 1910 to 360,000 tons in 1920 and is said to be still increasing.

Canned fruit of many kinds is too familiar a product to require description here. On account of the rapid recent growth of the Hawaiian canned pineapple industry, the following data from the recent paper of Miller are of interest.

In the Hawaiian Islands, where climatic and soil conditions are unusually favorable for the production of pineapples suitable for canning, the canned pineapple business has grown enormously since 1906 and is now the second largest industry, with an annual pack of over 100,000,000 cans. The larger part of this canned product is shipped to the mainland of the United States, where the amount of canned pineapple used annually is somewhat less than that of canned peaches. Practically the only variety grown in Hawaii for canning is that known as

Smooth Cayenne. Great care is exercised in picking the fruit at the proper stage of ripeness as experiments by the Hawaii Agricultural Experiment Station have shown that "during the growth of the fruit relatively small amounts of sugars are stored in it, but within the short period of normal ripening there is a rapid accumulation of sugar in the fruit. Pineapples gathered green do not develop a normal sugar content in subsequent ripening. The sugars of the fruit are derived from the starch previously stored in the stalk."[1] After cutting, coring, slicing, and grading, the fruit goes into the cans and is siruped. The temperature of the sirup is 70° C. and its strength is from twenty-six per cent to fifty-five per cent sugar, according to the grade of product desired. The open cans pass from the siruping machines to a steam-heated exhaust box, where they remain for five minutes, their contents reaching a temperature of approximately 54° C. The cans are then sealed by machinery and go into the cooker; this is a huge, slowly revolving steel drum within a steam box, in which the cans are subjected to a temperature of 98° C. for twelve minutes. The temperature of the contents of the cans at the end of this period is about 90° C. The cans are then lacquered and cooled. The total process from cutting the pineapple to lacquering the cans consumes about twenty minutes.

According to Miller, the pineapple is a good source of vitamins A and B, and both of these are well conserved in the canning process just described.

Olives are grown in California both for use as fruit and for oil. In a study of 26 varieties of olives at the University of California it was found that the percentage of oil in the whole fruit varied from 11.23 to 29.34 per cent, the pits constituted from 12.0 to 30.0 per cent of the weight of the fruit. The olives varied in size to such an extent that the number of olives per

[1] *The Ripening of the Pineapple Fruit*, Hawaii Agricultural Experiment Station Bulletin, No. 28, 1912.

pound ranged from 36 to 398; usually one pound contains from 100 to 250. The pickling of olives is a troublesome process, often involving much loss. Green olives are more easily pickled, but are much inferior to ripe olives as food. Ripe olives canned in dilute salt solution are being put up to some extent in California. Such a product is obviously of much greater food value than the usual immature olive impregnated with strong brine. The production of olive oil will be considered in Chapter X.

Nut growing in California. Almonds and English walnuts are the nuts chiefly grown. The crop varies much from year to year, especially in the case of almonds, but is estimated at about 5,000,000 pounds of almonds and 16,000,000 pounds of walnuts per year.

Almonds are gathered soon after the hulls burst and before the shells become discolored. Hulls are removed by special machinery. The nuts are then dried in the sun, after which they are generally exposed to fumes of burning sulphur in order to insure the light color of shell which the market demands. It is claimed that if the shell has been properly dried, the sulphur dioxide does not penetrate it sufficiently to affect the kernel.

Walnuts are dried and passed over a revolving grader having a wire screen of one inch mesh; those that fall through are graded as seconds. The shells are commonly bleached either by sulphur dioxide, hypochlorite, or chlorine.

Composition of Fruits and Nuts

The average composition of fruits (fresh, dried, and preserved), as found in the American markets, and of such kinds of nuts as are of commercial importance, is shown in the following tables; Table 52 based chiefly on data compiled by Atwater and Bryant, and Table 53 on the composition of some subtropical fruits analyzed by Jaffa and Albro.

As these tables do not show fruit juices, it may be pointed out here that fruits such as the grape and loganberry, whose juices are commercially important, consist so largely of juice that the composition of the juice must necessarily be much like that of the edible portion of the fruit. Grape juice contains about 15 to 20 per cent of total solids; loganberry juice about 9 to 11 per cent. In both cases the solids are chiefly sugars with smaller amounts of organic acids or acid salts, and only fractional percentages of protein and ash.

TABLE 52. AVERAGE COMPOSITION OF FRUITS AND NUTS

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
FRUITS, BERRIES, ETC., FRESH									
Apples:									
Edible portion . .	29	—	84.6	.4	.5	14.2	(7)*1.2*	.3	285
As purchased . .	—	25.0	63.3	.3	.3	10.8	——	.3	214
Apricots:									
Edible portion . .	11	—	85.0	1.0	—	13.4	——	.5	263
As purchased . .	—	6.0	79.9	1.0	—	12.6	——	.5	247
Bananas:									
Edible portion . .	6	—	75.3	1.3	.6	22.0	(1)*1.0*	.8	447
As purchased . .	—	35.0	48.9	.8	.4	14.3	——	.6	290
Blackberries	9	—	86.3	1.3	1.0	10.9	(1)*2.5*	.5	262
Cherries:									
Edible portion . .	16	—	80.9	1.0	.8	16.7	(1) *.2*	.6	354
As purchased . .	—	5.0	76.8	.9	.8	15.9	——	.6	337
Cranberries	3	—	88.9	.4	.6	9.9	(2)*1.5*	.2	212
Currants	1	—	85.0	1.5	—	12.8	——	.7	259
Figs, fresh	28	—	79.1	1.5	—	18.8	——	.6	368
Grapes:									
Edible portion . .	5	—	77.4	1.3	1.6	19.2	(1)*4.3*	.5	437
As purchased . . .	—	25.0	58.0	1.0	1.2	14.4	——	.4	328

TABLE 52. AVERAGE COMPOSITION OF FRUITS AND NUTS — Continued

Description	Number of Analyses	Refuse	Water	Protein	Fat	Total Carbohydrates (including Fiber)	Fiber (Number of Determinations in Parentheses)	Ash	Fuel Value per Pound
FRUITS, BERRIES, ETC., FRESH		*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals*
Huckleberries, edible portion	1	—	81.9	.6	.6	16.6	——	.3	336
Lemons:									
Edible portion . .	4	—	89.3	1.0	.7	8.5	(2)*1.1*	.5	201
As purchased . .	—	30.0	62.5	.7	.5	5.9	——	.4	140
Lemon juice . . .	22	—	—	—	—	9.8	——	—	178
Muskmelons:									
Edible portion . .	1	—	89.5	.6	—	9.3	*2.1*	.6	180
As purchased . . .	1	50.0	44.8	.3	—	4.6	——	.3	90
Nectarines:									
Edible portion . .	1	—	82.9	.6	—	15.9	——	.6	299
As purchased . . .	1	6.6	77.4	.6	—	14.8	——	.6	280
Oranges:									
Edible portion . .	23	—	86.9	.8	.2	11.6	——	.5	233
As purchased . .	—	27.0	63.4	.6	.1	8.5	——	.4	169
Peaches:									
Edible portion . .	2	—	89.4	.7	.1	9.4	(1)*3.6*	.4	188
As purchased . . .	2	18.0	73.3	.5	.1	7.7	——	.3	153
Pears:									
Edible portion . .	2	—	84.4	.6	.5	14.1	(1)*2.7*	.4	288
As purchased . . .	—	10.0	76.0	.5	.4	12.7	——	.4	245
Persimmons, edible portion	1	—	66.1	.8	.7	31.5	*1.8*	.9	615
Pineapple, edible portion	1	—	89.3	.4	.3	9.7	*.4*	.3	196
Plums:									
Edible portion . .	3	—	78.4	1.0	—	20.1	——	.5	383
As purchased . . .	—	5.0	74.5	.9	—	19.1	——	.5	363
Pomegranates, edible portion	2	—	76.8	1.5	1.6	19.5	*2.7*	.6	447
Prunes:									
Edible portion . .	24	—	79.6	.9	—	18.9	——	.6	359
As purchased . . .	20	5.8	75.6	.7	—	17.4	——	.5	328

TABLE 52. AVERAGE COMPOSITION OF FRUITS AND NUTS — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
FRUITS, BERRIES, ETC., FRESH									
Raspberries, red	1	—	85.8	1.0	—	12.6	*2.9*	.6	247
Raspberries, black	3	—	84.1	1.7	1.0	12.6	——	.6	300
Strawberries:									
Edible portion	22	—	90.4	1.0	.6	7.4	(19) *1.4*	.6	177
As purchased	—	5.0	85.9	.9	.6	7.0	——	.6	168
Watermelons:									
Edible portion	2	—	92.4	.4	.2	6.7	——	.3	136
As purchased	—	59.4	37.5	.2	.1	2.7	——	.1	57
FRUITS, ETC., DRIED									
Apples	3	—	28.1	1.6	2.2	66.1	——	2.0	1318
Apricots	2	—	29.4	4.7	1.0	62.5	——	2.4	1260
Citron	2	—	19.0	1.5	1.5	78.1	——	.9	1487
Currants, Zante	4	—	17.2	2.4	1.7	74.2	——	4.5	1459
Dates:									
Edible portion	2	—	15.4	2.1	2.8	78.4	——	1.3	1575
As purchased	—	10.0	13.8	1.9	2.5	70.6	——	1.2	1416
Figs	3	—	18.8	4.3	.3	74.2	——	2.4	1437
Prunes:									
Edible portion	15	—	22.3	2.1	—	73.3	——	2.3	1368
As purchased	—	15.0	19.0	1.8	—	62.2	——	2.0	1160
Raisins:									
Edible portion	3	—	14.6	2.6	3.3	76.1	——	3.4	1562
As purchased	—	10.0	13.1	2.3	3.0	68.5	——	3.1	1407
Raspberries	1	—	8.1	7.3	1.8	80.2	——	2.6	1662
FRUITS, ETC., CANNED; AND JELLIES, PRESERVES, ETC.									
Apples, crab, as purchased	1	—	42.4	.3	2.4	54.4	——	.5	1090
Apple sauce, as purchased	1	—	61.1	.2	.8	37.2	——	.7	711

TABLE 52. AVERAGE COMPOSITION OF FRUITS AND NUTS — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
FRUITS, ETC., CANNED; AND JELLIES, PRESERVES, ETC.		*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
Apricots, as purchased	1	—	81.4	.9	—	17.3	—	.4	320
Apricot sauce, as purchased	1	—	45.2	1.9	1.3	48.8	—	2.8	973
Blackberries, as purchased	1	—	40.0	.8	2.1	56.4	—	.7	1124
Blueberries, canned .	3	—	85.6	.6	.6	12.8	—	.4	268
Cherries, as purchased	1	—	77.2	1.1	.1	21.1	—	.5	407
Cherry jelly:									
1st quality, as purchased	1	—	21.0	1.1	—	77.2	—	.7	1421
2d quality, as purchased	1	—	38.4	1.2	—	59.8	—	.6	1107
Figs, stewed, as purchased	1	—	56.5	1.2	.3	40.9	—	1.1	776
Grape butter, as purchased	1	—	36.7	1.2	.1	58.5	—	3.5	1087
Marmalade (orange peel), as purchased	1	—	14.5	.6	.1	84.5	—	.3	1548
Peaches, as purchased	3	—	88.1	.7	.1	10.8	—	.3	213
Pears, as purchased .	4	—	81.1	.3	.3	18.0	—	.3	344
Pineapples, as purchased	1	—	61.8	.4	.7	36.4	—	.7	696
Prune sauce, as purchased	1	—	76.6	.5	.1	22.3	—	.5	417
Strawberries, stewed, as purchased . . .	1	—	74.8	.7	—	24.0	—	.5	448
Tomato preserves, as purchased . . .	1	—	40.9	.7	.1	57.6	—	.7	1062
NUTS									
Almonds:									
Edible portion . .	11	—	4.8	21.0	54.9	17.3	2.0	2.0	2940
As purchased . .	—	45.0	2.7	11.5	30.2	9.5	—	1.1	1615

TABLE 52. AVERAGE COMPOSITION OF FRUITS AND NUTS — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
NUTS		*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
Beechnuts:									
Edible portion . .	1	—	4.0	21.9	57.4	13.2	——	3.5	2980
As purchased . .	1	40.8	2.3	13.0	34.0	7.8	——	2.1	1766
Brazil nuts (*Bertholletia excelsa*):									
Edible portion . .	1	—	5.3	17.0	66.8	7.0	——	3.9	3162
As purchased . . .	1	49.6	2.6	8.6	33.7	3.5	——	2.0	1595
Butternuts (*Juglans cinerea*):									
Edible portion . .	1	—	4.4	27.9	61.2	3.5	——	2.9	3068
As purchased . .	1	86.4	.6	3.8	8.3	.5	——	.4	417
Chestnuts, fresh:									
Edible portion . .	9	—	45.0	6.2	5.4	42.1	*1.8*	1.3	1097
As purchased . . .	9	16.0	37.8	5.2	4.5	35.4	——	1.1	920
Chestnuts, dried:									
Edible portion . .	8	—	5.9	10.7	7.0	74.2	*2.7*	2.2	1828
As purchased . . .	8	24.0	4.5	8.1	5.3	56.4	——	1.7	1386
Coconuts:									
Edible portion . .	1	—	14.1	5.7	50.6	27.9	——	1.7	2675
As purchased . .	1	48.8	7.2	2.9	25.9	14.3	——	.9	1369
Coconut without milk, as purchased . .	1	37.3	8.9	3.6	31.7	17.5	——	1.0	1677
Coconut milk, as purchased	1	—	92.7	.4	1.5	4.6	——	.8	152
Coconut, prepared .	2	—	3.5	6.3	57.4	31.5	——	1.3	3028
Filberts:									
Edible portion . .	1	—	3.7	15.6	65.3	13.0	——	2.4	3185
As purchased . .	1	52.1	1.8	7.5	31.3	6.2	——	1.1	1526
Hickory nuts:									
Edible portion . .	1	—	3.7	15.4	67.4	11.4	——	2.1	3238
As purchased . .	1	62.2	1.4	5.8	25.5	4.3	——	.8	1224
Lichi nuts:									
Edible portion . .	1	—	17.9	2.9	.2	77.5	——	1.5	1466
As purchased . . .	1	41.6	10.5	1.7	.1	45.2	——	.9	855

TABLE 52. AVERAGE COMPOSITION OF FRUITS AND NUTS — Continued

Description	Number of Analyses	Refuse	Water	Protein	Fat	Total Carbohydrates (including Fiber)	Fiber (Number of Determinations in Parentheses)	Ash	Fuel Value per Pound
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
NUTS									
Peanuts:									
Edible portion . .	4	—	9.2	25.8	38.6	24.4	*2.5*	2.0	2490
As purchased . . .	—	24.5	6.9	19.5	29.1	18.5	——	1.5	1858
Peanut butter, as purchased	2	—	2.1	29.3	46.5	17.1	——	5.0	2741
Pecans, unpolished:									
Edible portion . .	1	—	2.7	9.6	70.5	15.3	——	1.9	3330
As purchased . .	1	46.3	1.5	5.1	37.9	8.2	——	1.0	1788
Pine nuts:									
Pignolias, edible portion	1	—	6.4	33.9	49.4	6.9	——	3.4	2757
Piniones (*Pinus monophylla*):									
Edible portion .	1	—	3.8	6.5	60.7	26.2	——	2.8	3060
As purchased . .	1	41.7	2.2	3.8	35.4	15.3	——	1.6	1792
Piñon (*Pinus edulis*):									
Edible portion .	1	—	3.4	14.6	61.9	17.3	——	2.8	3105
As purchased . .	1	40.6	2.0	8.7	36.8	10.2	——	1.7	1905
Sabine pine nut (*Pinus sabiniana*):									
Edible portion .	1	—	5.1	28.1	53.7	8.4	——	4.7	2855
As purchased . .	1	77.0	1.2	6.5	12.3	1.9	——	1.1	655
Pistachios:									
First quality, shelled, edible portion . .	1	—	4.2	22.3	54.0	16.3	——	3.2	2905
Second quality, shelled, edible portion	1	—	4.3	22.8	54.9	14.9	——	3.0	2928
Walnuts, California:									
Edible portion . .	1	—	2.5	18.4	64.4	13.0	*1.4*	1.7	3200
As purchased . . .	1	73.1	.7	4.9	17.3	3.5	——	.5	859

TABLE 52. AVERAGE COMPOSITION OF FRUITS AND NUTS — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
NUTS									
Walnuts, California, black:									
Edible portion	2	—	2.5	27.6	56.3	11.7	*1.7*	1.9	3012
As purchased	—	74.1	.6	7.2	14.6	3.0	——	.5	781
Walnuts, California, soft shell:									
Edible portion	4	—	2.5	16.6	63.4	16.1	*2.6*	1.4	3182
As purchased	—	58.1	1.0	6.9	26.6	6.8	——	.6	1335

TABLE 53. COMPOSITION OF SOME SUBTROPICAL FRUITS, AS FOUND BY JAFFA AND ALBRO (1920)[1]

	WATER	PROTEIN	FAT	CARBOHYDRATE	FIBER	ASH
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Lemon guava	84.00	0.76	0.95	8.05	5.57	0.67
Strawberry guava	79.42	0.88	0.80	11.55	6.58	0.77
Sapotes	72.64	0.64	0.46	24.56	1.26	0.44
Sapotes	74.74	0.87	0.55	21.75	1.62	0.47
Feijoa	84.86	0.82	0.24	9.97	3.55	0.56
Feijoa	83.87	1.02	0.05	11.16	3.45	0.45
Cacti (6 analyses)	86.02	0.76	0.07	12.46	0.26	0.43
Avocado (28 analyses)	69.16	2.08	20.10	7.40	—	1.26

Fat of avocado has been found to be as digestible as other edible oils.

[1] Jaffa and Albro. *Studies on the Composition and Nutritive Value of Some Subtropical Fruits.* Annual Report California Avocado Association 1917, pages 85–91; *Chemical Abstracts,* Vol. 14, page 1393 (1920).

Chemical Changes in the Ripening of Fruits

During ripening many fruits undergo distinct changes in composition, and these changes may continue after the gathering of the fruit. In general the ripening involves a decrease in acid and starch with an increase in sugar content. Oxidation processes also go on in the fruit with the development of " ethereal " substances (probably esters) and evolution of carbon dioxide.

Quite elaborate investigations of the changes which fruits undergo during ripening have been carried on by Bigelow and by Langworthy and their associates, in the United States Department of Agriculture. With winter apples, for example, it was found that the starch content reaches its maximum about midsummer and then decreases and finally disappears almost entirely. This change is strikingly shown by treating the cut surface of specimen apples with iodine, which colors starch deep blue. The decreasing depth of color with decreasing starch content as the apple approaches maturity is readily seen in Fig. 33. The acid content of the apples was found to decrease from early summer until maturity, while the sugar content increases.

In bananas also there is a marked conversion of starch into sugar as the fruit ripens.

The peach, on the other hand, contains no appreciable amount of starch at any time, but shows a steady increase in sugar content as it approaches maturity.

In fruits generally there is an apparent decrease of the pectin substances as the fruit ripens, as indicated by the fact that under-ripe fruit yields firmer jelly.

Digestibility and Nutritive Value of Fruits and Nuts

In dietary studies and digestion experiments fruits and nuts are often considered together, largely because a large proportion of the accurately recorded data has been gathered by Jaffa

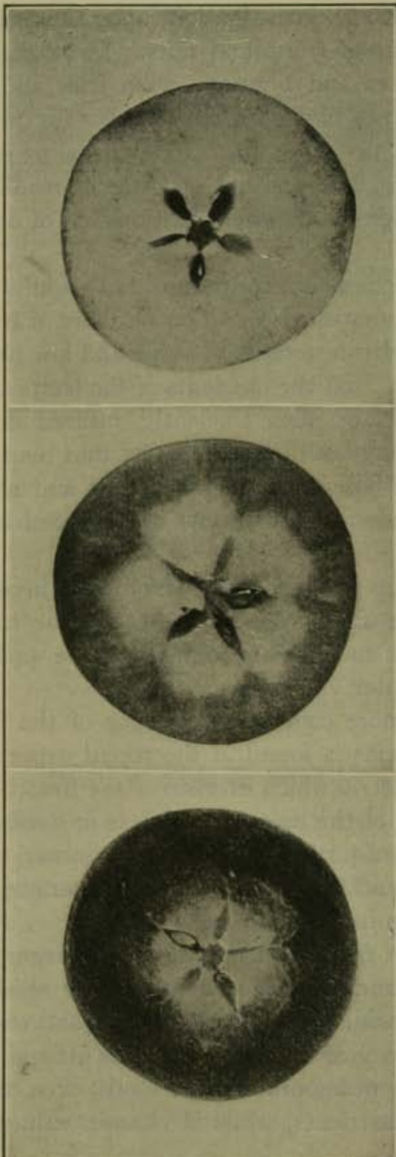

FIG. 33. — Showing decrease of starch with ripening of apple. (See explanation in text, page 396.)

in connection with his investigations upon California fruitarians whose diet is one of fruits and nuts. In 28 digestion experiments with 2 men and 1 woman upon fruit and nut diet the average coefficients of digestibility were: for protein, 90 per cent; for fat, 85 per cent; for carbohydrate, 95 per cent.

Apparently the fruit and nut diet was as readily and almost as completely digested as would be expected of ordinary mixed diet.

The fact that consistent fruitarians, both adults and children, maintain a well-nourished condition on diets of fruits and nuts which are of moderate total food value and low protein content is strong evidence that the nutrients of the fruits and nuts must be well digested and also efficiently utilized in metabolism. This is in harmony both with the belief that man is descended from ancestors whose chief food was fruit and nuts, and with the results of modern investigations of the chemical structure of the nut proteins.

The nut proteins in so far as they have been investigated have shown an amino acid make-up rather similar to that of the proteins of meat and fish. (Compare Table 54 herewith and Table 32 in Chapter VII.)

Further and more conclusive evidence of the food value of typical nut proteins is found in the recent experiments of Osborne and Mendel, in which excelsin of the Brazil nut has been shown to be one of the proteins which is in itself ample for all the requirements of protein metabolism in normal nutrition, and those of Cajori and others who have fed various nuts as sole sources of protein in nutrition experiments.

It is plain that fruits and nuts are to be regarded as staple articles of food and by no means as simply relishes or accessories. By a consideration of composition and cost it will also be found that many of the fruits and nuts are quite economical as compared with many other staple foods, even on the basis of the well-known nutrients, while if vitamin values also are included in such a comparison the result will usually be still more favorable.

TABLE 54. PERCENTAGES OF AMINO ACIDS FROM NUT PROTEINS (COMPILED FROM DIFFERENT SOURCES)

	AMANDIN (ALMONDS)	EXCELSIN (BRAZIL NUTS)	COCONUT GLOBULIN	ARACHIN (PEANUTS)
Glycine	0.51	0.6	trace	0.00
Alanine	1.40	2.3	4.11	4.11
Valine	0.16	1.5	3.57	1.13
Leucine	4.45	8.7	5.96	3.88
Phenylalanine	2.53	3.5	2.05	2.60
Tyrosine	1.12	3.1	3.18	5.50
Proline	2.44	3.6	5.54	1.37
Serine	——	—	1.76	——
Aspartic acid	5.42	3.8	5.12	5.25
Glutamic acid	23.14	12.9	19.07	16.69
Cystine	——	—	1.44	0.85
Arginine	11.85	16.1	15.92	13.51
Lysine	0.70	1.6	5.80	4.98
Histidine	1.58	2.5	2.42	1.88
Tryptophane	present	present	present	present
Ammonia	3.70	1.8	1.57	2.03
Summation	59.00	62.0	77.51	63.78

Place of Nuts in the Diet

From the tables of composition given above it is apparent that nuts vary considerably in composition, some (as chestnuts) being starchy, others (as coconuts and walnuts) being especially rich in fat, while many (as almonds, Brazil nuts, butternuts, and peanuts) are rich in both protein and fat.

Nuts in general, being rich in both protein and fat, are comparable with meats as food and may be used interchangeably with meat in the diet; in fact they are being so used to an increasing extent. With the constant tendency toward higher cost of meat, which must be anticipated, and with growing knowledge of nut culture, we may look for a much larger use of nuts as " meat substitutes "[1] in the future. Even at present prices the economy of nuts both as sources of energy and of protein will doubtless be surprising to many who have not previously compared the composition and cost of typical articles of these groups.

Typical nuts resemble typical meats, not only in their richness in protein but also in their lack of a satisfactorily balanced mineral and vitamin content, being poor in calcium and in vitamins A and C. They may be regarded as substitutes for other seed products, or for meat, but not as a satisfactory substitute for dairy products or eggs.

In the work of Johns, Finks, and Gersdorff, coconut protein was found by feeding experiments to furnish all the essential amino acids. Since the chemical examination shows it to be fairly high in lysine it should be of value as a supplement to the grain proteins. Its lysine content of about six per cent gives it rank in this respect somewhat below the milk proteins and about equal with the proteins of eggs, meat, fish, and gelatin.

Cajori has shown that nuts furnish proteins which are adequate for growth and that they are good sources of vitamin B. Working with rats which consumed about 6 to 8 grams of total food per day, he found that if almonds, English walnut, black walnut, chestnut, Brazil nut, or pecan was included in the ration to the extent of 1 to 2 grams per day, the nut sufficed as sole source of the B vitamin. This would imply that nuts are nearly but not quite as rich in vitamin B as are the whole cereals, the dry legumes, or the solids of milk or eggs.

While, broadly considered, the nuts are similar in nutritional character to the grains, in respect to protein they may supplement the proteins of certain grain products. Eddy and Eck-

[1] To speak of nuts as " meat substitute " is natural under present conditions and reflects the prominence which has been given to meat and the casual way in which nuts have been regarded for some generations. Looking at the matter in evolutionary perspective it might be more logical to speak of meats as " nut substitute " instead.

man comparing peanut protein with meat protein in this respect conclude:

"When the protein supplementing power of peanut flour is compared with that of muscle protein by feeding rations so constituted as to contain only about 10 per cent of protein, 6 to 7 per cent of this protein being contributed by wheat flour and the rest by peanut flour or meat residue, respectively, and when these rations are further supplemented with 3 per cent of butter-fat, 4 per cent salts and brought to nearly equal caloric value per gram; the peanut flour proves slightly superior to the meat as a growth producer and markedly superior for promoting reproduction."

Johns and Finks had found that bread made with a mixture of 25 per cent peanut flour and 75 per cent wheat flour (74 per cent extraction) furnished adequate proteins and water-soluble vitamin for normal growth.

Johns reports the quantitative digestibility of the peanut to be good. Fed in the form of peanut flour it showed digestibility coefficients of: protein 89 per cent, fat 96 per cent, carbohydrates 97 per cent. He recommends the use of bread containing 25 per cent of peanut flour.

Since the ravages of the boll-weevil made it unprofitable to grow cotton in many parts of the South, increased attention has been given to peanut culture, and a number of mills which formerly produced cottonseed oil are now pressing oil from peanuts. The residual "peanut press cake" is rich in protein, and the work of Johns and Jones of the Bureau of Chemistry, United States Department of Agriculture, has shown that peanut proteins are relatively rich in basic amino acids in which the cereal proteins are relatively poor, and promise therefore to be of considerable value for feeding in connection with grain products. In 1916, they described two globulins from the peanut, *arachin* and *conarachin*, containing 4.96 and 6.55 per cent of basic nitrogen, the latter figure being characterized as the highest which had been reported for any seed protein. For comparison they give the figures shown in Table 55.

TABLE 55. BASIC NITROGEN IN PERCENTAGE OF THE TOTAL NITROGEN OF PROTEINS

PROTEIN	SOURCE	BASIC NITROGEN[1] PER CENT OF PROTEIN
Zein	Maize	0.49
Gliadin	Rye	0.91
Gliadin	Wheat	1.09
Phaseolin	Kidney bean	3.62
Vicilin	Pea	4.92
Arachin	Peanut	4.96
Legumin	Pea	5.11
Excelsin	Brazil nut	5.76
Edestin	Hempseed	5.97
Globulin	Coconut	6.06
Conarachin	Peanut	6.55

Shiba and Koyama found peanut protein somewhat more efficient than soy bean protein in the support of growth.

Morgan and Heinz have shown that the protein mixture contained in the almond functions efficiently in human nutrition.

Rose and MacLeod (working with grown people) found that the calcium of almonds was fairly well utilized but in most cases not as well as was the calcium of milk.

The Place of Fruits and Vegetables in the Diet

Considered as sources of energy, potatoes and dry beans and peas are at ordinary prices about as economical as grain products and much more economical than the meats; while the dried fruits are comparable in economy as fuel with milk, butter, and the fatter and cheaper kinds of meat. Even those fruits and

[1] The term "basic nitrogen" covers the nitrogen present in the protein, in the form of the radicles of those amino acids which are basic (more basic than acidic) in their chemical nature. Arginine, histidine, and lysine belong to this group of amino acids.

green vegetables which are eaten for flavor with little thought of food value, and which are often thought of as luxuries because of their high water content, will often be found to furnish energy at no greater cost than many of the familiar cuts of meat when account is taken of the extent to which the fat of the meat is usually lost or rejected in cooking or at the table.

That the dry legumes are both absolutely and relatively rich in protein is a fact so well recognized as not to require elaboration here. Less generally realized is the fact that while the green vegetables contain too much water to show high absolute values or percentages by weight of protein, yet they show as much or more of the total fuel value in the form of protein as is customary or desirable in ordinary dietaries. In fruits, on the other hand, the relative proportion as well as the absolute amount of protein is usually low. The proportion of energy furnished by protein, as well as other data, may be found for all the common articles of food in the table of 100-Calorie portions at the back of this book (Appendix D).

The vegetables differ among themselves in the nutritive efficiency of their proteins. Probably the proteins of the leaf vegetables are, weight for weight, of somewhat higher nutritive efficiency than the proteins of the seeds. Even among the latter, there are also differences, which naturally have been studied mainly in the legumes, since these are so generally regarded as significant largely if not chiefly for their protein content. Finks, Jones, and Johns, in their paper "The Rôle of Cystine in the Dietary Properties of the Proteins of the Cowpea, *Vigna sinensis*, and of the Field Pea, *Pisum sativum*" (Journal of Biological Chemistry, Vol. 52, pages 403–410) have pointed out that the proteins of the cowpea, *Vigna sinensis*, like those of the beans of the genus *Phaseolus*, are limited in their nutritive value by a low content of cystine, while the proteins of field peas, *Pisum sativum*, fed at the same level, were adequate for growth without added cystine.

McCollum, Simmonds, and Parsons had reported that "pea proteins are of very poor quality," but, according to Finks, Jones, and Johns, they identified their peas as *Vicia sativa*, which would mean that, strictly speaking, they were vetches.

Finks, Jones, and Johns say: "Some confusion of names has arisen between the cowpea, *Vigna sinensis*, and the field pea, *Pisum sativum*, and between the latter and the vetch, *Vicia sativa*, which is sometimes erroneously referred to as 'peas.'"

In the Southern states the cowpea (which is there the most extensively grown leguminous crop) is frequently called the field pea or simply pea. Botanically, however, the cowpea is more closely related to the bean (*Phaseolus*) than to the pea (*Pisum*).

The true pea (*Pisum sativum*), largely grown in the Northern states and in Canada, consists of two groups of varieties, the sugar or garden peas whose seeds wrinkle when dry, and the field peas which remain smooth and round when dry. The former are grown only for human food and are used green; the latter are used as split peas and are also grown as a forage crop, particularly in Canada, and are therefore called Canada field peas.

The Vetch (*Vicia sativa*) is grown chiefly for forage; but one variety yields yellow seeds which are used to some extent as human food. Apparently it is these and not true peas that McCollum, Simmonds, and Parsons tested.

Finks, Jones, and Johns find the proteins of peas to be distinctly more efficient in nutrition than those of beans or cowpeas — presumably also than those of vetches.

Pea meal has been shown by Osborne and Mendel to supplement satisfactorily the deficiencies of corn proteins (Journal of Biological Chemistry, Vol. 29, page 69).

Taking the fruits and vegetables as a whole, while often more economical as sources of energy and protein than is generally considered, yet they are even more significant for their ash constituents and for the vitamins which they contain.

The percentages of individual ash constituents in the edible portion of each of the important fruits and vegetables (in so far as trustworthy analyses are available) are tabulated in the Appendix to the writer's *Chemistry of Food and Nutrition, Revised Edition.* In Chapters IX, X, and XI of the same book will be found a fuller discussion than can be undertaken here of the significance of the mineral elements in nutrition and food values and the relative richness of different foods in calcium, in phosphorus, and in iron, as compared both on the basis of percentage by weight and on the basis of quantities of equal calorie value.

As sources of iron the vegetables, and especially the green vegetables, are perhaps the most important of all our foods. Since there has been among dietitians of the older school a tendency to regard meats as the main source of food-iron, a brief comparison of meats with vegetables and fruits from this standpoint may be desirable.

In the average of 15 American dietary studies the cost of meat and fish was 35 per cent of the total expenditure for food and the cost of vegetables and fruits was 18 per cent; the former furnished 35 per cent of the total iron and the latter 27 per cent. Thus *in proportion to cost* the fruits and vegetables furnished much more iron than the meats and fish.

The question, however, is one of kind as well as amount. The iron in meat is chiefly due to the blood remaining in the small blood vessels with which the meat is permeated. The iron compounds of blood are mainly in the red blood corpuscles which do not yield very readily to the digestive ferments, so that probably the iron of fruits and vegetables is better absorbed and becomes more completely available for nutrition than the iron of the meats.

Moreover, the use of too much meat (especially by persons of sedentary habits or indoor occupation) tends toward excessive intestinal putrefaction with resulting absorption of putrefactive products, which are detrimental to the red blood cells and may in this or other ways interfere with the economy of iron in the body. Fruits and vegetables, on the other hand, have the opposite property, and their use in liberal quantities tends to prevent or correct intestinal putrefaction, both by stimulating peristalsis and by furnishing a medium less favorable to the activities of the putrefactive bacteria. Herter showed that in a large proportion of anemic people the anemia is closely correlated with excessive intestinal putrefaction and that improved condition of the blood followed quickly upon the establishment of a better intestinal hygiene. Interesting in this connection is Herter's observation that anemia is much more common among the carnivorous than among the herbivorous animals, and that the feces of carnivora are much more likely to show putrefactive bacteria of the actively injurious types such as *B. welchii* (*B. aërogenes capsulatus*).

The mild laxative tendency of many fruits and vegetables depends in part upon the fact that they furnish to the digestive tract a sufficiently bulky residue (largely of cellulose and related substances) to stimulate mechanically and render effective the peristaltic action, and in part upon the occurrence in many fruits and some vegetables of substances which, aside from the mechanical considerations, exert a mild laxative effect. Sometimes the raw fruit is found to be more laxative than the same fruit when thoroughly cooked. In some cases the astringent substances in the skin may counteract the laxative effect of the raw flesh of the fruit; thus, some persons find the flesh of raw (or even stewed) apples too laxative, but experience no inconvenience when the skin of the apple is eaten with the flesh and the whole is thoroughly chewed.

Another important effect of eating fruit is the introduction of an acid substance into the digestive tract, which later yields an alkaline or basic substance in the blood and tissues. This acidity of fruits is largely due, not to free acids, but to acid potassium salts, of which the acid potassium citrate of oranges may serve as an example.

When the acid potassium citrate is absorbed into the system, its citric acid is burned, leaving potassium carbonate in its place, and this potassium carbonate acts to increase the reserve alkalinity of the body fluids. Blatherwick and Long found that drinking even large amounts of orange juice always resulted in production of alkaline urine. "It was impossible to overreach the organism's ability to oxidize the contained citric acid," even though the amount drunk were the equivalent of 24 large oranges eaten per day.

Newell and Miller ("The Effect of Adding Orange Juice to the Diets of Underweight Children," Journal of Home Economics, Vol. 15, pages 241–248) found that the addition of 45 cc. of orange juice daily to the diets of underweight children from 5 to 13 years old resulted in unmistakable improvement in growth. This was attributed either to the ash constituents or to the vitamin content of the orange juice.

The presence of potassium carbonate (potash) in wood ashes is familiar to every one and accounts for the fact that the wood ashes are alkaline or basic. Similarly, those parts of plants which are used for food in the form of fruits and vegetables yield, on burning, a basic or alkaline ash due to the fact that the base-forming elements predominate over the acid-forming elements in these foods, chiefly because of the presence of the organic potassium compounds just mentioned. The surplus of base-forming elements which remains as carbonate and makes the ash distinctly alkaline when the food is burned at a high temperature in the air will, when the material is oxidized in the body, remain as bicarbonate, which is a practically neutral substance, yet capable of neutralizing acids such as the sulphuric acid produced in the protein metabolism. Thus the predominance of base-forming elements among the ash constituents of fruits and vegetables is of great value to the body in facilitating the maintenance of the normal neutrality of the blood and tissues.

To obtain a quantitative expression of the extent to which either the acid-forming or the base-forming elements predominate, calculate from the amounts of acid-forming elements the volume of normal acid which these elements could yield, and similarly the volume of normal alkali from the base-forming elements. The excess of acid or alkali, as the case may be, expressed in cubic centimeters of normal solution, affords a convenient expression of the acid-forming or base-forming tendency of the food, or, as sometimes called, its "potential acidity" or "potential alkalinity."

Table 56 shows the potential alkalinity or predominance of base-forming elements — expressed in the units already explained — (1) in each 100 grams of *edible portion* of the fruit or vegetable, (2) in the 100-Calorie portion, (3) in one pound of the material *as purchased*.

TABLE 56. "POTENTIAL ALKALINITY" OR "SURPLUS OF BASE-FORMING ELEMENTS" IN VARIOUS FRUITS AND VEGETABLES

FOOD MATERIAL	PER 100 GM. EDIBLE PORTION	PER 100 CALS.	PER POUND AS PURCHASED
Apples	3.7	6.0	12.8
Apricots	6.8	10.9	26.9
Asparagus	0.8	3.6	3.6
Bananas	5.6	5.6	16.2
Beans, dried	18.0	5.0	78.3
lima, dried	41.6	12.0	190.3
fresh	14.0	11.6	29.0
string, fresh	5.4	12.9	22.7
Beet, fresh	10.9	23.6	39.4
Cabbage	6.0	18.0	21.8
Carrots	10.8	23.9	37.8
Cauliflower	5.3	17.5	24.3
Celery	7.8	42.1	28.6
Chard	15.8	41.1	69.7
Cherry juice	4.4		
Citron	9.8	3.0	44.6
Cucumbers, fresh	7.9	45.5	30.9

TABLE 56. "POTENTIAL ALKALINITY" OR "SURPLUS OF BASE-FORMING ELEMENTS" IN VARIOUS FRUITS AND VEGETABLES — Continued

FOOD MATERIAL	PER 100 GM. EDIBLE PORTION	PER 100 CALS.	PER POUND AS PURCHASED
Dates	11.0	3.2	45.3
Grapes	2.7	2.8	9.2
Grape juice	3.9	4.0	18.1
Lemons	5.5	12.3	27.4
Lemon juice	4.1	10.7	19.0
Lettuce	7.4	38.7	27.9
Mushrooms	4.0	9.0	1.8
Muskmelons	7.5	18.8	16.6
Olives	47.2	18.9	188.1
Onions	1.5	3.1	6.2
Oranges	5.6	10.9	18.4
Orange juice	4.5	14.3	28.0
Parsnips	11.9	18.1	42.7
Peas, fresh	1.3	1.3	3.3
dried	5.0	1.4	22.6
Peaches, fresh	5.0	12.2	15.6
Pears, fresh	3.6	5.6	14.3
Pineapple, fresh	6.8	15.7	30.8
Potatoes	7.0	8.6	26.0
Potatoes, sweet	6.7	5.4	24.1
Pumpkins	1.5	5.7	3.4
Radishes	2.9	9.8	8.9
Raisins	23.7	6.9	97.0
Raspberry juice	4.9		
Rhubarb	8.6	37.4	23.6
Rutabagas	8.5	29.8	
Spinach	27.0	113.0	122.0
Tomato juice	6.2		28.1
Tomatoes	5.6	24.5	25.5
Turnips	2.7	6.8	25.0
Watermelon	2.7	8.9	5.1

Since meats and eggs show a distinct excess of the acid-forming elements, while in vegetables and fruits the base-forming elements predominate, it follows that the greater the amount of meat, fish, and eggs eaten the more important it is that fruits and vegetables be also used liberally. The relative efficiencies of different fruits and vegetables in this respect may be judged from the accompanying table (Table 56).

The vitamins of fruit and vegetables constitute a factor in their food values which, while only recently discovered and not yet fully understood in all respects, is undoubtedly of very great importance.

The vitamin A content of leaf vegetables and of some other vegetables has been referred to earlier in the chapter. McCollum groups leaf vegetables with milk and eggs as "protective foods" because their mineral and vitamin content, and especially their content of calcium and of vitamins A and C, protect the consumer from the nutritional deficiencies which are most likely to occur upon dietaries composed too largely of grain products, meats, sweets, and most fats. As has been pointed out, however, there is a great difference between the thin green leaves of spinach and the thick-ribbed white inner leaves of cabbage. Green string beans, carrots, and tomatoes rank in vitamin A content with lettuce, below spinach but above cabbage. Most roots rank lower as sources of vitamin A and with them the tubers and seeds. Here again, however, differences appear between species or even between varieties of the same species. Yellow corn has more vitamin A than white corn, sweet potatoes than white potatoes, and small wrinkled green peas have more vitamin A than other kinds of peas that have been tested. Fruits have not been tested extensively for vitamin A. Apples, bananas, oranges, pineapples, and prunes seem to be fairly good, but not rich sources, ranking about with white cabbage and many of the root vegetables.

Osborne and Mendel (1920) fed equal weights (0.1 gram per rat per day) of butter fat, dried spinach, dried alfalfa leaves, or dried tomato separately as sole source of vitamin A and concluded from the resulting rate and extent of growth that the dry matter of tomato or of green leaves such as spinach contains an even higher concentration of vitamin A than does butter fat. Similar results have been obtained in the writer's laboratory by Miss Munsell, on whose work (not yet published in full at time of writing — 1923) many of the statements made in this book regarding the relative amounts of vitamin A in different food materials are based.

Vitamin B is apparently more evenly distributed among vegetables and fruits than is vitamin A. The seed vegetables appear to contain vitamin B in about the same proportion as do the whole grains (Chapter VIII); most roots seem to rank about with these, and most leaves slightly higher when compared on the basis of dry matter.

The potato was found by McCollum, Simmonds, and Parsons (1918) to be capable of supplying all of the needed B vitamin; but since large proportions of potato were used in all the experiments which they describe, their data do not show how the potato compares with other foods quantitatively in this respect. Osborne and Mendel (1920) find the potato to compare favorably with roots as a source of vitamin B.

Steenbock and Gross (1919) report the sweet potato as containing less of this vitamin than carrots or rutabagas, of which 15 per cent sufficed to make the food mixture adequate. Osborne and Mendel found turnip, onion, beet leaves, or beet stems to contain about twice as much vitamin B in the dry matter as beet roots, while tomato was about twice as rich in this respect as the turnip or onion, and about half as rich as yeast when all were compared on the basis of dry matter. They also found that 10 per cent of dried spinach or 15 per cent of dried cabbage sufficed as sole source of vitamin B.

Thus in general the leaves appear to be slightly richer than the whole seeds in the B vitamin when compared on the basis of dry matter.

Compared in the fresh fluid form, orange, lemon, and grapefruit juice were found by Osborne and Mendel to contain about the same concentration of vitamin B as does milk, while grape juice and fresh apples and pears appear to contain less.

Vitamin C, the vitamin **which prevents scurvy**, and to which therefore the so-called antiscorbutic property of many foods is due, is an extremely important factor in food value, and the one in respect to which the fresh fruits and vegetables are preëminent among foods. A few words in regard to its formation and distribution in plants in general may therefore be of interest.

Mature, resting seeds evidently contain very little if any of this vitamin. In a diet otherwise adequate the amount of grain fed has no appreciable effect upon the appearance or severity of scurvy. But if properly sprouted grain be fed, it is found to have pronounced antiscorbutic properties. Evidently in the sprouting of the grain (and this applies to legumes as well as cereals) there occurs a marked development of vitamin C. As nothing but water need enter the seed, it is plain that something preëxisting in the seed must become transformed into vitamin C as the seed sprouts.

This formation of vitamin C in the seed as it passes from the resting stage into a condition of active metabolism is undoubtedly of fundamental significance. From which of the preëxisting substances in the seed the vitamin C is formed we do not know. It is has been suggested that it may be formed from vitamin B, but there does not seem to be adequate evidence either to establish or to disprove this suggestion. Neither do we yet know where or when the plant forms its vitamin C beyond that which is formed in the sprouting of the seed.

Being readily soluble in water, the vitamin C passes as a constituent of the juice or sap into the growing parts of the plant, and in general the studies of the distribution of this vitamin in plant materials show it to occur most abundantly in the actively functioning and the succulent parts, — in the fresh green leaves, the growing shoots, and the juicy stems, roots, tubers, bulbs, and fruits. Thus oranges, lemons, tomatoes, and raw cabbage are among the richest sources of vitamin C; apples and bananas do not contain such a high concentration of the vitamin, but are often important as antiscorbutics because of the quantities eaten.

Vitamin C occurs in varying proportions in the roots and tubers; but as these are usually cooked before eating, the concentration of vitamin C is thus diminished, and as ordinarily eaten none of the roots or tubers contains vitamin C in any such proportion as it is contained in raw leaves, tomatoes, or onions. Nevertheless potatoes are an important source of vitamin C because of the large quantities in which they enter into the daily dietaries of many people, and in practice it is often largely upon potatoes that the adequacy of the supply of vitamin C in low-cost winter dietaries depends, so that, as stated by Hess, "A failure of the potato crop is followed by scurvy in the spring."

While many fruits and vegetables are thus seen to contain significant amounts of vitamin C, the best-recognized and most popular antiscorbutics are orange or lemon juice and tomato. Special emphasis may well be given to the antiscorbutic value of tomatoes and tomato juice because these retain their vitamin C content almost unchanged in cooking or canning and are available in canned form, in most parts of this country at least, throughout the year and at prices which are neither prohibitive nor subject to violent fluctuations. Moreover, tomatoes, both fresh and canned, are also good sources of vitamins A and B, and the growing and canning of tomatoes is an industry which can readily expand to meet any probable increase in the demand for the product.

For fuller discussions of the antiscorbutic values of foods reference may be made to Hess's *Scurvy, Past and Present*, and to Sherman and Smith's *The Vitamins*.

A general indication of the relative values of different foods as sources of vitamin C may be obtained from the table shown at the back of this book (Appendix E).

Strictly quantitative comparisons of vitamin C content have been attempted for relatively few foods, and even for these the results can as yet be regarded as only approximate. Because of the growing importance of the subject, however, some of the available data are brought together in Table 57.

TABLE 57. RELATIVE RICHNESS IN VITAMIN C OF CERTAIN FRUITS AND VEGETABLES COMPARED WITH THAT OF ORANGE JUICE AS 100

Apple, raw	10 to 20
Banana, raw	10 to 20
Beef juice, raw	0 to 10
Cabbage, raw	100
Cabbage, slightly cooked	30
Cabbage, fully cooked	5 to 10
Carrots, raw	5 to 50 (?)
Carrots, cooked	very variable
Grapes or grape juice	4 to 5
Lemon juice	100
Lime juice, fresh	25
Onions, raw	100
Oranges or orange juice	100
Pineapple juice, fresh, raw	70
Potatoes, raw	50 (?)
Potatoes, cooked	10 to 30
Sprouted beans or peas, raw	70
String beans, raw	70
Tomato, fresh or canned	100
Turnip juice, raw	30 to 70

In general, vitamin values have not yet been measured with sufficient exactness to permit of our expressing them in quantitative terms. Neither can we give quantitative expression to some of the other very important properties of fruits and vegetables, such as their effects in stimulating the appetite and the flow of the digestive juices, and in promoting good intestinal hygiene and facilitating the removal of uric acid and other waste products through the kidneys. But even if we consider only the factors of food value which are easily expressible in accepted quantitative terms, we find that fruits and vegetables (though doubtless usually bought with little conscious regard to any other property than flavor) are more economical than is generally supposed.

Thus the data of 15 American dietary studies, supposed to be representative of ordinary food habits in their respective localities, show the following average results when the cost of, and returns from, the fruits and vegetables, the vegetables alone, and the potatoes alone are calculated in percentage of the total food (Table 58). (See also Chapter XIII.)

TABLE 58. ECONOMY OF FRUITS AND VEGETABLES IN THE DIET

IN FIFTEEN AMERICAN DIETARIES	PER CENT OF TOTAL COST	PER CENT OF TOTAL CALORIES	PER CENT OF TOTAL PROTEIN	PER CENT OF TOTAL PHOSPHORUS	PER CENT OF TOTAL IRON
Fruits and Vegetables .	18.7	11.8	10.6	18.7	27.3
Vegetables	11.1	9.0	9.8	18.0	20.6
Potatoes	3.9	5.3	4.2	8.7	13.5

If we take account of the fact that we must purchase phosphorus, iron, and at least three kinds of vitamins as well as protein and energy in our food, we see that the money spent for fruits and vegetables yielded fully its proportionate return in nutritive value, as we now understand it, if not in Calories and protein. Potatoes, it will be seen, were very economical sources of protein and energy as well as of ash constituents.

In any case the percentages of nutrients give an inadequate expression of the true value of fruits and vegetables as food. In fact, the low protein, fat, and carbohydrate content which, in the past, has caused some of the fruits and green vegetables to be regarded merely as luxuries may at times be an actual advantage in enabling one to balance a dietary and make it richer in vitamins by adding these foods without either making protein or energy intake excessive or necessitating a restriction of the consumption of foods already in use.

For many and good reasons, therefore, the more general and more liberal use of fruits and vegetables is to be encouraged. Where the cost of food must be strictly limited, the dietary may often be improved by diminishing the expenditures for meats and sweets in order that vegetables and fruits may be used more freely.

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II

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CHAPTER X

EDIBLE FATS AND OILS

Edible fats and oils are separated on a commercial scale from a great variety of food materials: butter from milk; oleomargarine, lard, and suet from meat fats; corn oil from grain; olive oil from a fruit; peanut (arachis) oil from a legume seed of nut-like character; coconut oil from a true nut; cottonseed oil from the seeds of a plant of still a different family. Of the various food fats of commerce, butter is, in America at least, by far the most prominent, and the butter industry will therefore be treated more fully than the other fat and oil industries.

Butter

The butter reported made in the United States in the year 1921 amounted to 1,705,438,000 pounds.

Since relatively small amounts of butter are imported or exported, the consumption may be taken as approximately equal to the production, and amounts therefore to about 16 pounds of butter per capita per year, or about three fourths of an ounce per person per day.

Butter making was, until fifty years ago, entirely a household industry. Since then the industry of making butter in central creameries or butter factories has grown until at present about two fifths of the butter is made in such establishments, and the proportion is constantly increasing. The description which follows relates chiefly to the making of butter in creameries or butter factories.

It is said that the first creamery was built by Alanson Slaughter in Orange County, New York, in 1861, and received the milk of about 375 cows. Less than forty years later, in 1900, a single creamery at St. Albans, Vermont, received the milk (or cream) from more than 30,000 cows, from which was made in one room between 20,000 and 25,000 pounds of butter per day.

A considerable proportion of the creameries or butter factories are owned by associations of farmers and conducted on a co-operative plan. The farmer who sends milk to the creamery is often spoken of as a patron. When the farm is at a distance from the creamery, the farmer often separates the cream and sends it alone to the creamery. Payment either for milk or cream is usually based upon the actual determination of fat content (usually by means of the Babcock test).

In order to simplify this part of the work, it is common to weigh the milk in a large cylindrical can (which remains on the scale) and after weighing each delivery take a sample by means of a Scovell or McKay sampling tube which will accurately represent the milk of the can from top to bottom and will be proportional in quantity to the amount of milk delivered. This sample is poured from the tube into a bottle or jar which contains a preservative and the jar kept closed to prevent evaporation. One jar thus serves for each patron, and the daily samples are composited in the jar for as many days as desired (usually a week, ten days, or two weeks), then tested, and the percentage of fat found in the composite sample is multiplied by the total weight of milk which it represents.

A butter factory makes more pounds of butter than it receives of butter fat in the milk because the losses of fat are more than compensated for by the water, curd, and salt of the butter. The excess of butter made over butter fat received is called the "overrun."

The amount of overrun depends on: (1) the thoroughness of skimming, (2) the completeness of churning, (3) the general losses in the factory, (4) the composition of the butter. It is generally calculated in percentage of the fat received and may usually be expected to exceed 10 per cent.

Under good conditions and management, the fat content of the skim-milk should not exceed 0.1 per cent, and of the buttermilk 0.2 per cent, as determined by the Babcock test.

Cream may be obtained from milk either by gravity or by centrifugal force. The prevailing method at present is by means of centrifugal separators, in which the milk flows continuously into a rotating bowl containing thin metal plates which separate the milk into inclined sheets in which by centrifugal force the heavier part is thrown toward the outer rim[1] and the lighter fat globules are forced toward the center. Thus while the separator is in operation, a continuous stream of cream and another of skimmed milk is obtained from the inner and outer layers respectively of the rotated bowl of milk. In order that the skimmed milk shall not be thrown out of the machine with too great force, the tubes which receive it from the outer portion of the bowl are carried back toward the center of the bowl, where they discharge into the outlet pipe. The size of the skim-milk outlet may be made to bear any desired relation to the size of inlet, size of bowl, and speed of rotation, and thus any desired proportion of the whole milk may be drawn off as skimmed milk, while the remainder is forced to the center of the bowl and discharged through the cream outlet. McKay and Larsen state that for butter making, a cream containing from 25 per cent up to 50 per cent of fat may be taken, according to the preference of the butter-maker.

Pasteurization of milk or cream for use in butter making is growing in favor. It eliminates not only any pathogenic bacteria which may be present, but most other bacteria as well, and makes it possible to control the ripening of the cream by

[1] Suspended solids heavier than the skimmed milk are forced against the outer surface and result in a deposit of "separator slime."

adding to the pasteurized cream a culture of bacteria which will produce the type of fermentation desired. This enables the trained butter-maker to produce butter of more uniform character and better keeping quality.

Ripening of cream is an acid fermentation, the object of which is to produce a butter of desirable flavor and aroma. Ripened cream also churns more easily and completely than that which has not been ripened.

Different butter-makers use temperatures varying from 60° to 80° F. in ripening cream, the higher temperatures being employed when it is desired to complete the process as rapidly as possible. Ordinarily it is considered that a better type of fermentation is secured at 60° to 70° F. than at a higher temperature. The desired temperature is maintained by keeping the cream, during the ripening process, in a water-jacketed vat.

In the ripening vat the cream is mixed with (usually) one tenth to one fifth of its volume of "starter," which consists of clean skimmed milk in active lactic acid fermentation induced either by the addition of commercial cultures of lactic acid bacteria or by keeping a good natural milk at about 70° F. until it shows a clean pleasant acid odor and taste, and coagulates to a smooth uniform curd. Before the starter is added to the cream, it is strained or poured back and forth between sterilized cans until the curds which it contains are broken into very small particles; otherwise the lumps of curd may appear as whitish mottles in the finished butter. If necessary, the starter may be strained before mixing with the cream. The cream and starter should be thoroughly stirred together and the stirring should be repeated at intervals during the ripening process in order that the acid fermentation may predominate uniformly throughout and that the fat globules may have the most favorable conditions for absorbing the desired aroma.

In general, the degree of acidity reached by the cream in the ripening process is an indication of the degree of flavor that the butter will have. Some markets require a more highly flavored butter than others.[1]

Churning consists in agitating cream in such a way that the fat globules stick together into masses of butter large enough to be separated from the buttermilk.

The churns now in general use in American butter factories, and which are being introduced into Europe, are the "combined churns," which are so arranged that they can be used not only to churn the cream and gather the butter, but also to wash, salt, and work the butter so that all these successive operations can be carried out without handling or exposure to flies and in an apparatus which permits of a controlled temperature.

In transferring the cream from the ripening-vat to the churn it is run through a tin strainer to remove any lumps of curd which might otherwise affect the appearance of the butter.

Butter color is usually also added to the cream before churning. Both annatto and synthetic colors are widely used. Different markets require different degrees of color. The commercial preparations used for coloring butter are employed in quantities varying from none in May and June (when the natural color of butter is highest) to about 2 ounces per 100 pounds of fat in winter when the butter would naturally have a much paler color than in early summer.

Churning is usually continued until the fat has gathered into irregular, flaky, granular masses between the size of a grain of wheat and that of a kernel of corn. The buttermilk is then drawn off and the butter washed with pure water, usually at a temperature about that at which the cream was churned or a little below. Warmer or colder water is sometimes used when it is desired to alter the texture of the butter.

[1] Usually the ripening process is continued until 50 cc. of the cream neutralize about 35 cc. of tenth normal sodium hydroxide, using phenolphthalein as indicator. This is called 35 degrees of acidity. The acidity is also sometimes expressed as percentage of lactic acid, and is often measured by means of alkali tablets which contain a fixed amount of alkali along with enough phenolphthalein to serve as indicator.

Salting of butter has the object (1) of imparting the desired flavor, (2) of increasing the keeping quality, (3) of facilitating the removal of the buttermilk.

The amount of added salt desired in butter by different markets varies from 0 to 4 per cent, American markets tending as a rule to prefer a rather highly salted butter.

When the salting is done without removing the butter from the churn, the amount of salt added is calculated on the basis of the amount of fat known to have been contained in the cream.

The quality of the salt used is regarded as quite important. Good dairy salt should have a clean, white, silky appearance and should dissolve quickly. Woll[1] gives the following as the analysis of a sample of purest American dairy salt:

	Per Cent
Sodium chloride	99.18
Magnesium chloride	.05
Calcium sulphate	.54
Calcium chloride	.19
Insoluble matter	.03
Moisture	.01
	100.00

All of the salt contained in butter should dissolve in the water which the butter retains. Butter containing particles of undissolved salt is called "gritty." When the butter as packed contains undissolved granules of salt, these attract moisture and cause unevenness of appearance. This is one of the causes of mottles in butter. In order to avoid mottling of butter from this or other causes, the buttermilk should be washed out as completely as possible and the salt carefully applied and well worked in. The washing out of the proteins in the buttermilk also results in a butter of better keeping qualities.

Working. The butter, having been washed and salted, is next worked to distribute the salt evenly, to bring the butter into compact form, and to press out any excess of water or

[1] Bulletin 74, Wisconsin Agricultural Experiment Station.

diluted buttermilk. The amount of water left in the finished product is largely determined by the working, since the more it is worked after it has become firm, the lower the percentage of moisture will be. For most markets the moisture must not exceed 16 per cent.

Packing. Extra quality butter is often put up in prints bearing the name of the farm or creamery where made. As the print butter must be firm in order to keep its shape well, it is apt to contain slightly less moisture than the butter put up in tubs.

The butter is transferred from the churn or working table to the tub by wooden ladles which just before use are thoroughly scalded and then chilled in cold water. By means of the ladles, the butter should be smoothly and firmly packed into the tub so as to leave no air spaces either in the butter or between the butter and the sides of the tub or at the top.

Stored butter should be kept at 50° F. or below in as dry a place as possible and separate from any other foods or anything from which it might absorb an odor.

The expense of making butter from the whole milk was investigated in Iowa and is reported to range in the different factories from one and one fifth to six cents, with an average of two and one fourth cents per pound of butter produced. The cost of ordinary creamery butter depends therefore much more largely upon the cost of milk or cream than upon the expense of manufacture.

Judging butter is very important in the industry because the price is so largely dependent upon the grade given the butter by the butter judge.

On a scale of 100 the weight given to the different factors of quality in America is usually as follows:

Flavor	45
Body	25
Color	15
Salt	10
Package	5

For discussion of judging, grading, and the market classification of butter, see McKay and Larsen, *Principles and Practice of Butter-making*, Chapter XX. Under the recent Food Products Inspection Law, the United States Department of Agriculture has adopted an official system of classification and grading, the current rules of which can be obtained on application to the Secretary of Agriculture, Washington, D. C.

Composition of Butter. McKay and Larsen found the average composition of 221 samples of butter from 55 creameries in different parts of Iowa to be:

	Per Cent
Fat	84
Moisture	12.73
Curd	1.30
Salt and ash	1.97

The figures for *curd* include any milk sugar which may sometimes be present. Under present conditions of manufacture the curd is the least variable constituent. It is very generally kept below 2 per cent because if more than this is present, the brine which exudes from the butter is apt to be noticeably milky, and such a butter would not be acceptable to the trade. In butter which is to be kept for some time special care is taken to keep down the protein as much as possible. Such butter will probably contain only 0.5 to 1 per cent of curd.

Preparations for increasing the amount of butter obtainable from a given amount of cream have been put on the market from time to time. Since in the ordinary manufacture very little fat is lost in the buttermilk, it is obvious that these butter increasers must act, if at all, not by a saving of fat, but by inducing the formation of a butter with a lower fat content. Usually the result is accomplished by the incorporation of an undue amount of curd and water by a sort of emulsification of buttermilk with the butter. Such a butter is of course fraudulent, and is also of very inferior keeping quality on account of its high protein content. Such frauds can be practiced only on a small scale, as a butter of this sort would be quickly detected and rejected by those engaged in the wholesale butter trade.

The *salt* in butter is both a flavoring and a preservative. A comparatively small variation in the salt content of butter is recognizable to the taste, and different consumers prefer very different amounts of salt. About 2 per cent of salt is demanded by most American markets. Some brands of butter are made extra salty with the idea that the consumer having acquired a taste for this will find ordinary butter "flat" and so will continue to demand the highly salted brand. On the other hand, some consumers demand unsalted (so-called "sweet") butter, and this can usually be found in the market.

When unsalted butter is stored, its flavor deteriorates and becomes "cheesy," while salted butter deteriorates less rapidly and usually in a different manner.

Moisture is the most abundant and most variable constituent of butter aside from the fat. The amount ranges from 6 to 16 per cent, more than 16 per cent being forbidden both by legal and trade regulations in many states and in the large markets. Butter which exudes large drops of water is called "leaky" and is commonly supposed to contain excessive moisture, but this is not necessarily the case. Both the moisture content and the physical condition which makes the butter "leaky" are largely influenced by the conditions which obtain during churning.

The United States Department of Agriculture, in 1902, made a systematic investigation of the moisture content of American butter as ordinarily manufactured. In 800 samples of butter from 400 creameries in 18 states the extremes were 7.20 and 17.62 per cent moisture; 85 per cent of the samples showed between 10 and 14 per cent, and the average of all was 11.78 per cent of moisture.

During the subsequent twenty years the water content of butter has been gradually increased, professional butter-makers having become skillful in increasing the " overrun " by leaving more water in the butter without detriment to its appearance and commercial rating, until now butter may be expected to contain not much less than the 16 per cent of water which legal and trade standards permit. The legal standard for the fat content of butter has recently been lowered from 82.5 per cent to 80 per cent.

The standard of the Association of Official Agricultural Chemists is as follows: Butter is the clean, sound product made by gathering in any manner the fat of fresh or ripened cream into a mass which includes also a small portion of the other natural milk constituents, with or without salt, and contains not more than 16 per cent of water and not less than 80 per cent of milk fat. By acts of Congress approved August 2, 1886, and May 9, 1902, butter may also contain added coloring matter.

Fuel value of butter. Atwater and Bryant estimated the average fat content of butter at 85 per cent, which, according to modern factors of fuel value, would yield about 3500 Calories per pound; but if butter contains only 80 per cent of fat, its fuel value will be only 3232 Calories per pound. The present average is probably about 3300 Calories per pound.

Process butter. Butter of inferior flavor or which has become more or less rancid is often " renovated " or " processed." This usually consists in melting the butter, removing the froth or scum, and drawing off the curd and brine which settle out of the melted butter, blowing air through the melted fat to expel faulty odors, and re-churning the fat thus purified with fresh milk or cream.

In the butter markets, process butter is an established grade. In many states, however, restrictions are placed upon the sale of process butter, while good and bad grades of original butter are sold side by side without restriction.

A simple test much used to distinguish original butter from process butter or oleomargarine is to heat some of it in a tablespoon or small dish, with stirring, until it boils briskly, and stir two or three times thoroughly while boiling. Original butter boils without much noise but with an abundance of foam. Process butter and oleomargarine boil more noisily, sputtering like a mixture of water and fat in a frying pan, and give less foam than butter.

Oleomargarine (Margarine)

"Oleomargarine" in America, "margarine" in England, France, and Germany, is the term applied to butter substitutes made by churning fats other than butter fat with milk or cream to a butter-like emulsion.

The soft beef fat which was the original basis of these preparations is called "oleo oil" in America; Lewkowitsch states that in England it is called "oleomargarine."

Legislation in the United States has generally been such as to discourage the oleomargarine industry, and our present knowledge of the wide difference in vitamin value between butter and oleomargarine naturally and properly tends to increase the preference of consumers for butter.

The manufacture of oleomargarine was first described in 1870 by Mége, a French chemist, who was led to study the subject through his desire to furnish to poor people and to sailors a cheaper and more stable article than ordinary butter. The details of the process used by Mége, many of which are now known to be unnecessary, are given in his United States Patent, No. 146012, dated December 30, 1873, and in Bulletin 13, Bureau of Chemistry, United States Department of Agriculture, pages 10–12.

Prominent among the many fats used in the manufacture of oleomargarine are "oleo oil" prepared from beef fat, and "neutral" lard. The preparation of "oleo oil" may be described first.

Oleo oil. The fat of freshly killed beeves, chiefly the fat of visceral cavity, known as "caul fat," is thoroughly washed, first in tepid and then in cold water, and then thoroughly chilled either by means of ice water or by hanging for some time in artificially cooled rooms. The hardened fat is then cut up and ground and the disintegrated mass transferred to a jacketed melting kettle.

Formerly this fat was rendered at 55° to 80° C. (130°–175° F.), the fluid fat thus obtained was allowed to cool slowly until a considerable proportion of the stearin and palmitin had crystallized out, the pasty mass then subjected to hydraulic pressure, and the fluid pressed out (about two thirds of the whole) was run into cold water and allowed to solidify into a granular mass, — the "oleo" or "oleo oil" of commerce.

According to Lewkowitsch the temperature of rendering is now much lower, not above 42° C. (107° F.), this temperature being maintained for a longer time by means of steam or hot water in the jacket of the kettle. At this temperature the tissue slowly sinks, and a part of the fat melts and separates at the top. Sprinkling salt on the mass assists in the settling of the tissue and the clearing of the surface fat. The latter is then run off and either allowed to cool to the proper point and pressed, or (for the better grades of oleomargarine) may be r melted and freed from the last portions of membrane and tissue by further standing and sprinkling with salt. Finally it is carefully cooled to the proper temperature for crystallizing out the desired proportion of "stearin," and is sometimes held at this temperature for 3 to 5 days before going to the hydraulic presses.

Neutral lard. For the preparation of lard to be used in making butter substitutes the "leaf fat" of the hog is quickly removed, freed from flesh, chopped into small pieces, and then thoroughly washed with cold water. It is then rendered at a temperature of 40° to 50° C., yielding a practically neutral product known in the trade as Neutral Lard No. 1. When the leaf fat cannot be rendered at once, it is kept in refrigerating rooms until it can be worked up. This prolonged cooling process is considered by some an advantage, inasmuch as it is said to be more effective than simple washing in removing the " animal flavor."

The neutral lard or the oleo oil is, of course, brought to different degrees of hardness in different cases, a harder fat being prepared in case cottonseed oil or other oil is to be admixed.

The chief desiderata are that each fat (except the butter which is churned in later) shall be as free as possible from taste and odor, and that the final mixture of fats have practically the same melting point as butter fat for this climate; for a warm climate a little harder and for a cold climate a little softer.

Cottonseed oil especially prepared for use in butter substitutes is called " butter oil " and is considerably used, as is also ordinary cottonseed oil and cottonseed " stearin." In Europe sesame oil is used in the same way. *Coconut fat* and *arachis* (*peanut*) *oil* are also used in making butter substitutes.

Final mixing. The foreign fats having been obtained in proper condition and mixed in the desired proportions, the mixture is fed into a churn containing milk or an emulsified mixture of milk and butter (sometimes also cream). The amounts of milk, cream, and butter vary greatly according to the quality of product being made. In some countries the amount is restricted by law in order that the product may be easily distinguishable from butter. In this country any proportions may be used, but the product must always be called oleomargarine, and whatever its quality, is subject to the restrictions noted later. The foreign fats having been gradually churned into the milk (or milk and butter mixture) and the whole mass having been " pulverized " by means of rotating paddles into a granular emulsion which will not permit any subsequent crystallization of the beef fat, the product is cooled, washed, salted, and worked as in butter-making.

According to Garard[1] the production of oleomargarine in the United States in 1920 was 381,564,722 pounds, an amount equal to about one fifth of the butter produced; and about 50 per cent of this was made from vegetable fats only, 48 per cent from mixtures of animal and vegetable fats, and only 2 per cent from animal fats alone.

Legal Control. In the United States the oleomargarine industry has been regulated by the Federal Laws of August 2, 1886, and May 9, 1902. The latter law taxes uncolored oleomargarine 0.25 cent and colored oleomargarine 10 cents per pound. This prevents the use of artificial coloring matter in oleomargarine made and used in this country.

Vegetable Fats as Butter Substitutes

Edible fats of the consistency of butter are obtainable from a number of vegetable sources.

Any of the edible oils may be chilled and pressed at such a temperature as to leave a soft solid residue.

Coconut and palm nut fat are of nearly the desired melting point in their natural state and so lend themselves readily to this purpose, but require careful refining to remove their characteristic tastes and odors. Different methods have been patented for the refining of these fats and no reliable information is at hand as to which methods are most used, but the results are now sufficiently satisfactory so that large quantities of these fats are sold for food.

Olive Oil

In comparison with other food fats, olive oil plays a relatively less prominent part in the United States than in many European countries. The total weight of olive oil consumed in this country is probably between 2 and 3 per cent of the weight of butter.

Olives for green pickles are gathered very soon after they reach

[1] *Applied Chemistry.*

full size and before they have begun to color or soften, but for ripe pickles and for oil making olives are gathered when they contain the maximum amount of oil, which is soon after they are well colored and before they become black. If the olives are too green, the oil will be bitter; if too ripe, it will be rancid.

The flesh of ripe olives is about one half oil. When the skin is broken, a considerable proportion of this oil exudes from the pulpy flesh, either spontaneously or under very slight pressure in the cold. This is called "virgin," "sublime," or "first-expressed" oil, and the highest grades are obtained from selected, hand-picked olives.

In the manufacture of ordinary olive oil the olives are thoroughly crushed either by corrugated metal rolls or by heavy stones revolving in masonry trenches.

The crushed pulp is placed in fabric of woven esparto grass (in Europe) or coarse linen cloth (in California), and the fabric folded over it to make a cheese about three feet square and three inches thick. Ten or more of these cheeses are placed one above the other, with slats between them, and pressure is applied.

The oil obtained by pressure under these conditions is second in quality to the "virgin oil," and constitutes the bulk of the edible olive oil of commerce.

After obtaining as much oil as possible in this way, the cheeses are taken out, broken to pieces, mixed with hot water and pressed again, yielding a third grade oil. Further yields of much inferior oil may be obtained by repeated pressing with hot water in very powerful presses or by extraction with solvents, but in California this is not usually done. The residual pulp is used for fattening swine.

In order to clarify the dark-colored oil obtained from the press, it is usually filtered first through cotton wool, then allowed to settle for 24 hours in funnel-shaped tanks from which the greater part of the sediment is drawn off, and finally run into settling tanks lined with tin or glass, where the oil stands for 2 to 5 months, being repeatedly racked off (usually three times in all) until it is entirely clarified.

The flavor of olive oil, which chiefly determines its commercial value quite apart from any question of genuineness or purity, depends largely upon the variety of olive, its ripeness when picked, the manner of handling, the length of time it is stored before pressing, the temperature and pressure at which the oil is drawn, and other conditions of manufacture.

Chemically olive oil consists chiefly of olein, the glyceride of oleic acid. The chief adulterants are the seed oils — in the United States most commonly cottonseed oil.

Out of the first 25 prosecutions for adulteration or misbranding of olive oil under the Food and Drugs Act, 23 were because of the presence of cottonseed oil not properly declared, one was for short weight, and one was because the label bore a false statement that the oil had been inspected by a government chemist.

The courts have upheld the position of the government that the term "salad oil" when *used alone* is understood to mean olive oil; but in one case in which a label bore the words "salad oil" in large letters and "cottonseed oil" in small letters the court decided against the government charge of misbranding.

In the administration of the Food and Drugs Act the following notice has been issued: "Pending a final decision of this matter, no objection will be made to the use of the term Salad Oil on oils other than olive oil, when such oils are pure, harmless, and edible, providing the term Salad Oil be plainly qualified by the common name of the oil or oils actually used. These qualifying names should be stated on the label with a prominence equal to that of the term Salad Oil."

Other Edible Oils

Many fatty oils besides that of the olive are entirely suitable for use as human food.

The Association of Official Agricultural Chemists include among edible vegetable oils and fats of sufficient importance to warrant standardizing, the oils of *corn*, *cotton seed*, *olive*, *peanut*, *sesame seed*, *palm kernel*, *poppy seed*, *rape seed*, *soy bean*, and *sunflower*, as well as the solid fats *cocoa butter*, *coconut fat*, and *cottonseed* "*stearin.*"

Of these, peanut oil bears the closest resemblance to olive oil in chemical and physical properties, and is used to a considerable extent as a substitute for olive oil in Europe, but not to such a large extent in this country because of the elaborate refining required to remove the characteristic flavor.

Cotton seed and sesame seed yield oils very similar to each other and not very different from olive oil in general nature but each possessed of characteristic color reactions by which it is readily identified. It is for the latter reason that sesame oil, which is abundant in Europe and is known to be a wholesome food, is required by the laws of some of the European countries to be added in the manufacture of oleomargarine as a means of making the latter easily distinguishable from butter.

Sesame oil is not produced in this country, and there is no inducement to import it in any quantity, because cottonseed oil, having nearly the same properties and being equally adapted to the same uses, is produced here in such abundance as to supply the entire home market and leave a large surplus for export.

It is estimated that the average cotton crop of the United States yields about 12,000,000 bales of fiber and about 6,000,000 tons of seed and that about 4,000,000 tons of seed are crushed and pressed with the production of about 3,000,000 barrels of crude cottonseed oil annually (three fourths of the world's production).

A typical modern process of refining cottonseed oil involves treatments (1) with sodium hydroxide, (2) with fuller's earth, and (3) by a secret method for removal of the "earthy flavor." The final product is nearly free from any characteristic flavor and is steadily growing in favor both as a substitute for olive oil and as a cooking fat.

Corn (*maize*) *oil* won favor only very slowly as a human food until the shortage of fats during the World War led to its more general acceptance, and it has since held an important place as a food fat.

Lard and Lard Substitutes

Under the conditions ordinarily obtaining in the fattening and slaughter of swine, each hog yields about 30 pounds of lard. The refining of lard constitutes an important branch of the industry of slaughtering and meat packing.

Commercial lard is nearly pure fat, the total amount of other substances being usually less than one per cent.

Lard substitutes are usually mixtures of beef fat and cottonseed oil. The solid residual fat from which " oleo oil " has been pressed, and which is technically known as " oleostearin," is commonly used for this purpose.

Some of these " lard compounds " are widely advertised and favorably known under trade names and sell for about the same price as lard.

Refined cottonseed oil is sometimes chilled and pressed at such a temperature that about one fifth of the whole is obtained as a solid which is called " cottonseed stearin," and may be used as a lard substitute either alone or in admixture with other fats. The other four fifths of the oil, being free from the more readily solidifiable glycerides, can be subjected to low temperature without yielding crystals or showing turbidity and is known commercially as " winter oil."

Hydrogenated oils. In recent years the transformation of liquid glycerides of unsaturated fatty acids into the corresponding saturated compounds which are solids, with resultant thickening or hardening of the fat containing such glycerides, has been developed on a commercial scale. Cottonseed oil is the material chiefly used in this country, and the " hydrogenation " is accomplished by heating with hydrogen in the presence of a catalytic agent, usually finely divided nickel, the process being carried to such a point as to yield a product of the appearance and consistency of lard.

Place of Fats in the Diet

Fats have more than twice the energy value of either proteins or carbohydrates in nutrition, and it has repeatedly been seen in earlier chapters that the energy values of food materials which contain a mixture of nutrients are often chiefly due to their fat content. The food fats which appear in commerce in an approximately pure state are closely similar to, if not identical with, those which have already entered into our consideration of the food values of meats, milk, grains, etc. Hence there is no occasion to question the general wholesomeness and food value of such staple food fats as butter, oleomargarine, lard, olive oil, cottonseed oil, etc., and we need only consider whether these are of equal value with each other and whether their liberal use is likely to make the total fat content of the diet excessive or the diet one-sided in any way.

Comparative digestibility of fats. The fats ordinarily used as food by man do not differ greatly in the extent to which they are absorbed from the digestive tract under normal conditions. Such differences as have been found seem to be explained by the differing hardness or melting points of the fats. If the melting point of the fat lies much above the body temperature, the fat will not become sufficiently fluid in the intestine to be readily emulsified and digested. The data shown in Table 59, determined by Munk and Arnschink, are cited by Von Noorden in this connection.

These results show good utilization and no significant differences in digestibility among fats melting at or below 43° C., while with melting points from 49° to 55° C. the losses were considerable, and with stearin melting at 60° C. much the greatest part failed of digestion. Notice, however, that the admixture of sufficient almond oil to lower the melting point a few degrees resulted in very greatly increased digestibility. Hence while stearin eaten alone is only slightly digested, yet fats containing much stearin may be digested very well, provided they also contain enough olein so that the melting point of the mixture as a whole is not much above body temperature. Since oleomargarine contains notably more stearin than butter, it was at one time thought that it might show correspondingly larger losses in digestion; but repeated experiments have shown that oleomargarine (being made so as to have about the same hardness) shows practically the same small losses in digestion as does butter. Thus in experiments by Luhrig the coefficient of digestibility was 97.86 per cent for the butter and 97.55 per cent for the oleomargarine.

Table 59. Melting Points and Digestibility of Fats

Nature of Fat	Melting Point °C.	Per cent Lost in Feces
Stearin	60	86–91
Mixture of stearin and almond oil	55	10.6
Mutton fat	50–51	9.2
Mutton fat	49	7.4
Lard	43	2.6
Bacon fat	34	2.8
Goose fat	25	2.5
Olive oil	fluid	2.3

More recently a long series of experiments to determine the digestibilities of different fats have been published by Langworthy, Holmes, and Deuel of the United States Department of Agriculture. References to the individual papers will be found at the end of this chapter and attention may be called to a summary of the results published by Langworthy in *Industrial and Engineering Chemistry* for March, 1923. Practically all of the many food fats tested showed high coefficients of digestibility.

Very rarely under ordinary normal conditions does as much as one tenth of the fat eaten escape digestion and usually the loss is only one twentieth or less.

As regards " digestibility " in the more popular sense of relating to the ease, comfort, and rapidity with which the digestive organs carry on their work, it may be said that the fats generally retard the secretion of the gastric juice and tend to make the food stay longer in the stomach. To the extent that the ease of digestion is inferred from the rapidity with which a meal passes from the stomach into the intestine the eating of fat appears to retard the process, and this is true to a greater extent the higher the melting point of the fat.

While the eating of much fat may thus prevent the digestion of food in the stomach from going forward as promptly and pleasantly as it otherwise might, it is unlikely that the fat will exert any direct effect tending toward discomfort except in the sense that if fat is overheated in cooking, it may in part be decomposed with the production of irritating substances. It should also be remembered that if foods are cooked in or with fat in such a way as to form a coating of fat over the other constituents of the food, the digestion of the proteins and carbohydrates may be retarded, since the materials which are coated with layers of fat will not be permeated readily by the saliva or the gastric juice. These latter possibilities of unfavorable action of fat are not properly chargeable to fat itself, but rather to the unintelligent way in which it is sometimes cooked.

Moreover it must be remembered that a moderate slowing of the passage of food from the stomach is not objectionable, whereas the more rapid emptying of the stomach when the food is poor in fat leads to earlier and more severe hunger, so that during the World War fat shortage was a serious hardship, even when it did not imply a deficiency of total food value.

Fat, being a very compact form of fuel, properly finds its largest place in the diet in those cases in which the energy requirement is high, as in persons doing large amounts of muscular work or exposed to severe cold. In such cases there is largely increased need for fuel without any corresponding increase in the need for protein or for other specific nutrients. Here a large part or even all of the extra energy requirement may be met by feeding practically pure fats, and it has been found that the organism, whether at hard muscular work, or only moderate exercise, is able to digest quite large amounts of fat. It is generally believed that about 200 grams (7 ounces) of fat per day is as much as the human digestive tract can safely be expected to handle to good advantage, though individual instances of satisfactory utilization of larger amounts might be cited.

In nutrition, fat can serve interchangeably with carbohydrate as fuel within fairly wide limits. The different food fats have nearly the same fuel value when in the same state of purity. Lard, olive oil, cottonseed oil, etc., are practically 100 per cent fat and have energy values of about 4000 Calories per pound, while butter, as stated above, contains a considerable percentage of water and salt, and shows usually 80 to 85 per cent of fat with about 3300 to 3500 Calories per pound.

But it is now well understood that the nutritive value of a commercial fat depends not simply upon the number of Calories it furnishes, but also upon whether and to what extent it furnishes fat-soluble vitamin also.

Fat-soluble vitamin. Butter occupies a unique position among the food fats because of its richness in vitamin A. The concentration of vitamin A in butter fat has been found to be somewhat variable, depending to some extent certainly upon the food of the cow and possibly also upon the manner in which the butter is made and stored. It is only very recently that quantitative comparisons of vitamin A content have been possible and therefore neither the causes nor the extent of the variations among different samples of butter have been at all fully worked out as yet. It appears, however, safe to say that none of the butter substitutes approaches good butter in vitamin value and that butter, even when of poor quality, is likely to be much richer in vitamin than any other commercial form of food fat. Any substitution of other fats for butter fat in food is therefore a dubious economy, since it tends to lower the fat-soluble vitamin content of the dietary. In view of the very great importance of a liberal intake of fat-soluble vitamin to health and vigor, and the fact that so many of our staple foods are poor in this vitamin, any tendency to lower it still further should be resisted, and care should be taken to increase it whenever it is practicable to do so. The liberal use of butter, cream, milk, and ice cream is, therefore, to be encouraged.

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CHAPTER XI

SUGARS, SIRUPS, AND CONFECTIONERY

The Cane Sugar Industry

CANE sugar or sucrose, $C_{12}H_{22}O_{11}$, occurs widely distributed in the vegetable kingdom. It is found in the fruits and juices of many plants, usually mixed with more or less of the simpler sugars, glucose (dextrose), and fructose (levulose). The separation of the sucrose is commercially profitable only in the case of a plant whose juice is relatively rich in this sugar and contains but small proportions of other substances. Only two plants, the sugar cane and the sugar beet, play an important part in the world's supply of sugar. The manufacture of sugar from the juices of the maple tree and of the palm tree are relatively small industries whose products enter but little into the world's sugar trade. We shall therefore confine our study of the technology of the industry to the manufacture of sugar from the cane or the beet. The accounts which follow are very largely based upon lectures delivered at Columbia University by Dr. C. A. Browne and Dr. W. D. Horne.

Production of raw sugar from sugar cane.[1] The sugar cane, which is the oldest and best known sugar-producing plant, grows only in tropical and semitropical countries; it resembles in many ways the Indian corn, producing a jointed stalk varying from 6 to 12 feet or even more in length. The native home of the cane is India, and it is mentioned frequently in the old sacred books of the Hindoos and in ancient Chinese writings centuries

[1] Browne, *School of Mines Quarterly*, April, 1911, and January, 1913.

FIG. 34. — Sugar cane ready for harvest (American Photo Co., Havana).

before Christ. The Greek soldiers of Alexander the Great saw the sugar cane growing in India at the time of his conquest, and brought back stories of the wonderful reed which yielded a juice sweeter than honey. The Persians and Arabs carried the cultivation of the sugar cane westward, and we find that sugar was both grown and refined in the valleys of the Tigris and Euphrates in the tenth century A.D. The Crusaders found sugar cane and sugar factories in Syria and Palestine, and brought back samples of the product upon their return from the East. The Saracens introduced the cultivation of sugar cane into Sicily and the Moors into Spain; the Spaniards in their turn carried the sugar cane with them to the New World during their voyages of discovery and colonization; and so the sugar cane was carried from its original home in India throughout the entire tropical and semitropical world.

At present the countries which lead in the production of sugar from cane are British India, Cuba, Java, and the United States, including Porto Rico, Hawaii and the Philippine Islands.

The cane is propagated by planting in plowed furrows the tops of the canes of the preceding crop. When the sprouts of young cane appear above ground, the fields are cultivated until the growth of the cane is well started or until the rainy season begins, and then left to grow for varying lengths of time depending upon the climatic conditions and custom of the locality. In Louisiana the whole period of growth is considerably less than a year; in Hawaii the cane is often allowed to grow for practically two years.

The sugar cane, when the crop is ready, is harvested by cutting off the stalk as close to the ground as possible, trimming off the green tops, and stripping off the leaves (Figs. 34 and 35). These and the other agricultural operations of planting, fertilizing, and cultivating require a large amount of labor, the expense for which makes up about three fourths of the cost of the raw sugar, the remaining one fourth being due to the expense of manufacture.

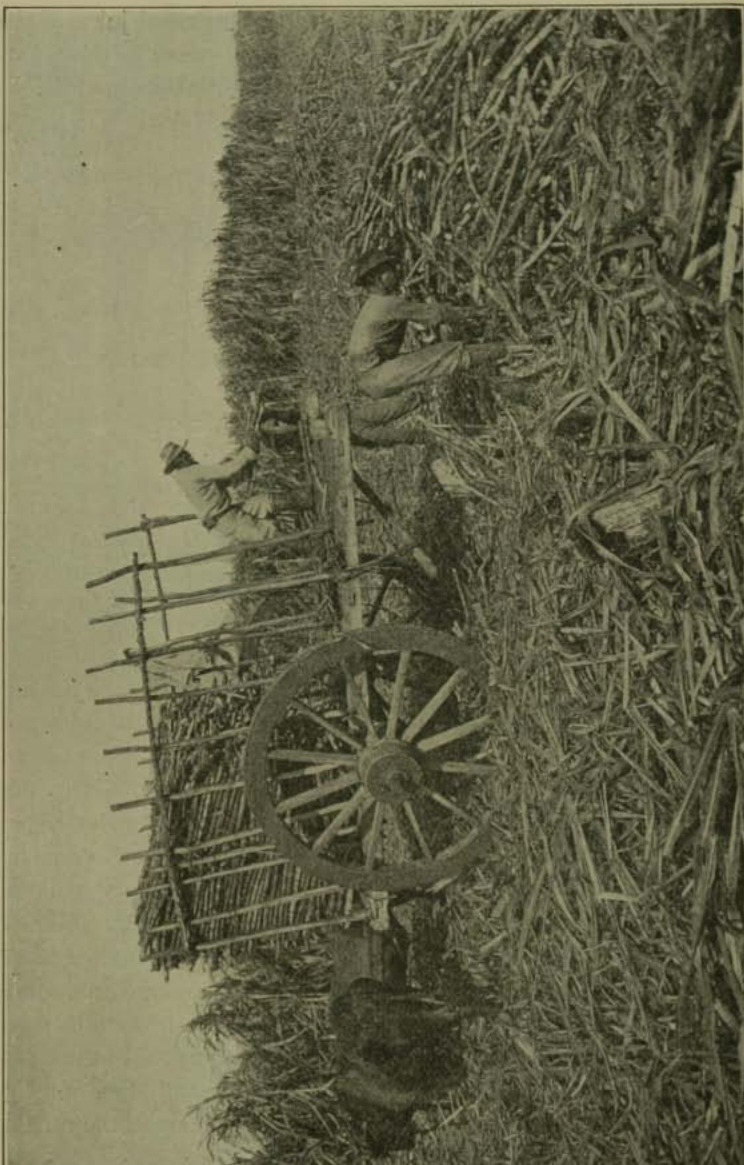

FIG. 35. — Harvesting sugar cane (American Photo Co., Havana).

The composition of the stalks and the expressed juice of the sugar cane vary considerably. The general range of the different constituents, as compiled from analyses made in different countries is given in the following table (Table 60):

TABLE 60. COMPOSITION OF SUGAR CANE AND ITS JUICE (BROWNE)

	WHOLE CANE	CANE JUICE
	Per cent	*Per cent*
Water	67–75	80–86
Dry substance	33–25	20–14
Fiber (cellulose, etc.)	10–15	
Sucrose	11–16	12–18
Invert sugar	0.5–1.5	0.5–2.0
Ash	0.5–1.0	0.4–0.8
Nitrogenous substances	0.4–0.6	0.1–0.4
Gums, acids, etc.	0.2–0.5	0.3–0.6
Wax and fat	0.4	0.2

Individual cases may show variations above or below these figures.

The sugar cane after it is hauled to the factory is first **passed through mills** to remove the juice (Fig. 36). The cane mills are of all kinds and types, and range from the crude ox-driven mills employed in the Philippines and other primitive countries to the high-power, steam-driven hydraulic nine- and twelve-roller mills employed in Cuba, Java, Hawaii, Porto Rico, Louisiana, and other countries where the most modern machinery is used. In the best-equipped factories the cane is delivered by an endless carrier to huge corrugated crushers, which reduce the stalks to a thick blanket of pulpy fiber, removing at the same time some 50 per cent to 60 per cent of the juice. The crushed stalks pass next through a mill of 3 rollers, where still more of the juice is removed; and then through a second, third, and sometimes a fourth set of such rollers, the hydraulic pressure upon the rollers

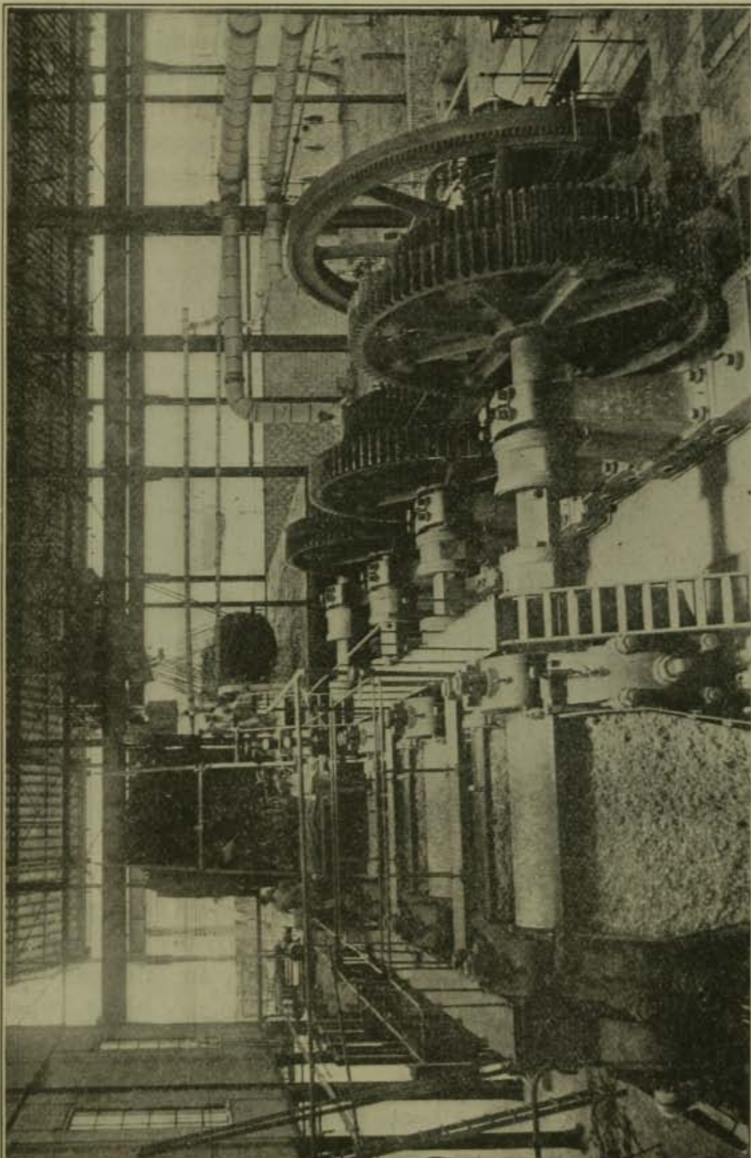

FIG. 36. — Cane mill with corrugated crusher and three sets of rolls (American Photo Co., Havana).

being increased at each mill in order to remove more and more of the juice. It is also customary to wet the pulp with a thin spray of water between the sets of rollers, the water thus soaked up facilitating the removal of the residual sugar by the succeeding roller. This process of wetting, or maceration, as it is called, is highly important, but requires to be carefully controlled; the water added must, of course, be afterwards evaporated, and the question which the chemist must decide is when the cost of evaporation begins to exceed the value of the extra sugar recovered. The quantity of water used for wetting the fiber is usually about 15 per cent, *i.e.* 15 parts of water per 100 parts of normal undiluted juice, although 25 per cent and more is sometimes used. With 15 per cent maceration about 90 per cent of the sugar in the cane is extracted in the juice; with 25 per cent maceration over 95 per cent of the sugar may be extracted. The residue of cane fiber as it leaves the last mill contains about 45 to 50 per cent moisture and from 3 to 5 per cent sugar, *i.e.* from 5 to 10 per cent of the original sugar in the cane. This residue of fiber is called "bagasse" and is burned under the boilers; it constitutes the chief, and in some countries the only, supply of fuel for operating the sugar factory.

The polarization[1] *and "purity" of the raw juice* are the first important factors to be determined in the chemical control of a cane sugar factory. The "polarization" of the juice will give the approximate sugar content; the dissolved solids in the juice are estimated by means of a floating hydrometer called a Brix spindle. The polarization of the juice multiplied by 100 and divided by the reading of the Brix spindle gives the "purity" of the juice. Good cane juices run over 90 per cent purity, juices running from 85 to 90 per cent purity are fair, and from 80 to 85 per cent medium. Juices with a purity below 80 per cent are poor and very unsatisfactory to work.

[1] The term "polarization" implies the estimation of sugar by means of the polariscope; see, for example, *Methods of Organic Analysis*, Revised Edition, pages 79–100.

The second step in the manufacture of cane sugar is the **clarification** or purification of the raw juice. The best clarifying agent and the one that has been used from time immemorial is lime.

Many methods of using lime are practiced, only one of which need be described here. Cane juice as it comes from the mill

FIG. 37. — Clarifying cane juice (American Photo Co., Havana).

is slightly acid. One method of clarification is to neutralize this free acid of the juice by adding lime to slight alkalinity, and then to heat to boiling (Fig. 37). The lime combines with the organic acids and phosphoric acid of the juice, and the heat coagulates the proteins present; a thick scum of impurities rises to the surface, which is skimmed off, and the hot juice is run into settling tanks, when the suspended impurities settle out, or, more often, the juice is passed through filter presses (Fig. 38), and the impurities removed in this way. The residue of impurities, called "filter press cake," contains the phosphates and nitrogenous matters of the juice and is returned to the canefields as a fertilizer.

In many factories the cane juice is sulphured before liming; sulphur dioxide, produced by burning sulphur, is led into the

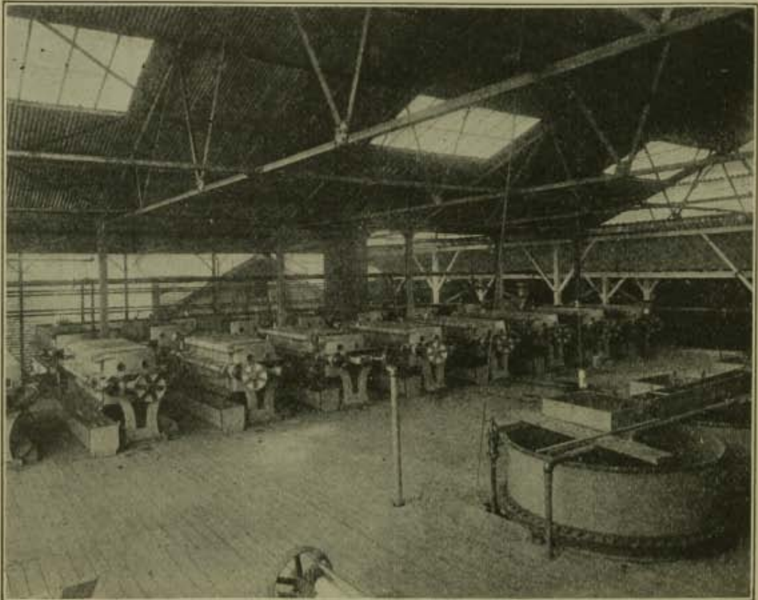

FIG. 38. — Filter presses in sugar factory (American Photo Co., Havana).

juice to a certain point of acidity; the free acid is then neutralized with lime and the juice heated as first described. The sulphurous acid has a favorable bleaching effect upon the juice, and the mechanical separation of the impurities is greatly facilitated by its action. Objections against its employment are the increase in scale (mostly calcium sulphate) which forms upon the tubes of the evaporators and the contamination of the molasses with sulphites. In some factories phosphoric acid is used with the lime.

In some countries, notably in Java, lime is added to the juice to strong alkalinity and the excess of lime then removed by means of carbon dioxide. This process of clarification, called carbonatation, is the only one used in beet sugar manufacture. It works well with cane juices when but little invert sugar is present. If the latter occurs in large amounts, the lime forms dark-colored soluble compounds, which not only give a dark colored sugar but interfere seriously with the work of evaporation and crystallization. Such juices are said to be lime-burnt. The tendency at present in cane sugar manufacture is against carbonatation and all other methods of strongly alkaline clarification.

The third process in the manufacture of cane sugar is that of **evaporation.** In primitive countries and out-of-the-way plantations evaporation is carried out over the direct fire in open pans or kettles. The juice is either boiled down in one single kettle or passed through a train of pans. When crystallization of the sugar has begun, great care must be exercised that the mass be kept in constant motion; otherwise there will be burning and caramelization next to the surface of the evaporator. Such caramelization is in fact unavoidable, and all open-kettle sugars are characterized by a dark color and by an agreeable aromatic taste which is preferred by many to that of the pure refined sugars. In some countries the cane juice, after evaporating to a thick, pasty mass, is allowed to cool and solidify, just as molasses candy hardens after cooling. This solidified mass is called *concrete sugar* and is ground up in mills and marketed as a coarse lumpy sugar of very uneven composition. This concrete sugar contains of course all the molasses with the soluble impurities of the juice.

In other primitive countries, especially in parts of South

America, the juice is not evaporated to concrete, but only to the consistency of a thick mush; this mush is run into hogsheads having a fine perforated bottom through which the molasses, or mother liquor surrounding the crystals of sugar, percolates. When as much as possible of the molasses has drained away, the residue of sugar is removed and sold as *muscovado* sugar. This is purer than concrete sugar and polarizes sometimes as high as 92 per cent. It is usually quite moist and for this reason very liable to deteriorate.

In the open-kettle process of evaporation there is always considerable loss of sugar due to caramelization and inversion caused by the high temperature of heating, which may be from 20° to 30° F. above the boiling point of water. To avoid these losses all modern sugar factories employ **vacuum evaporators**, which allow evaporation to proceed at a temperature much below the boiling point of water and at the same time permit the utilization of waste steam from the exhaust of the engines and other points about the factory. Vacuum evaporators are manufactured in many different forms, and are arranged usually in a series of 2, 3, or 4, sometimes even as high as 5 or 6, the combination being called double, triple, quadruple, quintuple, or sextuple effects. In the first vessel of an effect, a lower vacuum is maintained than in the second, a lower in the second than in the third, and so on, the temperature of boiling for each succeeding vessel is thus progressively reduced. Figure 39 shows the general arrangement of a triple effect. The steam which is evaporated from the juice in the first vessel (or "body") goes to heat the coils of the second, the steam from the second vessel goes to heat the coils of the third, the reduction in temperature of the steam for each vessel being of course counterbalanced by the greater vacuum and lower temperatures necessary for boiling. With a long series of vessels, as in a quadruple, quintuple, or sextuple effect, the thin juice in the first body may be boiled under atmospheric pressure or even at a few pounds above this;

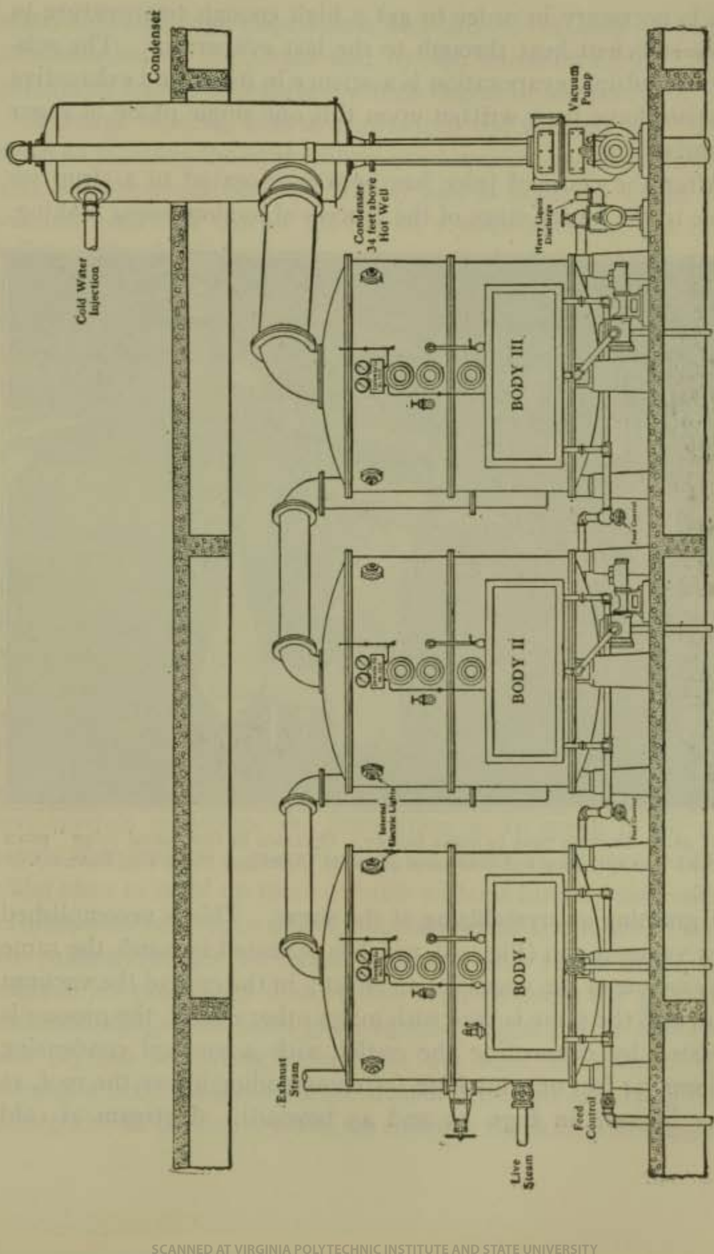

FIG. 39. — Arrangement of triple effect. Zaremba evaporators.

this is necessary in order to get a high enough temperature to carry sufficient heat through to the last evaporator. The subject of multiple evaporation is a science in itself, and exhaustive treatises have been written upon this one single phase of sugar manufacture.

After the clarified juice has been evaporated to a sirup we come to the fourth stage of the process of modern sugar making,

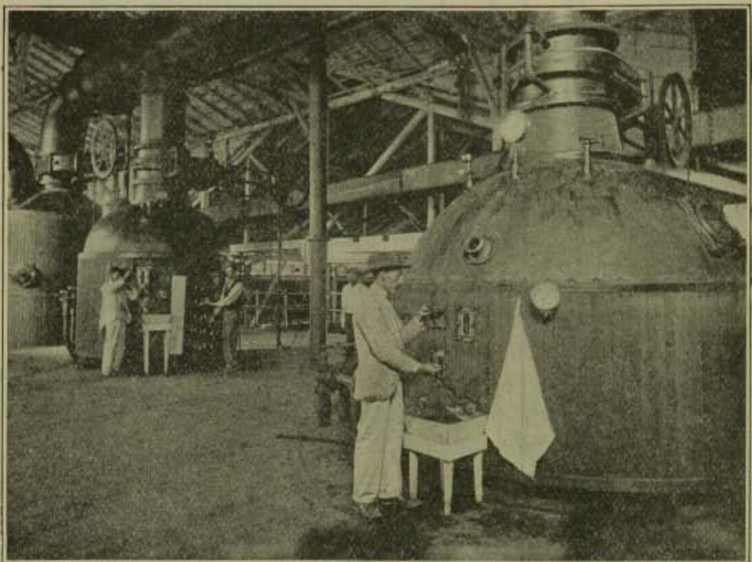

FIG. 40. — Vacuum pans in sugar factory. Operator in foreground using "proof stick" to withdraw test portion of contents (American Photo Co., Havana).

the **graining** or **crystallizing** of the sugar. This is accomplished in a vacuum pan (Fig. 40), which is operated in much the same way as one of the vessels of an effect; in the case of the vacuum pan, and the same is true with many other effects, the process is assisted by connecting the outlet with a vertical condensing column 34 feet or more high (often extending above the roof, as may be seen in Figs. 42 and 43 beyond). A stream of cold water flows through the column, and this serves, both by rapid condensation of the steam and by the barometric pull of its column of liquid, to maintain a high degree of vacuum.

A charge of sirup is first drawn into the vacuum pan; this sirup as it leaves the evaporators has a specific gravity of about 1.25 (or about 50 per cent solids) and is boiled down in the vacuum pan to a specific gravity of 1.50 or about 90 per cent solids. The ebullition in the vacuum pan is violent, and unless the sugar boiler is careful some of the sirup may be carried over with the vapor into the condenser. This is called *entrainment* and is a source of frequent losses in sugar manufacture. In all modern sugar factories the chemist makes constant examination of the condensation water, so that any loss due to this cause may be promptly detected and stopped.

The handling of the vacuum pan requires more skill than any other operation of the sugar house; care must be taken to avoid entrainment and care must be taken to build up crystals of uniform grain or size. The usual practice is to boil down the first charge of sirup to what is called "string proof," *i.e.* to the point when a few drops of sirup withdrawn from the pan will draw out between the fingers in fine strings or threads. When this point is reached, a large charge of fresh cold sirup is drawn into the pan, the sudden cooling of the supersaturated contents starting the formation of innumerable fine crystals. These first crystals constitute the foundation so to speak of all the sugars obtained in a given boiling or strike of the pan. The boiler aims to build up these crystals without forming new ones; he aims from now on to avoid supersaturation and to avoid sudden chilling through drawing in too much sirup at one time. He controls his process by drawing out samples every few minutes and examining these upon glass against a light; if he sees fine new crystals appearing among the old ones, he reduces the vacuum a little, thus raising the temperature and dissolving this false grain, as the fine crystals are called. By skillful manipulation, which comes only with long practice and experience, the sugar boiler is able to build up his crystals to any desired size. The usual practice is a crystal about the size of ordinary granulated sugar; in certain localities, however, a large crystal is favored; as, for example, in Peru, where the sugar is boiled slowly and for a long time, thus building up a very large grain. The

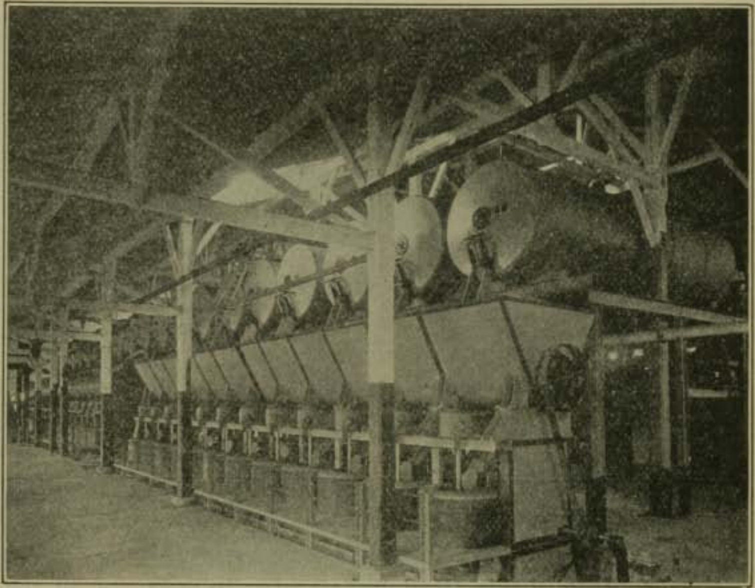

FIG. 41. — Horizontal cylindrical crystallizers with mixing tank and centrifugals beneath (American Photo Co., Havana).

attachment for withdrawing samples of sirup from the vacuum pan is called the "proof stick."

When the vacuum pan is filled with a thick magma of sugar crystals, of about the consistency of mortar, the steam is shut off, air is admitted, the bottom of the pan opened, and the entire contents dumped into a mixer, which keeps the mass in slow movement by means of revolving arms. This mixer is situated over a row of centrifugal machines; the mass of crystals (sometimes called *masse cuite* from the French, or *Füllmass* from the German) is drawn off gradually in successive charges into the centrifugals. The inner walls of the latter are lined with fine brass meshing, and as the drums are rotated the masse cuite is whirled against the meshing, which retains the sugar but allows the molasses to pass through. After spinning for a few minutes until as much of the molasses is removed as possible, the revolving mass of sugar may be sprayed with a fine spray of water or a jet of steam in order to remove more of the film of molasses which remains adhering to the crystals; the amount of spraying depends upon the whiteness of sugar desired. In Louisiana a very pure, white sugar is made by spraying with several sprinklings of water; such sugar is over 99 per cent pure sucrose, the remainder being mostly moisture. In Cuba and Porto Rico they aim to make a 96 per cent sugar. In Hawaii and Java a sugar testing about 97 per cent is desired. Spraying will, of course, dissolve some of the sugar, so that the process is one which must be carefully controlled.

When the molasses has been removed as completely as possible, the centrifugals are stopped and the sugar emptied through the bottom of the drum into a conveyor, by which it is carried to the bagging department, where it is prepared for shipment. The raw sugar from the centrifugal contains considerable moisture, and in some countries the sugar is dried in revolving drums before being bagged. This drying is advantageous for two reasons: first, the excess moisture is removed, thus saving the cost of transporting water; and, second, the sugar is sterilized and protected against the attacks of ferments and bacteria. The drying of raw sugar is not practiced in Cuba, Porto Rico, or Louisiana, but is carried out in Java and the Hawaiian Islands, where the sugar has to be shipped long distances for refining. The storage of undried raw sugar for long periods of time is a risky operation, as many speculators in sugar have found to their cost.

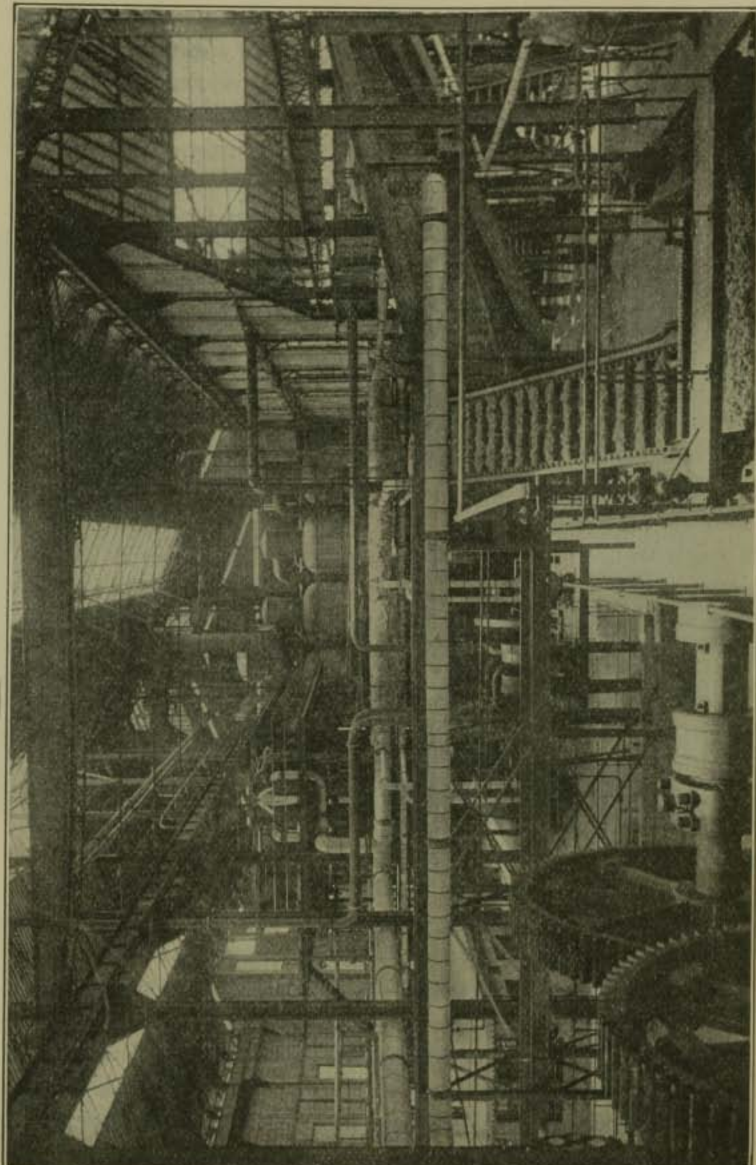

Fig. 42. — View in a sugar factory showing multiple evaporators in the background (American Photo Co., Havana).

The sugar which is made from the pure juice of the cane is called "first sugar" and the molasses drained from this sugar is called "first molasses." The latter still contains a large amount of sucrose, and various processes are used to recover as much of this as will crystallize. The first molasses is sometimes boiled down again in the vacuum pan and a second crop of sugar crystals obtained; this is the second sugar and the molasses obtained from this the second molasses. The second molasses may be boiled over again and a third sugar obtained, the molasses from which is the third or final molasses. Of course, as the sugar is removed the impurities become more and more concentrated in the molasses, until finally a thick, stringy mass is obtained which will no longer crystallize. Such a molasses may still contain, however, 30 per cent sucrose; there is also present about 30 per cent invert sugar, 8 to 10 per cent of ash, and 8 to 10 per cent of gums, organic acids, amino compounds, etc.

The tendency of modern methods in cane sugar manufacture is against the repeated boiling of molasses, and the aim is to get as much sugar as possible in one operation. Many processes have been devised to attain this end. One method is to take the molasses from the first strike of sugar, draw this into the vacuum pan with the sirup for the succeeding strike, and boil the two down together. The masse cuite from this mixture is then run while still hot into large tanks, called *crystallizers* (Fig. 41), where it is kept in slow motion by means of revolving arms. As the mass cools and thickens more molasses is drawn to keep the proper degree of fluidity. When no more sugar will crystallize, as determined by analysis of samples, the contents of the crystallizer are spun out in centrifugals and the molasses withdrawn from the factory.

Several of the features above described are shown in Fig. 42. In the foreground at the left are the large wheels of the cane mill; at the right is the conveyor which carries away the bagasse. In the background a multiple-effect evaporator may be seen at the center, while slightly to the left is the condensing column, which extends through the roof. At the top of each of the condensing columns of the factory in which these photographs were taken is a small covered platform easily seen above the roofs in Fig. 43.

Sugar Refining[1]

The process of manufacture described above yields "raw sugar," which is usually from 95 to 98 per cent pure. The removal of the remaining impurities constitutes the "refining" of the sugar and is usually carried on in places where fuel is more abundant than in the tropical countries where the sugar cane is chiefly cultivated, since about 25 pounds of coal are consumed in refining 100 pounds of sugar. The difference in price between raw and refined sugar is usually 0.7 to 0.9 cent per pound and the cost of refining is estimated at 0.6 to 0.65 cent per pound, leaving a margin of profit so small that it is necessary for the operation to be conducted on a large scale in order to make it remunerative. In the United States the industry is carried on in a relatively small number of large establishments in or near the principal ports on the Atlantic and Pacific coasts.

Nearly all of the three million tons of sugar brought into the United States annually is refined in about 20 establishments. Thus the average output of the refineries now in operation is about 1,000,000 pounds of sugar per day each, some establishments having a much larger output than this.

In principle the refining process consists in washing off as much as is practicable of the molasses which adheres to the crystals of raw sugar, then dissolving the crystals, purifying and decolorizing the solution as thoroughly as possible, and recovering the sugar in a purified state by recrystallization. While the process is simple in principle, the large scale upon

[1] Horne, *School of Mines Quarterly*, April, 1911.

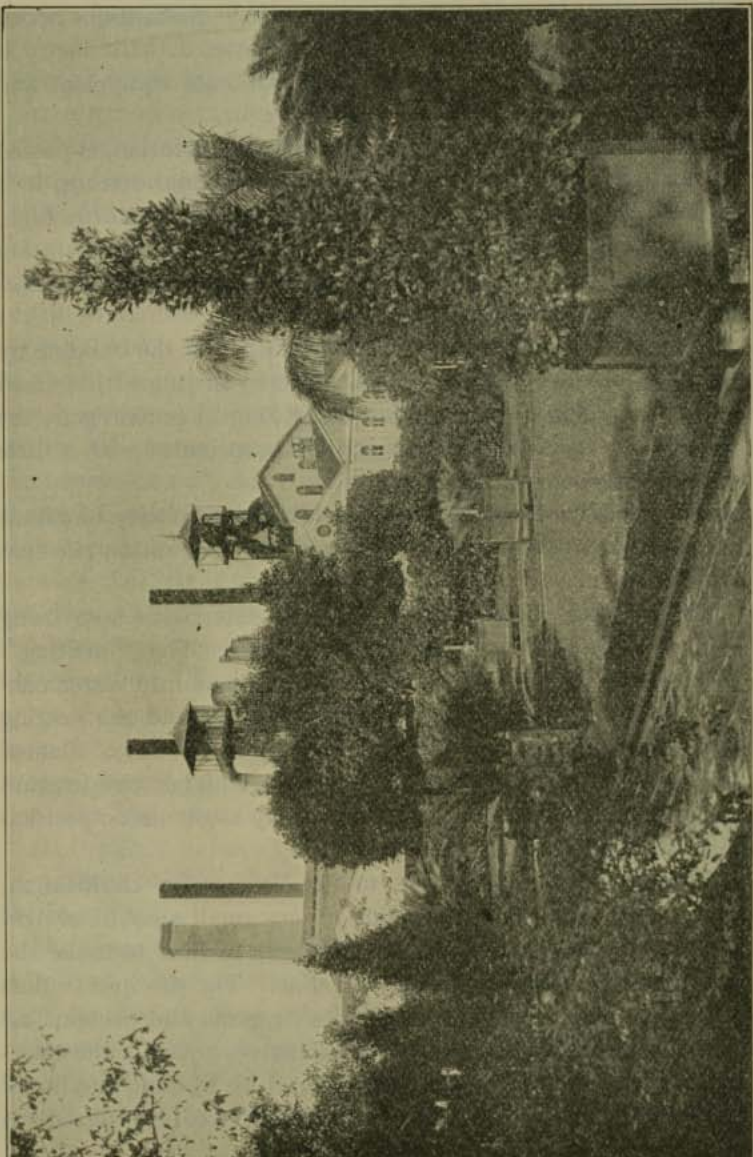

FIG. 43. — Sugar factory showing tops of condensing columns (American Photo Co., Havana).

which it must be carried out and the extreme precautions necessary to guard against apparently small losses if the industry is to be economically successful require elaborate equipment and constant chemical control.

As the sugar, either in granular form or in solution, is passed through a number of operations in a continuous stream, it is found advantageous to build the refineries several stories high, so that after the first lifting of the material its transportation from place to place for the successive steps of the processes may be effected chiefly by gravity.

The raw sugar is usually carried to the top of the building by means of a bucket elevator and **washed** by mixing with a small amount of sugar sirup and then separating in centrifugals, the sugar in the centrifugal being sometimes sprinkled with a little water for further purification.

After this washing the sugar usually has a purity of about 99, *i.e.* of the total solids in the moist sugar about 99 per cent is sucrose.

The sugar is then dissolved in hot water, this step being technically known as **melting** the sugar. The "melting" process is accomplished by running the sugar into water contained in steam-heated pans, the proportions and the heating being so regulated as to obtain a solution of 28° to 30° Baumé and a temperature of 150° to 170° F. A higher temperature might result in darkening the solution by slight decomposition of some of its constituents.

The hot solution then goes to the *blowups* for **clarification**, which is accomplished by adding a very small amount of acid calcium phosphate and then enough milk of lime to make the mixture neutral or very faintly alkaline. The precipitate thus formed carries down such impurities as gums and proteins, as well as suspended particles, and also removes a part of the coloring matter. The precipitate is removed by running the liquid through **Taylor filters**, which consist of twilled cotton bags about six feet long encased in strong, coarse-meshed hempen sheaths. A single filter box may contain 400 or more of these bags, each attached to the filter head by means of a metal bell and socket.

An alternative method is to mix the liquid with diatomaceous or infusorial earth (" kieselguhr," " celite ") and then filter by means of a filter press, usually of the " shell plate " type.

The filtrate from the bags is clear but not colorless. Most of the color is removed from this filtrate by passing it through **boneblack filters**. These are large, strong iron cylinders, often 10 feet in diameter and 20 to 30 feet high, filled with boneblack through which the sugar solution flows very slowly, usually at about the rate of one foot per hour. On account of the immense amounts of boneblack required in a modern refinery, this part of the process requires very careful control in order to use the boneblack or " char " as economically as possible. Freshly charred boneblack removes the color from the sugar solution almost completely, but with accumulation of impurities in the pores of the char it naturally becomes less effective until finally the filtrate shows so much color that it must be re-treated and the boneblack must be washed and sent to the " char house " for reburning. Every reburning or " revivifying " leaves the pores of the boneblack somewhat clogged by the added carbon from the absorbed impurities, so that after 10 or 12 reburnings it is no longer economical to use. In the Weinrich oxidizing revivifier the reburning is carried out with a limited supply of air designed to burn out the carbon of the impurities but not that of the original char, and thus to prolong the usefulness of the boneblack.

The sugar solution which has passed the boneblack filter, and is both clear and practically colorless, is **evaporated** in vacuum pans of 1000 to 2000 cubic feet capacity, wherein the sugar solution is " boiled to grain " and concentrated to a low water content. In order to accomplish this satisfactorily a vacuum is first created in the pan, some sugar solution admitted, and steam then passed through the heating coils and the solution concentrated until supersaturated. The exact point to which the concentration should be carried is determined by an experienced workman, who withdraws samples from the pan by means of a "proof stick," which is a long brass rod sliding through an air-tight fitting in the side of the pan and carrying a cup-like depression by means of which a small sample of the liquid in the pan can be removed without disturbing the vacuum. The test portion thus withdrawn from the pan is examined by drawing between the thumb and finger, and when the exact degree of viscosity necessary to insure the immediate production of "grain" is found, more of the sugar solution is admitted to the pan, thus chilling its contents and starting the crystallization, which is then continued as in the corresponding operation of raw sugar production described above, until the pan is charged with a magma of crystals and mother liquor, which is then dropped into the *mixer* on the floor below.

In the **mixer** or **crystallizer** the mass is thoroughly stirred while cooling and is then allowed to fall into the centrifugals, where the mother liquor, usually known as *refinery sirup* rather than molasses, is thrown out through the perforated walls of the rotating drum, leaving the mass of crystals, which is sprayed lightly with water for the further removal of the sirup, and usually with a solution of ultramarine or "permitted" blue dyestuff in order to offset the tendency toward a slightly yellowish color due to the very minute trace of mother liquor which still adheres to the crystals.

The washed sugar from the centrifugals is either barreled directly as "confectioner's sugar," pressed into cubical or domino form, or sent to the **granulator** to be made into the ordinary granulated sugar of commerce.

The granulator is a long inclined revolving cylinder heated by a current of hot air and provided with paddles to keep the sugar stirred and screens to separate the crystals into standard sizes. After granulation and sifting the sugar is barreled and sent into commerce.

The Beet Sugar Industry

About the middle of the eighteenth century Margraf succeeded in separating about 6 per cent of sugar from beets, and later (1769) Archard in Austria established the first beet sugar factory; but the beet sugar industry first became of commercial importance when the European supply of imported sugar was shut off by the blockade established during the Napoleonic war. The industry is commonly considered as dating from about 1810.

At about this same time the polariscope was developed into a practicable apparatus for determining sugar, and it became possible to test individual sugar beets, and plant for seed the ones of highest sugar content. By breeding systematically with constant chemical control the average sugar content of the beet has been more than doubled, beets showing 16 to 18 per cent of sugar being now not uncommon, while in some cases from 20 to 24 per cent of sugar has been found. The sugar beet thrives in temperate climates. For the year 1912–1913 the countries showing largest production of sugar from beets were (in order): (1) Germany, (2) Austria, (3) Russia, (4) France, (5) the United States.

Beets of medium size are usually of better quality than large ones. The average composition of the sugar beet and its juice is given by Browne as follows (Table 61).

It will be noted that there is more water and less fiber in the sugar beet than in the sugar cane; there is also more ash (or salts) and more nitrogenous matter, but much less invert sugar, in the beet than in the cane. These differences in composition have an important bearing upon the differences in process of manufacture.

Table 61. Composition of Sugar Beet and Its Juice (Browne)

	Sugar Beet	Sugar Beet Juice
	Per cent	*Per cent*
Water	75–85	78–84
Dry substance	15–25	16–22
Fiber (cellulose, etc.)	4–6	
Sucrose	12–16	13–17
Invert sugar	0.0–0.3	0.0–0.3
Ash (salts)	0.8–1.5	0.6–1.0
Nitrogenous substances	1.5–2.5	0.8–1.5
Gums, acids, etc.	0.4–0.8	0.3–0.6
Wax, fat, etc.	0.2	

The beets, after they are dug and have had their green tops removed, are hauled to the factory; they are first washed to remove adhering dirt and then passed over knives, which reduce them to fine slicings or chips.

The fine slicings are next carried by a conveyor to the diffusion battery, which consists of a series of tall, boiler-shaped cylinders called cells. These cells are connected by pipes, the outlet from the top of one cell passing downward into the bottom of the next and so on around. Each cell is filled with beet slicings through a manhole at the top and when full is tightly closed with a cover which is clamped into place. Twelve cells connected in series usually constitute a battery, and when they are filled, warm water of about 80° C. is passed through the system. The water circulating upwards through each cell removes the sugar from the beet slicings and becomes richer and richer in sugar with each succeeding cell. Heaters are placed between the cells, so that the circulating water is kept always at the right temperature. When the water has made a complete circuit through the cells of the battery, the slicings in the first cell are practically exhausted; this cell is then thrown out of circulation, emptied of exhausted chips, refilled with fresh slicings, and reconnected with the system, while the second cell undergoes replenishing. The process is thus a continuous one; 10 cells are always in circulation, while one is always being emptied and one always being refilled.

The exhausted slicings from the diffusion cells are dried by the heat of the flue gases from the boilers and are then sold as a cattle food.

The diffusion juice as it leaves the last cell of the battery contains from 12 to 15 per cent sugar and is ready for clarification. The juice is first treated with a considerable excess of lime, and the dissolved lime precipitated by leading in a stream of carbon dioxide. This process is called "carbonatation."

After the first treatment with lime and carbon dioxide the precipitated calcium carbonate and other impurities are filtered off in filter presses and the juice subjected to a second carbonatation.

The juice from the second carbonatation is again filtered, when it is evaporated, grained, and centrifugaled, these processes being carried out essentially as described for cane juice.

There is a great difference in the physical properties of raw cane sugar and raw beet sugar. Raw cane sugar has usually a fragrant odor and a pleasant taste which many prefer to the refined product, while raw beet sugar has a bitter and nauseating taste and an odor suggestive of glue.

In this country beet sugar is usually refined in the same factories in which it is extracted from the beets.

The question is frequently raised whether cane and beet sugars are strictly identical. The answer depends upon the way in which the question is understood. The sugar in each case is sucrose, and if this were rendered absolutely pure, it would be the same whether derived from beet or cane. But absolute purity is not quite attained in the refining process. According to Prinsen-Geerlings, "All white cane sugars contain traces of reducing sugars," while beet sugars do not. This may result in a difference in the products obtained from cane *versus* beet sugars in making, for example, some kinds of confectionery.

Development and Extent of the Sugar Industry as a Whole

In the above outlines of the production of sugar from cane and from beets the development of these industries has been briefly mentioned. Speaking generally, the beet sugar industry has been developed more quickly and more scientifically, but on a less strictly self-supporting basis. Until 1810 there was no beet sugar industry, and in 1852, of the world's supply, the cane furnished six times as much sugar as the beet; but under the application of strict scientific control, often combined with fostering legislation, the beet sugar industry developed until, in 1884, the production of sugar from the two sources was about equal. By 1899 almost twice as much sugar was made from beets as from cane, largely, however, because the sugar industry in Cuba had been almost extinguished by war. After the restoration of peace in Cuba modern methods were introduced into the cane sugar industry there, as was already being done in Hawaii, Java, and other cane-growing countries. In 1907 the production of sugar from beets and from cane was again about equal. The world's production for the year 1912–1913 was estimated at 18,144,638 tons, of which 9,178,574 tons were attributed to the cane and 8,968,064 tons to the beet. The production of each of the ten leading countries for the same year is given by Browne as follows:

(1)	Germany	2,700,913 tons		(beet)
(2)	British India	2,583,600 tons		(cane)
(3)	Cuba	2,428,537 tons		(cane)
(4)	Austria	1,901,615 tons		(beet)
(5)	United States and its colonies	1,770,837 tons	1,146,773	(cane)
			624,064	(beet)
(6)	Russia	1,374,500 tons		(beet)
(7)	Java	1,331,180 tons		(cane)
(8)	France	960,900 tons		(beet)
(9)	Holland	316,177 tons		(beet)
(10)	Belgium	298,584 tons		(beet)

Of the sugar attributed to the "United States and its colonies" somewhat more than half was produced in Hawaii, Porto Rico, and the Philippines, and somewhat less than half (about 800,000 tons) in the continental United States.

War conditions rendered abnormal the data for the years 1914 and following.

Molasses, Sirups, Honey

Molasses was formerly the mother liquor remaining after the removal of one crop of sugar crystals from the boiled-down juice of the sugar cane. Since the removal of cane sugar by one crystallization is far from complete, the molasses thus obtained was rich in sucrose and contained also much the greater part of the other constituents of the cane juice. Atwater and Bryant, in 1896, report the average of (12) American analyses published before that date as follows:

	Per cent
Water	25.7
"Protein" (Nitrogen × 6.25)	2.7
Carbohydrates	68.0
Ash	3.6

The introduction of modern methods into sugar-house practice has tended steadily to remove the sucrose more and more completely, with the result that the amount of molasses is decreased, its sugar content is lowered, and its content of impurities is increased. The term "impurities" is somewhat misleading, since the constituents other than sucrose which cane juice naturally contains are unquestionably of food value; in fact, the molasses is a much less one-sided food than the sugar removed from it. When, however, the ash constituents and amids (or other "nitrogenous extractives") of the cane juice are concentrated to such an extent as in the final molasses of a modern raw sugar factory, the product is too strong in flavor to be attractive as human food, and may contain such a high concentration of salts as to throw doubt upon its wholesomeness when eaten in any considerable quantity. To illustrate the difference in composition between molasses from successive crystallizations of sugar Wiley gives the following typical analyses of "first," "second," and "third" molasses, the composition being reduced to a uniform basis of water content:

TABLE 62. COMPOSITION OF FIRST, SECOND, AND THIRD MOLASSES (WILEY)

	FIRST MOLASSES	SECOND MOLASSES	THIRD MOLASSES
	Per cent	*Per cent*	*Per cent*
Water	20.00	20.00	20.00
Sucrose (cane sugar)	53.60	41.70	31.70
Dextrose (glucose)	8.76	12.20	15.00
Levulose (fructose)	8.00	12.50	16.50
Acids and gums	4.50	6.50	8.20
Proteins	0.20	0.25	0.30
Amids	0.94	1.50	2.00
Ash	4.00	5.35	6.30

According to the definitions and standards of the Association of Official Agricultural Chemists: *Molasses* is the product left after separating the sugar from masse cuite, melada, mush sugar, or concrete, and contains not more than 25 per cent of water and not more than 5 per cent of ash.

This standard would practically confine the term "molasses" as a commercial designation for human food to material of the nature of the "first molasses" of modern sugar manufacture.

Refiner's sirup is, as already explained, the "mother liquor" or residual liquid product obtained in the process of refining raw sugar.

This product is also called "sugar refinery molasses" and sometimes "sugar-house molasses." The latter expression is ambiguous since the term "sugar house" is more commonly applied to the raw sugar factory than to the refinery.

Mixed sirups. Refiner's sirup contains the coloring and flavoring substances which distinguish the brown or yellow raw cane sugar from the white refined sugar (which latter, as it appears in commerce, may have been made either from the cane or the beet).

The characteristic flavor of the raw cane sugar which is thus left in the sirup in the refining process is preferred by many people to the mere sweetness of sucrose or glucose. Hence refiner's sirup is in demand for mixing with commercial glucose sirup (made from corn, as described in Chapter VIII) for the production of "corn sirup with cane flavor."

Other mixed sirups are made from commercial glucose or corn sirup with refined cane sugar sirup (the product in this case being practically colorless), with sorghum sirup made by boiling down the juice of the sorghum cane, or with sirups made by concentrating the juice of the sugar cane without removing any of the sugar. More expensive mixed sirups are those made by mixing either glucose or sucrose sirup with maple sirup.

Maple sirup is the most highly prized of all table sirups. It is made by evaporating the sap of the sugar maple to such a point that the product contains only about 30 per cent of water.

Open-kettle cane sirup, made by boiling down in open vessels the juice of the sugar cane to a consistency similar to that of molasses, is said[1] to be a common article of food in the Southern States. The product contains all the sugars and ash constituents of the cane juice, and their relative proportions are changed only in so far as the sucrose is in part hydrolyzed to glucose and fructose, and in part caramelized, giving the sirup a reddish tint.

Honey. Before sugar became a common article of commerce, honey was the chief sweetening material in use. Honey consists chiefly of a mixture of sugars gathered from flowers and more or less changed by the honeybee. It is the only common

[1] Wiley's *Foods and Their Adulteration.*

food material which contains more fructose than glucose. The average of 92 analyses of normal honeys[1] shows:

	Per cent
Water	17.70
Sucrose	1.90
Fructose (levulose)	40.50
Glucose (dextrose)	34.48
Dextrin	1.51
Ash	0.18
Undetermined	3.73

In some instances genuine honey has been found to contain as high as 8 per cent of sucrose; more than that would usually be taken as an indication that the honey is either abnormal or adulterated. The differences in flavor are largely due to the characteristic esters (" ethereal " substances) found in the nectar of different flowers.

With the production of sucrose and glucose on a large scale and at a low price, honey has become relatively a luxury, and, except as prevented by legislation, has been largely adulterated with sucrose and glucose sirups. These adulterations are readily detected by chemical analysis, since genuine honey almost always contains enough fructose (levulose) to make it levo-rotatory to polarized light, whereas both sucrose and commercial glucose are dextro-rotatory. Adulteration of honey with " invert sugar," a mixture of equal parts glucose (dextrose) and fructose (levulose), obtained by hydrolysis of sucrose, is much more difficult of detection, since the main constituents of the honey and the adulterant are here the same.

Confectionery

The term "confectionery" covers a variety of products, all artificial or manufactured, consisting largely of sugar of some kind, with flavoring and usually also coloring material either added or developed by cooking processes.

[1] Browne, United States Department of Agriculture, Bureau of Chemistry, Bulletin 110.

Under the terms of the Food and Drugs Act confectionery is adulterated "if it contain terra alba, barytes, talc, chrome yellow, or other mineral substance or poisonous color or flavor, or other ingredient deleterious or detrimental to health, or any vinous, malt, or spirituous liquor or compound or narcotic drug." Since adulterated foods are illegal even if truthfully branded, the above provision amounts to a specific prohibition against the use in confectionery of any one of the substances named. In addition to these special provisions, the purity of confectionery is further protected by all the general provisions of the law against adulteration and misbranding of food, since the term "food", as used in the law, is defined as including "all articles used for food, drink, confectionery, or condiment."

Since all confections are artificial products, there is no natural guide to the establishment of any direct standards of food value, and as yet no standards other than those intended to exclude deleterious substances have been established.

Methods of making the different types of candies and other confections do not come within the scope of this work. The manufacture of the sugars, sucrose, and commercial glucose, which are the chief ingredients of confectionery, has already been discussed. Perhaps the only other ingredient which is commonly used in confectionery in sufficient quantity to have a significant bearing upon the food value of the product is chocolate.

Chocolate is made from the cocoa bean, the seed of *Theobroma cacao*, a tree native to Central America and grown only in tropical regions. The seeds are borne in large pulpy fruit, each about 10 inches long and 4 inches thick and containing 20 to 40 seeds. At the proper stage of maturity, the fruit is cut from the tree, split open, and the seeds (cocoa beans) removed. These seeds are sometimes dried at once in the sun, but for the production of a better-flavored product are commonly first allowed to undergo a fermentation process. After drying in the sun, the beans are roasted in revolving steel cylinders, after which the hulls are removed by machinery. The beans are then crushed and freed from the germs. The roasted and coarsely crushed product freed from hulls and germs is known as *cocoa nibs*. The nibs are thoroughly ground in stone mills, the material being reduced to a thin paste which on cooling sets to a hard cake. This is known as unsweetened or plain chocolate and has approximately the composition:

	Per cent
Water	3
Protein	12
Theobromine	1
Fat	50
Fiber	3
Carbohydrates (other than fiber)	28
Ash	3

About one half of the fat contained in plain chocolate can be removed by pressing.

The fat thus obtained is a soft solid at ordinary temperatures and is known as *cocoa butter*.

The following definitions and standards for cacao products were adopted by the Joint Committee on Definitions and Standards, September 29, 1922, and were approved by the Association of American Dairy, Food and Drug Officials, October 5, 1922, and by the Association of Official Agricultural Chemists, November 17, 1922:

1. **Cacao Beans, Cocoa Beans**, are the seeds of trees belonging to the genus Theobroma, especially those of *Theobroma cacao* L., and closely related species.

2. **Cacao Nibs, Cocoa Nibs, "Cracked Cocoa,"** are roasted or dried cacao beans, broken and freed from germ and from shell or husk.

3. **Chocolate, Plain Chocolate, Bitter Chocolate, Chocolate Liquor, Chocolate Paste, Bitter Chocolate Coating,**[1] is the solid

[1] Definitions and standards for alkalized products will form a separate schedule.

or plastic mass obtained by grinding cacao nibs and contains not less than fifty per cent (50 %) of cacao fat and, on the moisture- and fat-free basis, not more than eight per cent (8 %) of total ash, not more than four tenths per cent (0.4 %) of ash insoluble in hydrochloric acid, and not more than seven per cent (7 %) of crude fiber.

4. **Sweet Chocolate, Sweet Chocolate Coating**, is chocolate mixed with sugar (sucrose), with or without the addition of cacao butter, spices, or other flavoring materials, and contains, on the moisture-, sugar-, and fat-free basis, no greater percentage of total ash, ash insoluble in hydrochloric acid, or crude fiber, respectively, than is found in moisture- and fat-free chocolate.

5. **Milk Chocolate, Sweet Milk Chocolate**, is the product obtained by grinding chocolate with sugar, with the solids of whole milk, or the constituents of milk solids in proportions normal for whole milk, and with or without cacao butter and/or flavoring material. It contains not less than twelve per cent (12 %) of milk solids.

6. **Cocoa, Powdered Cocoa**, is chocolate deprived of a portion of its fat and pulverized, and contains, on the moisture- and fat-free basis, no greater percentage of total ash, ash insoluble in hydrochloric acid, or crude fiber, respectively, than is found in moisture- and fat-free chocolate.

7. "**Breakfast Cocoa**" is cocoa which contains not less than twenty-two per cent (22%) of cacao fat.

8. **Sweet Cocoa, Sweetened Cocoa**, is cocoa mixed with sugar (sucrose), and contains not more than sixty-five per cent (65%) of sugar in the finished product, and, on the moisture-, sugar-, and fat-free basis, no greater percentage of total ash, ash insoluble in hydrochloric acid, or crude fiber, respectively, than is found in moisture- and fat-free chocolate.

9. **Sweet Milk Cocoa** is the product obtained by grinding cocoa with sugar, with solids of whole milk, or the constituents of milk solids in proportions normal for whole milk, and with or

without flavoring material. It contains not less than twelve per cent (12%) of milk solids.

The foregoing definitions and standards have been adopted as a guide for the officials of the Department of Agriculture in enforcing the Food and Drugs Act.

Average Composition of Sugars and Sweets

The average composition of miscellaneous sugars, starches, and confectionery, as estimated by Atwater and Bryant, is shown in Table 63. The fuel values have been recalculated by the use of the modern factors, as already explained.

TABLE 63. AVERAGE COMPOSITION OF SUGARS, STARCHES, ETC.

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN	FAT	TOTAL CARBOHYDRATES (INCLUDING FIBER)	FIBER (NUMBER OF DETERMINATIONS IN PARENTHESES)	ASH	FUEL VALUE PER POUND
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
SUGARS, STARCHES, ETC.									
Candy	—	—	—	—	—	96.0	—	—	1743
Honey	17	—	18.2	.4	—	81.2	—	.2	1480
Molasses, cane	15	—	25.1	2.4	—	69.3	—	3.2	1300
Starch, arrowroot	1	—	2.3	—	—	97.5	—	.2	1770
Starch, cornstarch	—	—	—	—	—	90.0	—	—	1635
Starch, manioca	1	—	10.5	.5	.1	88.8	—	.1	1625
Starch, tapioca	7	—	11.4	.4	.1	88.0	(5).1	.1	1608
Sugar, coffee or brown sugar	328	—	—	—	—	95.0	—	—	1723
Sugar, granulated	—	—	—	—	—	100.0	—	—	1814
Sugar, maple	17	—	—	—	—	82.8	—	—	1502
Sugar, powdered	—	—	—	—	—	100.0	—	—	1814
Sirup, maple	50	—	—	—	—	71.4	—	—	1295
Chocolate	2	—	5.9	12.9	48.7	30.3	—	2.2	2772
Cocoa	3	—	4.6	21.6	28.9	37.7	—	7.2	2256

Place of Sugars in the Diet

Dogmatic statements regarding the proper place of sugars in the diet are apt to be seriously misleading. The problem is complicated and the evidence in many respects is still obscure.

Until relatively recent times sugar was too expensive to be used freely by most people, but with the development of the industry and the cheapening of the product the consumption of sugar has increased at an exceedingly rapid rate.

The thoughtful student of food problems must regard this development with mixed emotions. The cheapening of a staple article of food, which is almost universally popular and which, like the refined sugar of commerce, is of uniform and well-known composition and practically free from danger of adulteration or harmful deterioration, would be a source of great satisfaction but for the fact that refined sugar constitutes an extreme case of a one-sided food, its sole nutritive function being to serve as fuel, so that, as the energy requirement of the body is met to a larger and larger extent by the consumption of refined sugar, there is a constantly increasing danger of unbalancing the diet and making it deficient in some of the substances which are needed for the building and repair of body tissue and for the regulation of physiological processes.

Are we to assume that the ordinary dietary of the people of the United States furnishes such an abundance of all the essential elements and each specific necessary compound that a reduction in the intake through displacement of natural foods by refined sugar is of no consequence? The investigations of recent years indicate clearly that no such assumption is justified. From this standpoint it would be an improvement if, without other change in dietary habits, the sugar consumption were reduced, say to one half the present rate, and the same amount of energy obtained by increasing the consumption of other food materials.

It is doubtful whether in any other country the increase in consumption of refined sugar during the past two or three generations has been so rapid as in the United States. The pre-war per capita consumption of sugar in several of the chief countries of the world is given by Browne as follows:

	Pounds
England	95
United States	85
Germany	49
France	43
Austria	28
Russia	24
Turkey	20
Spain	16
Italy	11

It will be seen that the per-capita consumption of sugar in continental Europe is not over half that in the United States. England reports a larger per-capita consumption, but it is to be noted that these statistics include both the sugar eaten as such and that used in the preparation of manufactured foods. Since England exports large amounts of jam, marmalade, and other food products containing much added sugar, it may be doubted whether the actual per-capita consumption of sugar is any larger in England than in the United States.

The objection to the too free use of sugar, on the ground that it serves only as fuel and may replace to an undue extent other food materials which meet other nutritive requirements, applies equally to commercial glucose and to most candy. It does not hold to the same extent as regards molasses and those sirups which contain the natural ash constituents of the plant juices. Probably the most desirable of all materials with which to satisfy a desire for sweet-tasting foods are the fruits, several of which contain from 10 to 15 per cent of sugars in the fresh state and from 50 to 75 per cent when dried. Some of the advantageous characteristics of fruit as food have been discussed in Chapter IX.

In addition to the question to what extent sugar may be allowed to displace other foods without danger of making the diet one-sided, there are several other considerations which should be kept in mind in attempting to assign to sugar its proper place as a food.

Sucrose entering the blood as such is not utilized; only the products of digestion are normally absorbed into the body. The digestion of sugar is a relatively simple process since it involves only one hydrolysis. This digestive hydrolysis, however, is not effected until the sugar reaches the intestine. Hence nearly all the sugar eaten remains as such in the stomach unless it is decomposed there by the action of microörganisms. Herter found that cane sugar is more apt to undergo fermentation in the stomach than is milk sugar. The products yielded by the more common types of fermentation, of which lactic acid is perhaps the best example, are not in any ordinary sense poisonous but may be irritating when formed in large amount. Aside from the question of fermentation, sugar is often directly irritating to the stomach, for unless much diluted with other food or with water it is likely in some part of the stomach to furnish a sugar solution of sufficient concentration to result in a distinct abstraction of water from the mucous membrane. The effect of such abstraction of water from the mucous membrane on a small scale is easily observed by holding a piece of hard candy in one side of the mouth for some time without moving it. When the same action takes place on a much larger scale in the stomach, and especially when, from frequent free use of sugar, it occurs repeatedly, some injury to the stomach must be anticipated.

The fact that sugar may have a disturbing influence upon digestion does not imply that the sugar itself is at all likely to escape digestion. The readiness with which sugar is hydrolyzed by the sugar-splitting enzyme of the intestinal juice, combined with the susceptibility of sugar to the attack of bacteria, makes it unlikely that much sugar will pass through the digestive tract unchanged. In a bulletin of the United States Department of Agriculture,[1] Mrs. Abel cites experiments in which 5 ounces of sugar per day, fed to healthy men as part of a simple mixed diet, showed an average digestibility of 98.9 per cent. According to the same authority 3 or 4 ounces per day "seem to be digested by the healthy adult without difficulty."

Athletes and farm laborers at hard work have in many instances been observed to take large quantities of sugar, often as lemonade or in admixture with other fruit juices, without any apparent ill effects. In such cases the sugar is employed to furnish the extra energy required for the muscular activity and so does not necessarily tend toward a subnormal intake of the foods which are valuable for their ash constituents and vitamins as well as their energy. In fact, when the sugar is taken with fruit juices, the consumption of the latter may thereby be increased.

The paragraphs which follow are taken from Mrs. Abel's general conclusions in the Government bulletin referred to above.

One may say in general that the wholesomeness of sweetened foods and their utilization by the system is largely a question of quantity and concentration. For instance, a simple pudding flavored with sugar rather than heavily sweetened is considered easy of digestion, but when more sugar is used, with the addition of eggs and fat, we have as the result highly concentrated forms of food, which can be eaten with advantage only in moderate quantities and which are entirely unsuited to children and invalids.

It is true that the harvester, lumberman, and others who do hard work in the open air consume great amounts of food containing considerable quantities of sugar, such as pie and doughnuts, and apparently with impunity; but it is equally true that people living an indoor life find that undue amounts of

[1] Farmers' Bulletin 535, June, 1913.

pie, cake, and pudding, with highly sweetened preserved fruit, and sugar in large amounts on cooked cereals, almost always bring indigestion sooner or later.

From a gastronomic point of view it would seem also that in the American cuisine sugar is used with too many kinds of food, with a consequent loss of variety and piquancy of flavor in the different dishes. The nutty flavor of grains and the natural taste of mild fruits are very often concealed by the addition of large quantities of sugar.

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CHAPTER XII

FOOD ADJUNCTS, UNCLASSIFIED FOOD MATERIALS, AND EXTRA FOODS

Many articles commonly classed as foods are consumed rather for their condimental properties than for nutritive value. In commerce and in food legislation there is usually no attempt to define the boundary between foods and condiments. Thus it will be remembered that the Food and Drugs Act so defines the word "food" as to cover all articles used as food, drink, confection, or condiment. Some of the condiments offer considerable opportunity for adulteration, and in the enforcement of the pure food laws this group of materials usually receives a large share of attention.

For the purposes of the present work brief statements regarding these food adjuncts seem sufficient; but opportunity is taken to present here the directions given by Dr. Hirschfelder for reënforcing table salt with iodide as a safeguard against the iodine deficiency which sometimes leads to goiter.

Salt

Salt is prepared in many localities throughout the world, sometimes by mining rock salt, sometimes by pumping brine out of salt wells, sometimes by impounding the water of salt lakes or of the ocean, and allowing it to evaporate in the sun, then refining the product by recrystallization.

In the United States, salt is produced chiefly by Michigan, New York, Kansas, and Ohio, which together furnish about nine tenths of the total output.

According to Bailey most of the salts on the market contain from 97 to 99 per cent of sodium chloride.

In order to avoid the introduction of impurities which would alter the flavor, careful butter-makers pay much attention to the purity of the salt which they use, and thus the term " dairy salt " has come to signify as high a degree of purity as is usually attempted commercially. An analysis of high grade dairy salt has been given in the account of butter manufacture.

According to the standards of the Association of Official Agricultural Chemists: *Table salt, dairy salt*, is fine-grained crystalline salt containing, on a water-free basis, not more than 1.4 per cent of calcium sulphate, nor more than 0.5 per cent of calcium and magnesium chloride, nor more than 0.1 per cent of matters insoluble in water.

In order to prevent salt, which is to be exposed to atmospheric conditions on the table, from becoming caked through absorption of moisture, it is sometimes mixed with a small amount of starch or of calcium phosphate. To avoid conflict with the standard set by the Official Chemists, salt thus prepared should be labeled to show its nature and composition.

Hirschfelder's directions for reënforcing table salt with iodide.[1] It is now well established that the extreme prevalence of goiter in certain regions is attributable to deficiency of iodine in the food and water of these regions and may be prevented by simple administration of small quantities of iodide. Hirschfelder suggests that this be done through the medium of the table salt used in each household of such regions as follows: A stock of " iodized salt " consisting of 99 per cent table salt and 1 per cent potassium iodide is prepared, by grinding the two salts together until finely powdered and thoroughly mixed and is then kept constantly on hand. Thereafter as each 5-pound bag of table salt is purchased it is spread in a thin layer and 5 teaspoonsful of the iodized salt are evenly added to the 5 pounds of table salt

[1] Hirschfelder, *Journal of the American Medical Association*, Vol. 79, page 1426 (1922).

The volatile oil of allspice is similar to that of cloves and according to Leach is composed of *eugenol* ($C_{10}H_{12}O_2$) and a hydrocarbon belonging to the sesquiterpenes whose exact chemical constitution has not yet been determined.

According to the definition and standard of the Association of Official Agricultural Chemists: *Allspice, pimento*, is the dried fruit of the *Pimenta pimenta* (L.) Karst., and contains not less than 8 per cent of quercitannic acid, not more than 6 per cent of total ash, not more than 0.4 per cent of ash insoluble in hydrochloric acid, and not more than 25 per cent of crude fiber.

Anise is the fruit of the *Pimpinella anisum* L.

Bay leaf is the dried leaf of *Laurus nobilis* L.

Capers are the flower buds of a shrub, *Capparis spinosa* L. and are commonly pickled in vinegar.

Caraway is the fruit (so-called seed) of *Carum carui* L., an umbelliferous plant growing chiefly in the northern and central parts of Europe and Asia. The dry caraways yield 3 to 6 per cent of a volatile oil which is said to contain cymene, cymene aldehyde, carvone, and limonene.

Cassia is the dried bark of *Cinnamonum cassia* and some other species of the same genus. Its condimental properties are due to the volatile oil, which may be obtained as such in commerce under the name of oil of cassia, and of which the chief component is cinnamic aldehyde. *Cassia buds* are the dried immature buds of species of Cinnamonum.

Cayenne, or *cayenne pepper*, is the dried ripe fruit of *Capsicum frutescens*, *Capsicum baccatum*, or some other small fruited species of *capsicum*, and owes its pungency largely to the presence of a characteristic alkaloid *capsicine*.

Cinnamon in the stricter use of the term (true cinnamon) is the dried inner bark of *Cinnamonum zeylanicum* (Beyne). Commonly, however, the term cinnamon is applied to the dried bark of any species of *Cinnamonum* from which the outer layers by means of an ordinary salt shaker. The salt thus treated is thoroughly mixed and used in cooking and for table salt.

Spices

The spices owe their condimental properties most often, probably, to volatile oils, but also in several cases to other substances, as will be seen from the descriptions which follow. Adulteration of whole spice usually takes the form of abstracting a part of the valuable component, while ground spices are often adulterated by addition of ground hulls (or other fibrous material) or of starchy materials such as flour, and sometimes of mineral matter. Where standards of composition have been adopted it will be seen that they usually set limits to one or more of these components.

Allspice, or pimento, is obtained from an evergreen tree, belonging to the same family with the clove, which is found in the West Indies and is cultivated chiefly in Jamaica.

The commercial spice is obtained by drying the berries, which, in order to avoid loss of aroma, are gathered when they have grown to full size but before they are fully ripe.

The average percentages of some constituents in samples of pure whole allspice analyzed by Winton, Mitchell, and Ogden at the Connecticut Experiment Station were as follows:

	Per cent
Moisture	9.78
Total ash	4.47
Ash soluble in water	2.47
Ash insoluble in hydrochloric acid	0.03
Volatile oil	4.05
Nonvolatile oils and fats	5.84
Alcohol extract	11.79
Starch (by diastase method)	3.04
Crude fiber	22.39
Protein (Nitrogen × 6.25)	5.75
Quercitannic acid	9.71

may or may not have been removed. Cinnamon, like cassia, owes its characteristic properties to a volatile oil of which cinnamic aldehyde is the chief component.

Ground cinnamon or *ground cassia* is a powder consisting of cinnamon, cassia, cassia buds, or a mixture of these.

Cloves are the dried flower buds of the clove plant (*Caryophyllus aromaticus*, or *Eugenia caryophyllata*), which is an evergreen tree growing 20 to 40 feet high and cultivated largely in Brazil, Ceylon, India, Zanzibar, Mauritius, and the West Indies.

The average percentages of the more prominent constituents as found by Winton, Ogden, and Mitchell in analysis of eight samples of whole cloves of known purity were as follows:

	Per cent
Moisture	7.81
Total ash	5.92
Ash soluble in water	3.58
Ash insoluble in hydrochloric acid	0.06
Volatile oil	19.18
Nonvolatile oils and fats	6.49
Alcohol extract	14.87
Starch (by diastase method)	2.75
Crude fiber	8.10
Protein (Nitrogen × 6.25)	6.18
Quercitannic acid	18.19

The condimental property of cloves is chiefly due to the volatile oil, which consists mainly of eugenol with smaller quantities of a sesquiterpene known as caryophylene. Probably, however, the fixed oils and resins and the tannin may also contribute to the characteristic pungency of the clove.

According to the standard of the Association of Official Agricultural Chemists cloves must contain not more than 5 per cent of clove stems, not less than 15 per cent of volatile oil, not less than 12 per cent of quercitannic acid, not more than 7 per cent of total ash, not more than 0.5 per cent of ash insoluble in hydrochloric acid, and not more than 10 per cent of crude fiber.

Coriander is the dried fruit of *Coriandrum sativum* L.

Cumin seed is the fruit of *Cuminum cyminum* L.

Dill seed is the fruit of *Anethum graveolens* L.

Fennel is the fruit of *Fœniculum fœniculum*.

Ginger is the rhizome or root-stock of *Zinziber officinale* or *Zinziber zinziber*, an annual plant growing 3 to 4 feet high, a native of India and China, now cultivated also in tropical America, Africa, and Australia.

The root is either washed or peeled (decorticated), then dried, and sometimes bleached or sprinkled with carbonate of lime. Preserved ginger is prepared by boiling the root and then treating it with sugar or honey.

Ginger is distinguished by high starch content and by its volatile oil and its resinous matter. The latter is most abundant in the outer layers, and so is largely lost when the roots are peeled or decorticated.

Winton, Ogden, and Mitchell analyzed 18 samples of whole ginger representing both white and black varieties with the following results:

	Maximum	Minimum	Average
	Per cent	*Per cent*	*Per cent*
Moisture	11.72	8.71	10.44
Total ash	9.35	3.61	5.27
Ash soluble in water	4.09	1.73	2.71
Ash insoluble in HCl	2.29	0.02	0.44
Lime (CaO)	3.53	0.20	0.80
Volatile oil	3.09	0.96	1.97
Nonvolatile oils and fats	5.42	2.82	4.10
Alcohol extract	6.58	3.63	5.18
Starch (by diastase method)	60.31	49.05	54.53
Crude fiber	5.50	2.37	3.91
"Protein" (Nitrogen × 6.25)	9.75	4.81	7.74
Cold water extract	17.55	10.92	13.42

According to the standards of the Official Agricultural Chemists, *ginger* must contain not less than 42 per cent of starch and not more than 8 per cent of crude fiber, 7 per cent of total ash, 1 per cent of lime, 2 per cent of ash insoluble in hydrochloric acid; while *limed* ("*bleached*") ginger must contain not over 4 per cent of lime or 10 per cent of total ash and in other respects should conform to the standard for ginger.

Horseradish is the root of *Roripa armoracia* either by itself or ground and mixed with vinegar.

Mace is prepared by drying the arillus which surrounds the nutmeg kernel. Mace contains notable quantities of fixed oils and of resinous matter. Its volatile oil resembles that of nutmeg. It contains a considerable amount of carbohydrate, which behaves like starch in analysis but gives only a red reaction with iodine and is called an amylodextrin.

Four samples of pure Banda or Penang mace examined by Winton, Ogden, and Mitchell gave the following average results:

	Per cent
Moisture	11.05
Total ash	2.01
Ash soluble in water	1.13
Ash insoluble in hydrochloric acid	0.07
Volatile oil	7.58
Nonvolatile ether extract	22.48
Alcohol extract	23.11
Amylodextrin (as starch by diastase method)	27.87
Crude fiber	3.20
"Protein" (Nitrogen × 6.25)	6.47

According to the standard of the Association of Official Agricultural Chemists mace should contain between 20 and 30 per cent of nonvolatile ether extract and not more than 3 per cent of total ash, 0.5 per cent of ash insoluble in hydrochloric acid, or 10 per cent of crude fiber.

Marjoram is the leaf, flower, and branch of *Majorana majorana.*

Mustard seed is the seed of *Sinapis alba* (white mustard), *Brassica nigra* (black mustard), *Brassica juncea* (black or brown mustard). These are annual plants belonging to the family *Cruciferæ.*

The seeds contain a considerable proportion of fatty oil of the same general character as rapeseed oil. In preparing the ground spice the seeds are crushed and the hulls are usually separated more or less completely. A part of the fatty oil is then pressed out and the residual *mustard cake* is broken up and reduced to a fine powder, which is the *mustard flour* of commerce.

Winton and Mitchell made partial analyses of 18 samples of commercial mustards, believed to be pure, with the following results:

	Maximum	Minimum	Average
	Per cent	*Per cent*	*Per cent*
Total ash	7.35	4.81	5.99
Volatile oil	1.90	0.00	0.56
Nonvolatile ether extract	28.10	17.14	20.61
Starch (by diastase method)	2.08	0.28	1.07
Crude fiber	4.87	1.58	2.58
"Protein" (Nitrogen × 6.25)	43.56	35.63	39.57

While mustard seeds contain very little volatile oil as such, there are present substances which, under the influence of enzymes also present, readily undergo hydrolysis with formation of volatile oil.

Black mustard seed contains *sinigrin* (potassium myronate, $KC_{10}H_{16}NS_2O_9$), a glucoside which splits, yielding glucose, potassium acid sulphate, and allyl isothiocyanate (C_3H_5CNS). The last named is called "*mustard oil*" and is a volatile oily liquid of very strong odor and capable of forming blisters when dropped on the skin.

White mustard contains a different glucoside, *sinalbin*, ($C_{30}H_{42}N_2S_2O_{15}$). This substance undergoes hydrolysis in a manner analogous to sinigrin, and when thus hydrolyzed, yields glucose, sinapin acid sulphate ($C_{16}H_{24}NO_5HSO_4$), and *sinalbin mustard oil* (C_7H_7ONCS). The latter resembles the volatile oil from black mustard (allyl isothiocyanate) in pungency.

Nutmeg is the dried seed of the *Myristica fragrans*, a tree native to the Malay archipelago, which somewhat resembles the orange tree in appearance.

The nutmegs are prepared for commerce by drying, usually after washing in limewater, or are powdered with air-slaked lime after drying.

Winton, Ogden, and Mitchell analyzed 4 samples of nutmeg of known purity with the following maximum and minimum results:

	Maximum	Minimum
	Per cent	Per cent
Moisture	10.83	5.79
Total ash	3.26	2.13
Ash soluble in water	1.46	0.82
Ash insoluble in hydrochloric acid	0.01	0.00
Volatile oil	6.94	2.56
Nonvolatile ether extract	36.94	28.73
Alcohol extract	17.38	10.42
Starch (by diastase method)	24.20	14.62
Crude fiber	3.72	2.38
"Protein" (Nitrogen $\times$ 6.25)	7.00	6.56

As standardized by the Association of Official Agricultural Chemists, nutmeg should contain not less than 25 per cent of nonvolatile ether extract, not more than 5 per cent of total ash nor more than 0.5 per cent of ash insoluble in hydrochloric acid, and not more than 10 per cent of crude fiber.

Paprica is the dried ripe fruit of *Capsicum annuum*, or some other large-fruited species of *Capsicum*, excluding seeds and stems.

Pepper is the berry of a climbing plant (*Piper nigrum*) which is cultivated in tropical countries. *Black pepper* is obtained by picking the berries while immature; *white pepper*, by allowing the berries to ripen and become more starchy. The condimental properties are attributed chiefly to the volatile oil, a hydrocarbon of the formula $C_{10}H_{16}$, and the nitrogenous bases piperidine and piperine. Piperine is extracted by ether and may be estimated approximately by multiplying the nitrogen of the nonvolatile ether extract by the factor 20.46.

Analyses by Winton, Ogden, and Mitchell, and by Winton and Bailey, covering 20 samples of black and 10 samples of white pepper, and representing the leading varieties imported into the United States, gave the following average results:

	Black Pepper	White Pepper
	Per cent	*Per cent*
Moisture	11.86	13.47
Total ash	5.10	1.77
Ash soluble in water	.60	0.47
Ash insoluble in hydrochloric acid	0.70	0.10
Volatile oil	1.28	0.73
Nonvolatile ether extract	8.41	6.91
Alcohol extract	9.44	7.66
Starch (by diastase method)	33.28	56.47
Crude fiber	13.62	3.14
Total nitrogen	2.25	2.04
Nitrogen in nonvolatile ether extract	0.33	0.30
"Protein" (Nitrogen other than that of ether extract × 6.25)	11.93	10.89

To meet the standards of the Association of Official Agricultural Chemists: *Black pepper* must contain not less than 6.75 per cent of nonvolatile ether extract, not less than 30 per cent of starch, not more than 7 per cent of total ash, not more than 1.5 per cent of ash insoluble in hydrochloric acid; *white pepper* must contain not less than 7 per cent of nonvolatile ether extract, not less than 52 per cent of starch, not more than 3.5 per cent of total ash, not more than 0.3 per cent of ash insoluble in hydrochloric acid, and not more than 5 per cent of crude fiber.

Saffron is the dried stigma of *Crocus sativus* L.

Sage is the leaf of *Salvia officinalis* L.

Savory, summer savory, is the leaf, blossom, and branch of *Satureja hortensis* L.

Thyme is the leaf and tip of blooming branches of *Thymus vulgaris* L.

Flavoring Extracts

A large number of flavoring extracts are available in the market, the extracts of vanilla and of lemon being most commonly used.

Vanilla extract is made from the vanilla bean, the fruit of a climbing vine, *Vanilla planifolia,* which belongs botanically to the orchids and is indigenous to tropical America. The vanilla beans grown in Mexico are considered the finest. When the pods turn brown, they are gathered and allowed to undergo a process of fermentation which develops the characteristic aroma. The beans are then dried for market, and the commercial extract is made by cutting them up and soaking them in alcohol, usually with addition of sugar. The odor of vanilla and vanilla extracts is due chiefly to vanillin ($C_8H_8O_3$).

Lemon extract is made by soaking lemon peel in strong alcohol and owes its flavor chiefly to the volatile oil of the lemon peel, of which the chief component is *citral* ($C_{10}H_{16}O$).

Adulteration of flavoring extracts usually takes the form either of substituting artificial or inferior substances or of making the extract unjustifiably dilute. The question of the proper concentration must necessarily be fixed somewhat arbitrarily. The limits fixed by the Association of Official Agricultural Chemists have usually been upheld by the courts.

The definitions and standards for flavoring extracts as adopted by that Association are as follows:

1. *A flavoring extract*[1] is a solution in ethyl alcohol of proper strength of the sapid and odorous principles derived from an aromatic plant, or parts of the plant, with or without its coloring matter, and conforms in name to the plant used in its preparation.

2. *Almond extract* is the flavoring extract prepared from oil of bitter almonds, free from hydrocyanic acid, and contains not less than one (1) per cent by volume of oil of bitter almonds.

2a. *Oil of bitter almonds*, commercial, is the volatile oil obtained from the seed of the bitter almond (*Amygdalus communis* L.), the apricot (*Prunus armeniaca* L.), or the peach (*Amygdalus persica* L.).

3. *Anise extract* is the flavoring extract prepared from oil of anise and contains not less than three (3) per cent by volume of oil of anise.

3a. *Oil of anise* is the volatile oil obtained from the anise seed.

4. *Celery seed extract* is the flavoring extract prepared from celery seed or the oil of celery seed, or both, and contains not less than three tenths (0.3) per cent by volume of oil of celery seed.

4a. *Oil of celery seed* is the volatile oil obtained from celery seed.

5. *Cassia extract* is the flavoring extract prepared from oil of cassia and contains not less than two (2) per cent by volume of oil of cassia.

5a. *Oil of cassia* is the lead-free volatile oil obtained from the leaves or bark of *Cinnamonum cassia* Bl., and contains not less than seventy-five (75) per cent by weight of cinnamic aldehyde.

6. *Cinnamon extract* is the flavoring extract prepared from oil of cinnamon, and contains not less than two (2) per cent by volume of oil of cinnamon.

[1] The flavoring extracts herein described are intended solely for food purposes and are not to be confounded with similar preparations described in the Pharmacopœia for medicinal purposes.

6a. *Oil of cinnamon* is the lead-free volatile oil obtained from the bark of the Ceylon cinnamon (*Cinnamonum zeylanicum* Breyne), and contains not less than sixty-five (65) per cent by weight of cinnamic aldehyde and not more than ten (10) per cent by weight of eugenol.

7. *Clove extract* is the flavoring extract prepared from oil of cloves, and contains not less than two (2) per cent by volume of oil of cloves.

7a. *Oil of cloves* is the lead-free, volatile oil obtained from cloves.

8. *Ginger extract* is the flavoring extract prepared from ginger and contains in each one hundred (100) cubic centimeters, the alcohol-soluble matters from not less than twenty (20) grams of ginger.

9. *Lemon extract* is the flavoring extract prepared from oil of lemon, or from lemon peel, or both, and contains not less than five (5) per cent by volume of oil of lemon.

9a. *Oil of lemon* is the volatile oil obtained, by expression or alcoholic solution, from the fresh peel of the lemon (*Citrus limonum* L.), has an optical rotation (25° C.) of not less than + 60° in a 100-millimeter tube, and contains not less than four (4) per cent by weight of citral.

10. *Terpeneless extract of lemon* is the flavoring extract prepared by shaking oil of lemon with dilute alcohol, or by dissolving terpeneless oil of lemon in dilute alcohol, and contains not less than two tenths (0.2) per cent by weight of citral derived from oil of lemon.

10a. *Terpeneless oil of lemon* is oil of lemon from which all or nearly all of the terpenes have been removed.

11. *Nutmeg extract* is the flavoring extract prepared from oil of nutmeg, and contains not less than two (2) per cent by volume of oil of nutmeg.

11a. *Oil of nutmeg* is the volatile oil obtained from nutmegs.

12. *Orange extract* is the flavoring extract prepared from oil of orange, or from orange peel, or both, and contains not less than five (5) per cent by volume of oil of orange.

12*a*. *Oil of orange* is the volatile oil obtained, by expression or alcoholic solution, from the fresh peel of the orange (*Citrus aurantium* L.) and has an optical rotation (25° C.) of not less than + 95° in a 100-millimeter tube.

13. *Terpeneless extract of orange* is the flavoring extract prepared by shaking oil of orange with dilute alcohol, or by dissolving terpeneless oil of orange in dilute alcohol, and corresponds in flavoring strength to orange extract.

13*a*. *Terpeneless oil of orange* is oil of orange from which all or nearly all of the terpenes have been removed.

14. *Peppermint extract* is the flavoring extract prepared from oil of peppermint, or from peppermint, or both, and contains not less than three (3) per cent by volume of oil of peppermint.

14*a*. *Peppermint* is the leaves and flowering tops of *Mentha piperita* L.

14*b*. *Oil of peppermint* is the volatile oil obtained from peppermint and contains not less than fifty (50) per cent by weight of menthol.

15. *Rose extract* is the flavoring extract prepared from otto of roses, with or without red rose petals, and contains not less than four tenths (0.4) per cent by volume of otto of roses.

15*a*. *Otto of roses* is the volatile oil obtained from the petals of *Rosa damascena* Mill., *R. centifolia* L., or *R. moschata* Herrm.

16. *Savory extract* is the flavoring extract prepared from oil of savory, or from savory, or both, and contains not less than thirty-five hundredths (0.35) per cent by volume of oil of savory.

16*a*. *Oil of savory* is the volatile oil obtained from savory.

17. *Spearmint extract* is the flavoring extract prepared from oil of spearmint, or from spearmint, or both, and contains not less than three (3) per cent by volume of oil of spearmint.

17a. *Spearmint* is the leaves and flowering tops of *Mentha spicata* L.

17b. *Oil of spearmint* is the volatile oil obtained from spearmint.

18. *Star anise extract* is the flavoring extract prepared from oil of star anise, and contains not less than three (3) per cent by volume of oil of star anise.

18a. *Oil of star anise* is the volatile oil distilled from the fruit of the star anise (*Illicium verum* Hook).

19. *Sweet basil extract* is the flavoring extract prepared from oil of sweet basil, or from sweet basil, or both, and contains not less than one tenth (0.1) per cent by volume of oil of sweet basil.

19a. *Sweet basil, basil,* is the leaves and tops of *Ocymum basilicum* L.

19b. *Oil of sweet basil* is the volatile oil obtained from basil.

20. *Sweet marjoram extract, marjoram extract,* is the flavoring extract prepared from the oil of marjoram, or from marjoram, or both, and contains not less than one (1) per cent by volume of oil of marjoram.

20a. *Oil of marjoram* is the volatile oil obtained from marjoram.

21. *Thyme extract* is the flavoring extract prepared from oil of thyme, or from thyme, or both, and contains not less than two tenths (0.2) per cent by volume of oil of thyme.

21a. *Oil of thyme* is the volatile oil obtained from thyme.

22. *Tonka extract* is the flavoring extract prepared from tonka bean, with or without sugar or glycerin, and contains not less than one tenth (0.1) per cent by weight of coumarin extracted from the tonka bean, together with a corresponding proportion of the other soluble matters thereof.

22a. *Tonka bean* is the seed of *Coumarouna odorata* Aublet (*Dipteryx odorata* (Aubl.) Willd.).

23. *Vanilla extract* is the flavoring extract prepared from vanilla bean, with or without sugar or glycerin, and contains

in one hundred (100) cubic centimeters the soluble matters from not less than ten (10) grams of vanilla bean.

23a. *Vanilla bean* is the dried, cured fruit of *Vanilla planifolia* Andrews.

24. *Wintergreen extract* is the flavoring extract prepared from oil of wintergreen, and contains not less than three (3) per cent by volume of oil of wintergreen.

24a. *Oil of wintergreen* is the volatile oil distilled from the leaves of *Gaultheria procumbens* L.

Unclassified Food Materials

Soups containing both animal and vegetable substances, and a few other articles grouped as unclassified by Atwater and Bryant, are included in Table 64, which is taken from Atwater's and Bryant's tables except that the fuel values have been recalculated, as explained in previous chapters.

TABLE 64. COMPOSITION OF UNCLASSIFIED FOOD MATERIALS

Description	Number of Analyses	Refuse	Water	Protein (N × 6.25)	Fat	Total Carbohydrates	Ash	Fuel Value per Pound
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Cals.*
Soups, homemade								
Beef soup	2	—	92.9	4.4	.4	1.1	1.2	116
Bean soup	1	—	84.3	3.2	1.4	9.4	1.7	286
Clam chowder	2	—	88.7	1.8	.8	6.7	2.0	187
Meat stew	5	—	84.5	4.6	4.3	5.5	1.1	359
Soups, canned								
Asparagus, cream of	1	—	87.4	2.5	3.2	5.5	1.4	276
Bouillon	3	—	96.6	2.2	.1	.2	.9	47
Celery, cream of	1	—	88.6	2.1	2.8	5.0	1.5	243
Chicken gumbo	2	—	89.2	3.8	.9	4.7	1.4	191
Chicken soup	2	—	93.8	3.6	.1	1.5	1.0	97
Consommé	1	—	96.0	2.5	—	.4	1.1	53

TABLE 64. COMPOSITION OF UNCLASSIFIED FOOD MATERIALS — Continued

DESCRIPTION	NUMBER OF ANALYSES	REFUSE	WATER	PROTEIN (N × 6.25)	FAT	TOTAL CARBOHYDRATES	ASH	FUEL VALUE PER POUND
		Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Cals.
Soups, canned								
Corn, cream of	1	—	86.8	2.5	1.9	7.8	1.0	265
Julienne	1	—	95.9	2.7	—	.5	.9	57
Mock turtle	2	—	89.8	5.2	.9	2.8	1.3	182
Mulligatawny	2	—	89.3	3.7	.1	5.7	1.2	175
Oxtail:								
Edible portion	2	—	88.8	4.0	1.3	4.3	1.6	204
As purchased	1	1.8	87.8	3.8	.5	4.2	1.9	166
Pea soup	4	—	86.9	3.6	.7	7.6	1.2	232
Pea, cream of green	1	—	87.7	2.6	2.7	5.7	1.3	261
Tomato soup	2	—	90.0	1.8	1.1	5.6	1.5	179
Turtle, green	1	—	86.6	6.1	1.9	3.9	1.5	259
Vegetable	1	—	95.7	2.9	—	.5	.9	62
Miscellaneous	3							
Mincemeat, commercial	3	—	27.7	6.7	1.4	60.2	4.0	1271
Mincemeat, homemade	3	—	54.4	4.8	6.7	32.1	2.0	943
Salad, ham, as purchased	1	—	69.4	15.4	7.6	5.6	2.0	691
Sandwich, egg, as purchased	1	—	41.4	9.6	12.7	34.5	1.8	1319
Sandwich, chicken, as purchased	1	—	48.5	12.3	5.4	32.1	1.7	1026
Cereal coffee infusion (1 part boiled in 20 parts water)[1]	5	—	98.2	0.2	—	1.4	0.2	29
Yeast, compressed, as purchased	1	—	65.1	11.7	—	21.0	1.8	610

The Energy Content of Extra Foods

Under this title Benedict and Benedict have published in *The Boston Medical and Surgical Journal* for August 1, 1918,

[1] The average of five analyses of cereal coffee grain is: Water 6.2, protein 13.3, fat 3.4, carbohydrates 72.6, and ash 4.5 per cent. Only a portion of the nutrients, however, enter into the infusion. The average in the table represents the available nutrients in the cereal coffee infusion. Infusions of genuine coffee and of tea contain practically no nutrients.

October 2, 1919, and April 28, 1921, a series of papers dealing with the energy values of various foods and drinks which are likely to be taken between meals. The Benedicts estimate that it is not unusual for a tenth of the total calories consumed to be taken in the form of "extra foods," in which case it is illogical to treat them as negligible factors in the food supply of the individual. (So far as the food supply of a community is concerned the materials entering into the production of these extra foods will often already have been taken into account.) The first of these papers deals with candies, chocolate, crackers, and soda-fountain products; the second and third include such "light lunch" materials as olives, sardines, and sandwiches.

On account of the great variability of many of these materials, average results might easily be misleading and the data of individual products are too numerous for reproduction here. Readers interested in the energy values of "extra foods" not included in previous chapters, or in the differences between products of different manufacturers are therefore referred to the original papers as cited above.

Standardization of Soda-fountain Products

As yet (1923) only the first steps have been taken toward the standardization of soda-fountain products. The following definitions have been adopted by the Joint Committee on Definitions and Standards and published by the United States Department of Agriculture:

Ginger Ale Flavor, Ginger Ale Concentrate, is the flavoring product in which ginger is the essential constituent, with or without aromatic and pungent ingredients, citrus oils, and fruit juices.

Ginger Ale is the carbonated beverage prepared from ginger ale flavor, sugar (sucrose) sirup, harmless organic acid, potable water, and caramel color.

Presumably corresponding definitions for other products of this type will be officially adopted from time to time.

Tea, Coffee, and Cocoa

These three materials so largely used in making beverages are alike in having a certain stimulating property due to alkaloid and so are often discussed together.

Tea consists of the prepared leaves and leaf buds of the tea bush belonging to different species of *Thea*, chiefly *Thea Chinensis*. The choicest teas are made from young leaves only, the Chinese teas being classified according to the position of the leaf on the young shoot. Thus the very highest quality of tea (not to be found in ordinary trade) is the *pekoe tip* or *flowery pekoe*, made of the leaf buds at the very end of the twig; the leaf next this bud, that is, the youngest leaf which has opened, makes the *orange pekoe;* the next older leaf, the *pekoe;* the third leaf the *souchong first*, and so on through several grades. The difference between green and black teas is due to the mode of preparation. Green tea is made by steaming and drying the leaves while fresh, while black tea is prepared by allowing the leaves to undergo an oxidative fermentation which darkens their color.

More than half the tea consumed in the United States comes from China, most of the remainder from Japan, smaller quantities from India, Ceylon, and the East Indies, and about one part in ten thousand of what we use is grown in South Carolina.

A special law governs the importation of tea into the United States, and each shipment must be tested and found to comply with the standard of the grade claimed for it before it is allowed to pass through the custom house.

So little of the tea enters the infusion which is consumed that it seems unnecessary for the purposes of this book to quote analyses of the tea leaf.

The stimulating property of the infusion is attributed to the alkaloid first called *theine* and later found to be identical with *caffeine*, the characteristic alkaloid of coffee. This alkaloid is chemically a tri-methyl-xanthine, $C_8H_{10}N_4O_2$, belonging to the same group of substances with xanthine and hypoxanthine of meat extract.

The flavor of tea is also influenced by the tannin, and probably by the small amount of volatile oil which it contains.

Coffee is the seed of *Coffea arabica* or *Coffea liberica*. It was originally grown in Africa and Arabia, and afterward introduced into the East and West Indies and tropical America. It is estimated that at present Brazil furnishes over half the world's supply of coffee and nearly three fourths of that consumed in the United States.

The constituents of chief importance in coffee are the alkaloid caffeine which has just been described as occurring in tea, the caffetannic acid ($C_{15}H_{18}O_8$), and the volatile oil known as caffeol ($C_8H_{10}O_2$) to which the characteristic flavor and aroma of coffee are chiefly attributed.

Cocoa, in addition to the stimulating property due to the alkaloid *theobromine* ($C_7H_8N_4O_2$), and the flavor which makes it popular both as a beverage and in confectionery, has a considerable food value. A brief description of the chief cocoa products was given in the last chapter.

Other Beverages

Fruit juices, sometimes classed as beverages, are about equally entitled to recognition as foods with the fruits from which they are obtained. The fruits used commercially for this purpose are in most cases so juicy that what has been said of fruits as food in Chapter IX applies almost equally to the fresh fruit or its unfermented juice. Several analyses of fruit juices and references to the literature regarding them will be found in Chapter IX. It seems therefore unnecessary to discuss them separately here.

Wines have received much attention both from the standpoint of their place in the diet and in connection with pure food legislation. A discussion of the former topic would lead much beyond the scope of this work, and the latter has largely lost its importance in this country since commerce in wines has been prohibited.

Brandy is spirit obtained by the distillation of wine. It usually contains from 40 to 50 per cent of alcohol.

Gin is a distilled spirit flavored with volatile oil of juniper and sometimes other aromatic substances. It usually contains 30 to 45 per cent of alcohol.

Rum is made by distillation of the product obtained by fermentation of cane sugar molasses. It contains about 50 per cent of alcohol.

Cordials are made by steeping fruits or aromatic herbs in brandy or neutral spirit and distilling the product. *Absinthe* is a cordial made by distilling an infusion of wormwood and therefore contains oil of wormwood.

Malt liquor has been defined as a beverage made by the alcoholic fermentation of an infusion of barley malt and hops, with or without unmalted grains.

Non-alcoholic malt beverages are being manufactured to an increasing extent to meet the demand for a temperance drink having the flavor of a malt liquor.

Whisky is distilled spirit made from grain, colored and flavored by storage in charred barrels or by addition of caramel and suitable flavor. It usually contains from 40 to 50 per cent of alcohol.

Vinegar

The term *vinegar*, originally implying a product made from wine, has now come to be used much more broadly. The kinds of vinegar recognized officially in the United States are shown by the following definitions and explanation taken from Food Inspection Decision 140 issued February 27, 1912:

Vinegar, *cider vinegar*, *apple vinegar*, is the product made from the alcoholic and subsequent acetous fermentations of the expressed juice of apples.

Wine vinegar, grape vinegar, is the product made by the alcoholic and subsequent acetous fermentations of the juice of grapes.

Malt vinegar is the product made by the alcoholic and subsequent acetous fermentations, without distillation, of an infusion of barley malt or cereals whose starch has been converted by malt.

Sugar vinegar is the product made by the alcoholic and subsequent acetous fermentations of solutions of sugar, sirup, molasses, or refiner's sirup.

Glucose vinegar is the product made by the alcoholic and subsequent acetous fermentations of solutions of starch sugar or glucose.

Spirit vinegar, distilled vinegar, grain vinegar is the product made by the acetous fermentation of dilute distilled alcohol.

Several questions regarding these definitions have been raised, and after investigation the board has reached the following conclusions:

Meaning of the term "vinegar." While the term "vinegar" in its etymological significance suggests only sour wine, it has come to have a broader significance in English-speaking countries. In the United States it has lost entirely its original meaning and when used without a qualifying word designates only the product secured by the alcoholic and subsequent acetous fermentation of apple juice.

"*Second pressings.*" It is held that the number of pressings used in preparing the juice is immaterial so long as the pomace is fresh and not decomposed. The practice of allowing the pomace from the presses to stand in piles or in vats for a number of days, during which time it becomes heated and decomposed, and then pressing, securing what is ordinarily called "second pressing," in the opinion of the board produces a product which consists in whole or in part of a filthy and decomposed material and is therefore adulterated.

Vinegar from dried-apple products. The product made from dried-apple skins, cores, and chops, by the process of soaking, with subsequent alcoholic and acetous fermentations of the solution thus obtained, is not entitled to be called vinegar without further designation, but must be plainly marked to show the material from which it is produced. The dried stock from which this product is prepared must be clean and made from sound material.

Addition of water. When natural vinegars made from cider, wine, or the juice of other fruits are diluted with water, the label must plainly indicate this fact; as, for example, "diluted to —— per cent acid strength." When water is added to pomace in the process of manufacture, the fact that the product is diluted must be plainly shown on the label in a similar manner. Dilution of vinegar naturally reduces, not only the acid strength, but the amount of other ingredients in proportion to the dilution, so that reduced vinegars will not comply with the analytical constants for undiluted products; but the relations existing between these various ingredients will remain the same. Diluted vinegars must have an acid strength of at least 4 grams acetic acid per 100 cubic centimeters.

Mixtures of vinegars. As different kinds of vinegar differ in source, flavor, and chemical composition, mixtures thereof are compounds within the meaning of the Food and Drugs Act, and if they contain no added poisonous or other added deleterious ingredients, will not be held to be misbranded if plainly labeled with the word "compound," together with the names and proportions of the various ingredients.

Addition of boiled cider and coloring matter. The Food and Drugs Act provides that a product shall be deemed to be adulterated if it be mixed, colored, powdered, coated, or stained in a manner whereby damage or inferiority is concealed; and, in the opinion of the board, the addition of coloring matters, boiled cider, etc., to vinegar, wine vinegar, and the other types of vinegar, or mixtures thereof, is for the purpose of concealing damage or inferiority or producing an imitation product. In the first instance, the use of such products is an adulteration and therefore prohibited. Products artificially colored or flavored with harmless ingredients in imitation of some particular kind of vinegar will not be held to be misbranded if plainly labeled "Imitation vinegar" in accordance with the provisions of the law.

Mixture of distilled and sugar vinegars. The product prepared by submitting to acetous fermentation a mixture of dilute alcohol (obtained, for example, from molasses by alcoholic fermentation and subsequent distillation) and dilute molasses, which has undergone alcoholic fermentation, is not "molasses vinegar" but a compound of distilled vinegar and molasses vinegar; such mixtures, however, must contain a substantial amount of molasses vinegar and not a small amount for the purpose of coloring the distilled vinegar. The molasses used must be fit for food purposes and free from any added deleterious substances.

Acetic acid diluted. The product made by diluting acetic acid is not vinegar, and when intended for food purposes must be free from harmful impurities and sold under its own name.

Product obtained by distilling wood. The impure product made by the destructive distillation of wood, known as "pyroligneous acid," is not vinegar, nor suitable for food purposes.

Acid strength. All of the products described above should contain not less than four (4) grams of acetic acid per one hundred (100) cubic centimeters.

In addition to the requirement of 4 grams of acetic acid to 100 cc. in each case the full standards prescribe in the cases of several vinegars certain limits of solids, ash, alkalinity of ash, etc., designed to facilitate the identification of the vinegar as to source and the judgment as to whether it is wholly genuine and true to name.

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CHAPTER XIII

FOOD BUDGETS AND FOOD ECONOMICS

The Problem of the Best Use of Food

Several of the foregoing chapters include statistical estimates of the money values of the annual products of particular food industries, and in some cases the discussion of the place of food in the diet has included suggestions as to the desirable proportion which the expenditure for the food in question should bear to the total expenditure for food. The data thus far given have, however, not been sufficiently comprehensive or systematic to constitute either a record of the food budget of the people as a whole, or a complete recommendation as to what the food budget of an individual or a family should be. Full discussion of this subject, especially if approached from the standpoint of the science of nutrition, would lead us farther into the field of dietetics than belongs to the scope of this book; but some consideration of it from the standpoint of food economics seems essential to the proper rounding out of the general study of food products to which this book is devoted. In this concluding chapter, therefore, an attempt will be made to summarize the place of each of the most important articles or types of food in the food budget and to indicate, from the results of actual experience, the effects which differences in food selection may be expected to exert upon the nutritive value and economy of the diet as a whole.

As pointed out in Chapter I the requirements of nutrition, and therefore the factors of food value, may be summarized, from the point of view with which we are concerned in the present study, under the four general heads of: energy, usually expressed in terms of calories; protein; mineral elements; and vitamins. Viewed from this standpoint the nutritional-economic characteristics of the chief types of food materials may be very briefly summarized as follows:

1. Breadstuffs and other grain products — economical sources of energy and protein but not satisfactory in their mineral and vitamin content.

2. Sugars and fats — chiefly significant from the nutritional standpoint as supplementary sources of energy, although some fats are also important as sources of the fat-soluble vitamin.

3. Meats, including fish and poultry — rich in protein or fat or both, but showing, in general, the same mineral and vitamin deficiencies as do the grains and breadstuffs.

4. Fruits and vegetables — varying greatly in their protein and energy values, but very important as sources of mineral elements and vitamins.

5. Milk — important as source of energy, protein, mineral elements, and vitamins; the most efficient of all foods in making good the deficiencies of the grains and in insuring the all-round adequacy of the diet.

It is plain that differing prominence of any particular type of food in the food supply may readily influence its economy and its nutritional character. And it is also well known that the food supplies of different countries, and of different groups of people in the same country, do differ widely from each other in this respect, some people living more largely on fruits and vegetables, others more largely on meat, others more largely on grains or breadstuffs. The discussion which follows is based on American observations of actual normal conditions.

A Study of American Experience

The character of the American food supply may be studied by investigating any or all of three kinds of available data: First, the census statistics and crop and market reports for the various food industries of the United States with corrections when necessary for imports and exports. Second, the extensive inquiries of the Bureau of Labor Statistics covering data obtained through interviews and questionnaires from thousands of families in various parts of the United States. Third, the data of the more detailed and intensive dietary studies, each covering an accurate record of food consumed during a definite period of a week or more in a family or larger group, taken as typical and studied carefully by trained field workers such as those of the United States Department of Agriculture or of the New York Association for Improving the Condition of the Poor. The results obtained from these three methods of inquiry are in good agreement and show that the total or typical American food budget distributes its expenditures about as follows: For meats, poultry and fish, 30 to 40 per cent of the total expenditure for food; for eggs about 5 per cent; for milk, cream, and cheese, about 10 per cent; for butter and other fats, about 10 per cent; for breadstuffs and other grain products, about 15 to 20 per cent; for sugar and molasses, about 5 per cent; for vegetables and fruits, about 15 per cent; leaving a remainder amounting usually to about 5 per cent for unclassified food materials and food adjuncts.

Table 65, herewith, shows the average distribution of expenditure for food over the main groups of food materials and the corresponding contribution of each of these groups toward the total nutritive value of the diet in 224 representative American dietary studies. That these 224 groups of people are representative of the American people as a whole as regards their food budgets is shown by the close agreement in the percentage distribution of money spent for food in the average of these studies with that found from statistics of the food industries, and with that of the average found by the Bureau of Labor Statistics in its less detailed but very extensive inquiries. The 224 families whose dietary records are here taken for critical study are also representative of the American people as a whole in the sense that they represent all parts of the country, both urban and rural conditions, different years and seasons of the year, and a wide and representative range of economic conditions and levels of expenditure. There is ample reason therefore to believe that the data of these 224 records may be taken as representing average American food conditions, and that whatever differences they show when subdivided according to the differing prominence of any particular food are the differences which may be expected to result regularly and normally from such differences in food selection.

TABLE 65. AVERAGE PERCENTAGE DISTRIBUTION OF COST AND NUTRIENTS IN 224 AMERICAN DIETARIES

Type of Food	Relative Cost	Calories	Protein	Phosphorus	Calcium	Iron
Meat and fish	32.19	18.99	35.34	26.36	3.86	30.37
Eggs	5.47	1.77	4.64	4.02	3.64	6.25
Milk and cheese	10.59	8.08	11.56	20.61	55.76	5.11
Butter and other fats	9.55	10.32	.31	.32	.73	.33
Grain products	18.29	38.20	37.25	30.27	15.67	25.87
Sugar and molasses	4.57	10.06	.14	.20	1.81	1.80
Vegetables	10.55	9.05	9.55	15.58	14.87	26.42
Fruit	5.31	2.99	.78	1.82	3.15	3.29
Nuts	.15	.14	.11	.13	.07	.09
Food adjuncts and miscellaneous	3.33	.40	.32	.69	.44	.47
Per Man per Day	100[1]	3256	106 gms.	1.63 gms.	0.74 gm.	0.0179 gm.

In order to find what differences of this kind normally exist in American food budgets and how they affect the food economy, certain conventional limits were employed to divide the 224 dietaries into three groups with reference to each type of food according as the place of this type of food was "low," "medium,"

[1] The average cost per man per day of the entire 224 dietaries taken as a basis (expressed as 100) on which to express the relative costs of the various groupings made to study the influence of particular foods upon the nutritive value of the dietary as a whole as shown in subsequent tables.

or "high" in the dietary according to the average American practice of normal times. These limits are shown in Table 66.

TABLE 66. CONVENTIONAL LIMITS SET TO SEPARATE "LOW," "MEDIUM," AND "HIGH" PERCENTAGE OF EXPENDITURE FOR THE DIFFERENT TYPES OF FOOD

	"Low"	"Medium"	"High"
Meat and Fish	Up to 24.99%	25.00 to 39.99%	40.00% and over
Eggs	Up to 3.99%	4.00 to 7.99%	8.00% and over
Milk and cheese	Up to 6.99%	7.00 to 13.99%	14.00% and over
Fats	Up to 6.99%	7.00 to 13.99%	14.00% and over
Grain products	Up to 13.99%	14.00 to 19.99%	20.00% and over
Sugars	Up to 3.99%	4.00 to 7.99%	8.00% and over
Vegetables	Up to 6.99%	7.00 to 13.99%	14.00% and over
Fruit	Up to 3.99%	4.00 to 7.99%	8.00% and over
Vegetables and fruit	Up to 9.99%	10.00 to 19.99%	20.00% and over
Milk and cheese, vegetables and fruit	Up to 19.99%	20.00 to 33.32%	33.33% and over

By the use of this means of classification, the effect exerted by any one food or type of food in actual American experience can be studied by comparing the effect of the prominence of this food upon the prominence of other foods and upon the relative cost and nutritive value of the diet as a whole.

In accordance with the principle that "the dietary should be built around bread and milk," let us consider the effects of these two types of food first.

Grain products. It has already been seen from Table 65 that the grain products furnish a much larger share of the calories, protein, phosphorus, and iron of the total food supply than would correspond with their cost. The natural inference is that to increase the prominence of grain products in the diet should make it more economical so far as calories, protein, phosphorus, and iron are concerned. But one of the great advantages of the method of study which we are here using is that it frees us from the necessity of depending upon inference, since we are here dealing with concrete numerical records of what actually happened in the unbiassed experience of over 200 representative American families. When these dietaries are arranged into three groups according to the relative prominence of grain products in the food budget and the data of each group averaged, the results shown in Table 67 are obtained.

Table 67. Relation of the Prominence of Grain Products in the Dietary to the Percentage Distribution of Cost and to Food Value

Expenditure for Each Type of Food in Percentage of the Whole	"Low-grain" Dietaries	"Medium-grain" Dietaries	"High-grain" Dietaries
Grain products	10.32	16.96	26.89
Meats and fish	33.65	33.24	29.79
Eggs	6.93	5.77	3.84
Milk and cheese	11.98	11.10	8.84
Butter and other fats	10.68	8.64	9.42
Sugars	4.65	4.41	4.65
Vegetables	10.32	10.48	10.82
Fruit	7.44	5.67	3.02
Relative cost	120.	108.	76.
Calories, per man per day	3442.	3163.	3180.
Protein, grams, per day	113.	107.	99.
Phosphorus, gram, per day	1.80	1.65	1.45
Calcium, gram, per day	0.88	0.76	0.60
Iron, gram, per day	0.0204	0.0177	0.0157
In proportion to cost			
Calories	2870.	2930.	4180.
Protein	94.	99.	130.
Phosphorus	1.50	1.53	1.91
Calcium	0.73	0.70	0.79
Iron	0.017	0.016	0.020

From the relative costs of the three groups it is plain that the prominence of grain products in the food budget was inversely as the level of expenditure. The more meagerly the people are obliged to live the more largely they are forced to live upon breadstuffs and other grain products, since this type of food furnishes in general the most energy and protein for the least money. Increasing prominence of grain products means therefore increasing prominence of poverty, and correspondingly we find a decrease in the cost of the dietary as a whole and in nearly every factor of its food value. If, however, we consider the food values obtained *in proportion to money spent*, we see from the data as shown in the lower section of Table 67 that the dietaries in which grain products are prominent do represent a high degree of economy in expenditure in so far as the returns in terms of Calories, protein, etc. per unit of cost are concerned; but since the actual returns in calcium were dangerously near the limit of adequacy, and since we have strong reason to believe that such dietaries are likely to be deficient in vitamin A, we find here the warning of actual experience that when for reasons of economy bread or other grain products are made prominent in the dietary, it becomes all the more important to give prominence also to foods rich in calcium and vitamin A. Milk is preëminent among such foods.

Milk, cream, and cheese. For convenience the relatively small amounts of cream and of cheese used in these dietaries are grouped with milk in this discussion since they closely resemble milk in richness in calcium and fat-soluble vitamin, and since milk products are often grouped with milk in both dietary and industrial discussions of the economics of food supply.

Table 68 shows the relation of the prominence of milk in the food budget to the resulting nutritive value of the diet as a whole. It will be seen that an increase in the prominence of milk in the food budget from an average of 10.30 per cent of the total expenditure for food in the "medium" to 19.38 per cent in the so-called "high milk" dietaries resulted in an increase in all the factors of food value with no increase in the total cost. Moreover, the improvement is relatively greatest at the point at which it is most needed, that is, in the calcium content of the dietary, and there was doubtless a very important increase in the fat-soluble vitamin content also.

TABLE 68. RELATION OF THE PROMINENCE OF MILK IN THE DIETARY TO THE PERCENTAGE DISTRIBUTION OF COST AND TO FOOD VALUE IN 224 AMERICAN DIETARIES

EXPENDITURE FOR EACH TYPE OF FOOD IN PERCENTAGE OF THE WHOLE	"LOW-MILK" DIETARIES	"MEDIUM-MILK" DIETARIES	"HIGH-MILK" DIETARIES
Milk and cheese	4.56	10.30	19.38
Meats and fish	33.83	33.24	27.62
Eggs	5.44	5.56	5.31
Butter and other fats	9.97	9.19	9.77
Grain products	21.57	17.15	16.42
Sugars	4.71	4.57	4.36
Vegetables	11.51	10.27	9.89
Fruit	4.80	6.05	4.37
Relative cost	84.	108.	100.
Calories, per man per day	3271.	3130.	3516.
Protein, grams, per day	103.	106.	112.
Phosphorus, grams, per day	1.49	1.56	1.96
Calcium, gram, per day	0.51	0.74	1.06
Iron, gram, per day	0.0178	0.0176	0.0186

It is important to realize to what a large extent the amount of calcium received in the diet depends in actual practice upon the amount of milk consumed. Milk is a much larger factor in the calcium supply than is any other food; usually the calcium depends more largely upon the milk than upon all other foods combined. When the 224 dietaries here considered were arranged in 8 groups according to increasing quantities of milk consumed, it was found that this resulted in a strikingly regular corresponding increase in the total calcium of the diet as shown in Fig. 44. Since American dietaries are probably more often deficient in calcium than in any other element, the value of milk as a source of calcium is a large factor in its unique importance to the dietary.

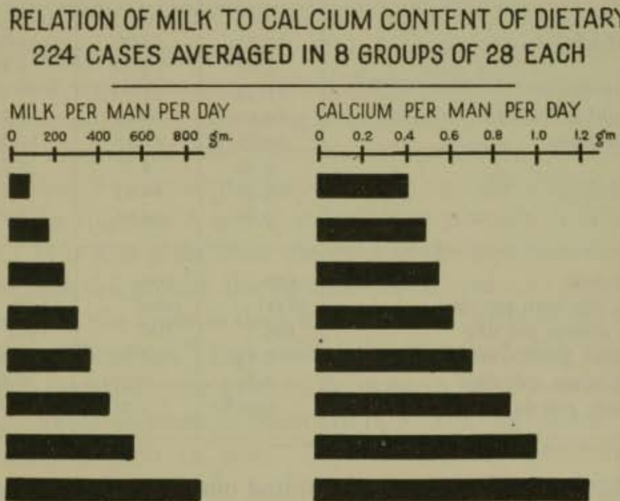

FIG. 44. — Relation of milk to the calcium content of the dietary.

Meat, poultry, and fish. Table 69 shows the relation which prominence of meat in the food budget bears to the expenditures for other foods and to the food value of the diet as a whole. Very fortunately for the purposes of this study, the average expenditure for total food per man per day was practically the same for the "low-meat," "medium-meat," and "high-meat" dietaries. Any differences which they show are therefore independent of any greater pressure of poverty in one group than in another.

The differing prominence of meat in these dietaries of essentially the same cost shows interesting results.

TABLE 69. RELATION OF THE PROMINENCE OF MEAT IN THE DIETARY TO THE PERCENTAGE DISTRIBUTION OF COST AND TO FOOD VALUE IN 224 AMERICAN DIETARIES

EXPENDITURE FOR EACH TYPE OF FOOD IN PERCENTAGE OF THE WHOLE	"LOW-MEAT" DIETARIES	"MEDIUM-MEAT" DIETARIES	"HIGH-MEAT" DIETARIES
Meats and fish	17.73	32.96	44.89
Eggs	5.68	5.76	4.49
Milk and cheese	11.34	11.19	8.27
Butter and other fats	13.10	9.13	7.02
Grain products	20.83	17.78	17.06
Sugar	5.39	4.56	3.75
Vegetables	13.46	10.17	8.56
Fruit	9.02	4.67	3.22
Relative cost	100.	100.	96.
Calories, per man per day	3821.	3202.	2822.
Protein, grams, per day	103.	108.	107.
Phosphorus, grams, per day	1.75	1.63	1.48
Calcium, gram, per day	0.89	0.76	0.55
Iron, gram, per day	0.0182	0.0181	0.0170

In the first place it may be pointed out that the expressions "low-meat," "medium-meat," and "high-meat," as here used, refer to the relation of these to the general average of American dietaries, and in these meat is much more freely used than in most other countries. In the so-called "low-meat" group of American dietaries, meat is actually as prominent as it is in the "liberal-meat" or "high-meat" dietaries of most countries, while in the dietaries which are grouped as "high-meat" in Table 69, the expenditure for meat (including poultry and fish) was almost as great as for all other foods combined. Because meat bulks so large in the American food budget, its relation to our food economy is deserving of careful study.

Naturally with the level of total expenditure uniform a higher expenditure for meats must mean a lower expenditure for some at least of the other foods. The effect of increasing prominence of meat in the food budget upon the relative prominence of other foods is easily seen from the data of the upper section of Table 69. It will be seen that with increasing expenditure for meats there were small decreases in the expenditures for eggs, milk, grain products, sugar, and vegetables, while the expenditures for fruit and for butter and other fats were reduced in relatively greater proportion. The moderate diminution of milk, eggs, and vegetables and marked diminution of butter and fruit which accompanies increasing prominence of meat in the food budget must mean that under actual conditions of normal living the more prominent meat is in the diet the poorer the diet will be in vitamins A and C at least and probably in vitamin B also. It is also plain from the data in the lower section of the table that the greater the prominence of meat in dietaries of a given cost, the lower is their food value in terms of the familiar factors. Thus the "high-meat" as compared with the "low-meat" dietaries show marked decrease in calories and calcium, considerable decrease in phosphorus, and no significant change in either protein or iron. That meat, notwithstanding its relatively high protein and iron content, does not make the dietary richer in protein and iron as it becomes more prominent in the food budget is because meat is a food which in the nature of the case must be relatively costly to produce in all countries which have passed the pioneer stage of agriculture, so that while the concentration of protein and iron in meat (or at least in lean meat) is relatively high, the amounts of protein and iron obtained for a given amount of money are no higher in meat than in the average of other food, while the amounts of other nutrients are usually much lower. This aspect of the relative cost of meat as a food has been briefly noted in earlier chapters and is further explained in the following statement issued by the Committee on Food and Nutrition of the National Research Council.

MEAT AND MILK IN THE FOOD SUPPLY

(Committee on Food and Nutrition of National Research Council, April 3, 1920)

"It has long been known, but perhaps never sufficiently emphasized, that the milch cow returns in the human food which she yields, a very much larger share of the protein and energy of the feed she consumes than does the beef animal. Doctor Armsby (*Science*, August 17, 1917) has estimated that of the energy of grain there is recovered for human consumption about 18 per cent in milk, and only about 3.5 per cent in beef.

"In the report on the food supply of the United Kingdom, it was estimated that to produce 100 Calories of human food in the form of milk from a good cow, required feed equivalent to 2.9 pounds starch; 100 Calories of milk from a poor cow was estimated to require the consumption of 4.7 pounds; and 100 Calories of beef from a steer two and one half years old, to require 9 pounds starch equivalent in feed.

"Stated in terms comparable with those of Dr. Armsby this would mean that the good milk cow returns 20 per cent of the energy value of what she consumes; the poor milk cow 12 per cent; the good beef steer 6 per cent. Although this estimate is more favorable to the beef steer than is that of Dr. Armsby, yet even here it will be seen that the poor cow is twice as efficient, and the good milk cow more than three times as efficient as the beef steer in the conservation of energy in the food supply.

"Considering the whole length of life of the animal, Wood estimates that the cow returns in milk, veal and beef, $\frac{1}{12}$ as much food as she has consumed, while the beef steer returns only $\frac{1}{64}$; in other words, the cow is five times as efficient as the beef steer when the whole life cycle of the animal is considered.

"Similarly it has been estimated by Cooper and Spillman (Farmers' Bulletin, U. S. Department of Agriculture) that the crops grown on a given area may be expected to yield from four to five times as much protein and energy for human consumption when fed to dairy cows as when used for beef production. As Wood has very strikingly shown, the longer beef animals are fattened on grain, the less economical the process becomes.

"Quite recently Dr. Armsby has pointed out (*Yale Review*, January, 1920) that 'the dairy cow shows the highest efficiency of any domestic animal, both as regards conversion of food into milk and availability of the product for man.'

"Not only is the milk cow several times more efficient than the beef steer in the conservation of proteins, fats and carbohydrate for human consumption; in the gathering and preparation of mineral elements and vitamins she contrasts even more favorably with the beef animal. It is largely because of its richness in calcium and in fat-soluble vitamin that milk is the most efficient nutritional supplement to bread or other grain products.

"Meat is strikingly poor in calcium and does relatively little to balance a diet consisting largely of bread or of other products of seeds. It does, of course, supplement the protein, but American dietaries would nearly always be adequate as regards protein even without the meat that they contain. On the other hand, dietaries containing little or no milk are very apt to be inadequate as regards calcium. Detailed analysis of the results of hundreds of American dietary studies shows that in practice the adequacy of the calcium intake depends more largely on the adequacy of milk supply than upon any other factor, or in fact upon all other factors combined.

"The vitamins furnished by hay and grains and thus consumed by cattle are stored in the animal's tissues to only a limited extent, but are transferred in relative abundance to the milk. Hence, the vitamins of the coarse material not directly available as human food, are brought into form for man's use very efficiently through milk production, and very inefficiently through the production of meat. Thus, the result of recent studies in nutrition which have made clearer the importance of the mineral elements and vitamins, is to emphasize strongly the great desirability of more abundant milk supply, even if this should somewhat reduce the production and consumption of meat. Our present knowledge of nutrition justifies more fully than ever before the statement that 'the dietary should be built around bread and milk,' bread or other grain products being the foods which furnish the most nutriment for their cost (whether in money or in land and labor) and milk being by far the most efficient nutritional supplement to bread or other grain products.

"Somewhat more of our grain crops than at the present should come directly into human consumption to augment the bread supply, and of the grain fed to cattle more should be used for the production of milk, and less for the production of meat.

"In general, 10 pounds of grain may be expected to produce not over 1 pound of meat or about 3 quarts of milk. If the 3 quarts of milk cost the consumer more (because of greater labor cost to produce) they are also certainly worth more to him. In so far as things so different as meat and milk in their nutritional properties can be compared, it is fair to say that one quart of milk is at least as great an asset in the family dietary as is a pound of meat. The per capita consumption of meat in the United States is so high that it might be reduced by one third or even one half with little or no nutritional loss, while a corresponding increase in milk consumption would certainly constitute a great improvement in the average American dietary.

"We are confident that a moderate shifting of emphasis from meat to milk will help in the normal evolution of American agriculture and improve the food economy and public health of the American people."

As a matter of fact it is only when meat is given an exaggerated place in the food supply that any question of " meat versus milk " is likely to ȧrise, for in a condition of good food economics the production of milk and of meat go on together and interdependently. It is only under frontier conditions of farming or under the pressure of an undue demand for the expensive grades of beef that large herds of cattle are raised merely for slaughter. The farmer can produce meat to the exclusion of milk but not milk to the exclusion of meat. It is estimated that about one third of the beef now produced in the United States comes from dairy herds. If the dairy industry were doubled, as in the interest of food economics and national health it might well be, then the herds kept to produce this milk would at the same time produce an amount of beef equal to two thirds of our present supply, which is a larger per capita amount than was consumed in England, France, and Germany in the prosperous years before the World War. Moreover intensification of dairy farming leads also to increased pork production, as well illustrated in the case of Denmark.

Study of these dietary data, like many other food and nutrition studies of recent years, suggests the desirability of a shifting of emphasis from meat to milk in the food budget, a suggestion which carries no implication whatever of " meat-less diet." For in the first place, as we have just seen, milk production carries with it the production of meat, and in the second place after the shift of emphasis here suggested has taken place, normal crops will amply provide for a liberal additional production of meat, especially through the raising and fattening of enough swine each year to make the best use of the crop surplus. All that is here suggested is a sane recognition of the well-known fact that meat is an expensive food, and that when people of average income spend as much as a third of their food money for meat, there arises a serious question whether the food budget will then provide for sufficient amounts of milk, butter, vegetables, and fruit to support the best condition of nutrition and the highest degree of health.

Eggs. Table 70 shows the relation of prominence of eggs in the food budget to the expenditures for other foods and to the nutritive value and economy of the diet as a whole. It will be seen that the percentage of the food money which was spent for eggs varied widely in the three groups and that the money taken for increased purchase of eggs in the high-egg dietaries came not from any other one type of food but from a slight general decrease in all or nearly all of them. In other words, the use of more or fewer eggs did not particularly change the relationships among the other foods used. High as is the nutritive value of

TABLE 70. RELATION OF THE PROMINENCE OF EGGS IN THE DIETARY TO THE PERCENTAGE DISTRIBUTION OF COST AND TO FOOD VALUE IN 224 AMERICAN DIETARIES

EXPENDITURE FOR EACH TYPE OF FOOD IN PERCENTAGE OF THE WHOLE	"LOW-EGG" DIETARIES	"MEDIUM-EGG" DIETARIES	"HIGH-EGG" DIETARIES
Eggs	1.68	5.82	10.57
Meats and fish	32.36	32.92	31.04
Milk and cheese	10.64	10.73	10.35
Butter and other fats	9.97	9.68	8.77
Grain products	21.60	16.14	16.09
Sugar	4.34	4.84	4.56
Vegetables	10.74	10.42	10.43
Fruits	5.26	5.91	4.67
Relative cost	88.	112.	96.
Calories, per man per day	3404.	3289.	3000.
Protein, grams, per day	104.	109.	107.
Phosphorus, gram, per day	1.62	1.65	1.62
Calcium, gram, per day	0.71	0.79	0.74
Iron, gram, per day	0.0170	0.0184	0.0186

the egg, it would seem that its actual use in current household practice is rather casual, eggs being used more or less freely according to their price, without much real attention to using them interchangeably with other high protein foods. Under these conditions the relative prominence of eggs in the diet bore little relation to the tabulated factors of food value. The high-egg dietaries were probably the richest in fat-soluble vitamin.

Butter and other fats. Table 71 shows the relation of the prominence of butter and other fats in the food budget to the use of other foods and to the food value of the diet as a whole. The "low-," "medium-," and "high-fat" dietaries furnished about equal amounts of protein and of phosphorus. The "high-fat" dietaries while lowest in cost were highest in calories and also in calcium and iron. These latter effects are doubtless due not directly to the fats themselves but to the fact that increasing prominence of fats in the diet was accompanied by increases also in vegetables and fruit. It is also very interesting to see from this table, as also from the one comparing the "low-," "medium-," and "high-meat" dietaries, that as the expenditure for butter and other fats rises, the expenditure for meats falls, and *vice versa.* The inverse relationship between the prominence (in the food budget) of meats, on the one hand, and of fats and fruits, on the other, together with the absence of a correspondingly well-marked inverse relation between meats and either milk or eggs, illustrates the fact (also found through other observations made in connection with food control and food conservation during the War) that in actual practice what leads people to spend so much of their money for meat is not a desire for its protein but rather for its fat and its flavor. Fat is much missed when the accustomed supply is curtailed, and people will readily buy fat either in the form of butter or some other commercial fat or in the form of meat; and in buying food for flavor the preference of the individual or the family determines whether more meat, or more fat, or more fruit shall be purchased. Obviously the richer the dietary in butter the richer it is likely to be in vitamin A.

TABLE 71. RELATION OF THE PROMINENCE OF BUTTER AND OTHER FATS IN THE DIETARY TO THE PERCENTAGE DISTRIBUTION OF COST AND TO FOOD VALUE IN 224 AMERICAN DIETARIES

EXPENDITURE FOR EACH TYPE OF FOOD IN PERCENTAGE OF THE WHOLE	"LOW-FAT" DIETARIES	"MEDIUM-FAT" DIETARIES	"HIGH-FAT" DIETARIES
Butter and other fats	4.43	10.01	18.29
Meats and fish	36.38	31.71	25.33
Eggs	5.35	6.10	3.46
Milk and cheese	10.77	10.61	10.19
Grain products	20.31	17.39	17.46
Sugar	4.00	4.53	5.84
Vegetables	10.18	10.34	12.05
Fruits	4.00	5.80	6.23
Relative cost	96.	108.	84.
Calories, per man per day	2781.	3328.	3963.
Protein, grams, per day	103.	109.	104.
Phosphorus, grams, per day	1.56	1.67	1.62
Calcium, gram, per day	0.66	0.77	0.80
Iron, gram, per day	0.0166	0.0183	0.0191

Sugar and molasses. The grouping together of sugar and molasses is usual and natural because of their industrial and commercial relationship and the richness of both in sugar, and the usual grouping was followed in this respect in the dietary calculations here considered. We now realize, however, that such a group is too heterogeneous to be useful for the purpose of the present discussion because modern commercial sugar is a highly refined form of carbohydrate, whereas molasses contains in concentrated form those natural constituents of the cane juice from which sugar has been so carefully freed.

Vegetables. The relation of the prominence of vegetables in the food budget to the expenditures for other foods and to the cost and food value of the diet as a whole is shown in Table 72.

Increasing prominence of vegetables is seen to have been accompanied by increasing prominence of fats and decreasing prominence of meats. The result was a decrease in the total cost of the dietary, an increase in its total calories, calcium and iron, and no significant change in the protein and phosphorus content. The richness of the dietaries in all three of the vitamins was doubtless increased by the increased use of vegetables. The effects of fruits and vegetables combined, and of milk, vegetables, and fruits combined are perhaps more significant than the effects of the vegetables alone, probably because relatively few people in the United States yet appreciate vegetables sufficiently to make much use of any but the few commonest kinds. The appreciation of vegetables is growing, and it is to be hoped that it will grow much further still.

TABLE 72. RELATION OF THE PROMINENCE OF VEGETABLES IN THE DIETARY TO THE PERCENTAGE DISTRIBUTION OF COST AND TO FOOD VALUE IN 224 AMERICAN DIETARIES

EXPENDITURE FOR EACH TYPE OF FOOD IN PERCENTAGE OF THE WHOLE	"LOW-VEGETABLE" DIETARIES	"MEDIUM-VEGETABLE" DIETARIES	"HIGH-VEGETABLE" DIETARIES
Vegetables	4.58	10.30	18.24
Meats and fish	36.37	32.26	27.09
Eggs	5.44	5.69	4.83
Milk and cheese	10.86	10.85	9.49
Butter and other fats	8.54	9.49	10.87
Grain products	20.25	17.51	18.43
Sugar	4.55	4.71	4.14
Fruit	4.95	5.77	4.35
Relative cost	96.	108.	80.
Calories, per man per day	3165.	3235.	3428.
Protein, grams, per day	108.	107.	104.
Phosphorus, grams, per day	1.65	1.60	1.68
Calcium, gram, per day	0.68	0.76	0.76
Iron, gram, per day	0.0163	0.0181	0.0191

Fruits. The prominence of fruit in the food budget varies greatly and the results of these variations are shown in Table 73. Low-fruit dietaries are seen to be essentially dietaries of low cost, and to differ but little in other respects from medium-fruit dietaries, the eggs being less prominent and the grain products more prominent in the low-cost dietaries here as elsewhere.

TABLE 73. RELATION OF THE PROMINENCE OF FRUIT IN THE DIETARY TO THE PERCENTAGE DISTRIBUTION OF COST AND TO FOOD VALUE IN 224 AMERICAN DIETARIES

EXPENDITURE FOR EACH TYPE OF FOOD IN PERCENTAGE OF THE WHOLE	"LOW-FRUIT" DIETARIES	"MEDIUM-FRUIT" DIETARIES	"HIGH-FRUIT" DIETARIES
Fruit	1.38	5.76	12.58
Meats and fish	33.87	34.27	27.13
Eggs	5.02	6.49	5.50
Milk and cheese	10.58	10.87	10.37
Butter and other fats	9.30	9.28	10.26
Grain products	21.25	15.72	14.71
Sugar	4.43	4.87	4.57
Vegetables	10.93	8.98	11.13
Relative cost	80.	116.	124.
Calories, per man per day	3049.	3361.	3570.
Protein, grams, per day	103.	114.	107.
Phosphorus, grams, per day	1.51	1.77	1.74
Calcium, gram, per day	0.66	0.82	0.83
Iron, gram, per day	0.0169	0.0194	0.0184

The high-fruit dietaries are more costly than the medium-fruit dietaries but the difference here is not nearly so great, the cases of very low cost being evidently almost entirely confined to the low-fruit group. The grouping according to prominence of fruits and vegetables combined seems more significant for the purpose of our present study than the grouping according to prominence of either vegetables or fruits alone.

Vegetables and fruit. Table 74 shows the relation of prominence of vegetables and fruit in the food budget to its other items and to the cost and food value of the diet as a whole. It will be seen that this combined item becomes more prominent in the dietaries of higher cost and that increasing prominence of vegetables and fruits is accompanied by increasing prominence of fats and decreasing prominence of meats and grain products. With increasing prominence of vegetables and fruits there is increase in the energy, phosphorus, calcium, and iron values, and it is safe to infer in the vitamin values also, of the diet, while the protein remains practically unchanged. It will be noted that prominence of fruit and vegetables improves the food value of the diet at every point at which the American dietary is likely to need improvement.

TABLE 74. RELATION OF THE PROMINENCE OF VEGETABLES AND FRUIT IN THE DIETARY TO THE PERCENTAGE DISTRIBUTION OF COST AND TO FOOD VALUE

EXPENDITURE FOR EACH TYPE OF FOOD IN PERCENTAGE OF THE WHOLE	FRUIT AND VEGETABLES "LOW"	FRUIT AND VEGETABLES "MEDIUM"	FRUIT AND VEGETABLES "HIGH"
Fruit and vegetables	6.77	14.85	26.98
Meats and fish	37.69	32.81	25.39
Eggs	4.37	6.02	4.82
Milk and cheese	10.82	10.73	9.98
Butter and other fats	8.77	9.21	11.25
Grain products	22.63	18.21	14.68
Sugar	4.68	4.61	4.33
Relative cost	76.	104.	112.
Calories, per man per day	3086.	3170.	3661.
Protein, grams, per day	105.	108.	105.
Phosphorus, grams, per day	1.58	1.60	1.76
Calcium, gram, per day	0.59	0.75	0.87
Iron, gram, per day	0.0157	0.0180	0.0193

Milk, vegetables, and fruit. The relation of the prominence in the food budget of milk, vegetables, and fruit taken together, upon the other expenditures for food and upon the food value of the resulting diet is shown in Table 75. With increasing prominence of milk, vegetables, and fruit there is decreasing prominence of meats and grain products, the expenditures for eggs, fats, and sugar remaining essentially unchanged. The dietaries low in milk, vegetables, and fruit include most, if not all, of the poverty dietaries, the American poor tending, as a rule, to underestimate the value of milk, vegetables, and fruit and to overestimate the value of meat (largely no doubt because their more prosperous and more highly educated neighbors so often make the same mistake).

TABLE 75. RELATION OF THE PROMINENCE OF MILK, VEGETABLES, AND FRUIT IN THE DIETARY TO THE PERCENTAGE DISTRIBUTION OF COST AND TO FOOD VALUE

EXPENDITURE FOR EACH TYPE OF FOOD IN PERCENTAGE OF THE WHOLE	MILK, VEGETABLES, AND FRUIT — "LOW"	MILK, VEGETABLES, AND FRUIT — "MEDIUM"	MILK, VEGETABLES, AND FRUIT — "HIGH"
Milk, vegetables and fruit	15.30	26.23	39.74
Meats and fish	38.17	33.05	22.94
Eggs	5.18	5.97	4.37
Butter and other fats	9.55	9.25	10.40
Grain products	23.54	17.20	15.48
Sugar	4.56	4.51	4.73
Relative cost	80.	104.	100.
Calories, per man per day	2985.	3185.	3765.
Protein, grams, per day	101.	107.	110.
Phosphorus, grams, per day	1.40	1.61	1.92
Calcium, grams, per day	0.46	0.75	1.03
Iron, gram, per day	0.0157	0.0183	0.0191

The dietaries low in milk, vegetables, and fruit were low in total calories, phosphorus, calcium, and iron and we may be sure that they were low in vitamin values also. Compared with the "medium" dietaries those higher in milk, vegetables, and fruit were lower in cost, higher in calories, protein, phosphorus, calcium, and iron and unquestionably in vitamins A, B, and C also.

Thus increased prominence of milk, vegetables, and fruit combined (over that of the average or " medium " dietaries) had the effect of improving the diet materially in every known factor of food value without any increase in its cost.

Suggestions for Family Food Budgets

It does not lie within the scope of this work to offer suggestions regarding the planning of nutritionally well-balanced meals from day to day. This has been done most admirably and interestingly by Professor Mary S. Rose in her book entitled *Feeding the Family*.

Those who for any reason do not thus plan the daily meals with conscious reference to the food value of each may yet make use of the newer knowledge of nutrition and food values and be reasonably assured of a well-balanced diet by assigning to each important article or type of food its proper place in the food budget and " checking up " the budget monthly in connection with the paying of the bills. From the data examined in the preceding section it is plain that our present knowledge very clearly indicates that the average or typical American food budget can be easily improved by giving greater prominence to milk, vegetables, and fruit, the money needed for this being obtained if necessary by reducing the expenditure for meat.

In the writer's own household one fourth or more of the money spent for food is spent for milk, about one fifth for vegetables and fruit, and less than one sixth for meats, poultry, and fish.

Based apparently upon the experience of Miss Gillett in her work upon family nutrition problems for the New York Association for Improving the Condition of the Poor, the Food Administration issued, as a part of its educational program, a simple suggested family food budget essentially as follows:

Divide your food money into fifths:

One fifth, more or less, for vegetables and fruit;
One fifth, or more, for milk and cheese;
One fifth, or less, for meats, fish, and eggs;
One fifth, or more, for bread and cereals;
One fifth, or less, for fats, sugar, and other groceries and food adjuncts.

The recommendation that a fifth or more of the total food-money be spent for bread and cereals aims at making a dietary more economical than the American average.

In the writer's opinion the proportion spent for bread and cereals may well vary with the need for strict economy. It must be high in an extremely low-cost dietary and may be considerably lower where the level of expenditure is more liberal. No one fixed percentage for this item, therefore, would seem best for all cases. The same seems true of butter and eggs, which naturally will occupy a larger place in dietaries on a comfortable plane of expenditure than in those which must be held to the minimum cost which is consistent with adequate nutrition.

Whatever the level of expenditure, however, it seems wise to observe the two "rules" that

(1) at least as much should be spent for milk (including cream and cheese if used) as for meats, poultry, and fish, and

(2) at least as much should be spent for fruits and vegetables as for meats, poultry, and fish.

These simple "rules," suggested by the writer many years ago, are said to have been found useful as a guide in both low-cost and liberal-cost food budgets, and can obviously be used in all cases in which even the simplest of records of expenditure are kept. They tend to make milk, vegetables, and fruits more prominent and meat somewhat less prominent than in the average American dietary for reasons which have been discussed in this and in previous chapters. The food budget of the writer's household for over twenty years, in the course of which time the dietary needs both of adults and of children in all stages of growth and development has been provided for, has always met or more than met these "rules," and there has never been any reason to doubt their desirability, or any desire for a dietary such as is represented by the average food budget shown in the first column of Table 65 and which has been considered typical in the past.

From among the 224 American dietary records above discussed, 25 were taken at random and a calculation was made to see how their nutritive values would have been affected if, with no change in the amount of money spent or in the nature of the foods selected, the quantities had been simply readjusted in accordance with the two "rules" just given. It was found that such readjustment without change in cost would leave the protein practically unchanged in amount while the Calories and iron would be slightly increased and the calcium and phosphorus materially increased and brought into better quantitative relations with each other. There is also ample evidence that the dietaries thus adjusted would be improved in their content of all three of the vitamins.

In summarizing nutritive requirements we usually follow the order which seems to offer the best sequence for study, namely, energy (or calories), protein, mineral elements, and vitamins. In the actual purchase of food, however, it is usually best to begin by providing the requisite amounts of those articles of food upon which we are chiefly dependent for vitamins and mineral elements, after which the remainder of the protein and energy required may be obtained from the other types of food with few limitations other than those imposed by appetite, purse, and individual digestive powers. In accordance with this principle, Lusk pronounced the dictum which has been widely quoted that "the housewife having a family of five to feed should buy three quarts of milk a day before she buys a pound of meat."

Combining the principle of providing first of all for an adequate milk supply, with that of a simple budgetary division of the money available for food, it has been recommended that the person responsible for the selection of food proceed somewhat as follows:

First set aside the money for a constant milk supply sufficient to provide a quart of milk a day for every child and a pint for every adult; then divide the rest of the food money into three approximately equal parts, one for fruits and vegetables, one for breadstuffs and cereals and for butter and other fats, and one for meats, eggs, sweets, and miscellaneous.

The Relation of Food to Health

Health is defined in the Century Dictionary as follows: "Soundness of body; that condition of a living organism and of its various parts and functions which conduces to efficient and prolonged life; a normal bodily condition. Health implies also, physiologically, the ability to produce offspring fitted to live long and to perform efficiently the ordinary functions of their species."

This is both a positive and a comprehensive conception of health, and it is of much interest to note that all its phases have now been covered in studies of the influence of foods upon the health of experimental animals. In human experience so many factors may enter to influence health in the course of a lifetime that it is hard to separate and measure the effects of food alone upon the whole duration and efficiency of life. But this can be done with laboratory animals of rapid growth and early maturity, such as the rat, and in experiments with the rat it has been possible to determine, under conditions uniform in all other respects, the influence of modifications of the diet upon the various factors of health comprised in the broad definition above quoted. And among the recent findings of nutrition experiments carried through successive generations of such laboratory animals is the fact that starting with a dietary already adequate according to current standards we may by improvement of the diet induce a higher degree of health and vigor. This has been repeatedly and conclusively shown to result from an improvement consisting of increasing the proportion of milk in an already adequate diet; and the diet thus improved was rendered still more effective by the addition of a fresh green vegetable. In several such investigations the families under test have been kept upon the same diets for several generations. A family of experimental rats in the writer's laboratory has thrived for twelve generations upon an absolutely uniform diet of whole wheat and whole milk.

Obviously, experiments extending through whole generations cannot be duplicated upon human beings, but very conclusive experiments and observations have been made upon many growing children which show plainly that more than average prominence of milk, fruit, and vegetables in the dietary results in better than average health and development. McCollum has also repeatedly pointed out that similar results are observable in the large-scale experience of whole communities living under different conditions of food supply.

The results of animal experimentation and of human experience agree, and together they give us good ground for the confident belief that the sane application of our present newer knowledge of nutrition and food values will materially improve our food economics and will bring to a larger proportion of our people that full measure of health and vigor which only the more fortunate now enjoy.

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APPENDIX A

THE FOOD AND DRUGS ACT ("PURE FOOD LAW"), WITH EXTRACTS FROM THE RULES AND REGULATIONS ADOPTED FOR ITS ENFORCEMENT AND THE FOOD INSPECTION DECISIONS THEREUNDER

THE FOOD AND DRUGS ACT, JUNE 30, 1906, AS AMENDED AUGUST 23, 1912, MARCH 3, 1913, AND JULY 24, 1919

AN ACT For preventing the manufacture, sale, or transportation of adulterated or misbranded or poisonous or deleterious foods, drugs, medicines, and liquors, and for regulating traffic therein, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be unlawful for any person to manufacture within any Territory or the District of Columbia any article of food or drug which is adulterated or misbranded, within the meaning of this act; and any person who shall violate any of the provisions of this section shall be guilty of a misdemeanor, and for each offense shall, upon conviction thereof, be fined not to exceed five hundred dollars or shall be sentenced to one year's imprisonment, or both such fine and imprisonment, in the discretion of the court, and for each subsequent offense and conviction thereof shall be fined not less than one thousand dollars or sentenced to one year's imprisonment, or both such fine and imprisonment, in the discretion of the court.

SEC. 2. That the introduction into any State or Territory or the District of Columbia from any other State or Territory or the District of Columbia, or from any foreign country, or shipment to any foreign country of any article of food or drugs which is adulterated or misbranded, within the meaning of this act, is hereby prohibited; and any person who shall ship or deliver for shipment from any State or Territory or the District of Columbia to any other State or Territory or the District of Columbia, or to a foreign country, or who shall receive in any State or Territory or the District of Columbia from any other State or Territory or the District of Columbia, or foreign country, and having so received, shall deliver, in original unbroken packages, for pay or otherwise, or offer to deliver to any other person, any such article so adulterated or misbranded within the meaning of this act, or any person who shall sell or offer for sale in the District of Columbia or the Territories of the United States any such adulterated or misbranded foods or drugs, or export or offer to export the same to any foreign country, shall be guilty of a misdemeanor, and for such offense be fined not exceeding two hundred dollars for the first offense, and upon conviction for each subsequent offense not exceeding three hundred dollars or be imprisoned not exceeding one year, or both, in the discretion of the court: *Provided*, That no article shall be deemed misbranded or adulterated within the provisions of this act when intended for export to any foreign country and prepared or packed according to the specifications or directions of the foreign purchaser when no substance is used in the preparation or packing thereof in conflict with the laws of the foreign country to which said article is intended to be shipped; but if said article shall be in fact sold or offered for sale for domestic use or consumption, then this proviso shall not exempt said article from the operation of any of the other provisions of this act.

SEC. 3. That the Secretary of the Treasury, the Secretary of Agriculture, and the Secretary of Commerce and Labor shall make uniform rules and regulations for carrying out the provisions of this act, including the collection and examination of specimens of foods and drugs manufactured or offered for sale in the District of Columbia, or in any Territory of the United States, or which shall be offered for sale in unbroken packages in any State other than that in which they shall have been respectively manufactured or produced, or which shall be received from any foreign country, or intended for shipment to any foreign country, or which may be submitted for examination by the chief health, food, or drug officer of any State, Territory, or the District of Columbia, or at any domestic or foreign port through which such product is offered for interstate commerce, or for export or import between the United States and any foreign port or country.

SEC. 4. That the examinations of specimens of foods and drugs shall be made in the Bureau of Chemistry of the Department of Agriculture, or under the direction and supervision of such bureau, for the purpose of determining from such examinations whether such articles are adulterated or misbranded within the meaning of this act; and if it shall appear from any such examination that any of such specimens is adulterated or misbranded within the meaning of this act, the Secretary of Agriculture shall cause notice thereof to be given to the party from whom such sample was obtained. Any party so notified shall be given an opportunity to be heard, under such rules and regulations as may be prescribed as aforesaid, and if it appears that any of the provisions of this act have been violated by such party, then the Secretary of Agriculture shall at once certify the facts to the proper United States district attorney, with a copy of the results of the analysis or the examination of such article duly authenticated by the analyst or officer making such examination, under the oath of such officer. After judgment of the court, notice shall be given by publication in such manner as may be prescribed by the rules and regulations aforesaid.

SEC. 5. That it shall be the duty of each district attorney to whom the Secretary of Agriculture shall report any violation of this act, or to whom any health or food or drug officer or agent of any State, Territory, or the District of Columbia shall present satisfactory evidence of any such violation, to cause appropriate proceedings to be commenced and prosecuted in the proper courts of the United States, without delay, for the enforcement of the penalties as in such case herein provided.

SEC. 6. That the term "drug," as used in this act, shall include all medicines and preparations recognized in the United States Pharmacopœia or National Formulary for internal or external use, and any substance or mixture of substances intended to be used for the cure, mitigation, or prevention of disease of either man or other animals. The term "food," as used herein, shall include all articles used for food, drink, confectionery, or condiment by man or other animals, whether simple, mixed, or compound.

SEC. 7. That for the purposes of this act an article shall be deemed to be adulterated:

In case of drugs:

First. If, when a drug is sold under or by a name recognized in the United States Pharmacopœia or National Formulary, it differs from the standard of strength, quality, or purity, as determined by the test laid down in the United States Pharmacopœia or National Formulary official at the time of investigation: *Provided*, That no drug defined in the United States Pharmacopœia or National Formulary shall be deemed to be adulterated under this provision if the standard of strength, quality, or purity be plainly stated upon the bottle, box, or other container thereof, although the standard may differ from that determined by the test laid down in the United States Pharmacopœia or National Formulary.

Second. If its strength or purity fall below the professed standard or quality under which it is sold.

In the case of confectionery:

If it contain terra alba, barytes, talc, chrome yellow, or other mineral substance or poisonous color or flavor, or other ingredient deleterious or detrimental to health, or any vinous, malt, or spirituous liquor or compound or narcotic drug.

In case of food:

First. If any substance has been mixed and packed with it so as to reduce or lower or injuriously affect its quality or strength.

Second. If any substance has been substituted wholly or in part for the article.

Third. If any valuable constituent of the article has been wholly or in part abstracted.

Fourth. If it be mixed, colored, powdered, coated, or stained in a manner whereby damage or inferiority is concealed.

Fifth. If it contain any added poisonous or other added deleterious ingredient which may render such article injurious to health: *Provided*, That when in the preparation of food products for shipment they are preserved by any external application applied in such manner that the preservative is necessarily removed mechanically, or by maceration in water, or otherwise, and directions for the removal of said preservative shall be printed on the covering or the package, the provisions of this act shall be construed as applying only when said products are ready for consumption.

Sixth. If it consist in whole or in part of a filthy, decomposed, or putrid animal or vegetable substance, or any portion of an animal unfit for food, whether manufactured or not, or if it is the product of a diseased animal, or one that has died otherwise than by slaughter.

SEC. 8. That the term "misbranded," as used herein, shall apply to all drugs, or articles of food, or articles which enter into the composition of food, the package or label of which shall bear any statement, design, or device regarding such article, or the ingredients or substances contained therein which shall be false or misleading in any particular, and to any food or drug product which is falsely branded as to the State, Territory, or country in which it is manufactured or produced.

That for the purposes of this act an article shall also be deemed to be misbranded:

In case of drugs:

First. If it be an imitation of or offered for sale under the name of another article.

Second. If the contents of the package as originally put up shall have been removed, in whole or in part, and other contents shall have been placed in such package, or if the package fail to bear a statement on the label of the quantity or proportion of any alcohol, morphine, opium, cocaine, heroine, alpha or beta eucaine, chloroform, cannabis indica, chloral hydrate, or acetanilid, or any derivative or preparation of any such substances contained therein.

Third. If its package or label shall bear or contain any statement, design, or device regarding the curative or therapeutic effect of such article or any of the ingredients or substances contained therein, which is false and fraudulent.

In the case of food:

First. If it be an imitation of or offered for sale under the distinctive name of another article.

Second. If it be labeled or branded so as to deceive or mislead the purchaser, or purport to be a foreign product when not so, or if the contents of the package as originally put up shall have been removed in whole or in part and other contents shall have been placed in such package, or if it fail to bear a statement on the label of the quantity or proportion of any morphine, opium, cocaine, heroine, alpha or beta eucaine, chloroform, cannabis indica, chloral hydrate, or acetanilid, or any derivative or preparation of any such substances contained therein.

Third. If in package form, the quantity of the contents be not plainly and conspicuously marked on the outside of the package in terms of weight, measure, or numerical count:

Provided, however, That reasonable variations shall be permitted, and tolerances and also exemptions as to small packages shall be established by rules and regulations made in accordance with the provisions of section three of this act.[1]

Fourth. If the package containing it or its label shall bear any statement, design, or device regarding the ingredients or the substances contained therein, which statement, design, or device shall be false or misleading in any particular: *Provided,* That an article of food which does not contain any added poisonous or deleterious ingredients shall not be deemed to be adulterated or misbranded in the following cases:

First. In the case of mixtures or compounds which may be now or from time to time hereafter known as articles of food, under their own distinctive names, and not an imitation of or offered for sale under the distinctive name of another article, if the name be accompanied on the same label or brand with a statement of the place where said article has been manufactured or produced.

Second. In the case of articles labeled, branded, or tagged so as to plainly indicate that they are compounds, imitations, or blends, and the word "compound," "imitation," or "blend," as the case may be, is plainly stated on the package in which it is offered for sale: *Provided,* That the term "blend" as used herein shall be construed to mean a mixture of like substances, not excluding harmless coloring or flavoring ingredients used for the purpose of coloring and flavoring only: *And provided further,* That nothing in this act shall be construed as requiring or compelling proprietors or manufacturers of proprietary foods which contain no unwholesome added ingredient to disclose their

[1] This section has been amended (Kenyon amendment, 41 Stat. 271) as follows: That the word "package" where it occurs the second and last time in the act entitled "an act to amend section 8 of an act entitled 'An act for preventing the manufacture, sale, or transportation of adulterated or misbranded or poisonous or deleterious foods, drugs, medicines, and liquors, and for regulating traffic therein, and for other purposes,'" approved March 3, 1913, shall include and shall be construed to include wrapped meats inclosed in papers or other materials as prepared by the manufacturers thereof for sale.

trade formulas, except in so far as the provisions of this act may require to secure freedom from adulteration or misbranding.

SEC. 9. That no dealer shall be prosecuted under the provisions of this act when he can establish a guaranty signed by the wholesaler, jobber, manufacturer, or other party residing in the United States, from whom he purchases such articles, to the effect that the same is not adulterated or misbranded within the meaning of this act, designating it. Said guaranty, to afford protection, shall contain the name and address of the party or parties making the sale of such articles to such dealer, and in such case said party or parties shall be amenable to the prosecutions, fines, and other penalties which would attach, in due course, to the dealer under the provisions of this act.

SEC. 10. That any article of food, drug, or liquor that is adulterated or misbranded within the meaning of this act, and is being transported from one State, Territory, District, or insular possession to another for sale, or, having been transported, remains unloaded, unsold, or in original unbroken packages, or if it be sold or offered for sale in the District of Columbia or the Territories, or insular possessions of the United States, or if it be imported from a foreign country for sale, or if it is intended for export to a foreign country, shall be liable to be proceeded against in any district court of the United States within the district where the same is found, and seized for confiscation by a process of libel for condemnation. And if such article is condemned as being adulterated or misbranded, or of a poisonous or of a deleterious character, within the meaning of this act, the same shall be disposed of by destruction or sale, as the said court may direct, and the proceeds thereof, if sold, less the legal costs and charges, shall be paid into the Treasury of the United States, but such goods shall not be sold in any jurisdiction contrary to the provisions of this act or the laws of that jurisdiction: *Provided, however*, That upon the payment of the costs of such libel proceedings and the execution and delivery of a good and sufficient bond to the effect that such articles shall not be sold or otherwise disposed of contrary to the provisions of this act, or the laws of any State, Territory, District, or insular possession, the court may by order direct that such articles be delivered to the owner thereof. The proceedings of such libel cases shall conform, as near as may be, to the proceedings in admiralty, except that either party may demand trial by jury of any issue of fact joined in any such case, and all such proceedings shall be at the suit of and in the name of the United States.

SEC. 11. The Secretary of the Treasury shall deliver to the Secretary of Agriculture, upon his request from time to time, samples of foods and drugs which are being imported into the United States or offered for import, giving notice thereof to the owner or consignee, who may appear before the Secretary of Agriculture, and have the right to introduce testimony, and if it appear from the examination of such samples that any article of food or drug offered to be imported into the United States is adulterated or misbranded within the meaning of this act, or is otherwise dangerous to the health of the people of the United States, or is of a kind forbidden entry into, or forbidden to be sold or restricted in sale in the country in which it is made or from which it is exported or is otherwise falsely labeled in any respect, the said article shall be refused admission, and the Secretary of the Treasury shall refuse delivery to the consignee and shall cause the destruction of any goods refused delivery which shall not be exported by the consignee within three months from the date of notice of such refusal under such regulations as the Secretary of the Treasury may prescribe: *Provided*, That the Secretary of the Treasury may deliver to the consignee such goods pending examination and decision in the matter on execution of a penal bond for the amount of the full invoice value of such goods, together with the duty thereon, and on refusal to return such goods for any cause to the custody of the Secretary of the Treasury, when demanded, for the purpose of excluding them from the country, or for any other purpose, said consignee shall forfeit the full amount of the bond: *And provided further*, That all charges for storage, cartage, and labor on goods which are refused admission or delivery shall be paid by the owner or consignee, and in default of such payment shall constitute a lien against any future importation made by such owner or consignee.

SEC. 12. That the term "Territory" as used in this act shall include the insular possessions of the United States. The word "person" as used in this act shall be construed to import both the plural and the singular, as the case demands, and shall include corporations, companies, societies, and associations. When construing and enforcing the provisions of this act, the act, omission, or failure of any officer, agent, or other person acting for or employed by any corporation, company, society, or association, within the scope of his employment or office, shall in every case be also deemed to be the act, omission, or failure of such corporation, company, society, or association as well as that of the person.

SEC. 13. That this act shall be in force and effect from and after the first day of January, nineteen hundred and seven.

Approved June 30, 1906.

RULES AND REGULATIONS FOR THE ENFORCEMENT OF THE FEDERAL FOOD AND DRUGS ACT

INTRODUCTION

The accompanying rules and regulations for the enforcement of the food and drugs act of June 30, 1906, as amended, supersede those previously promulgated.

Under date of October 17, 1906, 40 rules and regulations for the enforcement of the act were adopted. These original 40 regulations have been amended and modified from time to time by subsequent decisions, but heretofore their numerical order has not been changed. The present revision contains but 31 regulations. A few of the original regulations have been dropped, several new regulations have been added, and the numerical order has been changed. In order to prevent confusion in consulting publications of the department relating to the enforcement of the act which were issued prior to July 1, 1922, there is appended a list of the numbers of the new regulations with the corresponding numbers in the original regulations where there are such corresponding regulations. Where reference is made to a regulation by number in any publication of the department relating to the act issued prior to July 1, 1922, the corresponding number in the new regulations may be obtained from this list.

Detailed information regarding import procedure under the act has been published in Food Inspection Decision 183, issued April 6, 1922. The regulations in Food Inspection Decision 183 differ in no material way from those contained in the present regulations, but set forth the procedure in greater detail.

HENRY C. WALLACE,
Secretary of Agriculture.

WASHINGTON, D. C., *May 20, 1922.*

RULES AND REGULATIONS FOR THE ENFORCEMENT OF THE FOOD AND DRUGS ACT OF JUNE 30, 1906, AS AMENDED

Regulation 1. Short Title of the Act

The act, "For preventing the manufacture, sale, or transportation of adulterated or misbranded or poisonous or deleterious foods, drugs, medicines, and liquors, and for regulating traffic therein, and for other purposes," approved June 30, 1906 (34 Stat. 768), as amended by the act approved August 23, 1912 (37 Stat. 416), by the act approved March 3, 1913 (37 Stat. 732), by the act approved July 24, 1919 (41 Stat. 271), and as it may be amended hereafter, shall be known and referred to as the Federal food and drugs act.

Regulation 2. Scope of the Act

The provisions of the act apply to foods and to drugs which have been shipped or delivered for shipment in interstate commerce, or which are exported or offered for export to foreign countries, or which are being transported in interstate commerce for sale or have been transported in interstate commerce, or which have been received from a foreign country, or which are manufactured, sold, or offered for sale in the District of Columbia, Territories of the United States, or insular possessions.

Regulation 3. Collection of Samples and Evidence for action under Sections 1, 2, and 10

(Section 3)

(*a*) A sample for examination by or under the direction and supervision of the Bureau of Chemistry shall be collected by —

(1) An authorized agent of the Department of Agriculture.

(2) A health, food, or drug officer of any State, Territory, city, or the District of Columbia, commissioned by the Secretary of Agriculture for this purpose.

(3) An agent of any health, food, or drug officer of any State, Territory, city, or the District of Columbia when such agent is authorized by the Secretary of Agriculture through such health, food, or drug officer commissioned by the Secretary of Agriculture for this purpose.

(*b*) Foods or drugs within the scope of sections 1, 2, and 10 of the act may be sampled wherever found. The sample shall be representative in all cases. A sample of packaged goods shall consist usually of three packages when the individual package is 4 pounds or less in weight or 2 quarts or less in volume. If the goods are in larger packages, one or two packages may suffice, depending on the character of the goods and the nature of the examination to be made. Samples whether from package or bulk goods shall, when practicable, be divided into three parts or subdivisions. All subdivisions shall be properly identified and sealed with a seal provided for the purpose by the Department of Agriculture.

(*c*) The sample shall be delivered for examination by or under the supervision of the Bureau of Chemistry. Subdivisions of the sample remaining intact after analysis, except when perishable, shall be held under seal. Upon request one subdivision if available shall be delivered to the party or parties interested.

(*d*) At the time of collection all marks, brands, or tags, or accompanying printed or written matter pertaining to the article sampled shall be recorded. The names of the vendor and agent from whom the sample is collected, together with the date of collection, shall also be recorded. All original invoices, bills of lading, freight bills, and other documentary evidence of shipment or sale, or copies thereof, shall be procured from the dealers, carriers, warehousemen, or other persons having possession of such documents.

(*e*) Records of common carriers and warehousemen shall be examined from time to time for the purpose of obtaining evidence of violations of the Federal food and drugs act.

(*f*) Establishments in which foods or drugs are prepared in whole or in part for sale in the Territories or the District of Columbia or for transportation in interstate or foreign commerce may be inspected by any authorized agent of the Department of Agriculture.

Regulation 4. Methods of Analysis

(Section 4)

(*a*) Drugs recognized in the United States Pharmacopœia or National Formulary for which methods of analysis have been prescribed in said Pharmacopœia or National Formulary shall be analyzed by these methods.

(*b*) All foods and such drugs as are not included in paragraph (*a*) of this regulation shall be analyzed by the methods prescribed by the Association of Official Agricultural Chemists, when applicable, provided, however, that any method of analysis or examination satisfactory to the Bureau of Chemistry may be employed.

(*c*) All foods or drugs for which no methods of analysis have been prescribed, either in the Pharmacopœia or National Formulary or by the Association of Official Agricultural Chemists, shall be analyzed or examined by methods satisfactory to the Bureau of Chemistry.

Regulation 5. Hearings — Procedure without Hearing

(Sections 4 and 5)

(*a*) Whenever it appears that an article is adulterated or misbranded within the meaning of the act, and proceedings are contemplated under section 1 or 2, notice shall be given to the party or parties against whom prosecution is under consideration and to other interested parties, and a date shall be fixed at which such party or parties may be heard. The hearing shall be held at the office of the Bureau of Chemistry most convenient to the parties cited, and shall be private and confined to questions of fact. The parties notified may present evidence, either oral or written, in person or by attorney, to show cause why the matter should not be referred for prosecution as a violation of the Federal food and drugs act.

(*b*) After a hearing is held, if it appears that the act has been violated, the Secretary of Agriculture shall report the facts to the proper United States attorney.

(*c*) The health, food, or drug officer or agent of any State, Territory, city, or the District of Columbia who shall obtain satisfactory evidence of a violation of the act may present such evidence direct to the proper United States district attorney for appropriate action under the Federal food and drugs act.

(*d*) When the procedure outlined in paragraph (*c*) is not followed, the health, food, or drug officer or agent of any State, Territory, city, or the District of Columbia, commissioned by the Secretary of Agriculture, who obtains satisfactory evidence of any violation of section 1 or 2 of the act shall submit such evidence to the Bureau of Chemistry in order that a date for a hearing may be fixed and notice given to the proper party.

Regulation 6. Guaranty

(Section 9)

(*a*) Any wholesaler, manufacturer, jobber, or other party residing in the United States may furnish to any dealer to whom he sells any article of food or drug a guaranty that such article is not adulterated or misbranded within the meaning of the Federal food and drugs act.

(*b*) Each guaranty to afford protection shall be signed by, and shall contain the name and address of, the wholesaler, manufacturer, jobber, dealer, or other party residing in the United States making the sale of the article or articles covered by it to the dealer, and shall be to the effect that such article or articles are not adulterated or misbranded within the meaning of the Federal food and drugs act, specifically designating said act.

(*c*) If a particular guaranty in respect to any article or articles be given, it should be incorporated in or attached to the bill of sale, invoice, bill of lading, or other schedule, giving the name and quantity of the article or articles sold, and shall not appear on the label or package. A guaranty, if worded substantially according to the following form, will comply with all the requirements of the act:

I (we), the undersigned, do hereby guarantee that the articles of food (or drugs) listed herein (or specifying the same) are not adulterated or misbranded within the meaning of the Federal food and drugs act.

(Signature and address of guarantor.)

(*d*) In lieu of a particular guaranty for each consignment, lot, or article of food or drugs, a general continuing guaranty may be furnished by the guarantor to actual or prospective purchasers. Such general guaranty shall conform to the requirements of paragraph (*b*) of this regulation.

(*e*) It having been determined that the legends "Guaranteed under the food and drugs act, June 30, 1906," and "Guaranteed by (name of guarantor), under the food and drugs act, June 30, 1906," borne on the labels or packages of foods and drugs, are each misleading and deceptive, in that the public is induced by such legends to believe that the articles to which they relate have been examined and approved by the Government and that the Government guarantees that they comply with the law, the use of either legend, or any similar legend, on labels or packages is prohibited.

(*f*) A dealer in food or drug products will not be liable to prosecution if he can establish that the articles were sold to him under a guaranty given in compliance with this regulation.

Regulation 7. Publication

(Section 4)

(*a*) After judgment of the court in any proceeding under the act, notice shall be given by publication. Such notice shall include the finding of the court and may include the findings of the analyst and such explanatory statements of facts as the Secretary of Agriculture may deem appropriate.

(*b*) This publication may be made in the form of a circular, notice, or bulletin, as the Secretary of Agriculture may direct.

(*c*) If an appeal be taken from the judgment of the court before such publication, that fact shall appear.

Regulation 8. Standards for Drugs

(Section 7, in the case of drugs)

(*a*) A drug sold under or by a name, or a synonym, recognized in the United States Pharmacopœia or National Formulary, unless labeled as prescribed by paragraph (*b*) of this regulation, shall conform to the standard of strength, quality, or purity for the article as determined by the test laid down in the United States Pharmacopœia or National Formulary official at the time of investigation. An article shall not be deemed to conform to such standard of strength, quality, or purity unless it conforms in every respect to all the requirements and specifications of the United States Pharmacopœia or the National Formulary for the article.

(*b*) A drug sold under or by a name, or a synonym, recognized in the United States Pharmacopœia or the National Formulary which does not conform to the standard of strength, quality, or purity for the article as determined by the test laid down therein shall be labeled with a statement to the effect that the drug is not a United States Pharmacopœia or National Formulary article; in addition it shall be labeled with a statement showing its own actual strength, quality, or purity, or else with a clear and exact statement of the nature and extent of the deviation from a standard of strength, quality, or purity set out for such article in the United States Pharmacopœia or National Formulary.

Regulation 9. Confectionery

(Section 7)

The term "food" includes articles used for confectionery. The provisions of the act relating to food, as well as the specific provisions relating to confectionery, apply to confectionery.

Regulation 10. Powdered

(Section 7, paragraph fourth, in the case of food)

An article of food shall neither be covered with a powder nor reduced to a powder in such manner that damage or inferiority is concealed.

Regulation 11. Poisonous or Deleterious Ingredients

(Section 7, paragraph fifth, in the case of food)

A poisonous or other deleterious ingredient shall not be added to an article of food in such quantity as may by any possibility render the article injurious to health. Any ingredient artificially introduced into an article of food is an added ingredient.

Regulation 12. External Application of Preservatives

(Section 7, proviso of paragraph fifth, in the case of food)

A food to which a preservative is applied externally, in order to be within the proviso of section 7, paragraph fifth, must bear on the covering or package directions for the effective removal of such preservative.

Regulation 13. Colors and Preservatives

(Section 7, in the case of food)

(*a*) Only harmless colors and harmless preservatives may be used in articles of food.

(*b*) A color, preservative, or other substance, even though harmless, shall not be used in the preparation of any article of food in a manner whereby damage or inferiority is concealed.

(*c*) The Secretary of Agriculture shall determine from time to time the wholesomeness of colors, preservatives, and other substances which are added to foods, and shall make public announcement in such manner as he may deem appropriate of the results of the investigations. When so published, the results of the investigation shall serve as a guide in enforcing the act.

(*d*) The Secretary of Agriculture may authorize the certification of colors found by him to be in compliance with the law and these regulations.

Regulation 14. Label

(Section 8)

(*a*) The term "label," as used in the act, includes any legend and descriptive matter or design appearing upon the article or its container, and also includes circulars, pamphlets, and the like which are packed and go with the article to the purchaser, and such letters, circulars, and pamphlets to which reference is made either on the label attached to the package or on the package itself.

(*b*) The label shall bear, plainly and conspicuously displayed, all the information specifically required by the act, *e.g.*, the quantity of the contents of food in package form, in accordance with regulation 26, and the quantity or proportion of the drugs named in section 8 of the act, in accordance with regulations 24 and 25. The label shall also bear such other descriptive matter as the character of the product may require.

(*c*) A label in a foreign language shall conform to these regulations and shall bear all the information required by the act in English, as well as in each of the foreign languages used to describe the article of food or drugs.

(*d*) The label shall be free from any statement, design, or device regarding the article or the ingredients or substances contained therein, or quality thereof, or place or origin, which is false or misleading in any particular. The terms "design" and "device" include pictorial matter of every description, abbreviations, characters, and signs.

(*e*) A food or drug product shall not be labeled or branded in such a manner as to deceive or mislead the purchaser. Direct misstatements and indirect misrepresentations regarding the article or its ingredients by means of designs, printed testimonials, devices, or artifices in the arrangement, style, or dress of the package, or in the arrangement of the printed or pictorial matter in or upon the label or package are prohibited.

(*f*) An article containing more than one food product or active medicinal agent is misbranded if named after a single constituent. In the case of drugs the nomenclature employed by the United States Pharmacopœia and the National Formulary shall obtain.

(*g*) The statement of the formula is not required on the label except in so far as may be necessary to prevent adulteration or misbranding.

(*h*) An article so labeled as to convey the impression that all of its ingredients are declared is misbranded if the list of ingredients is incomplete.

Regulation 15. When Label Is Required

(Section 8)

The use of a label is not compulsory except in the following cases:

(*a*) Imitations (regulation 20, (*a*)).

(*b*) Foods and drugs containing the ingredients mentioned in section 8, paragraph second, in the case of drugs, and paragraph second, in the case of foods (regulations 24 and 25).

(*c*) Drugs which fall within the proviso of section 7, paragraph first, in the case of drugs (regulation 8, (*b*)).

(*d*) Foods in package form (regulation 26).

(*e*) Compounds and blends which are brought within the proviso of section 8, paragraph fourth, in the case of foods (regulations 19 and 20).

(*f*) Substitution (regulation 21).

(*g*) Foods which fall within the proviso of section 7, paragraph fifth, in the case of food (regulation 12).

(*h*) By-product or waste material (regulation 22).

(*i*) Articles intended for export which fall within the proviso of section 2 of the act (regulation 27, (*b*)).

(*j*) Articles which require specific labeling to avoid adulteration or misbranding.

Regulation 16. Name and Address of Manufacturer

(Section 8)

(*a*) The name of the manufacturer or producer need not be given upon the label, but if given it must be the true name. The words "Packed for ——," "Distributed by ——," or some equivalent phrase, shall be added to the label in case the name which appears upon the label is not that of the actual manufacturer or producer.

(*b*) The place of manufacture or production need not be given upon the label except where, in order to avoid misbranding, it is necessary to indicate clearly that the article is of domestic and not foreign origin, and also in the case of mixtures and compounds sold under their own distinctive names (regulation 19), to bring the articles within the terms of the proviso of section 8, paragraph fourth, of the act.

(*c*) The place of manufacture or production, if given, must be correctly stated.

(*d*) When a person, firm, or corporation actually manufactures or produces a food or a drug in two or more places, the actual place of manufacture or production of each particular package need not be stated on the label except when the mention of any place, to the exclusion of the others, deceives or misleads.

Regulation 17. Character of Name

(Section 8)

(*a*) A simple or unmixed food or drug product shall be sold by its common name in the English language; or, if a drug recognized in the United States Pharmacopœia or National Formulary, by the name or names therein designated.

(*b*) A geographical name indicating that a food or drug product was manufactured or produced in a specific place shall not be used unless such product was manufactured or produced in that place.

(*c*) A name which is distinctive of a product of a specific foreign country shall not be used upon an article not manufactured or produced in that country, except as an indication of the type or style of quality or manufacture, and then only when the product possesses substantially the characteristic qualities of the product of that foreign country. Such name shall be so qualified as to remove any impression that the article was manufactured or produced in the country in which the name is distinctive.

Regulation 18. "Distinctive Name" and "Own Distinctive Name"
(Section 8)

(*a*) A "distinctive name" is a name that distinguishes one kind of food from another.

(*b*) The expression "own distinctive name," as used in section 8, paragraph fourth, means a name which is purely arbitrary or fanciful and distinguishes a particular article of food from all other articles of food. It shall not give a false indication of origin, character, composition, ingredients, or place of manufacture, and shall not lead the purchaser to suppose that the product is other than what it is.

Regulation 19. Mixtures or Compounds with Distinctive Names
(Section 8, paragraph fourth, in the case of food, subparagraph first)

(*a*) The terms "mixtures" and "compounds" are interchangeable.

(*b*) Mixtures or compounds with distinctive names shall not be imitations of other articles, whether simple, mixed, or compound, or offered for sale under the names of other articles. In addition to the distinctive name, they shall bear on the same label or brand the name of the place of manufacture or production. If the name of the place be one which is found in different States, Territories, or countries, the name of the State, Territory, or country, as well as the name of the place, must be stated.

(*c*) An article of food is not within the terms of the proviso of section 8, paragraph fourth, subparagraph first, unless it is labeled in accordance with this regulation.

Regulation 20. Imitations, Blends, Compounds without Distinctive Names
(Section 8, paragraph first, in the case of food, and paragraph fourth, in the case of food, subparagraph second)

(*a*) An imitation shall bear on the label the word "imitation," and, in addition, a clear statement of the principal or essential ingredients of the article.

(*b*) Compounds and blends, in order to be within section 8, paragraph fourth, in the case of food, subparagraph second, shall bear on the label the word "compound" or "blend," as the case may be, and, in addition, a clear statement of the principal or essential ingredients of the article.

Regulation 21. Substitution

(Sections 7 and 8)

When a substance of a recognized quality commonly used in the preparation of a food product is replaced in whole or in part by another substance not injurious or deleterious to health, the name of the substitute shall appear upon the label.

Regulation 22. By-product or Waste Food Material

(Sections 7 and 8)

A food which consists in whole or in part of sound by-product or waste food material, such as pieces, stems, trimmings, and the like, shall not be labeled with the unqualified name of the substance from which such material is derived.

Regulation 23. Certain Adulterations not Corrected by Label

(Section 7)

Proper labeling alone will not remove an article from the operation of the law. Certain forms of adulteration, *e.g.*, the addition of a poisonous or deleterious ingredient which may render the article injurious to health, cannot be corrected by any form of labeling.

Regulation 24. Substances Required to Be Stated on the Label

(Section 8, paragraph second, in the case of drugs, and paragraph second, in the case of food)

(*a*) A drug is misbranded if it fails to bear a statement on the label of the quantity or proportion of alcohol of any kind, morphine, opium, heroine, cocaine, alpha or beta eucaine, chloroform, cannabis indica, chloral hydrate, acetanilid, or any derivative or preparation of any such substances therein contained. Such statement shall be made in a plain and conspicuous manner.

(*b*) A food is misbranded if it fails to bear a statement on the label of the quantity or proportion of any morphine, opium, heroine, cocaine, alpha or beta eucaine, chloroform, cannabis indica, chloral hydrate, or acetanilid, or any derivative or preparation of any such substances therein contained. Such statement shall be made in a plain and conspicuous manner.

(*c*) The term "alcohol" without qualification means ethyl alcohol. If any alcohol other than ethyl alcohol be present in a drug, the kind must be stated on the label. No statement is required of the presence of alcohol in foods.

(*d*) In declaring the quantity or proportion of any of the substances specified in paragraphs (*a*) and (*b*) of this regulation, the names by which they are designated in the act shall be used. In declaring the quantity or proportion of derivatives of any of the specified substances, in addition to the trade name of the derivative, the name of the specified substance shall also be stated so as to indicate clearly that the product is a derivative of the particular specified substance.

Regulation 25. Method of Stating Quantity or Proportion

(Section 8)

(*a*) The quantity of alcohol in a drug shall be stated in terms of the average percentage by volume of absolute alcohol in the finished product.

(*b*) In a liquid the quantity of any substance specified in regulation 24, except alcohol, and the quantity of any derivative or preparation of any such substance, including derivatives of alcohol, shall be stated in terms of grains or minims per fluid ounce; in a solid, the quantity shall be stated in terms of grains or minims per avoirdupois ounce, provided that statements may be in terms of the metric system, if preferred.

(*c*) When two or more pills, wafers, tablets, powders, capsules, and the like are put up for sale or distribution in the same container, the quantity of the specified substance or derivative present in each pill, wafer, tablet, powder, capsule, or other unit shall be stated.

(*d*) A statement of the maximum quantity or proportion of any substance specified in regulation 24 present will meet the requirements, provided the maximum stated does not vary materially from the average quantity or proportion.

Regulation 26. Statement of Weight, Measure, or Count

(Section 8, paragraph third, in the case of food)

(*a*) Except as otherwise provided by this regulation, a package of food shall be plainly and conspicuously marked with the quantity of the contents in terms of weight, measure, or numerical count on the outside of the container, or of the covering of the package usually delivered to the consumer.

(*b*) The quantity of the contents so marked shall be the quantity of food in the package.

(*c*) The statement of the quantity of the contents shall be plain and conspicuous, shall not be a part of or obscured by any legend or design, and shall be so placed and in such characters as to be readily seen and clearly legible when the size of the package and the circumstances under which it is ordinarily examined by purchasers or consumers are taken into consideration.

(*d*) The quantity of the contents when stated by weight or measure shall be marked in terms of the largest unit contained in the package, except that, in the case of an article with respect to which there exists a definite trade custom for marking the quantity of the article in terms of fractional parts of larger units, it may be so marked in accordance with the custom. Common fractions shall be reduced to their lowest terms; fractions expressed as decimals shall be preceded by zero and shall be carried out to not more than two places.

(*e*) Statement of weight shall be in terms of the avoirdupois pound and ounce; statement of liquid measure shall be in terms of the United States gallon of 231 cubic inches and its customary subdivisions, *i.e.*, gallons, quarts, pints, or fluid ounces, and shall express the volume of the liquid at 68° F. (20° C.); statement of dry measure shall be in terms of the United States standard bushel of 2150.42 cubic inches and its customary subdivisions, *i.e.*, bushels, pecks, quarts, or pints, or, in the case of articles in barrels, in terms of the United States standard barrel and its lawful subdivisions, *i.e.*, third, half, or three quarters barrel, as fixed by the act of March 4, 1915 (38 Stat. 1186): *Provided*, That statement of quantity may be in terms of metric weight or measure. Statement of metric weight shall be in terms of kilograms or grams. Statement of metric measure shall be in terms of liters or cubic centimeters. Other terms of metric weight or measure may be used if it appears that a definite trade custom exists for marking articles with such other terms and the articles are marked in accordance with the custom.

(*f*) The quantity of solids shall be stated in terms of weight and the quantity of liquids in terms of measure, except that in case of an article in respect to which there exists a definite trade custom otherwise the statement may be in terms of weight or measure in accordance with such custom. The quantity of viscous or semisolid foods or of mixtures of solids and liquids may be stated either by weight or measure, but the statement shall be definite and shall indicate whether the quantity is expressed in terms of weight or measure, as, for example, "weight 12 oz." or "12 oz. avoirdupois," "volume 12 ounces" or "12 fluid ounces."

(*g*) The quantity of the contents shall be stated in terms of weight or measure unless the package is marked by numerical count and such numerical count gives accurate information as to the quantity of the food in the package.

(*h*) The quantity of the contents may be stated in terms of minimum weight, minimum measure, or minimum count, for example, "minimum weight 10 oz.," "minimum volume 1 gallon," or "not less than 4 fl. oz.," but in such case the statement must approximate the actual quantity and there shall be no tolerance below the stated minimum.

(*i*) The following tolerances and variations from the quantity of the contents marked on the package shall be allowed:

(1) Discrepancies due exclusively to errors in weighing, measuring, or counting which occur in packing conducted in compliance with good commercial practice.

(2) Discrepancies due exclusively to differences in the capacity of bottles and similar containers, resulting solely from unavoidable difficulties in manufacturing such bottles or containers so as to be of uniform capacity: *Provided*, That no greater tolerance shall be allowed in case of bottles or similar containers which, because of their design, cannot be made of approximately uniform capacity than is allowed in case of bottles or similar containers which can be manufactured so as to be of approximately uniform capacity.

(3) Discrepancies in weight or measure due exclusively to differences in atmospheric conditions in various places and which unavoidably result from the ordinary and customary exposure of the packages to evaporation or to the absorption of water.

Discrepancies under classes (1) and (2) of this paragraph shall be as often above as below the marked quantity. The reasonableness of discrepancies under class (3) of this paragraph will be determined on the facts in each case.

(*j*) A package containing one half avoirdupois ounce of food or less is "small" and shall be exempt from marking in terms of weight.

(*k*) A package containing one fluid ounce of food or less is "small" and shall be exempt from marking in terms of measure.

(*l*) When a package is not required by paragraph (*g*) to be marked in terms of either weight or measure and the units of food therein are six or less, it shall, for the purpose of this regulation, be deemed "small" and shall be exempt from marking in terms of numerical count.

Regulation 27. Articles Intended for Export

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Regulation 28. Declaration on Imports

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Regulation 29. Import Procedure

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Regulation 30. Articles Suitable Only for Technical or Restricted Use, Denaturing

(Section 11)

(*a*) A food or drug which is adulterated or misbranded within the meaning of this act and which is offered for import for industrial purposes must be denatured and the invoice thereof must bear a statement showing that the article is to be used for industrial purposes.

Where, however, it is impracticable to denature such article, it may be permitted entry provided —

(1) It is plainly and conspicuously labeled, in the case of food, "inedible," and, in the case of drugs, "not for medicinal use."

(2) At the time of entry the importer submits a statement in writing that the article will not be used as a food or drug.

(3) At the time of entry the importer submits a statement that the article will be used in a certain suitable manner by a certain named party or parties.

(4) At the time of entry the importer agrees to furnish satisfactory proof as to the actual use of the article and the name or names of the parties who use it.

The penal bond given at the time of entry will not be canceled until such evidence of satisfactory disposition shall have been received.

EXTRACTS FOR FOOD INSPECTION DECISIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE

Since space does not permit the quoting of all food inspection decisions in full, the attempt has been made to reproduce here such selections as will be most useful to readers of this book.

FOOD INSPECTION DECISION 44

Scope and Purpose of Food Inspection Decisions

From the tenor of many inquiries received in this Department it appears that many persons suppose that the answers to inquiries addressed to this Department, either in letters or in published decisions, have the force and effect of the rules and regulations for the enforcement of the food and drugs act of June 30, 1906. * * *

It seems highly desirable that an erroneous opinion of this kind should be corrected. The opinions or decisions of this Department do not add anything to the rules and regulations nor take anything away from them. They therefore are not to be considered in the light of rules and regulations. On the other hand, the decisions and opinions referred to express the attitude of this Department in relation to the interpretation of the law and the rules and regulations, and they are published for the information of the officials of the Department who may be charged with the execution of the law and especially to acquaint manufacturers, jobbers, and dealers with the attitude of this Department in these matters. They are therefore issued more in an advisory than in a mandatory spirit. It is clear that if the manufacturers, jobbers, and dealers interpret the rules and regulations in the same manner as they are interpreted by this Department, and follow that interpretation in their business transactions, no prosecution will lie against them. It needs no argument to show that the Secretary of Agriculture must himself come to a decision in every case before a prosecution can be initiated, since it is on his report that the district attorney is to begin a prosecution for the enforcement of the provisions of the act. * * *

It may be proper to add that in reaching opinions and decisions on these cases the Department keeps constantly in view the two great purposes of the food and drugs act, namely, to prevent misbranding and to prohibit adulteration. From the tenor of the correspondence received at this Department and from the oral hearings which have been held, it is evident that an overwhelming majority of the manufacturers, jobbers, and dealers of this country are determined to do their utmost to conform to the provisions of the act, to support it in every particular, and to accede to the opinions of this Department respecting its construction. . . .

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FOOD INSPECTION DECISION 52

Form of Label

To meet the requests for the opinion of the Department regarding the proper arrangement of a label, the following order is suggested:

1. Name of substance or product.

2. In case of foods, words which indicate that the articles are compounds, mixtures, or blends, and the word "Imitation," "Compound," or "Blend," as the case may be.

3. Statements designating the quantity or proportions of the ingredients enumerated in the law, or derivatives and prepara-

tions of same, as mentioned under regulation 28; also statements of other extraneous substances whose presence should be declared, such as harmless coloring matter, or any necessary statement regarding grade or quality.

(The statements specified in paragraphs 1, 2, and 3 should appear together without any intervening descriptive or explanatory matter.)

4. Name of manufacturer (if given).

5. Place of manufacture (if given, or when required in case of food mixtures or compounds bearing a distinctive name).

It is stated in regulation 17 that if the name of the manufacturer and place of manufacture be given, they should appear upon the principal label. Although the law does not require that the name of the manufacturer be given, or the place of manufacture, except in case of food mixtures and compounds having a distinctive name, it is held that if they are given, they must be true, and should be placed with the required information on the principal label.

Sample Label for Food Product

[Name of product.]	KETCHUP.
[Declaration required by paragraphs 2 and 3.]	ARTIFICIALLY COLORED.
	[Descriptive matter, if desired, but preferably at bottom of label.]
[Name of manufacturer, if given.]	BLANK & CO.,
[Place of manufacture, if given.	PORTLAND, ME.
	[Descriptive matter, if desired.]

Any descriptive or explanatory matter that may appear on the principal label, therefore, should be placed at the bottom of the label, or between No. 3 and No. 4, and should be clearly separated from other features of the label by means of a suitable line or space.

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Each substance required to be declared under No. 3 should be printed on a separate line and in type specified in regulation 17 (*c*).

FOOD INSPECTION DECISIONS 76 AND 180

Dyes, Chemicals, and Preservatives in Foods

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Common salt, sugar, wood smoke, potable distilled liquors, vinegar, and condiments may be used. Pending further investigation, the use of saltpeter is allowed.

Pending the investigation of the conditions attending processes of manufacture, and the effects upon health, of the combinations mentioned in this paragraph, the Department of Agriculture will institute no prosecution in the case of the application of fumes of burning sulphur (sulphur dioxid), as usually employed in the manufacture of those foods and food products which contain acetaldehyde, sugars, etc., with which sulphurous acid may combine, if the total amount of sulphur dioxid in the finished product does not exceed 350 milligrams per liter in wines, or 350 milligrams per kilogram in other food products, of which not over 70 milligrams is in a free state.

The label of each package of sulphured foods, . . . shall bear a statement that the food is preserved with sulphur dioxid, . . . and the label must not bear a serial number assigned to any guaranty filed with the Department of Agriculture nor any statement that the article is guaranteed to conform to the food and drugs act.

The use of any dye, harmless or otherwise, to color or stain a food in a manner whereby damage or inferiority is concealed is specifically prohibited by law. The use in food for any purpose of any mineral dye or any coal-tar dye, except those coal-tar dyes hereinafter listed, will be grounds for prosecution. Pending further investigations now under way and the announcement thereof, the coal-tar dyes hereinafter named, made specifically for use in foods, and which bear a guaranty from the manufacturer that they are free from subsidiary products and represent the actual substance the name of which they bear, may be used in foods. In every case a certificate that the dye in question has been tested by competent experts and found to be free from harmful constituents must be filed with the Secretary of Agriculture and approved by him.

The following coal-tar dyes which may be used in this manner are given numbers, the numbers preceding the names referring to the number of the dye in question as listed in A. G. Green's edition of the Schultz-Julius Systematic Survey of the Organic Coloring Matters, published in 1904.

The list as amended to the end of 1923 is as follows:

Red shades:

107. Amaranth.
56. Ponceau 3 R.
517. Erythrosine.

Orange shade:

85. Orange I.

Yellow shades:

4. Naphthol yellow S.
94. Tartrazine.
Yellow A. B. (Benzeneazo-β-naphthylamine).
Yellow O. B. (Ortho-Tolueneazo-β-naphthylamine).

Green shade:

435. Light green S. F. yellowish.

Blue shade:

692. Indigo disulfoacid.

FOOD INSPECTION DECISIONS 135 AND 142

Saccharin in Food

At the request of the Secretary of Agriculture, the Referee Board of Consulting Scientific Experts has conducted an investigation as to the effect on health of the use of saccharin. The investigation has been concluded, and the Referee Board reports that the continued use of saccharin for a long time in quantities over three tenths of a gram per day is liable to impair digestion; and that the addition of saccharin as a substitute for cane sugar or other forms of sugar reduces the food value of the sweetened product and hence lowers its quality.

Saccharin has been used as a substitute for sugar in over thirty classes of foods in which sugar is commonly recognized as a normal and valuable ingredient. If the use of saccharin be continued, it is evident that amounts of saccharin may readily be consumed which will, through continual use, produce digestive disturbances. In every food in which saccharin is used, some other sweetening agent known to be harmless to health can be substituted, and there is not even a pretense that saccharin is a necessity in the manufacture of food products. Under the food and drugs act articles of food are adulterated if they contain added poisonous or other added deleterious ingredients which may render them injurious to health. Articles of food are also adulterated within the meaning of the act, if substances have been mixed and packed with the foods so as to reduce or lower or injuriously affect their quality or strength. The findings of the Referee Board show that saccharin in food is such an added poisonous or other added deleterious ingredient as is contemplated by the act, and also that the substitution of saccharin for sugar in foods reduces and lowers their quality.

The Secretary of Agriculture, therefore, will regard as adulterated under the food and drugs act foods containing saccharin.

*   *   *   *   *   *   *

After full consideration of the representations made in behalf of the manufacturers of saccharin at the hearing before us and of the briefs filed by their attorneys, as well as the briefs filed, at our request, by officers of the Department of Agriculture, we conclude that the use of saccharin in normal foods, within the jurisdiction of the food and drugs act, is a violation of law and will be prosecuted.

It is true that the Referee Board did not find that the use in foods of saccharin in small quantities (up to 0.3 gram daily) is injurious to health. However, the Referee Board did find that saccharin used in quantities over 0.3 gram per day for a considerable period is liable to disturb digestion, and the food and drugs act provides that articles of food are adulterated which contain any added poisonous or other added deleterious ingredient which may render them injurious to health.

The Bureau of Chemistry of the Department of Agriculture reports that saccharin has been found in more than fifty kinds of foods in common use. It is argued, therefore, that if the use of saccharin in foods be allowed, the consumer may very easily ingest, day by day, over 0.3 gram, the quantity which, according to the findings of the Referee Board, is liable to produce disturbances of digestion. On the other hand, it is claimed by the manufacturers that the sweetening power of saccharin is so great that, in a normal dietary, the amount of saccharin ingested daily would not exceed 0.3 gram, the amount found to be harmless by the Referee Board.

However this may be, it is plain, from the finding of the Referee Board, that the substitution of saccharin for sugar lowers the quality of the food. The only use of saccharin in foods is as a sweetener, and when it is so used, it inevitably displaces the sugar of an equivalent sweetening power. Sugar has a food value and saccharin has none. It appears, therefore, that normal foods sweetened with saccharin are adulterated under the law.

In making this decision we are not unmindful of the fact that persons suffering from certain diseases may be directed by their physicians to abstain from the use of sugar. In cases of this kind, saccharin is often prescribed as a substitute sweetening agent. This decision will not in any manner interfere with such a use of saccharin. The food and drugs act provides that any substance which is intended to be used for the prevention, cure, or mitigation of disease is a drug, and a product containing saccharin and plainly labeled to show that the mixture is intended for the use of those persons who, on account of disease, must abstain from the use of sugar, falls within the class of drugs and is not affected by this decision.

APPENDIX B

FEDERAL MEAT INSPECTION

THE MEAT–INSPECTION LAW

[Extract from an act of Congress entitled "An act making appropriations for the Department of Agriculture for the fiscal year ending June thirtieth, nineteen hundred and seven," approved June 30, 1906 (34 Stat., 674).]

That for the purpose of preventing the use in interstate or foreign commerce, as hereinafter provided, of meat and meat food products which are unsound, unhealthful, unwholesome, or otherwise unfit for human food, the Secretary of Agriculture, at his discretion, may cause to be made, by inspectors appointed for that purpose, an examination and inspection of all cattle, sheep, swine, and goats before they shall be allowed to enter into any slaughtering, packing, meat-canning, rendering, or similar establishment, in which they are to be slaughtered and the meat and meat food products thereof are to be used in interstate or foreign commerce; and all cattle, swine, sheep, and goats found on such inspection to show symptoms of disease shall be set apart and slaughtered separately from all other cattle, sheep, swine, or goats, and when so slaughtered the carcasses of said cattle, sheep, swine, or goats shall be subject to a careful examination and inspection, all as provided by the rules and regulations to be prescribed by the Secretary of Agriculture as herein provided for.

That for the purposes hereinbefore set forth the Secretary of Agriculture shall cause to be made by inspectors appointed for that purpose, as hereinafter provided, a post-mortem examination and inspection of the carcasses and parts thereof of all cattle, sheep, swine, and goats to be prepared for human consumption at any slaughtering, meat-canning, salting, packing rendering, or similar establishment in any State, Territory, or the District of Columbia for transportation or sale as articles of interstate or foreign commerce; and the carcasses and parts thereof of all such animals found to be sound, healthful, wholesome, and fit for human food shall be marked, stamped, tagged, or labeled as "Inspected and Passed;" and said inspectors shall label, mark, stamp, or tag as "Inspected and Condemned," all carcasses and parts thereof of animals found to be unsound, unhealthful, unwholesome, or otherwise unfit for human food; and all carcasses and parts thereof thus inspected and condemned shall be destroyed for food purposes by the said establishment in the presence of an inspector, and the Secretary of Agriculture may remove inspectors from any such establishment which fails to so destroy any such condemned carcass or part thereof, and said inspectors, after said first inspection shall, when they deem it necessary, reinspect said carcasses or parts thereof to determine whether since the first inspection the same have become unsound, unhealthful, unwholesome, or in any way unfit for human food, and if any carcass or any part thereof shall, upon examination and inspection subsequent to the first examination and inspection, be found to be unsound, unhealthful, unwholesome, or otherwise unfit for human food, it shall be destroyed for food purposes by the said establishment in the presence of an inspector, and the Secretary of Agriculture may remove inspectors from any establishment which fails to so destroy any such condemned carcass or part thereof.

The foregoing provisions shall apply to all carcasses or parts of carcasses of cattle, sheep, swine, and goats, or the meat or meat products thereof which may be brought into any slaughtering, meat-canning, salting, packing, rendering, or similar establishment, and such examination and inspection shall be had before the said carcasses or parts thereof shall be allowed to enter into any department wherein the same are to be treated and prepared for meat food products; and the foregoing provisions shall also apply to all such products which, after having been issued from any slaughtering, meat-canning, salting, packing, rendering, or similar establishment, shall be returned to the same or to any similar establishment where such inspection is maintained.

That for the purposes hereinbefore set forth the Secretary of Agriculture shall cause to be made by inspectors appointed for that purpose an examination and inspection of all meat food products prepared for interstate or foreign commerce in any slaughtering, meat-canning, salting, packing, rendering, or similar establishment, and for the purposes of any examination and inspection said inspectors shall have access at all times, by day or night, whether the establishment be operated or not, to every part of said establishment; and said inspectors shall mark, stamp, tag, or label as "Inspected and Passed" all such products found to be sound, healthful, and wholesome, and which contain no dyes, chemicals, preservatives, or ingredients which render such meat or meat food products unsound, unhealthful, unwholesome, or unfit for human food; and said inspectors shall label, mark, stamp, or tag as "Inspected and Condemned" all such products found unsound, unhealthful, and unwholesome, or which contain dyes, chemicals, preservatives, or ingredients which render such meat or meat food products unsound, unhealthful, unwholesome, or unfit for human food, and all such condemned meat food products shall be destroyed for food purposes, as hereinbefore provided, and the Secretary of Agriculture may remove inspectors from any establishment which fails to so destroy such condemned meat food products: *Provided*, That, subject to the rules and regulations of the Secretary of Agriculture, the provisions hereof in regard to preservatives shall not apply to meat food products for export to any foreign country and which are prepared or packed according to the specifications or directions of the foreign purchaser, when no substance is used in the preparation or packing thereof in conflict with the laws of the foreign country to which said article is to be exported; but if said article shall be in fact sold or offered for sale for domestic use or consumption, then this proviso shall not exempt said article from the operation of all the other provisions of this act.

That when any meat or meat food product prepared for interstate or foreign commerce which has been inspected as hereinbefore provided and marked "Inspected and Passed" shall be placed or packed in any can, pot, tin, canvas, or other receptacle or covering in any establishment where inspection under the provisions of this act is maintained, the person, firm, or corporation preparing said product shall cause a label to be attached to said can, pot, tin, canvas, or other receptacle or covering, under the supervision of an inspector, which label shall state that the contents thereof have been "Inspected and Passed" under the provisions of this act; and no inspection and examination of meat or meat food products deposited or inclosed in cans, tins, pots, canvas, or other receptacle or covering in any establishment where inspection under the provisions of this act is maintained shall be deemed to be complete until such meat or meat food products have been sealed or inclosed in said can, tin, pot, canvas, or other receptacle or covering under the supervision of an inspector, and no such meat or meat food products shall be sold or offered for sale by any person, firm, or corporation in interstate or foreign commerce under any false or deceptive name; but established trade name or names which are usual to such products and which are not false and deceptive and which shall be approved by the Secretary of Agriculture are permitted.

The Secretary of Agriculture shall cause to be made, by experts in sanitation or by other competent inspectors, such inspection of all slaughtering, meat-canning, salting, packing, rendering, or similar establishments in which cattle, sheep, swine, and goats are slaughtered and the meat and meat food products thereof are prepared for interstate or foreign commerce as may be necessary to inform himself concerning the sanitary conditions of the same, and to prescribe the rules and regulations of sanitation under which such establishments shall be maintained; and where the sanitary conditions of any such establishment are such that the meat or meat food products are rendered unclean, unsound, unhealthful, unwholesome, or otherwise unfit for human food, he shall refuse to allow said meat or meat food products to be labeled, marked, stamped, or tagged as "Inspected and Passed."

That the Secretary of Agriculture shall cause an examination and inspection of all cattle, sheep, swine, and goats, and the food products thereof, slaughtered and prepared in the establishments hereinbefore described for the purposes of interstate or foreign commerce to be made during the nighttime as well as during the daytime when the slaughtering of said cattle, sheep, swine, and goats, or the preparation of said food products is conducted during the night time.

That on and after October first, nineteen hundred and six, no person, firm, or corporation shall transport or offer for transportation, and no carrier of interstate or foreign commerce shall transport or receive for transportation from one State or Territory or the District of Columbia to any other State or Territory of the District of Columbia, or to any place under the jurisdiction of the United States, or to any foreign country, any carcasses or parts thereof, meat, or meat food products thereof which have not been inspected, examined, and marked as "Inspected and Passed," in accordance with the terms of this act and with the rules and regulations prescribed by the Secretary of Agriculture: *Provided*, That all meat and meat food products on hand on October first, nineteen hundred and six, at establishments where inspection has not been maintained, or which have been inspected under existing law, shall be examined and labeled under such rules and regulations as the Secretary of Agriculture shall prescribe, and then shall be allowed to be sold in interstate or foreign commerce.

That no person, firm, or corporation, or officer, agent, or employee thereof shall forge, counterfeit, simulate, or falsely represent, or shall without proper authority use, fail to use, or detach, or shall knowingly or wrongfully alter, deface, or destroy, or fail to deface or destroy, any of the marks, stamps, tags, labels, or other identification devices provided for in this act, or in and as directed by the rules and regulations prescribed hereunder by the Secretary of Agriculture, on any carcasses, parts of carcasses, or the food product, or containers thereof, subject to the provisions of this act, or any certificate in relation thereto, authorized or required by this act or by the said rules and regulations of the Secretary of Agriculture.

That the Secretary of Agriculture shall cause to be made a careful inspection of all cattle, sheep, swine, and goats intended and offered for export to foreign countries at such times and places, and in such manner as he may deem proper, to ascertain whether such cattle, sheep, swine, and goats are free from disease.

And for this purpose he may appoint inspectors who shall be authorized to give an official certificate clearly stating the condition in which such cattle, sheep, swine, and goats are found.

And no clearance shall be given to any vessel having on board cattle, sheep, swine, or goats for export to a foreign country until the owner or shipper of such cattle, sheep, swine, or goats has a certificate from the inspector herein authorized to be appointed, stating that the said cattle, sheep, swine, or goats are sound and healthy, or unless the Secretary of Agriculture shall have waived the requirement of such certificate for export to the particular country to which such cattle, sheep, swine, or goats are to be exported.

That the Secretary of Agriculture shall also cause to be made a careful inspection of the carcasses and parts thereof of all cattle, sheep, swine, and goats, the meat of which, fresh, salted, canned, corned, packed, cured, or otherwise prepared, is intended and offered for export to any foreign country, at such times and places and in such manner as he may deem proper.

And for this purpose he may appoint inspectors who shall be authorized to give an official certificate stating the condition in which said cattle, sheep, swine, or goats, and the meat thereof, are found.

And no clearance shall be given to any vessel having on board any fresh, salted, canned, corned, or packed beef, mutton, pork, or goat meat, being the meat of animals killed after the passage of this act, or except as hereinbefore provided for export to and sale in a foreign country from any port in the United States, until the owner or shipper thereof shall obtain from an inspector appointed under the provisions of this act a certificate that the said cattle, sheep, swine, and goats were sound and healthy at the time of inspection, and that their meat is sound and wholesome, unless the Secretary of Agriculture shall have waived the requirements of such certificate for the country to which said cattle, sheep, swine, and goats or meats are to be exported.

That the inspectors provided for herein shall be authorized to give official certificates of the sound and wholesome condition of the cattle, sheep, swine, and goats, their carcasses and products as herein described, and one copy of every certificate granted under the provisions of this act shall be filed in the Department of Agriculture, another copy shall be delivered to the owner or shipper, and when the cattle, sheep, swine, and goats or their carcasses and products are sent abroad, a third copy shall be delivered to the chief officer of the vessel on which the shipment shall be made.

That no person, firm, or corporation engaged in the interstate commerce of meat or meat food products shall transport or offer for transportation, sell or offer to sell any such meat or meat food products in any State or Territory or in the District of Columbia or any place under the jurisdiction of the United States, other than in the State or Territory or in the District of Columbia or any place under the jurisdiction of the United States in which the slaughtering, packing, canning, rendering, or other similar establishment owned, leased, operated by said firm, person, or corporation is located unless and until said person, firm, or corporation shall have complied with all of the provisions of this act.

That any person, firm, or corporation, or any officer or agent of any such person, firm, or corporation, who shall violate any of the provisions of this act shall be deemed guilty of a misdemeanor, and shall be punished on conviction thereof by a fine of not exceeding ten thousand dollars or imprisonment for a period not more than two years or by both such fine and imprisonment, in the discretion of the court.

That the Secretary of Agriculture shall appoint from time to time inspectors to make examination and inspection of all cattle, sheep, swine, and goats, the inspection of which is hereby provided for, and of all carcasses and parts thereof, and of all meats and meat food products thereof, and of the sanitary conditions of all establishments in which such meat and meat food products hereinbefore described are prepared; and said inspectors shall refuse to stamp, mark, tag, or label any carcass or any part thereof, or meat food product therefrom, prepared in any establishment hereinbefore mentioned, until the same shall have actually been inspected and found to be sound, healthful, wholesome, and fit for human food, and to contain no dyes, chemicals, preservatives, or ingredients which render such meat food product unsound, unhealthful, unwholesome, or unfit for human food; and to have been prepared under proper sanitary conditions, hereinbefore provided for; and shall perform such other duties as are provided by this act and by the rules and regulations to be prescribed by said Secretary of Agriculture; and said Secretary of Agriculture shall, from time to time, make such rules and regulations as are necessary for the efficient execution of the provisions of this act, and all inspections and examinations made under this act shall be such and made in such manner as described in the rules and regulations prescribed by said Secretary of Agriculture not inconsistent with the provisions of this act.

That any person, firm, or corporation, or any agent or employee of any person, firm, or corporation, who shall give, pay, or offer, directly or indirectly, to any inspector, deputy inspector, chief inspector, or any other officer or employee of the United States authorized to perform any of the duties prescribed by this act or by the rules and regulations of the Secretary of Agriculture any money or other thing of value, with intent to influence said inspector, deputy inspector, chief inspector, or other officer or employee of the United States in the discharge of any duty herein provided for, shall be deemed guilty of a felony and, upon conviction thereof, shall be punished by a fine not less than five thousand dollars nor more than ten thousand dollars and by imprisonment not less than one year nor more than three years; and any inspector, deputy inspector, chief inspector, or other officer or employee of the United States authorized to perform any of the duties prescribed by this act who shall accept any money, gift, or other thing of value from any person, firm, or corporation, or officers, agents, or employees thereof, given with intent to influence his official action, or who shall receive or accept from any person, firm, or corporation engaged in interstate or foreign commerce any gift, money, or other thing of value given with any purpose or intent whatsoever, shall be deemed guilty of a felony and shall, upon conviction thereof, be summarily discharged from office and shall be punished by a fine not less than one thousand dollars nor more than ten thousand dollars and by imprisonment not less than one year nor more than three years.

That the provisions of this act requiring inspection to be made by the Secretary of Agriculture shall not apply to animals slaughtered by any farmer on the farm and sold and transported as interstate or foreign commerce, nor to retail butchers and retail dealers in meat and meat food products, supplying their customers: *Provided*, That if any person shall sell or offer for sale or transportation for interstate or foreign commerce any meat or meat food products which are diseased, unsound, unhealthful, unwholesome, or otherwise unfit for human food, knowing that such meat food products are intended for human consumption, he shall be guilty of a misdemeanor, and on conviction thereof shall be punished by a fine not exceeding one thousand dollars or by imprisonment for a period of not exceeding one year, or by both such fine and imprisonment: *Provided also*, That the Secretary of Agriculture is authorized to maintain the inspection in this act provided for at any slaughtering, meat canning, salting, packing, rendering, or similar establishment notwithstanding this exception, and that the persons operating the same may be retail butchers and retail dealers or farmers; and where the Secretary of Agriculture shall establish such inspection then the provisions of this act shall apply notwithstanding this exception.

That there is permanently appropriated, out of any money in the Treasury not otherwise appropriated, the sum of three million dollars, for the expenses of the inspection of cattle, sheep, swine, and goats and the meat and meat food products thereof which enter into interstate or foreign commerce and for all expenses necessary to carry into effect the provisions of this act relating to meat inspection, including rent and the employment of labor in Washington and elsewhere, for each year. And the Secretary of Agriculture shall, in his annual estimates made to Congress, submit a statement in detail, showing the number of persons employed in such inspections and the salary or per diem paid to each, together with the contingent expenses of such inspectors and where they have been and are employed.

EXTRACTS FROM MEAT INSPECTION REGULATIONS UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ANIMAL INDUSTRY

Order 211

[Effective November 1, 1914.]

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Regulation 8. Sanitation

SECTION 1. Prior to the inauguration of inspection, an examination of the establishment and premises shall be made by a bureau [1] employee and the requirements for sanitation and the necessary facilities for inspection specified.

SECTION 2. Triplicate copies of plans, properly drawn to scale, and of specifications, including plumbing and drainage, for remodeling plants of official establishments and for new structures, shall be submitted to the chief of bureau in advance of construction.

SECTION 3. *Paragraph 1.* Official establishments, establishments at which market inspection is conducted, and premises on or in which any meat or product is prepared or handled by or for persons to whom certificates of exemption have been issued, shall be maintained in sanitary condition, and to this end the requirements of paragraphs 2 to 8, inclusive, of this section shall be complied with.

[1] Throughout the regulations the word bureau is used to designate the Bureau of Animal Industry.

Paragraph 2. There shall be abundant light, both natural and artificial, and sufficient ventilation for all rooms and compartments, to insure sanitary condition.

Paragraph 3. There shall be an efficient drainage and plumbing system for the establishment and premises, and all drains and gutters shall be properly installed with approved traps and vents.

Paragraph 4. The water supply shall be ample, clean, and potable, with adequate facilities for its distribution in the plant. Every establishment shall make known, and whenever required shall afford opportunity for inspection of, the source of its water supply and the location and character of its reservoir and storage tanks.

Paragraph 5. The floors, walls, ceilings, partitions, posts, doors, and other parts of all structures shall be of such materials, construction, and finish as will make them susceptible of being readily and thoroughly cleaned. The floors shall be kept water-tight. The rooms and compartments used for edible products shall be separate and distinct from those used for inedible products.

Paragraph 6. The rooms and compartments in which any meat or product is prepared or handled shall be free from odors from dressing and toilet rooms, catch basins, hide cellars, casing rooms, inedible tank and fertilizer rooms, and stables.

Paragraph 7. Every practicable precaution shall be taken to keep establishments free of flies, rats, mice, and other vermin. The use of rat poisons is prohibited in rooms or compartments where any unpacked meat or product is stored or handled; but their use is not forbidden in hide cellars, inedible compartments, outbuildings, or similar places, or in storerooms containing canned or tierced products. So-called rat viruses shall not be used in any part of an establishment or the premises thereof.

Paragraph 8. Dogs shall not be admitted into official establishments except, upon permission of the inspector in charge, for the purpose of destroying rats. Dogs which are admitted shall be kept free from tapeworm infestation. Such examinations shall be made to determine freedom from infestation as the chief of bureau may prescribe. Contamination by the excreta of these animals shall not be permitted, nor shall the dogs be allowed to eat the raw viscera of cattle, sheep, swine, or goats.

SECTION 4. Adequate sanitary facilities and accommodations shall be furnished by every official establishment. Of these the following are specifically required:

(*a*) Dressing rooms, toilet rooms, and urinals, sufficient in number, ample in size, conveniently located, properly ventilated, and meeting all requirements as to sanitary construction and equipment. These shall be separate from the rooms and compartments in which meat and products are prepared, stored, or handled. Where both sexes are employed, separate facilities shall be provided.

(*b*) Modern lavatory accommodations, including running hot and cold water, soap, towels, etc. These shall be placed in or near toilet and urinal rooms and also at such other places in the establishment as may be essential to assure cleanliness of all persons handling any meat or product.

(*c*) Properly located facilities for disinfecting and cleansing utensils and hands of all persons handling any meat or product.

(*d*) Cuspidors of such shape as not readily to be upset and of such material as to be readily disinfected. They shall be sufficient in number and accessibly placed in all rooms and places designated by the inspector in charge, and all persons who expectorate shall be required to use them.

SECTION 5. Equipment and utensils used for preparing, processing, and otherwise handling any meat or product shall be of such materials and construction as will make them susceptible of being readily and thoroughly cleaned and such as will insure strict cleanliness in the preparation and handling of all meat and products. Trucks and receptacles used for inedible products shall bear some conspicuous and distinctive mark and shall not be used for handling edible products.

Section 6. Rooms, compartments, places, equipment, and utensils used for preparing, storing, or otherwise handling any meat or product, and all other parts of the establishment, shall be kept clean and sanitary.

Section 7. *Paragraph 1.* Operations and procedures involving the preparation, storing, or handling of any meat or product shall be strictly in accord with cleanly and sanitary methods.

Paragraph 2. Rooms and compartments in which inspections are made and those in which animals are slaughtered or any meat or product is processed or prepared shall be kept sufficiently free of steam and vapors to enable bureau employees to make inspections and to insure cleanly operations. The walls and ceilings of rooms and compartments under refrigeration shall be kept reasonably free from moisture.

Paragraph 3. Butchers and others who dress or handle diseased carcasses or parts shall, before handling or dressing other carcasses or parts, cleanse their hands of grease, immerse them in a prescribed disinfectant, and rinse them in clean water. Implements used in dressing diseased carcasses shall be thoroughly cleansed in boiling water or in a prescribed disinfectant, followed by rinsing in clean water. The employees of the establishment who handle any meat or product shall keep their hands clean, and in all cases after visiting the toilet rooms or urinals shall wash their hands before handling any meat or product or implements used in the preparation of the same.

Paragraph 4. Aprons, frocks, and other outer clothing worn by persons who handle any meat or product shall be of material that is readily cleansed, and only clean garments shall be worn. Knife scabbards shall be kept clean.

Paragraph 5. Such practices as spitting on whetstones, placing skewers or knives in the mouth, inflating lungs or casings, or testing with air from the mouth such receptacles as tierces, kegs, casks, and the like, containing or intended as containers of any meat or product, are prohibited. Only mechanical means may be used for testing.

SECTION 8. The wagons and cars in which any meat or product is transported shall be kept in a clean and sanitary condition. Wagons used in transferring loose meat and products between official establishments shall be closed or so covered that the contents shall be kept clean.

SECTION 9. *Paragraph 1.* Second-hand tubs, barrels, and boxes intended for use as containers of any meat or product shall be inspected when received at the establishment and before they are cleaned. Those showing evidence of misuse rendering them unfit to serve as containers for food products shall be rejected. The use of those showing no evidence of previous misuse may be allowed after they have been thoroughly and properly cleaned. Steaming, after thorough scrubbing and rinsing, is essential to cleaning tubs and barrels.

Paragraph 2. Interiors of tank cars about to be used for the transportation of any meat food product shall be carefully inspected for cleanliness even though the last previous content was edible. Lye and soda solutions used in cleaning must be thoroughly removed by rinsing with clean water. In their examinations bureau employees shall enter the tank with a light and examine all parts of the interior.

SECTION 10. The outer premises of every official establishment, embracing docks and areas where cars and wagons are loaded, and the driveways, approaches, yards, pens, and alleys, shall be properly drained and kept in clean and orderly condition. All catch basins on the premises shall be of such construction and location and be given such attention as will insure their being kept in acceptable condition as regards odors and cleanliness. The accumulation on the premises of establishments of any material in which flies may breed, such as hog hair, bones, paunch contents, or manure, is forbidden. No nuisance shall be allowed in any establishment or on its premises.

SECTION 11. No establishment shall employ in any department where any meat or product is handled or prepared any person affected with tuberculosis or other communicable disease.

SECTION 12. When necessary, bureau employees shall attach a "U. S. rejected" tag to any equipment or utensil which is insanitary, or the use of which would be in violation of these regulations. No equipment or utensil so tagged shall again be used until made sanitary. Such tag so placed shall not be removed by any one other than a bureau employee.

Regulation 9. Ante-mortem Inspection

SECTION 1. *Paragraph 1.* An ante-mortem examination and inspection shall be made of all cattle, sheep, swine, and goats about to be slaughtered in an official establishment before their slaughter shall be allowed.

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SECTION 2. *Paragraph 1.* All animals plainly showing on ante-mortem inspection any disease or condition that under these regulations would cause condemnation of their carcasses on post-mortem inspection shall be marked "U. S. condemned" and disposed of in accordance with section 8 of this regulation.

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SECTION 3. All animals required by these regulations to be treated as suspects, or to be marked as suspects, or to be marked so as to retain their identity as suspects, shall be marked by or under the supervision of a bureau employee, "U. S. suspect," or with such other distinctive mark or marks to indicate that they are suspects as the chief of bureau may adopt. No such mark shall be removed except by a bureau employee.

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SECTION 8. Animals marked "U. S. condemned" shall be killed by the establishment, if not already dead, and shall not be taken into an establishment to be slaughtered or dressed, nor shall they be conveyed into any department of the establishment used for edible products, but they shall be disposed of and tanked in the manner provided for condemned carcasses. . . .

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Regulation 10. Post-mortem Inspection

SECTION 1. A careful post-mortem examination and inspection shall be made of the carcasses and parts thereof of all cattle, sheep, swine, and goats slaughtered at official establishments.

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SECTION 3. *Paragraph 1.* Each carcass, including all parts and detached organs thereof, in which any lesion of disease or other condition is found that might render the meat or any organ unfit for food purposes, and which for that reason would require a subsequent inspection, shall be retained by the bureau employee at the time of inspection and taken to the place designated for final inspection.

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SECTION 4. Each carcass or part which is found on final inspection to be unsound, unhealthful, unwholesome, or otherwise unfit for human food shall be conspicuously marked on the surface tissues thereof by a bureau employee at the time of inspection "U. S. inspected and condemned." Condemned detached organs and parts of such character that they cannot be so marked shall be immediately placed in trucks or receptacles which shall be kept plainly marked "U. S. inspected and condemned" in letters not less than 2 inches high. All condemned carcasses, parts, and organs shall remain in the custody of a bureau employee and shall be tanked as required in these regulations at or before the close of the day on which they are condemned, or be locked in the "U. S. condemned" room or compartment. Condemned articles shall not be allowed to accumulate unnecessarily in the condemned room or compartment.

SECTION 5. *Paragraph 1.* Carcasses and parts passed for sterilization shall be conspicuously marked on the surface tissues thereof by a bureau employee at the time of inspection "Passed for sterilization." All such carcasses and parts shall be sterilized in accordance with regulation 15 and until so sterilized shall remain in the custody of a bureau employee.

Paragraph 2. In all cases where carcasses showing localized lesions of disease are passed for food or for sterilization the diseased parts shall be removed before the "U. S. retained" tag is taken from the carcass, and such parts shall be condemned.

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Regulation 15. Rendering Carcasses and Parts into Lard and Tallow, and Other Sterilization

SECTION 1. Carcasses and parts passed for sterilization may be rendered into lard or tallow provided that such rendering is done in the following manner: The lower opening of the tank shall first be securely sealed by a bureau employee, then the carcasses or parts shall be placed in the tank in his presence, after which the upper opening shall be securely sealed by such employee, who shall then see that a sufficient force of steam is turned into the tank. Such carcasses and parts shall be cooked at a temperature not lower than 220° F. for a time sufficient to render them effectually into lard or tallow.

SECTION 2. Establishments not equipped with steaming tanks for rendering carcasses and parts into lard or tallow as provided in section 1 of this regulation may render such carcasses or parts in open kettles under the direct supervision of a bureau employee. Such rendering shall be done at a temperature and for a time sufficient to render the carcasses and parts effectually into lard or tallow, and shall be done only during regular hours of work.

SECTION 3. *Paragraph 1.* Carcasses and parts passed for sterilization and which are not rendered into lard or tallow may be utilized for food purposes provided they are first sterilized by methods, and handled and marked in a manner approved by the chief of bureau.

Paragraph 2. Any carcasses or parts prepared in compliance with paragraph 1 of this section may be canned if the container be plainly and conspicuously marked so as to show that the product is second grade, class, or quality and has been sterilized.

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APPENDIX C

METHODS AND STANDARDS FOR THE PRODUCTION AND DISTRIBUTION OF CERTIFIED MILK

(Adopted by the American Association of Medical Milk Commissions, May 1, 1912.)

HYGIENE OF THE DAIRY

UNDER THE SUPERVISION AND CONTROL OF THE VETERINARIAN

1. *Pastures or paddocks.* Pastures or paddocks to which the cows have access shall be free from marshes or stagnant pools, crossed by no stream which might become dangerously contaminated, at sufficient distances from offensive conditions to suffer no bad effects from them, and shall be free from plants which affect the milk deleteriously.

2. *Surroundings of buildings.* The surroundings of all buildings shall be kept clean and free from accumulations of dirt, rubbish, decayed vegetable or animal matter or animal waste, and the stable yard shall be well drained.

3. *Location of buildings.* Buildings in which certified milk is produced and handled shall be so located as to insure proper shelter and good drainage, and at sufficient distance from other buildings, dusty roads, cultivated and dusty fields, and all other possible sources of contamination; provided, in the case of unavoidable proximity to dusty roads or fields, the exposed side shall be screened with cheesecloth.

4. *Construction of stables.* The stables shall be constructed so as to facilitate the prompt and easy removal of waste products. The floors and platforms shall be made of cement or other nonabsorbent material and the gutters of cement only. The floors shall be properly graded and drained, and the manure gutters shall be from 6 to 8 inches deep and so placed in relation to the platform that all manure will drop into them.

5. The inside surface of the walls and all interior construction shall be smooth, with tight joints, and shall be capable of shedding water. The ceiling shall be of smooth material and dust tight. All horizontal and slanting surfaces which might harbor dust shall be avoided.

6. *Drinking and feed troughs.* Drinking troughs or basins shall be drained and cleaned each day, and feed troughs and mixing floors shall be kept in a clean and sanitary condition.

7. *Stanchions.* Stanchions, when used, shall be constructed of iron pipes or hard wood, and throat latches shall be provided to prevent the cows from lying down between the time of cleaning and the time of milking.

8. *Ventilation.* The cow stables shall be provided with adequate ventilation either by means of some approved artificial device, or by the substitution of cheesecloth for glass in the windows, each cow to be provided with a minimum of 600 cubic feet of air space.

9. *Windows.* A sufficient number of windows shall be installed and so distributed as to provide satisfactory light and a maximum of sunshine, 2 feet square of window area to each 600 cubic feet of air space to represent the minimum. The coverings of such windows shall be kept free from dust and dirt.

10. *Exclusion of flies, etc.* All necessary measures should be taken to prevent the entrance of flies and other insects and rats and other vermin into all the buildings.

11. *Exclusion of animals from the herd.* No horses, hogs, dogs, or other animals or fowls shall be allowed to come in contact with the certified herd, either in the stables or elsewhere.

12. *Bedding.* No dusty or moldy hay or straw, bedding from horse stalls, or other unclean materials shall be used for bedding the cows. Only bedding which is clean, dry, and absorbent may be used, preferably shavings or straw.

13. *Cleaning stable and disposal of manure.* Soiled bedding and manure shall be removed at least twice daily, and the floors shall be swept and kept free from refuse. Such cleaning shall be done at least one hour before the milking time. Manure, when removed, shall be drawn to the field or temporarily stored in containers so screened as to exclude flies. Manure shall not be even temporarily stored within 300 feet of the barn or dairy building.

14. *Cleaning of cows.* Each cow in the herd shall be groomed daily, and no manure, mud, or filth shall be allowed to remain upon her during milking; for cleaning, a vacuum apparatus is recommended.

15. *Clipping.* Long hairs shall be clipped from the udder and flanks of the cow and from the tail above the brush. The hair on the tail shall be cut so that the brush may be well above the ground.

16. *Cleaning of udders.* The udders and teats of the cow shall be cleaned before milking; they shall be washed with a cloth and water, and dry wiped with another clean sterilized cloth — a separate cloth for drying each cow.

17. *Feeding.* All foodstuffs shall be kept in an apartment separate from

and not directly communicating with the cow barn. They shall be brought into the barn only immediately before the feeding hour, which shall follow the milking.

18. Only those foods shall be used which consist of fresh, palatable, or nutritious materials, such as will not injure the health of the cows or unfavorably affect the taste or character of the milk. Any dirty or moldy food or food in a state of decomposition or putrefaction shall not be given.

19. A well-balanced ration shall be used, and all changes of food shall be made slowly. The first few feedings of grass, alfalfa, ensilage, green corn, or other green feeds shall be given in small rations and increased gradually to full ration.

20. *Exercise.* All dairy cows shall be turned out for exercise at least 2 hours in each 24 in suitable weather. Exercise yards shall be kept free from manure and other fifth.

21. *Washing of hands.* Conveniently located facilites shall be provided for the milkers to wash in before and during milking.

22. The hands of the milkers shall be thoroughly washed with soap, water, and brush and carefully dried on a clean towel immediately before milking. The hands of the milkers shall be rinsed with clean water and carefully dried before milking each cow. The practice of moistening the hands with milk is forbidden.

23. *Milking clothes.* Clean overalls, jumper, and cap shall be worn during milking. They shall be washed or sterilized each day and used for no other purpose, and when not in use they shall be kept in a clean place, protected from dust and dirt.

24. *Things to be avoided by milkers.* While engaged about the dairy or in handling the milk employees shall not use tobacco nor intoxicating liquors. They shall keep their fingers away from their nose and mouth, and no milker shall permit his hands, fingers, lips, or tongue to come in contact with milk intended for sale.

25. During milking the milkers shall be careful not to touch anything but the clean top of the milking stool, the milk pail, and the cow's teats.

26. Milkers are forbidden to spit upon the walls or floors of stables, or upon the walls or floors of milk houses, or into the water used for cooling the milk or washing the utensils.

27. *Fore milk.* The first streams from each teat shall be rejected, as this fore milk contains large numbers of bacteria. Such milk shall be collected into a separate vessel and not milked onto the floors or into the gutters. The milking shall be done rapidly and quietly, and the cows shall be treated kindly.

28. *Milk and calving period.* Milk from all cows shall be excluded for a period of 45 days before and 7 days after parturition.

29. *Bloody and stringy milk.* If milk from any cow is bloody and stringy or of unnatural appearance, the milk from that cow shall be rejected and the cow isolated from the herd until the cause of such abnormal appearance has been determined and removed, special attention being given in the meantime to the feeding or to possible injuries. If dirt gets into the pail, the milk shall be discarded and the pail washed before it is used.

30. *Make-up of herd.* No cows except those receiving the same supervision and care as the certified herd shall be kept in the same barn or brought in contact with them.

31. *Employees other than milkers.* The requirements for milkers, relative to garments and cleaning of hands, shall apply to all other persons handling the milk, and children unattended by adults shall not be allowed in the dairy nor in the stable during milking.

32. *Straining and strainers.* Promptly after the milk is drawn it shall be removed from the stable to a clean room and then emptied from the milk pail to the can, being strained through strainers made of a double layer of finely meshed cheesecloth or absorbent cotton thoroughly sterilized. Several strainers shall be provided for each milking in order that they may be frequently changed.

33. *Dairy building.* A dairy building shall be provided which shall be located at a distance from the stable and dwelling prescribed by the local commission, and there shall be no hogpen, privy, or manure pile at a higher level or within 300 feet of it.

34. The dairy building shall be kept clean and shall not be used for purposes other than the handling and storing of milk and milk utensils. It shall be provided with light and ventilation, and the floors shall be graded and water-tight.

35. The dairy building shall be well lighted and screened and drained through well-trapped pipes. No animals shall be allowed therein. No part of the dairy building shall be used for dwelling or lodging purposes, and the bottling room shall be used for no other purpose than to provide a place for clean milk utensils and for handling the milk. During bottling this room shall be entered only by persons employed therein. The bottling room shall be kept scrupulously clean and free from odors.

36. *Temperature of milk.* Proper cooling to reduce the temperature to 45° F. shall be used, and aërators shall be so situated that they can be protected from flies, dust, and odors. The milk shall be cooled immediately after being milked, and maintained at a temperature between 35° and 45° F. until delivered to the consumer.

37. *Sealing of bottles.* Milk, after being cooled and bottled, shall be immediately sealed in a manner satisfactory to the commission, but such

seal shall include a sterile hood which completely covers the lip of the bottle.

38. *Cleaning and sterilizing of bottles.* The dairy building shall be provided with approved apparatus for the cleansing and sterilizing of all bottles and utensils used in milk production. All bottles and utensils shall be thoroughly cleaned by hot water and sal soda, or equally pure agent, rinsed until the cleaning water is thoroughly removed, then exposed to live steam or boiling water at least 20 minutes, and then kept inverted until used, in a place free from dust and other contaminating materials.

39. *Utensils.* All utensils shall be so constructed as to be easily cleaned. The milk pail should preferably have an elliptical opening 5 by 7 inches in diameter. The cover of this pail should be so convex as to make the entire interior of the pail visible and accessible for cleaning. The pail shall be made of heavy seamless tin, and with seams which are flushed and made smooth by solder. Wooden pails, galvanized-iron pails, or pails made of rough, porous materials, are forbidden. All utensils used in milking shall be kept in good repair.

40. *Water supply.* The entire water supply shall be absolutely free from contamination, and shall be sufficient for all dairy purposes. It shall be protected against flood or surface drainage, and shall be conveniently situated in relation to the milk house.

41. *Privies, etc., in relation to water supply.* Privies, pigpens, manure piles, and all other possible sources of contamination shall be so situated on the farm as to render impossible the contamination of the water supply, and shall be so protected by use of screens and other measures as to prevent their becoming breeding grounds for flies.

42. *Toilet rooms.* Toilet facilities for the milkers shall be provided and located outside of the stable or milk house. These toilets shall be properly screened, shall be kept clean, and shall be accessible to wash basins, water, nail brush, soap, and towels, and the milkers shall be required to wash and dry their hands immediately after leaving the toilet room.

TRANSPORTATION

43. In transit the milk packages shall be kept free from dust and dirt. The wagon, trays, and crates shall be kept scrupulously clean. No bottles shall be collected from houses in which communicable diseases prevail, unless a separate wagon is used and under conditions prescribed by the department of health and the medical milk commission.

44. All certified milk shall reach the consumer within 30 hours after milking.

VETERINARY SUPERVISION OF THE HERD

45. *Tuberculin test.* The herd shall be free from tuberculosis, as shown by the proper application of the tuberculin test. The test shall be applied in accordance with the rules and regulations of the United States Government, and all reactors shall be removed immediately from the farm.[1]

46. No new animals shall be admitted to the herd without first having passed a satisfactory tuberculin test, made in accordance with the rules and regulations mentioned; the tuberculin to be obtained and applied only by the official veterinarian of the commission.

47. Immediately following the application of the tuberculin test to a herd for the purpose of eliminating tuberculous cattle, the cow stable and exercising yards shall be disinfected by the veterinary inspector in accordance with the rules and regulations of the United States Government.

48. A second tuberculin test shall follow each primary test after an interval of six months, and shall be applied in accordance with the rules and regulations mentioned. Thereafter, tuberculin tests shall be reapplied annually, but it is recommended that the retests be applied semiannually.

49. *Identification of cows.* Each dairy cow in each of the certified herds shall be labelled or tagged with a number or mark which will permanently identify her.

50. *Herd-book record.* Each cow in the herd shall be registered in a herd book, which register shall be accurately kept so that her entrance and departure from the herd and her tuberculin testing can be identified.

51. A copy of this herd-book record shall be kept in the hands of the veterinarian of the medical milk commission under which the dairy farm is operating, and the veterinarian shall be made responsible for the accuracy of this record.

52. *Dates of tuberculin tests.* The dates of the annual tuberculin tests shall be definitely arranged by the medical milk commission, and all of the results of such tests shall be recorded by the veterinarian and regularly reported to the secretary of the medical milk commission issuing the certificate.

53. The results of all tuberculin tests shall be kept on file by each medical milk commission, and a copy of all such tests shall be made available to the American Association of Medical Milk Commissions for statistical purposes.

54. The proper designated officers of the American Association of Medical Milk Commissions should receive copies of reports of all of the annual, semiannual, and other official tuberculin tests which are made and keep copies of the same on file and compile them annually for the use of the association.

[1] See Circular of Instructions issued by the Bureau of Animal Industry for making tuberculin tests and for disinfection of premises.

55. *Disposition of cows sick with diseases other than tuberculosis.* Cows having rheumatism, leucorrhea, inflammation of the uterus, severe diarrhea, or disease of the udder, or cows that from any other cause may be a menace to the herd shall be removed from the herd and placed in a building separate from that which may be used for the isolation of cows with tuberculosis, unless such building has been properly disinfected since it was last used for this purpose. The milk from such cows shall not be used nor shall the cows be restored to the herd until permission has been given by the veterinary inspector after a careful physical examination.

56. *Notification of veterinary inspector.* In the event of the occurrence of any of the diseases just described between the visits of the veterinary inspector, or if at any time a number of cows become sick at one time in such a way as to suggest the outbreak of a contagious disease or poisoning, it shall be the duty of the dairyman to withdraw such sickened cattle from the herd, to destroy their milk, and to notify the veterinary inspector by telegraph or telephone immediately.

57. *Emaciated cows.* Cows that are emaciated from chronic diseases or from any cause that in the opinion of the veterinary inspector may endanger the quality of the milk shall be removed from the herd.

BACTERIOLOGICAL STANDARDS

58. *Bacterial counts.* Certified milk shall contain less than 10,000 bacteria per cubic centimeter when delivered. In case a count exceeding 10,000 bacteria per cubic centimeter is found, daily counts shall be made, and if normal counts are not restored within 10 days the certificate shall be suspended.

59. Bacterial counts shall be made at least once a week.

60. *Collection of samples.* The samples to be examined shall be obtained from milk as offered for sale and shall be taken by a representative of the milk commission. The samples shall be received in the original packages, in properly iced containers, and they shall be so kept until examined, so as to limit as far as possible changes in their bacterial content.

61. For the purpose of ascertaining the temperature, a separate original package shall be used, and the temperature taken at the time of collecting the sample, using for the purpose a standardized thermometer graduated in the centigrade scale.

62. *Interval between milking and plating.* The examinations shall be made as soon after collection of the samples as possible, and in no case shall the interval between milking and plating the samples be longer than 40 hours.

63. *Plating.* The packages shall be opened with aseptic precautions after the milk has been thoroughly mixed by vigorously reversing and shaking the container 25 times.

64. Two plates at least shall be made for each sample of milk, and there shall also be made a control of each lot of medium and apparatus used at each testing. The plates shall be grown at 37° C. for 48 hours.

65. In making the plates there shall be used agar-agar media containing 1.5 per cent agar and giving a reaction of 1.0 to phenolphthalein.[1]

66. Samples of milk for plating shall be diluted in the proportion of 1 part of milk to 99 parts of sterile water; shake 25 times and plate 1 c. c. of the dilution.[1]

67. *Determination of taste and odor of milk.* After the plates have been prepared and placed in the incubator, the taste and odor of the milk shall be determined after warming the milk to 100° F.[2]

68. *Counts.* The total number of colonies on each plate should be counted, and the results expressed in multiples of the dilution factor. Colonies too small to be seen with the naked eye or with slight magnification shall not be considered in the count.

69. *Records of bacteriologic tests.* The results of all bacterial tests shall be kept on file by the secretary of each commission, copies of which should be made available annually for the use of the American Association of Medical Milk Commissions.

CHEMICAL STANDARDS AND METHODS

The methods that must be followed in carrying out the chemical investigations essential to the protection of certified milk are so complicated that in order to keep the fees of the chemist at a reasonable figure, there must be eliminated from the examination those procedures which, whilst they might be helpful and interesting, are in no sense necessary.

For this reason the determination of the water, the total solids, and the milk sugar is not required as a part of the routine examination.

70. The chemical analyses shall be made by a competent chemist designated by the medical milk commission.

71. *Method of obtaining samples.* The samples to be examined by the chemist shall have been examined previously by the bacteriologist designated by the medical milk commission as to temperature, odor, taste, and bacterial content.

72. *Fat standards.* The fat standard for certified milk shall be 4 per cent, with a permissible range of variation of from 3.5 to 4.5 per cent.

[1] Directions for laboratory work, included in the original report, are here omitted.

[2] Should it be deemed desirable and necessary to conduct tests for sediment, the presence of special bacteria, or the number of leucocytes, the methods adopted by the committee of the American Public Health Association should be followed.

73. The fat standard for certified cream shall be not less than 18 per cent.

74. If it is desired to sell higher fat-percentage milks or creams as certified milks or creams, the range of variation for such milks shall be 0.5 per cent on either side of the advertised percentage and the range of variations for such creams shall be 2 per cent on either side of the advertised percentage.

75. The fat content of certified milks and creams shall be determined at least once each month.

76. The methods recommended for this purpose are the Babcock,[1] the Leffmann-Beam,[1] and the Gerber.[1]

77. Before condemning samples of milk which have fallen outside the limits allowed, the chemist shall have determined, by control ether extractions, that his apparatus and his technique are reliable.

78. *Protein standard.* The protein standard for certified milk shall be 3.50 per cent, with a permissible range of variation of from 3 to 4 per cent.

79. The protein standard for certified cream shall correspond to the protein standard for certified milk.

80. The protein content shall be determined only when any special consideration seems to the medical milk commission to make it desirable.

81. It shall be determined by the Kjeldahl method, using the Gunning or some other reliable modification, and employing the factor 6.25 in reckoning the protein from the nitrogen.

82. *Coloring matter and preservatives.* All certified milks and creams shall be free from adulteration, and coloring matter and preservatives shall not be added thereto.

83. Tests for the detection of added coloring matter shall be applied whenever the color of the milk or cream is such as to arouse suspicion.

84. Tests for the detection of formaldehyde, borax, and boracic acid shall be applied at least once each month. Occasionally application of tests for the detection of salicylic acid, benzoic acid, and the benzoates is also recommended.

85. *Detection of heated milk.* Certified milk or cream shall not be subjected to heat unless specially directed by the commission to meet emergencies.

86. Tests to determine whether such milks and creams have been subjected to heat shall be applied at least once each month.

87. *Specific gravity.* The specific gravity of certified milk shall range from 1.029 to 1.034.

88. The specific gravity shall be determined at least each month.

[1] Directions for laboratory work, included in the original report, are here omitted.

METHODS AND REGULATIONS FOR THE MEDICAL EXAMINATION OF EMPLOYEES. THEIR HEALTH AND PERSONAL HYGIENE

89. A medical officer, known as the attending dairy physician, shall be selected by the commission, who should reside near the dairy producing certified milk. He shall be a physician in good standing and authorized by law to practice medicine; he shall be responsible to the commission and subject to its direction. In case more than one dairy is under the control of the commission and they are in different localities, a separate physician should be designated for employment for the supervision of each dairy.

90. Before any person shall come on the premises to live and remain as an employee, such person, before being engaged in milking or the handling of milk, shall be subjected to a complete physical examination by the attending physician. No person shall be employed who has not been vaccinated recently or who upon examination is found to have a sore throat, or to be suffering from any form of tuberculosis, venereal disease, conjunctivitis, diarrhea, dysentery, or who has recently had typhoid fever or is proved to be a typhoid carrier, or who has any inflammatory disease of the respiratory tract, or any suppurative process or infectious skin eruption, or any disease of an infectious or contagious nature, or who has recently been associated with children sick with contagious disease.

91. In addition to ordinary habits of personal cleanliness all milkers shall have well-trimmed hair, wear close-fitting caps, and have clean-shaven faces.

92. When the milkers live upon the premises their domitories shall be constructed and operated according to plans approved by the commission. A separate bed shall be provided for each milker and each bed shall be kept supplied with clean bedclothes. Proper bathing facilities shall be provided for all employees on the dairy premises, preferably a shower bath, and frequent bathing shall be enjoined.

93. In case the employees live on the dairy premises a suitable building shall be provided to be used for the isolation and quarantine of persons under suspicion of having a contagious disease.

The following plan of construction is recommended:

The quarantine building and hospital should be one story high and contain at least two rooms, each with a capacity of about 6,000 cubic feet and containing not more than three beds each, the rooms to be separated by a closed partition. The doors opening into the rooms should be on opposite sides of the building and provided with locks. The windows should be barred and the sash should be at least 5 feet from the ground and constructed for proper ventilation. The walls should be of a material which will allow proper disinfection. The floor should be of painted or washable wood, preferably of concrete, and so constructed that the floor may be flushed and properly disinfected. Proper heating, lighting, and ventilating facilities should be provided.

94. In the event of any illness of a suspicious nature the attending physician shall immediately quarantine the suspect, notify the health authorities and the secretary of the commission, and examine each member of the dairy force, and in every inflammatory affection of the nose or throat occurring among the employees of the dairy, in addition to carrying out the above-mentioned program, the attending physician shall take a culture and have it examined at once by a competent bacteriologist approved by the commission. Pending such examination, the affected employee or employees shall be quarantined.

95. It shall be the duty of the secretary, on receiving notice of any suspicious or contagious disease at the dairy, at once to notify the committee having in charge the medical supervision of employees of the dairy farm upon which such disease has developed. On receipt of the notice this committee shall assume charge of the matter, and shall have power to act for the commission as its judgment dictates. As soon as possible thereafter, the committee shall notify the commission, through its secretary, that a special meeting may be called for ultimate consideration and action.

96. When a case of contagious disease is found among the employees of a dairy producing certified milk under the control of a medical milk commission, such employee shall be at once quarantined and as soon as possible removed from the plant, and the premises fumigated.

When a case of contagion is found on a certified dairy it is advised that a printed notice of the facts shall be sent to every householder using the milk, giving in detail the precautions taken by the dairyman under the direction of the commission, and it is further advised that all milk produced at such dairy shall be heated at 145° F. for 40 minutes, or 155° F. for 30 minutes, or 167° F. for 20 minutes, and immediately cooled to 50° F. These facts should also be part of the notice, and such heating of the milk should be continued during the accepted period of incubation for such contagious disease.

The following method of fumigation is recommended:

After all windows and doors are closed and the cracks sealed by strips of paper applied with flour paste, and the various articles in the room so hung or placed as to be exposed on all sides, preparations should be made to generate formaldehyde gas by the use of 20 ounces of formaldehyde and 10 ounces of permanganate of potash for every 1,000 cubic feet of space to be disinfected.

For mixing the formaldehyde and potassium permanganate a large galvanized-iron pail or cylinder holding at least 20 quarts and having a flared top should be used for mixing therein 20 ounces of formaldehyde and 10 ounces of permanganate. A cylinder at least 5 feet high is suggested. The containers should be placed about in the rooms and the necessary quantity of permanganate weighed and placed in them. The formaldehyde solution for each pail should then be measured into a wide-mouthed cup and placed by the pail in which it is to be used.

Although the reaction takes place quickly, by making preparations as advised all of the pails can be "set off" promptly by one person, since there is nothing to do but pour the formaldehyde solution over the permanganate. The rooms should be kept closed for four hours. As there is a slight danger of fire, the reaction should be watched through a window or the pails placed on a noninflammable surface.

97. Following a weekly medical inspection of the employees, a monthly report shall be submitted to the secretary of the medical milk commission, on the same recurring date by the examining visiting physician.

The following schedule, filled out in writing and signed by himself, is recommended as a suitable form for the attending physician's report:

This is to certify that, on the dates below indicated, official visits were made to the —— dairy, owned and conducted by —— of —— (indicating town and State), where careful inspections of the dairy employees were made.

(*a*) Number and dates of visits since last report. ——.

(*b*) Number of men employed on the plant. ——.

(*c*) Has a recent epidemic of contagion occurred near the dairy, and what was its nature and extent? ——.

(*d*) Have any cases of contagious or infectious disease occurred among the men since the last report? ——.

(*e*) Disposition of such cases. ——.

(*f*) What individual sickness has occurred among the men since the last report? ——.

(*g*) Disposition of such cases. ——.

(*h*) Number of employees now quarantined for sickness. ——.

(*i*) Describe the personal hygiene of the men employed for milking when prepared for and during the process of milking. ——.

(*j*) What facilities are provided for sickness in employees? ——.

(*k*) General hygienic condition of the dormitories or houses of the employees. ——.

(*l*) Suggestions for improvement. ——.

(*m*) What is the hygienic condition of the employees and their surroundings? ——.

(*n*) How many employees were examined at each of the foregoing visits? ——.

(*o*) Remarks.

—— ——,
Attending Physician.

Date, ——.

APPENDIX D

TABLE OF 100-CALORIE PORTIONS OF FOODS

EXPLANATION OF TABLE. — The first column of figures in the table gives the number of 100-Calorie portions in one pound of the food as purchased. The next four columns show the weight of food which yields 100 Calories, *i.e.* the weight of the 100-Calorie portion, both in ounces and in grams, and both for the material as purchased and for the edible portion. Next follow columns showing the amount of protein first in Calories and then in grams, which the 100-Calorie portion of food contains. The protein content as thus expressed often gives a truer impression of the food as a source of protein than does the percentage by weight of protein which the food material contains.

HUNDRED-CALORIE PORTIONS OF FOOD

FOOD MATERIAL	PORTIONS IN ONE POUND AS PURCHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		PROTEIN IN 100-CALORIE PORTION	
		As purchased	Edible portion	As purchased	Edible portion	Calories	Grams
Almonds	16.1	.99	.54	28	15	12.9	3.22
Apples, fresh	2.1	7.49	5.61	212	159	2.6	.65
dried	13.2	1.21	1.21	34	34	2.6	.65
Apricots, fresh	2.4	6.48	6.08	184	172	7.6	1.90
dried	12.6	1.27	1.27	36	36	7.6	1.90
Asparagus, fresh	1.	15.89	15.89	450	450	32.4	8.10
cooked	2.1	7.46	7.46	213	213	17.9	4.47
Bacon, smoked	23.7	.62	.56	17	16	6.7	1.67
Bananas	2.9	5.52	3.58	156	101	5.3	1.32
Barley, pearled	16.2	0.99	0.99	28	28	9.5	2.37
Beans, baked, canned	5.8	2.75	2.75	78	78	21.5	5.30
dried	15.7	1.02	1.02	29	29	26.1	6.52
lima, canned	3.5	4.59	4.59	130	130	20.8	5.20
dried	15.9	1.02	1.02	29	29	20.7	5.17
fresh	2.5	6.40	2.88	182	82	23.2	5.80
string, canned	9.3	17.10	17.10	488	488	21.5	5.38
fresh	1.7	9.11	8.50	259	241	22.2	5.55

HUNDRED-CALORIE PORTIONS OF FOOD — (*Continued*)

FOOD MATERIAL	PORTIONS IN ONE POUND AS PURCHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		PROTEIN IN 100-CALORIE PORTIONS	
		As purchased	Edible portion	As purchased	Edible portion	Calories	Grams
Beans, kidney, canned . .	5.4	2.93	2.93	83	83	23.3	5.82
kidney, dried	12.3	1.02	1.02	29	29	47.3	11.82
Beef, brisket, medium fat .	11.3	1.41	1.09	40	31	19.6	4.90
chuck, average . . .	8.	2.05	1.62	58	46	30.7	7.67
corned	12.3	1.30	1.18	37	34	20.9	5.22
cross ribs, average . .	12.6	1.27	1.13	36	32	20.4	5.10
dried, salted, smoked .	7.2	2.11	1.96	60	56	66.6	16.65
flank, lean	8.4	1.94	1.91	55	54	44.8	11.20
fore quarter, lean . . .	6.5	2.43	1.91	69	54	40.8	10.20
fore shank, lean . . .	4.1	3.88	2.47	110	70	61.6	15.40
heart	12.9	1.41	1.23	40	35	25.6	6.40
hind quarter, lean . .	7.6	2.12	1.76	60	50	40.0	10.00
hind shank, lean . . .	2.5	6.31	2.65	179	75	65.7	16.42
hind shank, fat . . .	5.5	2.93	1.41	83	40	32.6	8.15
juice	1.1		14.11		400	78.4	19.60
kidney	3.3	4.91	3.17	139	90	59.7	14.92
liver	5.4	2.97	2.73	85	78	63.3	15.82
loin	7.6	2.09	1.83	60	52	40.7	10.17
neck, lean	5.1	3.11	2.19	88	62	53.0	13.25
neck, medium fat . .	7.5	2.14	1.54	61	44	35.1	8.77
plate, lean	8.7	1.84	1.52	52	43	27.0	6.75
porterhouse steak . .	10.8	1.48	1.30	42	37	32.3	8.07
rib rolls, lean	8.	2.01	2.01	57	57	46.1	11.52
ribs, lean	6.5	2.44	1.89	69	54	42.0	10.50
ribs, fat	14.8	1.09	.92	31	26	15.6	3.90
roast	15.8	1.03	1.03	29	29	27.5	6.87
round, lean	6.5	2.45	2.26	70	64	54.5	13.62
round, free from visible fat	5.1	3.07	3.07	87	87	80.7	20.18
rump, lean	8.	2.01	1.70	57	49	40.4	10.10
rump, fat	13.6	1.16	.92	33	26	17.5	4.37
sides, lean	7.2	2.56	1.80	64	51	39.4	9.85
shoulder and clod, lean .	4.8	3.35	2.71	95	77	62.7	15.67
shoulder and clod, medium fat	7.0	2.28	1.96	65	56	43.5	10.87

HUNDRED-CALORIE PORTIONS OF FOOD — (*Continued*)

FOOD MATERIAL	PORTIONS IN ONE POUND AS PURCHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		PROTEIN IN 100-CALORIE PORTION	
		As purchased	Edible portion	As purchased	Edible portion	Calories	Grams
Beef, sirloin	9.6	1.67	1.46	48	41	31.5	7.87
Beets, cooked	2.1		8.87		252	23.2	5.80
fresh	1.7	9.56	7.66	271	217	13.9	3.47
Blackberries	2.6	6.10	6.10	173	173	9.0	2.25
canned	11.2	1.43	1.43	40	40	1.3	0.32
Blackfish	1.8	9.79	4.09	279	116	86.8	21.70
Blueberries, canned	2.6	5.98	5.98	170	170	4.1	1.02
Bluefish	2.	7.77	3.99	220	113	87.9	21.95
Bouillon	0.5		33.6		952	83.8	20.95
Brazil nuts	15.9	1.01	.51	28	14	9.8	2.45
Bread, graham	11.9	1.35	1.35	38	38	13.7	3.42
rolls, water	12.7	1.27	1.27	36	36	13.0	3.25
rye	11.5	1.39	1.39	39	39	14.2	3.55
white, average	11.8	1.34	1.34	38	38	14.0	3.50
whole wheat	11.1	1.44	1.44	41	41	15.8	3.95
Buckwheat flour	15.8	1.01	1.01	29	29	7.4	1.85
Butter	34.9	0.46	0.46	13	13	.5	.13
Butter fish	4.4	3.61	2.06	102	59	42.1	10.52
Buttermilk	1.6	9.86	9.86	280	280	33.6	8.40
Butternuts	4.2	3.84	0.52	109	15	16.5	4.12
Cabbage	1.2	13.26	11.20	376	317	20.3	5.07
Calf's-foot jelly	4.	4.06	4.06	115	115	19.8	4.95
Catfish	8.8	1.80	1.45	51	41	23.7	5.92
Carrots	1.6	10.08	7.80	286	221	9.7	2.42
Cauliflower	1.4	11.57	11.57	328	328	23.6	5.90
Celery	.7	23.67	19.07	671	540	23.7	5.92
Celery soup, canned	2.4	6.60	6.60	187	187	15.6	3.90
Chard	1.7	9.23	9.23	262	262	33.5	8.37
Cheese, Cheddar	20.8	.77		22		24.2	6.05
cottage	5.0	3.21		91		76.2	19.05
Neufchâtel	14.8	1.08		31		22.8	5.70
Roquefort	16.5	.97		28		24.9	6.22
Swiss	19.5	.82		23		25.7	6.42
Cherries, fresh	3.4	4.74	4.52	134	128	4.8	1.20
candied	15.9	1.01	1.01	29	29	.6	.15

HUNDRED-CALORIE PORTIONS OF FOOD — (*Continued*)

Food Material	Portions in one Pound as Purchased	Weight in Ounces		Weight in Grams		Protein in 100-Calorie Portion	
		As purchased	Edible portion	As purchased	Edible portion	Calories	Grams
Cherries, canned	4.1	3.93	3.93	112	112	4.9	1.22
Chestnuts, dried	13.9	1.15	0.87	33	25	10.6	2.65
fresh	9.2	1.74	1.46	49	41	10.2	2.55
Chicken, broilers	2.9	5.53	3.27	157	93	79.6	19.90
Chocolate	27.7	.58	.58	16	16	8.4	2.10
Citron	14.9	1.08	1.08	31	31	.6	.15
Clams, long	1.2	13.89	8.12	394	230	79.3	19.82
round			7.61		216	56.0	14.00
Cocoa	22.5	.71	.71	20	20	17.4	4.35
Coconut prepared	30.3	.53	.53	15	15	3.8	0.95
Coconuts	14.	1.17	.60	33	17	3.9	0.97
Cod, dressed	2.1	7.63		216		96.0	24.00
salted	3.6	4.43	3.38	126	96	97.3	24.32
Consommé, canned	0.5	30.40	30.40	862	862	86.2	21.55
Corn, canned	4.4	3.60	3.60	102	102	11.5	2.87
green	1.7	9.00	3.49	255	99	12.2	3.05
Corn meal	16.2	0.99	0.99	28	28	10.4	2.60
Corn flakes	16.3	.99	.99	28	28	6.1	1.52
Corn flour	16.0	.99	.99	28	28	8.0	2.00
Corn starch	16.3	.99	.99	28	28	*	*
Cottolene	40.8	.39	.39	11	11	*	*
Cowpeas, dried	15.5	1.03	1.03	29	29	24.8	6.20
green			2.68		76	28.6	7.15
Crackers, Boston	18.4	.87	.87	25	25	11.0	2.75
graham	19.	.84	.84	24	24	9.5	2.37
oyster	19.	.84	.84	24	24	10.7	2.67
saltines	19.5	.82	.82	23	23	9.8	2.45
soda	18.8	.85	.85	24	24	9.5	2.37
Crackers, water	18.6	.89	.89	25	25	11.8	2.95
Cranberries	2.1	7.57	7.57	215	215	3.4	0.85
Cream, 18.5% fat	8.8	1.81	1.81	51	51	5.1	1.27
40% fat	17.3	.93	.93	26	26	2.3	.57
Cucumbers, fresh	0.7	23.53	20.28	667	575	18.4	4.60
pickles	0.7	22.76	22.76	645	645	12.9	3.22
Currants, dried (Zante)	14.6	1.10		31		3.0	0.75

* In these cases the amounts are assumed to be negligible.

Hundred-Calorie Portions of Food — (*Continued*)

Food Material	Portion in one Pound as Purchased	Weight in Ounces		Weight in Grams		Protein in 100-Calorie Portion	
		As purchased	Edible portion	As purchased	Edible portion	Calories	Grams
Currants, fresh	2.6	6.17		175		10.5	2.62
Dates	14.2	1.13	1.02	32	29	2.4	.60
Doughnuts	19.4	.82	.82	23	23	6.2	1.55
Eggs, whole	6.	2.69	2.38	76	68	36.2	9.05
white	2.3		6.92		196	96.5	24.12
yolk	16.4		.97		28	17.3	4.32
Eels, dressed	5.6	2.85	2.26	81	64	47.6	11.90
Eggplant			12.64		358	17.2	4.30
Farina	16.4	.97	.97	28	28	12.2	3.05
Figs, dried	14.4	1.12		32		5.4	1.35
Fig bars	16.2	.99	.99	28	28	5.2	1.30
Filberts	15.3	1.05	.50	30	14	8.8	2.20
Flounder (entrails removed)	1.1	12.45		350		90.4	22.60
Flour, rye	15.9	1.01	1.01	29	29	7.8	1.95
wheat, entire	16.3	.98	.98	27	27	15.4	3.85
wheat, graham	16.3	1.00	1.00	28	28	12.7	3.17
wheat, patent	16.2	1.00	1.00	28	28	12.7	3.17
wheat, straight	16.1	1.00	1.00	28	28	12.1	3.02
wheat average high and medium grades	16.1	1.00	1.00	28	28	12.8	3.20
Flour, wheat, low grade	16.3	1.00	1.00	28	28	15.7	3.92
Fowl	7.5	2.13	1.58	60	45	34.5	8.62
Frog's legs	2.0	8.12	5.53	233	157	97.2	24.30
Gelatin	16.6	.96	.96	27	27	99.8	24.95
Ginger, crystallized	15.8	1.02	1.02	29	29	.4	.10
Ginger snaps	18.5	.86	.86	25	25	6.4	1.60
Goose, young	14.6	1.10	.90	31	26	16.7	4.17
Grape butter	10.9	1.48	1.48	42	42	2.0	.50
Grapes	3.3	4.87	3.66	138	104	5.4	1.35
Grape juice	4.5	3.53	3.53	100	100		
Greens, dandelion	2.7	5.78	5.78	164	164	15.7	3.92
Haddock (entrails removed)	1.6	9.96	4.94	283	139	96.2	24.05
Haddock, smoked	3.2	5.50	3.71	156	105	98.1	24.52
Halibut, smoked	9.2	1.74	1.62	49	46	38.0	9.50
Halibut, steaks	4.5	3.49	2.93	99	83	61.4	15.35

HUNDRED-CALORIE PORTIONS OF FOOD—(*Continued*)

Food Material	Portions in one Pound as Purchased	Weight in Ounces		Weight in Grams		Protein in 100-Calorie Portion	
		As purchased	Edible portion	As purchased	Edible portion	Calories	Grams
Ham, fresh lean	10.3	1.55	1.55	44	44	44.0	11.00
medium fat	13.	1.23	1.10	35	31	19.0	4.75
smoked, lean	10.7	1.49	1.32	42	38	29.7	7.42
smoked, medium fat	19.	.98	.85	28	24	15.7	3.92
boneless	13.8	1.16	1.16	33	33	18.8	4.70
Ham, deviled	17.4	.92	.92	26	26	19.8	4.95
Headcheese	13.2	1.21	.92	34	26	20.4	5.10
Herring, smoked	7.3	2.19	1.22	62	35	50.9	12.72
whole	3.6	4.25	2.49	125	71	55.0	13.75
Hickory nuts	12.2	1.31	.49	37	14	8.6	2.15
Hominy	16.1	1.00	1.00	28	28	9.4	2.35
Honey	14.8	1.08	1.08	31	31	0.5	0.12
Huckleberries	3.4	4.76		135		3.3	0.82
Koumiss	2.3	6.82	6.82	193	193	21.7	5.42
Lamb, breast	10.6	1.51	1.22	43	35	26.4	6.60
chops, broiled	14.2	1.13	.99	32	28	24.4	6.10
fore quarter	11.2	1.41	1.16	40	33	24.2	6.05
hind quarter	9.5	1.69	1.41	48	40	31.4	7.85
leg, medium fat	8.4	1.90	1.57	54	44	34.1	8.52
loin	12.7	1.26	1.06	36	30	22.7	5.67
neck	11.0	1.46	1.20	41	34	24.1	6.02
shoulder	12.3	1.31	1.04	37	29	21.3	5.32
side	10.2	1.59	1.27	45	36	25.4	6.35
tongue	9.5	1.68		48		25.8	6.45
Lard	40.9	.39	.39	11	11	*	*
Lemons	1.4	11.41	7.96	324	226	9.0	2.25
Lemon juice	1.8	9.00	9.00	255	255	*	*
Lentils	15.8	1.01	1.01	29	29	29.5	7.37
Lettuce	0.7	22.32	18.47	633	524	25.1	6.27
Lobster	1.3	11.48	4.23	326	120	78.6	19.65
canned	3.8	4.30		119		85.9	21.47
Macaroni	16.3	.99	.99	28	28	14.8	3.70
Mackerel, fresh	3.6	4.49	2.54	127	72	53.9	13.47
salt	10.0	1.43	1.15	41	33	22.6	5.65
salt canned	7.0	2.25		64		50.0	12.50

* In these cases the amounts are assumed to be negligible.

Hundred-Calorie Portions of Food—(*Continued*)

Food Material	Portions in one Pound as Purchased	Weight in Ounces		Weight in Grams		Protein in 100-Calorie Portion	
		As purchased	Edible portion	As purchased	Edible portion	Calories	Grams
Marmalade, orange . . .	15.5	1.02	1.02	29	29	0.7	0.17
Milk, condensed, sweetened	14.8	1.08	1.08	31	31	10.8	2.70
condensed, unsweetened	7.5	2.11	2.11	59	59	23.0	5.75
skimmed	1.6	9.61	9.61	273	273	37.0	9.25
whole	3.1	5.10	5.10	145	145	19.0	4.75
Molasses	13.0	1.23	1.23	35	35	3.3	.83
Mushrooms	2.0	7.86		223		31.2	7.80
Muskmelons	.9	18.00	8.91	510	252	6.0	1.50
Mutton, chuck	14.4	1.11	.91	32	26	15.0	3.75
flank, medium fat . .	17.5	.91	.87	26	25	15.0	3.75
fore quarter	12.2	1.30	1.02	37	29	18.0	4.50
hind quarter	9.5	1.34	1.09	38	31	20.7	5.17
hind leg, lean	7.2	2.22	1.85	63	52	41.5	10.37
hind leg, medium fat .	8.7	1.83	1.50	52	42	31.4	7.85
loin, medium fat . . .	14.0	1.14	.97	32	28	17.7	4.42
neck, medium fat . .	9.5	1.68	1.22	48	35	23.4	5.85
shoulder, medium fat .	8.8	1.82	1.41	52	40	28.3	7.07
side	10.1	1.30	1.06	37	30	19.4	4.85
Nectarines	2.7	5.71	5.34	162	152	3.6	.90
Oatmeal, rolled oats . .	18.1	.88	.88	25	25	16.1	4.02
Okra	1.5	10.54	10.54	299	299	16.8	4.20
Oleomargarine	34.1	.47	.47	13	13	0.6	0.15
Olives	10.	1.61	1.18	46	33	1.5	0.37
Onions	2.0	8.03	7.24	228	205	13.2	3.30
Oranges	1.7	9.45	6.86	268	195	6.2	1.55
Orange juice	2.	8.17	8.17	232	232	*	*
Oysters, fresh solids . .	2.3		7.00		198	49.2	12.30
canned	3.3	4.87		138		48.6	12.15
Parsnips	2.4	6.78	5.43	192	154	9.9	2.47
Pea soup, canned . . .	2.3	6.91	6.91	196	196	28.2	7.05
Peaches, canned	2.1	7.50	7.50	213	213	5.9	1.47
fresh	1.5	10.47	8.53	297	242	6.8	1.70
Peanuts	18.8	.85	.64	24	18	18.8	4.70
Peanut butter	27.4	.58	.58	16	16	19.4	4.85
Pears, fresh	2.5	6.25	5.57	177	158	3.8	.95

* In these cases the amounts are assumed to be negligible.

Hundred-Calorie Portions of Food — (*Continued*)

Food Material	Portions in one Pound as Purchased	Weight in Ounces		Weight in Grams		Protein in 100-Calorie Portion	
		As purchased	Edible portion	As purchased	Edible portion	Calories	Grams
Pears, canned	3.4	4.65	4.65	132	132	1.6	.40
Peas, canned	2.5	6.37	6.37	181	181	26.1	6.52
dried	16.1	.99	.99	28	28	27.7	6.92
green	2.5	6.37	3.52	180	100	28.0	7.00
Pecans	17.9	.89	.48	25	14	5.2	1.30
Perch	2.6	6.32		174		89.0	22.25
Pies, apple	12.3	1.30	1.30	37	37	4.6	1.15
custard	8.0	1.98	1.98	56	56	9.4	2.35
lemon	11.6	1.38	1.38	39	39	5.6	1.40
squash	8.2	1.98	1.98	56	56	9.8	2.45
Pineapple, fresh			8.18		232	3.7	.92
canned	7.0	2.30		65		1.0	.25
Pine nuts, shelled	27.5	.58	.58	17	17	22.3	5.57
Pistachios, shelled	29.0	.55	.55	16	16	13.9	3.47
Plums	3.6	4.41	4.18	125	118	4.8	1.20
Porgy, whole	2.2	7.27	2.93	206	83	61.9	15.47
Pork, loin chops, lean	9.	1.83	1.40	52	40	32.2	8.05
loin chop, medium fat	12.3	1.30	1.04	37	30	19.7	4.92
fat, salt	35.5	.45	.45	13	13	1.0	.25
side, not lard and kidney	21.4	.75	.66	21	19	6.8	1.70
shoulder, smoked	13.	1.21	.99	34	28	17.9	4.47
sausage	20.5	.78	.78	22	22	11.4	2.85
tenderloin	8.8	1.83	1.83	52	52	39.2	9.80
Potato chips	26.0	.62	.62	17	17	4.8	1.20
Potatoes	3.0	5.27	4.23	150	120	10.6	2.65
Potatoes, sweet	4.5	3.58	2.86	101	81	5.8	1.45
Prunes, dried	11.6	1.37	1.17	39	33	2.8	.70
Pumpkins	0.6	26.52	13.72	752	389	15.6	3.90
Radishes	1.3	17.21	12.04	488	341	17.7	4.42
Raisins	14.0	1.14	1.02	32	29	3.0	.75
Raspberries	3.0	5.33	5.33	151	151	10.3	2.57
Raspberry juice	2.	9.38	9.38	266	266	*	*
Rhubarb	0.6	25.20	15.27	714	433	10.4	2.60
Rice	15.9	1.01	1.01	29	29	9.1	2.27
Rice flour	16.4	.97	.97	28	28	9.5	2.37

* In these cases the amounts are assumed to be negligible.

Hundred-Calorie Portions of Food — (*Continued*)

Food Material	Portions in one Pound as Purchased	Weight in Ounces		Weight in Grams		Protein in 100-Calorie Portion	
		As purchased	Edible portion	As purchased	Edible portion	Calories	Grams
Rutabagas	1.	12.37	8.62	351	246	12.6	3.15
Salmon, fresh	6.4	2.50	1.75	71	49	43.3	10.82
canned	6.6	2.41	1.80	69	51	44.5	11.12
Sausage, bologna	11.4	1.50	1.50	43	43	31.9	7.97
frankfort	11.3	1.12	1.12	40	40	31.3	7.82
summer	21.6	0.74	0.70	21	20	20.6	5.15
Sardines	9.2	1.73	1.31	49	37	34.2	8.55
Scallops	3.3	4.79	4.79	135	135	80.3	20.07
Shad	3.6	4.37	2.19	124	62	46.8	11.70
Shad roe	5.8	2.75	2.75	78	78	65.2	16.30
Shredded wheat	16.6	.97	.97	27	27	14.0	3.50
Shrimp, canned	5.0	3.17		90		90.8	22.70
Smelt	2.2	7.14	4.07	202	116	81.3	20.32
Spinach			14.76		418	35.2	8.80
Squash	1.0	15.62	7.65	443	217	12.2	3.05
Strawberries	1.7	9.53	9.04	270	256	10.2	2.55
Strawberry juice	0.9	17.60	17.60	500	500	*	*
Sturgeon, anterior sections	3.3	4.72	3.94	134	112	80.9	20.22
Sugar, granulated	18.2	.88	.88	25	25	*	*
maple	15.0	1.07	1.07	30	30		
brown	17.2	.93	.93	26	26		
Tapioca	16.	.99	.99	28	28	.4	.10
Terrapin	1.3	12.20	3.03	346	86	72.9	18.22
Tomatoes, canned	1.	15.63	15.63	443	443	21.2	5.30
fresh	1.	15.47	15.47	439	439	15.8	3.95
Tripe	2.6	6.12		174		81.2	20.30
Trout, salmon	3.7	4.29	2.15	122	61	43.4	10.85
Turkey	10.4	1.53	1.21	44	34	29.0	7.25
Turtle, green	.9	17.90	4.21	508	119	94.6	23.65
Turnips	1.8	12.92	8.95	366	254	13.2	3.30
Vanilla wafers	19.9	.80	.80	23	23	6.0	1.50
Veal, breast, lean	5.	2.97	2.25	84	64	54.1	13.52
breast, medium fat	7.	2.19	1.75	62	50	38.4	9.60
chuck, lean	3.6	4.34	3.54	132	101	82.8	20.70
chuck, medium fat	6.	3.18	2.57	90	78	57.4	14.35

* In these cases the amounts are assumed to be negligible.

HUNDRED-CALORIE PORTIONS OF FOOD — (*Continued*)

FOOD MATERIAL	PORTIONS IN ONE POUND AS PURCHASED	WEIGHT IN OUNCES		WEIGHT IN GRAMS		PROTEIN IN 100-CALORIE PORTION	
		As purchased	Edible portion	As purchased	Edible portion	Calories	Grams
Veal, flank, medium fat	8.	2.01	2.01	60	60	46.6	11.65
kidney	5.6	2.82	2.82	80	80	54.0	13.50
leg, lean	5.	3.18	2.89	90	81	69.8	17.45
leg, medium fat	6.	2.65	2.18	75	62	49.9	12.47
liver	5.6	2.85	2.85	81	81	61.4	15.35
loin, lean	4.6	3.42	2.67	97	76	61.8	15.45
loin, medium fat	6.6	2.39	1.99	68	57	45.0	11.25
neck	4.4	3.63	2.47	103	70	56.8	14.20
rib, medium fat	4.6	3.41	2.56	97	73	60.1	15.02
rump	7.	2.25	1.57	64	44	35.2	8.80
shank, fore	3.4	4.60	2.72	130	77	63.9	15.97
shank, hind	2.	7.65	2.84	217	81	66.6	16.65
shoulder, lean	4.6	3.43	2.84	97	81	66.7	16.67
shoulder, medium fat	7.	2.21	1.69	63	48	37.8	9.45
Vegetable soup	0.6	25.83	25.83	735	735	85.2	21.30
Walnuts, California	8.6	1.86	.50	53	14	10.4	2.60
black	7.8	2.05	.53	58	15	16.6	4.15
Watermelons	.6	28.22	11.68	800	331	5.3	1.32
Weak fish	2.0	7.96	3.80	226	108	76.7	19.17
Wheat, cracked	16.4	.97	.97	28	28	12.3	3.07
Whey	1.2	13.20	13.20	375	375	15.0	3.75
Whitefish	3.2	5.08	2.35	144	67	61.0	15.25
Zwieback	19.1	.84	.84	24	24	9.3	2.32

APPENDIX E

FOOD PRODUCTS AS SOURCES OF VITAMINS A, B, AND C

+ indicates that the food contains the vitamin.

++ indicates that the food is a good source of the vitamin.

+++ indicates that the food is an excellent source of the vitamin.

– indicates that the food contains no appreciable amount of the vitamin.

? indicates doubt as to presence or relative amount.

* indicates that evidence is lacking or appears insufficient.

Food	Vitamin A	Vitamin B	Vitamin C
Alfalfa	+++	++	*
Almonds	+	++?	*
Artichoke		+	
Apples, raw	+	+	++
Asparagus	*	+++	*
Bacon	– to +	+	?
Bananas, raw	+?	+	++
Barley, whole	+	++	–
Beans, kidney	+	+++	*
Beans, navy	+	+++	*
Beans, soy	+	+++	*
Beans, sprouted	+	++?	++
Beans, string, fresh, raw	++	++	++
Beans, string, cooked	++	++	
Beechnut	*	++	*
Beef	– to +	+	– to +
Beef juice	*	+	– to +
Beef fat	+	–	–
Beets (roots)	*	+	*
Beet leaves	++	+	*
Beet stems	*	+	*
Brains	+	++	?
Brazil nuts	+?	++	*

Food Products as Sources of Vitamins A, B, and C — (*Continued*)

Food	Vitamin A	Vitamin B	Vitamin C
Bread, white, water	?	+	–
Bread, white, milk	+	+	?
Bread, whole wheat, water . .	+	++	?
Bread, whole wheat, milk . .	++	++	?
Butter	+++	–	–
Buttermilk	+	++	+ variable
Cabbage, green, raw	++	++	+++
Cabbage, head, raw	+	++	+++
Cabbage, head, cooked . . .	+	++	+
Cabbage, head, canned . . .	+	++	?
Cabbage, head, dried	+	++	+?
Carrots, fresh, raw	++	++	++
Carrots, cooked	++	+	+
Cauliflower	+	++	+
Celery, bleached stems . . .	– to +	++	*
Celery, bleached leaves . . .	+	++	*
Celery, green leaves.	++	++	*
Chard	++	+	*
Cheese, full milk	++	*	*
Cheese, cottage (skim) . . .	+	*	*
Clover, young	+++	++	*
Chestnut	*	+	*
Cloudberries	*	*	+++
Cloudberries, canned	*	*	+++
Coconut	+	++	*
Coconut oil	–	–	–
Cocum, dried	*	*	+
Codliver oil	+++	–	–
Corn (maize) white	– to +	++	–
Corn (maize) yellow	+	++	–
Corn oil	?	–	–
Cottonseed (flour or meal) . .	+	++	*
Cottonseed oil	?	–	–
Cream	+++	++	+ variable
Cress	*	*	+
Cucumber	*	+	++?
Dandelion greens	++	++	+
Dasheens	–?	+	+
Eggs	+++	+	+?
Egg white	–	*	*

FOOD PRODUCTS AS SOURCES OF VITAMINS A, B, AND C — (*Continued*)

Food	Vitamin A	Vitamin B	Vitamin C
Egg yolk	+++	+	*
Eggplant	*	++	*
Endive	+	*	+
Filberts	*	++	*
Fish, fat	+	+	*
Fish, lean	− to +	+	*
Flour, white	−	+	−
Flour, whole wheat	+	++	−
Glucose	−	−	−
Grains, whole, dry	+	++	−
Grains, sprouted	+	++?	++
Grapes	*	+	+
Grape juice	*	+	+
Grape fruit	*	++	++?
Ham	− to +	+	−
Heart	+	+	+?
Hickory nuts	*	++	*
Honey	−	+	−
Horse fat	+	−	−
Ice cream (genuine)	++	++	+?
Kidney	+	++	+?
Lard	− to +	−	−
Legumes, sprouted	*	++?	++
Lemon juice	?	++	+++
Lemon juice dried	?	++	+++
Lentils (dry)	*	++	−
Lettuce	++	++	+++
Limes	*	+	+
Linseed oil	−	−	−
Liver	++ variable	++	+
Malt, green	+	++?	++
Mango	*	*	+
Margarine, animal fat	− to +	−	−
Margarine, vegetable fat	−	−	−
Meat (muscle)	− to +	+	to +
Meat, canned	− to +	+	−
Meat extract	−	−?	−
Milk (whole)	+++	++	+ variable
Milk "scalded"	+++	++	+ variable
Milk condensed	+++	++	+ variable

FOOD PRODUCTS AS SOURCES OF VITAMINS A, B, AND C — (*Continued*)

Food	Vitamin A	Vitamin B	Vitamin C
Milk evaporated	+++	++	−?
Milk dried, whole	+++	++	+ variable
Milk dried, skim	+	++	+ variable
Milk fresh, skim	+	++	+ variable
Millet	+	++	*
Mulberries	*	*	+
Mutton	− to +	+	?
Mutton fat	+	−	−
Oatmeal	− to +	++	−
Oleo oil	+	−	−
Olive oil	−?	−	−
Onions, raw	− to +	++	++
Onions, cooked	− to +	++	+
Orange juice	+ to ++	++	+++
Orange peel	+	+	++
Orange peel oil	++	*	*
Palm oil	+	−	−
Parsley	*	++	*
Parsnips	−?	++	*
Peaches, raw	*	*	++
Peanuts	+	++	*
Peanut butter	+	++	*
Peanut oil	−	−	−
Pears	*	+	*
Peas, young green	++	++	++?
Peas, dry	+	++	?
Peas, sprouted	+	++?	++
Pecans	*	+	*
Pig kidney fat	++	−	−
Pine nuts	+	+	*
Pineapple, fresh, raw	++	++	+++
Pineapple, canned	++	++	*
Pork	− to +	+	−
Potatoes, sweet	++	+	*
Potatoes, white, raw	+	++	++
Potatoes, white, boiled 15 min.	+	++	++
Potatoes, white, boiled 1 hr.	+	++	+
Potatoes, white, baked	+	++	+
Prunes	+	+	−
Radish	*	+	*

Food Products as Sources of Vitamins A, B, and C — (*Continued*)

Food	Vitamin A	Vitamin B	Vitamin C
Raisins	?	+	−
Raspberries, fresh	*	*	+++
Raspberries, canned	*	*	++
Rhubarb	*	*	+
Rice ("polished") white	−	−	−
Rice, whole grain	+	++	−
Roe (fish)	+	++	?
Rutabaga	−?	++	+++?
Rye, whole	+	++	−
Sauerkraut	+	+	−?
Spinach, raw	+++	+++	+++
Spinach, cooked	+++	+++	*
Spinach, canned	++	*	*
Spinach, dried	+++	++	*
Squash, Hubbard	++	*	*
Starch	−	−	−
Sugar	−	−	−
Swede	*	++	+++?
Sweetbreads	+	+	*
Tamarind, dried	*	*	+
Tomato, raw	++	+++	+++
Tomato, cooked	++	+++	+++
Tomato, canned	++	+++	+++
Tomato, dried	++	+++	++
Turnip	− to +	++	*
Veal	*	+	*
Walnuts	*	++	*
Whale oil	++	−	−
Wheat bran	+	++?	−
Wheat embryo	++	+++	−
Wheat endosperm	−	+	−
Wheat flour, white	−	+	−
Wheat middlings	*	++	−
Wheat whole	+	++	−
Yeast	−	+++	−
Yeast extract	−	+++	−

B.P.
Extracts

SUBJECT INDEX