COOKING AND NUTRITIVE VALUE

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BY

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PREFACE

IN recent years scientific research has thrown much new light on the nutritive value of food. This book aims at providing a brief survey of one aspect of this work—the effects of the preparation, processing, and above all the cooking of food on its nutritive value. It is intended not only for dietitians, food supervisors, domestic science teachers, and students, but also for the many others who are interested in food research but who have not time to cope with the ever-increasing mass of scientific papers on nutrition. References have had to be reduced to a minimum. The footnotes, mainly concerned with recent work which is not yet widely known, are for the use of readers who wish to follow up some special point. Full details of the publications mentioned in footnotes, tables, and figures are given in the Literature List at the end of the book. Temperatures are expressed by centigrade or Fahrenheit scale, according to current usage. A diagram for converting one scale to the other is given on the back endpaper.

The book was planned several years ago and was almost all written by 1939. But when war broke out it had to be set aside. It was finally completed under war-time conditions in 1944. Research has, however, been so active during the war that this delay has made it possible to mention a good deal of important new work.

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A. B. C.

CAMBRIDGE, 1944

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I

THE NUTRITIVE VALUE OF FOOD

The study of words is the first distemper of learning.

BEN JONSON

BEFORE approaching the subject of food preparation and cooking, we shall consider very briefly what makes one food more nutritious than another. This question is closely linked with the chemical composition of food. Protein, fat, carbohydrate, water, mineral elements, and vitamins all have special functions in the body, and the nutritive value of a food depends on how much of each is present.

Protein

Proteins are an essential component of all living things. In the human body they occur in all the tissues and are the main solid constituents of flesh and blood. We need proteins for building up new flesh during the years of growth and for keeping the body in a state of good repair throughout our lives. Both growth and maintenance are included in the term body-building.

Proteins are exceedingly complicated compounds, containing carbon, hydrogen, oxygen, and nitrogen. Fats and carbohydrates also supply us with the first three of these elements, but proteins are our one great source of nitrogen. Healthy adults are in what is known as nitrogen equilibrium: the amount of nitrogen they gain from their food is equal to the amount they lose by excretion. During starvation, nitrogen is still excreted, and the body's own flesh has to supply it since food does not. A daily allowance of nitrogen (as protein) is thus essential to prevent the wasting away of the tissues.

So far we have considered only the nitrogenous portion of the protein. The remaining portion is burnt in the body and acts as a source of muscular energy and heat. Foods containing protein are thus energy-producing as well as body-building.

An interesting point recently brought to light is that the body proteins are constantly being broken down and built up again. This is true of fats too. The materials of the body are in a state of continuous flow,[1] although the composition of the tissues remains unchanged—just as a fountain keeps the same shape, although new water is always flowing through it. Part of the nitrogen from our food finds its way into our flesh, and the nitrogen it displaces is excreted.

Animal flesh, like our own flesh, contains protein; and meat and fish are among the best sources of protein in our food. Milk, cheese, and eggs are equally good, and also of animal origin. The chief protein-containing foods from the plant world are cereals and legumes. Other vegetables and fruit contain only small amounts of protein, but some nuts contain a good deal.

Biological value. Proteins are made up of an assortment of amino-acids, some of which we can manufacture in our bodies. Those we cannot manufacture have to be provided ready-made by the proteins in our food, and are known as essential amino-acids. Obviously proteins that are rich in essential amino-acids are more useful for body-building than those that are not.

It is possible to measure the relative value of different proteins by means of feeding experiments, carried out either on animals or man. The object is to find how much of the protein under investigation can 'spare' a given amount of body protein. The results are expressed as biological values, the maximum being taken as 100. According to the original definition, a protein with a biological value of 100 is one that spares its own weight of body protein; one that spares half its own weight of body protein has a biological value of 50, and so on.

Generally speaking, plant proteins have a lower biological value than animal proteins and are called second-class, whereas animal proteins are called first-class. Possibly too

[1] R. Schoenheimer, 1942. (Full details of this and other publications mentioned are given in the Literature List on pp. 144 to 147.)

much stress has been laid on this distinction, for one protein often acts as a supplement to another, with the result that the biological value of a mixture of proteins may be far greater than would be expected from the component parts.[1] Moreover, fresh grass has been found to contain a first-class protein, as good as that of milk. This does not mean that we should follow the example of Nebuchadnezzar and eat grass, though it has been seriously suggested that we should extract the protein from grass or other suitable leaves and add it to our food.[2] But grass protein is not a particularly attractive form of food, and it is difficult to prepare, since even the best leaves contain only a very small amount. It is probably cheaper, and much more sensible, to let cows collect the grass, concentrate the protein, and pass it on to us in milk.

Fat

Fats are composed of carbon, hydrogen, and oxygen, and their chief function is to provide fuel for energy production. Foods rich in fat include butter, margarine, lard, dripping, cooking fats and oils, the fat of meat, bacon, ham, poultry and game, and also milk, cheese, eggs, nuts, and oily fish such as herrings and salmon.

Fatty foods take a long time to digest in the body, and a meal containing plenty of fat gives a feeling of inward satisfaction that lasts for some time. If too much fat is eaten, however, and not enough carbohydrate to balance it, trouble may result. Fats cannot be completely burnt in the body without carbohydrates; when only half burnt, they remain in the stage of ketones, which give rise to ketosis (popularly known as biliousness).

[1] T. F. Macrae, K. M. Henry, and S. K. Kon, 1943.
[2] N. W. Pirie, 1942.

Carbohydrate

Carbohydrates, like fats, are composed of carbon, hydrogen, and oxygen, but here the proportions of the elements and their arrangement are quite different.

Sugar and starch. These are by far the most important carbohydrates in our food, because they are completely utilized in the body. For this reason they are called 'available' carbohydrates. Their main function is energy production, and for this purpose they are largely interchangeable with fat.

Ordinary white sugar, known in chemistry as sucrose, is made up of two simpler sugars, glucose and fructose. Fruits and some vegetables contain one or more of these three sugars—sucrose, glucose, and fructose—and honey contains invert sugar, a special mixture of glucose and fructose, formed from sucrose. Other sugar-containing foods are treacle, golden syrup, jam, and marmalade. Malt and malt-extract contain a sugar called maltose. Animal foods contain no sugar at all, except for milk which contains lactose.

White sugar is highly refined and contains 99·9 per cent. of sucrose, whether it is prepared from sugar-beet or sugar-cane. Many cooks have a strange prejudice against beet sugar, but in reality it is just as good as cane sugar for jam-making or any other purpose. Indeed, when the refining processes have been carried out, the two sugars are virtually indistinguishable. Another widespread notion is that brown sugar has some special value. There is no scientific evidence for this. Demerara sugar contains 99·3 per cent. of sucrose, and the impurity that gives the characteristic taste and colour has no known dietetic significance.

Sugars are rapidly digested and absorbed in the body, and glucose and fructose are among the few constituents of food that need no digestion but are absorbed straight away.

Starch is more complicated in structure than sucrose, and consists of a long chain of glucose units. It is abundant in cereal products and fairly abundant in peas, beans, lentils, and potatoes. Foods from animal sources contain no starch; but there is a small amount of a rather similar substance, glycogen, in liver and shell-fish. During digestion the starch in cooked food is readily broken down to glucose, and absorbed. But the starch in raw foods is not so easy to digest. Raw starch may escape digestion and set up fermentation in the large intestine. The gas formed in this way causes considerable discomfort.

Unavailable carbohydrates.[1] Plants contain a number of substances which belong to the chemical group of carbohydrates, but which are not digested or absorbed in the usual way. These are called unavailable carbohydrates. Chief among them is cellulose, the fibrous substance that forms the cell-walls of plant tissues.

Cellulose is insoluble in water and cannot be digested in the body. Yet it does not pass through the body completely unchanged. A small amount of it is fermented by bacteria in the intestine, with the production of fatty acids and gas. The gas is a mixture of carbon dioxide, hydrogen, and methane (marsh-gas). The fatty acids are absorbed to some extent and used for energy production. Only a negligible amount of energy, however, can be obtained by human beings in this way. Cows and sheep can do much better because they are able to ferment far greater quantities of cellulose. This fermentation is a very slow process, and the only animals that can make a success of it are those with a relatively large alimentary canal, through which the food passes very slowly.

Inulin is soluble in water but is partially unavailable. It is not changed at all by digestive enzymes, but some of it is broken down by bacteria in the intestine.

The insoluble unavailable carbohydrates, such as cellulose, are popularly known as roughage, and act as laxatives. Their rough texture stimulates the muscular movements of the intestinal wall by friction. Since they remain undigested, they increase the bulk of the excreted material, and thus hasten its rate of passage through the intestine. Moreover, they

[1] R. A. McCance and R. D. Lawrence, 1929.

make a further increase in bulk by absorbing large quantities of water.

It may be mentioned that roughage includes some fibrous substances that are not carbohydrates. Lignin is an example. It forms the woody part of plant fibres, and is insoluble in water, and completely resistant both to digestion and to the action of intestinal bacteria.

Water

Water forms about 70 per cent. of the weight of the human body and is present in all the tissues. We obtain it from beverages and also from solid foods, many of which contain a great deal of water.

The Energy Value of Food

We have seen that protein, fat, sugar, and starch all provide fuel for the production of muscular energy. The heat that keeps our bodies warm is a by-product of this energy. We burn up energy foods and use the resultant energy when we stand, walk, run, dig, or do any other kind of physical work; and the more we use our muscles, the more energy food we require. Miners, farm labourers, &c., therefore need more energy food than people who work in offices most of the day. On the average, women need less energy food than men, partly because they weigh less and use their muscles less, and partly because their bodies work in a slightly more economical way.

The energy value of a food can be looked up in suitable food tables or calculated from the chemical composition of the food. One gramme of fat yields 9·3 calories when it is burnt in the body, 1 gm. of protein yields 4·1 calories, and 1 gm. of available carbohydrate (expressed as glucose) yields 3·75 calories.[1]

Water cannot be burnt in the body and therefore has no energy value. For this reason foods that contain a great deal

[1] R. A. McCance and E. M. Widdowson, 1942.

of water have low energy values. On the other hand, foods that contain a great deal of fat have high energy values, since fat yields more than twice as many calories as an equal weight of either protein or carbohydrate.

Mineral Elements

The mineral elements in food include sodium, potassium, calcium, magnesium, iron, copper, chlorine, iodine, fluorine, phosphorus, and sulphur. They occur in the form of mineral salts, like salt itself, or bound up with proteins or other organic (that is, carbon-containing) compounds. Practically all the sulphur in food is in organic compounds; most proteins contain it, and the casein of milk contains phosphorus as well. Copper, iodine, and fluorine occur only in minute traces in the human body, and are sometimes called 'trace' elements. In English diets the mineral elements most likely to be present in insufficient amounts are calcium, iron, and iodine.

Sodium and Chlorine. We obtain most of our sodium and chlorine from salt (sodium chloride) and from foods of animal origin. Plant foods contain very little sodium, and vegetarians should therefore add to their food slightly more salt than meat-eaters do. Extra salt is also needed by people who perspire a great deal, since perspiration contains salt. 'Miners' cramp' occurs when large amounts of water are drunk after excessive perspiration; the remedy is to add a little salt to the drinking-water.

Potassium. There is so much potassium in both plant and animal foods that we are in danger of getting too much, rather than too little.

Calcium. Bones and teeth contain calcium phosphate as one of their main constituents, and calcium is therefore of great importance in nutrition. In this country before the outbreak of this war, children's diets often showed deficiencies of calcium. Now, however, the majority of children obtain a larger supply of calcium because of the priority allowance of milk for young children and the provision of milk in schools. Milk is rich in calcium, and the best way to guard against calcium deficiency is to provide plenty of milk. Other good sources of calcium are cheese, green vegetables, and fish with edible bones. Hard drinking-water also supplies it. Cereal foods contain calcium, but they contain phytic acid too, and this has an anti-calcifying effect, as we shall see later.

It has recently been discovered that more calcium is absorbed from food if there is a great deal of protein in the diet.[1] This probably explains why lean meat protects dogs against rickets. The large amount of protein in the diet enables an extra amount of calcium to be utilized, and in this way wards off rickets.

Phosphorus. Phosphorus, like calcium, is an important component of bones and teeth. A number of foods contain a relatively large amount of phosphorus, for example, meat, fish, milk, cheese, eggs, and cereals. Unfortunately, however, some of the phosphorus in plant foods is combined in a substance called phytic acid, which has an anti-calcifying action. The husks of grains contain a good deal of phytic acid, with the result that cereal products contain an inconveniently large amount of this substance, unless they are highly refined (in which case they lose other mineral elements and vitamins). There is not much phytic acid in fresh vegetables and fruits, but a good deal in dried peas and beans, and in some nuts. Cocoa husks also contain phytic acid, and some brands of cocoa contain an appreciable amount. In a recent experiment with rats it was found that very large amounts of cocoa interfered with the absorption of the calcium and phosphorus of milk; this effect was attributed partly to the presence of oxalic acid in the cocoa.[2] Possibly another factor was the presence of phytic acid.

Magnesium. Many foods contain magnesium, for example, meat, fish, milk, cheese, and nuts.

Iron. This is one of the constituents of the red colouring matter of blood, and if our diet lacks iron we become pale and

[1] R. A. McCance, E. M. Widdowson, and H. Lehmann, 1942.
[2] W. S. Mueller and M. R. Cooney, 1943.

anaemic. In this country, deficiencies of iron are not uncommon in the diets of women and adolescent girls. Milk contains practically no iron at all, and none of our foods are very rich in iron. Foods that are relatively rich include liver and kidney, green vegetables and legumes, oatmeal and rolled oats, brown bread and National bread, eggs, dried fruits, black treacle, chocolate, cocoa, and curry powder.

An investigation carried out a few years ago seemed to indicate that the iron in food is not available to any great extent unless it occurs in inorganic compounds. Iron bound up in organic compounds, such as the iron in blood, was thought to be largely unavailable. More recent work, however, has shown that the iron in blood is by no means unavailable. A further complication is that the phytic acid in food is able to precipitate iron and render it unavailable. The question of the availability of iron is thus extremely difficult and still unsettled.

A considerable amount of iron may be added to our food by the use of iron-containing utensils, such as mincing machines, iron pans, and non-stainless steel knives;[1] chipped enamelware also adds iron, but it cannot be recommended as it may add chips of enamel to the food.

Copper. It may seem odd to see copper in this list, since its salts are well known to be highly poisonous. In spite of this, a minute trace of copper is essential for health. Most ordinary diets supply us with the amount we require.

Iodine. Thyroxine, the active principle of the thyroid gland, contains iodine, and a deficiency of iodine in a diet leads to an enlargement of the thyroid gland, known as a goitre. There are minute traces of iodides in sea-water, and hence in sea-fish, cod-liver oil, and seaweed. In districts near the sea the sea-spray may deposit iodides in the soil, and the local water and vegetables may therefore contain iodides. In districts with inland valleys far from the sea, on the other hand, there is usually a deficiency of iodides in both water and vegetables. Derbyshire and Switzerland are examples of such

[1] E. M. Widdowson and R. A. McCance, 1943.