THE ECONOMY OF FOOD

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A POPULAR TREATISE ON NUTRITION, FOOD AND DIET

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PREFACE

The scope of this work is fairly indicated by the sub-title. It is described as a popular treatise because it is intended for students of domestic economy, cooks, caterers, housekeepers and managers of institutions, rather than for specialists in physiology, chemistry and hygiene. The subject cannot be adequately treated without reference to the principles of these sciences; but the more difficult parts have been relegated to footnotes, and the use of technical terms in the text has been avoided as far as possible.

The first section deals mainly with the requirements of the body. The origin, properties and composition of the commoner kinds of food are discussed in the second. In the third, an attempt is made to combine these two branches in a form suitable for practical everyday use—to translate protein, carbohydrates, etc., into terms of bread and meat, i.e., of breakfast, dinner and supper.

The interest is largely centered upon the pecuniary aspects of the subject. The prices quoted are, in most cases, those of London stores. They are, of course, liable to fluctuation; but they represent, as nearly as could be ascertained, the average prices prevailing in different parts of the country. All calculations in which prices are involved are explained in detail; and the reader can therefore adjust any possible differences due to this cause.

In regard to the method of estimating the relative pecuniary values of foods which the author has ventured to propound in Chapter XIV, there may be room for some difference of opinion. The object might, perhaps, have been achieved by other means; but most of the methods hitherto adopted have proved unsatisfactory to the class of reader chiefly concerned. The calculated results given in the tables will be found easily intelligible and convenient in form.

The author disclaims any special sociological skill. He does not pretend to say authoritatively what proportion of the family income either is or should be expended on food. For the purposes of Chapter XVIII, the sum of 5*s*. per head, per week, affords an opportunity of discussing the difficulties and possibilities of the subject, and may be regarded as a typical case.

With the exception of a few illustrative examples, practically all the tabular matter has been collected together in the form of an appendix to Section II. This arrangement is handy for reference, and it possesses the further advantage that the reader's attention is not distracted by masses of figures—often not wholly relevant to the issue—which would otherwise appear on nearly every page.

As so much is founded upon data obtained by the use of calorimeters, it was deemed advisable to illustrate the apparatus, though it was impossible, within the limits of space, to attempt any description of their construction or the methods of using them.

Standard works on dietetics, chemistry and physiology have been freely consulted, and much information has been culled from the bulletins of the Office of Experiment stations of the U.S. Department of Agriculture. The researches of Atwater and Bryant have furnished most of the data relating to the composition of foods, but some are derived from other sources. The analyses of patent and proprietary articles were supplied by the makers. For information regarding the composition of pastry, soups and other compounded foods, the author has relied chiefly upon Mrs. Beeton's cookery book. Practical men engaged in the meat, fish and grocery trades have rendered valuable assistance in connexion with the matter relating to their several departments. The help received from Dr. T. P. Beddoes, Mr. W. R. Thomas, and Miss Elsie H. Penry in revising the proofs must also be gratefully acknowledged.

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CHAPTER I

INTRODUCTORY

> Economics, so far as they regard only inanimate things, serve only the low purposes of gain; but where they regard human beings they rise higher.
>
> *Plutarch.*

A GOOD deal of confusion exists regarding the meaning of the term economy. In the ordinary language of the housekeeper it is associated with the idea of frugality, thrift or saving. Ruskin has pointed out that "economy is not saving any more than it is spending." It is obvious, however, that it does, or may, mean saving if one chooses that it shall do so.

The word is also used in a different sense. It is derived from the Greek *οἰκος*, a house, and *νόμος*, to manage or control. That, no doubt, is what it originally implied, and the expression "domestic economy" is, therefore, redundant. But the meaning was gradually extended to the administration of the resources and concerns of any community or establishment, and ultimately to the organization of any complex unity. Thus we speak of animal and vegetable economy, the economy of nature, and so on.

It is in this latter sense that the term economy has been introduced into the title of this book, which treats of the nature, sources, composition and functions of various kinds of food. As, however, it is intended to deal with the subject largely from the former point of view, i.e. with reference to the cost and thrifty use of food, the very ambiguity of the term renders it a peculiarly appropriate one for the purpose.

In the sense of saving, economy is often confounded with parsimony; but they are not the same. Saving is not economy if it interferes with the purpose in view. The purpose of taking food is to satisfy the cravings of hunger, to provide for the requirements of the body, and, to a certain extent, to gratify the legitimate sensations of the palate. Fifty per cent. of the food might be saved by going on half rations; but if hunger were not appeased, this could not properly be called economy, except under famine conditions. Potatoes are cheaper than meat, and hunger may be appeased by the former at less cost than by the latter; but if the body be not properly nourished, there would be no true economy; the saving would be, in effect, not gain but loss.

Gratification of the palate is, perhaps, a matter of secondary, but still of considerable, importance, especially for those engaged in sedentary occupations. Nervous exhaustion is frequently accompanied by loss of appetite, and in such a condition a person may not eat enough to sustain him properly if the food be not to his taste. It is not economy, therefore, but the reverse to provide food—however cheap—which the person for whom it is intended can't or won't eat. Even minor preferences should be considered as far as possible. Condiments and flavouring materials, though of no value in themselves, may prove useful in this connexion.

Any saving in cost may be regarded as economy, in the pecuniary sense, provided the food is of a kind suitable for the nourishment of the body, sufficient in quantity, and sufficiently attractive to be eaten with a relish. Any expenditure beyond the minimum required to obtain such food may be, by contrast, regarded as extravagance. It is beside the question to argue that the more expensive food might be nicer, and that, if the person could afford it, such extravagance would be justifiable. At present, the object is merely to arrive at an understanding regarding the meaning of the terms employed.

The kind and quantity of food that should be eaten are indicated, to some extent, by instinct—the sensations of the stomach, the palate and the nostrils ; but under the conditions of civilized life, this is not a sufficient or altogether reliable guide. A person might habitually over-eat and yet be in a state bordering upon starvation. Cases of this kind are probably of rare occurrence, but they are conceivable. They are more likely to arise in connexion with the feeding of children than of adults. If the food be unsuitable, either in quantity or quality, some portion of it will be wasted, and health and comfort will be more or less deranged.

Profound ignorance concerning the requirements of the body and of the properties and functions of the various kinds of food is very prevalent, even amongst the educated classes. The majority of people are content to be guided in their choice of food, by what is customary in the class and country to which they belong. Many of the well established dietetic customs are based on experience, traditional and personal, and they are usually, but not invariably, sound and satisfactory in the main. But they are subject to modification in detail, and owing to the general lack of knowledge, errors in diet are far from uncommon. Stunted growth and retarded development in children, and various disorders in adults, may often be traced to this cause. Waste of resources is another consequence, and, for the poorer classes at least, a very serious one. The effects of an occasional indiscretion may be almost imperceptible if the normal diet of the individual be well adapted to his requirements; it is the systematic error that it is important to guard against.

The vague and indefinite phraseology used in describing foods is, no doubt, responsible for the inaccuracy of many of the popular notions. "Rich," "strong" and similar expressions are used in different, sometimes in contradictory, senses, and not infrequently without any definite meaning at all. Terms such as nutritious, fattening, digestible, are imperfectly understood. Cost and value are often confused.

The confusion of ideas is particularly striking in connexion with the use of the word nutritious. Synonyms might easily be found for it, but it is by no means easy to define it. All foods are nutritious —otherwise they could not properly be called foods. When one food contains a larger proportion of nutritive substances than another, it is commonly said to be more nutritious; but it would be more accurate to say, simply, that it is more concentrated. A pound of bread contains, roughly, about four times as much nourishment as a pound of potatoes, and may, therefore, be said to be more nutritious. But, on this hypothesis, a pound of bread is not more nutritious than four pounds of potatoes.

Highly concentrated foods have their special uses; so also have those of more bulky character. The concentration of the foods is perhaps more important when they are considered with reference to their cost than in any other connexion.

A larger or smaller proportion of the nutritive matters of foods is usually present in such a condition that it cannot be assimilated and is, therefore, said to be indigestible.[1] No nourishment can be derived from this material; it simply passes through the intestines and is excreted unchanged. Two foods which contain the same proportions of nutritive matter will not, therefore, be equally nutritious unless they are equally digestible. For example, suppose the digestibility of an egg to be affected—adversely or otherwise—by cooking, the egg would be rendered less, or more, nutritious accordingly, though the amount of nutrients remained the same.

The nature of the nutrients must also be taken into consideration. For present purposes, they may be roughly divided into two classes, viz. nitrogenous and non-nitrogenous. They are sometimes referred to as flesh-formers and heat-producers, respectively. This distinction was introduced some years ago in order to avoid the use of scientific terms; but it is radically unsound and has

[1] The term digestibility is also used with reference to the length of time the food remains in the stomach. (See p. 22.)

proved misleading. The "flesh-formers" produce more heat than some of the so-called "heat-producers"; and the latter are intimately connected with the phenomena of tissue formation. It is true, however, that they have different functions, and there can be no true comparison between foods in which the relative proportions of these ingredients vary widely.

The foods in which nitrogenous nutrients predominate—chiefly those of animal origin—are generally the more expensive; and this appears to have given rise to a widespread belief that these foods are the more nutritious. It may be true that many people would do better if the proportion of nitrogenous nutrients in their food were increased. It is true that, within certain limits, an excess of these constituents is harmless, and that a deficiency is fatal; but the generalization above referred to is, to say the least, extremely rash. It is also commonly held that the non-nitrogenous nutrients—especially starch and sugar—are essentially and intrinsically fattening. It is not a little curious that these two opinions should be frequently entertained by the same persons, for the one is a manifest contradiction of the other.

Neither nutrition nor fattening is attributable to any single constituent of the food; they depend largely upon the proportions of the two classes of nutrients. The proportions required vary according to the circumstances; but when—and only when—all the other requirements of the body have been satisfied, the excess of either kind may be stored up as fat.

Persons who for any reason desire to reduce their weight—chiefly athletes in training and those who have a disposition towards obesity—are frequently quite eccentric about their diet; they shun potatoes and certain other kinds of food, take all their bread toasted, eat raw or only partially cooked meat, and so on. In some cases the systems adopted involve considerable self-denial for which there is no necessity. The purpose could usually be accomplished equally well on a rational ordinary diet if properly regulated.

Comparisons of one food with another are apt to be misleading unless all the circumstances are taken into account. It may be said, however, that, whereas bread contains four or five times as much nutritive matter as an equal weight of potatoes and is not less digestible, it is difficult to see what advantage is gained by substituting the former for the latter in the diet of a person who wishes to reduce weight.

Bread may possibly be rendered more—or less—digestible by toasting, but the amount of nutritive matter in it is not perceptibly altered. As, however, a certain amount of moisture escapes in the process, what is left—the toast—is more concentrated than the fresh bread. Possibly some people may find toast less fattening because they eat less of it. In that case, of course, it is merely a question of the quantity and not of the condition of the bread.

It is a mistake to suppose that raw, or semi-raw, meat is more nutritious than that which has been moderately cooked. The latter is more easily masticated, and probably on that account more readily digestible;[1] and as it is drier it contains

[1] The contrary has been maintained but the evidence on this subject is not very satisfactory.

actually a larger proportion of nutritive matter than the same meat in the raw condition. In this case also, the quantity eaten must be taken into account. A certain amount of loss is incidental to nearly all processes of cooking (see p. 144), but if the cooking be not overdone, the loss is not, as a rule, very great. When meat is over-cooked it is probably rendered less digestible than that which is underdone, and the incidental loss is much greater. The notion that raw meat is the more nutritious may be attributable to this fact.

Soups and meat extracts are popularly supposed to be very nourishing, and are frequently administered to invalids on that account. The term "essence of beef" and similar expressions found in the advertisements of commercial preparations of this kind, are probably intended to encourage this idea. But if it be true, as indicated above, that the loss of nourishing matter, resulting from the moderate cooking (boiling) of meat, is not very great, it follows that there cannot be much in the broth so prepared. If the meat be "boiled to rags" the loss will be considerable, but the amount of nutrients in the soup will not be correspondingly large. Much of the substance extracted from meat by boiling or stewing undergoes a partial decomposition whereby its nourishing properties are greatly reduced. The products, however, impart an agreeable, appetizing flavour and odour to the broth, and they have a marked stimulating effect which may be highly beneficial to invalids or to persons suffering from bodily or nervous exhaustion. Soups which have been thickened by the admixture of considerable quantities of flour, barley, fresh vegetables, etc., are, of course, an entirely different case. Each of these foods possesses a definite nutritive value of its own; but this value is not altered—neither increased nor diminished—by mixing the foods with the "stock" or soup proper.

With very few exceptions, foods do not react upon or affect each other in any way; they do not, therefore, become more nutritious when mixed together. It is highly advantageous to partake of certain different kinds of foods, e.g. meat and potatoes, in conjunction; but nothing is gained by actually mixing them. The nutritive value of, say an egg and milk, or bread and milk, is no greater than that of the same two foods taken separately at, or about, the same time. On the other hand, some foods are rendered much more palatable or agreeable by mixing. Half the art of cookery consists in the concoction of such judicious mixtures; and, since the nutritive value of the foods is not affected, there is no reason why taste should not be gratified in this way.

The nutritive value of certain foods has sometimes been attributed to wrong causes, and in other cases it has been greatly exaggerated. Milk and eggs are cases in point.

Milk is a very useful and valuable food. It is pre-eminently suitable for young children and invalids. It has been called a perfect food. This, however, is an exaggeration except in its application to infants. For adults, there is no perfect food; their requirements vary, but they are not the same as those of children. Milk is recommended for invalids, not because it contains a large proportion of nutritive matter, but largely for the contrary reason, i.e. because it is not too concentrated; even so, it is often necessary to dilute it.

The nutritive matter in milk is present in smaller proportion than in many other foods; but it is present in such a condition that it is very easily assimilated. It is chiefly to this fact that milk owes both its special and its general utility.

The statement that skim milk and butter milk are more nutritious than fresh whole milk can scarcely be called a popular fallacy, as it is not generally accepted, though often repeated. At any rate, it is absurd. It probably originated with some one obsessed with a morbid love of paradox. The amount of nourishment in a food cannot be increased by abstracting a portion of it.

Eggs are commonly regarded as a highly nutritious food, but they are somewhat sparingly used "because they are so dear." But if eggs contain more nourishment than other foods, they may be actually cheaper, even at a relatively higher price. As a matter of fact, eggs do not contain so large a proportion of nourishment as is sometimes supposed; and compared with many other foods, they are dear. That is to say, that the same amount of nourishment could be obtained from other foods at less cost.

In the celebrated system of Banting, great attention was paid to the quantity of liquids consumed; and many people entertain the ridiculous notion that water itself is fattening. In Banting's case the restriction referred chiefly to the use of alcoholic beverages which, when taken in large quantities, have a tendency to increase weight. This effect, however, is due, not to the water, but to the solids, of which malt liquors and certain wines contain a considerable proportion. In the treatment of obesity, restriction of the quantity of water frequently leads to a reduction of weight; but it has been shown that this result is due simply to reduction of the quantity of water in the body, and that the quantity of fat is scarcely affected one way or the other. It may be questioned whether it is wise to effect a reduction of weight in this way. If less than a certain minimum quantity of water be consumed daily, health and comfort will suffer. Medical men consider that many people—especially women—do not drink enough. A very large excess of water may also prove injurious; but considerably more than is actually necessary may be taken without any perceptible effect whatever. Any normal healthy individual may safely drink as much *water* as he feels inclined to.

Another notion, which still lingers, is that "fish is good for the brain because it contains a large proportion of phosphorus." It is probably true that fish is good for the brain, not for the reason alleged, but because, being readily digestible, it is good for the stomach. Many brain workers prefer fish to meat for luncheon on this account. The theory of Buchner,[1] *Ohne Phosphor kein Gedenke*, on which the notion is apparently founded, is not supported by reliable evidence, and is now discredited. There is no reason to believe that the proportion of phosphorus in other foods is insufficient for the nourishment of the brain as well as other parts of the body. Some foods, e.g. eggs, contain a larger proportion of phosphorus than fish does. The shimmering or so-called phosphorescent appearance that fish exhibits in the dark is no evidence of the presence of phosphorus—a substance

[1] Kraft und Stoff.

which in that condition is intensely poisonous. The phosphorescent appearance is due to the action of certain bacteria, and is a sign of incipient decomposition.

The list of popular fallacies concerning food might be extended indefinitely ; but they cannot be properly discussed at this stage, and nothing is gained by multiplying the instances of erroneous ideas. The only effective way of dealing with them is by systematic statement of the truth so far as it is known.

CHAPTER II

THE PHYSIOLOGY OF NUTRITION

> It is certain that the bodies of all animals are in a constant flux, from that never ceasing attrition which there is in every part of them.
>
> *Butler's Analogy.*

It is common knowledge that the body is made up mainly of the skeleton, flesh, organs or viscera, and the blood and nervous systems.

The heart and lungs are situated in the chest or thorax, and are commonly referred to as the thoracic viscera. The remainder, consisting chiefly of the alimentary canal, i.e. the stomach, gut or intestines, and the glands connected with the same, are situated in the belly or abdomen, and are collectively known as the abdominal viscera.

The relative proportions in which these various parts contribute to the mass of the body are estimated to be, on the average, as follows :—

Estimated Average Proportion of Parts in the Body.

	Per cent.
Flesh (including fat and skin)	66
Skeleton	16
Viscera (thoracic and abdominal)	9
Blood	7
Brain and nerves	2
	100

By multiplying each of these items by $\frac{3}{2}$ we should obtain approximately the actual weight of each, in a person of 150 lbs. weight, which is about the average weight of a full grown man.

The lungs are chiefly concerned with respiration. The air, which is inhaled by their action, is absorbed by the blood and so carried to all parts of the system. In this way all the tissues are subjected to a continuous process of gentle oxidation, which is the very essence of life and which has several consequences, highly important from a dietetic point of view.

The oxidation which takes place in animal bodies may be compared to a smouldering fire. It is actually and in truth, a process of slow combustion. The warmth or heat of the body is produced by it. The substance is gradually consumed, and fresh fuel, i.e. food, must be constantly supplied in order to maintain it.

If fuel be added to a smouldering heap more quickly than it is consumed, the mass will be increased. If it be not added so quickly, the mass will be gradually diminished and in time combustion will cease. But if fuel be added to the heap at exactly the same rate as it is consumed, the mass will remain practically constant.

The nourishment of animal bodies by food is an exactly parallel case. If the quantity of food be not sufficient to counterbalance the loss of substance due to oxidation, the body loses weight, and will ultimately die of starvation. On the other hand, if more material be absorbed than is lost by oxidation in the same time, the excess can be stored up, and increase of weight results. The normal case is that in which the quantity of food absorbed into the system is just sufficient to make good the loss, and neither gain nor loss of weight occurs.

The food by which the body is nourished undergoes many transformations. It is first digested, then absorbed and distributed to all parts of the system.

The process of digestion is performed by various fluids called digestive juices, to the action of which the food is successively exposed. The digestive juices contain certain peculiar products, called enzemes or unorganized ferments, which act upon the various constituents of the food and cause them to undergo the changes about to be described.

Digestion begins in the mouth. In the process of mastication the food becomes mixed with saliva. This fluid contains a ferment which acts upon the starchy matter of bread and farinaceous foods, and con-

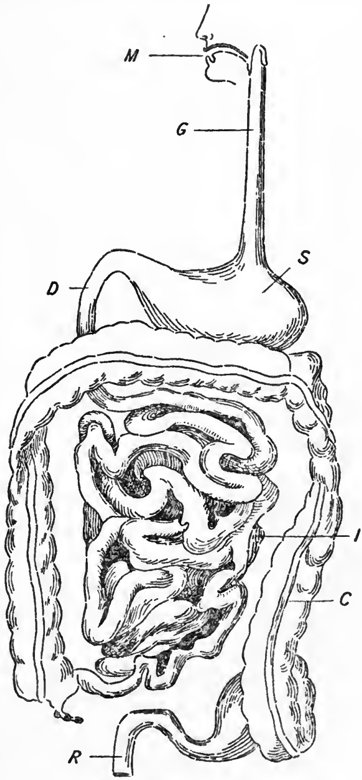


Fig. 1.

Alimentary canal, showing the mouth (M); gullet (G); stomach (S); duodenum (D); small intestine (I); large intestine (C); and rectum (R).

verts it into a soluble sugar-like compound which is afterwards easily absorbed.

In the stomach, the food is acted on by the gastric juice. This is of quite a different character from saliva. It is slightly acid, and contains a ferment called pepsin, which acts on the albuminoid or protein compounds such as the lean of meat. The latter are thereby converted into soluble forms called peptones, and are, therefore, said to be peptonized.

The partially digested food passes from the stomach into the intestine which also receives the secretions from two large and important glands called, respectively, the liver and the pancreas.

The secretion from the liver is called bile; it is chiefly concerned with the digestion of fats. The latter do not entirely lose the fatty character, but become emulsified, i.e. broken up into extremely minute particles of a semi-liquid character, which remain diffused through the fluid in which they are suspended. This condition, it will be seen, somewhat resembles that of the cream in fresh milk.

The pancreatic juice, though it differs from both the saliva and the gastric juice, possesses peculiar properties which enable it to perform, to some extent, the functions of both. It acts upon starchy matters which have escaped the action of the saliva, and also upon protein compounds which have not been completely digested in the stomach. These effects are due to the action of ferments similar to those previously referred to.

As digestion proceeds, the food is reduced first to a sloppy condition and finally to a liquid state. This fluid is of a milky consistency, and is called chyme. As it passes downwards, it is absorbed by hair-like processes, called villi, which project from the walls of the intestine.

Within the walls of this tube, the constituents of the food which has been absorbed undergo further changes, and soon pass into the blood vessels with which the intestine is abundantly supplied.

The smaller vessels unite to form the larger ones by which the blood is distributed to all parts of the body. The system is much too complex to be described here. Suffice it to say that the larger vessels branch in various directions, and branch again, gradually diminishing in size, and end finally in a close meshwork of fine capillaries in intimate contact with the tissues with which they are associated.

The walls of these capillary vessels are very thin, and some of the blood plasma exudes through them. This fluid is called the lymph. It fills up all the spaces between the cells and thoroughly bathes the tissues, which are nourished and restored by it. It is in this way that the waste due to oxidation is repaired.

The lymph is then drained off by a special set of vessels called the lymphatics, and is ultimately returned to the blood to be reoxidized in the lungs, and fortified again by additions from the intestines.

It will be seen that digestion consists essentially in the reduction of solid foods to the liquid state, in which alone they can be absorbed and pass into the system. Surplus and indigestible portions of the food, i.e. any solid matter which has not been dissolved, or otherwise rendered fluid, by the action of the digestive juices, together with any excess of the latter, effete membranes, etc., pass right through the intestine and are excreted as fæces.

The term digestibility refers to the rapidity and thoroughness with which food is transformed into chyme. Obviously, it depends partly on the individual and partly on the food. If one of two different foods, or portions, of food undergo this transformation more rapidly or more thoroughly than the other in a given, normal individual, it is said to be more digestible.

The digestibility of any food depends upon a number of circumstances of which the following are the more important :—

1. *The Extent of Surface.*

The greater the extent of surface exposed to the action of the digestive juices the more rapidly will the process be accomplished. The extent of surface is greatly increased by pulverizing and disintegrating the food before it is swallowed. This is generally effected by chewing, and it is one of the ends to be served by thorough mastication. Food swallowed in lumps is not so much exposed to the action of the ferments, and it may be excreted practically unchanged. In that case comparatively little nourishment will be derived from it ; if not discharged, it tends to block the passage and hinders the other processes. Tough meats should, therefore, be minced ; if very hard, they should be reduced to the condition of potted or sausage meat. This not only makes them more readily digestible, but it has the further advantage that it affords an opportunity of making them more appetizing by mixing, spicing and garnishing in various ways. Some of the cheaper meats, e.g., lights, hearts, etc., which are so hard or tasteless as to be practically uneatable, can be profitably used when so treated.

The flesh of nimble and active creatures, such as deer, goats and wild birds, is generally tougher than that of the more sedentary sheep, oxen and barnyard fowls. Newly killed meat, too, is tougher than that which has been "hung" for a few days, because the *rigor mortis*—the rigidity of the body which sets in shortly after death—gradually passes away. Fowls and other small animals, which can be killed on the premises, may sometimes be cooked before *rigor mortis* sets in, and may thus be obtained in a tender condition in warm weather without risk of decomposition. In the case of butcher's meat, this is not usually convenient.

The tissues both of animals and vegetables become tougher as they get older. In vegetables—and especially in green vegetables—the proportion of woody fibre increases very rapidly after a certain stage. This material is difficult to masticate, is very resistant to the action of the digestive juices, and apt to produce flatulence. Cereals, e.g. wheat and oats, are generally either crushed or ground, and, it appears, the more finely they are ground the better. Green vegetables, such as cabbage, are sometimes "mashed," but if they have already got to the tough stage, they will not be much improved thereby, as the process of mashing has very little effect upon the fibre. The admixture of butter or other fat with mashed potatoes has an adverse effect on the digestibility; the fat tends to protect the constituents from the action of the aqueous digestive juices, and it causes the substance to cohere in such a way that it may be swallowed in clots unmixed with saliva. Quite a different effect is produced by crushing potatoes in a perforated presser; by this means any hard lumps are reduced or eliminated, the extent of surface is greatly increased, and the substance is rendered more digestible.

2. *The Activity of the Digestive Juices.*

Many substances retard or inhibit the action of ferments. They are called antiseptics. Some of them, e.g. formalin, borax, salicylic acid, common salt, etc., are used as preservatives for food. If they do preserve the food from the action of ferments, they must render it less digestible. In some respects digestion closely resembles the initial stages of decay. A certain amount of salt is necessary, but excess is probably injurious, for the reasons given above. Much of the salt or other substances used to preserve bacon, fish, etc., can be extracted with water before cooking, and the digestibility of the food is thereby increased.

The ferments act best at, or about, the temperature of the body, and very hot liquids, e.g. tea, soup, or cold substances, such as iced foods or water, tend to retard their action. If these substances are slowly sipped, they will be comparatively innoxious, as they will be cooled, or warmed, before reaching the stomach, and can only affect the saliva ; but if they are taken in gulps along with food, the temperature effects may be considerable. Cold liquids have also a tendency to consolidate fats and so reduce digestibility.

3. *A Suitable Proportion of Water.*

A certain amount of water is required to form the juices, and to dissolve and carry off the products resulting from their action. Insufficiency of water, therefore, tends to retard digestion. Highly concentrated foods like cereals, etc., require to be cooked with a large quantity of water. Some persons can take oatmeal porridge only if it is "made very thin," others cannot take it unless it is diluted to the condition of gruel. Dried meats, fish and fruits, are less digestible than the same foods in a fresh condition; this has been attributed to deficiency of water, but it may be due, in part, also, to other causes. Excess of water taken along with food, by unduly diluting the juices, also renders them less effective and retards digestion.

In general, the constituents of animal foods are more completely digested than those of vegetables;

DIGESTIBILITY OF FOODS (ATWATER).

(*Proportions digested*).

Animal Foods.	Percentages Digested.		
	Protein.	Fat.	Carbohydrates
	P. ct.	P.ct.	P. ct.
Beef . .	100	95	—
Veal . .	100	95	—
Mutton .	100	95	—
Pork . .	100	95	—
Fish and Oysters	100	95	—
Milk . .	100	96	100
Cheese .	100	95	100
Butter .	—	96	—
Margarine	—	95	—
Tallow .	—	95	—
Lard . .	—	95	—
Oils . .	—	95	—
Eggs . .	100	98	—

Vegetable Foods.	Percentages Digested.		
	Protein.	Fat.	Carbohydrates
	P.ct.	P. ct.	P.ct.
Wheat flour (fine) .	85	80 per cent. assumed for all.	95 per cent. assumed for all.
Do. (medium)	81		
Do. (coarse)	75		
Rice . .	85		
Macaroni .	85		
Rye flour .	78		
Maize-meal	85		
Potatoes .	75		
Cabbage .	80		
Turnips .	80		
Peas . .	85		
Beans .	85		

the latter are often so enclosed in the cellular and fibrous tissues with which they are associated that they are protected from the action of the digestive juices. A certain proportion of the nutrients in vegetable foods is therefore usually excreted unchanged in the fæces.

Within limits, digestibility is not affected by the amount of the food, bodily work, age or other accidental circumstances, and it does not vary greatly in different individuals in normal health.

In popular language, the term digestion is generally used exclusively with reference to the processes which take place in the stomach. In this respect, the differences between individuals are more considerable. Weak or slow gastric digestion arises from immobility of the organ, or from defective secretion of ferments. Too rapid secretion of gastric juice causes dyspepsia. Persons who suffer from these disorders are not, however, necessarily or usually deficient in absorptive capacity.

Under like conditions, the time occupied in gastric digestion of any given food probably does not vary much in normal healthy individuals. But considerable differences have been observed in the digestibility of different kinds of food. Some remain much longer in the stomach than others; but there is no reason why these should be avoided by healthy people, as they are ultimately transformed into chyme without discomfort or inconvenience.

Observations upon the length of time that various foods remain in the stomach are probably reliable so far as they go. They are, however, of very little real value because, apart from the differences in individuals, the time depends upon the quantity of food, what it is associated with, how it has been prepared and cooked, degree of mastication and so on. It is said that beef leaves the stomach in less time than pork, but it is probable that, *ceteris paribus*, a tough sample of beef will require more time than one of tender pork. Also the digestibility of the various joints of each are not alike. Some of the results obtained are given in the following table, but they must be accepted with considerable reserve.

* DIGESTIBILITY OF FOODS.

(*Length of time food remains in stomach.*)

Animal Foods.		Vegetable Foods.	
Beef, raw . . .	2 hours	Bread	$2\frac{1}{3}$ hours
,, boiled . .	3 ,,	Potatoes. . .	$2–2\frac{1}{2}$,,
,, roasted. .	4 ,,	Rice	$3\frac{1}{2}$,,
Eggs, raw. . .	$2\frac{1}{4}$,,	Lentils . . .	4 ,,
,, soft boiled .	$1\frac{3}{4}$,,	Peas	$4\frac{1}{4}$,,
,, hard boiled	3 ,,	Apple, raw . .	$3\frac{1}{6}$,,
Fresh fish. . .	$2\frac{1}{2}$,,	Cabbage . . .	3 ,,
Salt fish . . .	4 ,,	Cauliflower . .	$2\frac{1}{4}$,,

* Hutchison.

When ordinary fuel is burned in a fire, the principal products of the change are carbonic acid gas and water. The same substances are also produced by the oxidation that takes place in animal bodies, and they are given off from the lungs in respiration. There is, however, one respect in which the analogy does not hold, and it is of considerable importance. When nitrogenous compounds are consumed by fire, the nitrogen is liberated in the free state, and escapes with the other products (carbonic acid, etc.); but when the nitrogenous compounds, of which animal bodies are largely composed, are oxidized in the normal course of respiration, the change takes place at a much lower temperature, and the nitrogen appears in the form of a compound called urea. This substance is non-volatile; it does not, therefore, escape with the other gases from the lungs, but passes into solution in the blood, whence it is eliminated by the kidneys, and is discharged in the urine.

Excess of salt and certain other useless or effete matters are also eliminated from the blood and discharged in the same way; the latter are, however, of minor importance from the present point of view.

CHAPTER III

THE CHEMISTRY OF NUTRITION

Der Mensch ist was er isst.

Feuerbach.

A VERY large number of chemical compounds enter into the chemical composition of the animal body. For present purposes they may all be grouped under the following heads—albuminoids or proteids, fats, water and the so-called mineral or earthy substances. The relative proportions in which these various constituents are present vary according to circumstances. In a healthy adult man, the average may be approximately as follows :—

	Per cent.	Per cent. (Dry).
Water	64	—
Fat	18	50 } 89
Albuminoids	14	39 } 89
Mineral matter	4	11
	100	100

The red flesh or muscular tissue, skin, nerves, vessels and various organs—heart, stomach, liver, etc.—all consist mainly of albuminoid compounds mixed or associated with a large proportion—70 to 80 per cent.—of water. The substance of hair, cartilage (nails, etc.) is of a similar nature, and even bones contain a large proportion of the same material.

Fat is found in largest quantity in the region of the kidneys which it surrounds and encloses; but it also occurs in masses or layers in various other parts of the body. Fat enters into the composition of bones, and it is usually associated also with the muscular and other tissues in larger or smaller quantities. Beefsteak, free from all *visible* fat, contains from 1 to 3 per cent. of that ingredient.

The earthy or mineral matter consists mainly of phosphate of lime. It occurs chiefly in the bones, and it is to the presence of this constituent that bones owe their hardness and rigidity. The proportion increases with advancing age, and the bones gradually become harder and more brittle.

Phosphate of lime, as the name implies, is a compound [1] of lime and phosphoric acid. It may be formed by the action of lime on other phosphates, e.g. phosphate of potash. Phosphates are essential constituents of plants, and are, therefore, present in nearly all vegetable as well as animal foods. The phosphate of lime found in the bones is derived from this source.

Water is a compound of two chemical elements called hydrogen and oxygen, respectively. It is produced when hydrogen, or compounds of hydrogen, are burned or otherwise oxidized. Being, itself, a product of oxidation, water does not burn,

[1] The composition is shown by the chemical formula [CaO,P_2O_5 or $Ca_3(PO_4)_2$.

i.e. it cannot be further oxidized. It is of necessity well known to every one, and it is unnecessary to enter into any further description of its properties.

It has been shown above, that about 90 per cent. of the dry matter of human bodies consists of compounds classed as albuminoids and fats. Both suffer continual loss by oxidation, and the need of food arises chiefly from the necessity of constantly replacing them. It is obvious, therefore, that only substances which contain these compounds, or constituents capable of being changed into them by the physiological processes to which they are subject, will be suitable for use as food.

Meat, bread, vegetables and other foods contain albuminoids and fats, and some of them a number of compounds which belong to a different class called carbohydrates. Experience shows that the last-mentioned may be used to satisfy hunger, and that they also have nutrient properties.

In order to explain this, it is necessary to refer to the composition and properties of these different classes of compounds, and show their relations, one to another. They are all complex substances, and the complete investigation ranges into the most difficult branches of organic chemistry. All that is necessary for present purposes, however, is tolerably well known, and is not difficult to follow.

The group of albuminoids or proteids, as they are indifferently [1] called, comprises a large number of compounds. Some of these, e.g. white of egg, milk curd, blood clots, lean meat, etc., are externally

[1] The terms albuminoids and proteids are used by some authors in different senses, and from a purely chemical standpoint it is sometimes advantageous to do so, but for present purposes it is unnecessary to make any distinction.

very different; but they all resemble each other very closely in chemical composition; and they exhibit characteristic properties which show that they belong to the same class. They are composed of the elements, carbon, hydrogen, oxygen, nitrogen and sulphur. The proportions of the elements are constant in any given substance, but are not exactly the same in all. The limits of variation are, however, very narrow, and in no case does the composition of the compounds differ much from the following, which may be taken as the average for the group.

CHEMICAL COMPOSITION OF ALBUMINOIDS.

	Per cent.
Carbon	52·2
Hydrogen	7·2
Oxygen	23·1
Nitrogen	15·9
Sulphur	1·6
	100·0

Most of the albuminoid compounds are practically insoluble in water, but some of them, like white of egg, are soluble. Others, though insoluble in pure water, are soluble in solutions of salt and other reagents. They may be precipitated, redissolved and even crystallized; they form many curious compounds, and exhibit various interesting properties. They all undergo a curious transformation called coagulation, which profoundly affects their properties, but does not materially alter their composition. The setting or hardening of eggs on boiling, curdling of milk, and clotting of blood are familiar examples of this change. Coagulation may be caused by heat, by certain reagents, e.g. alcohol, tannin, etc., and by certain ferments such as rennet.

All albuminoids, soluble or insoluble, coagulated or uncoagulated, are converted into peptones by the action of pepsin—the ferment of the gastric juice. They are thus rendered readily soluble and diffusible and, therefore, capable of absorption by the villi. Peptones belong to, and exhibit the characteristic properties of the albuminoid group.

When albuminoids are burned they are completely oxidized; the constituent elements—except nitrogen which is liberated in the free state—unite with oxygen, and carbonic acid gas, water and oxide of sulphur are formed. For 100 parts of the dry substance, 175 parts of oxygen, in addition to what it already contains, are required to complete the change. The oxidation of albuminoid compounds which takes place in the course of animal respiration is not complete—the nitrogen appears in the form of urea [1]—and only 148 parts of oxygen are required.

There are many different kinds of fat, e.g lard, tallow, butter, palm oil, linseed oil, etc. Some are of animal, and others of vegetable origin, but they all resemble each other, more or less closely, in composition and general properties, and all belong to the same class or group.

There is no essential difference between fats and oils. Those which remain liquid at ordinary temperatures are generally called oils, and the more solid are called fats. The solid fats melt at comparatively low temperatures, and in that state are indistinguishable from oils.

These compounds are not so complex as the albuminoids; they contain neither sulphur nor nitrogen. Only three elements—carbon, hydrogen

[1] Urea is represented by the chemical formula N_2H_4CO.

and oxygen—enter into their composition; they are always united together in a similar manner,[1] but the proportions vary slightly in different members of the group.

Three of the commonest fats—known respectively as olein, stearin and palmitin—contain the elements in the following proportions :—

	Olein.	Stearin.	Palmitin.
	(Per cent.).	(per cent.).	(per cent.).
Carbon	77·3	76·9	75·9
Hydrogen	11·8	12·3	12·2
Oxygen.	10·9	10·8	11·9
	100·0	100·0	100·0

It will be seen that the differences in composition are comparatively slight, and that, in all three cases, carbon forms more than three-fourths of the whole.

The fats and oils are all insoluble in water and in salt solutions. They are dissolved by the action of strong alkalis, which converts them into soap and glycerine. Under certain conditions, they can be so intimately mixed with water that they remain in a state of semi-permanent suspension, without losing the essential properties of fats. Such mixtures are called emulsions; they are most readily formed in slightly alkaline solutions.

[1] The pure fats are all glycerides of fatty acids. Stearin, one of the commonest, may be represented by the chemical formula $C_3H_5(C_{18}H_{35}O_2)_3$. The natural fats are, for the most part, complex mixtures of such glycerides. Butter contains at least nine different compounds of this kind.

When fats are burned, or otherwise oxidized, carbonic acid gas and water are produced. Each 100 parts of fat (stearin), require 292 parts of oxygen, in addition to what it, itself, contains, to completely oxidize it. Fat, it will be seen, combines with nearly twice as much oxygen as an equal weight of protein when oxidized in the animal system.

The carbohydrate group also includes a large number of compounds, some of which are externally very dissimilar. They are characteristically vegetable products ; starch, cellulose and some others are exclusively so. Sugars and one or two other compounds are produced by animals as well as plants, e.g. sugar of milk.

There are several kinds of sugar besides the ordinary table sugar. The latter is generally called cane sugar, or sucrose, even when derived from beet. Milk sugar [1] resembles cane sugar very closely, but is not quite so sweet to the taste. The sugars commonly found in fruits and vegetables are of a different character, though similar in appearance and general properties ; they are called glucose[1] and fructose.[1] All sugars are soluble in water, and can be directly assimilated by animals without change of any kind. When yeast grows in a solution of sugar, the latter is converted into alcohol and carbonic acid. This change takes place in the manufacture of beer ; it is called alcoholic fermentation.

Starch [2] is produced in larger or smaller quantities by nearly all plants, and is an important constituent

[1] Cane sugar and milk sugar are represented by the chemical formula $C_{12}H_{22}O_{11}$; glucose and fructose, by the formula $C_6H_{12}O_6$.

[2] Starch, cellulose, dextrin and mucilage are all represented by the chemical formula $C_6H_{10}O_5$.

of potato tubers, cereal grains and many other foods. It is made up of minute granules, and under the microscope, it is seen that these vary in size and exhibit peculiar markings which are characteristic of the plant from which the starch is derived. There is, however, no difference in the chemical composition, and very little difference in the properties of the several kinds of starch.

Starch is insoluble, and is not affected by cold water; but when it is treated with boiling water, the grains swell up, lose their characteristic structure, and form a kind of paste or jelly. The starch, however, is not even then dissolved. When heated in the dry state to a certain temperature, starch is converted into dextrin,[1] the common gum used for postage stamps.

By the action of certain ferments such as those found in saliva, in malt, etc., and also by the action of dilute acids, starch is resolved into glucose, a kind of sugar which, it has been said, is soluble, fermentable, and can be directly assimilated. The conversion of starch into sugar by the action of ferments is called diastatic fermentation. The change is an essential part of the process of digestion of starchy foods. Dextrin and mucilage undergo a similar change.

Cellulose[1] has the same chemical composition as starch, but, except in very young plants, it is practically indigestible, and is consequently of little or no value for nutrient purposes.

Notwithstanding the differences in the properties of sugars, starch, mucilages and cellulose, noted above, they possess certain properties in

[1] Starch, cellulose, dextrin and mucilage are all represented by the chemical formula $C_6H_{10}O_5$.

common, and these are characteristic of the whole carbohydrate group. They are composed of the same chemical elements as the fats, viz., carbon, hydrogen and oxygen, but in very different proportions. They do not, however, differ much from each other in this respect, as may be seen from the following examples :—

	Starch.	Cane Sugar.	Glucose.
	(per cent.).	(per cent.).	(per cent.).
Carbon	44·4	42·1	40·0
Hydrogen	6·2	6·4	6·7
Oxygen	49·4	51·5	53·3
	100·0	100·0	100·0

The carbohydrates undergo oxidation even more readily than the fats, but the products are the same, viz., carbonic acid and water. As they contain a relatively larger proportion of oxygen than the latter, a smaller quantity of that substance is required to consume them. Thus, 100 parts of starch combine with 118 parts of oxygen, 100 parts cane sugar combine with 112 parts of oxygen, and 100 parts of glucose combine with 107 parts of oxygen. It will be seen, therefore, that, on the average, 100 parts of carbohydrate require 112·5 parts of oxygen, in addition to what they contain, to completely oxidize them.

It has been previously shown that 148 parts of oxygen are required to oxidize 100 parts of protein and 292 parts to oxidize 100 parts of fat. In other words fat consumes nearly twice as much oxygen as an equal weight of protein, and $2\frac{1}{2}$ times as much as an equal weight of carbohydrates, in the process of oxidation.

Now, when a substance is oxidized, heat is given out. If oxidation take place rapidly, as in burning, a high temperature results ; but if it take place more slowly, as in respiration, the temperature will be correspondingly lower. The *amount of heat* produced, however, is the same in both cases. For substances of the same kind, the amount of heat evolved depends upon the amount of oxygen they consume.

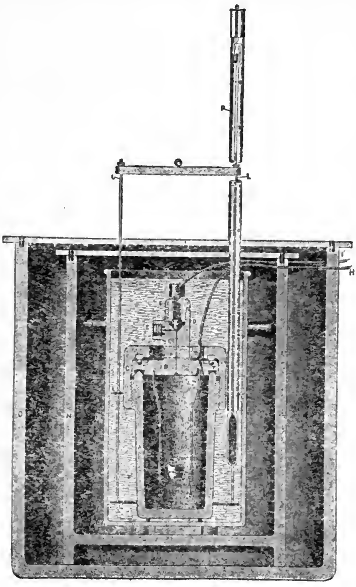


FIG. 2. Section of Bomb-calorimeter.

The heat of combustion, i.e. the heat of oxidation, can be determined by means of an apparatus, called a calorimeter, of the kind shown in the illustration[1] (Fig. 2). The results are expressed in calories. A calorie is the amount of heat required to raise the temperature of 1 gram. of water 1° C.

The following average results have been obtained :—

[1] Bul. 21, U.S. Dept. of Ag.

1 gram.	protein	yields	5,700	calories.
1 ,,	fat	,,	9,500	,,
1 ,,	carbohydrate	,,	4,100	,,

It will be seen that these figures bear very nearly the same relation to each other as those showing the amount of oxygen consumed.

As protein is not completely oxidized in the body, it consumes less oxygen and consequently gives out less heat than is shown above. The heat of combustion of the products (urea) must, therefore, be deducted in order to obtain the physiological heat value. Taking the average of a great many determinations, Rübner puts the physiological heat value of protein at 4,100 calories, i.e. the same as that of the carbohydrates. Atwater's estimate of 4,400 calories is probably the more accurate, but Rübner's is the one commonly used.

The calorie is inconveniently small, and it is usual to take the kilo-calorie as the unit for physiological purposes. A kilo-calorie is 1,000 calories. On this basis the factors become 9·3 for fat and 4·1 for carbohydrates and protein. Kilo-calories may be designated by the symbol "Kal."

The facts quoted above—especially those relating to the composition and oxidation of the compounds, protein, fat and carbohydrates—are of fundamental importance in regard to the phenomena of nutrition.

These compounds are the principal constituents of food. It is from them that the tissues of the body are built up. The heat produced by their ultimate oxidation, maintains the temperature of the body and furnishes the energy required for the performance of all the internal and external work.

Some physiologists speak as if the compounds were directly oxidized in the blood. It is more probable, however, that they are first changed into actual tissues which are subsequently oxidized. The point is one of considerable interest, but it need not be discussed here, as it makes no difference to the amounts of oxygen which they can ultimately consume, or to their potential capacities as heat producers; in other words, it does not affect the nutritive or food value of the compounds.

It has been shown that fat and carbohydrates are composed of the same chemical elements. They do not resemble each other very closely, but each can be formed from the other. As constituents of food, they perform the same functions in the body. Both are used to form fatty tissue which undergoes oxidation and so provides the heat and energy for the performance of work; but any excess over what is required, remains unaffected and forms an addition of fatty tissue to the body.

Fat and carbohydrates are not, however, of equal value for these purposes. According to Rübner their heat-producing values stand in the relation of 93 to 41 (vide ante) or 2¼ to 1, and they bear a like relation as tissue (fat) formers. Some authorities ascribe an even higher value to the fat. They consider 1 lb. of fat equal to 2½ lb. of carbohydrate, but that is probably too high for the average.

It is evident that fat and carbohdyrates cannot be changed into protein, for they lack the elements nitrogen and sulphur, which are essential constituents of the latter.

It has been clearly demonstrated that the protein of animal bodies is derived from the protein of the food. One kind of proteid may be transformed into another, but cannot be formed from non-proteid.[1] The amount of protein in the food must, therefore, be sufficient to make good the loss of protein from the body; otherwise the animal will gradually lose weight and will ultimately die of starvation, i.e. nitrogen starvation, however much of the other constituents may be present.

But protein, like other constituents of the food, also undergoes oxidation and gives out heat—its fuel value is given above—and it is believed that

[1] Many foods contain a number of other nitrogenous compounds such as gelatin, amides, etc., which are more or less closely allied to protein but cannot be ranked as true proteids. These are certainly of lower nutritive value; it was formerly believed, and many recognized authorities still hold, that they have no nutritive properties. Recent researches have, however, tended to throw some doubt on this point. When protein is decomposed by chemical means it is resolved into glycocine $C_2H_5O_2N$; leucine $C_6H_{13}O_2N$, tyrosine $C_9H_{11}O_3N$, cystine $C_6H_{12}O_4N_2S_2$, and other bodies all belonging to the amino-acid group and commonly called amides. Protein may be split up in a similar manner by prolonged action of ferments, and it is considered probable that such disintegration actually takes place in the process of digestion, the proteids being subsequently re-synthesized, after absorption, in the walls of the intestine. In that case it should be possible to maintain life by the ingestion of these products, and evidence is not wanting to show that this can be done. Gelatin alone, has been proved to be insufficient because it contains no tryptophane, tyrosine or cystine radicles; but when administered along with certain amino-acid bodies, it has been found to maintain life. Dogs and rats have been kept alive for considerable periods on a mixture of aminoacids without gelatin.

The total nitrogen of all ordinary foods is therefore usually reckoned as protein, though it is probably true that the amides have a lower nutritive value than true proteids. This does not apply to gelatin, meat extracts and some other substances which are not ordinary foods.

fat is produced from excess of protein when enough of the other constituents is present to provide all the energy required. This change is theoretically possible, and it certainly takes place in some cases, but recent experiments have made it doubtful whether it occurs under normal conditions. In any case, however, it is not the proper function of protein to make fatty tissue. Still less is it the proper function of protein to furnish heat, but there is no doubt that if the food be deficient in fat and carbohydrates, protein will be oxidized to furnish the energy required.

This, then, is another function of the non-nitrogenous constituents of the food, viz., to spare or save the protein from oxidation, and it is of the highest importance to see that it is fulfilled. Protein is the most expensive constituent of the food; protein tissues are formed more slowly than fat, and if subjected to excessive oxidation, loss of body weight results.

CHAPTER IV

QUANTITY OF FOOD

> Talking of a man who was grown very fat, so as to be incommoded with corpulency; he said, "He eats too much, Sir." Boswell: "I don't know, Sir; you will see one man fat who eats moderately, and another lean who eats a great deal." Johnson: "Nay, Sir, whatever may be the quantity a man eats, it is plain that if he is too fat, he has eaten more than he should have done. One man may have a digestion that consumes food better than common; but it is certain that solidity is increased by putting something to it." Boswell: "But may not solids swell and be distended?" Johnson: "Yes, Sir, they may swell and be distended; but that is not fat."
>
> *Boswell's Life of Johnson.*

It has been shown in the preceding chapter that the nitrogenous and non-nitrogenous constituents of the food have different functions. Neither can be substituted for the other, nor can they act properly, independently of each other. It may, therefore, be laid down, as a fundamental principle, that a certain amount of each is necessary for bare subsistence, and additional quantities are required for work, growth or production of any kind.

It is necessary, therefore, to inquire, not only what total quantity of food, but also what kind of food, is suitable under various conditions. The two questions are really one, and must be considered together. In short, what we have to discover is, how much protein, and how much fat and carbohydrates are necessary and desirable in each case.

The quantitative methods by which the requirements of the body are investigated fall, broadly, into two classes, viz. (1) observations upon the quantities of food consumed by individuals, and (2) observations upon the products of metabolism given off or excreted from the body, under various conditions. It cannot be said that either of the two methods is entirely satisfactory; and it is only by comparing the results of numerous experiments made in both ways that we can hope to arrive at an approximation to the truth. The evidence obtained by the second method is, perhaps, the more reliable as a primary indication; but it must be controlled and confirmed by experiments made according to the first plan.

The nitrogenous compounds—chiefly urea—resulting from the oxidation of protein in the body, are excreted in the urine; the amount of nitrogen so excreted in a given time is, therefore, a measure of the rate at which oxidation of the protein takes place.

The estimation of urea is a simple process. A measured quantity of urine is introduced into a tube or small bottle, and mixed with excess of sodium hypobromite; the urea is completely oxidized by this substance, and the free nitrogen gas liberated by the reaction, is collected and measured [1] in a

[1] For detailed description of the process, and also for an account of other and more accurate methods, the reader is referred to any of the numerous works on quantitative chemical analysis.

graduated tube. A form of apparatus (Dupré's) commonly used for this purpose, is shown in the illustration[1] (Fig. 3). Since protein contains 16 per cent. of nitrogen, the weight of this element multiplied by $\frac{100}{16} = 6{\cdot}25$ gives the corresponding quantity of protein.

The carbonic acid gas, which is exhaled from the lungs, can also be collected and measured by means of an apparatus known as the respiration calorimeter. This apparatus may also be made to serve other purposes in connexion with experiments of this kind; but it is much too complicated to be described here. A general view of the respiration calorimeter used by Atwater is shown in the illustration[2] (Fig. 4).

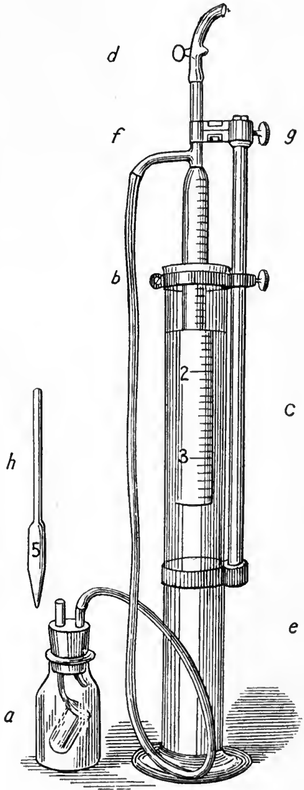


FIG. 3.
UREA APPARATUS (DUPRÉ).

The quantity of carbonic acid exhaled shows the amount of carbon oxidized. This carbon is derived mainly from the fat of the body, or, indirectly, from the fat and carbohydrates of the food. A certain

[1] Messrs. Baird & Tatlock's catalogue.
[2] Bul. No. 136. Exp. Sta. U.S. Dept. of Ag.

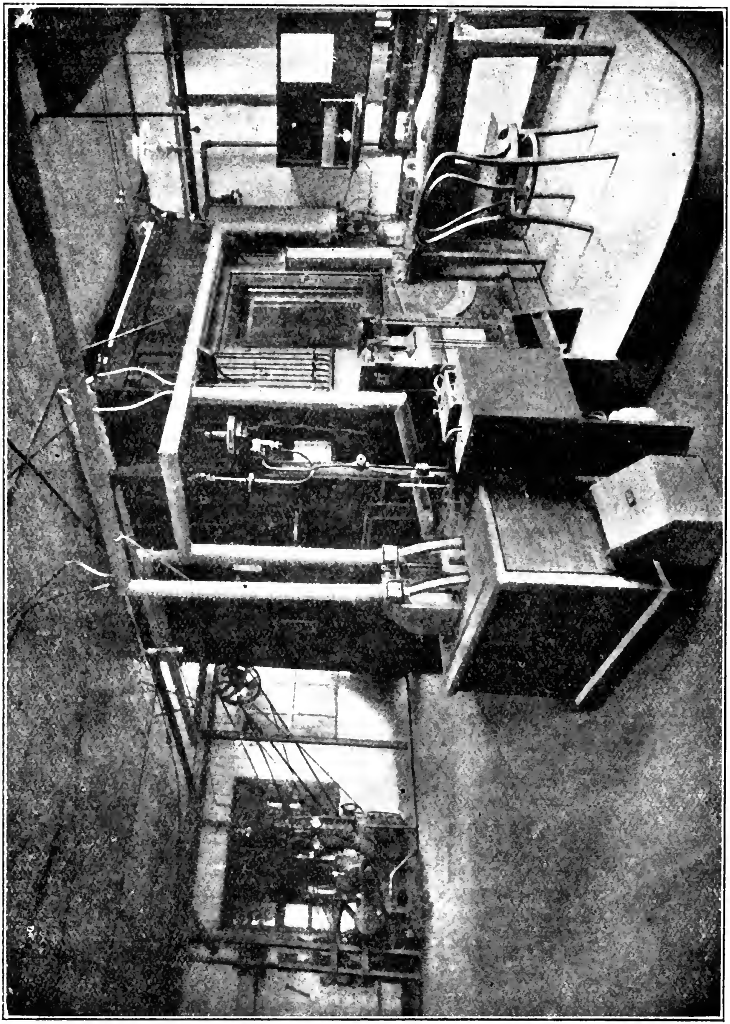


FIG. 4. A GENERAL VIEW OF THE RESPIRATION CALORIMETER

amount of it, however, is due to the oxidation of protein; but when the amount of the latter is known, the corresponding quantity of carbonic acid is easily calculated, and can be deducted from the total, in cases where it is necessary to discriminate; the remainder may then be expressed in terms of fat or carbohydrates. It is not usually necessary, however, to make any distinction; it is more convenient to express the results in terms of the total energy liberated by the oxidation, irrespective of the particular compounds from which it may have been derived. By this means [1] then, we can estimate the total number of calories of heat produced by oxida-

[1] In one series of experiments, the following results were obtained by Voit and Pettenkofer, in the case of a man doing no external work.

	Nitrogen in Urine.	Carbonic Acid Exhaled.	Water in Urine.	Water Evaporated.	Oxygen Absorbed.
	Gms.	Gms.	Gms.	Gms.	Gms.
(*a*) Fasting	12·5	716	1,006	821	762
(*b*) On average diet	17·0	928	1,218	931	832

Calculating from the results obtained in the fasting experiment (*a*) we have—

$12{\cdot}5 \times 6{\cdot}25 = 78{\cdot}12$ gms. of protein.

$78 \times 0{\cdot}52 = 40{\cdot}56$ gms. of carbon $= 148{\cdot}72$ gms. CO_2.

$(716 - 149) \times 0{\cdot}35 = 198$ gms. of fat $= 446$ gms. of carbohydrate.

The fat may also be calculated from the amount of oxygen absorbed thus—

78 gms. of protein $\times 1{\cdot}48 = 115{\cdot}4$ gms. of oxygen.

$(762 - 115) \times 0{\cdot}34 = 220$ gms. of fat.

The fuel values of these quantities may be calculated from Rübner's factors thus—

$$\left.\begin{array}{ll} 198 \text{ gms. of fat} \times 9{\cdot}3 & = 1841{\cdot}4 \text{ kal.} \\ 78 \quad ,, \quad \text{protein} \times 4{\cdot}1 & = 319{\cdot}8 \quad ,, \end{array}\right\} = 2{,}161 \text{ kal.}$$

tion in the body, and what proportion of it is due to the protein.

The results of numerous observations made in this way with regard to the nitrogenous matter may be summarized as follows :—

1. When a man is fasting absolutely (receiving no food of any kind) the amount of nitrogen excreted in the urine, corresponds to about 80 grams of protein per day.

2. When abstaining only from nitrogenous nutrients, but receiving a sufficient amount of fat and carbohydrates, the amount of nitrogen excreted in the urine is reduced to about a fourth, i.e. it corresponds to only about 20 grams. of protein per day.

3. When small quantities of protein are consumed along with a sufficient amount of fat and carbohydrates, there is little or no increase in the amount of nitrogen excreted.

4. When the amount of protein consumed (along with fat and carbohydrates) exceeds some 30 or 40 grams per day, a marked increase in the amount of nitrogen in the urine follows very rapidly, and it is greater in proportion to the amount of protein consumed.

5. On an ordinary mixed diet, the amount of nitrogen in the urine of an average man corresponds to from 90 to 110 grams. of protein per day.

It appears, therefore, that in the absence of fat and carbohydrate foods, the nitrogenous tissues of the body suffer great loss by oxidation. But when enough of these nutrients is consumed, the daily waste of protein may be reduced to about 30 grams per day in the case of a man of average size. Add to this the nitrogen in the fæces (about 2½ grams per day) equal to about 15 grams of protein, and we get 45 grams per day as the minimum quantity of protein required in the food of an average man. This quantity is exclusive of any loss in the processes of cooking and preparation, but includes the indigestible portion of what is actually consumed.

Examination of the customary diet of all sorts and conditions of men shows that those who are free to choose, commonly consume from two to three times the amount of protein given above. It remains to be seen, however, whether they derive any advantage, or the reverse, by so doing. We are certainly not justified in accepting men's desires as evidence of their requirements in this respect; at the same time they cannot be altogether ignored. The point is a very difficult one to decide, and the opinions of authorities regarding it are divided.

Chittenden made observations, extending over a period of five months, upon the diet of athletes, workmen, professional and business men, and he concluded, not only that 50 grams of protein, per day, is sufficient for all ordinary purposes, but also that any considerable excess beyond that amount throws an unnecessary strain on the kidneys, and may be positively injurious. Physiologists are now generally agreed that there is no foundation for the latter part of this statement; and recent experiments on animals tend to show that though health may be maintained for several months on a low nitrogenous diet, yet, in the course of years, unsatisfactory results are produced.

Deficiency of protein in the diet means starvation. A moderate excess over and above the minimum—whatever that may be—is certainly harmless, and may be beneficial; probably it is beneficial. It is advisable, therefore, to ensure sufficiency by using a moderate excess. This may be put at from 90 to 100 grams, say 3 to 3½ oz. per day. The smaller quantity is probably ample for men engaged in sedentary occupations.

In Voit's experiments, when the man was fasting, the carbonic acid exhaled, after deducting the amount due to oxidation of protein, corresponds to 198 grams of fat (or 446 grams of carbohydrate); the oxygen absorbed, minus that required for the protein, is sufficient to oxidize 220 grams of fat. When the man was on average diet, the carbonic acid corresponded to 250 grams of fat, and the oxygen to about 230 grams.

The discrepancy between the results calculated from the oxygen and carbonic acid, respectively, in each of these two cases, is indicative of some experimental error; but in view of the difficulties connected with experiments of this kind absolute accuracy is scarcely to be expected.

The results, however, serve to show approximately the amount of loss per day (24 hours) under the conditions of the experiments; and they afford, therefore, some indication of the quantities of non-nitrogenous nutrients required to repair the waste of tissue. Similar results have been obtained in other experiments; and they are confirmed by observations upon the quantities commonly consumed by men under like conditions. The general conclusion arrived at is that, for a man of average size, the daily food should have a total fuel value of about 2,500 kal. or 3,000 kal. For those engaged in sedentary occupations, the minimum is estimated at 2,400 kal. per day; for sick persons confined to bed, a smaller quantity suffices.

If we take 2,800 kal.[1] as the average, and deduct 350 kal. due to oxidation of protein, the remainder corresponds to about 260 grams of fat, or 590 grams of carbohydrate. Theoretically, i.e. so far as the production of heat is concerned, it makes no difference in which of these two forms the non-nitrogenous matter is supplied. Practically, however, there are other points to be considered. On the one hand, the stomach would probably revolt against so large a quantity of fat; on the other, a certain amount of fat is necessary, or at least desirable, for lubrication and other purposes. The quantity commonly used varies from about 50 to 100 grams per day; and it may be assumed, therefore, that any intermediate quantity, say about 85 grams or 3 oz. would be suitable. The remainder of the fuel value must, of course, be supplied in the form of carbohydrates of which, in the case supposed, 405 grams, say 14¼ oz., would be required.

Thus we arrive finally at the conclusion that the diet should contain the following quantities of the several food constituents:—

Standard Diet for Simple Maintenance.

3 oz. (85 grams) protein,	giving	350	kal.
3 ,, (,, ,,) fat,	,,	790	,,
14¼ ,, (405 ,,) carbohydrates	,,	1,660	,,
Total fuel value . . .		2,800	,,

The quantities prescribed above are not the

[1] This amount includes the indigestible portion. In Voit's experiment, the calculated quantities of fat correspond to 2,459 kal. and 2,645 kal. respectively, exclusive of indigestible matter; that is in the case of a man on average diet but doing no external work. In the fasting condition, vitality is lower and less is oxidized.

absolute minimum required for bare subsistence, but may be regarded as constituting a standard for simple maintenance, i.e. for a man of average size, living in a temperate climate, engaged in a sedentary occupation, and taking but little exercise. This standard is not, therefore, applicable to all conditions alike, but must be modified according to circumstances. Chief among these are: the size of the individual, climate and exposure, work, growth, increase or reduction of weight, and in the case of women, condition as regards pregnancy and lactation.

It is a matter of common knowledge that, under similar conditions, small individuals require less food than those of larger size. Children and women, for instance, generally consume less food than full grown men.

The normal weight of a man of average size is about 11 stones, say 150 lb. The quantities given in the standard diet are, therefore, equal to 0·02 oz. of protein and 18·7 kal. fuel value, per lb. weight. Assuming that the quantity of food required is proportional to the weight of the individual, these factors may be used to determine the dietary requirements of any individual whose weight is known. Thus, for a person of 100 lb. weight, the quantities would be :—

$0{\cdot}02 \times 100 = 2$ oz. of protein,
and $18{\cdot}7 \times 100 = 1{,}870$ kal. fuel value.

For a person of 200 lb. (about 14 stone) weight :—

$0{\cdot}02 \times 200 = 4$ oz. of protein,
and $18{\cdot}7 \times 200 = 3{,}740$ kal. fuel value.

But, it may be asked, is the assumption correct? So far as the protein is concerned, it is probably sufficiently accurate for practical purposes, provided the weight of the person is strictly normal. The normal weight of a man of average size (5 ft. 8 in.), it has been said, is about 150 lb.; but it may be 10 or 15 lb. more or less. In abnormal cases the weight of a man of average height may run up to 200 lb., or it may fall as low as 100 lb.; but it does not follow that in the former case the man requires twice as much food as in the latter; on the contrary, the allowance of protein should be very nearly the same in each. In calculating with this factor, therefore, it is the normal rather than the actual weight of the individual that should be considered.

As regards the fuel value, so far as it depends upon the fat and carbohydrates, the assumption is not correct. Small individuals expose a relatively large body surface, and so lose more heat by radiation.[1] The food of small individuals should, therefore, have a higher fuel value, i.e. it should contain a larger quantity of non-nitrogenous nutrients.

A dog weighing 6 lb. was found to radiate nearly twice as much heat as one weighing 40 lb. At the same rate,[2] we should add to, or subtract from, the

[1] Of the total energy converted from the potential to the kinetic form by oxidation in the body, a considerable part may be used to perform work; in any case, a part is rendered latent in the water vapour given off from the lungs and skin; and a smaller proportion is used to warm the ingesta and inhaled air; the remainder is lost by radiation from the surface of the body. As stated in the text, the amount of heat lost by radiation varies according to the extent of surface exposed; but in average cases, it is estimated that, when no external work is done, from 60 to 70 per cent. of the whole is accounted for in this way.

[2] $\frac{2800 \times 6}{40} = 420$; $150 - \frac{150 \times 6}{40} = 127{\cdot}5$; $\frac{420}{127{\cdot}5} = 3{\cdot}3$.

If a larger or smaller fuel value than 2,800 kal. be adopted amount previously given ($18·7 \times w$), 3·3 kal. for each lb. below or above the average weight of 150 lb. This is embodied in the following formula :—

$$F = [(18{\cdot}7 \times w) - 3{\cdot}3\,(w - 150)]$$

where F is the total fuel value required, and w the normal [1] weight of the individual.

The equivalent of F in fat and carbohydrates is easily found by Rübner's factors.

AVERAGE WEIGHT OF INDIVIDUALS.

Men.		Women.		Children.		
Height.	Weight.	Height.	Weight.	Age.	Boys.	Girls.
ft. in.	st. lb.	ft. in.	st. lb.	Years.	st. lb.	st. lb.
5 2	9 0	4 10	7 0	5	3 8	2 12
5 3	9 7	4 11	7 4	6	3 12	3 1
5 4	9 13	5 0	7 7	7	4 1	3 6
5 5	10 2	5 1	7 12	8	4 4	3 10
5 6	10 5	5 2	8 2	9	4 9	4 1
5 7	10 8	5 3	8 9	10	4 13	4 6
5 8	11 1	5 4	9 2	11	5 3	4 13
5 9	11 8	5 5	9 9	12	5 9	5 8
5 10	12 1	5 6	9 13	13	6 0	6 5
5 11	12 6	5 7	10 8	14	6 8	7 0
6 0	12 10	5 8	11 4	15	7 5	7 8

as the standard, the factors 18·7 and 3·3 must be altered to correspond.

[1] If an individual put on much flesh, his weight will be increased much more largely than his radiating surface, and vice versa; hence, in this case also, it is the normal rather than the actual weight that should be used. The normal weights are given in the table.

INFANTS.

At birth	about	8 lb.
At 3 months	,,	13 ,,
At 6 ,,	,,	16 ,,
At 9 ,,	,,	19 ,,
At 12 ,,	,,	22 ,,

The examples given in the footnote[1] show how the formula may be used to calculate the diet corresponding to the standard for individuals of various sizes.

In cold climates, cold weather, or as a result of exposure, the body loses more heat by radiation, and more fuel is required to maintain it. Men who spend much time in the open air, e.g. farmers, soldiers, fishermen, require more food than engineers, factory hands, tailors and others whose work may be equally hard but is done in dry warm rooms. Builders and workmen eat more when engaged on sea walls, high towers, or other exposed positions. Driving in motor cars and open carriages increases the appetite for the same reason, viz. because it promotes loss of heat by radiation. Clothes help to maintain the warmth of the body by diminishing radiation, but if the clothing be insufficient the body will demand more food. In very warm cli-

[1] (*a*) For a man 5 ft. 10 in. in height, normal weight 12 stones.

$12 \times 14 = 168$ lb.

Protein: $0{\cdot}02 \times 168 = 3{\cdot}36$ oz.

Fuel value: $[(18{\cdot}7 \times 168) - 3{\cdot}3\,(168 - 150)] = 3{,}141{\cdot}6 - 59{\cdot}4 = 3{,}082{\cdot}2$ kal.

(*b*) For a woman 5 ft. 2 in. in height, normal weight 8 stone 2 lb.

8 st. 2 lb. $\times 14 = 114$ lb.

Protein: $0{\cdot}02 \times 114 = 2{\cdot}28$ oz.

Fuel value: $[(18{\cdot}7 \times 114) - 3{\cdot}3\,(114 - 150)] = 2{,}131{\cdot}8 + 118{\cdot}8 = 2{,}250$ kal.

mates or under any conditions that tend to diminish radiation, less food is necessary.

It is impossible to say what additions should be made to the food under these various circumstances. The quantity is generally determined by the appetite, and it apparently makes little difference whether the heat be derived from protein, fat or carbohydrates, or from a mixture of the three. Protein is the most expensive, and for other reasons it is probably undesirable to increase the quantity of this constituent beyond a certain amount—say 5 or 6 oz. per day at the outside. Carbohydrates are the cheapest source of heat, but are comparatively bulky, and having regard to the amount prescribed in the standard diet, it is not generally desirable to make very large additions. Under conditions of extreme cold or exposure, such as those which obtain in the Arctic regions, the additional food generally consists largely of fat. There are also, no doubt, other reasons for this.

There is some difference of opinion regarding the additions that should be made to the diet of a man when doing work. In this connexion, the term work includes all forms of exercise and muscular effort, whatever their object may be.

Formerly, it was held by Liebig and others that bodily work is accomplished at the expense of the muscular tissues, i.e. of the protein. This opinion was, apparently, founded on the fact that the work is accomplished by contraction and relaxation of the muscles ; but it does not follow that the energy which causes them to contract is derived from oxidation of their substance. The work of an engine is done by the forward and backward thrust of the piston ; but the energy which produces the movement is derived from the combustion of fuel, not of the iron of which the piston is composed.

At any rate, Liebig's view is no longer tenable. When a man does bodily work, very little, if any, more protein is oxidized than when he is at rest, and the whole amount is not, as a rule, sufficient to account for the energy expended. On the other hand, a much larger amount of oxygen is absorbed, and a larger amount of carbonic acid is respired.

The natural conclusion, therefore, is that the energy for the performance of bodily work is derived mainly, if not entirely, from the oxidation of non-nitrogenous matter, and that the quantities of fat and carbohydrates in the diet should be increased when the man does work. It has also been argued, from these premises, that it is unnecessary to increase the allowance of protein. Experience shows, however, that men doing hard work exhibit a strong desire for more nitrogenous diet, and that such diet appears to markedly increase the capacity for work [1] both of men and beasts. It was forbidden by the Law to "muzzle the ox that treadeth out the corn." Almost every recognized authority considers that the quantity of protein—as well as that of the non-nitrogenous nutrients—should be increased when the man does work. The additional quantities

[1] It is not easy to account for this; but in the absence of more reliable information, it may be attributed to the stimulating effects of the dissociation products into which the protein is rapidly resolved. Similar effects have been observed to result from the direct ingestion of such compounds in the form of meat extracts. As stimulants, the latter have been found to be much superior to alcohol; they have been largely used for soldiers on the march, and are said to greatly increase the men's power of endurance.

recommended vary from about 25 to 35 per cent. of the quantity for simple maintenance of the individual in question, i.e. about 1 oz. for an average man.

It is also generally agreed that the additional quantity of non-nitrogenous matter should be proportional to the work done; but it is not easy to determine exactly what the amount should be in any given case. A simple calculation [1] shows that 326·4 kal. of energy is required to perform 1,000,000 foot pounds of work, which is reckoned a fair day's work for a man. But when bodily work is done, a considerable amount of energy is also expended in other ways—chiefly in evaporation of water—and this, also, must be allowed for in the diet.

In one experiment, a man on average diet exhaled 281 grams more carbonic acid, and evaporated 769 grams more water, when at work than when at rest. The carbonic acid is equivalent to 98 grams of fat, i.e. to 915 kal. The water evaporated accounts for 462 kal. Add to this 326 kal. for work done, making a total of 788 kal., and there remains 127 kal. still unaccounted [2] for.

Further consideration leads to the conclusion that, from 800 to 1,000 kal. of energy must be expended in order to perform 1,000,000 foot pounds of work, and the additions should be sufficient to

[1] 772 ft. lb. of work is the mechanical equivalent of the heat required to raise the temperature of 1 lb. of water 1° F., i.e. to raise the temperature of 453·59 grams $\frac{5}{9}$° C, = 0·252 kal. Therefore, $\frac{0·252 \times 1,000,000}{772} = 326·4$ kal.

[2] In this experiment, the amount of oxygen absorbed did not correspond with that of the CO_2 and it is probable that the latter is too high.

produce this amount. The standard diet for a working man should, therefore, be as follows :—

STANDARD DIET FOR WORK.

	Protein.	Fuel Value.
	oz.	kal.
For simple maintenance . . .	3	2,800
Additional for work	1	800
Total diet for work . . .	4	3,600

Many other experiments might be mentioned and criticized, but it will be sufficient to quote the conclusions arrived at by several authorities.

[1] STANDARDS FOR DAILY DIET OF LABOURING MEN.

Authority.	Nutrients in Food.			Fuel Value.
	Protein	Fat.	Carbo-hydrates.	
	oz.	oz.	oz.	kal.
Playfair (England) . .	4·16	1·76	18·72	3,140
Atwater (U.S.A.) . .	4·48	2·7–5·3	19·36	3,500
Moleschott (Italy) . .	4·64	1·44	19·36	3,160
Wolff(Germany). . .	4·48	1·28	19·04	3,030
Voit (Germany)—				
For moderate work	4·16	1·92	17·60	3,055
,, hard work . .	5·12	3·52	15·84	3,370
Mean	4·51	2·32	18·32	3,209

[1] *Year Book,* U.S. Dept. of Ag. 1894.

It will be seen that in most cases the amount of protein is higher and the fuel value lower than that given above. The average of all is probably not far from the truth; but it must be remembered that it is only a standard, suitable for an average man, subject to modification in particular cases.

It is a matter of common experience that some individuals consume much larger quantities of food than others. No doubt some men eat too much, and others too little; but recorded observations show that, under exactly similar conditions as regards size, work, etc., the quantities of food consumed by apparently normal individuals vary considerably; and it must be assumed that the quantities correspond approximately with the requirements, because the weights of the persons remain practically constant. Also, under like conditions, some men grow fat and others thin on quantities of food that are found to be just sufficient to maintain average individuals without gain or loss of weight.

The question of the difference between individuals is a very difficult one and involved in obscurity; but the more important facts are clear and simple.

If a man consume one pound of food, his weight will be increased, for the time being, by that amount. Very soon the water will be eliminated, and, together with a trifling quantity of salts and other substances, will be discharged in the urine. Of the solids a portion is indigestible, and will in time be dejected as fæces. The remainder undergoes oxidation, more or less rapidly, and the products are given off as gases. If more food be consumed than is oxidized in the same time, the excess remains and adds to the body weight, and vice versa. In short, the weight of the body can remain constant only when the total outgoings are exactly balanced by what is taken in.

In normal cases, water passes through the body so quickly that it scarcely affects the weight, and may, therefore, be ignored. There may be some difference in individuals as regards the power of absorption, but it is generally considered that such differences are not very great—certainly not enough to account for the observed differences in the quantities of food consumed. It appears, therefore, that these differences must be referred to the rate at which oxidation takes place.

Oxidation is effected by the action of the lungs, which may be compared to that of a bellows blowing a fire. The larger the bellows and the more rapidly it is worked, the greater will be the quantity of air driven into the fire, and the more rapidly will the fire burn. So it is with the lungs. Some men have larger lungs, and some use them more efficiently than others. In some cases, too, the action may be more or less rapid than in others. Physiologists may, perhaps, trace this to the action of the heart, and ultimately to the nervous system, by which the whole of the functions of the organism are controlled. However this may be, it is obvious that in all these cases the amount of oxidation taking place in a given time will be affected; and that the quantity of food required by the individual will vary accordingly.

Whatever the rate of oxidation in any given individual, he will require more food when he does work than when he is at rest; he will require more food when subject to exposure, and so on.

Large individuals require more than small ones because, as a rule, they have correspondingly larger lungs. Such, however, is not always the case, and sometimes small men consume more food than those of larger size.

If a person desire to increase his weight, either the rate of oxidation must be reduced, or the quantity of food consumed daily must be increased. The former is not, as a rule, either practicable or desirable. Any addition to the food may be useless unless it be of the right kind.

When a man, in a normal state of health, gains weight, the increase is made up of about 70 parts of fat, 20 parts of water, and 10 parts of protein, per cent. An increase of 24 lb. in a year is at the rate of 2 lb. per month, or, say 1 oz. per day. To produce this increase, therefore, the person must absorb about 0·08 oz. of protein and 0·7 oz. of fat or its equivalent in carbohydrates—say 6·5 kal.—in addition to what is required for his maintenance and work. In other words, the additional food should contain about 9 parts of fat to 1 of protein. To produce a larger or more rapid increase of weight, larger quantities must be allowed.

In the case of a person whose weight is much below the normal, such as a convalescent, or one who is much "run down," the proportion of protein in the additional food should be larger; in extreme cases, it may be as high as one of protein to one of fat.

In order to reduce weight, either the rate of oxidation must be increased, or the quantity of food must be reduced. Increased oxidation results from increased work or exercise, and by all conditions which promote radiation, e.g. light clothing, cool rooms, cold bathing, etc.

In the case of an individual whose weight is above the normal, the loss of weight consists mainly of fat. Thus it is estimated that in the case of a reduction of 20 lb. weight, about 14 lb. would be fat, 1·6 lb. protein, and the remainder water. Such a reduction might, therefore, be expected to result in greatly increased activity as the person would have so much less mass to move. In the case of athletes, the slight reduction of the muscular tissues would probably be more than compensated by the increased contractile power due to the training.

When weight is reduced much below the normal, a more considerable loss of protein is involved, and loss of power results.

It will be seen, therefore, that if it be necessary or desirable to restrict the allowance of food in order to effect a reduction of weight, it is chiefly the proportion of fat and carbohydrates that should be diminished. In general, the best and quickest results will be obtained by combining both methods, i.e. by increasing the rate of oxidation and at the same time restricting the quantity of food.

The question of obesity differs in some respects from that of an ordinary gain or loss of weight. It is further considered in a later chapter.

In pregnancy, the rate of growth of the fœtus is not uniform throughout the period, but for simplicity it may be assumed to be so. A full grown, well-nourished infant weighs at birth from 7 to 9 lb. The process of maturation occupies approximately nine months; let it be 9 lb. in nine months, or, roughly, 1 lb. per month, i.e. about half an ounce per day. Of this quantity, at least 60 per cent. is water, and the remainder is made up mainly of protein and fat in about equal proportions. We may take it therefore that about 0·1 oz. of each of these constituents [1] is required for the growth of the fœtus, and the ordinary diet of the mother must be increased accordingly.

During the period of lactation, a healthy mother yields from 20 to 40 oz. of milk [2] per day ; the quantity gradually increases with the requirements of the child, from the first to about the ninth month. From the second to the sixth month the average yield is about 30 oz. per day. The milk contains about 2·3 per cent. of protein, 3·8 per cent. of fat, 6·2 per cent. of sugar, and 87 per cent. of water. These quantities are, therefore, equivalent to 0·7 oz. of protein and 600 kal. per day, and the diet for maintenance of a nursing mother must be increased by these amounts. Corresponding to the amount of milk produced, the additional quantities of food may be rather smaller at first, but should be gradually increased, and, after the sixth month, should be greater than those calculated above.

To calculate appropriate diets for a woman under these conditions, we may take the normal weight of the mother as 130 lb., i.e. the average weight of a woman 5 ft. 4 in. in height. The maintenance diet, calculated according to the formula (p. 50) is as follows :—

Protein : $0{\cdot}02 \times 130 = 2{\cdot}6$ oz.

Fuel value : $(18{\cdot}7 \times 130) - 3{\cdot}3\ (130 - 150) = 2{,}431 + 66 = 2{,}497$ kal.

$0{\cdot}1$ oz. fat $\times 28 \times 9{\cdot}3 = 26$ kal.

[1] According to medical authorities the deposition of material in the fœtus takes place at the rate of about 3 grams of protein and 3½ grams of fat per day during the last three months of pregnancy (0·1oz. = 2·8 grams).

[2] Pfeifer.

	Diet for Pregnancy.		Diet for Lactation.	
	Protein.	Fuel Value.	Protein.	Fuel Value.
	oz.	kal.	oz.	kal.
For maintenance .	2·6	2,497	2·6	2,497
Additional . . .	0·1	26	0·7	600
Total . .	2·7	2,523	3·3	3,097

It will be seen that lactation constitutes a much heavier drain upon the physiological resources of a woman than pregnancy. In fact, the fuel value of the food required is not much less than some of the estimates for the diet of working men. Of course, if the woman be called upon to do bodily work during the periods of pregnancy or lactation—as she generally is—still further additions must be made to the diet on that account, as previously shown.

The dietetic requirements of children are not the same as those of adults; they are governed by the same general principles, but allowance must be made for growth and greater activity, as well as for difference in stature and power of digestion. Not only do individuals differ considerably in all these respects, but also, any given child varies from year to year. The formula previously given for adults is not, therefore, applicable to children.

For young children, an indication of their requirements is afforded by the composition of mother's milk. This, it has been shown, yields about 0·7 oz. of protein and 600 kal. fuel value per day. Assuming that this is adequate nourishment for a child of six months, weighing, say 16 lb., the requirements of children may be estimated at about 0·044 oz. of protein and 37·5 kal. per lb. weight per day. These quantities, it will be seen, are almost exactly twice as much as are required for simple maintenance of adults (p. 48).

During the first five years, the diet of children should consist very largely of milk, and whatever is given along with it, the whole should furnish the quantities of nutrients indicated above according to the size (weight) of the child.

From the age of ten to fifteen years, the diet of children should gradually approach that of adults in composition; but having regard to the restless active character of children of that age, it is the diet for work, rather than that for simple maintenance, that it should be brought to resemble.

The diet of children between the ages of five and ten years should be of intermediate character. In other words, from the age of five years upwards, the proportion of non-nitrogenous nutrients may be gradually increased; but of course, the total quantity of protein must be augmented in proportion to the growth of the child.

The following are the averages of some of the numerous diets which have been prescribed for healthy children by various authorities.

	Nutrients in the Food.			Fuel Value.
	Protein.	Fat.	Carbo-hydrates.	
	oz.	oz.	oz.	kal.
Age 1– 2 years .	0·96	1·28	2·72	765
,, 2– 6 ,, .	1·92	1·44	7·04	1,420
,, 6–15 ,, .	3·20	1·60	14·08	2,040

No doubt the diet of children is often deficient in protein ; but the proportions of that constituent in the diets given in the table seem unnecessarily large. In the three cases quoted, it is respectively at the rate of 1·25, 1·35 and 1·57 oz. of protein to each 1,000 kal. fuel value, whereas in mother's milk, the proportion is only 1·15 oz. of protein to the 1,000 kal. The quantities of both nitrogenous and non-nitrogenous nutrients must be increased according to the growth of the child, but the proportion of protein to non-nitrogenous matter need not be increased ; on the contrary, it may be slightly diminished.

Taking the weight of a boy of fifteen years of age as 100 lb., and calculating from the diet for work for adults, we get, after adding an allowance for growth, 2·7 oz. of protein and 2,636 kal. fuel value as the appropriate diet. This, it will be seen, is practically at the rate of 1 oz. of protein to 1,000 kal., which is probably sufficient.

SECTION II. FOOD

CHAPTER V

CLASSIFICATION AND GENERAL PROPERTIES OF FOODS

> Next to the market places that I spake of stonde meatte markettes, whether be brought not only all sortes of herbes, and the fruit of trees with breade, but also fishe, and all manner of iiii footed beastes, and wilde foule that be mans meate.
>
> *More's Utopia.*

Man is, in practice, omnivorous, using both animal and vegetable products as food.

The former includes all kinds of butcher's meat, poultry, game, fish, the so-called shell fish, eggs, dairy produce, cured, canned and preserved goods such as bacon, lard, sausages, etc.

To the latter belong fresh, dried and preserved fruits and vegetables, legumes, cereals and farinaceous products, certain vegetable oils, sugar, molasses, jam, etc.

The common beverages, tea, cocoa, ale, wine, and also spices and condiments, are nearly all of vegetable origin. These products, however, are not generally valued for the nourishment they contain —the proportion is usually very small—and it is only by an extension of the term that they can be regarded as foods.

The character of a food depends upon the digestibility of the nutrients—protein, fat and carbohydrates—it contains, and upon the actual and relative proportions in which they are present.

The fat and carbohydrates, since they perform similar functions in the animal economy, may be grouped together. The nutritive values of these constituents, however, are not the same; they stand in the relation of 9·3 to 4·1 or 2·27 to 1. In order to express the ratio of nitrogenous to non-nitrogenous nutrients in a food, the fat and carbohydrates must, therefore, be reduced to the same denomination. By a generally accepted convention, this is accomplished by multiplying the percentage of fat by 2·27; the percentage of carbohydrates is then added and the sum is divided by the percentage of protein.

This ratio is called the nutritive ratio of the food.[1]

In the natural state, the foods always contain, in addition to the nutrients, a certain amount of water, some proportion of mineral salts, and also other compounds, which, either on account of their chemical nature or indigestible character, have no nutritive value.

When the non-nutritive parts are unedible, e.g. feathers, bone, cartilage, skin, entrails, potato

[1] Example, to find the nutritive ratio of a sample of milk which contains 3·5 per cent. protein, 3·6 per cent. fat, and 4·88 per cent. sugar—

$$\frac{(3{\cdot}6 \times 2{\cdot}27) + 4{\cdot}88}{3{\cdot}5} = \frac{13{\cdot}05}{3{\cdot}5} = \frac{3{\cdot}73}{1}$$

The nutritive ratio is 1—3·73.

peelings, stones of fruit, husk of grain, etc., they are wholly or partially removed in preparing the food for the market and for the table, and finally set aside as refuse. The amount of such refuse must be taken into account in comparing the prices and composition of different foods.

The indigestible fibre of cereals and many other vegetable products is not unedible, and cannot be entirely separated from the nutrient constituents; it cannot therefore be regarded as refuse, though it is practically of that nature.

By removing the non-nutritive parts, the food is rendered more concentrated, and the percentage digestibility is increased. Medical men are, however, inclined to regard this as a very doubtful advantage; at least they consider that the process is, nowadays, rather overdone.

Animal foods are generally rich in protein, and, as the latter is always associated with a large proportion of water, they undergo decomposition very readily. They cannot, as a rule, be preserved by simply drying—it is very difficult to drive off the water without spoiling the food—but must be treated with salt or some other antiseptic for this purpose.

With very few exceptions, the non-nitrogenous nutrients of animal foods consist entirely of fat; this constituent is generally present in larger or smaller amount, but the proportion is very variable.

Apart from the unedible portions, the digestibility of animal foods is very high; for most of them it may be taken roughly as 100 per cent. In general, animal foods are more expensive than those of vegetable origin.

Of the vegetable foods, some, e.g. fresh fruits and vegetables, contain a very large proportion of water, while others, e.g. cereals, etc., are sold in a comparatively dry state. The former decompose readily, but the latter may be kept in good condition indefinitely.

As compared with the animal foods, they generally have a somewhat lower nutritive ratio, though some of them, owing to the comparatively dry condition, contain a larger proportion of protein.

The non-nitrogenous nutrients consist mainly of carbohydrates—chiefly starch and sugar—but a few vegetable foods contain considerable proportions of fat. The latter are generally relatively deficient in carbohydrates.

The fibre which is present in all plants, and, therefore, in most vegetable products, consists of cellulose and belongs to the carbohydrate group (p. 32). Except in very young and tender plants, it is practically indigestible, and is not, therefore, included with the total carbohydrate in estimating the nutritive value of the food.

Certain kinds of cellulose undergo chemical changes in the intestines and gaseous products[1] are evolved. The production of intestinal gases is chiefly due to this cause.

The digestibility of vegetable products is considerably lower than that of animal foods; in ordinary cases, it varies from about 75 to 85 per cent., and may be taken, roughly, as about 80 per cent. of all the nutrients in the edible part of the food.

The composition of plants, especially of the vegetative organs—roots, stems and leaves—is very variable. It depends largely upon the age, i.e.

[1] Chiefly hydrogen and methane.

the stage of growth of the plant. Those parts which are always taken at or about the same stage of growth, e.g. fruit and seeds, are more nearly constant, but the composition of these also is affected by the ripeness, conditions under which they have been gathered, etc.

Vegetable foods are, generally, much cheaper than animal products containing a like amount of nutrients.

The price of food fluctuates from time to time, and varies in different localities; it depends upon the quality of the goods and usually also, to some extent, on the quantity purchased. For example, apples are often quoted at 2*d.* per lb. or 7 lb. for 1*s.*; oatmeal is priced at 1½*d.*, 2*d.* and 2½*d.* per lb. according to quality. In this case, and in many others, the quality is purely a matter of taste; the nutritive value of the cheapest does not differ perceptibly from that of the most expensive. Sometimes, however, it is otherwise.

The prices quoted in this section are the retail prices current in the London Stores for high class goods in their proper season. In the case of butcher's meat, the prices are for good quality English meat; chilled or frozen meat from foreign and colonial sources can be obtained at rates about 20 to 30 per cent. lower.

CHAPTER VI

BUTCHER'S MEAT

> Home from my office to my Lord's lodgings, where my wife had got ready a very fine dinner—viz., a dish of marrow bones ; a leg of mutton ; a loin of veal ; a dish of fowl, three pullets and a dozen of larks all in a dish ; a great tart, a neat's tongue, a dish of anchovies ; a dish of prawns and cheese.
>
> *Pepys' Diary.*

BUTCHER'S meat consists of the carcasses of oxen, sheep—including veal and lamb—and pigs, to gether with the edible portions of the viscera such as kidneys, liver, etc. Other animals, e.g. deer, goats and horses, are sometimes used, but they are not considered here.

BEEF

The weight of oxen varies, according to the breed, age and condition of the animals, from about 1,000 lb. to 1,500 lb. In general, the weight of a well fed ox, three years old, is about 1,200 lb. when it comes into the hands of the butcher.

The animal is killed by bleeding ; the pelt and the abdominal and thoracic viscera are removed, and the head, tail and lower joints of the limbs are cut off. The weight of the dressed carcass is then about 600 or 800 lb., i.e. about 60 per cent. of the total live weight. By cutting radially through the middle of the back bone, the carcass is divided into two equal parts, called "sides of beef," each of which may weigh from 300 to 400 lb. The anterior portion, including the ribs, is known as the fore quarter, and the remainder—the posterior portion—as the hind quarter. The former weighs from 110 to 160 lb., and the latter from 200 to 260 lb. In some cases they are divided so as to be of nearly equal weights.

The method of cutting up the quarters for retail varies slightly in different localities, but the common practice in this country will be understood from the illustration (Fig. 5).

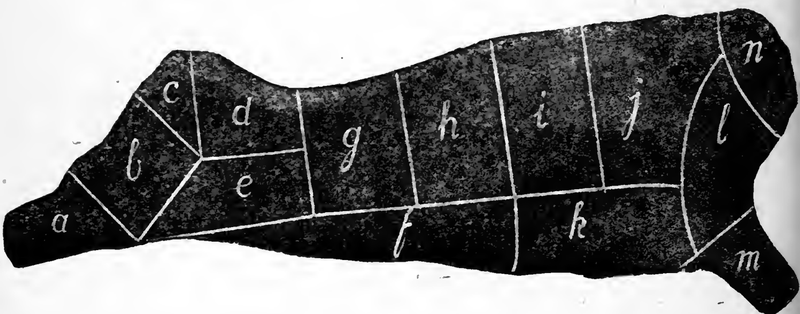


Fig. 5.

The hind quarter is divided into (*a*) the leg, (*b*) round, (*c*) aitchbone, (*d*) rump, (*e*) thick flank, (*f*) thin flank, and (*g*) sirloin. The forequarter comprises (*h*) fore rib, (*i*) middle rib, (*j*) chuck, (*k*) brisket, (*l*) clod, (*m*) shin, and (*n*) neck or sticking piece.

Legs and shins are very similar in composition and quality. They weigh from 10 to 20 lb. each, and are sold at 5*d.* per lb. If a portion of the adjacent cuts is included, higher prices are charged. About half the total weight of these pieces is bone; they are used chiefly for making stock for soups, and meat jellies. The meat is rather hard and strong tasted, but is practically free from fat; it may be purchased separately at about 7*d.* per lb. When properly cooked, it makes excellent stew.

The upper part of the hind limb, called the "round," includes the great thigh bone and the meat attached to the same. The whole piece weighs about 40 or 50 lb. including some 3 or 4 lb. of bone. The meat is usually very lean, but is too hard for first quality. The portion from the inside of the leg is the more tender, and is distinguished as the topside, as it generally lies uppermost in the shops. The topside may amount to about 25 lb. weight, and is sold at 9*d.* per lb. for the whole piece or 10*d.* per lb. in cuts. The middle portion is more highly esteemed than either end, and a higher price—usually 10½*d.* per lb.—is charged for it. The outside portion of the leg, commonly called the silver side, weighs from 20 to 24 lb. and is sold at 8*d.* per lb. for the whole piece or 9*d.* for prime cuts. The round yields good boneless roasts and beef steak. The silver side is often pickled for boiling.

The aitch bone is a wedge-shaped joint taken from between the round and the rump. It weighs about 14 or 16 lb., including from 2 to 2½ lb. of bone, and is sold at 6½*d.* per lb.; smaller pieces, including a larger proportion of bone, are sold at 6*d.* per lb., and those of larger size, including portions of the round or rump, and, therefore, having a smaller proportion of bone, are more expensive. The meat is not, as a rule, very fat; it is fairly tender and makes good roasts, but it is esteemed of second quality.

The rump, as a whole, weighs from 26 to 30 lb., including from 3½ to 5 lb. of bone. The meat of this portion is slightly fatter than that of the round; it is of first quality and very tender. It is sold at 10½*d.* per lb. for the whole piece or 11*d.* for the top end (i.e. the anterior end). Smaller cuts, e.g. rump steaks, are charged at 1*s.* 2*d.* per lb.; these of course are free from bone and unedible parts.

The term sirloin is commonly applied to the whole of the loin piece, amounting to about 30 or 40 lb., between the rump and the ribs. It includes from 3½ to 4½ lb. of bone, and is sold at 11*d.* per lb. for the whole piece or 1*s.* per lb. for prime cuts. In some localities, the anterior portion is known as the small end of loin or short steak, and the term sirloin is reserved for the posterior end next the rump. The middle portion, including the larger part of the undercut and the kidney suet, is known as the tender loin. Porterhouse steaks are cut from this part and sometimes also from the small end, but the sirloin is chiefly used for roasting. The meat is all of first quality and resembles that of the rump, but is generally rather leaner.

The thick flank piece weighs from 24 to 28 lb. It contains no bone, but the sinew and unedible matter amounts to about ½ lb. The meat is ranked as second quality, i.e. as inferior to the rump and sirloin, for roasting, but it is a prime boiling piece, and is often salted or corned. It can be obtained for 8*d.* per lb. for the whole piece or 9½*d.* in cuts.

The thin flank is of markedly inferior quality, and, as it is not easily sold, the whole piece, weighing from 20 to 26 lb., may be purchased at 5*d.* per lb. or 5½*d.* for smaller cuts. It contains no bone, but from 2 to 10 per cent. of it is unedible ; it is chiefly used for sausage making and similar purposes. The edible portion is not unduly fat or strong tasted and, minced or stewed, it makes excellent food. At the price mentioned, it is by far the most "profitable" portion of beef.

The rib cuts weigh, altogether, from 35 to 50 lb. The finest part, known as the wing ribs, is cut from the posterior end, i.e. next to the sirloin, and is sold at 1*s.* per lb. From this forward, the proportion of bone gradually increases, and the prices are correspondingly lower. The middle portion, commonly called the fore rib, is the largest ; it weighs from 24 to 30 lb., including from 5 to 6 lb. of bone, and is sold at 11*d.* per lb. The anterior portion, about 12 or 16 lb., known as the middle or back rib, is sold at about 8½*d.* per lb. The rib cuts are prime roasting pieces. The meat is tender and of excellent flavour ; it is often cut off from the bone and rolled.

The chuck or top ribs, as it is sometimes called, amounts to about 12 or 16 lb., but if a portion of the shoulder is included, it may be more. The whole piece may be bought at 8½*d.* per lb., including bone, but it is chiefly sold as steaks of second quality at 10*d.* per lb.

In the brisket, about 4 or 5 lb. out of a total weight of 18 to 22 lb. is bone and unedible matter. The meat is tender but rather fat, and is chiefly used for salting and boiling. It costs about 7*d.* per lb. in small cuts, but the whole piece may be purchased at 6½*d.* per lb.

The neck and clod contain a large amount of bone and unedible matter, and are chiefly used for making stock and gravies. They are sold at 5*d.* or 6*d.* per lb. The term clod is sometimes used by butchers in a different sense.

VEAL

The term veal is generally understood to refer to the flesh of calves, but as there is no particular age at which they are killed, it is rather indefinite, and both the weights and the composition of the joints are consequently very variable. Veal is in season only from February to November, and it is best in the summer months. It is not cut up in exactly the same manner as beef.

The average prices of the principal joints of veal are as follows :—

Hind Quarter.	Price per lb.	Fore Quarter.	Price per lb.
(*a*) Hock . . .	6*d.*	(*e*) Breast . .	8½*d.*
(*b*) Fillet . . .	1*s.* 1*d.*	(*f*) Neck (best end)	10½*d.* to 1*s.*
(*c*) Loin (best end)	10*d.*		
(*d*) ,, (chump end) . .	9*d.*	(*g*) ,, (scrag) .	6*d.*
		(*h*) Shoulder. .	8*d.*
		(*i*) Knuckle . .	6*d.*

The hock, sometimes called the hind knuckle, is the lower part of the leg ; the fillet is the upper part of the leg and corresponds to the round of beef ; the portion known as the best end of loin includes the rump, and the chump end is the loin proper ; the best end of the neck is really the ribs or chuck, and the scrag is the anterior portion including the neck proper ; the knuckle, sometimes called the fore knuckle, corresponds to the shin of beef.

MUTTON

Mutton, like beef, is nominally in season all the year round, but it is best from September to April. During the summer months, its place in the market is largely taken by lamb.

The total live weight of sheep, like that of oxen, varies with the breed, age and condition of the animal, from about 100 to 150 lb.; the average is about 120 lb. The weight of the dressed carcass is usually about 60 or 80 lb.

Mutton is cut up for retail in a very simple manner. The hind quarter is divided merely into the leg and the loin; the two loin parts, when undivided, are known as the saddle of mutton. The joints of the fore quarter are the shoulder, breast and neck. The neck, so called, really includes the ribs or chuck, and the posterior part is known as the best end; the anterior portion, or neck proper, is called the scrag or top end.

Legs weigh from 8 to 10 lb. each; of this from $1\frac{1}{4}$ to $1\frac{3}{4}$ lb. is bone. Smaller joints are often charged at higher rates, but the average price is about 10*d.* per lb.

Loins weigh from 7 to 9 lb. The proportion of bone is rather less than in legs, but the meat is fatter, and the price is usually higher, viz. from 10*d.* per lb. for the whole piece to 1*s.* 1*d.* per lb. for the best end, trimmed.

Shoulders weigh from 6 to 8 lb., and cost from 8*d.* to 9*d.* per lb. The meat, like that of the leg, is lean, but the proportion of bone is large, amounting in some cases to a quarter of the total weight.

The best end of the neck, usually about 4 or 5 lb. weight, is sold at 10*d*. per lb. It is not quite so fat as the loin, but includes a larger proportion of bone—about 3 oz. per lb. The top end of the neck, or scrag, contains about 4½ oz. bone to the lb. but is not so fat. It weighs about 2 or 3 lb. and is sold at 6*d*. per lb.

The breast includes the lower ends of the ribs and about 10 per cent. of the whole is unedible. The meat is very fat, and as it is not much appreciated, is sold at 4*d*. per lb.

Mountain sheep, e.g. the Welsh and Cheviots, are usually smaller than the common English breeds. The meat is very lean, dark coloured, and possesses a rich flavour that is much appreciated. Such mutton is, therefore, generally quoted at higher prices. The properties mentioned appear to be due, in large measure, to the fact that the sheep are mountain bred, and are, therefore, half starved and very active. It is certainly a fact that when these sheep are reared on rich lowland pastures, they grow much larger and fatter, and the mutton is scarcely distinguishable from that of the common English breeds. Mutton from Wales, it will be seen, has not necessarily the qualities of "Welsh Mutton" unless it be mountain reared.

LAMB

Lamb is in season only from March to September, though it may be had at other times of the year. It is best from May to July ; when very young it is apt to be flabby and tasteless, and when more than six months old, it resembles mutton, but has not the firm texture and rich flavour of the latter.

As in the case of veal, the weight, composition and price of the various joints vary with the age of the animal. The following are about the average prices in the month of August.

Hind Quarter.		Fore Quarter.	
Whole . . .	11*d.* per lb.	Whole . . .	9½*d.* per lb.
Leg	1*s.* ,,	Shoulder . .	11*d.* ,,
Loin . . .	11*d.* ,,	Breast . . .	7*d.* ,,
		Neck . . .	9½*d.* ,,

PORK

Fresh pork is in season only during the winter months, and is at its best from November to March. Pigs are killed at different ages and varying degrees of fatness, and the weight consequently varies within much wider limits than does that of sheep and oxen. The very large and fat animals generally go to the curers; of those killed for fresh pork, the live weight may run from about 80 to 400 lbs.

The hind quarter includes the leg and the hind loin; the fore quarter comprises the foreloin, the hand or shoulder, the belly or spring and the head.

In the leg and hand, from 10 to 12 per cent. of the total weight is bone, and usually from ¼ to ⅓ of the meat is fat. In the loin cuts, the proportion of fat is about the same, but the proportion of bone and unedible matter is nearly double. The belly part, or spring, contains no bone but about 1 oz. in each lb. is unedible and usually more than half the meat is fat ; it is very often pickled and boiled.

In this country, pork is eaten perhaps more largely in the cured than in the fresh condition. It is subjected to a process of salting, either with dry salt, or by steeping in brine, and sometimes smoked. It is then commonly known as bacon ; this term, however, is sometimes applied exclusively to the body or trunk portion, and the hind limb is distinguished as ham, but the "side of bacon" generally includes the ham or gammon as it is called. Bacon is not cut up quite in the same manner as fresh pork, and the various cuts are known in the trade by different (i.e. special) names. The three principal parts of the side are the fore-end, middle and hind end, and these are subdivided as shown in the illustration (Fig. 6).

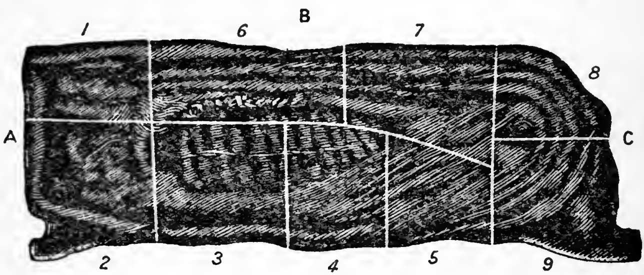


Fig. 6.

The average weights and prices of the pieces are as follows ;—

Piece.	Average Weight.	Average Price per lb.
	lb.	*d.*
A. Fore End—		
1. Collar	8	7½
2. Forehock	8	5
B. Middle—		
3. Thick streaky	8	10½
4. Thin streaky	4	9½
5. Flank	3	7
6. Back and ribs	8	11½
7. Long loin	7	11½
C. Hind End—		
8. Corner of gammon . . .	4	11½
9. Gammon	10	7
Whole side	60	8½

COMPARISON

The several kinds of meat—beef, mutton, pork, etc.—exhibit strongly marked differences of colour, odour, and flavour, which render them more or less agreeable to certain individuals. Certain kinds of meat are apt to disagree with some persons, and it is often said that these are less digestible. It is probable that they do differ to some extent in digestibility, i.e. in the length of time required for complete peptonization, but the differences have probably been greatly exaggerated. Lamb and veal are softer in texture than mutton and beef, and it is commonly believed that they are more readily digestible. There is very little certain information on this subject, but such as is available tends to cast doubt upon the popular notions.

It is true, in general, that the meat from old and poorly-fed animals is harder and more difficult to masticate than that from younger and better fed beasts, and it may be therefore concluded that it is not so easily digestible.

It is not true, however, though it is very generally believed to be, that the softer and more tender kinds of meat are of a more watery and less nourishing character than that from more mature animals. On examination of the tables in the appendix, it will be seen that the proportion of water in the various kinds and cuts of meat is very variable—it depends largely upon the proportion of bone and fat they contain—but the ratio of water to protein is approximately constant. The ratio is about 3·3 to 1 in all kinds and cuts of meat, and is nearly the same in fat and lean portions; in veal it is a little higher, viz., about 3·5 to 1, but in lamb it is slightly less.

All kinds of fresh meat must therefore be regarded as practically alike in this respect, but cured meats are often different; smoked bacon, for instance, is a partially dried product, and contains only about 2 parts of water to 1 of protein.

The proportion of bone in the different portions of meat is chiefly of importance from the point of view of pecuniary economy. The proportion of fat is, perhaps, of less importance in that connexion but, to a large extent, it determines the character of the meat and the dietetic purposes for which it is suitable. Of course, much depends upon the condition of the beast in this respect, but it may be said that, in general, beef is leaner and pork is fatter than mutton; and that lamb and veal are not so fat as mutton and beef respectively.

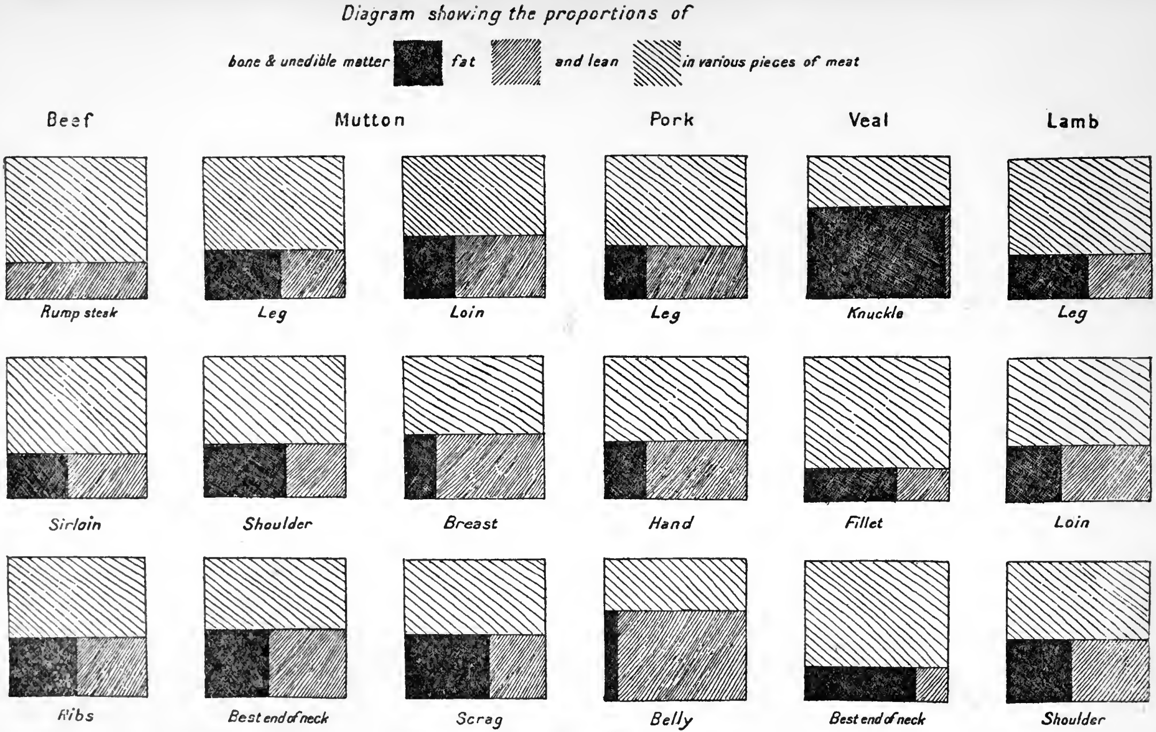


Diagram showing the proportions of
bone & unedible matter
fat
and lean
in various pieces of meat
Beef
Mutton
Pork
Veal
Lamb
Rump steak
Leg
Loin
Leg
Knuckle
Leg
Sirloin
Shoulder
Breast
Hand
Fillet
Loin
Ribs
Best end of neck
Scrag
Belly
Best end of neck
Shoulder

FIG. 7.

The proportions of bone, fat and lean in various pieces of meat are shown in the illustration (Fig. 7).

SUNDRIES

Under this head may be included all those organs, etc., which, though not part of the carcass proper, are sometimes used as food.

Ox-tails contain nearly a third of their weight of bone, and it is difficult to separate the meat entirely from it. They are used practically only for making soup, to which they impart a peculiar flavour that is much esteemed. Ox-tails cost from 1*s.* 3*d.* to 1*s.* 6*d.* each. A much larger amount of shin or other stock meat could be obtained for a similar expenditure.

Ox tongues vary in size from about 4 to 6 lb. The meat is lean, but rather tough, and about a fourth of the whole is unedible. They are usually pickled, but may be eaten fresh, and are almost invariably boiled. The price of fresh tongues at the butchers is about 2*s.* 6*d.* or 3*s.* 6*d.* each; when pickled they are more expensive.

Sweetbreads—the pancreatic glands—are esteemed a rare delicacy. The meat is soft, easily masticated, and is supposed to be readily digestible. It contains about 4 parts of water to 1 of protein, i.e. considerably more than ordinary meat. A pair of good ox sweetbreads, free from unedible matter, weigh about ¾ lb. and are sold at 1*s.* 6*d.* Lamb sweetbreads weigh about 2 oz. and cost about 2*d.* each. Those of sheep are smaller and cheaper.

Kidneys are found attached to the loins, and when sold separately, are usually dissociated from the fat in which they are always embedded, even in lean animals. The meat is practically all lean, but unless very carefully cooked, is apt to be hard—although it contains about 4½ parts of water to 1 of protein—and is considered rather indigestible.

Ox kidneys weigh from about 1 lb. to 1½ lb. each and cost about 1*s*. per lb. Those of sheep and pigs are smaller—from 1 to 2 oz.—and are sold at 2*d*. to 3*d*. each. Ox kidneys, as purchased, generally include a certain amount of unedible matter.

Liver somewhat resembles kidneys in appearance and in chemical composition, but differs markedly in flavour and other respects. Ox liver is very rarely used as food for human beings. Sheep's liver weighs from 1½ to 3 lb. and can be purchased for about 5*d* per lb. Lamb's liver is more expensive owing to the greater demand for it.

Ox hearts weigh from 4 to 6 lb., and cost about 2*s*. each. The meat contains a considerable proportion of fat, and as it is very hard and unpalatable, it is rarely used as food for human beings. Sheep's hearts weigh from 6 to 8 oz. and cost about 2*d*. or 3*d*. each. In chemical composition, they resemble ox hearts, but are not quite so tough. They are generally sold along with the lungs and liver, the whole being known as a "sheep's pluck." The lungs or lights, as they are called, weigh about 4 or 5 oz.; the meat is lean and resembles ordinary meat in composition, but is considered not very agreeable in taste. The price of the sheep's pluck is about 1*s*. or 1*s*. 3*d*. each.

All these tough meats are rendered more readily digestible when minced or reduced to the finely shredded condition of potted or sausage meat; they may then be well salted, spiced and mixed with breadcrumbs, and so rendered more palatable.

Tripe is the substance of the large receptacle or first stomach of the animal. The total quantity obtainable from a full grown ox is about 10 or 12 lb. It is cleaned and dressed by the butcher, and is sold, free from unedible matter, at 6*d.* per lb. It is practically free from fat,[1] and, by prolonged boiling, may be rendered very tender. It is, howevery, watery in character; it contains about 7½ parts of water to 1 of protein, i.e. more than twice as much as ordinary meat. In other words, one pound of tripe contains less nourishment than half a pound of lean beef steak or other meat free from bone.

Suet is the name commonly given to the kidney fat of oxen and sheep; that of pigs is generally known as lard. Beef suet, as purchased, contains a certain amount of non-fatty matter, but the fat generally amounts to over 80 per cent., and moisture to 10 or 12 per cent. It is sold at 7*d.* per lb. Mutton suet, sometimes known as tallow, contains a larger proportion of moisture and non-fatty matter, and is sold at 5*d.* per lb. Pork fat is derived both from the back and belly parts. It is somewhat softer, i.e. it melts at a lower temperature, than suet, but it contains about the same proportion of fat. When refined, all the impurities are removed, and the pure leaf lard contains nothing but fat.

[1] According to Atwater's analyses, pickled tripe contained only 1·2 p.c. of fat, but canned tripe contained 8·5 p.c. For tripe purchased at the butchers, other authorities give the proportion of fat as from 10 to 15 p.c.

CHAPTER VII

POULTRY, GAME AND FISH

> It is observed by the most learned physicians, that the casting off of Lent and other fish days (which hath not only given the lie to so many learned, pious, wise founders of colleges, for which we should be ashamed) hath doubtless been the chief cause of those many putrid, shaking, intermitting agues, unto which this nation of ours is now more subject than those wiser nations that feed on herbs, salads and plenty of fish; of which it is observed in story, that the greatest part of the world now do. And it may be fit to remember that Moses (Lev. xi. 9; Deut. xiv. 9) appointed fish to be the chief diet for the best commonwealth that ever yet was.
>
> *The Compleat Angler.*

POULTRY

The weight of common fowls runs from about 3 to 5 lb. each. The unedible matter, consisting of the feathers, head, lower joints of the legs, entrails and bones, form, altogether, about a quarter of the total live weight; the entrails alone, not including the giblets, weigh from 6 to 8 oz. In chickens, the proportion of unedible matter is larger; in very young birds, it may amount to more than half the total weight, but in the plumper and more mature birds it is not so much. The meat of chickens is very lean—much leaner than that of grown fowls—but the proportion of water to protein in both, is about the same as in butcher's meat. The price of fowls is very variable; for well-fed birds the average is about 3*s*. each; roughly about 1*s*. per lb.

The weight of turkeys varies from about 10 to 20 lb., though both larger and smaller birds can be obtained. Of those reared for the Christmas market, the average weight is about 12 or 15 lb. Turkeys are usually fed to a very plump condition and consequently the proportion of refuse is somewhat less than in common fowls; the meat also is both fatter and drier. The price, at Christmas, runs from about 10*d*. to 1*s*. 1*d*. per lb.; the average is about 1*s*.

The meat of waterfowl—chiefly ducks and geese—also is drier than that of common fowls, and is much fatter. At Christmas, ducks weighing from 5 to 6 lb. are sold at 4*s*. to 5*s*. 6*d*. each, while geese, which weigh from 8 to 12 lb. each, are sold at about 8*d*. per lb.

Rabbits weigh from 3 to 5 lb. each. The weight of the pelt is from 5 to 8 oz., and that of the entrails about the same. The carcass which remains when these parts are removed may be from 2 to 4 lb. weight, including the head; the average is from 2½ to 3 lb. Rabbits are generally sold paunched, i.e. with entrails removed, but with the pelts on. They fetch from 1*s*. to 1*s*. 6*d*. according to size. Australian (frozen) rabbits may be had cheaper—from 9*d*. to 1*s*. each.

FRESH FISH

Of the many different kinds of fisht hat are used as food in this country, those mentioned below are, perhaps, the most important. They are often classified as round and flat fish; the distinction may be convenient for certain purposes, but it bears no more relation to the dietetic value than a division into large and small fish. The meat of fish is soft in texture, easily masticated, and, it is supposed, readily digestible. It contains, as a rule, more water to protein than butcher's meat—in some cases nearly twice as much—but salmon contains actually less, and herring, mackerel and some others, only a little more. These fish are frequently described as "rich"; this probably refers to the amount of fat rather than to the proportion of water they contain, but it might, in this case, be applied in either sense.

Cod, haddock, hake and flounders are practically destitute of fat, and skate contains very little. The unedible parts of fish—entrails, tails, heads, skin, fins, bones, etc.—form a large proportion, usually more than half the total live weight. In flounders and some other flat fish it amounts to over 60 per cent., but in herrings and mackerel, it is not much over 40 per cent.

Some fish vary in size within very wide limits; the weights given below are only approximate averages, both larger and smaller specimens being of common occurrence. The prices also are very variable; those quoted are, except where otherwise stated, per lb., for the whole fish weighed before being cleaned, and are those normally prevailing when the fish is in season. Small fish, such as herrings, flounders, and not infrequently mackerel, are usually priced at so much per fish, or per dozen; in these cases, the price, per lb., has been calculated from the average weight. Some fish, e.g. skate and halibut are often so large that they could not be conveniently sold whole, and the retail prices quoted are for cuts only. Even in the case of the smaller specimens of skate, the whole fish is rarely exposed for sale because its appearance is considered very unattractive. The average weights and prices, and times when the fish are in season are as follows :—

Fish.	Average Weight.	Season.	Best.	Price.
	lb.			per lb.
Haddock .	1–4	Aug. to Feb.	Winter	5*d.*
Cod . . .	6–20	Nov. to Mar.	Feb. to Mar.	4*d.* ; tail cut, 6*d.* middle cut, 8*d*
Hake . .	8–16	Whole year	Winter	Same as cod.
Flounder .	½–1	,,	Aug. to Nov.	4*d.*
Plaice . .	¼–4	,,	May to Nov.	6*d* to 7*d.*
Herring .	½–1½	May to Jan.	June to Sept.	1*d.*–1½*d.*
Mackerel .	¾–3	Whole year	Apl. to July	2*d.*
Salmon. .	10–25	Feb. to Sept.	Summer	1/4 to 1/6 ; middle cut, 1/9
Turbot .	4–12	Whole year	,,	10*d.* to 1/–
Skate . .	10–50	Sept. to April	Oct. to Mar.	6*d*
Halibut .	10–50	Whole year	Nov. to Jan.	7*d.* ; cuts, 10*d.*

CURED FISH

Fish are cured by salting, smoking and drying. The larger kinds are usually first prepared by removing the entrails and cutting off the heads ; the amount of refuse is thereby greatly reduced. When the fish are dried, a larger or smaller proportion of the water is evaporated.

The amount of nourishment in any given fish is not perceptibly affected by these processes, and when they are sold, like herrings for example, by the dozen, a cured fish may be reckoned simply as equivalent to a fresh one. But, when the fish are sold, like cod, by weight, it should be remembered that there is a much greater amount of nourishment in a pound of the cured product than in a pound of the fresh whole fish.

Herrings are pickled, i.e. salted, whole ; they are then called bloaters, and are sold at 1*s*. to 2*s*. per dozen. When salted, dried and smoked they are called red herrings, and are sold at from 1*s* to 1*s*. 6*d*. per dozen. Kippered herrings have the entrails removed, but the heads are not cut off ; they are lightly salted and smoked, with partial drying. They cost from about 1*s*. to 2*s*. per dozen.

Haddocks are cured in a similar manner. They are cut open, the heads and entrails are removed and the fish are then lightly salted and smoked. In Scotland they are called Finnan haddocks, or Aberdeen haddocks, but in England they are generally known as Scotch haddies, or simply haddies. Sometimes the skin and bones are also removed, leaving the "fillet" free from refuse of any kind. These fillets are often highly salted, but are usually only lightly smoked—sometimes not at all—the beautiful golden colour being produced by a dyestuff of some kind. London cured haddocks are sold from 5*d*. to 1*s*. 3*d*. each, according to size. Scotch haddies and Aberdeen fillets are usually priced at about 6*d*. per lb.

Cod or ling is not smoked, but only salted and dried, after removal of the entrails, head and skin. So prepared, it may be purchased at about 4*d*. per lb. In the table in the appendix it will be noticed that the proportion of water in the dried fish is given as 40·2 per cent. and only 38·7 per cent. in the fresh fish. This is due to the smaller proportion of refuse in the former. A simple calculation will show that the proportion of water in the edible matter of the fresh fish is over 80 per cent., whereas in that of the cured fish it is only 53 per cent.

SHELLFISH

The so-called shellfish are not fishes at all, in the scientific sense of the term; they belong chiefly to two orders known to zoologists as molluscs and crustaceans. The former includes oysters, clams, mussels, cockles, whelks, and also snails and other similar creatures. The latter are represented, among the esculents, by crabs, lobsters, prawns, shrimps, etc.

We should not, therefore, expect to find much resemblance between the two groups, and, as a matter of fact, they differ widely in appearance, composition, flavour and other characters. The members of each group, however, bear a certain resemblance to each other in regard to the composition of the edible matter and other respects.

Of the molluscs, oysters stand by far the highest in the estimation of *gourmets*. They are the most expensive. They are perhaps more tender, and are generally supposed to be more readily digestible than any of the others. They are probably less apt to disagree with people, but there is little or no certain information regarding their actual or relative digestibility in the proper sense of the term. The price runs from about 1*s*. to 2*s*. per dozen. The edible matter of a dozen fresh oysters amounts to about ½ lb.; it is of a very watery character, but is practically free from fat.

Oysters, clams, mussels and similar creatures undergo decomposition very rapidly, and, when not perfectly fresh, have been known to cause ptomaine poisoning. They are often found near the mouths of rivers, which may be contaminated with sewage, and are liable to be infected by the bacteria of typhoid and other diseases. The danger is more serious when the creatures are eaten uncooked.

The crustaceans, crabs, lobsters, crayfish, etc., bear a similar resemblance to each other, but they are very different from the molluscs. When whole, they include a very large proportion of unedible matter, but the edible part is drier and contains nearly twice as much protein as that of oysters. Lobsters weigh from 6 to 24 oz., and cost from 9*d.* to 3*s.* 6*d.* each; crabs are about the same weight, and cost from 6*d.* to 2*s.* 6*d.* each. Prawns cost 9*d.* per dozen (equal to about 7 oz.), and shrimps 3*d.* or 4*d.* per pint (equal to about ½ lb.).

These creatures should always be purchased alive and kept alive until the time of cooking, because the substance decomposes very rapidly, and when only slightly tainted may produce disastrous results. Even when perfectly fresh they are found to disagree with many people, and give rise to minor disorders.

CHAPTER VIII

DAIRY PRODUCE

> Milk, and all that comes of milk, as butter and cheese, curds, etc., increase melancholy (whey only excepted, which is most wholesome): some except asses' milk. The rest, to such as are sound, is nutritive and good, especially for young children, but because soon turned to corruption, not good for those that have unclean stomachs, are subject to headache, or have green wounds, stone, etc.
>
> *Burton's "Anatomy of Melancholy."*

THE word dairy is derived from the old English "dey," a farm servant, usually a female, whose duty it was to make cheese and butter, to attend to the calves, poultry and other odds and ends of a farm. The "dey-ry" was the department under her care.[1]

The term is still used in much the same sense; and dairy produce includes, not only milk, though that is by far the largest and most important, but also all the products—cream, butter, cheese, etc.—derived from it, eggs, and sometimes poultry. The last have been considered in a previous chapter, and need not be further referred to.

Milk is produced by the females of all species of mammalia after the birth of young, for which it is the

[1] Eliezer Edwards.

natural pabulum. It is only by depriving the progeny of other animals of this, their natural nourishment, that milk becomes available as human food. The milk commonly used is that of cows, and except when otherwise stated, it is cow's milk that is referred to. The milk of goats is also used to some extent; it is very convenient for small families who could not afford to keep a cow.

Cow's milk is not more suitable than that of certain other animals, but it is the most convenient. Cattle are reared for other purposes; they are big animals, and the naturally large yield which they produce has been greatly increased by careful breeding for many generations.

In point of composition, cow's milk is not the most concentrated. It is distinctly inferior to goat's milk in this respect. The composition of the milk of any given animal, however, is remarkably constant. It varies according to the breed, food and other circumstances of the animal, but only within comparatively narrow limits; and under ordinary conditions the composition of milk does not, as a rule, differ much from the average.

Milk is not a very highly concentrated food. It contains about 87 per cent. of water and 13 per cent. of solids. The latter is made up of 3·3 per cent. of protein, 4 per cent. of fat, 5 per cent. of carbohydrates (sugar), and 0·7 per cent. of ash.

The fat occurs in the form of tiny globules distributed throughout the liquid, with which they form a kind of emulsion. The globules are easily distinguished under the microscope, and present the appearance shown in the illustration (Fig. 8). The carbohydrate being in solution is invisible. A small portion of the protein is also present in solution, but by far the larger part—about $\frac{6}{7}$ of the whole—is insoluble in water; it is, however, so finely divided that it remains permanently suspended, and the particles are indistinguishable under the microscope.

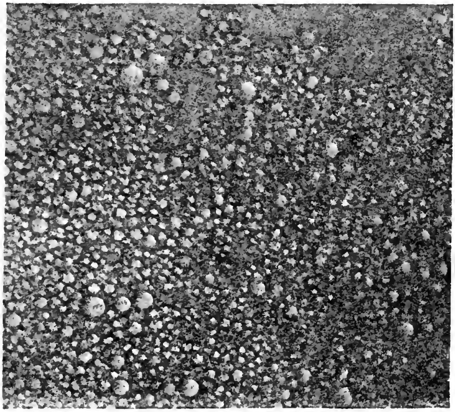


FIG. 8.
FAT GLOBULES IN MILK.
(magnified 200)

It is chiefly owing to these conditions that the nutrients in milk are so much more readily digestible than those of other foods, e.g. meat.

The soluble part of the protein is of the same nature as white of egg, and is called albumen. It is readily coagulated by heat, but is not perceptibly affected by dilute acids. The insoluble portion is called casein. It is not so readily coagulated by heat—milk may be boiled without producing the change—but is quickly curdled by the action of acid, and by certain ferments, e.g. rennet.

The human stomach normally contains both ferments and acids (p. 16). These produce the curdling effects upon the casein, which is therefore precipitated and subsequently peptonized. The clots are digested by adults without difficulty, but in young children they are liable to set up inflammation and other disorders.

This does not occur in the case of a child reared on its mother's milk. The latter contains about the same proportion of water and fat, more sugar, but less protein than cow's milk. Moreover, in mother's milk more than half the protein consists of albumen, which does not curdle in the stomach.

Should it be necessary, for any reason, to substitute cow's for mother's milk, water must be added, to such an extent that the diluted product shall contain no larger a proportion of casein than mother's milk, i.e. about 2 parts of water to 1 of milk. The addition of water, of course, reduces the proportions of all the other constituents in the same degree, but they can be replaced by the addition of sugar and cream. The latter is often, perhaps generally, omitted because fresh cream is expensive and not always available. The deficiency of fat is said to be a cause of rickets; it may be partially compensated by using a larger proportion of sugar, but this cannot be expected to agree so well with the infant.

In preparing a substitute for mother's milk, the quantities should be measured exactly in a druggist's measuring glass which can be obtained for a few pence, or in one of the specially graduated glasses, such as the "Materna," which are sold for the purpose. In the absence of special medical directions, the following quantities may be used: 3 oz. milk, 6 oz. water, 1 oz. cream and ½ oz. sugar; this gives a total quantity of ½ pint. The water should be measured first and the sugar dissolved in it, then the milk and cream may be added. The cream should be separated—not skimmed—so as to be fresh, and the sugar should, by preference, be milk sugar; it is obtainable at any druggist's shop.

Practically the same result is obtained by adding to 2 oz. of fresh whole milk the cream skimmed or separated from 4 oz., and the whey from a similar amount. To obtain the whey, the milk is coagulated with rennet, the curd is then thoroughly broken up, and the liquid strained through fine muslin; it should be boiled to destroy the fermentative action of the rennet, and then cooled. This process is more troublesome and more expensive than the previous one, and probably gives no better results. A sterilized product of this kind can be obtained commercially under the name of "humanized milk," and it is to be preferred to the home-made article.

Milk readily undergoes fermentation, and, in warm weather, preservatives of one kind or another are often added to it to retard the process, or disguise the effects. The preservatives generally consist of antiseptics, e.g. salicylic or boric acid or formalin, but carbonates are also sometimes used. The last do not hinder fermentation, but they neutralize the acid that is formed, and so keep the milk sweet. The quantities used are so small that they do not perceptibly affect the taste of the milk, but they are, nevertheless, objectionable. Antiseptics are inimical to digestion in proportion to their effectiveness, and are liable to set up inflammation in young children and invalids.

The simplest way to preserve milk is to boil it or steam it. This destroys all the ferments, and also any germs of disease which it may contain. The milk is then said to be sterilized. The process is, however, considered objectionable because at temperatures above 160° F. the albumin coagulates forming a scum on the surface, and the milk acquires a peculiar "burnt" taste. Most of the ferments and bacteria are destroyed at temperatures considerably below that of boiling water, and milk can be preserved, without producing the effects described, by exposing it for some time to a temperature of 158° F. This process is called pasteurization, after the name of the great discoverer.

Both sterilized and pasteurized milk can be obtained commercially in most towns, but the price is somewhat higher than that of ordinary fresh milk. The latter is commonly retailed at from 3*d.* to 4*d.* per quart, which is equal to about 1¼*d.* or 1½*d.* per lb.

The cream may be removed from milk either by skimming or by the mechanical separator. The former method is not so effective as the latter, and skim milk usually contains from 0·2 to 0·4 per cent. of fat. Separated milk contains hardly any fat, but the same price is usually charged for it as for skim milk, viz., 1½*d.* or 2*d.* per quart. The proportions of the other ingredients are not sensibly altered.

The composition of cream is very variable, especially as regards the proportion of fat which is the essential constituent. In cream which has been skimmed off, the proportion of fat is usually about 20 per cent., but it depends upon the temperature and method in which the milk is set, and the size of the globules which varies in the milk of different breeds of cows. In cream separated by the centrifugal machine, the proportion of fat varies from about 10 per cent. to over 50 per cent., according to the rate at which the machine is turned. Two qualities are commonly recognized, viz., thick or heavy cream which contains over 30 per cent. of fat, and light cream in which the proportion is usually under 20 per cent.

Cream of medium quality, i.e. containing about 20 per cent. of fat is sold at about 1*s.* 6*d.* per pint. Thick cream is, of course, more expensive.

Butter consists essentially of milk fat, and contains a small amount—usually about 1 per cent.—of proteids. The proportion of water is variable, but should not exceed 16 per cent. at the outside; the average is from 10 to 12 per cent. A certain amount of salt is usually added to preserve the butter and improve the flavour, and some artificial colour is often introduced. The average proportion of fat is about 85 per cent. The price varies from about 1*s.* to 1*s.* 6*d.* per lb.

Margarine is a substitute for butter, and is, therefore, made to resemble it as closely as possible, both in appearance and composition. It is made chiefly from animal fats, but is often mixed with others of vegetable origin, in order to improve the flavour and consistency. Some of the butter substitutes used by vegetarians are made wholly from nut oils and other vegetable fats. Margarine is sometimes mixed with dairy butter, and occasionally it is fraudulently sold in place of the latter. All these products have practically the same nutritive value as pure dairy butter, and are much cheaper. Good margarine can be obtained at 7*d.* or 8*d.* per lb.

Cheese consists essentially of partially dried, compressed milk curd. It is generally made from fresh whole milk which is curdled by the action of rennet. After standing some time, the curd is broken up and the whey is run off. The whey is mainly water, but it contains most of the sugar and some of the proteid (albumen) in solution. The curd consists mainly of casein, but contains the fat globules of the milk mechanically enclosed in it. It is collected, pressed, and when allowed to stand, undergoes a peculiar slow fermentation, by which it is changed from the green to the ripe condition.

By conducting the operations at different temperatures, varying the amount of salt and other details, many different varieties of cheese may be produced.

The composition of cheese is very variable, and can scarcely be said to be characteristic of the different kinds. The method by which it is prepared, however, determines the kind of fermentation that takes place, and it is upon this condition that the peculiar flavour and properties of the different kinds of cheese chiefly depend. If any part of the cream has been removed from the milk, the cheese prepared from it will be correspondingly deficient in fat. Skim milk cheese is very dry and unappetizing. Soft cheeses are made in a different way, and differ considerably in composition and properties.

The eggs principally used as food are, of course, the common hen's eggs ; but those of ducks, geese, turkeys and certain wild fowl are also employed. The shell forms from 10 to 12 per cent. of the whole. The edible matter of the eggs of different birds is very similar in composition, but in those of water fowl it contains a rather larger proportion of fat.

Several distinct parts may be recognized in an egg, as shown in the illustration (Fig. 9); for dietetic purposes it is sufficient to distinguish merely the white and the yolk. The former consists of practically pure albumin plus a large amount of water. The latter also contains proteids of a somewhat different character, a large amouut of fat and only about half the proportion of water that is present in the white. The average composition of the two parts of a hen's egg is as follows:—

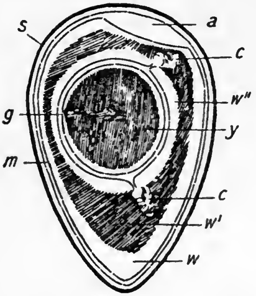


FIG. 9.

Section of an egg, showing air-chamber (*a*); chalaza (*c*); germ (*g*); membrane (*m*); shell (*s*); the albuminous layers (*w*, *w′*, *w″*), and yolk (*y*).

	Water.	Protein.	Fat.
White	86·2 ..	12·3 ..	— per cent.
Yolk	49·5 ..	15·7 ..	33·3 ,, ,,

The average weight of hen's eggs is a little under 2 oz.; they run about eight or ten to the pound, and cost anything from four to twenty-four for a shilling. In towns, the price is rarely under 1*d.* each, which is equal to about 9*d.* per lb.

Duck's eggs are slightly larger—about six or eight to the pound—and cost about 1½*d.* each. Turkey's eggs are about twice and goose eggs three times the size of hen's eggs.

When eggs are boiled, the proteids are coagulated, i.e. the contents change from a semi-fluid to a solid state. This change does not perceptibly alter the composition of the compounds, and does not affect the dietetic value unless the eggs are boiled very hard, when, of course, they are less readily digestible. Healthy adults, however, experience no difficulty in digesting even hard-boiled eggs if they are properly masticated.

The extremely offensive odour of rotten eggs is due to decomposition of the proteids, which is caused by the action of microbes. The latter are so minute that they find entrance to the eggs through the pores of the shell ; but if they are excluded the eggs may be kept in good condition indefinitely. There are several methods by which this may be effected. One of the commonest is to paint the shell over with a solution of sodium silicate (water-glass) which blocks up the pores, and so hinders the entrance of bacteria. Vaseline and some other substances have been tried, but they are not so good as water-glass.

Another plan is to bury the eggs in finely powdered slaked lime, or in common salt. These substances exclude the air, and by their antiseptic action destroy the bacteria. They are sometimes used in the form of solutions. Lime has the disadvantage that it acts on the substance of the shell and renders it very brittle. It is said also to impart a disagreeable flavour to the eggs, but this is denied by many who have used the method. To be successful, it is, of course, necessary that the eggs should be perfectly fresh and clean to begin with. They should be first wiped and then dipped in hot water for a second or two before preserving. According to one authority eggs may be preserved by simply immersing them in boiling water for twenty seconds. This, it is supposed, destroys the bacteria, and coagulates a thin layer of albumen within the shell, which prevents the entrance of others. Eggs packed in bran, sawdust or other substance which excludes the air, may be kept much longer than those packed in straw.

Perfectly fresh eggs are semi-transparent, and when held up to strong light, exhibit a uniform rose tint without any dark spots. The air chamber, also, is small. A cloudy appearance gradually develops, becomes darker as the egg gets older and finally renders them opaque. At the same time the size of the air space increases. This is the best test of the freshness of eggs.

CHAPTER IX

VEGETABLE FOODS: CEREALS, FARINACEOUS PRODUCTS, ETC.

Bread of flour is good.
Sesame and Lilies.

THE special characteristic of these foods is that they contain a large proportion of starch. The proportion of protein is variable but not, as a rule, very large, and that of the fats is generally small.

As purchased, they contain relatively small amounts of water. The cereal grains, for instance, are comparatively dry when harvested; they are further dried after cutting, and usually also again in the processes of milling and preparation to which they are subjected.

In the grains of cereals the fat and protein are concentrated towards the exterior, i.e. in the region next the husk; but as they are there associated with a large amount of fibre, the nutrients of that part of the grain are not so readily digestible. The exterior portions of the grain are, therefore, generally separated in the process of milling, and are sold under the name of bran, pollards, barley meal, rice meal, etc., as food for cattle and poultry. The germ, which lies at the centre, consists largely of nitrogenous matter, but is very small. It is surrounded by a thick coating of starchy matter, and it is this portion of the grain that is chiefly used as food.

Wheat is by far the most important of the cereal grains. It is the principal bread stuff, and is also used in a variety of other forms. Over seven million tons of dressed wheat grain are consumed annually in this country, i.e. over 1 lb. per head of the population daily. Many different varieties of wheat are grown in different districts. Some of them are bearded; some are red and others are white or yellow in colour. The composition of the grain is more or less characteristic of the variety, but varies within certain limits according to the climate, season, soil, and other conditions under which the plant is grown. The following results were obtained on analysis of 250 samples of wheat grown in different localities:—

COMPOSITION OF WHEAT GRAIN.

	Maximum.	Minimum.	Average.
	per cent.	per cent.	per cent.
Protein	24·6	8·2	12·4
Fat	2·6	1·0	1·7
Carbohydrates . . .	77·3	61·3	67·9
Fibre	6·4	1·2	2·6

The proportion of nitrogenous matter (protein) is always greater in wheats grown in hot, dry climates. Such grain is harder, denser, and more translucent in appearance than others which contain a larger proportion of starch. The latter have thinner husks and skin and yield a larger quantity of fine flour on grinding, and the flour is more suitable for making bread ; they are, therefore, deemed of better quality. Some samples of wheat yield as much as 80 per cent. of fine flour, and others only from 50 to 60 per cent.

Wheat is subjected to a very elaborate process of grinding in order to obtain the finer qualities of flour. The finest flour is derived from the inner portions of the grain. It is whiter, more starchy and makes better bread than that derived from the outer parts. The latter is sold as second and third qualities. The bran is removed by processes of repeated grinding and sifting. The grain is sometimes ground up whole after removal of the husks and skins. The product is called whole meal or wheaten meal, and is, of course, practically a mixture of bran and white flour ; it is, in fact, sometimes made by mixing the two.

At some mills, as many as ten different grades of flour are produced, but in this country the principal products are as follows :—

Finest flour	40	per cent.
Seconds	18	,,
Middlings	12	,,
Tailings	8	,,
Sharps	6	} 18 ,,
Pollards	9	
Bran	3	
Waste and loss	4	,,
	100	

The various qualities of white flour do not differ much in chemical composition. They contain, as a rule, from 10 to 12 per cent. of protein, about 75 per cent. of starch and 1 per cent. of fat. When the starch is removed by the action of saliva, or in other ways, a yellowish elastic substance called gluten remains behind. It consists mainly of protein, and it is the presence of this substance which gives the cohesive plastic character to dough produced by kneading flour with water. This is the principal difference between wheat flour and pure starch.

Fine white flour of various makes may be purchased in sacks of 280 lb. at about $1\frac{1}{2}d.$ per lb., in retail quantities at *2d.*, or usually 7 lb. for a shilling. The finest Hungarian, self-raising and patent flours are more expensive. Inferior grades are, of course, somewhat cheaper.

Ordinary loaf bread is prepared, essentially, by mixing the flour with water, kneading the dough —yeast being added to make it "rise"—and then firing, i.e. baking, it. The effects of these processes are more fully discussed in a later chapter (p. 139), but it may be said now that the chemical changes, though important, are not very extensive. The composition of bread does not, therefore, differ much from that of the flour except in regard to the proportion of water it contains. This also constitutes the largest difference between one sample of bread and another.

Fresh white bread usually contains from 35 to 40 parts of water, 8 or 9 of protein, from 50 to 60 of carbohydrates, and 1 of fat, per cent. Brown bread, made from whole meal, contains a slightly larger proportion of protein and fat. As compared with white bread the difference in nutritive value is small, but owing to the presence of the coarser elements—bran, etc.—it has a slightly laxative effect and is, therefore, preferred by people who are predisposed to constipation.

The quality of bread depends partly upon that of the flour, and partly upon the method by which it is made. Bread made from the cheaper qualities of flour is often darker in colour, and alum, copper salts and other substances are sometimes introduced to whiten it. All these compounds are, however, more or less deleterious to health, and their use is illegal. If excessive quantities of yeast are employed, or if its action be unduly prolonged, the bread acquires a sour taste from the lactic acid which is formed. Such bread is rightly regarded as of inferior quality as the taste is disagreeable. It is not, however, at all injurious, nor is it necessarily less nourishing.

The average price of bread is about 1½*d.* per lb., but fancy loaves and those of finer quality are more expensive.

Unleavened bread, and that made from other cereals, e.g. barley, rye, maize, etc., necessarily differ to some extent both in composition and properties.

Macaroni, spaghetti, vermicelli and other similar products are made from harder varieties of wheat which are not suitable for making bread owing to the large amount of gluten they contain. The flour, which is prepared by a peculiar process, is mixed to a paste with water, moulded in the desired form, and dried by heat. For semolina, the paste is not moulded but simply dried hard and ground to a coarse meal. Shredded wheat has practically the same composition as whole meal, but owing to its peculiar mechanical condition, it is supposed to be more readily digestible.

In the milling of barley, the product which remains after removal of the bran, is called pot barley; by further treatment this is converted into pearl barley. The latter costs about *2d.* per lb. or 7 lb. for 1*s.*; pot barley is rather cheaper.

Rice is not grown in this country—it requires a moist, warm climate—but is imported in large quantities. In appearance, the grain bears a certain resemblance to wheat and barley. Compared with these in point of composition, rice contains less protein and fat. In the process of removing the bran from the exterior, some of the grains become bruised and broken; these are separated and sold as ground rice at 1½*d.* per lb. The whole grains, polished, are sold at 2*d.* per lb. Large grained varieties, used for curry, and certain special brands cost from 2½*d.* to 4*d.* per lb.

The many different varieties of oats may be broadly divided into two classes, viz. (1) the small and black varieties with thick husk and skin, used chiefly for feeding horses, and (2) the larger white varieties from which oatmeal is prepared. The composition of the oat grain differs markedly from that of the cereals previously mentioned. Oats contain less starch and much larger proportions of fat and fibre. The fat is of a peculiar quality; it contains a certain amount of free fatty acid (p. 30) which gives the grain its peculiar piquant flavour. Very little but the husk and skin is removed in milling, practically the whole of the grain being ground into meal. Oatmeal is sold in three grades known as fine, medium and coarse. These terms refer merely to the fineness of grinding and not to the quality. The superior quality of Scotch oatmeal is commonly attributed to the character of the grain grown in that country; probably, however, it is due, in large measure, to the skill of the

Scotch millers. English oatmeal often has a peculiar bitter taste, which is very disagreeable, and which may be due to over heating. Crushed and rolled oats have practically the same composition and properties as oatmeal.

Maize is not largely employed as such, in this country, but a number of products derived from it are in common use. Of these, perhaps the most important are hominy and corn-flour. In making these products, the cereal is subjected to treatment with alkalis which extract a considerable part of the protein and fat, and leaves sometimes nearly pure starch. In England cornflour is also made from rice,[1] but there is not much difference in the composition. Hominy costs about 2*d.* per lb. and cornflour, from 4*d.* to 6*d.* per lb.

Sago, tapioca and arrowroot consist of practically pure starch of which they contain about 85 per cent., the remainder being moisture and a trace of mineral matter.

Arrowroot is obtained from the tuberous roots of certain herbaceous plants (Maranta). The tubers are pulped and worked with water on a sieve through which the starch granules escape, and are thus separated from the fibre with which they are associated in the plant. The starch is then collected, purified and dried in the sun. So prepared, the arrowroot imported from Bermuda commands the very high price of 3*s.* 3*d.* per lb., though it is practically indistinguishable from that imported from St. Vincent, which is sold here at 4*d.* per lb.

Tapioca also is obtained from tuberous roots, but the plants belong to a different order. The starch is contained in the juice expressed from the

[1] Bell, *Chemistry of Food.*

pulped tuber; when washed with water and dried, it is known as cassava starch, or Brazilian arrowroot. This product is partially dried and exposed to heat, which causes the starch granules to burst and cohere in irregular masses; this forms the tapioca of commerce which is sold at 3*d.* to 3½*d.* per lb.

Sago is obtained from still another kind of plant known as the sago palm, which often attains a height of over 30 ft. The starchy matter is found, not in the root, but in the stem. The tree is cut down and the pith is scooped out; the starch is then separated from fibrous impurities by working with water on a sieve as in the case of arrowroot. When it is purified and dried, it is called sago flour. This is granulated by mixing to a paste with water and heating till the starch grains burst and cohere in granules on drying. Genuine sago is sold at 4*d.* and 5*d.* per lb. Special qualities consisting of larger granules are more expensive. It is of a brownish colour, and has a peculiar earthy taste. Pearl tapioca is frequently sold under the name of white sago. This practice is not regarded as fraudulent, although tapioca is a cheaper product.

The term legume is used in different senses. Here, it refers to the seeds of certain leguminous plants, of which beans, peas and lentils are the most important. They are also known as pulse grains. As compared with the cereal grains, these seeds are distinguished by the presence of a much larger proportion of nitrogenous matter and a smaller proportion of starch. The three mentioned above are much alike in composition. Beans contain a slightly larger proportion of fat, and peas contain more woody fibre than lentils. This fact regarding peas lends colour to the popular notion that they are apt to produce flatulence, and lentils are often preferred to peas on this account. Beans and peas are too well known to need any description. Lentils are, perhaps, less familiar. They are not grown in this country as the climate is unsuitable. The plant of which they are the seed somewhat resembles vetches in appearance. The ordinary varieties of peas, beans and lentils cost about 2*d.* per lb., but some special qualities are sold at 4*d.* or 4½*d.* per lb.

The various kinds of nuts in common use are all well known, and need no description. They are valuable foods, and are much esteemed by vegetarians, chiefly on account of the large proportion of oil they contain, but they are also fairly rich in protein. The composition is given in the tables in the appendix. They are considered somewhat indigestible, but it is said no difficulty is experienced when they are finely ground. In any case they should be thoroughly masticated. The following are the average prices of the commoner sorts :—

	per lb.		per lb.
Almonds	6*d.*	Walnuts,	6*d.*
Filberts	6*d.*	,, kernels	1*s.*
Peanuts	3*d.*	Brazil nuts	6*d.*
Barcelonas	4*d.*	Cocoanuts . each	3*d.*
Chestnuts	3*d.*		

There are several different kinds of natural sugar, and many others can be prepared by artificial means. They are divided, by chemists, into groups. The various kinds of sugar used for domestic purposes all belong to the cane sugar group, and were formerly obtained exclusively from sugar cane. Large quantities are now obtained from beet. It is estimated that about two-thirds of the sugar now on the market comes from this source. Beet sugar is practically identical with that derived from sugar cane, and as a rule no distinction is made commercially.

The processes by which the sugar is extracted from the two plants, of necessity differ in detail, but in general outlines they are very similar. In both cases, the material is reduced to pulp, and the sugar is expressed in the juice or washed out with water. The grosser impurities are then removed, and the water evaporated until the sugar begins to crystallize. The product so obtained is called raw sugar, and the liquor which remains is called molasses or treacle.

Raw sugar from Demerara and Trinidad is sometimes used without further refining. It is a soft, moist, easily soluble product, sometimes called brown sugar. It contains about 90 per cent. of pure cane sugar, 5 per cent. sugar of another kind, called invert sugar, and 5 per cent. of moisture. It is sold at 2½*d.* per lb. Certain inferior products of the refineries are sometimes dyed and sold as best Demerara. These consist of very small crystals, hold a large proportion of water, and have less sweetening power than raw sugar.[1]

White sugar is prepared from the raw product by a very elaborate process of refining. The substance is dissolved in water, decolourized, purified and crystallized in vacuum pans. The vacuum pan is a device to make water boil at a lower temperature, and it is used to prevent the sugar from being converted into an uncrystallizable form. It is impossible, however, entirely to prevent this change,

[1] Bell, *Chemistry of Food.*

but the sugar which undergoes it is recovered and sold as golden syrup.

The common granulated sugar produced by this process is almost absolutely pure and free from moisture; it is sold at 2*d.* per lb. Loaf sugar is practically the same product crystallized in moulds, but as some manipulation is involved, the price is higher, viz., 2½*d.* to 3*d.* per lb.

Treacle and syrup are sometimes confused. The former term generally refers to the molasses obtained in the crystallization of raw sugar, but is occasionally applied to the syrup or drip obtained in refining. The viscous, black treacle or molasses, contains about 60 per cent. sugar, of which two-thirds is cane sugar, 10 per cent. protein and 30 per cent. water. It is sold at 2½*d.* to 3*d.* per lb. The molasses obtained in crystallizing crude beet sugar, is unfit for use as food. Golden syrup is lighter in colour than treacle, but is very similar in composition.

Vegetable fats and oils are used to a considerable extent in the pure state, i.e. after extraction from the seeds, nuts or other parts of the plants which contain them.

Olive oil is derived from the fruit of the olive trees, of which a number of different varieties are cultivated in the South of Europe, Asia Minor and elsewhere. The oil is obtained both from the fleshy part of the fruit and also from the stones. The former is much superior and is known as the "finest virgin oil (sublime)." The latter has a slightly rancid flavour, and is often adulterated with cotton-seed, sesame and other cheaper oils. A low grade, mixed oil, is obtained by crushing the whole fruit and kernels together. Even the finest qualities rapidly go rancid when exposed to heat and light, e.g. in shop windows. When pure, it should be of a light yellow colour, thin and almost tasteless. The French and Italian products are sold in this country at from 1*s*. to 1*s*. 3*d*. per pint, but the Spanish is dearer, about 2*s*. per bottle.

Cotton-seed oil and oil of sesame closely resemble olive oil; they are used not only to adulterate it, but are often substituted entirely for it, both avowedly and fraudulently. The so-called salad oil generally consists of pure cotton-seed oil. It is sold at 10*d*. to 1*s*. per pint.[1]

Almond oil, properly so called, is obtained by pressure, both from sweet and from bitter almonds, which contain about 50 per cent. of bland oil. It is not to be confounded with the volatile product known as oil of bitter almonds. The latter is of the nature of an essence and is obtained by distillation after the fat has been expressed (p. 134). Pure almond oil is of a light yellow colour, thin and almost tasteless. It is one of the most expensive vegetable oils, being sold at from 2*s*. to 2*s*. 6*d*. per pint, and is, therefore, frequently adulterated with cheaper oils.

What is called peachnut kernel oil, but is in reality largely made from the stones of apricots, plums and other fruits, resembles almond oil. It is considerably cheaper and may be used in place of the latter; as a matter of fact it is used to adulterate almond oil and is sometimes fraudulently substituted for it.

Arachis or peanut oil, which is also extensively used, has a somewhat disagreeable flavour similar to that of the nuts themselves, and which becomes more pronounced on standing some time. Peanut

[1] A little over 1 lb. weight.

oil is fairly cheap, about 9*d*. to 10*d*. per pint, and enters into the composition of most of the so-called vegetable margarines or butter substitutes. The fundamental substance of the latter, however, is cocoanut oil. These vegetable margarines are sold at prices ranging from 8*d*. to 1*s*. per lb.

The vegetable oils, with the exception of the last mentioned products, consist of pure fat and are all of equal nutritive value. The butter substitutes contain from 10 to 12 per cent. of moisture.

CHAPTER X

FRUITS AND VEGETABLES

. . . . entreat thy Lord that he give us what the earth produceth, beets, cucumbers, garlick, lentils and onions . . . . Eat of the fruits of the earth.

The Alcoran.

Fresh vegetables generally consist of edible roots, stems and leaves, the composition of which is very variable. They always contain a large amount of water.

The dry or solid matter rarely exceeds 10 or 12 per cent. of the whole. It is composed mainly of carbohydrates. Either starch or sugar generally predominates, but a considerable amount of cellulose is always present. The last becomes fibrous and more or less indigestible as the plants get older, and in that condition, it is apt to produce flatulence and disagree with people of weak digestion. Fats are often absent, or occur only in negligible quantities.

The nutritive ratio is generally low, and, of the total nitrogenous matter, a variable but usually considerable part is in the form of amides which have very inferior, if any, nutritive properties (p. 37). The true proteids also are less easily and less completely digestible than those of seeds.

It is obvious, therefore, that the nutritive value of fresh vegetables is small compared with that of the more concentrated foods previously mentioned. On the other hand they are relatively very cheap, i.e. when considered weight for weight. Many of them are more valuable for their hygienic properties than for any directly nutritive effects.

As a rule, the corresponding parts of the plants exhibit a general similarity of composition, and they may be arranged in groups accordingly as follows—

Roots.	*Tubers.*	*Stems and Leaves.*	*Seeds and Fruits.*
Turnips.	Potatoes.	Cabbages.	Peas.
Carrots.	Artichokes.	Spinach.	Beans.
Beetroot.	*Leafbulbs.*	Lettuces.	Tomatoes.
Parsnips.	Onions.	Celery.	Marrows.
Radishes.	Leeks.	Cauliflower.	Cucumbers.

Tubers are often classed as roots, but they are, in reality, underground stems, and their nutritive and other properties are very different from those of turnips, etc. Potatoes are the most important. They contain less water and more nutrient matter than any of the other vegetables mentioned. The carbohydrates consist mainly of starch, and the proportion of fibre is small. Potatoes form the staple diet of large numbers of people, and having regard to their composition, price, etc., they rank next to bread itself in this respect. Artichokes have a higher nutritive ratio than potatoes and are not much inferior in other respects.

Roots are more watery. They contain only a small amount of nitrogenous matter, and of this, more than half is sometimes present in the form of amides. The carbohydrates, which consist mainly of sugar, are the most important nutrients of these vegetables.

Cabbages and other vegetables of that class are even more watery than the roots. From a fifth to a third of the total carbohydrates generally consists of fibre of a rather indigestible character, and except when the plants are very young and tender, these vegetables do not agree with many people. Cauliflowers have been put in the same group, but they are very different in character. The edible substance consists mainly of the undeveloped flower buds; consequently, the nutritive ratio is higher, and the proportion of fibre is smaller than in cabbages.

In ordinary language, the term fruit is applied only to vegetable products that are suitable for dessert, and peas, marrows, cucumbers etc., are regarded as fruits only in the botanical sense that they are the part of the plant that contains the seed.

In the case of peas and beans, it is the pod that is the fruit, and though this is the edible part of French beans, etc., it is the seed alone of green peas that is eaten. The latter are, therefore, simply undried legumes and, apart from the water they contain, closely resemble those previously described. They have a high nutritive ratio.

Fresh fruits are relatively very expensive and, as a rule, they are consumed only in comparatively small quantities. They are valued more on account of their pleasant flavours and hygienic properties than for the nourishment they contain. Protein generally forms about 1 per cent. of the edible matter; and fats about half that amount. Some of them, however, contain much smaller amounts of the former, and some are practically destitute of the latter constituent. Carbohydrates occur in more variable but, usually, more considerable quantities. They are, in all cases, the most important nutrient in these products, and generally consist largely of sugar.

In the unripe condition, most fruits are hard, sour and unpalatable; but as they approach maturity, the cellulose becomes converted into the softer pectic compounds, the proportion of sugar increases, and the acids are partly changed into ethereal substances which impart the characteristic aroma to the fruit. The pectic compounds are soluble in hot water but insoluble in cold, and solutions, therefore, solidify in the form of jellies on cooling. By the action of ferments which are present in the fruit, and also by prolonged boiling with water, the pectic compounds are changed into substances which are soluble in cold water and which do not, therefore, form jellies. This is what occurs when fruit becomes over ripe. In the process of making jam, therefore, it is advisable to select fruit that is barely ripe. Boiling completes the process by which pectic compounds are formed, destroys the ferments and evaporates off some of the water so that the product sets well on cooling. But if the fruit be too ripe to start with, or if the boiling be unduly prolonged, the pectic compounds are destroyed, and the jam will not set.

Fruits are preserved by drying, which either destroys the ferments or renders them inoperative. By abstraction of water, the proportions of all the nutrients are increased. Some of the dried fruits are highly concentrated foods, and have a fairly high nutritive ratio. Carbohydrates always predominate, and, in some cases, amount to about 75 per cent.; protein forms from 15 to 20 per cent. and fat from 2 to 4 per cent. of the edible matter. Dried fruits are used in puddings and in various other ways. If steeped for a few hours before using, they take up a considerable amount of water and are much improved in all respects. They are not so much esteemed for hygienic purposes as fresh fruits, but are an excellent substitute when the latter are unobtainable.

Honey may be regarded as a vegetable rather than an animal product inasmuch as it is collected rather than produced by bees. It is probable, however, that the saccharine substances undergo modification in the honey bags of the bees. These creatures certainly have the power of transforming sugar into wax. Honey consists mainly of a mixture of several different kinds of sugars, with smaller quantities of wax, gum, pollen, formic acid and other organic substances.

The flavour and odour of the honey depend largely upon the kind of flowers from which it has been collected. Bees fed on sugar or glucose produce large quantities of honey of very inferior quality. Glucose is used to adulterate honey and is sometimes substituted for it, either fraudulently, or avowedly under the name of artificial honey. Genuine honey should contain not more than 25 per cent. of water.

CHAPTER XI

PREPARED FOODS: PACKET GOODS, PATENT AND PROPRIETARY ARTICLES

> If then plain bread and milk will do the feat.
> The pleasure lies in you and not the meat.
>
> *Pope* ("*Satires*").

ALMOST every variety of cereal, pulse and farinaceous product is put up in packets and sold by various firms, either under their own or some registered fancy name. These goods are usually prepared from selected materials of fine quality. Many of them are mixed products derived from several sources, and they are often subjected to special processes of milling. Partly on this account, but perhaps more largely because the cost of the packets, packing and advertising must be borne by the consumer, packet goods are usually more expensive than similar products sold from bulk.

The distinction between packet goods and patent and proprietary articles is rather a fine one. The latter term is generally understood to refer more particularly to those foods which are, or are supposed to be, specially adapted to the requirements of infants and invalids, as regards their composition and digestibility. They are very numerous, diverse in character, and can only be briefly noticed here.

Patent and proprietary articles are relatively very expensive. In some cases, the prices are ridiculously out of proportion to the cost of production; but in others, the prices cannot be considered excessive when the methods of preparation and other circumstances are taken into account. The majority of those which have an established reputation are more or less suitable for their ostensible purposes.

Apart from meat preparations—which are suitable only for adults—infants' and invalids' foods are mostly derived from cereals, or from milk, or a mixture of the two. They may be classified according to the nature of the product and the treatment to which it has been subjected.

In cereal preparations, the grains are reduced to very fine flour, and all husks and bran are removed by repeated grinding and sifting. Some of them are disintegrated with water, cooked, dried, baked, and again ground. Others are merely well baked in the dry state. Baking destroys bacteria and fungi with which the grains are often infected, and converts some of the starch into dextrine. The last mentioned substance is soluble in water, and, therefore, easily assimilated. A large proportion of the starch, however, always remains unchanged. Several well-known foods belong to this type. Wheat is the cereal principally employed, but some contain an admixture of barley. Cane sugar, milk sugar, and dextrine are sometimes added to increase the amount of soluble carbohydrates. In certain cases, pulse flour and finely ground nuts are mixed with the cereals to increase the proportions of protein and fat.

Infants under the age of six months are unable to assimilate starch, and foods which contain a large proportion of that ingredient are, therefore, unsuitable for them. Small quantities of starch are probably harmless, provided the infant is not starved for lack of other nourishment, but in large amounts it may be positively injurious.

For this reason, a large number of the cereal foods intended for infants are prepared with malt, which promotes the digestion of starch.

Malt may be described simply as sprouted grain. It is usually made from barley, but other cereals may be used. To prepare it, the grain is soaked in water, and then piled in heaps till the seeds germinate, i.e. begin to grow. It is then dried, and the growths are removed. Malt, so prepared, contains a large proportion of diastase—a ferment closely resembling that of saliva—which in the presence of warm water converts starch into maltose and other soluble carbohydrates. The diastatic ferment is most active at temperatures of about 60° C.; its properties are permanently destroyed by boiling water.

The malted or predigested cereal foods contain active diastase mixed with the cereal flour, and the chemical change which the starch undergoes takes place when the food is in course of preparation for use. It is highly important, therefore, that the directions for the preparation of these foods should be followed exactly. In some malted foods, practically the whole of the starch is converted; in others, a larger or smaller proportion remains unchanged. The latter are intended chiefly for older children.

Malt extracts are prepared by grinding the malt to a coarse meal, and soaking in warm water. The solutions so obtained are usually concentrated to a thick syrup containing about 25 per cent. of water; in some cases they are desiccated. Besides the soluble carbohydrates of which they are chiefly composed, they contain a small amount of protein, and have, therefore, a certain nutritive value in themselves. They are chiefly used, however, in small quantities, to promote the digestion of starch in other foods taken at the same time.

By removal of the starch from wheat and other cereals, the protein can be obtained in a fairly pure state. A product of this kind, sold under the name of gluten flour, is used for making "gluten bread" for diabetics. A cheaper substance of the same kind, known as legumin or vegetable casein, is prepared from peas and beans. Other commercial varieties of vegetable protein are obtained from rape and other seeds, and are sold under various names.

The processes by which special milk foods are prepared are of two kinds, viz. those which affect the digestibility of the milk, and those which affect its composition.

Peptonized or predigested milk can be obtained commercially. There are many different brands. It is easily prepared at home by treating fresh milk with one of the peptonizing powders, of which several kinds are sold for the purpose.

The composition of milk may be modified (1) by altering the relative proportions of casein, albumen, fat and carbohydrates, e.g. the so-called "humanized milk" previously referred to (p. 96), and similar products of which there are many varieties on the market; (2) by concentration, e.g. condensed and desiccated milks; (3) by a combination of both methods.

Condensed milk is prepared by evaporating off a portion of the water. The process is carried out at a low temperature, under diminished pressure, in order to avoid coagulating the albumen and spoiling the taste of the milk.

The composition of the product depends upon the composition of the sample from which it is prepared, and upon the degree of concentration. Commonly, fresh whole milk is used, and is reduced to about half, or a third, of its original volume. The product therefore contains two or three times as much of all the nutrients as the original. A quantity of sugar is sometimes added. This product, called sweetened condensed milk, is sold at 5*d.* per tin; the unsweetened variety is sold at 4*d.*

Condensed skim milk can also be obtained; it is, of course, much cheaper. Sometimes a portion of the cream is fraudulently removed, but most of the well-known brands are fairly reliable in this respect.

Desiccated milk may be regarded simply as condensed milk from which practically the whole of the water has been expelled. It may be made from whole, skim, or partially defatted milk. Cow and Gates brand is sold in packets (equal to 3 pints of whole milk) at 8*d.* "Glaxo" and "lacvitum" are similar products; 1 lb. of the latter is said to be equal to about 6 pints of whole milk and costs about 1*s.* "Lacumen" is a desiccated skim milk. "Casumen" and "biogene" are similar but contain a certain amount of fat.

To save expense, skim-milk products are generally prepared by precipitation of the casein, a process which facilitates escape of the sugar. The casein may be rendered soluble by treatment with alkalis, as in "nutrose," "plasmon," etc., or by the action of ammonia, as in the so-called "eucasein." In "sanose," about a fifth of the protein consists of albumoses derived from white of egg, the remainder being milk casein. "Santogen" has about 5 per cent. of glycero-phosphate associated with the casein ; when mixed with cold water, it forms a milk-like emulsion.

These preparations are recommended for diabetic and rheumatic invalids, on the ground that they are free from carbohydrates and purin bodies. For persons in health, they should be used along with starchy and fatty substances, but fresh foods are better if they can be obtained.

Most of the purely cereal foods, whether malted or otherwise, are designed to be used along with fresh milk. This fact should be kept in mind when their composition is compared with that of the mixed foods, i.e. those which contain the constituents of milk mixed with cereal flours. Mixed foods are usually malted to promote digestion of the starch, and in many, the protein is peptonized as well.

Benger's food differs in some respects from those previously described. It is purely a cereal preparation, intended to be used with milk ; but it is impregnated with both diastatic and tryptic ferments ; the former acts on the starch of the cereal and the latter peptonizes the casein of the milk which is added in the course of preparation for use.

The composition of some of the well-known brands is given in appendix C. (p. 174). The figures are in most cases those supplied by the makers. It is obvious, however, that chemical analysis, by itself, affords but little information regarding the character of these foods.

Meat preparations are of several different kinds. They may be classified as Extracts, Peptones, dried meat powders, and fresh meat pastes.

A distinction is commonly drawn between hot and cold water extracts of meat. The former are known as meat tea or essences, and the latter as meat juice, but they are often very similar in composition. The most important constituent of both is the nitrogenous extractives or meat bases as they are called. The nutritive value of these substances is doubtful (p. 37), but they are more or less powerful stimulants and are useful for certain purposes.

The extracts, if made with cold water, contain also a certain amount of soluble albumen, but very little gelatin. If hot water be employed, the soluble albumen is coagulated, but the proportion of gelatin is greatly increased.

To prepare an extract, the meat, after removal of the fat and unedible matter, is chopped very fine and covered with water, to which a little salt is added, and allowed to stand for three or four hours ; the liquid is then strained off with pressure. This preparation cannot be kept for any length of time as it decomposes very rapidly. It exhibits the colour, taste and odour of blood, and is very disagreeable to sensitive people. A commercial product of similar nature and properties is obtained by expressing the juice from the meat in powerful hydraulic presses. The fluid so obtained is then concentrated, and as this has to be done under diminished pressure, to avoid coagulating the albumen, these products are very expensive.

To prepare meat tea, the initial procedure is the same as for the cold water extract, but the liquid is gradually warmed to about 75° C., and in some cases ultimately to boiling. Commercial products of this kind are always concentrated, and a certain amount of insoluble protein is generally added in the form of meat fibre which greatly increases their nutritive value. They are prepared for use by diluting with hot water. As they are concentrated by boiling, they are much cheaper than the so-called meat juices, and can be kept indefinitely without preservatives, but they decompose rapidly when once the bottles are opened. They are usually of a brown gravy colour, and possess the appetizing smell and flavour of meat.

The so-called peptones are simply predigested meats, intended chiefly for invalids suffering from stomach troubles. Some of them are liquids containing over 80 per cent. of water, and others are solids containing little or none. The degree of peptonization in the different brands is equally variable, and they contain the peptones and extractives in very different proportions.

Meat powders should be made from fresh meat lightly boiled, and then dried at a low temperature until it is brittle enough to be ground up fine. Like the dried milk products, they are chiefly valuable for convenience of transport, but they are more expensive than the latter. Some of them are compressed into the form of lozenges or tablets. Some varieties are said to be made from the residues remaining after preparation of meat extracts or meat juices.

Meat pastes or potted meats are simply finely shredded cooked meat, and, if pure, they have the characteristics of the meat from which they are prepared. Very often two or more kinds of meat are mixed together, and they are usually highly salted and spiced. In some, a certain amount of fat is introduced, either in clots or diffused. Not infrequently a considerable proportion of bread, or other starchy matter, is added. This may improve the taste; it certainly increases the bulk, and ought, therefore, to reduce the price.

Gelatin is a nitrogenous substance allied to protein, but it is not a true proteid; it lacks the element sulphur, and differs in other respects (p. 37). It is obtained commercially by boiling bones and other products. It is soluble in hot water, but not in cold; a hot solution, therefore, solidifies or "sets" in the form of a jelly on cooling, if it contain even so little as 1 per cent. of gelatin.

Stock or soup which forms a jelly on cooling is commonly regarded as very rich, but such is not necessarily the case. If made by gently stewing meat at a temperature below 70° C. it might contain a large proportion of meat bases, but not enough gelatin to cause it to solidify. On the other hand, stock made by boiling bones may contain enough gelatin to cause it to solidify on cooling, and but little of the more valuable extractives.

On prolonged boiling, gelatin undergoes a change and loses the power of gelatinizing, which is its most important property. Gelatin is sold in thin plates which consist of practically the pure substance plus about 10 or 15 per cent. of water. The price is about 1*s*. 6*d*. per lb.

Table jellies are made by dissolving gelatin in hot water—about 1 oz. of gelatin to a quart of water—and adding various colours and flavouring essences. Such jellies can be obtained commercially in a condensed form, i.e. containing a smaller proportion of water. They are prepared for use by merely dissolving the contents of the packets in a stated quantity of hot water and allowing the solution to cool.

Of the various brands of egg and custard powders now on the market, some are undoubtedly genuine, i.e. they are merely desiccated eggs. The great majority, however, are not represented as such, but as egg substitutes; and it is obvious from the prices at which most of these goods are sold, that they cannot have been prepared from eggs. As a rule, they consist mainly of starch, mixed with a certain amount of protein derived from skim milk, and contain little or no fat. Some of them are practically destitute of nitrogenous matter, and are merely mixtures of starch and baking powders in various proportions, with some yellow dye or colouring matter.

The composition of the commoner varieties of all these products is given in the appendix (p. 177).

CHAPTER XII

SPICES, CONDIMENTS AND MISCELLANEOUS ARTICLES

> I must have saffron to colour the warden pies; mace; dates ?—none, that's out of my note; nutmegs, seven; a race or two of ginger, but that I may beg; four pound of prunes, and as many of raisins o' the sun.
>
> *The Winter's Tale.*

THE substances described in this chapter are not regarded as foods, but merely as seasoning. They are mixed with various foods, but only small quantities are used, and they have no direct nutritive functions. They are valued chiefly for their appetizing qualities. A full account of these articles would occupy much space; a few examples only may be briefly noticed. The distinction commonly drawn between spices and condiments is purely conventional.

The spices are all vegetable products, derived from various species of tropical plants. They consist of the fruit, stems, roots or other parts. They are dried, or otherwise prepared, before being put on the market. They are composed mainly of cellulose, starch, fat and protein, but differ widely in regard to the proportions of these ingredients. By far the most important constituents, however, are the volatile oils, tannins and resinous substances to which they chiefly owe their aromatic properties.

The volatile or essential oils usually consist of ethers, aldehydes and terpene hydrocarbons. Some of them are complex mixtures of uncertain composition. The proportion of volatile oil is usually small; in cloves it varies from 10 to 20 per cent.; in most others, it rarely exceeds 3 or 4 per cent.; and in some, e.g. cinnamon, about 1 per cent. is common. The loss of a comparatively small amount of this important constituent, therefore, greatly reduces the pungency of the spices; and most of them rapidly deteriorate—losing flavour and aroma—on keeping, owing to evaporation of the volatile oils. Ground spices are, naturally, more largely affected in this way than those in the whole state.

Ground spices are very easily adulterated with cereal starches, nutshells, ground bark, sawdust and other worthless materials which resemble the spices in appearance and composition. The presence of such foreign ingredients is easily distinguished under the microscope. The abstraction of a portion of the volatile oil or admixture of a quantity of the spice which has been completely exhausted of this constituent is not so easily detected. This is by far the commonest form of fraud. It is applicable to whole as well as to ground samples, and it can only be determined by chemical analysis. The high price which spices command makes adulteration very profitable.

Nutmegs and mace are both obtained from the fruit of the nutmeg tree. The former are the kernels, and the latter the fleshy-fibrous covering which surrounds them. The aromatic principles of the two spices are much alike, but mace contains nearly twice as much volatile oil as nutmegs.

Pimento or allspice, is the dried fruit of a plant which belongs to the myrtle family. The essential oil is concentrated in the excrescences with which the berries are covered, but the spice is usually retailed in the powdered condition. It is fairly cheap, but not very pungent.

The clove tree also belongs to the myrtle family. Cloves are the undeveloped flower buds. They are plucked green, and when dried in the sun, they assume the well known dark brown colour and develop their characteristic flavour and aroma.

Cinnamon is the inner bark of the cinnamon tree—a species of laurel, extensively cultivated in Ceylon. The cylindrical form, in which it is usually placed on the market, is produced by rolling the bark before it is dried. Much of the bark sold as cinnamon is really cassia—another plant of the same species. The latter is usually thicker and coarser than the cinnamon of Ceylon, but in other respects they are very similar, and the substitution is not regarded as fraud.

Ginger is the root of a herbaceous annual. When the plant withers, after a year's growth, the root is dug up and dried. The irregularly branched fragments form the black or whole ginger of commerce. The white variety is produced by scraping off the epidermis; the inner part of the root is then bleached. The exterior portion thus removed contains a considerable quantity of resinous matter, and the decorticated variety is, therefore, not so strongly aromatic as the black or whole ginger. For the preparation of preserved ginger, the root is softened in boiling water and then saturated with sugar.

The flavouring essences of commerce are not, as might be supposed, pure essential oils, but dilute alcoholic solutions of the same, or, more commonly, alcoholic extracts of the spices from which they are derived. It is the exhausted residues from these processes that are used to adulterate the spices in the manner described above. They are frequently adulterated in various ways, e.g. by diluting or reducing the strength of the extract, by addition or substitution of an extract of some similar but cheaper commodity, or by addition or substitution of artificially prepared compounds, ethers, etc., which possess the characteristic flavour of the essence. The last mentioned substances are much cheaper, and are extensively used for flavouring sweets, and aerated waters. Most of the so-called fruit essences are of this kind. They are, however, usually described as "artificial," and not fraudulently substituted for genuine essences.

Vanilla essence is the extract prepared from the vanilla bean, the fruit of a tropical plant belonging to the orchid family. It contains about 40 per cent. of alcohol, 20 per cent. of added cane sugar, and rarely more than about 0·2 per cent. of vanillin, the principle to which it chiefly owes its peculiar flavour and odour.

Essence of almonds is an alcoholic solution of the oil of bitter almonds. To prepare the oil, the fixed fat is first removed by pressure (p. 114) and the crushed seeds are then distilled with water. The volatile oil contains a quantity of the highly poisonous prussic acid [1] which must be removed. The purified product consists of benzaldehyde; [1] it is commonly known as oil of bitter almonds,

[1] The benzaldehyde and prussic acid are both formed,

though generally prepared from apricot and peach stones. The commercial essence contains about 1 per cent. of this substance, a quantity which imparts a very strong almond flavour and odour.

Essence of lemon is an alcoholic solution of the oil of lemon, of which it should contain at least 5 per cent. The oil is obtained from the rind by pressure, or by treatment with hot water. The essence is coloured with the extract from the peel, but turmeric and other dyes are occasionally used. Essence of lemon is, perhaps, more extensively used for domestic purposes than any other flavouring. Some of the cheaper qualities contain much less than 5 per cent. of lemon oil.

The condiments commonly used at the table are, salt, pepper, mustard, vinegar and ketchup. They are necessarily very familiar, and need but little description.

Common salt is a mineral substance known to chemists as sodium chloride. It is sold in a nearly pure state, and, being very cheap, is rarely adulterated. A certain amount of it is necessary for physiological purposes, as well as for its savour. Excessive quantities, however, retard digestion (p. 20), and are otherwise deleterious. The quantities commonly used are much larger than are actually required.

Peppercorns are the dried fruit of the pepper plant, several varieties of which are grown in

during the process of distillation, by decomposition of the glucoside amygdalin which is present in the bitter almonds, thus—

$$\underset{\text{Amygdalin}}{C_{20}H_{27}O_{11}N} + {}_2H_2O = \underset{\text{benzaldehyde}}{C_7H_6O} + \underset{\text{prussic acid}}{HCN} + \underset{\text{glucose}}{{}_2C_6H_{12}O_6}.$$

different localities. When the berries are dried, the outer skin becomes black and shrivelled. This product is known as black pepper in contradistinction to the white pepper which is produced by soaking the berries in water and removing the husk when softened. Both black and white pepper are sold in the ground as well as in the whole condition. Ground black pepper is sometimes adulterated with the powdered husks of peppercorns. Ground olive stones, starches and other substances have also been used. The piquant taste of pepper is due to the volatile oil—a hydrocarbon—a peculiar acrid resin, and a neutral principle called piperin. Cayenne pepper is the ground dried pods of *Capsicum*, an entirely different plant, which belongs to the nightshade family.

Mustard is prepared from the dried seeds of the mustard plant of which there are two common varieties, known as black and white mustard respectively. Both varieties grow well in this country, and are extensively cultivated in the eastern counties. The seeds are merely ground to a fine powder and sifted to remove the refuse or dressings. Starch is not a constituent of mustard seed, but is occasionally added as an adulterant, turmeric being used to colour it. Genuine samples contain from 33 to 37 per cent. of fixed oil, but usually less than 1 per cent. of volatile oil [1]—the principle to which mustard owes its characteristic odour and irritant action.

Vinegar has been defined as soured wine and that, no doubt, is the source from which it was first obtained. The souring is due to oxidation of the alcohol, which is thereby converted into acetic

[1] Allyl isothyocyanate C_3H_5CNS.

acid. The term vinegar might, therefore, be applied as appropriately to soured beer or cider. As a matter of fact it has been applied to these and other similar products. The vinegar chiefly used in this country is known as malt vinegar. It is brewed in much the same manner as ordinary beer, but without the addition of hops. The malt is mashed and the wort is fermented with yeast. It is then allowed to flow over piles of birch twigs, or wood shavings, which are coated with a growth of a fungus, called the vinegar plant, because it induces the acetic fermentation. Practically the whole of the alcohol is converted into acetic acid, but traces remain—or are added—and gradually combine with the acid forming ether, which greatly improves the flavour. It is chiefly for this reason that the vinegar is stored for several months before being sold. White or distilled vinegar is prepared from this brown vinegar by distillation. Genuine vinegar of good quality contains from 5 to 6 per cent. of acetic acid, but it is sold at different strengths, and the cheaper qualities are more dilute. The alcoholic liquors produced by fermentation of glucose, molasses, etc., may also be subjected to acetic fermentation, but the products have not the properties of malt vinegar. Acetic acid can be artificially prepared, and it can also be obtained very cheaply by destructive distillation of wood. This product is sometimes used to adulterate genuine vinegar, or diluted with water and fraudulently substituted for the latter. It is also sold under the name of wood vinegar.

Saccharin is not usually described either as a condiment or a spice, though it is sometimes used to flavour foods. It has an intensely sweet taste estimated at from 300 to 500 times as sweet as that of cane sugar. Comparatively small quantities may, therefore, be used, and it is much appreciated by diabetics and others to whom the use of sugars is forbidden. It is a coal-tar[1] product, and has no nutritive value whatever.

Yeast is a kind of fungus, i.e. a plant or vegetable organism. It consists of minute cells which are not, singly, visible to the naked eye. When put

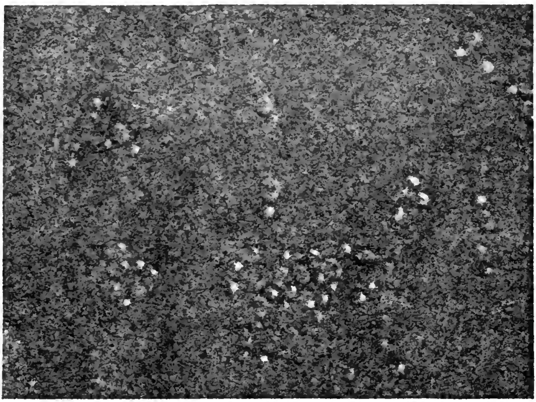


FIG. 10. YEAST CELLS.
(Magnified 200)

into beer worts, or other suitable medium, the cells sprout and produce buds which soon split off, forming new cells, and the process is repeated indefinitely. At a suitable temperature the multiplication of the cells takes place very rapidly. The growth of the yeast is accompanied by chemical changes in the wort or medium. Sugar is split up

[1] Benzoyl sulphimide ($C_6H_4.CO.SO_2.NH$).

into alcohol and carbonic acid gas; the process is called alcoholic fermentation. The yeast floats on the surface of the liquor; it can be skimmed off when its work is done, and used over again. The quantity of yeast increases each time it is used in this way, and the brewers are usually glad to sell some of it.

The action of yeast in bread making is of a similar kind. The yeast is mixed with the dough, and allowed to stand at a suitable temperature. Fermentation sets in and carbonic acid gas is produced. The tiny bubbles of gas, which remain entangled in the dough, expand greatly on the application of heat and cause the bread to "rise." If the fermentation be too long continued, or if the yeast be not pure, lactic acid may be formed, and the bread will be sour. The activity of the yeast is destroyed, and the process arrested, by the high temperature to which it is exposed when the bread is baked.

To facilitate distribution, yeast is put up in packets in the dry form. The yeast, after being separated from impurities and washed with water, is mixed with starch. A stiff dough is thus formed which can be moulded into cakes and dried at a low temperature. Sometimes the starch is dispensed with, the pure yeast being simply moulded into cakes by pressure. If kept in a cool place, these dry yeasts remain fresh and active for a long time.

The action of baking powders, which are sometimes used instead of yeast to "raise" bread and cakes, also depends upon the formation of carbonic acid gas. In this case, however, the gas is formed, not by the action of the powder on the carbohydrates of the flour, but by the inter-action of the ingredients of the powder itself. Two things, therefore, are essential, viz. a carbonate and an acid to act upon it. The former almost invariably consists of bicarbonate of soda. This substance has consequently been called "baking soda"; it is familiar to most housekeepers under that name.

Sour milk is sometimes used to supply the acid.[1] The dry baking powder is mixed with the flour, and when the sour milk is added carbonic acid gas is formed. This plan is, however, open to the very serious objection that it is impossible to tell exactly what quantities of baking soda and sour milk should be used. If any of the former remains unacted upon by the acid of the milk, it imparts a very disagreeable flavour to the bread. Generally, the older the milk the more acid it contains, and, therefore, the better it will act; but if it be too old, it becomes rancid,[2] and acquires a strong taste.

It is better, therefore, to use some dry acid, which can be mixed with the baking soda in properly adjusted proportions, i.e. so that none of either remains when the action is over. Tartaric acid, or cream of tartar, is, perhaps, the best; but alum or acid phosphate of lime are sometimes employed.

Both baking soda and tartaric acid are crystalline powders. They may be mixed together and will remain unchanged so long as the mixture is kept perfectly dry. But if the mixture be moistened

[1] Sour milk contains lactic acid.

[2] This due to the formation of a substance called butyric acid.

with water the two substances act upon each other, and carbonic acid gas is formed as a result of the chemical[1] change. Cream of tartar acts in an almost exactly similar manner.

Such baking powders may be conveniently prepared at home by simply mixing the ingredients in the proportion of 6 parts of baking soda to 5 parts of tartaric acid or 13½ parts of cream of tartar. The separate substances should be first dried in the oven for an hour at a low temperature, and then well ground in a mortar. The mixture, if exposed to the air, attracts moisture, and must be kept in a tightly corked bottle. Baking powder which has been allowed to become moist is useless. It forms lumps and does not act properly. To avoid this, commercial baking powders are generally mixed with starch, in addition to the constituents mentioned above. A smaller amount of carbonic acid is, therefore, produced from a given quantity of the mixture, and a slightly larger quantity of it must be used to produce the same effect. The proportion of starch is usually about 10 per cent., but it is sometimes much larger.

Rennet is a fluid prepared from the membrane or lining of the fourth stomach of a calf. Its composition is complex and not well understood, but the essential constituent is a ferment which causes the casein of milk to curdle. It is used for this purpose in the manufacture of cheese (p. 99) and also in the preparation of junket. The ferment is

[1] The chemical change may be represented by the following equation—

$$\underset{\text{Sod. bicarb}}{2NaHCO_3} + \underset{\text{Tartaric Acid}}{H_2C_4H_4O_6} = \underset{\text{Sod. tartrate}}{Na_2C_4H_4O_6} + \underset{\text{Water}}{2H_2O} + \underset{\text{Carbonic acid}}{2CO_2}.$$

most active at a temperature of about 90° F. If allowed to act too long, changes similar to those involved in the digestion of protein set in, and the curd acquires a very disagreeable flavour.

CHAPTER XIII

EFFECTS OF COOKING FOOD

One of the privileges of the human species is that of drinking without being thirsty. In the present state of the culinary art, cooks make us eat without being hungry.

Physiologie du Goût.

The term cooking is generally understood to include all the processes by which food, as purchased retail, is prepared for the table; but it is also used in a narrower sense with reference merely to the changes produced in the food by the application of heat.

Heat may be applied either by the wet or by the dry method. The former includes all processes —boiling, stewing, steaming, etc.—in which the food is "sodden with water"; the latter, all processes—broiling, baking, frying, etc.—in which it is "roast with fire."

All kinds of flesh foods, poultry, fish, and some vegetables may be cooked by either method. The fatter and more tender kinds of meat are usually roasted; the tougher and leaner kinds, and most vegetable products, are more commonly cooked in or with water.

The principal object of cooking is to improve the flavour of the food and stimulate the appetite by the odours which are given off. There are, however, other effects of considerable importance which must be briefly considered.

Cooking sterilizes the food. It, therefore, tends to preserve it from decomposition, and to destroy pathogenic forms which might otherwise set up diseases of various kinds. Spores of tubercle and other bacteria have been found in meats cooked in the ordinary ways, but such cases are probably exceptional. At all events, cooking greatly diminishes the risk.

The effect of cooking on the digestibility of meat is uncertain. According to some authorities, moderately cooked meat remains longer in the stomach than raw meat in a similar condition (p. 23). This, however, is doubtful, and it is probable that they are ultimately assimilated to a nearly equal extent by persons in health. Cooked meat, however, is much more easily masticated than similar meat in a raw state, and this fact probably has a much greater influence on the digestibility than any changes due to the processes of cooking.

When meat is cooked by any of the ordinary methods, it loses from 10 to 50 per cent. of its original weight. The loss always consists mainly of water, but both protein and fat are also involved to a greater or less extent.

The proteids are coagulated (p. 28) by heat; but some part—usually only a small proportion—undergoes chemical changes by which gelatin, nitrogenous extractives and other substances are produced. These changes are very complex and obscure, but it is evident that they must tend to reduce the nutritive value of the food, even if the products be collected and consumed.

The fat is melted by heat and, as is well known, its consistency is changed. A part of it—usually a considerable amount—escapes from the meat in the process, but this may be collected and consumed, and its nutritive value is not appreciably altered.

It is only within recent years that the loss due to cooking meat in various ways has been carefully investigated, and much work still remains to be done in this direction.

In Grindley's [1] experiments it was found that when meat is cooked in water at 80° to 85° C., placing the meat in hot or cold water at the start has very little effect upon the amount of material found in the broth. A contrary opinion is very generally entertained by cooks. It is supposed that when meat is plunged into boiling water the protein at the exterior is immediately coagulated, and that this hinders the escape of the juices. This procedure is, therefore, usually adopted when the meat is to be eaten and the broth rejected. When it is desired to extract as much as possible from the meat, e.g. in making soup, the meat is usually "put on" with cold water and the temperature is gradually raised.

In ninety tests, the average loss of protein was 7·25 per cent. The greatest loss, 12·67 per cent., occurred when the meat was cut into small cubes and cooked for a very long time. The smallest loss was 3·25 per cent.; this was from a large piece of very fat meat cooked for a little over two hours.

The loss of fat varied from 0·6 to 37·4 per cent., the average being 11·7 per cent. The smallest loss was noted when the meat was cooked at a low temperature, 65° to 70° C. for five and a half hours.

[1] *Bul. No.* 141. U.S. Dept. of Ag.

The greatest loss of fat took place when the meat was cooked in boiling water for ten minutes and then for three hours at 80° to 85° C. The loss of fat appears to depend largely upon the kind of fat, and only to a small extent upon the quantity present.

In the roasting experiments, the meat was generally cooked for fifteen minutes at about 250° C., and afterwards at 190° C. for various lengths of time. The total loss of weight was less than in any other method of cooking, but it included a larger proportion of fat.

The loss of fat varied from 4·53 to 57·49 per cent. and averaged 34·27, or nearly three times as much as in the boiling experiments.

The loss of nitrogenous matter varied from 0·25 to 4·55 per cent., the average being 1·97 per cent., or less than half that due to boiling.

The greatest losses occurred when the meat was roasted at high temperatures.

It was also found that, whatever the method of cooking, the loss was greater the longer the process was continued ; but, other things being equal, the larger pieces of meat lost relatively less than the smaller pieces. Marked differences were, however, observed, not only as between different kinds of meat, but also between different cuts of the same kind.

The presence of carbohydrates in vegetables introduces another factor for consideration in regard to these products. When vegetables are cooked in water, the cellulose absorbs water, and becomes much softer and more easily masticated, but it remains, in most cases, practically indigestible. The cell walls, however, are ruptured and the contents are thus exposed to the action of the water used in cooking. Starch granules swell up and are deformed (p. 32), and are thus rendered more digestible.

The whole of the nutrients in vegetables, however, are not always enclosed in the cells. A variable, but sometimes large proportion exists in solution in the juice, if any be present. This applies not only to the non-proteid nitrogenous substances—sometimes as much as half the total nitrogen is present in this form—but also to some of the true albuminoids, sugars, and, possibly, certain mucilaginous products.

A large proportion of these soluble substances is liable to be lost when the vegetables are cooked in water, and generally no attempt is made to recover it. Coagulation of the soluble protein by the heat tends to diminish the loss of that constituent, if it be not first extracted by cold water, but the sugars are not protected in any way. In some cases, even the starch, though insoluble, suffers a certain amount of loss mechanically.

It is obvious, therefore, that the loss of nutrients will be increased by cutting the vegetables into small pieces, and by soaking them in cold water before cooking. In the case of potatoes, turnips and similar products, the loss might be greatly diminished by cooking them whole with the skins on, but, as a rule, this method is not practicable.

These conclusions are confirmed by the experiments of Snyder,[1] Frisby and Bryant. They found that when potatoes were peeled, cut into pieces in the usual way, and soaked in cold water before

[1] *Bul* 43. U.S. Dept. of Ag.

boiling, about half the total nitrogen—including about a quarter of the true albuminoids—was lost. When put into cold water and cooked at once, only about a sixth of the total nitrogen—including a twelfth part of the true albuminoids—was lost. When the potatoes were put, at once, into boiling water, the loss was only about half the amount recorded in the last case; but, for some reason, this method is not suitable for some kinds of potatoes, as they "go to smash" if so treated. The loss from potatoes boiled in their skins was quite inconsiderable, being less than 1 per cent. of the total nitrogen.

In boiling carrots which had been scraped and cut into pieces, the amount of the loss was found to depend almost entirely upon the size of the pieces. Small pieces lost about 40 per cent. of the total nitrogen and 26 per cent. of the sugar. With large pieces, the loss of nitrogen was about 20 per cent. and of sugar 15 per cent.

The loss on cooking cabbages was very great. Under the most favourable conditions, it amounted to 30 or 40 per cent. of the dry matter and included about a third each of the total nitrogen and carbohydrates. The loss of nitrogen was chiefly non-proteid, only from 5 to 10 per cent. of true albuminoids being extracted.

In other experiments, onions and turnips lost over 80 per cent. of the carbohydrates on boiling.

In making soups, the constituents extracted by boiling water are, of course, not lost.

The loss from vegetables cooked by steaming is much smaller.

CHAPTER XIV

THE RELATIVE VALUE OF FOODS

> Utility is not the measure of exchangeable value, though it is absolutely essential to it.
>
> *Ricardo.*

It is clear from what has been said in previous chapters that there is very little connexion between the market prices of foods and their nutritive values. The former are regulated by the laws of supply and demand. The latter depend mainly upon the amounts of nutrients—protein, fat and carbohydrates—that the foods contain.

It is true, in general, that those kinds of food which contain the largest amounts of nutrients are in greater demand, and are, therefore, dearer; but it is quite wrong to suppose that the more expensive kinds of food necessarily, or even generally, contain more nutritive matters than the cheaper forms.

Questions of pecuniary economy cannot, therefore, be determined by consideration, either of the price alone or of the composition alone. Comparisons of the prices of foods, without reference to their composition, are meaningless. To compare the composition of foods apart from the prices is beside the question.

What is required is some method by which we could tell how much any given food is worth, compared with any other of which the price is known, e.g. if milk be worth 4*d.* per quart how many eggs should one get for a shilling? This problem cannot, of course, be solved by "rule of three," and its meaning is obscured by the fact that it is stated as if it might be. What the question really implies is this—if all the nutrients in a quart of milk be valued at 4*d.*, and if the nutrients of eggs be valued at the same rates, how much of the latter would correspond to a given sum of money.

The nutrients of milk consist of protein, fat and carbohydrates; those of eggs consist of protein and fat only. The protein and fat are not present in the same actual or relative proportions in the two foods. In order to solve the problem, therefore, it is necessary to assign values to each of the several nutrients in the milk; and these values must be such that, when they are multiplied by the percentages of the nutrients and the products are added together, the total will amount to 4*d.* If the same values be now multiplied by the percentages of the corresponding nutrients in the eggs and the products added together, the result will show how much the eggs are worth compared with milk, weight[1] for weight. This result, it will be seen, does not correspond with the *price* of the eggs, which is not under consideration. It may be called the *relative value* of the eggs, compared with milk.

It is a very difficult matter to decide exactly what values should be assigned to the several nutrients in a complex substance like milk. It is, however, comparatively simple in the case of those foods which contain only one nutrient, and a primary

[1] The weight of a quart of milk is about 2·5 lb.

indication of the values for other cases is thus obtained.

For example, the price of sugar is about 2*d.* per lb. The substance is practically pure, i.e. it contains 100 per cent. of the carbohydrate. The value of 1 per cent. is, therefore, $\frac{2}{100} = 0{\cdot}02$; and that of any food which contains, say 50 per cent. of sugar, $0{\cdot}02 \times 50 = 1d.$ per lb. In like manner, the value of the sugar in milk, which contains about 5 per cent. of that ingredient, will be $0{\cdot}02 \times 5 = 0{\cdot}1d.$ per lb. of milk.

The fats may be evaluated in a similar manner. Beef suet costs about 8*d.* per lb., and contains about 80 per cent. of fat. The value of 1 per cent. will therefore, be $\frac{8}{80} = 0{\cdot}1$, i.e. five times as much as in the case of carbohydrates.[1] Calculating with this factor, we get $0{\cdot}1 \times 3{\cdot}5 = 0{\cdot}35d.$ as the value of the fat in milk, per lb.

The value of the protein is not so easily determined. None of the ordinary foods consist of pure protein or contain that substance only. Lean beef, e.g. the round, however, contains a large proportion of protein and a comparatively small proportion of fat; and if the value of the latter be known, or can be determined, it can be eliminated and the value of the protein thus, approximately, ascertained. Assuming that the beef (round) costs 8*d.* per lb., and that it contains 20 per cent. protein and 10 per cent. of fat; the value of the latter may be estimated as before—$0{\cdot}1 \times 10 = 1d.$ per lb. of beef; deducting this from the price of the total we have $8 - 1 = 7d.$ as the value of the protein, of which there is 20

[1] This statement refers to the pecuniary value only. The nutritive value of fat is only 2·27 times that of the carbohydrates (see p. 36).

per cent. The value of 1 per cent. will, therefore, be $\frac{7}{20} = 0{\cdot}35$, i.e. 17·5 times as much as the carbohydrates. Calculating with this factor, we get $0{\cdot}34 \times 3{\cdot}5 = 1{\cdot}22$*d.* as the value of the protein in the milk, per lb.

The sum of the values of the several constituents, calculated as above, it will be seen, amounts to 1·67 pence per lb. of milk, or 4·17 pence per quart (2·5 lb.), whereas it should have been exactly fourpence. It must be understood, however, that the data were given merely to illustrate the method, not as final conclusions, and the factors are, therefore, subject to revision.

By the hypothesis, the differences in the prices of the foods imply that the same values cannot be assigned to the nutrients in each case. For example, the price of mutton suet is only about 5*d.* per lb.; on the other hand that of several of the vegetable oils is considerably higher. It is obvious that if the calculation had been based on any of these, a different factor for fat would have been obtained. In like manner, by selecting other foods, different factors might have been obtained for the protein and carbohydrates.

For the present purpose, i.e. in order to determine the relative values of foods, it is not necessary to decide exactly what values should be assigned to each nutrient. It is only necessary to assume that they bear the same relation to each other in all cases,[1] and to determine what that relation is.

[1] In some vegetables, e.g. turnips, the total nitrogen is not all present as true proteid, and in others there may be differences in the relative digestibility of the nutrients; these cases require special consideration, but do not necessarily invalidate the assumption.

In the case cited above the factors were 0·02 for carbohydrates, 0·1 for fat and 0·35 for protein. These factors stand to each other in the relation of 1, 5, and 17·5 ; but, it has been said, they are subject to revision, and the author has come to the conclusion, after examining a large number of cases, that the relation of 1, 4, and 20 more nearly represents the truth.

The relative value of foods may then be worked out according to the formula :—

$$V = \frac{20P_2 + 4F_2 + C_2}{20P_1 + 4F_1 + C_1}$$

V, is the relative value ; P_1, F_1 and C_1 are respectively the percentages of protein, fat and carbohydrates in any food of which the value is to be taken as unity ; and P_2, F_2 and C_2 are respectively the percentages of protein, fat and carbohydrates in any other food.

The formula may be used as a concise definition of the term relative value.

Sometimes, in order to get rid of fractions, it may be convenient to multiply the relative values by 100 and then take the nearest whole number.

For the purpose of illustration, the formula may be applied to determine the relative value of eggs compared with milk. These foods contain the following proportions of nutrients :—

	Protein.	Fat.	Carbohydrates.
Milk	3·5 ..	3·6 ..	4·9 per cent.
Eggs	13·1 ..	9·3 ..	— ,,

$$V = \frac{(13{\cdot}1 \times 20) + (9{\cdot}3 \times 4)}{(3{\cdot}5 \times 20) + (3{\cdot}6 \times 4) + 4{\cdot}9} = \frac{262{\cdot}0 + 37{\cdot}2}{70{\cdot}0 + 14{\cdot}4 + 4{\cdot}9} = \frac{3{\cdot}32}{1} \text{ or } \frac{332}{100}$$

The relative value of eggs, compared with milk as unity, is, therefore, 3·32; or, if 1 lb. of milk be worth 100, 1 lb. of eggs is worth 332.

To the housekeeper, this statement may acquire more definite meaning if translated into terms of pence. This may be easily done as follows :—

If 1 lb. of milk be worth 1, 1 lb. of eggs is worth 3·32; therefore, if 1 lb. of milk be worth 1·6 pence (4*d.* per quart), 1 lb. of eggs is worth $1·6 \times 3·32 = 5·3$ pence; or, assuming 9 eggs to the lb., they are worth 7*d.* per dozen, i.e., about 20 for a shilling.

It will be seen that the arithmetical process consists merely in multiplying the relative value of the eggs (3·32) by the price per lb. of the milk. Thus, if the milk were put at 3*d.* per quart (1·2*d.* per lb.), the eggs would be worth $3·32 \times 1·2 =$ 4*d.* per lb., or about 5¼*d.* per dozen.

A few further examples may be given. If it be desired to compare, say beef and bread respectively with milk and with each other, the composition of the foods must be looked up in the appendix. The percentages of the nutrients must then be multiplied by the coefficients given in the formula. Thus we have, for beef round, $19 \times 20 + 12·8 \times 4 = 431·2$; and for bread, $9·2 \times 20 + 1·3 \times 4 + 53·1 = 242·3$. The numbers 431·2 and 242·3 (i.e. the sum of the percentages multiplied by their respective coefficients) may be called the *number of units of value.* To find the relative values of the foods, compared with milk, these numbers are divided by the number of units of value in the milk, viz., 89·3, thus :—

$$\frac{431·2}{89·3} = \frac{483}{100} \qquad \frac{242·3}{89·3} = \frac{271}{100}$$

If it be desired to compare, say beef and milk respectively with bread as 100, we have—

$$\frac{431 \cdot 2}{242 \cdot 3} = \frac{177}{100} \qquad \frac{89 \cdot 3}{242 \cdot 3} = \frac{37}{100}$$

Translated into terms of pence as before, the results may be stated in tabular form as follows :—

Assumed Price of	Corresponding Value of	
Meat. 10*d*. per lb. 8*d*. ,,	Milk. 5¼*d*. per quart 4¼*d*. ,,	Bread. 5½*d*. per lb. 4½*d*. ,,
Milk. 4*d*. per quart 3*d*. ,,	Bread. 4⅓*d*. per lb. 3¼*d*. ,,	Meat. 7¾*d*. per lb. 5¾*d*. ,,
Bread. 2*d*. per lb. 1½*d*. ,,	Meat. 3½*d*. per lb. 2½*d*. ,,	Milk. 1¾*d*. per quart 1⅖*d*. ,,

The relative values of the common articles of diet have been calculated, by the method described, with reference to beef round, milk and bread respectively. The results are given in the tables, appendix F (p. 178 *et seq.*).

The results are also given in the form of pence per lb., for convenience of comparison with the average market prices. For this purpose animal products are compared with beef round at 8*d*. per lb. and vegetable products with bread at 1½*d*. If vegetable products, e.g. bread, oatmeal, beans, etc., be compared with beef at 8*d*. per lb., the results will be found to be three or four times greater than the market prices of these commodities. This, of course, is only another way of saying that, for an equivalent amount of nutrients, these products are much cheaper than beef and animal foods generally.

These results have been calculated to the nearest farthing. This tends, in some cases, to exaggerate small differences in the relative values, and in others it obscures them. Results expressed in this form (pence per lb.) are not, therefore, so satisfactory.

Nothing has been allowed for the bones in calculating the relative values of meat. In the case of legs, ribs and other pieces of meat which contain bone, the difference between the calculated and the market prices is partly attributable to this cause. In the case of shin of beef, knuckle of veal and some other pieces that are chiefly used for making soups and gravies, the bones may be esteemed by cooks of as much value as the meat. What is under consideration, at present, however, is neither the price nor the special uses of the substances, but the relative value of the edible nutrients.

No allowance is made for the fibre of vegetable products, as it is assumed to be indigestible; all the nutrients included are assumed to be wholly and equally digestible.

It will be seen that the calculated (relative) price of rump steak is less than that of the round and almost exactly half the actual market price. This piece of meat is much esteemed for its flavour and tenderness, and is consequently in great demand. The price is therefore higher. The difference between the calculated and the market price in this, and other similar cases, must be put down to the difference in quality. In other words, if 1*s.* 1*d.* be paid for a pound of rump steak, half the amount is for the nourishment in the food, and the other half for the gratification of the palate.

On examination of the tables, it will be seen that, if the foods be arranged in the order of their relative values, it makes no difference which food is taken as 100; the order is the same in each case, but owing to the difference in the composition of the foods the actual numbers are very different.

The relative values of all kinds of meat—beef, mutton, pork, etc.—are very nearly alike. The chief cause of difference is the amount of refuse in the different parts. If the edible matter alone were under consideration the differences would be very small.

The lean or fat condition of the beasts makes but little difference in the relative values because, though protein is valued at five times as much as the fat, yet protein forms only about a fourth part of the lean tissue; consequently fat and lean of meat have very nearly the same value per lb. on this basis. The relative value of the fat meat is, however, a little higher.

The relative value of vegetable products is very variable. That of oatmeal is nearly equal to that of beef; wheat flour comes out markedly lower, and the legumes, on the other hand, considerably higher. The relative value of the prepared starches, tapioca, etc., are necessarily low.

Substances which contain a large amount of refuse, e.g. nuts which have thick, heavy shells, and those which contain a large amount of water, such as the fresh fruits and vegetables, all have a low relative value.

The relative value of potatoes is only about a

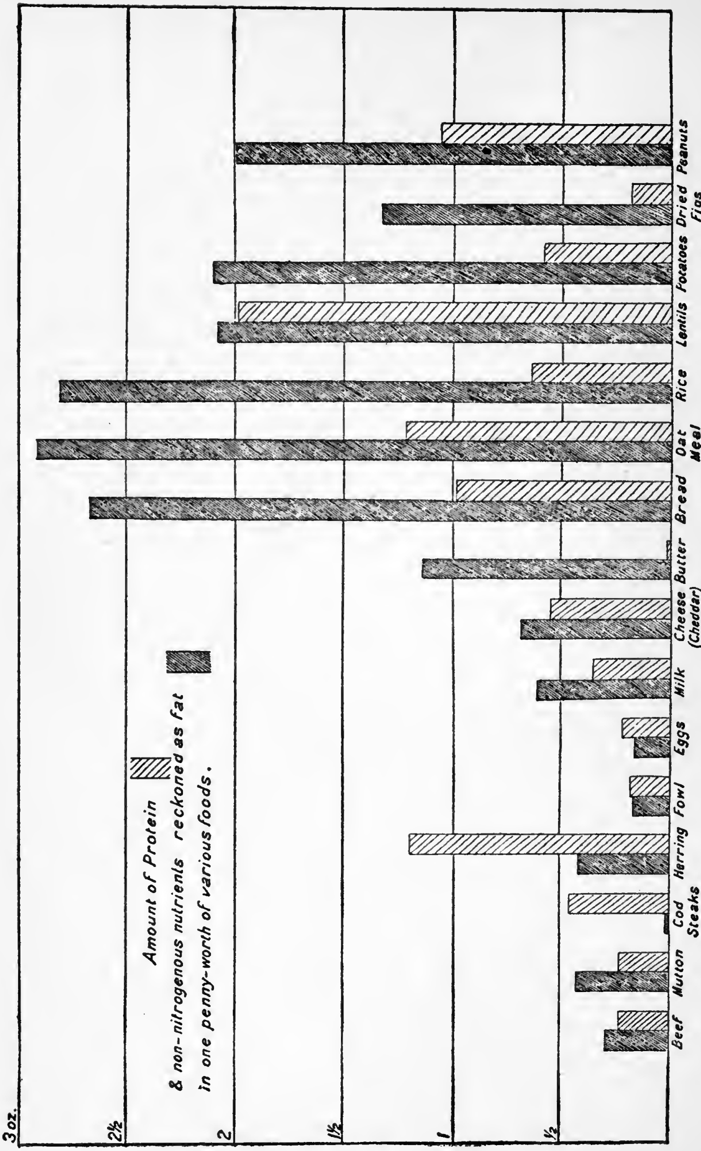

3 oz.
2½
2
1½
1
½
Amount of Protein
& non-nitrogenous nutrients reckoned as fat
in one penny-worth of various foods.
Beef
Mutton
Cod Steaks
Herring
Fowl
Eggs
Milk
Cheese (Cheddar)
Butter
Bread
Oat Meal
Rice
Lentils
Potatoes
Dried Figs
Peanuts

FIG. 11.

fifth of that of bread, and though the price is much lower, it is not correspondingly low. In other words, bread is the cheaper food.

The price of cereals and legumes is very much below that of meat and most animal foods, and having regard to their composition, it is clear that they are more economical.

In the diagram (Fig. 11) which shows the amount of nutrients in one pennyworth of various foods, the non-nitrogenous nutrients (fat and carbohydrates) are all reckoned as fat, this being the most convenient method for purposes of illustration. The beef and mutton represent, in each case, the whole side. For the former, the average price of 10*d.* per lb. has been taken, and for the latter 9*d.* per lb. The fowl includes the whole bird at an estimated price of 1*s.* per lb. The price of eggs has been taken at 9*d.* per lb. (about 12 for a shilling). For the other articles, the prices per lb. taken were as follows: Codsteaks, 6*d.*; herring, 1½*d.*; milk, 1½*d.* (about 4*d.* per quart); cheese, 8*d.*; butter, 1*s.*; bread, 1½*d.*; oatmeal, 2*d.*; rice, 2*d.*; lentils, 2*d.*; potatoes, ½*d.*; dried figs, 4*d.*, and peanuts, 3*d.*

CHAPTER XV

AN APPENDIX TO SECTION II, SHOWING THE COMPOSITION AND RELATIVE VALUES OF FOODS

THE figures in Tables A and B (animal and vegetable products) of this appendix relate to the composition of the foods *as purchased*, i.e. including the refuse or unedible parts such as the bones and sinews of meat, shells of eggs, stones and skins of fruit, etc. In all cases, the proportion of such refuse is given in the first column of the table; the composition of the edible portion is, therefore, easily calculated according to the formula :—

$$P = \frac{100p}{100 - r}$$

Where P is the percentage of any constituent in the edible portion which it is desired to find; p is the percentage of the same constituent in the food as purchased, i.e. the percentage given in the tables; and r is the percentage of refuse, also given in the tables. The formula may also be applied to the fuel value in the same way.

Example. To find the percentage of protein in the edible portion of rump beef, we have—

$$P = \frac{13{\cdot}8 \times 100}{100 - 20{\cdot}7} = \frac{13800}{793} = 17{\cdot}4$$

The values of P for the other constituents may be worked out in the same way. They are as follows: water, 56·7; fat, 25·5; fuel value, 1,400 kal.

The tables have been compiled from a number of different sources, but those relating to the common animal and vegetable products (A and B) are chiefly from analyses by Atwater [1] and Bryant. They are, therefore, uniform and comparable.

The analyses of the different kinds and cuts of butcher's meat refer, except when otherwise stated, to the average composition of the joints from beasts in the medium fat condition. Maximum and minimum results are also given in a few instances to show the variation due to condition.

The number of prepared foods, patent and proprietary articles is already very large, and is constantly being added to. These products have been grouped under the following heads:—(C) Cereal and milk foods; (D) meat preparations—meat juices, extracts and peptones; (E) milk preparations and miscellaneous products. The lists are not exhaustive, but some of the well known varieties of each kind are mentioned. With few exceptions, the analyses of the prepared foods are those supplied by the makers, attested by the certificates of well known analysts. The composition of these articles, however, is not absolutely constant. Meat preparations are peculiarly liable to variation. Probably the same analytical methods have not been followed in every case; and the results, as communicated to the author, have not always been expressed in precisely the same terms. The figures

[1] *Bul.* 28 (revised edition). U.S. Dept. of Agric.

given in Table D can, therefore, be regarded only as approximate and are not strictly comparable.

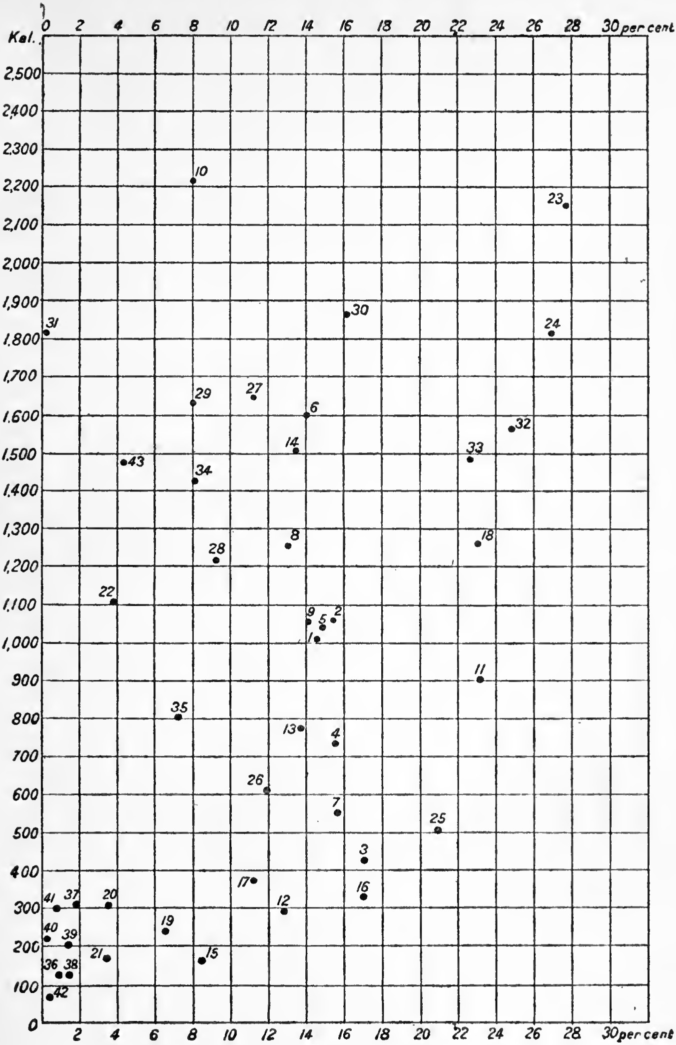
The relative values (Table F) have been calculated from the figures in Tables A and B, relating to the composition of the foods, according to the method described in Chapter XIV.

For the convenience of the reader, a table (G) has been added, showing the number of ounces of any constituent in a pound of food, corresponding to the percentages.

A ready means of comparing the nutritive values of different foods is illustrated in the diagram (Fig. 12).

The fuel values of the foods are plotted on the abscissæ (vertical lines), and the percentages of protein on the ordinates (horizontal lines); the intersection of these two lines for any given food determines the position of that substance on the chart and the point is indicated by a dot. The key to the numbers is given on page 164.

The greater the fuel value of, a food the higher up will be its position on the page, and the greater the percentage of protein the further to the right. Similar charts are easily constructed on squared paper, and the nutritive values of any two or more foods may therefore be easily compared by finding their position on the chart.


Kal.
2,500
2,400
2,300
2,200
2,100
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 per cent
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 per cent
10
23
30
31
24
29
27
6
32
14
33
43
34
8
18
28
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5
2
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11
35
13
4
26
7
25
3
17
16
41
37
20
12
40
39
19
21
15
36
38
42

FIG. 12.

Key to the Chart (Fig. 12).

The numbers affixed to the dots refer to the following foods :—

1. Beef, fore quarter, medium fat.
2. ,, hind quarter, medium fat.
3. ,, side, very lean.
4. ,, ,, lean.
5. ,, ,, medium fat.
6. ,, ,, very fat.
7. Veal, side, medium fat.
8. Mutton, side, medium fat
9. Lamb, side, medium fat.
10. Pork, side, medium fat.
11. Sheep's liver.
12. Chicken.
13. Fowl.
14. Goose.
15. Cod, whole.
16. ,, steak.
17. Herring.
18. Sardines in oil.
19. Oysters, edible part.
20. Whole milk.
21. Skim milk.
22. Cream, skimmed.
23. Cheddar cheese.
24. Cheshire ,,
25. Dutch ,,
26. Hens' eggs.
27. Wheat flour.
28. White bread.
29. Rice.
30. Oatmeal.
31. Arrowroot.
32. Lentils.
33. Split peas.
34. Chestnuts.
35. Walnuts.
36. Turnips.
37. Potatoes.
38. Cabbage.
39. Onions.
40. Apples.
41. Bananas.
42. Rhubarb.
43. Dried figs.

Appendix A

COMPOSITION OF FOODS, AS PURCHASED: ANIMAL PRODUCTS

	Refuse	Water.	Protein N × 6·25	Fat.	Carbo-hydrates.	Ash.	Fuel* Value per lb.	Nutritive Ratio.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Kal.	
Beef, average, med. fat—								
Leg	53·9	31·3	9·6	5·3	—	0·4	405	1–1·25
Round	7·2	60·7	19·0	12.8	—	1·0	895	1–1·53
H bone	16·0	49·5	15·5	18·0	—	0·8	1,043	1–2·63
Rump	20·7	45·0	13·8	20·2	—	0·7	1,110	1–3·32
Thick flank	10·2	54·0	17·0	19·0	—	0·7	1,115	1–2·54
Thin flank	11·4	42·2	13·8	32·3	—	0·7	1,620	1–5·31
Loin	13·3	52·5	16·1	17·5	—	0·9	1,040	1–2·47
Ribs	20·8	43·8	13·9	21·2	—	0·7	1,155	1–3·46
Chuck	16·3	52·6	15·5	15·0	—	0·8	920	1–2·19
Brisket	23·3	41·6	12·0	22·3	—	0·6	1,165	1–4·22
Clod and shoulder	18·8	59·4	16·4	4·4	—	0·9	490	1–0·61
Shin	36·9	42·9	12·8	7·3	—	0·6	545	1–1·29
Neck	27·6	45·9	14·5	11·3	—	0·7	770	1–1·77
Beef organs—								
Oxtails†	29·7	47·7	18·5	4·5	—	0·8	535	1–0·55
Ox tongues	26·5	51·8	14·1	6·7	—	0·8	545	1–1·08
Kidneys	19·9	63·1	13·7	1·9	—	1·0	335	1–0·31
Sweetbreads	—	70·9	16·8	12·1	—	1·6	825	1–1·63
Tripe ‡	—	86·5	11·7	1·2	0·2	0·3	270	1–0·23
Heart	5·9	53·2	14·8	24·7	—	0·9	1,320	1–3·79
Liver	7·3	65·6	20·2	3·1	2·5	1·3	555	1–0·47
Lungs	—	79·7	16·4	3·2	—	1·0	440	1–0·44
Suet	—	13·7	4·7	81·8	—	0·2	3,540	1–39·51

* Calculated from Rübner's factors. † Canned. ‡ Pickled.

	Refuse	Water.	Protein N × 6·25	Fat.	Carbo-hydrates.	Ash.	Fuel* Value per lb.	Nutritive Ratio.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Kal.	
Veal, average, med. fat—								
Hind knuckle (hock) . . .	62·7	27·8	7·7	1·7	—	0·4	215	1–0·50
Fillet . . .	14·2	60·1	15·5	7·9	—	0·9	620	1–1·15
Loin (whole). .	16·5	57·6	16·6	9·0	—	0·9	690	1–1·23
Breast . . .	20·6	52·7	15·6	11·0	—	0·8	740	1–1·60
Neck (best end) .	18·9	59·5	16·0	5·2	—	0·8	515	1–0·74
Shoulder (lean) .	18·3	59·9	16·9	3·9	—	1·0	480	1–0·52
Fore knuckle .	40·4	44·1	12·2	3·1	—	0·6	360	1–0·58
Scrag . . .	31·5	49·9	13·9	4·6	—	0·7	455	1–0·75
Veal organs—								
Calves heart .	—	73·2	16·8	9·6	—	1·0	720	1–1·29
,, kidneys .	—	75·8	16·9	6·4	—	1·3	585	1–0·86
,, liver . .	—	73·0	19·0	5·3	—	1·3	575	1–0·63
,, lungs .	—	76·8	17·1	5·0	—	1·1	530	1–0·66
Mutton, average, med. fat—								
Leg	18·4	51·2	15·1	14·7	—	0·8	900	1–2·21
Loin†. . . .	16·0	42·0	13·5	28·3	—	0·7	1,445	1–4·76
Neck (best end) .	21·3	39·9	11·9	26·7	—	0·6	1,350	1–5·09
Breast . . .	9·9	39·0	13·8	36·9	—	0·6	1,815	1–6·07
Scrag . . .	27·4	42·1	12·3	17·9	—	0·7	985	1–3·30
Shoulder . . .	22·5	47·9	13·7	15·5	—	0·7	910	1–2·57
Mutton organs—								
Kidneys‡ . .	—	78·5	16·5	3·2	—	1·3	440	1–0·44
Kidney fat . .	—	3·4	1·8	95·4	—	0·1	4,060	1–120·30
Heart . . .	—	69·5	16·9	12·6	—	0·9	845	1–1·69
Liver . . .	—	61·2	23·1	9·0	5·0	1·7	905	1–0·88
Lungs . . .	—	75·9	20·2	2·8	—	1·2	495	1–0·31
Lamb, average, med. fat—								
Leg	17·4	52·9	15·9	13·6	—	0·9	870	1–1·97
Loin	14·8	45·3	16·0	24·1	—	0·8	1,315	1–3·42
Shoulder . . .	20·3	41·3	14·4	23·6	—	0·8	1,265	1–3·65
Breast . . .	19·1	45·5	15·4	19·1	—	0·8	1,090	1–2·81
Neck	17·7	46·7	14·6	20·4	—	0·8	1,135	1–3·17
Pork, fresh, average, med. fat—								
Leg	10·7	48·0	13·5	25·9	—	0·8	1,345	1–4·35

* Calculated from Rübner's factors.
† Not including kidney or kidney fat. ‡ Not including fat.

	Refuse	Water.	Protein N × 6·25	Fat.	Carbo-hydrates.	Ash.	Fuel* Value per lb.	Nutritive Ratio.
Pork, fresh (*contd.*)	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Kal.	
Hind loin . .	19·7	41·8	13·4	24·2	—	0·8	1,270	1–4·11
Fore loin. . .	18·1	41·8	14·1	25·5	—	0·9	1,340	1–4·10
Hand. . . .	12·4	44·9	12·0	29·8	—	0·7	1,480	1–5·64
Belly	6·2	29·5	6·5	56·6	—	0·4	2,510	1–19·77
Head . . .	68·4	13·8	4·1	13·8	—	0·2	660	1–7·64
Lard (refined) .	—	—	—	100·0	—	—	4,220	—
Pork organs—								
Kidneys . . .	—	77·8	15·5	4·8	—	1·2	490	1–0·70
Liver	—	71·4	21·3	4·5	1·4	1·4	615	1–0·48
Heart . . .	—	75·6	17·1	6·3	—	1·0	585	1–0·83
Pork, cured—								
Bacon, smoked, lean	17·0	26·5	13·0	35·5	—	8·7	1,740	1–6·19
,, ,, fat	7·7	17·4	9·1	62·2	—	4·1	2,795	1–15·51
Ham, ,, lean	11·5	47·2	17·5	18·5	—	4·9	1,105	1–2·39
,, ,, fat	3·4	25·2	12·4	53·7	—	3·5	2,495	1–9·83
Beef—								
Fore quarter, med. fat	18·7	49·1	14·5	17·5	—	0·7	1,010	1–2·74
Hind quarter, med. fat . .	15·7	50·4	15·4	18·3	—	0·7	1,060	1–2·69
Side, very lean .	26·0	54·0	17·0	2·7	—	0·8	430	1–0·36
,, lean . . .	19·5	54·1	15·5	10·6	—	0·7	735	1–1·55
,, med. fat, max.	21·8	53·1	15·8	21·9	—	0·8	1,185	1–3·73
,, ,, min.	15·5	44·2	13·9	12·7	—	0·7	830	1–2·07
,, ,, avge.	17·4	49·4	14·8	18·1	—	0·7	1,040	1–2·77
,, very fat .	13·2	41·5	14·0	31·6	—	0·6	1,595	1–5·12
Veal—								
Fore quarter .	24·5	54·2	15·1	6·0	—	0·7	535	1–0·90
Hind ,, .	20·7	56·2	16·2	6·6	—	0·8	580	1–0·92
Side, with kidney, fat and tallow.	22·6	55·2	15·6	6·3	—	0·8	555	1–0·91
Mutton—								
Fore quarter .	21·2	41·6	12·3	24·5	—	0·7	1,265	1–4·52
Hind ,, .	17·2	45·4	13·8	23·2	—	0·7	1,235	1–3·82
Side + tallow. .	18·1	45·4	13·0	23·1	—	0·7	1,215	1–4·03
,, − tallow. .	19·3	43·3	13·0	24·0	—	0·8	1,255	1–4·19
Lamb—								
Fore quarter .	18·8	44·7	14·9	21·0	—	0·8	1,165	1–3·20
Hind ,, .	15·7	51·3	16·5	16·1	—	0·9	985	1–2·21
Side − tallow. .	19·3	47·0	14·1	18·7	—	0·8	1,055	1–3·01

* Calculated from Rübner's factors.

	Refuse	Water.	Protein N × 6·25	Fat.	Carbo-hydrates.	Ash.	Fuel* Value per lb.	Nutritive Ratio.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Kal.	
Pork—								
Side + lard and other fat .	11·2	26·1	8·3	54·8	—	0·4	2,465	1–14·99
„ — lard and kidney .	11·5	30·4	8·0	49·0	—	0·5	2,215	1–13·90
Poultry—								
Chickens . .	41·6	43·7	12·8	1·4	—	0·7	295	1–0·25
Fowls . . .	25·9	47·1	13·7	12·3	—	0·7	775	1–2·04
Turkeys . . .	22·7	42·4	16·1	18·4	—	0·8	1,075	1–2·59
Geese. . . .	17·6	38·5	13·4	29·8	—	0·7	1,505	1–1·50
Fish, fresh, whole—								
Haddock† . .	51·0	40·0	8·4	0·2	—	0·6	165	1–0·05
Cod	52·5	38·7	8·4	0·2	—	0·6	165	1–0·05
Hake† . . .	52·5	39·5	7·3	0·3	—	0·5	150	1–0·09
Flounder. . .	61·5	32·6	5·4	0·3	—	0·5	115	1–0·13
Herring . . .	42·6	41·7	11·2	3·9	—	0·9	375	1–0·79
Mackerel . .	44·7	40·4	10·2	4·2	—	0·7	365	1–0·93
Turbot . . .	47·7	37·3	7·7	7·5	—	0·7	460	1–2·21
Salmon . . .	34·9	40·9	15·3	8·9	—	0·9	660	1–1·32
Fish, fresh, portions								
Cod steaks . .	9·2	72·4	17·0	0·5	—	1·0	335	1–0·07
Halibut steaks .	17·7	61·9	15·3	4·4	—	0·9	470	1–0·65
Skate,lobe of body	51·0	40·2	8·9	0·7	—	0·6	195	1–0·18
Fish, cured—								
Cod, salted . .	24·9	40·2	19·0	0·4	—	18·5	315	1–0·05
Haddock, smoked	32·2	49·2	15·8	0·1	—	2·4	305	1–0·01
„ „ fillet	—	72·5	23·3	0·2	—	3·6	440	1–0·01
Herring, smoked	44·4	19·2	20·5	8·8	—	7·4	750	1–0·97
Salmon, canned .	14·2	56·8	19·5	7·5	—	2·0	680	1–0·87
Sardines, „ .	‡5·0	53·6	23·7	12·1	—	5·3	950	1–1·16
„ „ .	—	52·3	23·0	19·7	—	5·6	1,260	1–1·94
Shell Fish—								
Clams, in shell .	41·9	49·9	5·0	0·6	1·1	1·5	140	1–0·49
Mussels, in shell	46·7	44·9	4·6	0·6	2·2	1·0	150	1–0·77
Oysters, in shell	81·4	16·1	1·2	0·2	0·7	0·4	45	1–0·96
Lobsters, whole .	61·7	30·7	5·9	0·7	0·2	0·8	140	1–0·30
Crabs, whole. .	52·4	36·7	7·9	0·9	0·6	1·5	195	1–0·33
Crayfish, abdomen whole . . .	86·6	10·9	2·1	0·1	0·1	0·2	45	1–0·15

* Calculated from Rübner's factors.
† Entrails (about 5 per cent.) removed. ‡ Oil.

	Refuse	Water.	Protein N × 6·25	Fat.	Carbo-hydrates.	Ash.	Fuel* Value per lb.	Nutritive Ratio.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Kal.	
Dairy Produce—								
Cow's milk, whole								
Maximum .	—	90·3	6·4	6·5	6·1	1·2	—	—
Minimum . .	—	80·3	2·1	1·7	2·1	0·4	—	—
Average . .	—	87·3	Alb.† 0·5 Cas. 3·0	3·6	4·9	0·7	308	1–3·73
Mother's milk average . .	—	87·4	Alb.‡ 1·3 Cas. 1·0	3·8	6·2	0·3	318	1–6·44
Goat's milk . .	—	85·7	4·3	4·8	4·5	0·8	366	1–3·58
Skim milk (cow's)	—	90·5	3·4	0·3	5·1	0·7	170	1–1·70
Buttermilk . .	—	91·0	3·0	0·5	4·8	0·7	165	1–1·97
Whey . . .	—	93·0	1·0	0·3	5·0	0·7	125	1–5·68
Cream, skimmed	—	68·8	3·8	22·7	4·2	0·5	1,106	1–14·66
,, separated thick—								
maximum	—	54·8	—	46·4	§8·5	—	—	—
minimum	—	46·7	—	38·1	§4·2	—	—	—
average .	—	51·7	—	42·0	§6·3	—	1,889	—
Cream, separated, light—								
maximum	—	83·3	—	21·6	§9·3	—	—	—
minimum	—	70·5	—	8·6	§7·2	—	—	—
average .	—	77·9	—	13·9	§8·2	—	736	—
Butter . . .	—	11·0	1·0	85·0	—	3·0	3,605	1–192·95
Cheese—								
American, pale .	—	31·6	28·8	35·9	0·3	3·4	2,055	1–2·84
,, red .	—	28·6	29·6	38·5	—	3·5	2,165	1–2·95
Cheddar . . .	—	27·4	27·7	36·8	4·1	4·0	2,145	1–3·02
Cheshire . . .	—	37·1	26·9	30·7	0·9	4·4	1,810	1–2·63
Dutch . . .	—	72·0	20·9	1·0	4·3	1·8	510	1–0·31
,, . . .	—	41·8	31·9	10·6	—	6·3	1,040	1–0·75
,, . . .	—	37·6	29·5	22·5	—	6·5	1,498	1–1·73
Stilton . . .	—	21·2	26·3	45·8	—	2·9	2,421	1–3·95
Gorgonzola . .	—	40·3	27·7	26·1	—	5·3	1,616	1–2·10

* Calculated from Rübner's factors.
† Total protein 3·5.
‡ ,, ,, 2·3.
§ Total non-fatty solids.

	Refuse	Water.	Protein N × 6·25	Fat.	Carbo-hydrates.	Ash.	Fuel* Value per lb.	Nutritive Ratio.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Kal.	
Eggs—								
Hen's	11·2	65·5	11·9†	9·3	—	0·9	635	1–1·77
Turkey's . .	13·8	63·5	11·6	9·7	—	0·8	625	1–1·89
Duck's . . .	13·7	60·9	11·5	12·5	—	0·8	751	1–2·47
Goose's . . .	14·2	59·7	11·5	12·3	—	0·9	733	1–2·43

* Calculated from Rübner's factors.
† Too low ? By difference 13·1.

Appendix B

COMPOSITION OF FOODS AS PURCHASED: VEGETABLE PRODUCTS

	Refuse.	Water.	Protein.	Fat.	* Carbohydrates.	Fibre.	Ash.	Fuel value per lb.	Nutritive Ratio.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Kal.	
Wheat—									
Dressed grain		13·5	12·4	1·7	67·9	2·6	1·8	1,565	1–5·78
White flour	—	12·4	11·2	1·0	74·9	0·2	0·5	1,645	1–7·00
Whole-meal	—	11·4	13·8	1·9	71·9	0·9	1·0	1,675	1–5·52
White bread	—	35·3	9·2	1·3	53·1	0·5	1·1	1,215	1–6·09
Brown bread (Graham)	—	35·7	8·9	1·8	52·1	1·1	1·5	1,210	1–5·98
Macaroni	—	10·3	13·4	0·9	74·1	—	1·3	1,665	1–5·69
Vermicelli	—	11·0	10·9	2·0	72·0	—	4·1	1,625	1–7·02
Barley—									
Pot barley	—	14·4	8·5	1·7	73·3	0·9	1·2	1,593	1–9·08
Pearl barley	—	11·5	8·5	1·1	77·8	0·3	1·1	1,650	1–9·45
Rice—									
Whole, polished	—	12·3	8·0	0·3	79·0	0·2	0·4	1,630	1–9·96
Ground rice	—	11·5	8·1	0·3	79·4	0·2	0·5	1,640	1–9·89
Cornflour† (Brit.)	—	13·0	2·1	—	84·6	—	0·3	1,612	1–40·29
Oats—									
Oatmeal	—	7·3	16·1	7·2	67·5	0·9	1·9	1,860	1–5·09
Rolled oats	—	7·7	16·7	7·3	66·2	1·3	2·1	1,850	1–4·95
Maize—									
Whole-meal‡	—	15·0	8·2	3·8	68·7	1·9	1·4	1,610	1–9·43
Hominy	—	11·8	8·3	0·6	79·0	0·9	0·3	1,650	1–9·68
Cornflour	—	12·6	7·1	1·3	78·4	0·9	0·6	1,645	1–11·45
,, §Oswego	—	10·6	2·1	—	86·8	—	0·5	1,650	1–41·31
Prepared Starches									
Arrowroot	—	2·3	—	—	97·5	—	0·2	1,815	—
Tapioca	—	11·4	0·4	0·1	88·0	0·1	0·1	1,650	—
Sago	—	12·2	9·0	0·4	78·1	—	0·3	1,635	—
,, ‖	—	15·2	—	—	84·6	—	0·1	1,570	—

* Including fibre. † Bell, *Chemistry of Food*, compare maize.
‡ Used as fodder. § Bell, *Chemistry of Food*. Compare rice.
‖ Bell, *Chemistry of Food*.

	Refuse.	Water	Protein.	Fat.	* Carbohydrates.	Fibre.	Ash.	Fuel Value per lb.	Nutritive Ratio.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Kal.	
Legumes, † dry—									
Beans . . .	—	13·6	23·1	2·3	53·6	3·9	3·6	1,523	1–2·54
Peas . . .	—	14·3	22·6	1·7	53·2	5·6	2·7	1,480	1–2·52
Lentils . . .	—	12·5	24·8	1·9	54·8	3·6	2·5	1,560	1–2·38
Nuts, in shell—									
Almonds . .	45·0	2·7	11·5	30·2	9·5	—	1·1	1,660	1–6·78
Filberts . .	52·1	1·8	7·5	31·4	6·2	—	1·1	1,575	1–10·33
Peanuts . .	24·5	6·9	19·5	29·1	18·5	—	1·5	1,935	1–4·33
Cocoanuts ‡ .	48·8	7·2	2·9	25·9	14·3	—	0·9	1,413	1–25·20
Chestnuts . .	24·0	4·5	8·1	5·3	56·4	—	1·7	1,425	1–8·45
Walnuts . .	74·1	0·6	7·2	14·6	3·0	—	0·5	805	1–5·02
,, kernels	—	2·5	27·6	56·3	11·7	1·7	1·9	3,105	1–5·06
Brazil-nuts. .	49·6	2·6	8·6	33·7	3·5	—	2·0	1,655	1–9·30
Fresh Vegetables—									
Turnips . .	30·0	62·7	0·9	0·1	5·7	1·3	0·6	125	1–6·58
Carrots . .	20·0	70·6	0·9	0·2	7·4	1·1	0·9	160	1–8·73
Beetroot . .	20·0	70·0	1·3	0·1	7·7	0·9	0·9	170	1–6·09
Parsnips . .	20·0	66·4	1·3	0·4	10·8	2·5	1·1	240	1–9·00
Radishes . .	30·0	64·3	0·9	0·1	4·0	0·7	0·7	95	1–4·69
Potatoes . .	20·0	62·6	1·8	0·1	14·7	0·4	0·8	310	1–8·29
Artichokes . .	—	79·5	2·6	0·2	16·7	0·8	1·0	365	1–6·59
Onions . . .	10·0	78·9	1·4	0·3	8·9	0·8	0·5	205	1–6·84
Leeks . . .	15·0	78·0	1·0	0·4	5·0	0·6	0·6	130	1–5·91
Cabbages . .	15·0	77·7	1·4	0·2	4·8	1·1	0·9	125	1–3·75
Spinach . .	—	92·3	2·1	0·3	3·2	0·9	2·1	110	1–1·88
Lettuces . .	15·0	80·5	1·0	0·2	2·5	0·7	0·8	75	1–2·95
Celery . . .	20·0	75·6	0·9	0·1	2·6	—	0·8	70	1–3·14
Cauliflower. .	—	92·3	1·8	0·5	4·7	1·0	0·7	140	1–3·24
Green peas. .	—	74·6	7·0	0·5	16·9	1·7	1·0	465	1–2·52
Butter beans .	50·0	29·4	4·7	0·3	14·6	—	1·0	370	1–3·25
Lima beans .	55·0	30·8	3·2	0·3	9·9	0·8	0·8	255	1–3·30
Tomatoes . .	—	94·3	0·9	0·4	3·9	0·6	0·5	105	1–5·34
Cucumbers .	15·0	81·1	0·7	0·2	2·6	0·7	0·4	70	1–4·36
Mushrooms .	—	88·1	3·5	0·4	6·8	0·8	1·2	210	1–2·20

* Including fibre. † Winter Blythe, *Composition and Analysis of Food.*
‡ Including milk and shell.

	Refuse.	Water.	Protein.	Fat.	*Carbohydrates.	Fibre.	Ash.	Fuel Value per lb.	Nutritive Ratio.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent	Kal.	
Fresh Fruits—									
Bananas . .	35·0	48·9	0·8	0·4	14·3	1·0	0·6	300	1–19·01
Apples . . .	25·0	63·3	0·3	0·3	10·8	1·2	0·3	220	1–38·27
Pears . . .	10·0	76·0	0·5	0·4	12·7	2·7	0·4	260	1–27·21
Plums . . .	5·0	74·5	0·9	—	19·1	—	0·5	370	1–21·22
Cherries . .	5·0	76·8	0·9	0·8	15·9	0·2	0·6	345	1–19·68
Apricots . .	6·0	79·9	1·0	—	12·6	—	0·5	255	1–12·60
Peaches . .	18·0	73·3	0·5	0·1	7·7	3·6	0·3	155	1–15·85
Oranges . .	27·0	63·4	0·6	0·1	8·5	—	0·4	170	1–14·54
Lemons. . .	30·0	62·5	0·7	0·5	5·9	1·1	0·4	145	1–10·05
Raspberries .	—	84·1	1·7	1·0	12·6	—	0·6	310	1–8·75
Strawberries .	5·0	85·9	0·9	0·6	7·0	1·4	0·6	175	1–9·29
Watermelons .	59·4	37·5	0·2	0·1	2·7	—	0·1	60	1–14·63
Rhubarb . .	40·0	56·6	0·4	0·4	2·2	1·1	0·4	65	1–7·77
Dried Fruits—									
Figs. . . .	—	18·8	4·3	0·3	74·2	—	2·4	1,475	1–17·41
Dates . . .	10·0	13·8	1·9	2·5	70·6	—	1·2	1,450	1–40·14
Prunes . . .	15·0	19·0	1·8	—	62·2	—	2·0	1,190	1–34·55
Raisins. . .	10·0	13·1	2·3	3·0	68·5	—	3·1	1,445	1–32·74
Currants . .	—	17·2	2·4	1·7	74·2	—	4·5	1,495	1–32·52
Apples . . .	—	28·1	1·6	2·2	66·1	—	2·0	1,350	1–44·43
Pears . . .	—	16·5	2·8	5·4	72·9	3·7	2·4	1,635	1–30·41
Apple jelly . .	—	40·8	0·2	—	53·8	—	0·2	1,004	—
Damson jam . .	—	49·6	0·5	—	38·0	2·4	0·5	716	—
Marmalade . .	—	19·5	0·9	—	67·8	3·4	0·5	1,228	—
Honey . . .	—	17·4	0·1	0·4	81·9	—	0·2	1,525	—

* Including fibre.

Appendix C

CEREAL AND MILK PREPARATIONS

	Water.	Protein.	Fat.	Carbo-hydrates. Soluble.	Carbo-hydrates. Starch.	Ash.	Remarks.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Allenbury's—							
No. 1 Milk food .	1·8	10·7	16·8	66·6	—	4·1	Made from milk.
No. 2 Milk food .	2·2	10·2	14·9	68·8	—	3·8	" " "
No. 3 Malted Food	3·0	10·2	1·5	25·1	60·0	0·6	A partly malted wheat to be used with milk.
Benger's Food . .	5·3	12·2	1·0	3·3	77·2	1·0	A malted wheat flour, peptonizes milk used in preparation.
Cheltine's—							
Milk food No. 1 .	5·2	9·6	9·8	71·2	—	4·2	42 per cent. lactose, no cane sugar or starch.
Milk food No. 2 .	6·2	10·9	9·6	69·3	—	4·0	32 per cent. maltose, no cane sugar or starch.
Malted Infants' food No. 3	3·6	14·6	4·3	35·4	40·5	1·6	A partly malted cereal flour.
Maltose food . .	5·8	7·4	0·6	83·4	—	2·8	Completely malted.
Coomb's malted food .	6·0	10·6	0·9	—	81·7	0·8	Contains malt.
Fairchild's milk powder	5·5	1·2	—	92·0	—	1·2	Chiefly lactose.
Frame Food No. 1 .	2·1	12·4	—	82·9	—	2·6	Completely malted.
" " No. 2 .	1·4	16·3	—	30·3	50·1	1·9	Cooked wheat flour, plus sugar and Frame food extract

	Water.	Protein.	Fat.	Carbo-hydrates.		Ash.	Remarks.
				Soluble.	Starch.		
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Frame Food extract.	9·6	21·4	—	34·9	13·0	10·7	Made from wheat bran; contains 3·7 per cent. phosphoric acid.
Horlick's malted milk	3·2	16·2	8·8	67·6	—	4·2	A dry powder made from wheat flour, malt and fresh milk
Hovis Babies' Food No. 1	3·7	7·7	0·2	86·4	—	1·8	—
,, ,, ,, No. 2	2·4	5·8	0·1	82·4	7·5	1·7	—
Maltico Food . .	2·5	16·0	11·7	—	66·2	3·6	Malted cereals and milk.
Mellin's Food . .	3·5	9·1	0·1	83·7	—	3·3	A completely malted cereal extract, to be used with milk.
Muffler's Food . .	5·6	14·3	5·8	27·4	44·4	2·4	Desiccated milk, white of egg, wheat flour and lactose.
Neaves' Milk Food .	2·4	20·0	26·0	47·1	—	4·5	Diluted with 7 to 8 parts of water, the mixture resembles human milk.
,, Infants' Food	5·1	14·7	—	75	·5	1·2	A cereal flour to be used with milk.
Opmus Food . .	10·9	9·1	1·0	78	·6	0·4	A granulated wheat flour.
Ridge's Food . .	4·3	9·4	1·6	83	·7	0·9	A cooked cereal flour.
Savory & Moore's Food	5·3	10·8	1·1	27·8	54·1	0·9	Wheat flour, malt, glucose and cane sugar.

Appendix D

MEAT PREPARATIONS *

	Water.	Protein and Gelatin.	Nitro-genous Extrac-tives	Nitrogen Free Substance.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Meat Juice—					
Armour's Beef Juice .	74·4	8·1	9·5	—	7·5
Bovril " " .	52·0	7·2	14·0	20·7	5·9
Brand's " " .	60·7	5·1	10·1	1·3	10·0
Valentine's " " .	60·3	0·6	29·2	—	11·3
Weyth's " " .	44·9	38·0	—	—	17·1
Meat Extracts—					
Armour's Extract of Beef	24·3	16·1	20·5	20·1	19·0
Bovril	21·2	16·7	16·1	29·2	16·8
Invalid's Bovril. . .	21·5	31·4	32·6	—	15·2
Bouillon Fleet . . .	62·0	11·8	9·9	3·9	12·5
Brand's Essence of Beef	89·2	6·7	4·4	0·1	1·4
Liebig's Extract (Lemco)	19·3	49·8	10·7	—	20·2
Oxo	41·5	36·0	4·5	—	18·0
Home-made beef tea .	96·0	1·5	0·6	1·0	0·7

COMMERCIAL PEPTONES

	Water	Peptones.	Albu-moses.	Extrac-tives, etc.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Armour's Wine of Peptone	83·0	3	·0	12·9	1·1
Benger's Peptonized Beef Jelly	89·7	4·7	2·4	2·3	0·9
Carnrick's Liquid Pepton-oids	80·1	4·6	2·3	12·0†	1·0
Fairchild's Panopeptone .	81·0	3	·0	15·0†	—

* Variable. † Soluble carbohydrates.

Appendix E

MILK PREPARATIONS AND MISCELLANEOUS PRODUCTS

	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Remarks.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Condensed milk—						
Unsweetened . .	69·2	8·7	8·1	9·9	1·6	Condensed 2·2 times.
Sweetened . . .	25·7	8·5	10·6	53·8	1·3	Condensed 2·3 times and 42 per cent. cane sugar added.
„ skimmed	30·7	12·2	3·1	52·1	2·1	—
Desiccated milk . .	—	27·5	28·3	38·6	5·5	Calculated.
Lacvitum . . .	5·3	28·0	29·4	31·3	6·0	—
Plasmon	8·5	75·0	0·2	8·9	7·4	—
Biogene	10·0	78·7	1·6	4·0	4·7	—
Casumen	7·0	86·5	3·6	—	2·9	—
Gelatin	13·6	91·4*	0·1	—	2·1	Fuel value 1705 kal.
Isinglass	19·0	89·3†	1·6	—	2·0	„ „ 1730 „
Calvesfoot jelly . .	77·6	4·3	—	17·4	0·7	„ „ 405 „
Desiccated eggs . .	—	51·1	39·9	—	9·0	Calculated.
‡ „ „ . .	5·9	48·1	40·5	—	5·3	As sold.
Egg substitute . .	7·0	18·7	3·4	70	·9	—
§Custard powder (*a*) .	13·7	0·6	—	84·5	0·4	—
„ „ (*b*) .	8·2	5·0	—	53·9	26·7	Ash, baking soda; 6 per cent. tartaric acid.

* Too high; by difference 84·2.
† Too high; by difference 77·4.
‡ Leach, *Food Inspection.*
§ *Food and Sanitation,* 1893.

Appendix F

THE RELATIVE VALUE OF FOODS

Food.	Number of Units.*	Value compared with				Average Market Price per lb.
		† Beef as 100.	Milk as 100.	Bread as 100.	Beef at 8*d.* per lb.	
		Rel. val.	Rel. val.	Rel. val.	Pence.	Pence.
Beef—						
Leg, including bone .	213·2	52	239	88	‡4	5
,, edible matter .	461·6	107	517	191	8½	7–8
Round	431·2	*100*	483	178	8	9–10½
H bone	382·0	89	428	157	‡7	6–7
Rump	356·8	83	400	147	6½	11–14
Thick flank . . .	416·0	96	466	172	7¾	9–10
Thin flank . . .	405·2	94	454	167	7½	5–6
Loin	392·0	91	439	161	7¼	11–12
Ribs	362·8	84	406	150	‡6¾	9–11
Brisket	329·2	76	369	136	6	7
Neck	335·2	78	375	138	‡6¼	5
Side, very lean . .	350·8	81	393	144	6½	—
,, lean.	352·4	82	395	145	6¾	—
,, med. fat . .	368·4	85	413	152	6¾	—
,, very fat . .	406·4	94	455	168	7½	—
Ox tails	388·0	90	434	160	‡7¼	—
Ox tongues . . .	308·8	72	345	127	5¾	—
Kidneys	281·6	65	315	113	5¼	12
Sweetbreads . . .	384·4	89	430	158	7¼	—
Tripe	238·8	55	266	99	4½	6
Suet	327·2	76	366	135	6	8
Veal—						
Hock	160·8	37	180	66	‡3	6
Fillet	341·6	79	383	146	6¼	13
Loin, whole . . .	368·0	85	412	151	6½	9–10
Breast	356·0	83	399	147	6½	8½
Neck, best end . .	340·8	79	382	140	6¼	10–12
Shoulder	353·6	82	395	146	‡6½	8
Fore knuckle. . .	256·4	59	287	106	‡4¾	6
Scrag	296·4	68	332	122	‡5½	6

* This column may be read "Value compared with sugar as 100."
† Round. ‡ Add allowance for bone.

Food.	Number of Units.*	Value compared with † Beef as 100.	Milk as 100.	Bread as 100.	Beef at 8*d*. per lb.	Average Market Price per lb.
		Rel. val.	Rel. val.	Rel. val.	Pence.	Pence.
Mutton—						
Leg	360·8	84	403	149	6¾	10
Loin‡	383·2	89	429	158	7	12
Neck, best end	344·8	80	385	142	§6½	10
Breast	423·6	98	474	175	7¾	4
Scrag	317·6	74	356	131	§6	6–7
Shoulder	336·0	78	376	139	§6¼	8–9
Kidneys	342·8	79	384	141	6½	12
Heart	388·4	90	435	160	7¼	6
Lungs	415·2	96	465	171	7¾	4
Liver	503·0	114	563	208	9	5
Suet	381·6	88	427	157	7	5
Lamb—						
Leg	372·4	86	417	154	7	12
Loin	416·4	96	466	172	7¾	11
Shoulder	382·4	89	428	157	7	11
Breast	384·4	89	430	159	7	7
Neck	373·6	87	417	154	7	9½
Pork, fresh—						
Leg	373·6	87	417	154	7	9
Hind loin	364·8	85	409	151	6¾	10½
Fore loin	384·0	89	430	158	7	8½
Hand	359·2	83	402	148	6¾	7
Belly	356·4	83	399	147	6½	8½
Lard ‖	400·0	93	448	165	7½	7
Bacon, smoked, lean	402·0	93	450	166	7½	6–12
,, ,, fat	430·8	100	481	178	8	
Poultry—						
Chickens	261·6	61	293	108	5	12–15
Fowls	323·2	75	362	133	6	10–12
Turkeys	395·6	92	443	163	7¼	12
Geese	387·2	90	434	160	7	8
Fish, fresh, whole—						
Haddock ¶	168·8	39	189	70	3	6
Cod	168·8	39	189	70	3	4
Hake ¶	147·2	34	165	61	2¾	4
Flounder	109·2	25	122	46	2	4

* This column may be read "Value compared with sugar as 100."
† Round. ‡ Without kidney and suet. § Add allowance for bone.
‖ Vegetable oils and all pure fats, same as lard except in regard to price.
¶ Entrails removed.

Food.	Number of Units.*	Value compared with † Beef as 100.	Milk as 100.	Bread as 100.	Beef at 8*d.* per lb.	Average Market Price per lb.
Fish, fresh (*contd.*).—		Rel. val.	Rel. val.	Rel. val.	Pence.	Pence.
Herring	239·6	56	268	99	4½	1–1½
Mackerel	220·8	51	247	91	4	2
Turbot	184·0	43	206	76	3½	10–12
Salmon	341·6	79	382	141	6½	12–18
Cod steaks . . .	342·0	79	383	142	6½	6
Halibut steaks . .	323·6	75	362	134	6	10
Skate, lobe . . .	180·8	42	202	75	4	6
Fish, cured —						
Cod, salted . . .	381·6	88	427	158	7	4
Haddock, smoked .	316·4	73	354	131	5¾	6
,, fillet . .	466·8	108	523	193	8½	7
Herring, smoked. .	445·2	103	498	184	8	4
Dairy Produce—						
Milk (cow's), whole .	89·3	21	*100*	37	‡4¼	3–4
,, ,, skim .	74·3	17	83	31	‡3½	2
Cream, thick . .	174·3	40	195	72	§ 4	} 12–24
,, thin . . .	63·8	15	71	26	‡1½	
Butter ‖	360·0	83	403	149	6½	12
Cheese, Cheddar .	705·3	164	790	291	13	8
,, Dutch . .	426·3	99	477	176	8	5
Eggs (hen's) . . .	299·2	69	332	123	¶7½	12–24
Cereals and Farinaceous Products—					Bread at 1½*d* per lb.	
Wheat flour, white .	302·9	70	339	125	1¾	2
Bread, white . .	242·3	56	271	*100*	1½	1½
Macaroni . . .	345·7	80	387	143	2	4
Barley, pearl . .	252·2	58	282	104	1½	2
Rice	240·2	56	270	99	1½	2
Cornflour	126·6	29	143	52	¾	5
Oatmeal	416·5	97	466	172	2½	2
Tapioca	96·4	22	108	40	½	3
Arrowroot . . .	97·5	23	109	40	½	4
Legumes—						
Beans	524·8	122	587	233	3½	2
Peas	512·0	119	573	211	3	1½
Lentils	558·4	129	654	230	3½	2

* This column may be read "Value compared with sugar as 100."
† Round. ‡ Per quart. § Per pint.
‖ Margarine same as butter except price. ¶ Per dozen.

Food.	Number of Units.*	Value compared with † Beef as 100.	Milk as 100.	Bread as 100.	Bread at 1¼d. per lb.	Average Market Price per lb.
		Rel. val.	Rel. val.	Rel. val.	Pence.	Pence.
Nuts—						
Walnuts	205·4	48	230	85	1¼	6
Chestnuts	239·6	56	268	99	1½	3
Peanuts	524·9	121	588	217	3¼	6
Fresh Vegetables—						
Potatoes	51·1	12	57	21	¼	½
Onions	38·1	9	43	16	¼	1½
Leeks	26·6	6	30	11	‡	—
Turnips	24·1	6	27	10	‡	—
Carrots	26·2	6	29	11	‡	—
Cabbage	33·6	8	38	14	‡	—
Green Peas	158·9	37	178	66	1	—
Tomatoes	23·5	5	26	10	‡	—
Fresh Fruits—						
Bananas	31·9	7	36	13	‡	—
Apples	18·0	4	20	7	‡	—
Plums	37·1	9	42	15	‡	—
Oranges	20·9	5	23	9	‡	—
Dried Fruits—						
Figs	161·4	37	181	67	1	3
Dates	118·6	25	132	49	¾	2
Prunes	98·2	23	110	41	½	4
Raisins	126·5	29	142	52	¾	3½–7½
Currants	129·0	30	144	53	¾	3–4½
Miscellaneous—						
Sugar	100·0	23	112	41	½	2
Treacle	26·0	60	29	107	1½	2½–3
Damson jam	48·0	11	54	19	¼	4–6
Honey	85·5	19	95	35	½	7–11

* This column may be read "Value compared with sugar as 100."
† Round.
‡ Less than a farthing.

APPENDIX G

TABLE FOR THE CONVERSION OF PERCENTAGES INTO OUNCES PER POUND

per cent.	oz. per lb.	per cent.	oz. per lb.	per cent.	oz. per lb.	per cent.	oz. per lb.	per cent.	oz. per lb.	per cent.	oz. per lb.	per cent.	oz. per lb.	per cent.	oz. per lb.	per cent.	oz. per lb.	per cent.	oz. per lb.
1	0·16	11	1·76	21	3·36	31	4·96	41	6·56	51	8·16	61	9·76	71	11·36	81	12·96	91	14·56
2	0·32	12	1·92	22	3·52	32	5·12	42	6·72	52	8·32	62	9·92	72	11·52	82	13·12	92	14·72
3	0·48	13	2·08	23	3·68	33	5·28	43	6·88	53	8·48	63	10·08	73	11·68	83	13·28	93	14·88
4	0·64	14	2·24	24	3·84	34	5·44	44	7·04	54	8·64	64	10·24	74	11·84	84	13·44	94	15·04
5	0·80	15	2·40	25	4·00	35	5·60	45	7·20	55	8·80	65	10·40	75	12·00	85	13·60	95	15·20
6	0·96	16	2·56	26	4·16	36	5·74	46	7·36	56	8·96	66	10·56	76	12·16	86	13·76	96	15·36
7	1·12	17	2·72	27	4·32	37	5·92	47	7·52	57	9·12	67	10·72	77	12·32	87	13·92	97	15·52
8	1·28	18	2·88	28	4·48	38	6·08	48	7·68	58	9·28	68	10·88	78	12·48	88	14·08	98	15·68
9	1·44	19	3·04	29	4·64	39	6·24	49	7·84	59	9·44	69	11·04	79	12·64	89	14·24	99	15·84
10	1·60	20	3·20	30	4·80	40	6·40	50	8·00	60	9·60	70	11·20	80	12·80	90	14·40	100	16·00

SECTION III. DIET

CHAPTER XVI

COMPUTATION OF DIETS

> Any man endowed with the arithmetical faculty of a tapster, might have solved this problem without difficulty, yet for an untaught computant, the gift of divination was essential.
>
> *Carlyle (Germ Romance).*

The requirements of the body under various circumstances and the composition and properties of different kinds of food have been discussed in previous chapters. It now remains to be seen how these two branches of knowledge can be unified, i.e., how the foods may be adapted to the requirements of the body under any given conditions. If the food be not properly adapted to the requirements either waste of food, or imperfect nutrition, or possibly both, may result.

For theoretical examination of the subject, it is necessary to go into considerable detail, and when calculations have to be made they may as well be made exactly. The results, however, must be interpreted very broadly, and, for practical purposes, a close approximation is usually sufficient. There is no absolute certainty regarding the fundamental units upon which all calculations must be based. Differences in individuals, questions of taste, pecuniary economy and other matters must all be taken into account.

The question of adjusting the quantities of foods so as to provide given amounts of nutrients may, however, be considered separately; and it is necessary to describe the methods by which the quantities may be computed before entering upon the discussion of diets from other points of view.

The composition of foods is not absolutely constant; but the averages in normal samples are near enough for practical purposes. The figures given in the appendices (p. 165 *et seq.*) are used throughout this section, and will be found there when not quoted in the text.

The difficulty of adjusting the quantities lies principally in the fact that the nutritive ratios of the foods do not correspond exactly with those of the diets. For example, the standard diet (p. 47) provides 3 oz. of protein and 2,800 kal. fuel value; but none of the common foods contain the nitrogenous and non-nitrogenous nutrients in exactly similar proportions (1–7). A pound of bread yields 1,215 kal., and $\frac{2{,}800}{1{,}215} = 2{\cdot}3$ lb. are, therefore, required to furnish 2,800 kal. But bread contains 9·2 per cent. of protein, i.e. $\frac{9{\cdot}2 \times 2{\cdot}3 \times 16}{100}$ $= 3{\cdot}4$ oz. in 2·3 lb., whereas only 3 oz. are required. The quantity of bread which contains 3 oz. of protein is $\frac{100 \times 3}{9{\cdot}2 \times 16} = 2{\cdot}04$ lb. But this quantity yields only $(1{,}215 \times 2{\cdot}04) = 2{,}479$ kal.—a deficiency of 321 kal. In short, since the N. ratio of the diet is 1–7, and that of bread is 1–6·1, they cannot be made to correspond. There must always be either an excess of protein or a deficiency of non-nitrogenous nutrients.

In the above case, in which the difference between the N. ratios is comparatively small, the conditions of the diet may be satisfied by the larger quantity (2·3 lb.) of bread, part of the total fuel value being derived from the excess of protein. When the difference between the N. ratios is wider, the excess or deficiency is, of course, greater. For instance, 1·9 lb. of dates (N.r. 1–40·1) yields 2,800 kal., but contains only 0·58 oz. of protein, leaving a very large deficiency. If 9·8 lb.—which contains 3 oz. of protein—were used, there would be a very large excess of non-nitrogenous nutrients.

Under ordinary circumstances the nutrients are not all derived from one, but, usually, from several different kinds of food; and discrepancies of the kind referred to may be avoided by combining them in such proportions that the deficiency of any ingredient in one food is compensated by the excess in another.

When not more than two different foods are involved, the N. ratio of one must be higher, and of the other lower, than that of the diet.[1] Take as a simple illustration the case of a diet in which the N. ratio is 1 to 7, and two foods, (*a*) and (*b*), in which the N. ratio is 1 to 6 and 1 to 8 respectively. It is evident that the excess in (*a*) is exactly equal to the deficiency in (*b*). But if the N. ratios of the

[1] In the special case in which the N. ratios of both foods are exactly the same as that of the diet, they may be combined in any proportion whatever.

foods were (*a*) 1 to 5 and (*b*) 1 to 8, the differences, as compared with the diet, would be (*a*) $7-5=2$, and (*b*) $7-8=-1$; the excess in (*a*) is twice as great as the deficiency in (*b*) and two parts of the latter must, therefore, be taken to one of the former.

The required proportions can, therefore, be found by comparing the N. ratios of the foods with that of the diet.[1]

Take the actual case of meat and potatoes: the N. ratio of the former (rump beef) is 1 to 3·32, and of the latter 1 to 8·29; and that of the diet is 1 to 7. The differences, therefore, are:—

$$7-3{\cdot}32=3{\cdot}68 \text{ and } 7-8{\cdot}29=-1{\cdot}29$$

If the foods contained the same percentages of protein they should be taken in that proportion, i.e. in the proportion of 3·68 parts of potatoes to 1·29 parts of meat, or 2·85 of the former to 1 of the latter.[2] As a matter of fact, however, the meat contains 13·8 per cent. of protein and potatoes only 1·8 per cent., i.e. 1 part of meat contains $7{\cdot}\dot{6}$ times as much protein as 1 part of potatoes; therefore $7{\cdot}\dot{6}$ times 2·85 [= 21·83] parts of potatoes must be taken to 1 of meat, for this particular diet. This may be put more tersely as follows:—

$$\frac{(7-3{\cdot}32)\times 13{\cdot}8}{(8{\cdot}29-7)\times 1{\cdot}8}=\frac{50{\cdot}78}{2{\cdot}32}=21{\cdot}88$$

This method of calculation may also be illus-

[1] Or thus, $\frac{8x+5}{x+1}=7 \therefore 8x+5=7x+7 \therefore 8x-7x=7-5 \therefore x=2.$

[2] $\frac{8{\cdot}29x+3{\cdot}32}{x+1}=7 \therefore 8{\cdot}29x+3{\cdot}32=7x+7 \therefore 1{\cdot}29x=3{\cdot}68 \therefore x=2{\cdot}85$

trated graphically, as follows. If the percentages of protein and non-nitrogenous nutrients be plotted respectively on the axes *OY* and *OX*, a line *ON* may be drawn representing the N. ratio 1 to 7, and

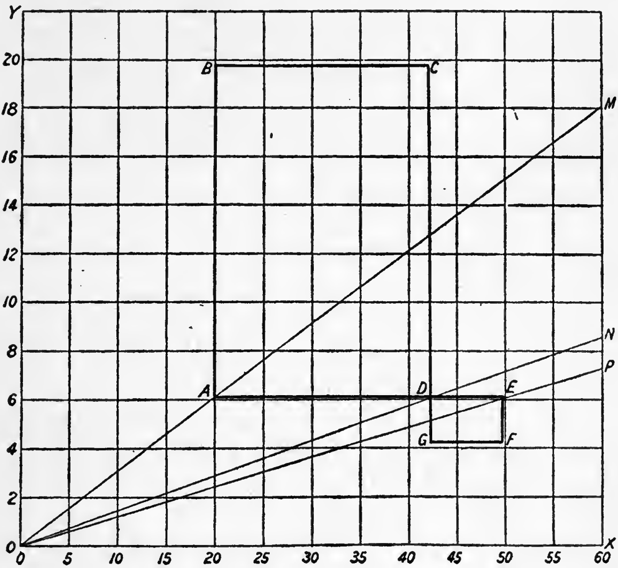

Fig. 13.

two others, *OM* and *OP*, representing the ratios of the meat (1 to 3·3) and potatoes (1 to 8·2) respectively. If any straight line *AE* be now drawn to cut the ratio lines, the two portions, *AD* and *DE*, will represent the differences between the N. ratios of the foods and that of the diet. Through *D* draw *CG* at right angles to *AE*, and cut off *DC* equal to the percentage of protein in the meat, and *DG* equal to the percentage of protein in potatoes; the areas of the completed rectangles, *ABCD* and *DEFG*, represent the relative proportions of the two foods required to produce a diet having an N. ratio of 1 to 7. The figure may be drawn on squared paper, and the areas of the rectangles computed from the number of squares in each. The method, however, is only suitable for purposes of demonstration.

Having found the relative proportions of the foods which produce a given N. ratio, the actual quantities, which together contain specified amounts of nutrients, are easily ascertained. Thus, in the above example we have :—

$$x\{(21{\cdot}83 \times 0{\cdot}018) + (1 \times 0{\cdot}138)\} = 3 \text{ oz.}$$

$$0{\cdot}53x = 3 \quad \therefore \quad x = 5{\cdot}65 \text{ oz.}$$

$$21{\cdot}83 \times 5{\cdot}65 = 123{\cdot}34 \text{ oz.} = 7{\cdot}7 \text{ lb.}$$

These quantities, 7·7 lb. of potatoes and 5·65 oz. of meat, together contain 3 oz. of protein and (the ratio being 1 to 7) 21 oz. of total non-nitrogenous nutrients.

When the relative proportions are not required, the actual quantities may be calculated directly.

The differences between the N. ratios of the foods and that of the diet are respectively :—

$$7 - 3{\cdot}32 = 3{\cdot}68 \text{ and } 7 - 8{\cdot}29 = -1{\cdot}29$$

making a total difference between the N. ratios of the foods of $3{\cdot}68 + 1{\cdot}29 = 4{\cdot}97$ (or $8{\cdot}29 - 3{\cdot}32 = 4{\cdot}97$), i.e. out of 4·97 parts of protein 3·68 parts come from potatoes and 1·29 parts from meat; how much out of 3 parts?

$$\frac{3{\cdot}68 \times 3}{4{\cdot}97} = 2{\cdot}22 \quad : \quad \frac{1{\cdot}29 \times 3}{4{\cdot}97} = 0{\cdot}78$$

but 100 oz. of potatoes contain 1·8 oz. of protein; how much contains 2·22 oz.? and similarly for the meat.

$$\frac{100 \times 2{\cdot}22}{1{\cdot}8} = 123{\cdot}34 \quad : \quad \frac{100 \times 0{\cdot}78}{13{\cdot}8} = 5{\cdot}65$$

The whole calculation may be given in more condensed form thus :—

$$\frac{(7 - 3{\cdot}32) \times 3 \times 100}{(8{\cdot}29 - 3{\cdot}32) \times 1{\cdot}8} = 123{\cdot}34 \quad \frac{(8{\cdot}29 - 7) \times 3 \times 100}{(8{\cdot}29 - 3{\cdot}32) \times 13{\cdot}8} = 5{\cdot}65$$

Those who have a knowledge of elementary mathematics will have perceived that problems of this kind may be solved by the method of simultaneous equations. It is, perhaps, simpler than the purely arithmetical process, the reasons for the successive steps are more clearly apparent, and as the trick of solving these equations is easily acquired without previous knowledge of algebra, the method may be briefly described.

Take the same example as before: how much meat and potatoes are required to furnish a diet containing 3 oz. of protein and 21 oz. of non-nitrogenous nutrients? The proportions of protein are 13·8 per cent. in the meat and 1·8 per cent. in potatoes; and of the non-nitrogenous nutrients, 45·85 per cent. in meat and 14·927 in potatoes.

The quantities of the foods are to be such that the protein in one plus the protein in the other will amount to 3 oz.; and the non-nitrogenous nutrients in one plus that in the other will amount to 21 oz. If the unknown quantities of potatoes and meat be respectively denoted by the symbols x and y, the proposition may be stated as follows :—

$$0{\cdot}018x + 0{\cdot}138y = 3 \quad : \quad 0{\cdot}14927x + 0{\cdot}4585y = 21$$

In order to eliminate one of the terms, x, we may divide[1] these two equations by the co-efficient of x in each and then subtract one equation from the other, thus :—

by division, $x+7\cdot\dot{6}y=166\cdot\dot{6}$: $x+3\cdot07y=140\cdot75$
by subtraction, $4\cdot59y=25\cdot91$
again by division, $y=5\cdot64$.

The term y may be eliminated and the value of x found in a similar manner, i.e. by dividing the equations by the co-efficients of y in each and then subtracting one from the other as before. But when the value of y is known, that of x may be found more readily by substituting the value of y in either of the two original equations or in those derived from them, thus :—

$$x+3\cdot07y=140\cdot75 \ : \ y=5\cdot64$$
$$x=140\cdot75-(3\cdot07\times5\cdot64)=123\cdot4$$

If fuel values be given instead of total non-nitrogenous nutrients, the equations may be stated and worked out in the same way; but as the fuel values are given in kal. per lb. of food, the protein must also be expressed in similar terms, i.e. as oz. per lb. of food. Percentages $\times$ 0·16 = oz. per lb. will be found in the appendix Table G.

Keeping to the same example, we have :—

$0\cdot288x+2\cdot208y=3$: $310x+1110y=2800$
by division $x+7\cdot\dot{6}y=10\cdot416$: $x+3\cdot58y=9\cdot032$
by subtraction $4\cdot08y=1\cdot39$ ∴ $y=0\cdot34$ lb. $=5\cdot44$ oz.
$31x+111y=280$: $y=0\cdot34$
by substitution $31x=280-(111\times0\cdot34)$
$=242\cdot26$ ∴ $x=7\cdot8$ lb.

[1] The term x may also be eliminated from two simultaneous equations by multiplying the first equation by the coefficient of x in the second, and the second equation by the coefficient of x in the first, and then subtracting as above.

The relative proportions of the foods may be found in a similar manner. In order to obtain x and y in terms of each other, the numerical terms must be eliminated, i.e. the equations must be divided by the numerical terms as shown in the following example :—

$$1{\cdot}8x+13{\cdot}8y=3 \; : \; 14{\cdot}927x+45{\cdot}85y=21$$
$$\text{by division} \quad 0{\cdot}6x+4{\cdot}6y=1 \; : \; 0{\cdot}71x+2{\cdot}18y=1$$
$$\text{by subtraction} \quad 0{\cdot}11x-2{\cdot}42y=0 \;\therefore\; x=22y$$

i.e. the proportion is 22 parts of potatoes to 1 of meat.

Two foods can be combined only in one proportion to satisfy any given conditions. If there be more than two foods they can be combined in an indefinite number of different proportions; but there are limits to the amount of each food that can be used along with the others.

When three different foods are included in the diet, the N. ratio of one must be higher, and that of another lower than that of the diet. The N. ratio of the third food may be either higher or lower. Thus it may happen either that the N. ratios of two of the foods are higher, and of one lower than that of the diet, or vice versa. The foods may be grouped accordingly, and there will always be two in one group, and one in the other.

For example, if the N. ratio of the diet be 1 to 7 and those of the foods (*a*) 1 to 5, (*b*) 1 to 6 and (*c*) 1 to 8 respectively, the differences,[1] compared with the diet are :—

$$7-5+7-6=3 \text{ and } 7-8=-1$$

It is evident, therefore, that 1 part of (*a*) plus 1

[1] Or $\dfrac{8x+5+6}{x+2}=7 \;\therefore\; x=3.$

part of (*b*) plus 3 parts of (*c*) would give the N. ratio required. In this case (*a*) and (*b*) are taken in equal proportions; if they were taken in any other proportion—as they might be—the proportion of (*c*) would also be different; and an indefinite number of combinations can thus be found to satisfy the conditions. Some of them are shown in the following table:—

a . . .	2	1·5	1	0·5	0
b . . .	0	0·5	1	1·5	2
c . . .	4	3·5	3	2·5	2

It will be seen that as the proportion of (*a*) increases that of (*b*) diminishes, and vice versa; also that each is maximum when the other is zero; (*c*) reaches the maximum when (*b*) is zero, and the minimum when (*a*) is zero, because the N. ratio of (*b*) is lower than that of (*a*); but (*c*) is never zero, i.e. the diet can be compounded from *a* and *c* or *b* and *c*, but not from *a* and *b*.

To take an actual case, it is required to compound a diet from three different foods, the data being as follows:—

	Meat.	Potatoes.	Bread.	Diet.
Protein .	2·208 ..	0·288 ..	1·47 ..	3 oz.
Fuel value	1,110 ..	310 ..	1,215 ..	2,800 kal.
N. ratio .	1—3·3 ..	1—8·3 ..	1—6·1 ..	1—7

Since the N. ratio of potatoes is lower than that of the diet, and those of the other two foods are higher, the quantity of potatoes cannot fall to zero, but that of each of the others may do so. Since the N. ratio of bread is lower than that of meat, the quantity of potatoes will be maximum when bread is zero and minimum when meat is zero. These values are easily calculated as follows :—

$$0{\cdot}288x+2{\cdot}208y=3 \ : \ 310x+1110y=2800$$
$$x=7{\cdot}82 \text{ and } y=0{\cdot}34$$
$$0{\cdot}288x+1{\cdot}47y=3 \ : \ 310x+1215y=2800$$
$$x=4{\cdot}47 \text{ and } y=1{\cdot}16$$

i.e. meat may be taken in any quantity from 0 up to 0·339 lb., and bread from 0 up to 1·16 lb.; but the quantity of potatoes must be not less than 4·47 lb. or more than 7·82 lb.

If the quantity of any one of the foods be fixed —arbitrarily or otherwise—the quantities of the other two foods that must be used along with it are thereby determined and can easily be calculated. For example, let the quantity of meat be fixed at $\frac{1}{4}$ lb., then we have

$$\cdot288x+1{\cdot}47y+\frac{2{\cdot}208}{4}=3 \ : \ 310x+1215y+\frac{1110}{4}=2800$$
$$\cdot288x+1{\cdot}47y=3-0{\cdot}552 \ : \ 31x+121{\cdot}5y=280-27{\cdot}75$$
$$\cdot288x+1{\cdot}47y=2{\cdot}448 \ : \ 31x+121{\cdot}5y=252{\cdot}25$$
$$x=6{\cdot}91 \text{ and } y=0{\cdot}305$$

When $\frac{1}{4}$ lb. of meat is specified, the quantities are 6·91 lb. of potatoes and 0·305 lb. of bread.

If 5 lb. potatoes had been specified instead of $\frac{1}{4}$ lb. of meat, the equations would have been :—

$$1{\cdot}47x+2{\cdot}208y+(0{\cdot}288\times5)=3 \ : \ 1215x+1110y+(310\times5)=2800$$
$$1{\cdot}47x+2{\cdot}208y=1{\cdot}56 \ : \ 1215x+1110y=1250$$
$$x=0{\cdot}98 \text{ and } y=0{\cdot}054$$

i.e. 5 lb. potatoes, 0·98 lb. bread, and 0·054 lb. of meat would give the diet required.

The following tabulated statement of the results obtained above shows how the proportions of the three foods vary in the cases considered :—

Potatoes . . .	4·47 ..	5·0 ..	6·91 ..	7·82
Bread	1·16 ..	0·98 ..	0·305 ..	—
Meat	— ..	0·054 ..	0·25 ..	0·34

Four different foods can be combined in an indefinite number of ways to satisfy any given conditions; but the N. ratio of one of them must be higher, and of another lower, than that of the diet. The N. ratios of both the remaining foods may be higher, or they may be lower than that of the diet; or the N. ratio of one of them may be higher, and of the other lower. In the last case, the foods can be arranged in pairs, i.e. in two groups of 2; in either of the two previous cases they can be arranged in two groups of 1 and 3.

For example, if the N. ratio of the diet be 1 to 7, that of one of the foods 1 to 4, and that of another 1 to 10; the N. ratios of the other two foods might be higher than that of the diet, viz. 1 to 5 and 1 to 6 respectively; or they might be lower, viz. 1 to 8 and 1 to 9 respectively; or the N. ratio of one might be higher, viz. 1 to 5, and of the other lower, viz. 1 to 9. In each case the foods might be arranged in two groups as follows:—

(*a*) (1 to 4, 1 to 5, 1 to 6) and (1 to 10).
(*b*) (1 to 4) and (1 to 8, 1 to 9, 1 to 10).
(*c*) (1 to 4, 1 to 5) and (1 to 9, 1 to 10).

In each case, the deficiency of any ingredient in one group is to be compensated by the excess in the other. But the foods, in each group that contains more than one, can be taken in an indefinite number of different proportions, and the quantities of the food, or foods, in the other group will vary accordingly.

The minimum quantity of any food in a group which contains 3 is zero; and that food reaches its maximum when the other two are zero. The quantity of any food in a group which contains only 1 can never fall to zero; but it reaches the minimum when combined with that one of the three which has the nearest N. ratio; and it reaches the maximum when combined with that one of which the N. ratio differs most from its own. For example, in (*a*) the maximum quantity of food which has a N. ratio of 1 to 10 is that which can be combined with the food which has a N. ratio of 1 to 4; and the minimum, that which can be combined with the food which has a N. ratio of 1 to 6.

If there be two foods in each group—arranged as in (*c*)—the quantity of any one of them may be zero, and that of the other will then be maximum.

If the quantities of any two of the foods—out of four—be fixed, the quantities of the other two are thereby determined and can easily be calculated as before.

In practice it very often happens that the quantity of some one or more of the foods is limited by reason of its cost, by custom, appetite, or other circumstance. Certain foods, also, are naturally associated together, e.g. meat and potatoes, bread and butter, rice and milk, and so on. As a rule, no difficulty is experienced in making whatever calculations are required.

CHAPTER XVII

NATIONAL DIETS

> At this day in China, the common people live in a manner altogether on roots and herbs, and to the wealthiest, horse, ass, mule, dogs, catflesh, is as delightsome as the rest. The Tartars eat raw meat, and most commonly horse-flesh, drink milk and blood, as the Nomads of old. They scoff at our Europeans for eating bread, which they call tops of weeds and horse meat, not fit for men. In Scandia their bread is usually dried fish, and so likewise in the Shetland isles; and their other fare, as in Iceland, saith Dithmarus Bleskenius, butter, cheese and fish. In Westphalia they feed most part on fat meats and wourts, knuckle deep, and call it *cerebrum Iovis*: in the low countries with roots, in Italy frogs and snails are used.
>
> *Burton's* "*Anatomy of Melancholy.*"

In all civilized countries, the food of the people consists, broadly, of meat, cereals, and fresh fruits and vegetables. Climatic and economic conditions, the habits and tastes of the people, and a variety of other circumstances, however, cause the inhabitants of different countries to use these various kinds of food in very different proportions; certain foods enter much more largely into the diet of some than of others.

The staple food of the English, and most other Europeans, is wheat. Asiatics depend more largely upon rice, and others upon lentils, dates, bananas, etc. The Scots use more oatmeal, and the Irish more potatoes, than the corresponding classes in England.

Such staple or principal foods are often spoken of as constituting the national diet of the peoples in question. In no case, however, do the people of any country exist exclusively upon any particular kind of food; nor is the use of any of the more important food stuffs entirely confined to any one country. The means of communication are now so well established that the principal products of every country can be obtained in nearly every other, and the demand for variety causes them to be used in larger or smaller quantities.

It is sometimes assumed, because certain peoples exist, or even thrive, on a diet largely composed of certain kinds of food, that these foods are peculiarly nourishing, or that they are peculiarly suited to the climatic conditions and requirements of the people. Such generalizations must, however, be accepted with considerable reserve.

People who live in the higher latitudes generally consume more animal foods than those who live nearer to the equator; but it does not follow that they require more, or that vegetable foods are more suitable for the inhabitants of the warmer regions. Vegetable products are generally scarcer in the colder climates, and the people are, therefore, compelled to depend more upon animal foods. Men soon become accustomed to the kind of food they can most easily procure, and generally prefer the kind of food they are accustomed to. Individuals to whom the common food of the country is not agreeable could not survive; and it is possible that, after countless generations, the inhabitants of different regions may have become slightly differentiated in respect of their capacity for certain kinds of food.

The Eskimos consume large quantities of seal blubber; but there is no reason to believe that this particular fat is peculiarly nourishing or specially suitable for these people. Living, as they do, in a very cold climate, they require a diet which has a higher fuel value than is necessary for people in more temperate zones; and fat contributes more to the fuel value than an equal weight of any other constituent of the food. There is no doubt that the fat might be, in part, replaced by carbohydrates; but in a climate where there is practically no vegetation, these are not available.

It is worth while to examine some of those staple and principal foods which constitute the so-called national diets, from various points of view, and to consider to what extent they may enter into a mixed diet, and what relation they bear to the question of pecuniary economy.

It has been shown that, in general, the N. ratios of the foods do not correspond exactly with those of the diets, and that, consequently, the largest quantity of any food that can, theoretically, be used with economy is that which supplies exactly the amount of one of the nutrients, and leaves a deficiency of the others to be supplied from another source. The importance of variety, however, is such that it would be inexpedient, even if it were practicable—which it is not—to derive the whole of either kind of nutrient from a single food. It is impossible to lay down any absolute general rule on this important point; but the author would suggest that the largest quantity of any food that is regularly used should not exceed two-thirds of the theoretic maximum, and, if possible, it should not be more than half that amount. In plain language, not more than two meals out of three should be " bread and butter " meals, and, if possible, the proportion should be even less.

The term bread is often used as a synonym for food, e.g. " daily bread," and the fact is significant of the general importance of bread as an article of diet. The prominent position which bread occupies in the diet of the people has been greatly emphasized by the recent history of political agitation in this country.

Bread, in the commoner and strictly limited sense of the term, is usually made from wheat flour. Other cereals are used, but the products are generally distinguished as rye bread, barley bread, etc. (see p. 107). When no qualification is used, the term bread is to be understood as referring exclusively to ordinary wheaten bread.

One pound of bread, as commonly baked in this country, contains about 1½ oz. of protein, and has a fuel value of 1,215 kal. The non-nitrogenous nutrients, amounting to some 56 per cent., consist almost entirely of starch ; and appetite prompts people to combine with their bread a certain amount of fat, usually in the form of butter. Butter is almost invariably used where bread forms the sole or principal part of the meal. The quantity used varies from about 1 to 3 oz. of butter per lb. of bread ; 2 oz. may be regarded as a fair average allowance. The amount of protein in 2 oz. of butter is negligible, but the fuel value, 450 kal., must be added to that of the bread.

The diet for a man of average size, doing hard work, was estimated (p. 55) at 4 oz. of protein and 3,600 kal. About 39 oz. of the combined food—bread and butter—would furnish the whole fuel value; but, it has been said, not more than two-thirds of this theoretic maximum, i.e. 23 oz. of bread and 3 oz. of butter, should be regularly used.

Taking the price of bread at 1½*d.* per lb., and of butter at 1*s.* per lb., or ¾*d.* per oz., the cost of the quantities given above would be 2¼*d.* for each or 4½*d.* per day for the combined food supplying two-thirds of the fuel value, but less than two-thirds of the protein, of the diet. It will be noticed that the butter costs as much as the bread, though it supplies less than a third of the total fuel value and none of the nitrogen.

Bread and butter enters into the diet of single women, seamstresses, etc., perhaps more largely than of any other class. Some of these people, indeed, subsist almost entirely on this food. The diet of a woman of average size, living a sedentary life, should contain about 2½ oz. of protein and have a fuel value of 2,340 kal. About 26 oz. of bread contain the required amount of protein; but, when combined with the appropriate amount of butter (3·3 oz.), this would supply an excess of non-nitrogenous nutrients, and the cost would amount to nearly 5*d.* per day.

Two-thirds of the fuel value of the diet could be obtained from 14 oz. of bread and 1¾ oz. of butter at a cost of 2½*d.* per day. This would contain less than two-thirds of the required amount of protein; but as it would cost only half as much as the complete diet of bread and butter, the difference, 2½*d.* per day, would be available to provide a third meal of a different and, possibly, more nitrogenous character, at the same total cost.

The excess of non-nitrogenous nutrients in the larger quantity of bread and butter would, of course, be available either for additional work or fattening, but, if not required for these purposes, it must be regarded as wasted. Besides, an unvaried diet of bread and butter is objectionable on other grounds. It tends to produce constipation and loss of appetite, especially in those who live sedentary lives. On such a diet the individual would probably not eat enough to provide all the protein required, and loss of weight would result.

Oatmeal is not so extensively used as wheaten bread. Many people dislike the taste of it, and others complain that it does not agree with them. It has a slightly laxative effect, but this property is less noticeable when it is very finely ground. The price is about the same as that of bread, but it contains more protein and has a higher fuel value.

One pound of oatmeal contains about 2½ oz. of protein, and has a fuel value of 1,860 kal. About 1½ lb., therefore, would supply all the protein—but not the fuel value—required in the diet of an average working man; and two-thirds of this amount or 1 lb. per day is the most that should be regularly used. Some of the labourers in the country districts in Scotland may eat as much as this in one form or another; but the working men in towns probably do not consume more than half that amount, and many of them not more than ¼ lb. Four oz. of oatmeal makes a moderate dish of porridge, and 8 oz. is a large quantity to be consumed at one time.

Porridge is generally eaten with either milk or sugar. The quantities commonly used are about $\frac{1}{2}$ pt. of the former, or from 1 to 2 oz. of the latter to, say, 6 oz. of oatmeal. Since the N. ratio of oatmeal is higher than that of the diet, sugar is obviously the more suitable, and it is certainly much cheaper than milk.

Oatmeal is also used in the form of oat cakes, but these generally include a certain amount of either fat or sugar, or sometimes both. The proportion of fat commonly used is from 1 to 2 oz. per lb. of meal.

Consider the case of a man who eats 10 oz. of oatmeal daily; 8 oz. as porridge and 2 oz. as oat cakes. Including the milk ($\frac{1}{2}$ pint) taken with the former and the fat in the latter, this would contain altogether nearly 2 oz. of protein and have a fuel value of 1,410 kal., i.e. half the amount of protein, but less than half the fuel value required. The cost works out at $2\frac{1}{4}d.$ per day, or nearly 1*s.* 4*d.* per week.

The half-pint. of milk costs 1*d.* or nearly as much as the oatmeal, though it contains less than one-fifth of the nutrients. If 2 oz. of sugar were substituted for the milk, the combined food would furnish 1·6 oz. of protein and 1,450 kal. at a cost of $1\frac{1}{2}d.$ per day or $10\frac{1}{2}d.$ per week. This, it will be seen, is not only cheaper, but more economical.

For an expenditure of $2\frac{1}{4}d.$ on bread and butter, only 1 oz. of protein and 1,100 kal. could be obtained; and for $1\frac{1}{2}d.$ only $\frac{3}{4}$ oz. of protein and 732 kal. If, therefore, porridge and milk, or porridge and sugar, be substituted for one of the bread and butter meals, the same amount of nourishment can be obtained for a smaller expenditure, and the advantages of variety are secured at the same time.

Potatoes contain a large amount of water and a comparatively small amount of nutrients. Much larger quantities of potatoes than of cereals are, therefore, required to satisfy any given conditions. A pound of potatoes contains about 0·29 oz. of protein and has a fuel value of 310 kal., so that about 11½ lb. would be required to furnish 3,600 kal. The quantities consumed by average individuals in this country are very much less than two-thirds of that amount. Generally, in families where potatoes are eaten only at one meal, which also includes meat and pudding, the average allowance is about 1 lb. per day for each adult. When potatoes are eaten at all three meals, as is common amongst the farmers and working classes in Canada, from 2 to 3 lb. per day may be consumed by each man. Still larger quantities are consumed by the peasants in some parts of Ireland, but probably never as much as 7 lb. per day.

The non-nitrogenous nutrients of potatoes consist almost entirely of starch, and a quantity of butter, or other fat, is often used along with them. This, no doubt, makes them more palatable, but the practice is economically unsound, because the N. ratio of potatoes is lower than that of the diet, and it is protein rather than non-nitrogenous nutrients that should be added.

Many housekeepers believe that when potatoes are mashed or beaten, people eat more of them, and that the process is, therefore, an extravagant one. It is obvious, however, that the mere fact of crushing the potatoes cannot affect the amount of nourishment in them; and that, if people eat more in that condition they will eat—or, at least, they will require—correspondingly less of other foods.

Taking the price of potatoes at ½*d.* per lb., 1½*d.*

would purchase 3 lb.; this quantity contains 0·87 oz. of protein and has a fuel value of 930 kal. It appears, therefore, that the amount of nourishment in a diet of potatoes is less than that in the oatmeal, but more than that in the bread and butter which can be obtained for a similar expenditure.

Meat, in this connexion, is a very indefinite term. It includes all the different cuts of various animals; and these, it has been shown, vary widely in composition and price. A lb. of beef round contains about 3 oz. of protein and has a fuel value of 900 kal. This quantity would, therefore, contain sufficient protein, but has only about one-third of the fuel value required for a sedentary diet, and 4 lb. would be required to furnish the diet of a working man.

The diet of normal individuals, of course, is never composed entirely of meat, but that of diabetic patients sometimes is. Such persons should choose the fattest kinds of meat obtainable, e.g. rump or flank of beef, loin or breast of mutton, bacon, etc. In this way the fuel value might be obtained from about 2 or 3 lb. of such meats—there would always be a certain excess of protein—at a cost of say 2*s.* 1*d.* per day (2½ lb. at 10*d.*) or 14*s.* 7*d.* per week.

A mixed diet, for a normal individual, should not include, at the outside, more than 1 lb. to 1½ lb. of meat of all kinds, including bone and unedible matter, as purchased. Such a quantity could only be used by persons to whom expenditure is a secondary consideration. A similar amount of nourishment can be obtained at much less cost in other forms.

It was suggested (p. 201) that if two meals per day consist of bread and butter, the third should be of a different character, e.g., meat and potatoes, and that this could be obtained at about the same total cost as a diet made up entirely of the former. Taking the price of beef round at 8*d.* per lb., 2 oz. could be purchased for 1*d.* and 2 lb. of potatoes for another 1*d.* Adding 1 lb. of bread and 2 oz. of butter, the whole diet would be as follows :—

	Protein.	Fuel Value.	Cost.
	oz.	Kal.	*d.*
2 lb. potatoes . . .	0·58	620	1
1 ,, bread . . .	1·50	1,215	1½
2 oz. meat . . .	0·38	112	1
2 ,, butter . . .	—	450	1½
Total	2·46	2,397	5

The whole diet, it will be seen, contains almost exactly the amounts of nutrients required by a woman living a sedentary life ; and the cost of the food is no more than that of a diet consisting entirely of bread and butter. It would, however, cost rather more to cook it.

Other diets, e.g., the Oriental's diet of rice, the so-called Manx national diet of potatoes and herring, etc., may be investigated in a similar manner.

CHAPTER XVIII

FAMILIAR DIET

> C— holds that a man cannot have a pure mind who refuses apple dumplings.
>
> *Essays of Elia.*

Of all branches of the subject embraced under the title Economy of Food, there is, perhaps, none of greater general interest than the question of ways and means. For pecunious persons this question practically does not exist. They select such foods as appeal to their tastes, and eat as much as they want. Under these circumstances, the nutrients are nearly always in excess of the requirements, and need not be checked except in cases of obesity or other trouble.

When the income is small and the margin narrow, the problem of ways and means becomes a very important one. It acquires, perhaps, its highest degree of interest when considered with reference to the diet of families, and examination of it from this point of view helps to illuminate the whole subject.

The diet of any group of persons should be such as to satisfy the requirements of all the members. In the case of a family these are extraordinarily diverse, because, in general, the family consists of several persons of both sexes and of various ages and occupations.

The subject can only be investigated from the point of view of the requirements of given individuals which, for present purposes, may be taken to be those of the standard diet (p. 47). To ascertain the requirements of a family, those of working men may be taken as 1·3 times, and of women 0·85 times, the standard diet; the factors for children are 0·25 under five years of age; 0·5 from five to ten years; and 0·75 from ten to fifteen years. The approximation is, in each case, a very rough one; but, having regard to what is customary and practicable, it is probably near enough for ordinary purposes.

For example, suppose a family to consist of eight persons, viz., the father (a working man), mother, son aged 17 (a clerk), daughter aged 16 (a milliner), and four children, aged 12, 8, 6 and 3 years respectively; the total requirements of the family would be found as follows:—

1 working man		=	1·3 men.
1 (standard) man . . .		=	1·0 ,,
2 women, . . .	2 × 0·85	=	1·7 ,,
4 children—			
(10–15 yrs.) .	1 × 0·75	=	0·75 ,,
(5–10 ,,) .	2 × 0·50	=	1·00 ,,
(–5 ,,) .	1 × 0·25	=	0·25 ,,
Total		=	6·00 men.

The total requirements of the family would, therefore, be the same as those of six men leading sedentary lives, or six times the standard diet, i.e. $3 \times 6 = 18$ oz. of protein, and $2,800 \times 6 = 16,800$ kal. per day.

The question of means and the apportionment of the same is a very difficult one. From data obtained by Mr. Charles Booth [1] in the course of his sociological investigations in London, the author has formulated the hypothesis that a man earning 25*s.* per week might expend about 15*s.* on food. If he had a wife and two children, of whom the combined requirements were equal to those of two men, the total requirements of the family would be the same as those of three men. In such a case the mean expenditure for food would be at the rate of 5*s.* per (man) head. At all events, this case may be considered, and the problem to be investigated is how the money could be most profitably expended, having regard to the requirements and the natural desire for such luxuries as could be obtained within the prescribed limits.

It was shown in the last chapter that a diet consisting exclusively of meat would cost about 14*s.* per week; if the nutrients were derived entirely from vegetable products—cereals, potatoes, etc.—the cost would only amount to some two or three shillings per week. It is clear, therefore, that 5*s.* per week would not cover the cost of a diet consisting exclusively of meat; but as that sum is more than sufficient for one consisting wholly of vegetable products, a certain amount of the former may be included.

How much of the 5*s.* may be spent on meat, and how much must be spent on vegetable foods depends upon the composition and cost of each. A simple calculation [2] will show that if the latter consisted entirely of wheat flour, as much as 3*s.* 6*d.*

[1] *Life and Labour of the People*, p. 133.

[2] Since the meat contains excess of protein, the fuel values alone need be considered; and the conditions are

might be devoted to the purchase of meat; but if it consisted entirely of potatoes, not more than 3*s.* would be available for this purpose. In each case, if more were spent on meat, either the amount of nutrients would be insufficient, or the total cost (5*s.*) would be exceeded. If less were spent on meat, either there would be excess of nutrients, or the whole sum would not be expended, and there would be a margin available for the purchase of fruit and other luxuries.

In practice, the food would not be of the uniform character assumed above. The vegetable portion would probably include at least 1 lb. of bread and from 1 to 2 lb. of potatoes per day. This would create a demand for butter, and probably a part of the meat would be in the form of bacon. These modifications would not only give variety to the food, but would also substantially increase the fuel value and still leave an excess of protein. This may be exemplified as follows :—

---

(1) that the fuel value of the meat plus that of the flour shall be together equal to 2,800 kal. per day; (2) that the cost of the meat plus that of flour shall be together equal to 5*s.* per week, or 8·57 pence per day. Taking the cost of meat at 8*d.* per lb., and of flour at 2*d.* per lb., these two propositions may be expressed in the following equations :—

$1040x + 1645y = 2800 \ : \ 8x + 2y = 8{\cdot}57.$

$x = 0{\cdot}767$ lb. of meat and $y = 1{\cdot}218$ lb. of flour per day.

$0{\cdot}767 \times 7 \times 8 = 42{\cdot}95$ pence $=$ 3*s.* 7*d.* per week for meat.

$1{\cdot}218 \times 7 \times 2 = 17{\cdot}05$,, $=$ 1*s.* 5*d.* ,, ,, flour.

Food (per week).	Cost.		Protein.	Fuel Value.
	s.	d.	Oz.	Kal.
7 lb. bread, at 1½*d*. . .	0	10½	10·3	8,505
15 ,, potatoes, at ½*d*. .	0	7½	4·3	4,650
2 ,, flour, at 2*d*. . .	0	4	3·6	3,290
3 ,, meat, at 8*d*. . .	2	0	7·1	3,120
1 ,, bacon, at 8*d*. . .	0	8	1·5	2,795
½ ,, butter, at 1*s*. . .	0	6	—	1,802
Total	5	0	26·8	24,162
Requirements . .	—		21·0	19,600

Thus arranged, the food contains considerable excess both of protein and of non-nitrogenous nutrients, and further modifications are, therefore, both possible and desirable.

In families, especially in those which include young children, milk and sugar, rice, sago and sometimes oatmeal would probably be used. The substitution of jam or treacle for part of the butter would not necessarily have much effect upon either the cost or the nutritive value of the whole ration. Fruit and fresh vegetables should be used; but they are at once relatively expensive and deficient in nutrients, and probably not more than about 1*d*. per day could be spared for this item out of 5*s*. per week. The other items might be adjusted as follows :—

Food (per week).	Cost.			Protein.		Fuel Value.	
	s.	*d.*		Oz.		Kal.	
5 lb. bread .	0	7½		7·4		6,075	
7 ,, potatoes.	0	3½		2·0		2,170	
1½ ,, oatmeal .	0	3		3·8		2,790	14525
1 ,, rice . .	0	2	2/1	1·3	14·5	1,630	
1 ,, sugar. .	0	2		—		1,860	
? ,, fruit . .	0	7		—		—	
2 ,, meat. .	1	4		4·7		2,080	
1 ,, bacon .	0	8		1·5		2,795	
½ ,, butter .	0	6	2/11¼	—	8·6	1,802	8,009
3½ pints milk .	0	5¼		2·4		1,332	
Total . .	5	0¼		23·1		22,534	

It will be noticed that, though three-fifths of the total cost of the ration is spent on animal products, more than two-thirds of the nutrients are derived from the vegetable foods. Nothing has been allowed for tea, which is not, properly speaking, a food; and on the other hand, the small amount of nutrients in the fresh fruit has been ignored. The nutrients are still in excess of the requirements; but, provided the expenditure is kept within the given limits, it is generally desirable that there should be a slight excess of nutrients so as to provide a margin for contingencies.

It should be remembered that this ration is for one man, and that, to find the ration for a family, the quantities of each item must be multiplied by the factors previously given (p. 207). In the case supposed, of a man with a wife and three children—the requirements of the woman and children being jointly equal to those of two men—the quantities would be three times those given above, and the cost would also be three times as great, viz. 15*s.* per week.

Five shillings per week is just a little over 8½*d.* per day, or, allowing three meals per day, a little less than 3*d.* for each meal. But the meat and fruit—the two most expensive items—are generally all consumed at one meal, which, therefore, costs more than the others. In some cases it may be necessary to allow as much as 4½*d.* for dinner, which leaves only 2*d.* each for breakfast and supper; but if the dinner can be contrived for 3½*d.* there will be 2½*d.* available for each of the other meals.

It is important that the N. ratio of each day's food should correspond as nearly as possible with that of the specified diet. The same rule applies—though not, perhaps, rigidly—to each separate meal. It is advisable, therefore, to use eggs, fish, bacon or meat and milk at each; but when all, or nearly all, the animal foods are consumed at one meal it is often impossible to adjust the N. ratios properly. Oatmeal, cheese and legumes are very useful in this connexion in cases where the margin of expenditure is very narrow.

The following is a possible way of dividing up the day's rations so as to provide sufficient nutrients (1 oz. of protein and 933 kal. fuel value) at each meal, without exceeding the stipulated cost.

BREAKFAST.

Food.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
4 oz. oatmeal	0·50	0·64	465
4 ,, bread	0·37	0·36	304
2 ,, sugar. . . .	0·25	—	232
3 ,, milk	0·23	0·11	57
½ ,, butter	0·37	—	112
	1·72	1·11	1,170

DINNER (1).

Food.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
4 oz. meat	2·0	0·60	260
2 lb. potatoes	1·0	0·58	620
½ ,, apples	1·0	0·02	110
	4·0	1·20	990

Or DINNER (2).

	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
4 oz. meat	2·00	0·60	260
1 lb. potatoes	0·50	0·29	310
½ ,, apples	1·00	0·02	110
2 oz. rice	0·25	0·16	204
4 ,, milk	0·30	0·14	76
1 ,, sugar	0·12	—	116
	4·17	1·21	1,076

SUPPER.

Food.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
½ lb. bread	0·75	0·73	608
2 oz. bacon	1·00	0·18	349
3 ,, milk	0·23	0·10	57
1 ,, sugar	0·12	—	116
	2·10	1·01	1,130

SUMMARY OF DAY'S RATIONS.

Food.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
Breakfast	1·72	1·11	1,170
Dinner (2)	4·17	1·20	1,076
Supper	2·10	1·10	1,130
	7·99	3·41	3,376
Total requirements	—	3·00	2,800

Arranged as above, the three meals contain about 10 per cent. more nutrients than is actually required. The total cost amounts only to 8*d.*; and if the dinner were as in (1) it would be actually a little less. On the other hand, if oatmeal were not used, breakfast might be the same as supper, but the cost would be thereby increased nearly to the limit.

The foregoing may be regarded as a typical example, but it is capable of almost infinite variation. Thus, beef, mutton, pork, lamb and veal may replace each other according to season and the taste of the individual. There are several different cuts of each, and they may be cooked in different ways. Poultry will probably be found too expensive for more than occasional use; but fish may be substituted for meat once a week or oftener. Rhubarb, gooseberries, cherries, strawberries, currants, plums, bananas, apples, pears, watermelons, tomatoes and oranges succeed each other throughout the year. Cherries, strawberries, and possibly also currants, will probably be found too expensive except in times of glut; but with supplies from abroad, the cheaper fruits have a long season. Figs, prunes, dates, dried currants and raisins, and also dried apples, may be used in the dead season if bottled or canned fruits are not available. In one way or another, a constant and changing supply of fruit may be maintained throughout the year.

From time to time it may be found convenient and desirable to substitute turnips, carrots, cabbage, or other fresh vegetables for fruit. Green peas, cauliflowers, onions, leeks, etc., are more expensive, but when served with white sauce or similar dressing, they may be substituted for the fruit and pudding. The rice, milk, sugar, and apples in dinner (2) cost 1·67 pence, contain 0·32 oz. of protein and have a fuel value of 506 kal. The cost and nutrients of a dish of cauliflower with white sauce are approximately as follows :—

	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
1 cauliflower (2 lb.) .	3·00	0·58	280
White sauce—			
1 oz. flour . . .	0·13	0·11	103
1 ,, butter . .	0·75	—	225
½ pint milk . . .	0·75	0·35	189
Total for 3 men .	4·63	1·04	797
Total for 1 man .	1·54	0·34	266

When pudding is used, the rice may be replaced by cornflour, arrowroot, sago or tapioca. These foods, however, are more expensive than rice; and as they are deficient in protein, they should be prepared with eggs or with a larger quantity of milk.

The point is chiefly of importance in connexion with the feeding of children. The N. ratio of the diet for young children should be rather higher than for adults. Nevertheless, there is a popular notion that children do not require much meat; they are often deprived of their fair share of the more nitrogenous items of the food, and given a larger dose of puddings and sweets. This may be agreeable to the taste of the youngsters, and at the same time satisfactory from a dietetic point of view, provided the concoction is a genuine *milk* pudding and not a mere starch pudding.

The use of eggs or additional quantities of milk adds to the cost of the dishes even more than the difference in the price of the cereal or farinaceous food. The cost and composition of a tapioca pudding prepared according to the cookery book [1] work out approximately as follows :—

TAPIOCA PUDDING
(*for* 5 *persons*).

Ingredients.	Cost.[2]	Protein.	Fuel Value.
	d.	Oz.	Kal.
3 oz. tapioca . . .	0·56	0·08	412
2 ,, butter . . .	1·50	—	451
¼ lb. sugar	0·50	—	465
1 qt. milk	3·00	1·40	757
4 eggs (say ½ lb.) . .	4·00	1·05	307
Total for 5 persons	9·56	2·53	2,392
For 1 person . .	1·91	0·51	478
For 1 penny. . .	1	0·26	250

The same authority gives, for a plain rice pudding, ½ lb. rice boiled soft and served with jam. This would work out as follows :—

PLAIN RICE PUDDING
(*for* 5 *persons*).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
½ lb. rice	1	0·64	815
¼ ,, jam . . .	1	—	232
Total for 5 persons.	2·0	0.64	1,047
Total for 1 person .	0·4	0·13	209
Total for 1 penny .	1	0·32	523

[1] Mrs. Beeton.

[2] The cost is calculated from the prices given in previous chapters and does not correspond with the cookery book estimate.

The tapioca pudding contains nearly four times as much protein and has twice the fuel value of the plain rice pudding, but it costs nearly five times as much. For 1*d.* the plain rice pudding yields 0·32 oz. of protein and 523 kal., whereas for the same sum the tapioca pudding yields only 0·26 oz. protein and 250 kal. Prepared as above, the tapioca pudding is doubtless the more palatable, and it is certainly the more nutritious and more expensive of the two. If the tapioca in the above recipe were replaced by 3 oz. of rice, the resulting pudding would be slightly more nutritious and less expensive than the tapioca pudding.

There is, of course, an almost endless variety of other puddings, but they may all be referred to one or other of two types, viz. (1) those in which the fundamental substance is wheat flour, or flour and fat, and (2) those in which it is bread.

Puddings made chiefly of wheat flour may be divided into (*a*) the so-called batter puddings, e.g. Yorkshire pudding and the sweetened varieties of the same, and (*b*) the dough puddings, e.g. dumplings, rolypoly, etc. The "boiled pastry" for beefsteak pudding belongs to the last variety.

Bread puddings are, as a rule, much alike so far as the fundamental substance is concerned; they differ chiefly in regard to the fruity element that is incorporated. The latter usually consists of currants, raisins, figs or dates, but jam, marmalade, or treacle may be substituted for the same.

The following analyses show the approximate cost and composition of some of these concoctions as recommended by the cookery books :—

Yorkshire Pudding

(*for* 2 *persons*).[1]

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
4 oz. flour	0·50	0·45	411
1 egg (2 oz.) . . .	1·00	0·26	77
½ pint milk. . . .	0·75	0·35	189
Total for 2 men .	2·25	1·06	677
Total for 1 man .	1·12	0·53	338
Total for 1 penny .	1·0	0·47	300

Sweet Batter Pudding

(*for* 4 *persons*).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
8 oz. flour	1·0	0·90	822
2 eggs (4 oz.) . . .	2·0	0·52	154
1 pint milk. . . .	1·5	0·70	378
2 oz. currants . .	0·5	0·05	187
Total for 4 men. .	5·0	2·17	1,541
Total for 1 man .	1·25	0·54	385
Total for 1 penny .	1·0	0·43	308

[1] The number of persons for which the quantities are suitable is the cookery book estimate; necessarily a very rough one.

Boiled Pastry

(*for* 6 *persons*).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
1 lb. flour	2·0	1·79	1,645
6 oz. beef suet. . .	2·6	0·28	1,327
Total for 6 men .	4·6	2·07	2,972
Total for 1 man .	0·77	0·35	495
Total for 1 penny .	1·0	0·45	646

Currant Dumpling

(*for* 7 *persons*).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
1 lb. flour	2·0	1·79	1,645
6 oz. beef suet. . .	2·6	0·28	1,327
8 ,, currants . . .	2·0	0·19	747
Total for 7 men .	6·6	2·26	3,719
Totol for 1 man .	0·94	0·32	531
Total for 1 penny .	1·0	0·34	564

The boiled pastry may be used for suet dumplings, currant dumplings, rolypoly pudding, apple dumpling, beefsteak pudding, etc. Currant dumpling is given as an example, showing the difference due to the addition of the other ingredient.

Bread Pudding (common)

(*for 3 persons*).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
½ lb. bread	0·75	0·73	608
3 oz. sugar	0·37	—	349
1 egg (2 oz.) . . .	1·00	0·26	77
¼ pint milk. . . .	0·37	0·17	95
2 oz. currants . . .	0·50	0·05	181
2 „ raisins . . .	0·50	0·05	187
Total for 3 men .	3·49	1·26	1,497
Total for 1 man .	1·16	0·42	499
Total for 1 penny .	1·0	0·36	429

Fig Pudding

(*for 2 persons*).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
6 oz. bread. . . .	0·56	0·55	455
1½ oz. sugar . . .	0·19	—	174
2 oz. butter . . .	1·50	0·02	451
4 „ milk	0·30	0·13	75
3 „ figs	0·56	0·13	276
Total for 2 men .	3·11	0·83	1,431
Total for 1 man .	1·55	0·41	715
Total for 1 penny .	1·0	0·26	460

Marmalade Pudding

(*for* 3 *persons*).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
½ lb. bread	0·75	0·73	608
½ pint milk. . . .	0·75	0·35	189
1 oz. sugar	0·12	—	116
2 eggs (4 oz.) . . .	2·00	0·52	153
¼ lb. marmalade . .	1·00	0·02	232
Total for 3 men .	4·62	1·62	1,298
Total for 1 man .	1·54	0·54	433
Total for 1 penny .	1·0	0·35	281

Treacle Pudding

(*for* 1 *person*).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
3 oz. bread. . . .	0·28	0·28	228
1 ,, butter	0·75	0·01	225
1 ,, treacle	0·19	0·10	70
2 ,, milk	0·15	0·07	38
Total for 1 man .	1·37	0·46	561
Total for 1 penny .	1·0	0·33	409

Some, or perhaps all, of these recipes might be modified in such a way as to reduce, or increase, the cost. The puddings might be called by the same names, but they would not contain the same amounts of nutrients. The examples given may be taken as typical, and any particular cases may be examined in the same way.

To facilitate comparison, the results have been summarized in the following table :—

ANALYSIS OF PUDDING RECIPES SUMMARIZED.

	For One Man.			For One Penny.	
	Cost.	Protein.	Fuel Value.	Protein.	Fuel Value.
	d.	Oz.	Kal.	Oz.	Kal.
Plain rice pudding .	0·40	0·13	209	0·32	523
Tapioca pudding .	1·91	0·51	478	0·26	250
Yorkshire pudding .	1·12	0·53	338	0·47	300
Sweet batter pudding	1·25	0·54	385	0·43	308
Boiled pastry . . .	0·77	0·35	495	0·45	646
Currant dumpling .	0·94	0·32	531	0·34	564
Bread pudding . .	1·16	0·42	499	0·36	429
Fig pudding . . .	1·55	0·41	715	0·26	460
Marmalade pudding .	1·54	0·54	433	0·35	281
Treacle pudding . .	1·37	0·46	561	0·33	409

Since the meat and potatoes cost from 2½*d.* to 3*d.*, not more than from 1½*d.* to 2*d.* can be spent on pudding and fruit jointly. It is obvious, therefore, that if tapioca pudding, prepared as above, be used, fruit must be dispensed with. The cost of the plain rice pudding, including the jam to be used along with it, amounts to less than ½*d.* per head, so at least 1*d.* might be spent on fruit. The boiled pastry costs about ¾*d.*, so a similar amount might be spent on apples or other fruit to be incorporated with it. The cost of the currant dumpling, sweet batter, bread and fig puddings includes that of the fruit they contain. The marmalade and treacle in the puddings called by these names, and the jam in roly-poly would probably be regarded as a substitute for fruit, though not so desirable from a hygienic point of view.

Flavouring, condiments, baking powder, etc., in the various recipes are not noticed here, as they are not, properly speaking, foods. The cost of such as are essential is almost negligible, though indefinite sums may be spent on essences, etc., which add nothing to the nutrients.

The day's rations can be further varied by the use of soup, which may be substituted either for meat and potatoes, or, preferably, for pudding, if stock or materials for making it be available.

The stock generally consists of meat extract, the composition of which, it has been shown, is extremely variable. The most important constituents are the amino-bodies and gelatin (p. 127), derived from the albuminoids. Stock made from meat has a richer flavour and contains more amino-bodies than that made from bones. The amount of gelatin in the stock depends largely upon the method of preparation; when the materials are subjected to prolonged boiling, it is usually considerable, but if stewed at a low temperature it may be much less. If the proportion of gelatin exceed 1 per cent., the stock will solidify on cooling. This is commonly regarded as an indication that it is "very rich," but it is by no means reliable, and in any case it affords no indication of the amount of amino-bodies.

The average composition of stock may perhaps be judged from the following analysis of a sample of beef tea prepared at St. Thomas' Hospital.

Analysis of Beef Tea.

	Per cent.
Water	96·00
Fat	0·20
Insoluble protein and meat fibre	0·21
Soluble protein and gelatin	1·34
Meat bases (amino-bodies)	0·61
Non-nitrogenous extract	0·84
Mineral salts	0·77
	99·97

It will be seen that the total solids only amount to 4 per cent., and the nutritive matters, including gelatin and meat bases, only to 3·23 per cent.

The sum of 5*s*. per week will not, therefore, admit of meat, or even bones, being specially purchased for the preparation of stock and afterwards discarded; but the water in which meat, ham, fowls, etc., have been boiled, or the bones which are included with many joints of meat, may be used. The cost of the bones has already been discounted in the price of the meat, and no further expenditure is therefore involved in using them for this purpose.

For certain kinds of soup, milk may be used instead of meat stock. It has a much higher nutritive value, but lacks the agreeable flavour, odour and stimulating effects of the latter; and, of course, it cannot be used for soups which contain fresh vegetables or acid substances of any kind.

For present purposes, stock soups may be divided into three groups, viz., (*a*) clear soups; (*b*) vegetable soups; (*c*) thick soups. Clear soups consist essentially of the stock or meat extract, usually coloured with caramel, and flavoured in various ways. Fresh vegetables are sometimes used for the latter purpose, but they are removed before the soup is served. If they are not removed, the soup belongs to class (*b*) here called vegetable soups. This may be regarded merely as a way of substituting fresh vegetables for fruit, the stock serving as a kind of sauce.

The soups of class (*c*) may, and usually do, also contain vegetables. The essential difference is that the stock, in this case, is thickened by the addition of substantial quantities of various other foods, e.g. wheat flour, vermicelli, barley, rice, peas, lentils, potatoes, etc. These soups are generally referred to by the name of the thickening ingredient, e.g. potato soup, rice soup, and so on. This is proper, because the soups owe their nourishing properties chiefly to the presence of the thickening ingredient. It will be seen, therefore, that this is, in effect, simply another way of preparing these foods—stock being used instead of milk—and that, just as the vegetable soups may be used as substitutes for fruit, so the thick soups may be used as substitutes for the puddings, or, if they contain fresh vegetables, for pudding and fruit.

In the following analyses, showing the approximate cost and composition of some of the common soups as recommended by the cookery books, the nutritive value of the stock is taken as equal to 0·5 oz. of protein and 100 kal. fuel value per quart. The money value is taken as 1*d.* per quart, though if this has been previously discounted, the actual cost will be zero.

Vegetable Soup

(*for* 8 *persons*).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
2 lb. turnips	1·0 (turnips and carrots)	0·28	250
1 ,, carrots		0·14	160
2 ,, cabbage	1·0	0·45	250
½ ,, onions	0·5	0·11	102
4 quarts stock . .	4·0	2·00	400
Total for 8 men .	6·50	2·98	1,162
Total for 1 man .	0·81	0·37	145
Total for 1 penny .	1·0	0·46	179

Barley Broth

(*for* 8 *persons*).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
2 lb. turnips	1·0 (turnips and carrots)	0·28	250
1 ,, carrots		0·14	160
2 ,, cabbage	1·0	0·45	250
½ ,, onions	0·5	0·11	102
1 ,, barley	2·0	1·36	1,650
4 quarts stock. . .	4·0	2·00	400
Total for 8 men .	8·5	4·34	2,812
Total for 1 man .	1·06	0·54	351
Total for 1 penny .	1·0	0·51	331

POTATO SOUP

(for 2 persons).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
1 lb. potatoes . . .	0·50	0·29	310
1 oz. butter . . .	0·75	0·01	225
4 ,, onions . . .	0·25	0·05	51
1 quart stock . . .	1·00	0·50	100
Total for 2 men .	2·50	0·85	686
Total for 1 man .	1·25	0·43	343
Total for 1 penny .	1·0	0·34	274

LENTIL SOUP

(for 6 persons).

Ingredients.	Cost.	Protein.	Fuel Value.
	d.	Oz.	Kal.
1 lb. lentils . . .	2·00	3·97	1,570
2 oz. dripping . . .	1·00	—	527
1 lb. carrots . . .	} 1·00	0·14	160
2 lb. turnips . . .		0·28	250
4 oz. onions . . .	0·25	0·05	51
6 pints water . . .	—	—	—
Total for 6 men .	4·25	4·44	2,558
Total for 1 man .	0·71	0·74	426
Total for 1 penny .	1·00	1·04	602

Analyses of Soup Recipes Summarized.

	For One Man.			For One Penny.	
	Cost.	Protein.	Fuel Value.	Protein.	Fuel Value.
	d.	Oz.	Kal.	Oz.	Kal.
Vegetable soup	0·81	0·37	145	0·46	179
Barley broth .	1·06	0·54	351	0·51	331
Potato soup .	1·25	0·43	343	0·34	274
Lentil soup. .	0·71	0·74	426	1·04	602

The vegetable soup here specified is not a cookery book recipe, but is merely the barley broth minus the barley. It may, however, be taken as a type of vegetable soup, and when compared with barley broth, shows the differences due to the thickening. Potato soup costs more per head than any of the others mentioned; it yields rather more nourishment than the vegetable soup, for a similar expenditure, but is inferior to the barley broth both as regards cost and composition.

Lentil soup costs less than any of the others, and it contains much larger amounts of nourishment. Made as above, with pure water instead of stock, it cannot have the stimulating effects due to amino compounds. It lacks also the rich appetizing flavour and odour of meat stock, and the strong leguminous taste of the lentils predominates. To disguise this, a quantity of wheat flour or other starchy matter is sometimes added; this, of course, reduces the N. ratio of the soup, and renders the use of stock more than ever advisable. It is deserving of special attention, because it is one of the few ways in which lentils are commonly used in this country. In view of the large proportion of protein which it contains, this soup may be substituted for meat and potatoes on a "*jour maigre*" without detriment to health, and with great advantage from the point of view of pecuniary economy.

The dinner may also be varied by dispensing with both pudding and soup, and, using appropriate quantities, making the meal off meat and potatoes, with the usual allowance of 1*d*. for fruit or fresh vegetables. This has the merit of simplicity, and may be adopted occasionally when work presses; but it lacks variety, and is not recommended for general use.

There is not, in general, the same demand for variety as regards the morning and evening meals; and when the monetary allowance is limited to 2*d*. for each meal, it is very difficult of attainment.

In the typical examples (p. 213), oatmeal was used at the morning and bacon at the evening meal; and it was assumed, in the latter case, that no butter would be required. When oatmeal is not used, it must be, to a large extent, replaced by bread, potatoes, etc., and if butter be added, the cost is thereby increased. Bread and butter is dearer than bread and bacon; and if eggs, fish, cheese, etc., be substituted for the latter, the cost is still further increased, as the butter is not then dispensed with. These points are more clearly brought out by the following analyses :—

Analyses of Various Rations for Morning and Evening Meals.

Food.	Cost.	Protein	Fuel Value.	Food.	Cost.	Protein	Fuel Value.
	d.	Oz.	Kal.		*d.*	Oz.	Kal.
10 oz. bread	0·94	0·92	759	½ lb. potatoes	0·25	0·14	155
1¼ ,, butter	0·94	0·01	281	8 oz. bread .	0·75	0·73	607
3 oz. milk .	0·23	0·11	57	1¼ oz. butter	0·94	0·01	281
1 ,, sugar.	0·12	—	116	3 ,, milk .	0·23	0·11	57
	2·23	1·04	1,213	1 ,, sugar.	0·12	—	116
					2·29	0·99	1,216
1 egg (2 oz.)	1·00	0·26	77	2 oz. fish[1] .	0·75	0·34	42
7 oz. bread .	0·66	0·64	531	7 ,, bread	0·66	0·64	531
1 ,, butter	0·75	0·01	225	1 ,, butter	0·75	0·01	225
3 ,, milk .	0·23	0·11	57	3 ,, milk .	0·23	0·11	57
1 ,, sugar.	0·12	—	116	1 ,, sugar.	0·12	—	116
	2·76	1·02	1,006		2·51	1·10	971
1 oz. cheese.	0·50	0·40	128	2 oz. peanuts[2]	0·37	0·37	242
7 ,, bread .	0·66	0·64	531	7 ,, bread .	0·66	0·64	531
1 ,, butter	0·75	0·01	225	1 ,, butter	0·75	0·01	225
3 ,, milk .	0·23	0·11	57	3 ,, milk .	0·23	0·11	57
1 ,, sugar .	0·12	—	116	1 ,, sugar .	0·12	—	116
	2·26	1·16	1,057		2·13	1·13	1,171

It will be seen that the cost of these various rations runs from about 2¼*d.* to 2¾*d.* each, or on the average, say 5*d.* for two. This leaves only 3½*d.* for the dinner, and certain restrictions may be necessary in order to keep within the limit of 8½*d.* On pecuniary grounds, therefore, it is desirable to use a moderate quantity of oatmeal once per day, unless it be found

[1] Cod-steak at 6*d.* per lb.

[2] For methods of using, see vegetarian cookery books.

harmful or disagreeable. For the same reason, bacon should be used more frequently than fish, eggs, etc.

Other solutions of this problem which will doubtless suggest themselves to the skilful housekeeper, may be investigated in a similar manner. The examples given above, however, are probably sufficient for present purposes, having regard to the common practice in English households of the class in question.

An expenditure of 5*s*. per (man) head per week on food may be a common case, but it is by no means general. A man who has a smaller income or a larger family than was supposed could not afford, under similar conditions, to spend so much; whereas one who has a larger income or a smaller family might spend more. In the former case, the difficulty of satisfying the requirements and desires of the family would be increased; in the latter, there would be greater liberty of choice as regards both quantity and quality of the food.

If, out of a sum of 4*s*. per week, or say 7*d*. per day, 4½*d*. were allowed for dinner, only 2½*d*. would remain for the other two meals. On the other hand, if 2*d*. each be allowed for the morning and evening meals, only 3*d*. remains for dinner. The latter is obviously the better arrangement of the two; and, though it is probably not the best under all circumstances, it may be taken as the basis of discussion.

As regards the morning and evening meals, not much need be added to the data previously given. It is evident, however, that the use of oatmeal becomes more than ever desirable; and that, failing this, the proportion of butter must be considerably reduced. By substituting margarine for butter, a certain saving can be effected in this direction.

It is in regard to the dinner that the greatest difficulty will be experienced. Something must be sacrificed. Probably, in the majority of cases, fruit and fresh vegetables would be regarded as the item that can be most easily dispensed with.

The simplest solution, on paper, would be to reduce the dinner to meat and potatoes, as in the typical case 1 (p. 213). That ration contains the required amounts of nutrients, and does not exceed the stipulated cost, but it lacks variety. There are, however, several ways in which it may be varied; as, for instance, by substituting soup and bread, soup and pudding, potatoes and herring or dried fish, or smaller quantities of the last and pudding. On reference to the figures given in the various tables, it will be found that many combinations of this kind can be arranged to give the required amounts of nutrients at a cost of from 1½*d*. to 2*d*. per day. There is thus a saving of about 1*d*.; and if some such variation be adopted twice a week, a dinner on the 5*s*. scale can be obtained on two other days, and the plain meat and potatoes on the three remaining days. This not only provides variety, but also a certain amount of fruit and fresh vegetables which are so much esteemed for their hygienic properties.

An allowance of 3*s*. per (man) head, per week, is about the least that life can be sustained on in the towns. Those who subsist on this amount are classed by Mr. Booth as the very poorest.

Three shillings per week is just 1*d*. over 5*d*. per day, and there are not many different ways in which it can be subdivided. Probably the most convenient general arrangement would be to allow $1\frac{1}{2}d.$ each for the morning and evening meals, and $2d.$ for the midday repast. With so meagre an allowance, it is obvious that not only such comparative luxuries as fruit and fresh vegetables must be entirely dispensed with, but even the use of meat must be to a large extent discontinued. The smaller the amount of money available, the larger must be the proportion of the diet derived from cereals and legumes, e.g. wheat, oats, lentils and peas.

It would be superfluous to give further examples relating to particular cases which the reader can investigate for himself. Those given above, the tables and data in various parts of the book, have been constructed chiefly to that end.

CHAPTER XIX

SPECIAL DIET

> I commend, rather, some diet for certain seasons than frequent use of physic, except it be grown into a custom; for those diets alter the body more and trouble it less.
>
> *Bacon.*

THE conclusions arrived at in previous chapters are to be regarded as general rules for normal healthy individuals. They are subject to modification in special cases. Invalids usually have very little appetite; being kept warm in bed and unable to exert themselves, they require less food than similar persons leading an ordinary sedentary life. In some cases, e.g. certain stages of fevers, the quantity should be, for other reasons, very small indeed. Convalescents recovering from exhaustion may require more than the usual amounts of food, or of certain nutrients. The food of invalids and convalescents should be of an easily digestible character. It may be supposed, however, that these patients will be under proper medical care, and no good purpose would be served by discussing this aspect of the subject in a small popular work.

Mild disorders which require dietetic rather than medical treatment, and certain chronic cases which are not usually under constant medical supervision, and in which the treatment is mainly dietetic, may be briefly mentioned. What is written here may help the sufferers to understand and carry out the directions they receive from qualified medical men, and deter them from the use of quack medicines.

Habitual constipation is conspicuously one of those complaints for which a modified diet is necessary. Common experience shows that brown bread, oatmeal, fatty foods, fruits and vegetables are suitable.

The laxative effects of brown bread, as compared with white bread, must be attributed to the presence of a certain amount of bran in the former. The effects of this ingredient are mainly mechanical. It may stimulate the action of the bowels by mild irritation. At any rate, the fact may be taken as an indication that the food should not be too concentrated. It is a mistake to reject all but the most tender and delicate portions. Everything may be swallowed that can be reduced to pulp by thorough mastication.

Oatmeal also acts, to some extent, mechanically. Many people are more or less affected by even the most finely ground samples. This may be due to the chemical action of some of the constituents, probably the fat; but coarsely ground oatmeal produces more marked effects.

Fats are particularly useful in constipation. They act as lubricants. Animal fats probably have no other effect, but some of the vegetable oils stimulate the action of the bowels. Castor oil, for instance, is a powerful purgative, and some of the edible oils have a similar if much milder effect.

The laxative effects of fresh fruits are usually attributed to the acids and acid salts which they contain. It is not certain, however, that these effects result entirely from the action of the acids, etc., on the bowels; they may be due, in some measure, to action on other foods and contents of the bowels. Acids certainly have a solvent action on starch and other carbohydrates. At all events, the effects of soft fruits, plums, strawberries, etc., must be attributed to chemical rather than mechanical causes.

Fresh vegetables may act, to some extent, in a similar manner; but the proportion of acids and acid salts in these products is usually much smaller than in fruits, and other causes may contribute. Vegetables, such as cabbage, turnips, etc., contain considerable amounts of cellulose. This substance is largely indigestible, and of little or no nutritive value; but in the intestines, it undergoes changes which result in the formation of gases, and the pressure tends to expel fæcal matter. The bulky nature of the cellulose also tends to prevent the formation of clots in the bowels.

Dyspepsia is a somewhat indefinite term, but is generally used to describe any disturbance of the processes of gastric digestion which results in a feeling of oppression and pain in the stomach after eating food. Flatulence and palpitation frequently accompany these symptoms. It is usually ascribed to acidity of the stomach, or, in other words, to excessive secretion of gastric juice.

So far as the dietetic treatment is concerned, the obvious general rule is to avoid anything likely to produce or increase irritation of the stomach. In this category must be placed all indigestible substances, i.e. those which normally remain long in the stomach, such as pastry; the harder kinds of meat, skin, sinew, etc.; coarse and bulky foods such as oatmeal, brown bread and those vegetables which contain much cellulose; strongly acid fruits and those which contain seeds, e.g. rasps, tomatoes, figs, etc.; and spices such as curry, pepper and mustard; even salt should be used with great moderation.

The total quantity of food should in many cases be reduced, only small quantities should be consumed at a time, and that should be thoroughly well masticated. The food should consist largely of milk, eggs, fish and tender meat, with a considerable amount of delicate fat and butter. Table jellies, i.e. those made of gelatine, are strongly recommended, but they should be free from alcohol, artificial colours and flavouring essences such as vanilla, etc. Sugar is probably the most suitable form of carbohydrate, but starchy puddings such as cornflour and arrowroot are also suitable. It is recommended that bread should be toasted to promote the conversion of starch into dextrin. Potatoes should be used only in small quantities, and should be crushed through a presser.

For drink, tepid water is the best, and may with advantage be used in considerable quantities. Tea and coffee, if used, should be very weak, should not be very hot, and should be slowly sipped.

Obesity, in its simpler forms, may be regarded merely as an extreme case of the tendency to increase weight which some individuals exhibit in more marked degree than others. The fundamental facts have already been discussed (p. 56 *et. seq.*); and it has been shown that it is a question of the relation between the amount of food consumed and the rate at which it is oxidized. In some cases, the condition is aggravated by defective circulation, constipation, a dropsical tendency or pathological phenomena which may require medical treatment; but so far as obesity itself is concerned, the problem is practically one of diet.

Let a man be ever so fat, if he eat nothing at all, he will lose weight, and soon die. If he eats a certain amount his weight will increase. There is a point, between these two, at which he will lose weight but not die; and another at which his weight will remain practically constant. These points depend chiefly upon the rate of oxidation, and are, of course, different for each individual. It is beside the question for a fat man to argue that he eats less than another, for "it is plain that if he is too fat, he has eaten more than he should have done." The word obesity itself implies as much.

The question, however, is not wholly one of quantity; the kind of food is also important. The popular notion that fats and sugar should be avoided by persons inclined to corpulency is sound only in certain circumstances, and it is often wrongly applied. A man might eat as much as he pleased of either or both of these nutrients and yet, if he ate nothing else, i.e. if he took no protein, he would lose weight, and ultimately die of starvation (p. 45). On the other hand, given a sufficiency of protein, any excess of non-nitrogenous nutrients may be laid up as fat.

The problem may therefore be solved either by limiting the allowance of protein to less than is required, in which case liberal quantities of fat and carbohydrates may be given; or by giving sufficiency of protein and restricting the allowance of non-nitrogenous matter. The latter is the orthodox and probably, in general, the better plan. In either case, the key to the situation is to be found in the answer to the questions, what is sufficiency of protein? and what is excess of non-nitrogenous matter? So we return again to considerations of quantity.

For normal individuals, the quantities may be taken to be those of the standard diet (p. 47); but for those inclined to obesity they are probably excessive; for, it must be remembered, this tendency implies less than the normal capacity for oxidation. According to Chittenden, the allowance of protein is nearly twice as much as is actually required; and in cases of obesity it might be considerably reduced, though this is not actually necessary when the allowance of non-nitrogenous nutrients is duly limited. In some cases, the fuel value may be reduced to half the quantity given in the standard diet; in others it may be more or less; no general statement can be made. The quantity should be gradually reduced until the weighing machine shows that the body weight is decreasing. Provided these rules are observed, there is no reason why any particular kind of food should be taken or shunned. The directions given to sufferers from obesity to avoid this, that or the other kind of food often fail because the omission is made up by a double dose of something else. To stop using sugar, or butter, or potatoes, or anything else, can only be effective provided they are simply dropped out of the menu, and nothing put in their place. In serious cases, negative directions of that kind are useless; they must be replaced by positive instructions to take so many oz. of certain foods, calculated to contain definite amounts of nutrients, and nothing else.

Harvey's system of diet—better known under the name of Banting, the patient for whom it was devised—provided 6 oz. of protein and 1,110 kal. fuel value. It is a very elaborate programme, full of absurd restrictions, but it proved so successful that many of the old-fashioned ideas embodied in it survive to this day. Perhaps the worst that can be said of this and other similar systems, e.g. those of Hirschfield, Oertel and others, is that they are not generally applicable.

Drugs and medicines are not only useless, but worse than useless. If they are in any degree effective, they must be more or less injurious. No drug is known to reduce fat. At best, they can only prevent absorption, either by action on the food, or more frequently, by injury to the digestive organs. Of course, in complicated cases, medical as well as dietetic treatment may be necessary.

Diabetes is an insidious disease of which the characteristic symptom is the appearance of sugar in the urine. It is not well understood, and there are probably several forms of the disease, all more or less serious in character; but the dietetic treatment is practically the same in all cases, viz., the more or less complete elimination from the diet of sugars and all carbohydrate compounds which are transformed into sugars in the system. This, of course, involves the exclusion from the menu of all cereals and farinaceous products, including bread, also potatoes, roots, e.g. turnips, carrots, etc., legumes (peas and beans) and fruits. The diet is, therefore, limited almost entirely to animal products, but certain fruits and green vegetables, e.g.

cabbage sprouts and cauliflower, may be used. Milk contains sugar and is, therefore, barred ; but butter, cheese and certain milk preparations, e.g. casumen, may be taken.

For sweetening, saccharine makes a satisfactory substitute for sugar ; and several substitutes for flour and bread can be obtained. The latter are very expensive, and bear little resemblance to ordinary flour and bread.

The sufferer from diabetes must depend mainly upon eggs, fish and meat. The last may be of any kind, including bacon and ham, but it should be as fat as can be obtained ; even so, the diet will always contain an excess of protein.

In certain cases, carbohydrates are not rigidly excluded, a certain amount of bread, potatoes or other starchy food being found not only harmless, but actually beneficial ; but these cases are perhaps exceptional.

Rheumatism and gout were formerly attributed to the presence of excessive quantities of uric acid in the blood ; but this condition is now more commonly regarded as a symptom than a cause of these disorders.

Considerable differences of opinion still exist as to the most suitable diet. There is, however, a general agreement that the food should be simple, of an easily digestible character and strictly moderate in quantity, especially as regards protein.

Pastry, highly spiced and cured foods should be avoided. An ordinary mixed diet is probably the best ; but the proportion of meat should be small. Fish and chicken are considered better than red meats, and sweetbreads are recommended. Carbohydrates—starch and sugar—should be partially replaced by butter and other fats, but milk may be used freely.

Vegetarian diet is not, as might be supposed, a self-defined term. Some vegetarians eschew all animal products of any kind whatever. Others, perhaps the majority, use honey, eggs, milk, etc. Vegetarianism is advocated chiefly on sentimental grounds ; but hygienic reasons also are sometimes advanced in support or defence of the principles. Any discussion of the former would be out of place here ; but the latter may be briefly considered.

Unprejudiced persons, if there be any such, will generally admit that many people eat too much meat ; and that occasional or complete abstinence from flesh foods may be good for some, but not for others. It has been abundantly proved that, so far as normal, healthy individuals are concerned, life and health may be maintained, and much bodily work accomplished, on a diet from which flesh, fish and fowl are rigidly excluded. Such diet is usually, but not necessarily, much cheaper than the ordinary mixed food of the omniver.

The question is largely one of taste. If eggs, milk, butter and cheese are used, vegetarian diet is probably not so cheap, or nasty, as is often supposed.

In the absence of milk and eggs, vegetarian diet may be suspected of a tendency to contain excessive amounts of carbohydrates. This may, or may not, imply deficiency of protein and fat. The tendency, if it exists, may be easily avoided. Chittenden's views are frequently cited by vegetarian protagonists ; but it does not appear that these are essential to their position. The standards recommended by other authorities are easily attainable on the strictest vegetarian diet.

The staple food of vegetarians in this country is wheat flour, in one form or another, the nutritive ratio of which (1 to 7) is the same as that of the standard diet. The addition of fat, sugar and starchy foods tends to reduce the nutritive ratio of the diet below the standard; but this is corrected by oatmeal, legumes and certain kinds of nuts. Suitable vegetarian diets may be computed from the figures given in the tables, in the manner previously described.

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Butler & Tanner, The Selwood Printing Works, Frome, and London.