

ELEMENTARY SCIENCE OF FOOD

By the same Author,
in collaboration with
W. Munn Rankin, M.Sc.

**INTERMEDIATE
DOMESTIC SCIENCE**

(Part I) Foods and Nutrition
5th (Revised) Edition.

(Part II) Textiles in the
Home.

3rd (Revised) Edition.

Illustrated.

Elementary Science of Food

by

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PREFACE

This book is essentially a simplified version of "Foods and Nutrition" written by the late W. Munn Rankin in collaboration with the author of this volume. It embodies the author's long and extensive experience in teaching the subject in secondary schools and technical colleges.

While the field it covers is an extensive one, the method of treatment makes it suitable for use by teachers and pupils in all types of secondary schools, to women in technical colleges preparing for cookery examinations of the City and Guilds of London Institute and similar bodies, and to students in domestic science training colleges.

The author is greatly indebted to the late W. Munn Rankin for much help and advice and to Miss M. King for reading the proofs and making many valuable suggestions.

Sincere thanks are also tendered to those who have supplied illustrations, the sources of which are acknowledged in the captions, and to the Himalayan Committee of the Royal Geographical Society and the Alpine Club of Great Britain for permission to reproduce the illustration on page 256.

E.M.H.

Worsborough Dale,
Barnsley.

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PART ONE

Chapter I

WHY WE NEED FOOD.

Like all other living things we need food to keep our bodies alive. This sounds very simple but is really very difficult because our bodies are extremely complicated organisms in which all sorts of processes are going on and all sorts of changes are taking place. For all these processes and changes which are involved in being alive, food is necessary in one way or another.

The body as a stove.

We can think of our bodies as slow combustion stoves which give out heat all the time to the surrounding air and which must be supplied with suitable fuel at regular intervals. The fuel our bodies require is, of course, food. Whether we live near the North pole or near the Equator, whether it is summer or winter, food keeps the temperature of our bodies steadily at blood heat, i.e., 98.4°F. unless we are ill and have a "temperature."

The body as a machine.

Or, again, our bodies can be considered as machines which obtain their energy to work by burning food as fuel just as motor cars and aeroplanes burn petrol, and locomotives burn coal. Our muscles need energy to move our limbs when we walk, run, dig, lift and carry things or, in fact, whenever we are in any way physically active. All the many movements of our internal organs such as the beating of the heart and breathing, require energy which must be supplied by food.

The body as a structure.

Our bodies can also be considered as buildings which are being built up and kept in repair from the materials supplied by food just as ordinary buildings are built up and kept in repair by the use of bricks, stone, wood, cement and so on. When we are young we are steadily growing, putting on weight, increasing in height and generally building more and more material into our

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bodily structure. This goes on until we are fully grown adults and, in addition, throughout our lives, parts of our bodies are constantly being replaced as they become worn out.

The body as a chemical laboratory.

Lastly, our bodies may be thought of as very busy chemical laboratories or workshops in which all sorts of complicated substances are being made out of the raw materials which go into them in the form of food. All these activities, and more, are those of ourselves as living organisms and all are dependent upon our getting not only enough food but food of the right kinds.

Summing up very briefly, the principal purposes for which we need food are: —

1. To supply energy as a source of work and heat.
2. To supply building and repair materials.
3. To supply substances which are required for the chemical changes which take place in our bodies.

Sources of food.

Green plants obtain their food from the carbon dioxide of the air which they take in through their leaves and from the water, with its dissolved mineral substances from the soil, which they obtain through their roots. The green colouring material in their leaves, which is called chlorophyll, enables green plants to absorb energy from the sun. This they use to convert the carbon dioxide, water and mineral salts into the substance of, say, grass, or an onion, or an oak tree. Some plants, known as *fungi*, such as mushrooms, toadstools, moulds, yeasts and bacteria can live without sunshine but only by feeding upon the substance of green plants or animals.

Animals either feed upon green plants or prey upon other animals which have eaten plants. The first type are *herbivorous* animals, e.g., sheep, cattle and horses; the second type are *carnivorous*, e.g., lion, tiger, and fox.

Human beings are both carnivorous and herbivorous i.e., *omnivorous*, since they eat both animal and plant foods. There

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are, however, races of people who are almost entirely carnivorous, e.g., the Eskimo. Other races of mankind are almost entirely herbivorous or vegetarian, e.g., the Hindu, and there are people who from principle or choice are strict vegetarians. The majority of human beings, however, rely upon a mixed diet of animal and plant foods and there is no doubt that, when wisely chosen, such a mixed diet is best able to maintain good health for most people.

Because human beings use both animals and plants as sources of food there is an enormous variety of articles from which to choose. But it is now known that all such articles of food consist of some half dozen sorts of substances which are known as *nutrients*, each of which plays its special part in meeting one or other of the needs of our bodies. The nutrients are CARBOHYDRATES, FATS, PROTEINS, MINERALS, VITAMINS and WATER. Carbohydrates and fats supply energy for work and heat. Proteins, and some minerals, supply building and repair materials. Other minerals, and the vitamins, regulate the chemical processes which go on in the body while water acts partly as a building material and partly as the medium for the transport of materials generally within the body.

THE NUTRIENTS.

1. CARBOHYDRATES.
The main supply of energy.
2. FATS.
The chief subsidiary supply of energy.
3. PROTEINS.
The building and repair substances. Also used to supply energy.
4. MINERALS.
Some provide building materials and others regulate chemical processes.
5. VITAMINS.
Substances which regulate chemical processes.
6. WATER.
A building material and a medium for the transport of materials generally, within the body.

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In any well-balanced mixed diet all the nutrients are present in sufficient amount to maintain our bodies in good health. If the diet is lacking in one or other of the nutrients then our bodies will be ill-nourished and our health suffer accordingly.

General Sources of Nutrients.

The carbohydrates are starches and sugars so that our main carbohydrate foods are such starchy foods as bread, potatoes and oatmeal, and such sugary foods as cane sugar, sweets, jam and syrup. Our chief fat foods are suet, dripping, butter, margarine and lard. Proteins and minerals for body-building are provided in milk, eggs, meat, fish, cheese, pulses, cereals and nuts. Minerals and vitamins for regulating chemical processes in the body are supplied by such foods as milk, fruit, vegetables, eggs and fat fish. We can now set out the main purposes of the nutrients in the form of a table:—

- A. NUTRIENTS AND FOODS PROVIDING ENERGY.
 - 1. *Carbohydrates* (*Starch*—bread, potatoes, oatmeal).
(*Sugar*—cane sugar, sweets, jam and syrup.)
 - 2. *Fats* (Suet, dripping, butter, margarine, lard).
- B. NUTRIENTS AND FOODS PROVIDING BUILDING AND REPAIR MATERIALS.
 - 3. *Proteins*. (Milk, eggs, meat, fish, cheese, pulses, cereals and nuts.)
 - 4. *Minerals*. (Same as proteins.)
- C. NUTRIENTS AND FOODS PROVIDING REGULATIVE MATERIALS.
 - 5. *Minerals*. (Milk, fruit, vegetables, eggs, fat fish.)
 - 6. *Vitamins*. (Same as minerals.)

A. FOOD AS A SOURCE OF ENERGY.—(WORK AND HEAT.)

As we have already seen, life consists essentially of processes and operations which require energy. Green plants are able to utilise energy from the sun which they absorb with the help of the chlorophyll of their leaves. Animals and human beings are

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unable to do this. They can only obtain their energy at second hand from either plants or from other animals which have eaten plants. This locked-up energy is released by burning, or oxidation by means of the oxygen which animals and human beings breathe into their lungs. This oxidation is exactly similar to burning in ordinary air except that it takes place very much more slowly and there is, of course, no flame. Just as carbohydrates (starch and sugar) and fats form carbon dioxide and water vapour when they are burnt in air, so they do in our bodies and these are the things we breathe out. In both cases the same amounts of heat and energy are released and this is the heat and energy which was originally absorbed by green plants from sunlight. So you see that the energy we use to work and move about and the heat that keeps us warm, are really the sun's heat and energy which have come to us by way of the plants and animals we have eaten.

We need food energy for the following purposes.

REQUIREMENTS FOR ENERGY.

1. To maintain the normal temperature of the body (98.4°F.)
2. For all physical activity—sitting, standing, walking, running, playing games and for all kinds of manual and muscular work in the home, workshop, garden, field and so on.
3. To maintain the beating of the heart and circulation of the blood, breathing, and the many other movements of internal organs.
4. To maintain the chemical processes within the cells of the body as in secretion, excretion and respiration.

We have now to consider how much food energy we require each day to keep going all this varied activity. First, we must understand how the energy in our food is to be measured, and in what units.

The simplest answer to this is that the food energy we take in and use up is most conveniently measured in terms of the heat that would be given out if all our food were burnt, i.e., oxidised, as in the body. That amount of heat equals exactly the sum of the energy which is converted into work and the waste heat given

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out as heat. We can only do any kind of physical work at the expense of energy. The more work we do, the more energy we require, which means we require more food containing energy. But it happens that most of the energy locked up in our food (about 80 per cent.) cannot be converted into energy, but is reduced to the lowest form of energy, which is heat, and is liberated as heat.

The unit of energy which is used in reckoning the energy values of foods and of fuels in general is the *Calorie*. The Calorie is defined as the amount of heat required to warm 1 Kilogram of water through 1°C. This Calorie (1 Kg.°C.) is roughly four times the British Thermal Unit (B.Th.U.) which is defined as the amount of heat required to warm one pound of water through 1°F. (1 lb.°F.). (1Kg. Cal=4 B.Th.U.)

It has been found that when one gram of a pure carbohydrate, such as sugar or starch, is completely burnt, it produces 4.1 Calories or roughly 4 Calories, corresponding to 116 Calories per ounce. An average pure fat, such as lard, gives 9.3 or roughly 9 Calories per gram or 263 Calories per ounce. When a protein is used up in the body it is not completely oxidised and its heat output is at the rate of 4.1 Calories or roughly 4 Calories per gram, the same as for a carbohydrate. This means that fats provide more than twice the amount of energy provided by the same weight of carbohydrate or protein. Fats are our most concentrated energy foods. Carbohydrates are less concentrated energy foods but are cheaper than fats while proteins are expensive and are really wasted as energy foods since their real purpose in the body is to supply material for growth and repair. Fats and carbohydrates are not body-builders.

Our main energy foods will thus be such fats as butter, margarine, suet, dripping and lard, such starchy foods as wheat, rice and oatmeal and such sugary foods as table sugar, treacle, syrup and jam. Our main starchy vegetable is the potato. Articles of food such as bread, cakes, pastry, biscuits and suet pudding which are made from carbohydrates and fats are also, of course, energy foods. Pulses such as peas, beans, lentils and soya and dried fruits are also useful sources of energy.

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ENERGY VALUES OF NUTRIENTS.

Carbohydrates. 1 gram yields 4 Calories; 1 ounce yields 116 Calories.

Fats. 1 gram yields 9 Calories; 1 ounce yields 263 Calories.

Proteins. 1 gram yields 4 Calories; 1 ounce yields 116 Calories.

The question now arises, how much energy do we require daily? It all depends. Grown-ups require more than young children; an average man more than his wife; growing and active boys and girls may require as much as, if not more than, their parents; persons engaged in heavy manual work, such as labourers, require more than others in sedentary jobs, such as clerks. The following table gives the requirements of several classes of persons and occupations.

DAILY CALORIE REQUIREMENTS AND OUTPUTS.

<i>Man</i> (weighing 70 Kgms. or 11 stones).	Calories
Sedentary (clerk, tailor, shoe-maker)	2,600
Moderately active (carpenter, painter, farmer)	3,000-3,400
Very active (mason, navy)	3,400-4,500
<i>Woman</i> (weighing 56 Kgms. or 9 stones).	
Sedentary	2,100
Moderately active	2,500
Very active	3,000
<i>Child.</i>	
Between 7 and 9 years old	2,000
Between 10 and 12 years old	2,500
<i>Girl</i> between 13 and 15 years old	2,800
Between 16 and 20 years old	2,400
<i>Boy</i> Between 13 and 15 years old	3,200
Between 16 and 20 years old	3,800

We may now proceed to calculate the energy values of dietaries. An average diet for an adult contains about 16 ounces of carbohydrate, 4 ounces of fat and 4 ounces of protein. What is its energy value?

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Carbohydrate. (Calorie value 116 Calories per ounce.)

$$116 \times 16 = 1856 \text{ Calories.}$$

Fat. (Calorie value 263 Calories per ounce.)

$$263 \times 4 = 1052 \text{ Calories.}$$

Protein. (Calorie value 116 Calories per ounce.)

$$116 \times 4 = 464 \text{ Calories.}$$

$$\text{Total} = 1856 + 1052 + 464 = 3372 \text{ Calories per day.}$$

Another example is given by the diet of a skilled worker in St. Andrews in 1932 which was found on the average to consist

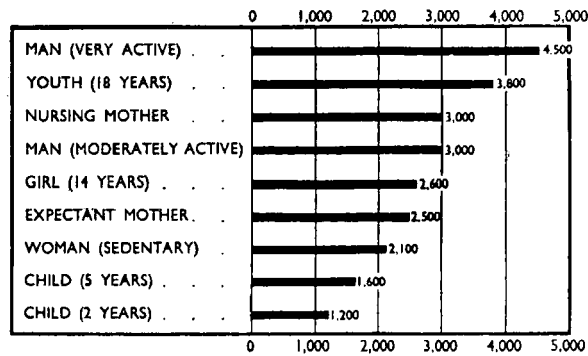


FIG. 1. Calorie requirements per day.

of 429 grams of carbohydrate, 122 grams of fat and 87 grams of protein. This works out as follows:—

<i>Nutrient</i>	<i>Quantity</i>	<i>Calorie Value per Gram</i>	<i>Calories</i>
Carbohydrate	429 grams	4	$429 \times 4 = 1716$
Fat	122 grams	9	$122 \times 9 = 1098$
Protein	87 grams	4	$87 \times 4 = 348$
<i>TOTAL Calories per day</i>			3162

Such a pre-war worker was fortunate, perhaps, in having so much fat in his dietary as compared with a post-war skilled worker.

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The Calorie value of a particular article of food can be calculated in a similar way. Bread made with National Flour contains 14.6 grams of carbohydrate, 0.3 grams of fat, and 2.4 grams of protein per ounce.

<i>Nutrient</i>	<i>Quantity</i>	<i>Calorie Value per Gram</i>	<i>Calories</i>
Carbohydrate	14.6 grams	4	$14.6 \times 4 = 58.4$
Fat	0.3 grams	9	$0.3 \times 9 = 2.7$
Protein	2.4 grams	4	$2.4 \times 4 = 9.6$
TOTAL Calorie value per ounce			<u>70.7</u>

If, for any reason, we do not obtain our Calorie needs from our food we quickly feel hungry and, sooner or later, find that we become slimmer and less and less capable of hard work. It will be clear that people who need a large number of Calories should eat increased amounts of the energy nutrients, i.e., fats and carbohydrates, and foods made from them such as bread, cakes, pastry, biscuits and puddings.

B. FOOD AS A SOURCE OF BUILDING MATERIALS. (PROTEINS AND MINERALS.)

We require food to supply material for the growth and repair of the tissues of the body. Our bodies are made up of millions and millions of microscopical units, the *cells*, which increase enormously in number as we pass from infancy to manhood or womanhood. The baby weighing a few pounds at birth cannot grow and develop into the adult weighing ten or more stones without obtaining considerable amounts of suitable building materials. In addition, throughout life, the cells are continually being reconstructed. All this growth and repair depends upon food and one type of nutrient in particular. This is *protein*. The cells of our bodies consist essentially of a substance called "*protoplasm*." This has been well described as "the physical basis of life." It consists almost entirely of protein. Plants can form their own protein and protoplasm from carbon dioxide of the air, and from water with its dissolved mineral substances absorbed from the soil. Human beings and animals cannot do this. We,

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and animals generally, are dependent for our supply of protein upon plants or other animals which live on plants. It is indeed true in a very real sense that "All flesh is grass."

There are thousands of proteins, for no two species of plants or animals contain exactly the same proteins.

Amino-Acids.

Nevertheless, all proteins, no matter what their sources, are now known to be built up of a very small number of units or "building blocks." These are known as *amino-acids*. By linking together in elaborate chains, networks and foldings, these amino-acids build up the vast variety of plant and animal proteins. When we digest the proteins in our food they are broken down bit by bit into their constituent amino-acids. These pass into our system and are used to build up the various proteins of its cells and tissues. It is plain that unless we get in our food the amino-acids required to build up and repair our own particular proteins, then growth and repair, and indeed life itself, will cease. Any amino-acids which our bodies do not require for building and repair may be used to produce heat and energy.

Sources of Protein.

Our main protein or body-building foods are milk, eggs, meat, fish and cheese. Of these, milk and eggs are much the best and cheese is, perhaps, the cheapest of all body-building foods. It is natural that the proteins of animals should be the best for human beings since we are animals. Among plant foods, the pulses—peas, beans, lentils and soya; the cereals—wheat and oatmeal; and some nuts, contain very useful amounts of protein. As will be explained in the next chapter, they are not so valuable singly as are animal proteins. They are, however, useful supplementary sources of body-building material, especially when mixed.

Building Minerals.

In addition to proteins the body requires certain minerals to help form part of its structure. Thus our bones and teeth are hardened and made rigid or "calcified" by being supplied with

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calcium (lime) and *phosphorus* from food. Milk is an excellent source of both ingredients.

The red corpuscles of the blood contain *haemoglobin* which absorbs oxygen from the air we breathe into our lungs and carries it in the circulation to every living cell in the body. There it helps in the release of energy from food substances also transported by the blood. An essential element in the haemoglobin is *iron* which must, therefore, be supplied in our food. Lack of iron is very evident in anaemia or "bloodlessness."

Another element of use as a building material is *iodine*. This is needed by the thyroid glands which lie on either side of the windpipe towards the base of the neck. They manufacture a substance called *thyroxine* which consists largely of iodine. Thyroxine is passed into the blood stream. Without thyroxine, physical and mental growth cannot proceed satisfactorily. One form of goitre is due to the low activity of the thyroid glands. Sea foods, iodised table salt and iodised sweets, are excellent sources of iodine.

A summary of the best food sources of the minerals required for body-building, is given below.

MINERALS FOR BODY-BUILDING.

<i>Mineral</i>	<i>Sources.</i>
Calcium	Milk, cheese, egg yolk, oatmeal, watercress, "hard water."
Iron	Liver, meat, egg yolk, peas, fish, almonds, raisins, watercress, cabbage, black treacle.
Phosphorus	Liver, kidney, egg yolk, meat, fish, milk, cheese.
Iodine	Sea foods (fish, shell fish), watercress, onions.

It has been found that one or two animal fats, and other substances which are closely related to fats, are essential for the building up of nervous tissues, e.g., a fat-like substance known as *lecithin* is greatly beneficial to the nervous system. It is found in egg yolk, liver, heart, sweetbread and "offals" generally, as well as in nuts, grains and "greens."

C. FOOD AS A SOURCE OF REGULATIVE OR "PROTECTIVE" MATERIALS. (VITAMINS AND MINERALS.)

Until about the year 1912 it was generally thought that if we ate sufficient fats and carbohydrates to supply the Calories we required and ate sufficient proteins for body-building and repair purposes, then our bodies would be getting everything necessary for life and health. We now know that in addition to fats, carbohydrates and proteins, our bodies require certain substances called vitamins and some minerals. Without these *regulative or protective foods*, as they are often called, our bodies are unable to release the energy locked up in fats and carbohydrates and unable to lay down the necessary amino-acids to build up our tissues. We are unable to make full and proper use of the energy and body-building foods we eat and our health suffers—often very seriously. In fact, we are liable to suffer, in some degree, from such diseases as beri-beri, pellagra, scurvy and rickets. These are known as *deficiency diseases* because they are caused through a deficiency of one or other of the protective substances in the diet. In extreme cases these deficiency diseases are grave disorders which lead to much suffering and shortening of life. Beri-beri affects millions of rice eaters of the East. Pellagra is a scourge among the maize-eating negroes in the Southern States of U.S.A. Scurvy has killed more sailors than warfare and shipwreck combined. Rickets crippled and stunted thousands of children in the slums of our great towns during the last century.

Sources of Vitamins.

The amounts of these substances our bodies require are very small indeed. The total amount needed for a whole lifetime is only an ounce or two, but this is no measure of their importance. These very small amounts are absolutely essential to our health and, in fact, to our very lives. We obtain them chiefly from *dairy foods* such as milk, cream, butter, eggs and cheese; *summer fruits* such as black, red and white currants, strawberries, gooseberries and raspberries; *foreign fruits* such as oranges, lemons, grapefruit and bananas; *green vegetables* such as cabbage and sprouts; *salad vegetables* such as watercress, mustard and cress and tomatoes;

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and *fat fish* such as herrings, salmon and sardines. In other words, the best protective foods are dairy foods, fruits, vegetables and fat fish.

We can now summarise what we have learned in the form of a table.

Type of food	Consist of	Common examples	Obtained from
Energy	Fats and carbohydrates	Butter, margarine, suet, lard and dripping. Cereals (wheat, rice, oatmeal). Sugar, treacle, syrup, jam. Potatoes. Pulses. Dried fruit. And, of course, things made from these, e.g., bread, cakes, pastry, biscuits, suet pudding. Cheese. Bacon and ham.	Grocer Baker
Body-building	Proteins and Minerals	Milk, eggs, meat, fish and cheese. Supplemented by peas, beans, lentils, soya, wheat flour and nuts.	Milkman Butcher Fishmonger Grocer
Regulative or 'Protective'	Minerals and Vitamins	Milk, cream, butter, eggs, cheese. Summer fruits and foreign citrus fruits. Vegetables, particularly salad vegetables. Fat fish such as herrings, salmon and sardines. Liver.	Milkman Greengrocer Fishmonger

There are several points about this table which must be made clear. Firstly, it is purely an artificial table drawn up for our convenience. With the exception of a very few foods such as sugar, which is purely an energy food, foods do not exactly fit into our scheme. Bacon and ham, for example, are important energy foods but they also supply protein and even some protective material as well. Secondly, some foods such as cheese, milk, eggs and fat fish appear in more than one group. This should show you how very valuable and important these particular foods are in our diet. Thirdly, a complete diet will contain an adequate amount of each type of food. The ones most likely to be insufficient in

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amount are the body-building and protective foods because these are the most expensive. We must first make certain that these are

GROWTH AND DIET.



FIG. 2. This rat ate only meal, potato, bread and butter. He weighed 89 grams when six months old.



FIG. 3. His bones also show the effect of poor diet.
By courtesy of U.S. Bureau of Home Economics.

included and then look to the energy foods. In planning our meals we should ask ourselves these questions: —

1. Have I included body-building foods?
2. Have I included protective foods?
3. Have I included sufficient energy foods to satisfy appetite?

WHY WE NEED FOOD

Fourthly, we must realise that we can ring the changes among foods of the same type. We can substitute one body-building

GROWTH AND DIET.

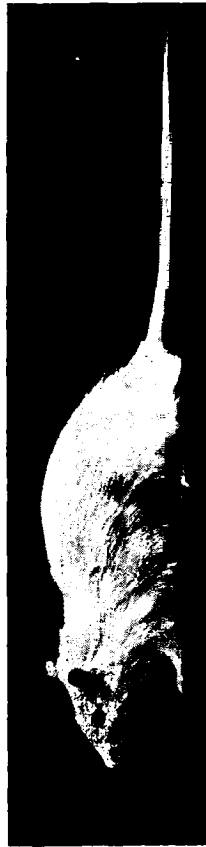


FIG. 4. His twin brother ate plenty of milk and vegetables, besides meat, potato, bread and butter. He weighed 194 grams at six months.

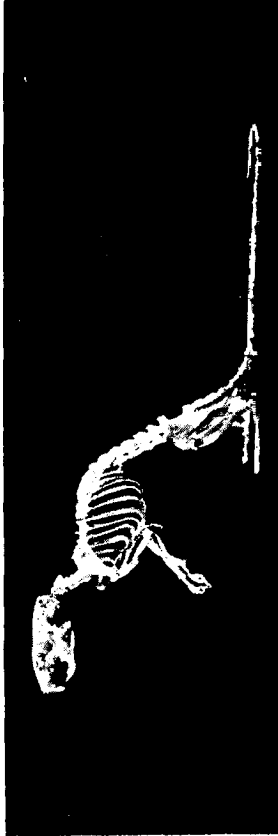


FIG. 5. His bones are strong and well formed.
By courtesy of U.S. Bureau of Home Economics.

food for another body-building food; one energy food for another energy food. Meat can be replaced by fish, cheese or eggs. Potatoes can be replaced by bread. Butter can be replaced by vitaminised margarine. But one type of food cannot do the work

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of another type. Meat cannot be replaced by jam; cheese cannot be replaced by cake; milk cannot be replaced by tea.

Fifthly, all this does not mean that we have to be cranks, and faddy about our food. There is no need for us to be forever wondering whether we are getting the right number of Calories or enough protein, or this particular mineral or that particular vitamin. Not at all! It simply means that our daily diet should be made up from the following foods:—

1. *Milk*. At least a pint for everyone daily and more for children and expectant and nursing mothers.
2. *Eggs, Cheese, Pulses*. At least three or four times per week.
3. *Meat, Fish or Poultry*. Once daily. Fish should preferably be fat fish such as herrings, salmon and sardines.
4. *Fruit*. Orange, grapefruit or tomato. At least once daily.
5. *Vegetables*. Two kinds daily in addition to potatoes, and including one salad or green vegetable.
6. *Fat*. Butter or vitaminised margarine.
7. *Cereals*. Wholemeal bread and oatmeal are the most valuable.
8. *Sugar*. This includes jam, treacle, syrup and sweets.
9. *Water*. About $2\frac{1}{2}$ pints of fluids daily, some of which should be in the form of water itself, i.e., not as tea, coffee or cocoa. Eat any other foods you like in order to satisfy your appetite.

If you look at the table again you will see that our body-building materials come from milk, eggs, meat and cheese, with additions from pulses; our protective material from milk, butter, eggs, cheese, fruit, vegetables and fat fish; and our energy requirements are supplied mainly by bread, oatmeal, sugar, jam, syrup, butter, margarine, cheese and potatoes. The additional foods we eat to please our palates or to satisfy our appetites, e.g., cakes, pastry, biscuits, puddings, etc., are mainly energy foods.

Chapter II

CARBOHYDRATES.

Carbohydrates consist of carbon, hydrogen and oxygen. The hydrogen and oxygen are present in the same proportions as in water (H_2O); hence the name carbohydrate. With very few exceptions, carbohydrates are plant products formed from carbon dioxide and water with the help of energy from the sun absorbed by the chlorophyll of leaves. At first, very simple carbohydrates are formed. From these, plants build up more complicated substances such as the sugar we call glucose. Glucose, in its turn, is built up into more complicated sugars, such as cane-sugar. Still further building-up, or synthesis, results in the formation of starch and cellulose.

When we digest carbohydrates, they are broken down by our digestive juices in the reverse direction until, finally, they become glucose again. This passes into our blood stream and thence into the living cells and tissues. There it is oxidised or burned to carbon dioxide and water by the oxygen we have breathed in and energy and heat are released. As pointed out in the previous chapter, this energy is the energy originally obtained by plants from sunlight.

THE BUILDING-UP OF CARBOHYDRATES IN PLANTS.

Carbon dioxide + water + energy from sunlight \longrightarrow
carbohydrates + oxygen.

THE BREAKING-DOWN OF CARBOHYDRATES IN OUR BODIES.

Carbohydrates + oxygen \longrightarrow carbon dioxide + water
+ energy for heat and work.

There are three kinds of carbohydrates:—

- (a) *Sugars* (b) *Starches* (c) *Cellulose*.

Sugars.

Sugars are divided into *single sugars (monosaccharides)* such as glucose or grape sugar and fructose or fruit sugar, and *double*

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sugars (disaccharides) which are formed by linking together two single sugars. Examples of double sugars are sucrose (cane sugar and beet sugar), lactose (milk sugar) and maltose (malt sugar). They all have a sweet taste, easily dissolve in water and are easily digested.

Glucose is found naturally in ripe fruits, plant juices and honey and, among vegetables, the onion is particularly rich in it. Glucose is now manufactured on a large scale from starch and much used in the manufacture of cheap jams and sweets.

All carbohydrate foods digested in the body are converted into glucose which circulates in the blood and is quickly available whenever needed as a source of energy. The amount of blood sugar, as this glucose in our blood is called, is controlled at a very steady level by a substance, *insulin*, which passes into the blood from the pancreas. Persons who are unable to form sufficient insulin from the pancreas suffer from *diabetes* due to excess of blood sugar. They have to restrict the amount of carbohydrate food they eat and also regularly to inject doses of insulin into their blood to bring down to normal the concentration of their blood sugar.

Glucose is frequently given to invalids as a restorative because it can pass at once into the circulation to be converted into energy and heat. Athletes, such as racing cyclists, long-distance walkers and runners, find glucose sweets very sustaining.

Any glucose not immediately made use of by the body is stored in the liver and muscles as "*animal starch*" or *glycogen*. In this form it can quickly be called upon again when needed to provide heat and energy.

If the body takes in more glucose than it can use or store as glycogen the excess is converted into fat which is laid down in various parts of the body as a reserve. This fat can be converted back into glucose and energy when necessary. Foods rich in carbohydrates, such as potatoes and bread, can thus be fattening foods if we habitually eat more of them than we require for energy purposes.

CARBOHYDRATES

Fructose, or fruit sugar, is another single sugar similar to glucose and is usually found along with it in ripe fruits, plant juices and honey. It is the sweetest of all sugars.

Sucrose is the scientific name for the sugar obtained from sugar cane and sugar beet. It is a *double sugar (disaccharide)* made up of a combination of glucose and fructose. Besides being found in sugar cane and sugar beet it occurs in ripe fruits, honey, sugar maple, beetroot, parsnips, carrots, and dried fruits such as dates, prunes, currants, raisins and sultanas.

The highly refined table sugar which we most commonly use is the purest food we eat. It consists entirely of sucrose. It is wholly converted into glucose during digestion in the intestines and is a readily available energy food. Its sweet taste makes many other foods more palatable.

Of course, sugar contains no protective material, and if eaten in excess, it takes the edge off our appetite so that we may eat less of more valuable foods. For this reason, children should not be given sweets immediately before a meal. It is far better to have them afterwards and, in any case, not to eat too many or too often, although there is no reliable evidence that sugar and sweets cause the teeth to decay.

Saccharin, which is often used as a sugar substitute, has no connection with sugar in spite of its sweet taste. It is an artificially prepared chemical substance and has no food value whatever. It passes through the body unchanged.

Lactose (milk sugar) is similar to sucrose but not so sweet. Unlike sucrose, it is an animal product present in all types of milk. It is added to cow's milk to make it sweet enough for babies who cannot digest cane sugar.

Maltose (malt sugar) is the sugar formed from starch when barley grains are made into malt by germination.

Starch.

Unlike the sugars, starch is not sweet and is insoluble in cold water. It is made up of thousands of glucose units linked together as in a long chain. Hence it is called a *polysaccharide*. It is in the form of insoluble starch that most plants store up as

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Pectin is another complicated carbohydrate. It is this substance which forms a jelly when fruit is made into jam. Without sufficient pectin fruit cannot be made to set into jam.

Dextrin is another complicated carbohydrate intermediate between starch and glucose. Starch is partly changed into dextrin when starchy foods are cooked. Thus the crust of bread and toast contain considerable amounts of dextrin formed from the starch of bread by moist heat.

Dextrin is more easily converted into glucose by our digestive juices than is starch and, for this reason, the crust of bread is more digestible than the crumb and toast more digestible than ordinary bread, besides being more palatable.

We eat many more carbohydrate foods than any others and starch is our main carbohydrate. In most countries, cereals provide the bulk of the food starch. Wheat, largely in the form of bread, is the staple cereal in this country while rice is "the staff of life" in eastern countries, viz., China, Japan and India. Potatoes come a good second as sources of food starch in this country. Other foods besides wheat, rice and potatoes, which consist largely of starch are sago, tapioca and arrowroot.

Besides being valuable energy foods, carbohydrates serve two other useful purposes in our diet. As previously stated, fat is a more concentrated energy food but our bodies have greater difficulty in completely burning fat than they have in burning carbohydrate. When carbohydrate and fat are eaten together, as in bread and butter, our bodies can burn the fat more completely just as a coal fire will burn better if we start it with paper and wood. Too much fat with too little carbohydrate is apt to upset digestion and the health generally.

Carbohydrates are also sometimes referred to as *protein spacers* because unless protein and carbohydrate are eaten together the valuable amino-acids of the protein which should be used as body-builders and repairers will be largely wasted by being burnt up instead of carbohydrate to provide us with sufficient energy.

CARBOHYDRATES

Protein and carbohydrate should always be eaten together at the same meal. We do this, of course, when we eat fish and chips, meat and potatoes, and bread and cheese.

Because carbohydrate foods are plentiful, cheap, easily stored and readily prepared, there is a great danger that many people, particularly the poor, may eat too much of them and too little of the more expensive body-building and protective foods. Another danger when carbohydrate foods form too large a part of the diet is that many cereal foods, especially white bread and polished rice, are very highly refined in the course of milling and the protective materials, the minerals and vitamins, which they contain in their

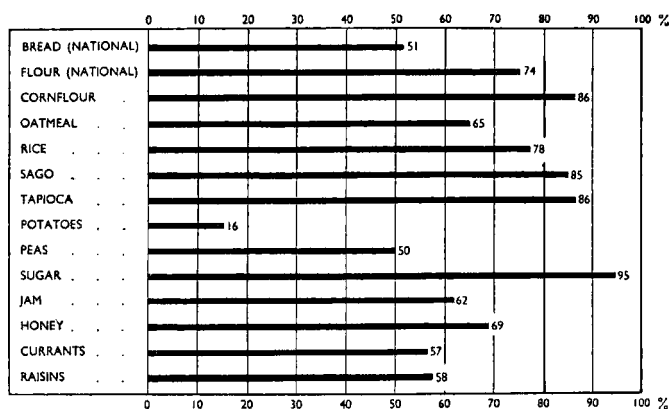


FIG. 8. Percentages of carbohydrates.

natural state, are removed. For this reason it is better to eat starchy foods in as natural a form as possible, i.e., wholemeal bread, unpolished rice, fruits, etc., or else to make up for their deficiency in protective materials by eating, in addition, foods which contain useful amounts of minerals and vitamins, e.g., vegetables.

In any balanced diet, carbohydrates should provide the major part of our energy requirements. This means that more than half our Calories should come from starchy and sugary foods.

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CARBOHYDRATES IN SOME COMMON FOODS.

<i>Food</i>	<i>Percentage Carbohydrate</i>		
Bread (National)	51
Flour (National)	74
Cornflour	86
Oatmeal	65
Rice	78
Sago	85
Tapioca	86
Potatoes	16
Peas	50
Sugar	95
Jam	62
Honey	69
Currants	57
Raisins	58

Chapter III

FATS.

Like carbohydrates, i.e., starches and sugars, fats are made up of carbon, hydrogen and oxygen, but the proportion of oxygen is much less in fats than in carbohydrates. Since carbon and hydrogen are the substances which burn with oxygen, their greater proportion in fats explains why fats are more concentrated energy foods than carbohydrates. You will remember that the Calorie value of a fat is some 9 Calories per gram compared with 4 Calories per gram for average carbohydrates and proteins. Fats thus provide Calories or energy in a compact form.

Oils are the same as fats except that they are liquid instead of solid at ordinary temperatures. Oils can be solidified to fats by cooling and fats melted to oils by heating. The fats we eat are melted into oils by the heat of our stomachs. Some of the higher melting-point fats, such as mutton fat (melting point 122°F) are not as quickly melted as lower melting-point fats such as butter (melting point 90°F).

Fats and oils are found in both plants and animals and, in both cases, are formed from glucose by loss of oxygen and gain of energy. Chemically, fats and oils are composed of combinations of two kinds of simpler substances. One of them is the sweet sticky liquid known as *glycerin* or *glycerol* and the other is an acid. Because they are found in fats these acids are called *fatty acids*. Among the twenty-five kinds of fatty acids found in food fats the commonest are palmitic acid, stearic acid and oleic acid. A less common one is butyric acid which is present in milk, cream and butter. The combination of glycerin and palmitic acid is called palmitin; of glycerin and stearic acid, stearin; of glycerin and oleic acid, olein; and of glycerin and butyric acid, butyrin.

Glycerin + palmitic acid — water = palmitin. (Solid.)

Glycerin + stearic acid — water = stearin. (Solid.)

Glycerin + oleic acid — water = olein. (Liquid.)

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an insulating action and keeps them warm. Thin people feel the cold more quickly than the plump who have the advantage of an insulating layer of fat just under the skin.

It is worth while pointing out again that fat foods should always be eaten along with carbohydrate foods. Otherwise the fats will be incompletely burnt to form substances which cause headaches, and sickness and loss of appetite will result. Doctors call it "acidosis" or more correctly "ketosis." In simpler words, we

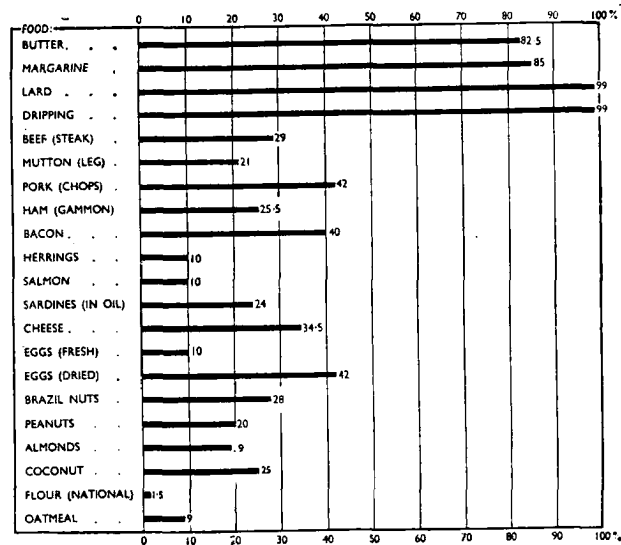


FIG. 9. Percentages of fat.

suffer from "biliousness." Examples of carbohydrate and fat eaten together include such things as bread and butter, strawberries and cream, cakes, pastry, suet pudding and chips. Perhaps you can think of other examples.

The digestion of fats is discussed in Chapter VIII and the use of fat for cooking in Chapter XV.

FATS

FAT IN SOME COMMON FOODS.

<i>Food</i>	<i>Percentage of Fat</i>
Butter	82.5
Margarine	85
Lard	99
Dripping	99
Beef Steak	29
Mutton (leg)	21
Pork (chops)	42
Ham (Gammon)	25.5
Bacon	40
Herrings	10
Salmon	10
Sardines (in oil)	24
Cheese	34.5
Egg (fresh)	10
Egg (dried)	42
Brazil nuts	28
Pea nuts	20
Almonds	19
Coconut	25
Flour (National)	1.5
Oatmeal	9

Chapter IV

PROTEINS.

The word *protein* is derived from a Greek word meaning "I am first," and in all living things proteins are of first importance. As pointed out in Chapter I, proteins are essential because the cells of all forms of life, whether animal or vegetable, are built up of the jelly-like material called *protoplasm* which consists of protein. There can be no life without protoplasm and, therefore, no life without protein. Proteins are the very basis of life.

Like carbohydrates and fats, proteins contain carbon, hydrogen and oxygen, but, in addition, they always contain *nitrogen*. Some proteins also contain sulphur and some few contain phosphorus. Proteins are far more complicated substances than either carbohydrates or fats. They are, in fact, the most complicated substances known to science.

Plants can build up their proteins for themselves from the carbon dioxide they obtain from air, and from the water and mineral substances containing nitrogen (nitrates) which they obtain from soil. A few plants, known as *legumes*, such as peas, beans and clover, with the help of bacteria in nodules on their roots, can make use of the nitrogen in air to build up their proteins. Animals and human beings are unable to make proteins from either the nitrates of the soil or the nitrogen of the air. They depend completely upon proteins already made in plants or other animals. Thus proteins have all come from plants. "All flesh is grass."

There are thousands of different plant proteins and thousands of different animal and human proteins. And plant proteins, animal proteins, and human proteins, are all different from one another. Our particular proteins naturally very closely resemble animal proteins. All the myriad proteins, however, are alike in one respect. They are all built up of simpler substances known as *amino-acids* of which there are some twenty-two different kinds. They are linked together, often in thousands, in chains folded in upon themselves.

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PROTEINS



FIG. 10.

FIG. 11.

FIG. 12.

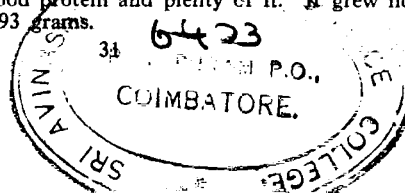
By courtesy of U.S. Bureau of Home Economics.

PROTEINS FOR BUILDING TISSUES.

Rats from the same litter, 11 weeks old.

- FIG. 10. This rat had good protein, but not enough. It weighed 70 grams.
- FIG. 11. This rat had enough protein, but of a poor kind. It weighed only 65 grams.
- FIG. 12. This rat had good protein and plenty of it. It grew normally and weighed 193 grams.

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Proteins differ from one another in the number, the kind and the arrangement of the amino-acids they contain. A particular amino-acid may be present in large amount in one protein, present in very small amount in a second protein and completely absent in a third. There are at least twenty-two different kinds of amino-acids found in proteins. Imagine a large number of each of twenty-two differently coloured kinds of beads. They would make an enormous number of strings of beads all different from one another. They would differ in almost every conceivable way—in either the total number of beads, or the numbers of different kinds of beads or in the order in which we grouped them on the string. Now, perhaps, you will appreciate why proteins are such complicated substances.

Below are given diagrams which may help you still further. We will take only twelve beads and suppose there are three each of four different kinds shown by different letters of the alphabet like this.

A, A, A.	B, B, B.	C, C, C.	D, D, D.
1st kind	2nd kind	3rd kind	4th kind
of bead	of bead	of bead	of bead

Then we might arrange some of them in a set like this:—

No. I. —A—A—A—B—B—B—D—D—

or like this:—

No. II. —A—A—C—C—D—B—B—A—D—B—C—D—

You will see that Set No. I differs from Set No. II because:—

- (1) It has a different total number of beads.
- (2) It has different numbers of the different kinds of beads.
- (3) The beads are differently arranged.
- (4) One kind of bead (—C—) is completely absent.

It is in ways such as these that the twenty-two different amino-acids can join together to form different proteins in vast numbers.

PROTEINS

When we digest protein foods our digestive juices break up the proteins into their different amino-acids. As these amino-acids are circulated in our blood, each cell of the body chooses for its growth and repair the amounts and the kinds of amino-acids it requires. Any surplus amino-acids which are not required at the time for growth and repair are burnt as fuel to supply heat and energy. The Caloric value in the body of proteins is much the same as that of carbohydrates, i.e., about 4 Calories per gram or 116 Calories per ounce.

The system is able to change some amino-acids into others but at least ten amino-acids out of the twenty-two found in proteins the body cannot manufacture for itself. Each of these ten amino-acids, in its own way, is absolutely essential for the growth and repair of the tissues of the body and must, therefore, be supplied in our food. Without them the growth and repair of the tissues is impossible and, therefore, life, too. These particular amino-acids are called the *essential amino-acids*.

Proteins which contain these essential amino-acids will obviously be better body builders and repairers and consequently more valuable foods than proteins from which one or more is missing. They are said to have a high *biological value*. Generally speaking, the animal proteins such as those in milk, cheese, eggs, meat and fish, contain all the essential amino-acids. These are termed *first-class proteins* and have a high biological value. Plant proteins, such as those in cereals, pulses and nuts, generally have one or more of the essential amino-acids missing or in short supply. They are *second-class proteins* and have a low biological value, singly.

There are, however, some exceptions to this rule, e.g., soya beans and gelatine. Soya bean flour contains first-class protein although it is a plant product. Soya beans have been used for centuries by the Chinese and Japanese as their main source of protein. Gelatine is an animal protein made by boiling bones and gristle. It is used in making table jellies and it is gelatine which

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causes meat stock to set to a jelly. Gelatine lacks four of the essential amino-acids and so is not a first-class protein.

The fact that the proteins of gelatine and the plant proteins of bread, flour, oatmeal, peas, beans, lentils and nuts are second-class does not mean that they are not valuable to us. Of course they are and we can best make use of them by taking them as supplementary body-builders. In fact, by mixing them with animal proteins we get the best out of both animal and plant proteins. Meat and peas eaten together at the same meal will supply us with more body-building material than if they were eaten at separate meals. Any amino-acids which may be present in small amounts or completely missing from one protein food can be made up from another protein food in which they are present in large amounts. The more varied the body-building foods we eat, the more likely we are to supply our bodies with the amounts and the kinds of amino-acids they need.

It is usually reckoned that the best results are achieved if we obtain half our protein from animal foods and half from plant foods. Remember, too, that proteins will be less likely to be wasted as fuel if eaten along with carbohydrate food. We shall make the best use of our protein foods and obtain their maximum value if we eat them along with carbohydrate in small amounts at each meal rather than eating a large amount to one meal, say dinner, and practically none at other meals of the day. Unfortunately, proteins, unlike carbohydrates and fats, cannot be stored in the body.

While it may be argued that to eat more protein than the body needs for growth and repair is in some degree wasteful, it cannot be said to be harmful. At one time it was thought that to eat large amounts of proteins, such as meat, would be to run the risk of a variety of crippling ailments such as rheumatism, kidney troubles and cancer. This view is no longer accepted. Indeed, there would appear to be this advantage in protein foods generally in that they stimulate the liberation of heat and energy from other non-protein foods.

PROTEINS

Protein foods are the most expensive foods. This is particularly true in the case of animal proteins. They are also the most tasty and appetising and give a feeling of being well-fed which carbohydrates never do. There is consequently a danger that the father of the family may, in some instances, get more than his share of meat, fish and eggs, and the mother and children less than they ought. Their need for protein foods may well be more than his. Growing children, and young persons generally, need a good share of first-class proteins, such as those of meat, fish and dairy products—milk, cheese and eggs. They can scarcely have too much milk. Children should not, as sometimes happens, be given gravy only with potatoes while the grown-ups get meat and potatoes, or chips only while the adults have fish and chips.

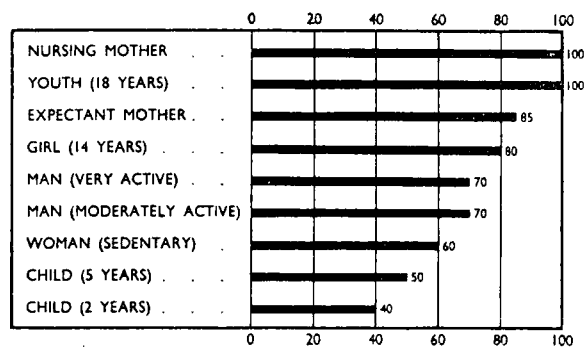


FIG. 13. Protein requirements in grams per day.

The total amount of protein required daily by different classes of persons is still a matter of some dispute. But it is generally accepted that a satisfactory daily ration for the average adult is about 70 grams or $2\frac{1}{2}$ to 3 ounces of mixed proteins, shared equally between first-class animal proteins and second-class plant proteins. This amount is certainly much less than most people would think enough. It is only the very poor in this country who under pre-war conditions were dangerously below the accepted ration of 70 grams and this chiefly in the matter of animal proteins.

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PROTEIN IN SOME COMMON FOODS.

<i>Food</i>	<i>Percentage of Protein</i>
Milk (Fresh)	3.3
Milk (Dried)	25.6
Cheese (Cheddar)	25
Eggs (Fresh)	11
Eggs (Dried)	46
Beef (Steak)	14
Mutton (Leg)	14
Pork (Chops)	10
Ham (Gammon)	14
Bacon	10
Herrings	10
Salmon	20
Sardines (in oil)	20
Flour (National)	9
Oatmeal	12
Peas (Dried)	25
Lentils	24
Pea Nuts	20

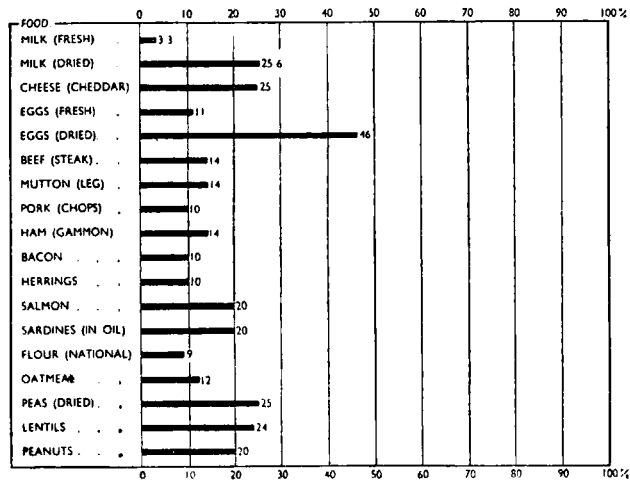


FIG. 14. Percentages of proteins.

Chapter V

MINERALS AND WATER.

We have seen that carbohydrates and fats consist of carbon, hydrogen and oxygen, and that proteins, in addition to these three elements, always contain nitrogen and sometimes sulphur and phosphorus. The term *minerals* is applied to elements other than carbon, hydrogen, oxygen and nitrogen which are found in the body and which must be provided in our food.

"Minerals" is not a particularly good name for them because they are not minerals in the sense that limestone and iron ore are minerals, nor are they minerals in the sense that lemonade is a mineral. Yet they are minerals in the sense that they form the ash left behind when bodies are cremated and the dust left behind when bodies decay underground. All have been derived originally from the soil and ultimately return to it.

This ash has been analysed and found to contain the surprisingly large number of nineteen different mineral elements. Their total weight amounts to about one twentieth of the weight of the body.

Some of them are present in very large proportions while others are present in such minute quantities that their amounts are described as being "traces" or even "mere traces." Yet even these "traces" and "mere traces" have been proved essential to health. Each and every one of them is necessary and no one mineral can do the work of another. Each of them must be supplied in our food.

The mineral substances present in largest amounts are calcium and phosphorus. In the form of calcium phosphate (phosphate of lime) they form the principal constituents of bones and teeth which account for a very large proportion of the weight of minerals in the body. Potassium, sulphur, chlorine, sodium, magnesium, iron, manganese and iodine are present in much smaller amounts while the remaining nine minerals—silicon, cobalt, boron, arsenic, fluorine, copper, zinc, aluminium and nickel—are present as traces or mere traces.

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The minerals are used by the body for three main purposes:—

- (1) They build up the bones and teeth.
- (2) They are essential constituents of every cell in the body. Muscle cells, nerve cells, liver cells, brain cells and so on, all contain minerals.
- (3) All the fluids which circulate in the body, such as the blood, the lymph, the digestive juices and so on, contain minerals. For example: blood, sweat, and tears, taste of salt.

Many of the minerals are needed in such small quantities and are present in so many different foods that there is little likelihood of our not getting sufficient of them. Others are either needed in much larger quantities or are not present in all foods and consequently there is a danger of a shortage of them in our bodies. Among these are calcium, iron and iodine, and, from our point of view, these three minerals require special notice.

Minerals are continually being lost from the body through:—

- (1) The kidneys, in the urine.
- (2) The skin, in perspiration.
- (3) The bowels, in faeces.

These lost minerals must be replaced or health will suffer. In the case of growing children the minerals taken into the body must more than replace those lost, otherwise normal growth such as the formation of bone and building up of tissue will be impossible.

Foods vary greatly in the amounts of each mineral which they contain. A particular food may be a good source of one mineral and a poor source of another. Milk, for instance, is particularly rich in calcium and phosphorus but poor in iron.

Unfortunately, too, the body is not always able to make full use of the minerals which may be present in a particular food. This is especially true of calcium, phosphorus and iron as will be explained later. Though present in a food they are not always *available* to the body.

MINERALS AND WATER

All foods in their natural state contain some minerals but the amounts are always much less than those of carbohydrates, fats and proteins. In fact, it is exceptional to find a natural food which contains as much as 1 per cent. of a particular mineral. Many of the refining and milling processes to which some foods are subjected reduce the amounts still further.

Rats from the same litter, 22 weeks old.

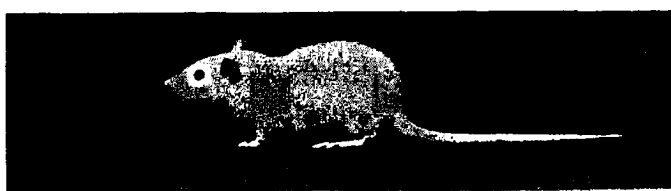


FIG. 15. This rat lacked calcium. It weighed 91 grams and showed the short stubby legs due to poorly formed bones.



FIG. 16. This rat had an abundance of calcium. It weighed 219 grams and its bones were well formed.

By courtesy of U.S. Bureau of Home Economics

Calcium (Lime) and Phosphorus.

Calcium (lime) is the mineral which is present in the body in the largest amount. It is mainly required to form the calcium phosphate (phosphate of lime) of which our bones and teeth are largely composed. In addition, calcium is necessary for the normal working of our muscles and the proper growth of children. Blood will not clot during bleeding unless it contains a certain definite proportion of calcium.

ELEMENTARY SCIENCE OF FOOD

Phosphorus is the mineral in the body which comes next to calcium in amount. It is used mainly in the formation of bones and teeth but is also found in all the tissues of the body and in every cell of the body, being an ingredient of some of the most important proteins. It is particularly important in the nerve and brain cells.

When a baby is born its bones are soft and pliable because they consist largely of cartilage or gristle. To convert this gristle into hard, solid bone, calcium and phosphorus must be deposited in it. As will be explained in the chapter on vitamins, vitamin D is also necessary for this process to take place. Should any of these three things—calcium, phosphorus and vitamin D—be lacking, bones and teeth will not form properly and rickets and decayed teeth may result.

Rats from the same litter, 9 weeks old.



FIG. 17. This rat did not have enough phosphorus. It grew slowly and weighed only 60 grams.



FIG. 18. This rat had plenty of phosphorus and weighed 115 grams.

By courtesy of U.S. Bureau of Home Economics.

Phosphorus is much more common in foods than is calcium. There is little likelihood of our getting too little phosphorus, even though the body cannot always utilise all the phosphorus in food, but there is a very great danger of our getting too little calcium.

MINERALS AND WATER

It is suggested that fully three quarters of our population did not have enough calcium daily before World War II. The danger is greatest in the cases of infants, growing children and expectant and nursing mothers, who need increased amounts of calcium. A growing child needs about twice as much calcium as an adult.

There are only a few foods which contain really substantial amounts of calcium. They are milk and milk products such as cheese, milk powder and condensed milk. Milk is the finest of all foods for building sound bones and teeth. A minimum amount of one pint per day is desirable for adults while even larger amounts are needed by the priority cases already mentioned.

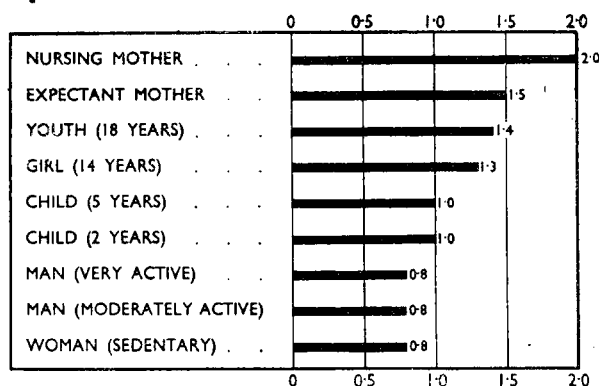


FIG. 19. Calcium requirements in grams per day.

Bones of fish like those of whitebait, sprats and sardines, supply valuable calcium. "Hard" water also contains calcium salts which help to supplement our supplies of food calcium. During and since World War II calcium carbonate (chalk) has been added to National flour (7 ozs. to a 280 lb. sack) to help to overcome the danger of calcium shortage in the diet. It seems likely that this practice of *fortifying* flour will be continued indefinitely. Eggs, oatmeal, green vegetables and nuts are other foods which contain useful amounts of calcium.

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Unfortunately our bodies are not always able to make full use of all the calcium present in foods. Some of it may be in an insoluble form which consequently cannot pass through the walls of the intestines into the blood stream. In the bran of cereal grains, such as wheat and oats, is found a substance called *phytic acid* which may combine with the calcium in other foods to form an insoluble calcium compound and thus make the calcium useless to us. Such calcium is said to be *unavailable*. *Oxalic acid* is another acid which can form an insoluble compound with calcium. Oxalic acid is found in rhubarb and spinach.

Iron.

Iron is present in the *hæmoglobin* of the red corpuscles of the blood which absorb oxygen from the air we breathe into our lungs. Lack of iron leads to lack of hæmoglobin which, in its turn, leads to lack of oxygen for burning up our fuel foods to provide energy. This explains the listlessness characteristic of *anæmia*, which is sometimes described as "the occupational disease" of the British housewife.

The body takes great care to preserve as much of its iron as possible. When red corpuscles become worn out, as they are continually doing, they are broken up in the liver, but the liver retains the iron of the old red corpuscles to use in making new ones. This building up of new red corpuscles takes place in a rather unexpected place—the marrow of the bones.

Nevertheless there is always a small loss of iron in the various secretions and in the general wear and tear of the body. Larger losses occur during bleeding and, in the case of women and girls, during menstruation. These losses must be made good by the provision of iron in their food.

The best foods for supplying iron are liver and kidneys, meat, egg yolk, peas, almonds, raisins, fish, black treacle, watercress and cabbage. In serious cases of anæmia, liver extract or medicine containing iron compounds are used to supply iron, e.g., "Blaud's pills."

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As in the case of calcium and phosphorus, the iron in foods is not always available to the body because it may be in an insoluble form. Phytic acid and oxalic acid, which can combine with calcium to make it unavailable to the body, can do the same with iron. Spinach is an example of a food which contains iron in an insoluble

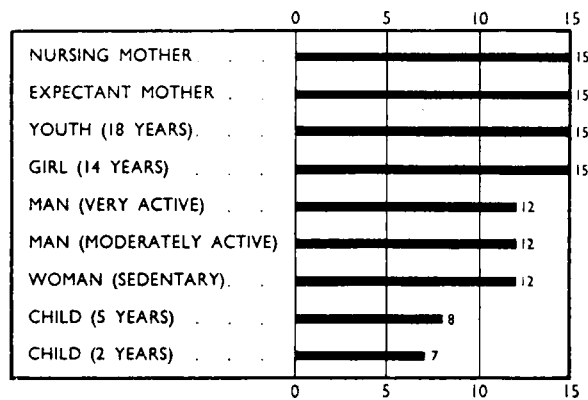


FIG. 20. Iron requirements in milligrams per day.

form which is thus useless to the body. It is very doubtful if most of the iron in "red" meat, liver and "black puddings" is available to the body.

It is an interesting fact that useful amounts of iron may be supplied to the body from the water used for drinking and cooking, and from kitchen knives and iron pans used in the preparation of foods. In this latter connection, the more up-to-date stainless steel cutlery and aluminium or enamel pans do not, of course, help.

A baby is born with enough iron stored up in his liver to last him for about six months. If the baby is breast-fed then he gets a small amount of iron from his mother's milk, but if he is bottle-fed he gets much less because cows' milk contains very little iron. A bottle-fed baby is thus liable to become anæmic after six months of age unless he gets additional supplies of iron. These can be

given in the form of "iron" medicines or small quantities of egg yolk, finely minced liver, or sieved green vegetables.

Iodine.

Iodine has already been mentioned as an essential substance for the thyroid glands in the neck. The secretion of the thyroid glands, *thyroxine*, consists largely of iodine which must be supplied in the food if these important glands are to work efficiently.

Without an adequate amount of iodine, the thyroid glands cannot secrete sufficient thyroxine and a form of *goitre* is likely to result. In extreme cases, the children of mothers suffering from goitre are born with inactive thyroid glands. Since the thyroid glands control physical and mental growth, such children become deformed idiots or *cretins*, but, in some cases, can be made normal by being fed with preparations of animal thyroid glands.

Iodine is derived mainly from sea foods—sea fish, oysters, mussels, cod liver oil, and so on. In addition, water used for drinking and cooking frequently contains iodine and so do vegetables, particularly watercress and onions, which have been grown in soil containing traces of iodine.

In spite of the very small amount of iodine needed by the body there are parts of the world where insufficient is present in food and drinking water. These districts are usually far removed from the sea or are mountainous, particularly limestone districts. Sea water contains iodine which is carried in sea spray several miles inland by the wind and thus finds its way into soil and drinking water and into the vegetables grown in such soil.

In some parts of America, in Switzerland and, in this country, in the hilly districts of Derbyshire, Yorkshire, Cumberland and Gloucestershire there is insufficient iodine in the soil and drinking water and, consequently, in the local vegetables. Goitre is common in these districts. In this country, goitre is often referred to as "Derbyshire neck."

Where such lack of iodine occurs it is wise practice to use salt with small amounts of iodine compounds (iodised salt) for cooking and at the table. Natural unrefined salt contains iodine

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compounds but these are removed during the process of refining. Iodised sweets and chocolate have also been recommended for children living in such districts.

Salt (Sodium Chloride).

Common salt is a compound of sodium and chlorine, known as sodium chloride. It is present in all the fluids of the body in a definite amount and it is essential that this amount should always be accurately maintained.

A shortage of salt is likely to result in cramp of the muscles, but so many of our foods contain large amounts of salt, and we use so much salt for seasoning and flavouring our food, that there is little probability of our being short of it.

Salt is lost from the body in the urine and in perspiration. For this reason, we may need additional salt during hot weather or after violent exercise. Stokers, steel workers and miners, who work in hot places, and people who live in hot countries, require additional salt to make up for the large amount lost in heavy perspiration. Troops campaigning in the tropical forests of Burma experienced cramps which were relieved by salt.

The chlorine of salt is used by the body to form the hydrochloric acid of the gastric juice of the stomach which helps in the digestion of proteins.

Salt in excess of the body's needs is harmlessly removed by the kidneys in the urine.

Foods which contain appreciable amounts of salt include cheese, kippers, ham, bacon, bread, butter and margarine.

We need not discuss the other mineral elements in detail. They are present in so many foods that there is little risk of our not getting sufficient of them. *Potassium*, which is found in the muscle cells and blood cells, is present in the majority of foods. *Magnesium* forms part of our bones and teeth. *Sulphur* is obtained mainly from certain proteins, e.g., those of egg yolk.

The following table shows the foods which contain the three minerals, calcium, iron and iodine. These are to us the important ones because they are the ones most likely to be deficient in the diet.

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<i>Mineral</i>	<i>Foods containing large amounts</i>
Calcium	Milk, cheese, milk powder, condensed milk. Whitebait, sprats, sardines. Eggs, oatmeal, green vegetables, nuts, "Hard" water.
Iron	Liver, kidneys, meat, egg yolk, fish. Peas, almonds, raisins. Watercress, cabbage. Black treacle, oatmeal.
Iodine	Sea fish, oysters, mussels. Vegetables, e.g., watercress, onions. Water. Iodised salt.

The chief sources of the essential mineral constituents of the diet are milk, cheese, eggs, green vegetables and fish. The same fact will be noticeable when we study the vitamins. Consequently these are amongst the most valuable of our foods.

Water.

Water is not commonly regarded as a food in the ordinary sense of the word but it is, nevertheless, of the very greatest importance in the diet. It is possible to live for several weeks without solid food but we can survive for a few days only without water. The body's need for water is indicated by thirst just as the need for food is indicated by hunger.

Nearly three quarters of the weight of the body is made up of water. Every tissue and organ in the body—even bone—contains water. All the processes which take place in the body do so in a watery medium. Water is essential for the digestion and absorption of all our foods and for their transport throughout the body. Water is the great purifying agent in the body and removes waste materials in perspiration, urine and faeces. We can thus realise the important role played by water in building our bodies and safeguarding our health.

Water is continually being lost from the body through the skin, the lungs, the kidneys and the bowels. The body obtains its water mainly from the fluids we drink. These include, in addition

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to water itself, such beverages as tea, coffee, cocoa, milk, lemonade, and so on.

Secondly, the body obtains water from the solid foods we eat. Many solid foods contain surprisingly large amounts of water. Fresh fruit, for example, may contain from 70 to over 90 per cent. of water. Putting this another way, an apple weighing 3 ounces contains as much as $2\frac{1}{2}$ ounces of water. Potatoes contain about 80 per cent. of water and turnips about 90 per cent. Even a "dry" food such as white bread contains 39 per cent. of water while foods such as dried peas, lentils, milk powder and dried egg still contain up to as much as 15 per cent. of water.

Finally, the body obtains water from the oxidation of energy foods. Fats and carbohydrates are ultimately oxidised in the body to carbon dioxide and water. The carbon they contain is oxidised to carbon dioxide (CO_2) and the hydrogen to water (H_2O).

The following table gives the amounts of water which are usually reckoned as being taken in and lost by the body each day. Under normal conditions these amounts balance each other. Any necessary adjustment is made by the kidneys which excrete a larger, or a smaller, amount of urine.

<i>Water taken in</i>		<i>Water given out</i>	
As drink	$2\frac{1}{2}$ pints	In urine	$2\frac{3}{4}$ pints
In food	$1\frac{1}{2}$ pints	From skin	1 pint
Formed in the body		From lungs	$\frac{3}{8}$ pint
by oxidation of food	$\frac{1}{4}$ pint	In faeces	$\frac{1}{8}$ pint
	$4\frac{1}{4}$ pints		$4\frac{1}{4}$ pints
	$4\frac{1}{4}$ pints		$4\frac{1}{4}$ pints

These are, of course, average figures which will vary for obvious reasons, particularly the amount of perspiration. Nevertheless, they serve a useful purpose in showing that many people drink far too little water. Reckoning that a tea-cup holds about $\frac{1}{4}$ pint and a tumbler about $\frac{1}{2}$ pint it will be realised that $2\frac{1}{2}$ pints represents a considerable amount of drinking. Two cups of tea at breakfast, $\frac{1}{3}$ pint of milk at school, a tumblerful of water at

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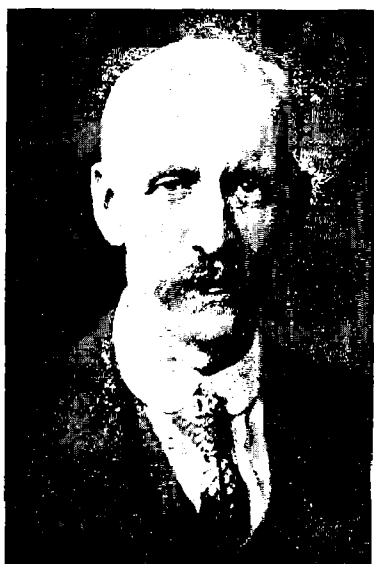
dinnertime, two cups of tea at tea-time and a glass of milk at supper time only amount to $\frac{1}{2} + \frac{1}{3} + \frac{1}{2} + \frac{1}{2} + \frac{1}{3} = 2\frac{1}{6}$ pints. The additional amount could be made up by drinking more milk or by a glass of hot water immediately on rising. This latter is a useful habit as it helps to flush the kidneys after the night's rest and thus helps in removing the accumulated waste materials from the body.

It is sometimes said that we should not drink much fluid with meals because this will dilute the digestive juices and weaken digestion. For a normal healthy person this is not true. The important thing is not when we drink but how much we drink.

Chapter VI

VITAMINS.

The most important advance in our knowledge of foods made during this century has been the discovery of a number of previously unknown nutrients which are absolutely essential to health and, indeed, to life itself. Up to the beginning of the



By courtesy of Cambridge University Press.

FIG. 21. Sir F. Gowland Hopkins,
O.M., P.P.R.S.

century it was thought that a diet which provided carbohydrate, fat, protein, minerals and water in suitable amounts was all that was necessary for maintaining health and activity. The Cambridge scientist *Dr. (later Sir) Frederick Gowland Hopkins* carried out a long series of experiments on the feeding of rats. He fed a group of them on carefully purified carbohydrates, fats, proteins, minerals and water. They failed to grow, soon began to lose weight and generally showed many signs of ill-health. Other rats were also fed on this purified diet but with the addition of a few drops of fresh milk, yeast extract or swede juice at different times of the day. These rats remained fit and active and grew at a normal rate. The rats which had been losing weight on the purified diet were then given a little milk in addition and, at once, they began to increase in weight and to become healthy again. The rats which had originally been given milk were now given the purified diet only. They soon stopped growing and began to lose weight.

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In 1912 Hopkins published the results of his experiments and suggested that in natural foods there are a number of substances additional to carbohydrates, fats, proteins and minerals which are no less essential ingredients of a complete diet. He called them *accessory food factors*.

At about the same time, two pairs of American scientists, Osborne and Mendel and McCollum and Davis, were also studying the effect of food on the health and growth of rats. Like Hopkins,

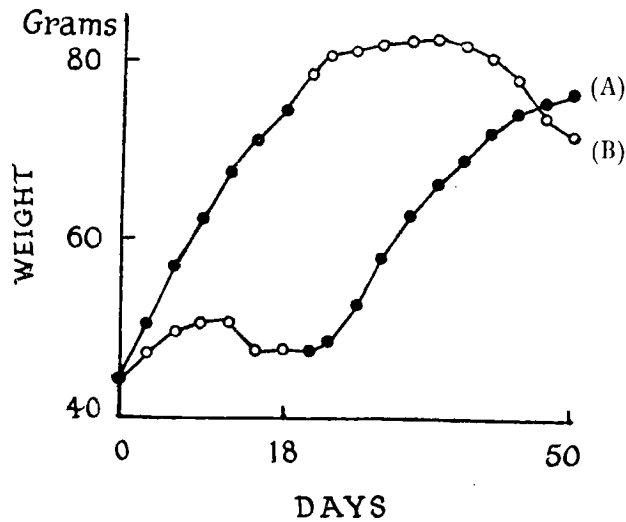


FIG. 22. GRAPH (A) showing growth with vitamins up to 18th day and decrease afterwards in absence of vitamins. GRAPH (B) showing failure of growth in absence of vitamins up to 18th day and restoration of growth with vitamins afterwards.

they found that rats could not be kept alive on a diet of purified foods but that, with the addition of a small amount of milk, growth was normal. They suggested there were two factors in the milk; one in the fat of the milk which they called *Fat Soluble A* and one in the water of the milk which they called *Water Soluble B*.

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Funk, a Polish chemist, thought the accessory food factors were protein in character and suggested the name *vitamines*. The first part of the name meant "vital" and the second part was derived from "amino-acids" of which proteins are formed. We now know that these accessory food factors are not protein in character at all. The name has, however, remained, but without the final "e" and we speak of *Vitamin A*, *Vitamin B*, *Vitamin C*, and so on. The use of these letters is no longer really necessary since the chemical composition of all common vitamins has been determined. Each such vitamin has now been given its proper chemical name.

The various vitamins are all distinct chemically. Each one plays a particular role in maintaining the processes of life and no one vitamin is able to do the work of another. It is, however, convenient to study them together for they are all organic (carbon-containing) substances which are required by the body, though in very small amounts, if it is to function properly.

Their function is the control of such bodily activities as growth, tissue repair and energy production. The body is unable to form vitamins for itself and must obtain them from food. They are present in foods in such small amounts that it is not surprising that their discovery has been so recent.

Lack of any one of the vitamins in the diet will lead to ill-health. In serious cases, *deficiency diseases*, such as scurvy, beriberi, pellagra and rickets are caused. Prolonged lack of any vitamin leads ultimately to death.

Vitamin A, Fat-Soluble A, Axerophthol, Anti-infective Vitamin.

Vitamin A is found in certain animal fats and in the fatty parts of some animal foods. Vegetable fats and oils contain little or no vitamin A.

A yellow substance, known as *carotene*, is found in certain vegetable foods and can be changed by the liver into vitamin A. Carotene gets its name from carrots to which it gives their orange colour. It is found in all green vegetables but, in their case, the

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yellow colour of the carotene is masked by the green colour of the chlorophyll they contain. The carotene in tomatoes is masked by a red pigment. Yellow fruits, such as apricots and oranges, and yellow vegetables, such as carrots and turnips, owe their colour to the carotene they contain.

VITAMIN A.

Rats from the same litter, 11 weeks old.



FIG. 23. This rat had no vitamin A. It weighed only 56 grams and had infected eyes, rough fur, and showed lack of vigour.



FIG. 24. This rat had plenty of vitamin A and weighed 123 grams. It had bright eyes, sleek fur, and was vigorous.
By courtesy of U.S. Bureau of Home Economics.

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Vitamin A is the better of the two because carotene is never completely changed into vitamin A in the body or completely absorbed by the intestines. It is usual to reckon that one third of the carotene in foods is actually absorbed by the body as vitamin A.

Vitamin A serves several purposes in the body:—

- (1) It is necessary for the growth of children.
- (2) It helps the eye to perceive light.
- (3) It protects the skin and ensures the activity of mucous membranes generally such as in the front of the eyes and the linings of the throat, bronchial tubes, stomach and intestines.

Lack of sufficient vitamin A checks the growth of children, particularly growth of the bones and teeth. It also leads to inability to see well in a dim light and, in serious cases, to *night-blindness* which is due to the inadequacy of the colouring matter known as “visual purple” in the retina of the eye. Night fighter pilots were given additional supplies of vitamin A during World War II. Long continued deficiency of vitamin A leads to an eye disease known as *xerophthalmia* and ultimately to blindness. The scientific name for vitamin A—*axerophthol*—is derived from this disease.

The mucous membranes lining the throat and bronchial tubes and the outside (epithelial) linings of many glands and organs quickly become unhealthy and lose their power of secreting the lubricating mucus when vitamin A is lacking in the diet. In this unhealthy condition they offer lowered resistance to disease bacteria and the body is thus more easily infected with disease. This applies particularly to the bacteria which cause the common cold and other diseases of the respiratory organs. Vitamin A is sometimes referred to as the *anti-infective vitamin*.

Foods Rich in Vitamin A.

Foods which contain vitamin A are fish liver oils, fat fish, liver and kidney, and dairy products—milk, cream, butter, cheese and egg yolk. Carotene is found in green vegetables, e.g., spinach,

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watercress, cabbage and green peas; in yellow vegetables, e.g., carrots and turnips; and in dried apricots and tomatoes.)

The amounts of carotene in vegetables and fruits depend upon the amount of sunlight they have received. The outer green leaves of cabbage, for example, are a good source of carotene while the inner white leaves of the heart contain none.

The vitamin A in milk, cream, butter and cheese has been formed by cows from the carotene in the green grass they have eaten. Summer milk and butter are thus better sources of vitamin A than winter milk and butter.

Vitamin A finds its way into fat fish and fish liver from the minute green plants floating on the surface of the sea known as *plankton*. Small fish feed on this plankton and convert its carotene into vitamin A. Large fish eat the small fish and store up the vitamin A in their body oils and livers. This explains why halibut liver oil and cod liver oil are such excellent sources of vitamin A.

Vitamin A is soluble in fats, hence the old name, *fat-soluble vitamin A*. Both vitamin A and carotene are insoluble in water. Consequently, they are not leached out when foods containing them are soaked, boiled or steamed. Boiled carrots and cabbages contain just as much carotene as raw carrots and raw cabbages and are more easily digested.

The temperatures used for cooking are not likely to destroy the vitamin A and carotene in foods. Canned fruits and vegetables still contain their original carotene, and condensed and dried milk and dried egg their original vitamin A.

We can store up vitamin A in the liver and so can utilise the excess supplies of one day to balance days when supplies are short. Plentiful summer supplies may carry us well into the winter when vitamin A is more difficult to obtain because greens and fruits are not so readily available.

Since milk and butter contain less vitamin A in winter when dairy herds are largely fed on hay and mostly kept indoors and since green vegetables are scarce and expensive, foods such as liver, fat fish and carrots are particularly valuable during the

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period from September to April. Young children, rapidly growing boys and girls and expectant and nursing mothers who need additional amounts of vitamin A should supplement their supplies by taking halibut liver oil or cod liver oil.

Vegetable fats and oils are devoid of vitamin A. Margarine made from such fats and oils now have vitamin A added to them so as to make them equivalent in this respect to the best summer butter.

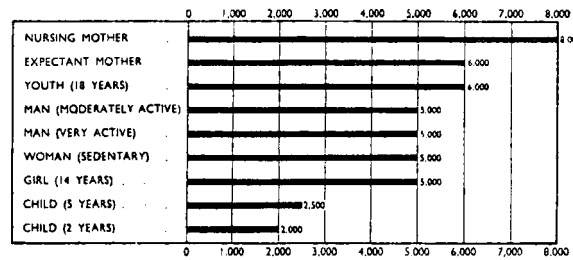


FIG. 25. Vitamin A requirements in international units per day.

Vitamin B, Water-Soluble B, The Vitamin B Complex.

The original water-soluble B factor has been found to be a mixture of several different vitamins which were numbered B₁, B₂ and so on, as they were discovered. Most of them now have their own chemical names and the whole collection of them (at least eleven) is known as the *vitamin B complex*. All are soluble in water and are usually, but not always, found together in the same foods. The body is unable to store these vitamins because of their solubility in water and, consequently, it must receive daily supplies of them.

It is only necessary for us to study three of the vitamins in the vitamin B complex. They are *thiamine*, *riboflavine* and *nicotinic acid*.

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Vitamin B, Thiamine, Aneurine, Anti Beri-Beri Vitamin, Anti-neuritic vitamin.

This vitamin is a white crystalline substance. It is known as *aneurine* (anti-neuritic vitamin) in England and as *thiamine* (sulphur-containing vitamin) in America. Its original name was *vitamin B₁*.

VITAMIN B₁.



FIG. 26. This rat did not have enough vitamin B₁ and suffered from the lack of muscle control (spastic paralysis).



FIG. 27. The same rat 24 hours later, after receiving a food rich in vitamin B₁, it has then recovered muscle control.

By courtesy of U.S. Bureau of Home Economics.

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The function of thiamine in the body is to control the liberation of energy from carbohydrate foods by way of complete oxidation of glucose in the system. If thiamine is absent the glucose is incompletely oxidised and pyruvic acid is formed which damages the nerves.

Lack of thiamine in the diet leads to:—

- (1) A check in the growth of children.
- (2) Loss of appetite, depression, fatigue, indigestion and constipation.
- (3) Nervous irritability and a special type of neuritis (inflammation of the nerves).
- (4) Prolonged deficiency leads to the disease beri-beri.

Beri-beri is a disease of the nervous system which causes a special type of paralysis. It is found chiefly in the Far East in such countries as Japan, the Malay Peninsula and the Dutch East Indies where most of the poor people live very largely on a diet of polished white rice. Natural unpolished rice contains thiamine in the outer "silver skin," or bran layer, which is removed during the preparation of polished rice.

The same loss of thiamine takes place when the bran layers and germ of wheat are removed in the milling of white flour. As with rice, the thiamine of wheat is found in the outside bran layers and the germ. National flour contains 85% of the wheat berry and thus retains the greater part of the original thiamine and, in this respect, is superior to pre-war white flour. (See page 78.)

Foods Containing Thiamine.

Thiamine is widely distributed among foods but nearly always in small amounts. Important sources are whole grains; wholemeal and National flours; oatmeal; dried brewers' yeast and yeast extracts; certain vegetables, especially legumes and potatoes; nuts; lean meat; pork and bacon; liver; fish roes; eggs; fish and milk. Bemax and Marmite are proprietary articles rich in thiamine prepared from wheat germ and yeast respectively, and most modern meat extracts are reinforced with the B vitamins.

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There are bacteria in the large intestine which can manufacture thiamine and some of this thiamine passes into the blood stream and supplements that obtained from food.

Persons eating a large amount of carbohydrate food and engaged in heavy work will require more thiamine than persons on a low carbohydrate diet engaged in light work. Amounts above the average are needed by rapidly growing boys and girls and by expectant and nursing mothers.

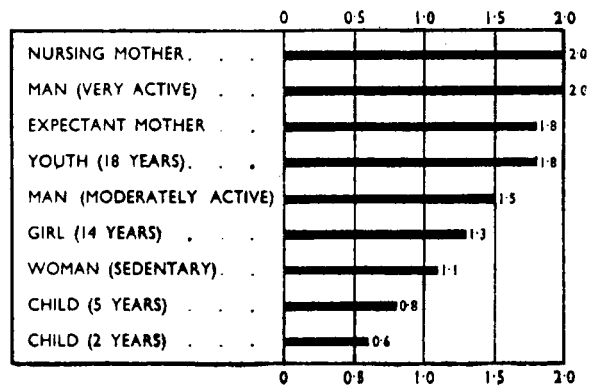


FIG. 28. Thiamine requirements in international units per day.

By eating a good mixed diet containing plenty of natural foodstuffs, particularly wholegrain cereals, meats, milk and eggs, we should be able to meet our daily requirements easily. It is only when the diet is restricted too largely to highly refined carbohydrate foods such as white flour, polished rice and sugar that a deficiency of thiamine is likely to occur with consequent disorders of digestion and nervous tone.

Thiamine is very soluble in water and nearly half goes into the water in which fruits and vegetables are cooked. With cooked fruits this does not matter because we use the liquid but with vegetables it is often unwisely thrown away. Its proper use should be in making stock, soups or stews.

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Thiamine is destroyed by high temperatures and particularly so in the presence of soda. There is some loss in the canning of meat and processed foods because of the high temperatures used. Temperatures reached in pressure cooking are likely to result in some loss of this vitamin. The temperature of boiling water is not high enough to affect thiamine unless the liquid is made

VITAMIN B₂ (G) Male rat, 28 weeks old.



FIG. 29. This rat had no vitamin B₂ (G) and weighed only 63 grams.

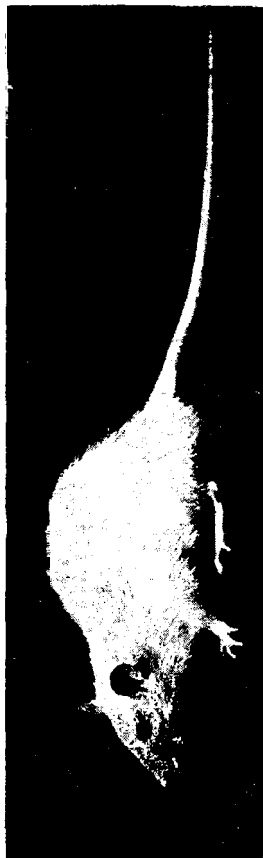


FIG. 30. The same rat six weeks later, after receiving food rich in vitamin B₂ (G). Its weight was then 169 grams.
By courtesy of U.S. Bureau of Home Economics.

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alkaline by the use of sodium bicarbonate. Thus, the use of sodium bicarbonate to soften green vegetables and to give them a rich green colour results in the destruction of the thiamine they contain. The sulphites used as preservatives in sausages have a similar effect upon the thiamine of the meat.

Vitamin B₂, Vitamin G, Riboflavine.

Riboflavine is the chemical name for the vitamin which was originally called B₂ in England and G in America. It is a greenish yellow substance which gives its characteristic colour to butter milk. It is concerned in the system with the production of energy by oxidation and also with the utilisation of food fats and amino acids.

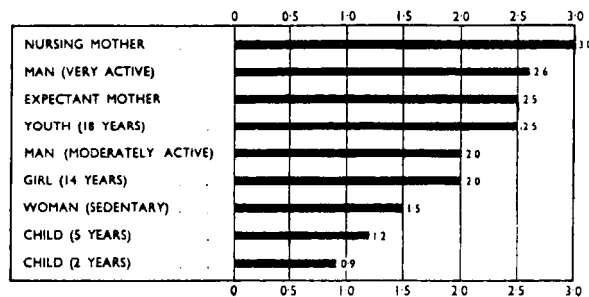


FIG. 31. Riboflavine requirements in milligrams per day.

The symptoms of insufficient riboflavine in the diet are: —

- (1) A check in the growth of children.
- (2) Inflammation of the mouth and tongue.
- (3) The transparent front of the eye (the cornea) may become misted and vision be impaired.

Foods Containing Riboflavine.

Riboflavine, like thiamine, is widespread in nature and, except that it is found in much larger amounts in milk and milk products, its distribution in foods is similar to that of thiamine. Important

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sources are dried brewers' yeast, liver, meat and meat extracts, cheese, eggs, pulses, nuts, milk and milk products, fish, whole-meal and National flour and bread. Bemax and Marmite contain large amounts. Beer and tea contain useful amounts. There is little likelihood of a deficiency of riboflavine in a mixed diet in this country.

Because it is soluble, some of the riboflavine in foods is dissolved out when they are cooked in water. Very little is destroyed during ordinary boiling but losses do occur during frying, roasting and canning because of the high temperatures reached.

Nicotinic Acid, Niacin, Anti-pellagra Vitamin.

Nicotinic acid is a white crystalline solid which is chemically allied to the nicotine of tobacco; hence the name. Nicotine is not a vitamin but a dangerous poison and cannot be converted into nicotinic acid. The alternative name, *niacin*, is sometimes used to avoid confusion, especially in the U.S.A.

Its function in the body, like that of the other B-vitamins, is to help in the release of energy from carbohydrate foods.

Shortage of nicotinic acid causes:—

- (1) A check in the growth of children.
- (2) Rough red skin and soreness of the tongue.
- (3) Diarrhœa and other digestive troubles.
- (4) In extreme cases, mental disorders and dementia.
- (5) Finally, the disease pellagra and ultimately, death.

Pellagra is rarely met with in Great Britain but is especially rife and severe among the poor negroes in the southern states of America whose diet consists very largely of maize and molasses. It has occurred in a mild form in institutions such as barracks, prisons, asylums and orphanages when the diet has been very restricted, monotonous, and over-cooked.

Foods Containing Nicotinic Acid.

Foods containing nicotinic acid are much the same as those containing thiamine and riboflavine. Important sources are dried brewer's yeast and yeast extracts; lean meat and meat extracts;

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liver and kidney ; wholegrain cereals, wholemeal and National flour and bread ; herrings and white fish ; vegetables, particularly potatoes. Bemax and Marmite contain large amounts.

Vitamin C, Ascorbic Acid, Anti-scorbutic Vitamin.

Vitamin C is a white crystalline substance. Its chemical name, *ascorbic acid*, means the anti-scorbutic acid. Scorbutus is the medical name for the disease *scurvy*.

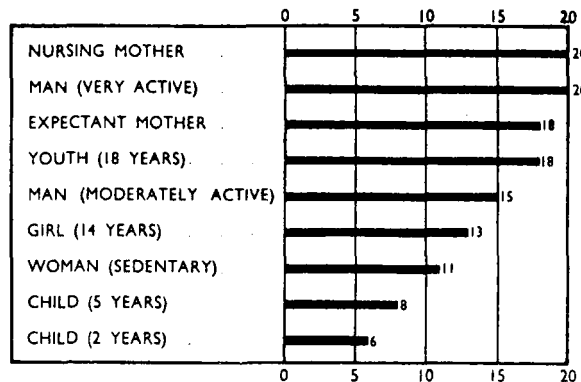


FIG. 32. Nicotinic acid requirements in milligrams per day.

Ascorbic acid is needed for buoyant health, vitality and endurance. It ensures a clear skin, a fresh complexion and healthy gums and teeth.

Lack of ascorbic acid in the diet leads to: —

- (1) A check in the growth of children.
- (2) Gums and teeth being easily infected.
- (3) Slow healing of wounds and fractures.
- (4) The disease, scurvy, in severe cases.

Scurvy is not simply a skin disease as most people imagine. It affects the whole system, particularly the blood vessels, gums, teeth and bones. The first symptoms of the disease are soreness of the gums and pains in the joints, e.g., the "growing pains" of quickly growing boys and girls. Later, the gums may become swollen

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and painful, the teeth become loose, the skin show bruise-like patches and the pains in the joints become unbearable. In extreme cases, the disease ends fatally unless stopped by an improvement in the diet.

To-day the disease is rarely seen except in cases of unnaturally restricted diets such as may occur during explorations, sieges and

VITAMIN C. Guinea pigs of the same age.



FIG. 33. This had no vitamin C and developed scurvy. Note its rough fur and crouched position due to sore joints.



FIG. 34. This had plenty of vitamin C. It has sleek fur and is healthy and alert.
By courtesy of U.S. Bureau of Home Economics.

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famines. In the days of the old sailing ships scurvy was a veritable scourge among the sailors whose diet consisted mainly of salted meat and biscuits. Any kind of fresh fruit or vegetables was unheard of on board. During Vasco da Gama's voyage round the Cape more than half his crew died of scurvy. Sir John Hawkins had similar experiences. He described how his crew on one journey was cured of scurvy by taking lemon juice. Captain Cook knew the advantage of fresh fruit and vegetables for his crew. In 1795 a regular issue of lemon juice was made compulsory in the British Navy. Scurvy became rare, although before that time there had been thousands of cases every year and more deaths than from wounds in battle.

Infantile scurvy or *Barlow's disease* was very prevalent at the beginning of this century when babies were fed largely on artificial baby foods with no fresh milk or fruit juice whatever. It is now common practice to give all artificially fed babies orange juice daily.

Foods Containing Ascorbic Acid.

We obtain our supplies of ascorbic acid from fruits and vegetables but it is important to realise that not all fruits and vegetables are good sources. The best are soft summer fruits, e.g., blackcurrants, gooseberries, strawberries, raspberries and tomatoes; citrus fruits, e.g., oranges, lemons and grapefruits; green vegetables, e.g., cabbages, cauliflowers and sprouts; root vegetables, e.g., swedes and turnips; salad vegetables, e.g., watercress and mustard and cress. Although the potato does not contain a relatively large amount of ascorbic acid we eat so much of it and so regularly that it is one of our most valuable sources of supply. Cherries, plums, grapes, pears, apples (except Bramleys' seedlings), carrots, lettuce and celery, contain very little ascorbic acid.

Seeds, including the cereals and dried peas and beans, contain no ascorbic acid but it is formed in them if they are soaked in water and then sprouted for a few days. Among animal foods the only ones to contain it are fresh liver, which contains a useful amount, and fresh meat. Milk contains small amounts only. Milk-fed babies need further supplies as from orange juice.

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Blackcurrant syrup and purée, concentrated orange juice and rose hip syrup are useful supplements for infants, young children, expectant and nursing mothers, all of whom need extra amounts of ascorbic acid. Invalids, convalescents and persons who have had fractured limbs or operations are other examples of individuals needing additional supplies of this vitamin.

If we have good helpings of freshly-cooked potatoes and of lightly-cooked green vegetables, or swedes or turnips when green vegetables are unobtainable, and a good helping of raw salad, or an orange or tomato each day we are not likely to suffer from lack of ascorbic acid. Contrary to general belief, "an apple a day" gives very little vitamin of any sort.

Home-grown supplies of ascorbic acid run short in the winter and spring months and imported summer fruits and green vegetables are scarce and expensive. The gap can be filled in various ways, as by oranges, lemons, grapefruit, watercress, mustard and cress, sprouts, spinach, swedes and turnips. In recent years, blackcurrant purée, concentrated orange juice and rose hip syrup have become valuable supplementary sources, particularly for children. Nor must we forget the potato although its value for ascorbic acid becomes less and less as it is stored and becomes older.

Ascorbic acid is easily soluble in water and, in addition, is readily destroyed by heat in cooked foods. This destruction takes place very quickly if air is present during the heating. Ascorbic acid is contained in the cells of plants and in these cells is also an enzyme or ferment which brings about the oxidation of ascorbic acid when the cells are broken open either by cooking, grating or mincing. The same destruction takes place, though more slowly, when vegetables wilt during long storage or during storage under unsuitable conditions.

Because of the ease with which the vitamin is lost or destroyed it is most important that fruit and vegetables should be eaten as fresh as possible. This is where a garden of one's own is a great advantage. Whenever possible, fruit and vegetables should be eaten raw. When fruit and vegetables are cooked, ascorbic acid is lost by way of heat, and of enzymes, and of its solution in the

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water in which they are soaked or cooked. These losses can be reduced to a minimum by:—

- (1) Using fruit and vegetables as fresh as possible.
- (2) Storing in a cool damp place.
- (3) Avoiding crushing or bruising.
- (4) Avoiding soaking whenever possible and never soaking for long.
- (5) Shredding vegetables and immediately placing them in the smallest possible quantity of boiling water.
- (6) Boiling with the lid on the pan so as to reduce the rate of oxidation.
- (7) Dishing up and serving immediately after cooking.
- (8) Using the cooking water for soups, stews and gravies.

The addition of soda to green vegetables to soften them and preserve their colour destroys vitamin B, but, contrary to general

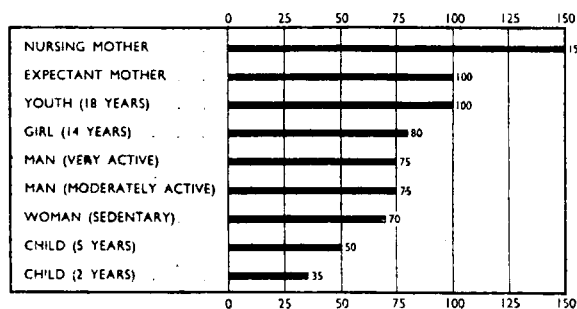


FIG. 35. Ascorbic acid requirements in milligrams per day.

belief, not ascorbic acid. Keeping potatoes and greens hot for a long time after cooking, or reheating after standing, as often happens in canteens and restaurants, is very definitely destructive of any ascorbic acid they may still contain and should be avoided whenever possible.

Commercially canned fruits and vegetables, when modern methods are used, often have higher ascorbic acid content than the

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corresponding home-cooked fresh foods. Commercial and home bottling of fruit is not so successful in retaining the vitamin. Recent improved methods of dehydrating vegetables have resulted in much smaller losses of ascorbic acid than was the case with older methods. Jams and marmalades still retain some of the ascorbic acid of the original fruits ; how much depends upon the circumstances of picking, storage and preparation.

All these points about ascorbic acid have been emphasised because, of all the vitamins we require, it is the one most likely to be deficient in the average diet in this country. This is because of the relatively few available home foods which contain it in large amounts and the ease with which it is either lost or destroyed during the storage, preparation, cooking and serving of such foods. It is a pity the body is unable to store any large amount of this vitamin because of its solubility in water.

Vitamin D, Calciferol, Calcifying Vitamin, Sunshine Vitamin, Anti-rachitic Vitamin.

Strictly speaking there are more than one vitamin D but in a text-book of this type it is not necessary for us to distinguish between them

Vitamin D has already been mentioned as being necessary, along with calcium and phosphorus, for the formation of sound bones and teeth. Its function is to help in the laying down of calcium and phosphorus as calcium phosphate in the cartilage of babies and young children in order to calcify it to solid bone. This is why it is called the *calcifying vitamin*. Its chemical name is *calciferol*.

The formation of sound bones and teeth thus depends upon the body receiving: —

- (1) Sufficient calcium in the diet.
- (2) Sufficient phosphorus in the diet.
- (3) Calcium and phosphorus in the right proportion to each other.
- (4) Sufficient vitamin D in the diet.

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If one or other of calcium, phosphorus or vitamin D is insufficient, or if the calcium and phosphorus are in the wrong proportions, then the disease *rickets*, in some greater or less degree, occurs. In extreme cases, the bones remain soft and bend easily thus leading to bow legs and knock-knees and swollen wrists and ankles. Until quite recently, rickets was very common in this

VITAMIN D.

Rats from the same litter, 20 weeks old.

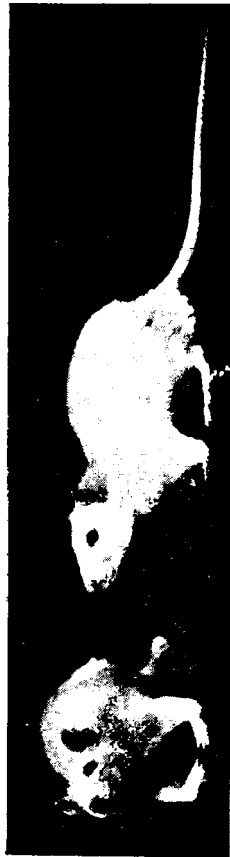


FIG. 36. This rat had no vitamin D and showed the short body and bow legs typical of rickets.



FIG. 37. This rat had plenty of vitamin D, its bones are strong and straight.
By courtesy of U.S. Bureau of Home Economics.

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country, particularly among the poorer people in thickly populated industrial areas. In fact, it is still known on the Continent as the "English disease." Fortunately, it is much less common at the present time and now that the cause is known it should never occur again. Because of its role in the prevention of rickets, vitamin D is sometimes referred to as the *anti-rachitic (anti-rickets) vitamin*.

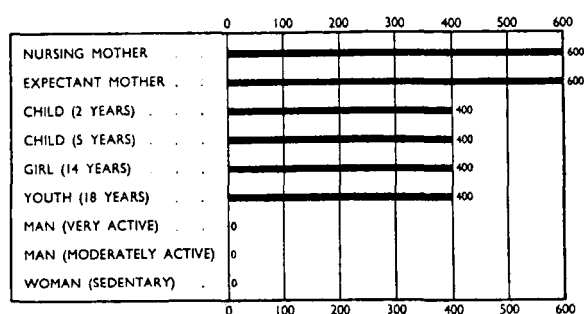


FIG. 38. Vitamin D requirements in international units per day.

Infants and young children, expectant and nursing mothers have the greatest need of vitamin D but adults require a small amount. When the diet of an adult is deficient in calcium, phosphorus or vitamin D, a disease of the bones similar to rickets may occur. It is known as *osteomalacia*.

Foods Containing Vitamin D.

Very few foods contain vitamin D and, with very few exceptions, they are animal foods. Those which contain most are halibut liver oil, cod liver oil; herrings, mackerel, sardines and salmon; eggs, butter, cheese, dripping, vitaminised margarine, and milk. In other words, they are fish liver oils, fat fish and dairy foods.

The fat fish are much richer sources of vitamin D than the dairy foods; halibut liver oil and cod liver oil contain very much larger quantities still. Unfortunately the taste of these fish liver oils is obnoxious to most people. Young children, however, if started early enough, can be trained not only to take them but

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actually to relish them. With older individuals they can be given in the form of capsules or their taste masked in fish sauces, soups, mayonnaise, savouries, and so on.

The supply of vitamin D from foods can be supplemented by the body itself in a most interesting way. Underneath the skin is a layer of fat which contains a fat-like substance called *ergosterol*. When the body is exposed to bright summer or mountain sunshine this substance is converted into vitamin D which the body is able to store and to utilise. It is the powerful ultra-violet rays of the sun which bring about this change. It is claimed that the rays given out by special mercury vapour lamps ("sun ray" lamps) similarly produce vitamin D under the skin. Clinics and hospitals use them to assist in the cure of rickets.

The formation of vitamin D from ergosterol by sunlight explains why rickets is seldom seen in hot tropical countries except where the purdah system is in operation and women and children are confined indoors. It explains why in our climate rickets was most common among the poorer children living in overcrowded conditions in smoky industrial towns. Such children were not getting sufficient vitamin D from either food or sunshine. It is an interesting fact that rickets is rare among Eskimos. They get very little sunshine but they live largely on fish.

Infants and expectant and nursing mothers need more vitamin D than others and should have halibut liver oil or cod liver oil daily. The rest of us should eat fat fish regularly, get out into the mid-day sunshine whenever possible, take fish liver oils during the winter and have our summer holidays at the seaside.

Like vitamin A, vitamin D is not soluble in water but is soluble in fats and consequently can be stored in the fats of the body. The two vitamins usually occur together in the same foods. Vitamin D is not lost in cooking water or destroyed by the heat of cooking. Modern margarines have vitamin D as well as vitamin A added to them.

Other vitamins, such as vitamin E, vitamin K, and vitamin P, have been distinguished but there is no apparent danger of our not getting sufficient of them. There is no need for us to discuss them in this book.

<i>name</i>	<i>Other Name</i>	<i>Uses in body</i>	<i>foods rich in it</i>	<i>Points to remember</i>
Vitamin A	Fat-soluble A, Axerophthol, Anti-infective vitamin.	1. Helps growth. 2. Prevents eye disease. 3. Helps resistance to disease.	Fat fish, fish liver oils, dairy foods, carrots, tomatoes, "greens."	Can be formed from carotene. Soluble in fat. Stored in the body. Not lost or destroyed during cooking.
Thiamine	Vitamin B ₁ , Aneurine, Anti-beri-beri vitamin, Anti-neuritic vitamin.	1. Helps growth. 2. Strengthens nervous system. 3. Prevents beri-beri.	Dried yeast, whole grains, pulses, liver, bacon, Bemax, Marmite, wholegrain cereals, wholemeal and National flour.	1. Very soluble in water. 2. Destroyed by high temperatures. 3. Cannot be stored by the body.
Riboflavine	Vitamin B ₂ , Vitamin G.	1. Helps growth. 2. Helps in production of energy.	Dried yeast, liver, meat and meat extracts, Bemax, Marmite, wholegrain cereals, wholemeal and National flour.	1. Soluble in water. 2. Not destroyed by heat except at high temperatures. 3. Not stored by the body.
Nicotinic Acid	Niacin, Anti-pellagra vitamin.	1. Helps growth. 2. Prevents pellagra.	Dried yeast, meat and meat extracts, liver, wholegrain cereals, wholemeal and National flour, Bemax and Marmite.	1. Soluble in water. 2. Not stored by the body.
Ascorbic Acid	Vitamin C, Anti-scorbutic vitamin.	1. Helps growth. 2. Buoyant health. 3. Prevents scurvy.	Summer fruits, citrus fruits, green vegetables, root vegetables, salad vegetables, potatoes.	1. Soluble in water. 2. Destroyed by heat. 3. Not stored by the body. 4. Lost when foods stored.
Vitamin D	Calciferol, sunshine vitamin, calcifying vitamin, anti-rachitic vitamin.	1. Helps growth. 2. Builds bones and teeth. 3. Prevents rickets.	Fish liver oils, fat fish, dairy foods.	1. Not soluble in water. 2. Not destroyed by heat. 3. Stored in the body

PART TWO

Chapter VII

THE CEREALS.

The term "cereals" includes wheat, oats, barley, rye, rice and maize. Sometimes the term is widened to include sago, tapioca and arrowroot which are not cereals at all, and sometimes narrowed to mean the specially prepared foods frequently eaten at breakfast. Strictly speaking, cereals are cultivated grasses. It is the seeds of these cultivated grasses with their rich storehouses of food for the young plants which we eat.

They are the most important of all plant foods. We eat more cereal food than any other. It is no exaggeration to say that without cereals modern civilisation would be impossible. Cereals are easily cultivated, can be conveniently transported and stored in bulk for long periods. They are palatable, cheap and readily prepared for the table. There are few parts of the world where a cereal of some type cannot be grown. For these reasons, man has been able to adopt a settled communal life, first in crude homesteads and settlements and finally in cities, instead of the nomadic life he would have had to follow had he remained dependent upon flocks and herds for his food. In the Lord's Prayer bread is taken as symbolical of food and we often refer to bread as "the staff of life." Cereals are the principal food of mankind and bread—usually made from wheat—is the staple article of diet for millions of human beings.

By centuries of cultivation and selection the original wild grass seeds have become modified and developed until their food value has been greatly increased and their yield multiplied. They are still, however, far from perfect foods. Though they contain a fair amount of protein (7.2 per cent. rice to 13.0 per cent. oats) yet its biological value is inferior to that of animal proteins. However, because cereals make up such a large proportion of our diet, they supply us with quite a large part of our total protein. They contain only small quantities of fat (1.7 per cent. wheat to

THE CEREALS

8.1 per cent. oats) and are deficient in vitamins A, C and D. Their content of the B group of vitamins depends upon the degree of milling to which they have been subjected. Certain minerals, notably calcium, phosphorus and iron, are also deficient and their availability is affected by the presence of phytic acid which makes them insoluble. The amount of carbohydrate in the whole grain varies from 59 per cent. in oats to 79 per cent. in rice, mainly in the form of starch.

Cereals are thus principally sources of carbohydrate and mainly energy foods. They provide the largest proportion of the energy value of the diet for most of mankind. The great preponderance of starch in cereals makes it necessary to eat them along with foods rich in protein and fat. This explains why we make puddings with eggs and milk and eat bread with butter or cheese.

Compared with other plant foods, the amounts of moisture in cereal grains are small, varying from 7 per cent. in oats to 12 per cent. in wheat. This makes them very compact foods and accounts for their keeping qualities. The indigestible cellulose of cereal grains is almost entirely confined to the outside skin layers. When this is removed during milling the starch which is left is easily digested.

Wheat.

So far as we are concerned in this country, wheat is the most important of the cereals just as, for climatic reasons, rice is the main food cereal of the Chinese and Japanese. This is fortunate for us because wheat is undoubtedly the king of the cereals. Compared with other cereals, its protein content is high and, when mixed with water, wheat flour forms an elastic, tenacious dough which can be aerated and made into a light, porous, palatable bread. It is impossible to make bread of the same character from rice, oats, barley, rye or maize. Unlike wheat, none contains sufficient of the protein, gluten, which combines with water to form a dough.

Wheat was probably first grown in Mesopotamia and Egypt and was originally a sub-tropical plant. Varieties of wheat have now been produced which can be cultivated from the Tropics to

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the very edge of the Arctic Circle. Some varieties can resist drought, others can withstand cold. The regions where wheat cultivation is most extensively practised are shown on the map of the world. (Fig. 39.)

The many varieties of wheat can be divided into two main classes, winter wheat and spring wheat. Different areas of the world, according to their climates, grow either one type or the other. Winter wheat is sown in the autumn and, after germination and

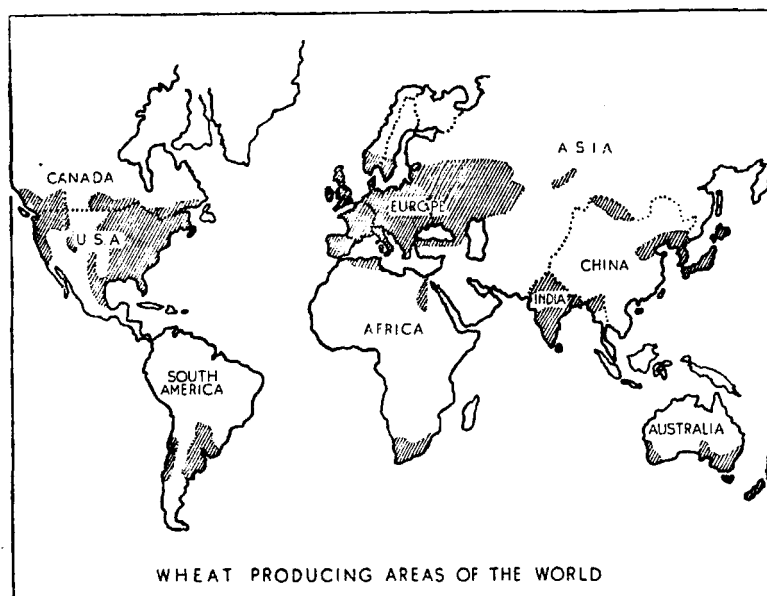


FIG. 39.

some growth, the young plant stays almost dormant until early spring. It is harvested in the following autumn. In regions where the soil is frozen for long periods in the winter, spring wheat must be grown. This is sown and harvested in the same year and a hot, dry summer is necessary for it to ripen. In this country we grow chiefly winter wheat: Argentina, Canada, U.S.A., the Soviet Union and the Danubian countries grow spring wheat.

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Winter wheat, with its long growing period, in temperate climates produces a "soft" flour with a good flavour but with only low gluten content. This flour forms a weak dough and bakes into small loaves of close texture. Spring wheat, ripened in hot dry summers, produces a "strong" flour with a harsh flavour but rich in gluten so that it forms a strong dough and bakes into well-risen and shapely loaves. Because of these differences, flours of the two types are usually blended by the miller to make them suitable for particular purposes. The doughs of strong flours are difficult to work by hand but are very suitable for large scale machine breadmaking. Soft flours are more suitable for household breadmaking, cakes and biscuits.

The Structure of the Wheat Grain.

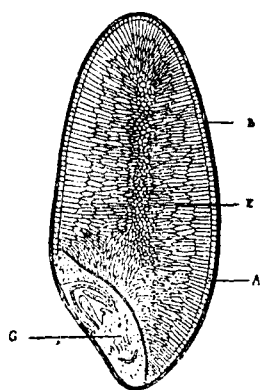


FIG. 40. Longitudinal Section of a Wheat Grain.

- A. Aleurone Grain Layer.
- B. Bran.
- E. Endosperm (starch).
- G. Germ.

A spike of ripe wheat consists of a stalk to which the wheat grains or "berries" are attached and each grain is covered by a protective yellow leaf or glume. When the wheat is threshed the grain is separated from the stalk and glumes that form straw and chaff respectively. The berries themselves are roughly barrel-shaped and more pointed at one end than the other. At the pointed end is a small tuft of hairs, known as the "beard" and at the blunt end, which was originally attached to the stalk, is a small rough protuberance. This is the wheat embryo—the living part of the grain from which, on germination, the seedling develops. On one side a deep crease or furrow passes along the whole length of the grain. The grain is split open along this furrow in an early stage of milling.

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The wheat grain is the fruit of the plant. Fruits in general contain a seed or seeds surrounded by a protective covering known as the seed coat or testa and the whole is enclosed in an outer fruit wall or pericarp. In the case of the wheat plant, the fruit consists of a single seed with both testa and pericarp closely attached to one another. In the milling of wheat these outside skins, which consist of cellulose impregnated with mineral matter, constitute the bran or "offal." They form about 13 per cent. by weight of the whole grain. Underneath comes the layer of roughly cubical cells known as the aleurone layer. The aleurone cells are packed with protein granules and contain also nicotinic acid, iron and enzymes. In spite of its food value the miller excludes this layer from white flour along with the outside bran layers since it is apt to spoil its keeping and baking qualities. The rest of the berry consists of the endosperm and the germ or embryo. The endosperm is packed with starch grains with the spaces between them filled with the protein, gluten. The endosperm is much the largest part of the wheat grain and makes up about 85 per cent. of its weight. It is the embryo's storehouse of food and is the part of the wheat berry which the miller makes into white flour. The embryo or germ lies to the base of the endosperm and is the living part of the berry. It consists of three parts—plumule, radicle and scutellum. Its weight is less than 2 per cent. of the whole grain. The plumule is the undeveloped shoot and the radicle the undeveloped root. The scutellum (or little shield) lies between the endosperm and the embryo proper, and contains the enzymes that can change the starch and gluten of the endosperm into soluble forms suitable as food for the embryo when it germinates. The embryo and scutellum contain most of the fat of the grain as well as some protein, calcium, iron and the vitamins thiamine, riboflavine and nicotinic acid. The fat and enzymes of the embryo affect the keeping quality of flour, for the fat is liable to turn rancid and the enzymes to attack the starch and gluten of the flour. For this reason it is excluded by the miller along with the bran or offal in the making of white flour, to be used for the feeding of cattle and poultry.

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The Milling of Wheat.

The outside skins of the wheat grain are so firmly attached to the endosperm that without some sort of preparation it is practically impossible to digest the whole grain. One old-fashioned method of using whole grains as food was to soak them in water until they burst and then gently to boil them in milk with the addition of sugar and sometimes dried fruit and spices as flavouring. This very nourishing dish was known as "frumenty." More modern and convenient methods are those of "shredding" or "puffing" such as are used in making some breakfast foods.

Usually, however, wheat before eating is reduced to a fine powdery flour by the process of grinding or milling. The old method was that of grinding the grains between flat grooved mill stones. All the parts of the grain were incorporated in a wholemeal flour. Sometimes the wholemeal was sifted through muslin to remove the coarser bran layers. This type of stone-ground flour retained the greater part of the nutritive value of the whole grain but it was dark in colour because of fine bran particles and did not keep well because it contained the fat and enzymes of the germ. It produced a dark, coarse and rather indigestible loaf which went stale quickly.

Modern roller milling involves a large number of complex processes which we can only describe very briefly. First the wheat is thoroughly cleaned by passing through a series of complicated machines which remove dust, soil, stones, weed seeds, chaff and so on. Next comes washing in cold water followed by drying, cooling and storing. The wheat grains are now perfectly clean with the outside bran layers toughened and the inside endosperm dry and brittle. Blending of different varieties of wheat now follows to give the type of flour required.

The next stage in the milling process is the passing of the grains through fluted rollers, one of which revolves more quickly than the other. The grains are split open at the crease and most of the endosperm is released. The outside skin layers are broken up into flakes. The mixture is sifted and the skin and coarser particles passed through further pairs of rollers until the remains of

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the endosperm are scraped off the skin. Finally the brittle particles of endosperm are passed through a series of smooth rollers which crush them to a fine powder. The tougher, oilier particles of germ are flattened out but not powdered so that in the final sieving through silk sieves they will not pass through while the flour will.

By this modern process of milling it is possible to produce a white flour consisting of practically nothing but the endosperm. Such a flour keeps well, bakes well and gives an attractive and easily digested white bread which does not go stale quickly. Its nutritive value, however, is less than that of stone ground flour because of the removal of the aleurone layer, germ and scutellum, with their valuable B vitamins, fat, protein, calcium and iron.

For a long time there has been controversy between millers and dietitians as to which is the best type of flour. The millers, on the one hand, prefer to produce a white flour containing only about 70 per cent. of the original grain (70 per cent. extraction), for such a flour keeps better and finds favour in the eyes of the baker and the general public because of its baking qualities and the good appearance and digestibility of the loaf it produces. The bran or offal is used for feeding poultry, pigs and cattle. Unlike human beings, they can digest it and convert it into meat, eggs and milk. The germ is used in making special "germ" flours such as Hovis and proprietary foodstuffs such as Bemax.

On the other hand dietitians argue that we ought to obtain the maximum food value from wheat by using a wholemeal flour from which only the coarser particles of bran have been removed (92 per cent. extraction). In this way we obtain not only the ingredients of the endosperm but also the protein, fat, B vitamins, calcium and iron of the germ and aleurone layer. The particles of bran act as roughage, assist the peristaltic action of the intestines, and so help to prevent constipation.

In order to economise in valuable shipping space during the World War II, the extraction rate was gradually increased from the 70 per cent. pre-war rate to 85 per cent., as the shipping shortage became more and more acute. By so doing a larger and

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larger proportion of the protein, fat, B vitamins, calcium and iron was included in the so-called "National" flour. Unfortunately, at the same time, the inclusion of increased amounts of bran and germ meant that phytic acid, which is present mainly in the bran and germ, made much of the calcium and iron "unavailable." Still more important is the fact that the phytic acid not only affects the calcium and iron of the flour but can also make "unavailable" the calcium in the rest of the diet and thus antagonise the calcification of bones and teeth. So serious a view was taken of this fact by the Ministry of Food that in 1943 the addition of calcium carbonate at the rate of 7 ozs. per 280 lbs. of flour was made compulsory and this "fortification" continued afterwards.

At one time during the war, flour was also "fortified" by the addition of vitamin B, but this was discontinued when it was discovered that this vitamin was found in the germ, more and more of which was incorporated in the flour as the extraction rate rose. In 1944 it was found that the vitamin B (thiamine), formerly thought to be distributed throughout the whole of the wheat germ, is largely concentrated in the scutellum. Improved milling technique, in which the wheat is milled dry, now reduces the scutellum to a powder which passes into the flour without the rest of the germ.

It thus became possible to separate out the most nutritious parts of the wheat offals and obtain a flour of 80 per cent. extraction which gives the loaf a highly satisfactory food value and, at the same time, a quite acceptable off-white colour, good flavour and good keeping quality. It represents a reasonable compromise between the competing claims of millers, farmers, bakers, housewives and dietitians. The milling of flour of a less extraction rate than 80 per cent became permissible in 1953. Such flour has restored to it vitamin B₁, nicotinic acid, iron and calcium which are lost in the additional refining.

Special Flours.

GERM MEALS.

Quite a number of these are sold as proprietary articles. One

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of the best known, Hovis, is prepared by mixing 75 per cent. white flour with 25 per cent. cooked germ. Before adding to the white flour, the germ is mixed with the necessary amount of salt for breadmaking and then partly cooked by superheated steam. This pre-cooking produces a characteristic flavour and destroys the enzymes of the germ as well as preventing the oil of the germ from going rancid.

SELF-RAISING FLOURS.

These are simply ordinary flours with the necessary aerators added to them for confectionery purposes. The necessary proportions of, for example, cream of tartar and bicarbonate of soda are carefully sieved and dried and then thoroughly mixed with dry flour. Convenience is their only advantage.

STARCH-REDUCED FLOURS.

Persons suffering from sugar diabetes (*diabetes mellitus*) do not secrete sufficient insulin to control the amount of glucose in their blood. In spite of injections of insulin it is usually necessary for such persons to eat as little starchy food as possible since this is converted into glucose during digestion. Special flours, from which much of the starch has been washed out but leaving the gluten, are manufactured for use by diabetics. Gluten bread and gluten biscuits are made from such starch-reduced flours, e.g., Energen and Procea.

Wheat Products.

SEMOLINA.

Semolina is made from the central part of the endosperms of hard wheats rich in gluten. Some wheats of hot dry countries, such as France and Italy, are particularly suitable for its preparation. The grains are granulated into coarse particles by not crushing them sufficiently to reduce them completely to flour. Semolina is useful for making puddings and for thickening soups.

MACARONI, VERMICELLI, SPAGHETTI AND ITALIAN PASTE.

These also are made from hard wheats grown in Italy, Southern Russia, and, more recently, Canada and U.S.A. The

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flour is made into a paste with water which, because of the large amount of gluten present, can be drawn into tubes or moulded into various shapes. The paste is afterwards dried and partly baked. They are energy foods whose nutritive value is greatly increased by the milk and cheese eaten with them.

SHREDDED WHEAT.

Shredded wheat is made from the whole wheat grains in the form of shreds which have been cooked.

FORCE AND GRAPE NUTS.

These are malted whole wheat which has been cooked.

PUFFED WHEAT.

Puffed wheat is made by cooking whole wheat grains in sealed ovens at a high temperature. When the pressure is released the grains swell up to many times their original size.

These breakfast foods are quickly prepared and easily digested but are a more expensive source of Calories than either porridge or bread.

Oats.

Oats have the highest food value of any of the cereals. Compared with the other cereals, they contain considerably more fat and have consequently a higher Calorie value. Their proteins are of higher biological value but do not include gluten so they do not form a dough with water and cannot be made into bread. A drawback is the presence of much phytic acid.

Oats are one of the hardiest cereals and can be grown in northerly latitudes unfavourable to wheat. It is for this reason that Scotland and the North of England grow large quantities of oats. Oats have for centuries been a staple article of diet in Scotland and until modern times were the main food of the workers of the North as in havercakes and porridge. When milled for human consumption, oats are first cleaned from weed seeds, small stones, etc., and then kiln dried and stored for 24 hours before the closely

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adherent outside husk can be removed. In this form they are known as groats which are ground to produce oatmeal. Rolled oats are made by partially cooking groats by steam before rolling them into flakes and drying them.

Oatmeal is usually eaten in the form of porridge or oatcakes. Rolled oats are more easily made into porridge than oatmeal because of their crushing and preliminary cooking. On account of the large amount of cellulose, oatmeal should always be thoroughly softened and well cooked, otherwise it will be indigestible. When combined with milk and sugar or syrup, porridge is an excellent food. The milk is particularly valuable in that its high proportion of calcium largely counterbalances the phytic acid of the oats which tend to make their calcium and iron unavailable. Cheese with oatcakes serves the same purpose.

Oatmeal is added to many meat and vegetable dishes and used to thicken soups and stews. If first toasted in the oven it may be used for coating fish cakes and rissoles. It may be added in small proportions to wheat flour in making pastry, scones, puddings, cakes and biscuits. It is a pity that so nutritious a cereal should be eaten less by human beings than by horses.

Because of its fat, oatmeal will not keep as well as wheat flour. It should be stored in a container with a tightly fitting lid and kept in a cool place.

Barley.

Barley is the hardiest of all cereals and can thrive under climatic conditions that would not permit the survival of wheat. In spite of this, its use as a human food has steadily declined throughout the centuries and barley has now been superseded by wheat. It is probable that the "daily bread" of the Lord's Prayer was made from barley as well as the five loaves that fed the five thousand. Barley is now used mainly for the manufacture of malt for making beer and whisky and for stock feeding. Its only uses as human food are as barley water and for thickening soups. It cannot be made into a light spongy bread because of its lack of gluten.

THE CEREALS

“ Pearl Barley ” is made by polishing the kernel after the husk has been removed. “ Scotch Barley ” retains some of the husk layers. “ Patent Barley ” is pearl barley ground into flour.

Barley water, when flavoured with orange or lemon juice, makes a pleasant drink which has valuable demulcent properties.

Rye.

Rye, like barley and oats, can grow under conditions unfavourable to wheat. It resembles wheat in its composition and contains a small amount of gluten which is sufficient to give an elastic dough with water capable of aeration by yeast, leaven or baking powder. Rye flour makes a dark, close, heavy bread with a sour flavour since it is usually aerated with sour dough (leaven). It is improved by mixing with a considerable proportion of wheat flour. Rye has been superseded in most parts of the world by wheat but is still a staple article of diet among the poorer people of Europe.

Ryvita is prepared from crushed whole rye.

Rice.

Rice, the main cereal of the orient, forms the staple article of food for nearly half the world's population. It requires a hot humid atmosphere, caused by heavy rains and hot sunshine and needs irrigation in its early stages of growth. It is the only cereal that can be grown in many parts of the tropics.

Rice contains more starch than any of the other cereals but is the poorest in protein, fat and mineral matter. Since it is eaten in this country mainly in the form of rice puddings in which milk, fat and sugar are used this is of little consequence to us. Eggs and cheese are also valuable supplements to rice.

In the milling of rice, the bran and germ are first removed and afterwards the silver skin underneath the bran is removed by polishing. As previously mentioned (page 57) the removal of the silver skin takes away the vitamin B it contains and, where the diet consists largely of polished rice, beri-beri frequently occurs.

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We eat so little rice that it does not matter whether we eat it polished or unpolished but it matters a great deal in predominantly rice-eating countries like India, Burma, Malaya, China and Japan. Attempts are being made to encourage the use of unpolished brown rice or polished rice which has been parboiled and dried before removing the bran, germ and silver skin. During the parboiling, sufficient of the soluble vitamin B is absorbed by the endosperm to prevent beri-beri.

Besides being used whole, rice is used in this country as ground rice or rice flour in cakes and so on.

Maize.

Maize originated in America where it is termed corn or Indian corn. It will flourish in any warm climate where there is summer rainfall. It does not require the swampy conditions necessary for rice. The wet summer suitable for maize is unsuitable for wheat.

The cultivation of maize has now spread to Mediterranean countries and Africa. In Italy a porridge, known as "polenta", is made from corn meal with the addition of cheese. In Africa, maize is called "mealies". Mealie pap, consisting mainly of maize with a little meat, forms the staple native diet.

Maize meal, or corn meal, is prepared by grinding after first removing the germ and husk. Hominy is less finely ground than corn meal and is in the form of hard gritty particles. Cornflour is essentially the crushed endosperm of the maize grain. The protein and fat are washed away so that cornflour consists almost entirely of starch. Cornflakes consist of cooked maize that has been dried, rolled and toasted.

The proteins of maize do not form a glutinous substance with water as do those of wheat, so that maize meal cannot be made into a spongy bread. Cornbreads are unleavened and flat. The fats of maize are next in amount to those of oats but are liable to go rancid and have a peculiar flavour. The small amount of nicotinic acid in maize renders persons eating a diet containing large amounts of maize liable to the disease pellagra (page 61). Maize

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has the further disadvantage of discouraging the growth of the bacteria in the intestines which normally produce nicotinic acid to supplement the supplies from food. Milk, on the other hand, encourages the growth of these bacteria. Thus, in a mixed diet the lack of nicotinic acid in maize is no great detriment. It is, in fact, a valuable cereal of which more use might well be made in this country.

We use it here only as cornflour, in custard powders, blancmanges and sauces and as the breakfast food "Cornflakes". Occasionally, it is used as a vegetable. "Corn in the cob" is the green unripe head of the corn stalk and contains sugar rather than starch. Maize is highly esteemed in this form in America.

The starch of cornflower is particularly suitable for custard powders and blancmanges because it forms a paste that sets with a "short" texture and leaves the mould more cleanly than the pastes formed by the starches of wheat, potatoes, tapioca or arrowroot. Cornflour is a concentrated Calorie food and forms an excellent vehicle for milk in blancmanges and custards.

Sago, Tapioca and Arrowroot.

These are not cereals, since they are not products of cultivated grasses, but it is convenient to consider them here. They contain practically no protein and are little more than refined preparations of starch. Sago is produced from the pith of the sago palm. Tapioca is derived from the roots of the tropical cassava plant after the removal of a bitter poisonous juice. Arrowroot is obtained from the underground stem (rhizome) of the West Indian plant, maranta. It has the most delicate flavour of the three.

Since these preparations consist almost entirely of carbohydrate, they should not be eaten alone but with substances rich in protein, fat, minerals and vitamins. This is usually done by making them into puddings with milk and eggs. During the preparation of sago, tapioca and arrowroot many of the starch cells are burst and this makes them easily cooked and digestible.

Chapter VIII

FATS AND SUGARS

Fats.

The chemical nature of fats and their purpose in the diet has already been fully discussed in Chapter III. Cream, butter and margarine have been described in the chapter on milk. It only remains here to give a few details about lard, suet, dripping and cooking fats.

LARD.

Lard is the rendered fat from the fat deposits of pigs. It is practically 100 per cent. fat and consequently has a high Calorie value. Lard has a low melting point, a soft consistency and a pleasant, mild flavour. It is more easily digested than harder fats with higher melting points such as beef and mutton fats. Unlike the majority of animal fats it contains no vitamin A or D. Lard is used chiefly for pastry making and for shallow fat frying.

SUET.

Suet is the fat deposited round the internal organs of animals. It is a hard solid fat enclosed in connective tissue. Suet can be used finely chopped or, more usually, it is rendered, flaked and mixed with flour to prevent the flakes sticking together. It can be used in a variety of ways and is a means of providing fat in the diet in a form acceptable to children and to those with an aversion to other forms of fat. Suet should be thoroughly cooked by boiling or steaming: otherwise it is indigestible.

DRIPPING.

Dripping is the fat collected during the cooking of beef or mutton. It is usually brown in colour and is flavoured by the meat. Owing to the water and meat extracts it contains it is liable to go rancid in keeping. If used for frying or pastry making it may give a noticeable flavour unless purified by clarifying. This is

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done by putting the fat in a saucepan without lid, covering with water, bringing to the boil and pouring into a clean basin. When cold, the fat will form a hard cake on top of the water and any impurities will be either in the water or on the bottom of the fat. The cake of fat is lifted out, turned upside down and the bottom scraped clean. The fat is then suitable for pastry or puddings. For frying or keeping, the water it contains should be removed by melting it in a saucepan and heating it gently until it stops bubbling, i.e., until all the water has been driven out as steam.

FRYING FATS.

These are manufactured from whale oil and vegetable oils such as groundnut oil, cotton seed oil, coconut oil, palm kernel oil and palm oil.

In their natural forms these oils have a strong smell and taste, and do not keep well. They can be hardened into solid fats which keep well and are tasteless and odourless by the process of hydrogenation. In this process hot hydrogen gas is pumped into the oils in the presence of finely divided nickel which enables the oils to combine with the hydrogen gas.

To be suitable for making pastry, cakes and puddings, a fat should have a pleasant flavour and high "shortening" power. Such a fat creams easily and makes a light cake or pudding mixture or a short pastry. Lard, cooking fats and dripping have a high shortening power and make the shortest pastry. Butter and margarine are most suitable for cakes because of their superior flavour.

To be suitable for frying a fat should be free from moisture that would make it splutter when heated and it should have a high "smoking temperature". When fat is heated it first of all melts and then, if it contains any water, begins to bubble as the water is changed into steam and escapes. When bubbling ceases, the fat surface is still and eventually a faint blue haze rises from the surface. This is the highest temperature to which it is safe to heat the fat. It is at this stage that the food to be fried should be placed in it. If heated beyond this temperature the fat begins

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to decompose into fatty acids and glycerin, gives off acrolein smoke and burns. It is then spoilt for further frying.

A good frying fat is one which can be heated to a high temperature (at least 360° F.) before it begins to smoke and burn. In other words, it has a high smoking temperature. The essence of frying is quick cooking at a high temperature. Fats with low smoking temperatures cook so slowly that there is time for the food to absorb some of the fat and thus become soggy and greasy. The specially prepared cooking fats have a high smoking temperature and so also have lard and dripping. Cooking fats are more suitable for deep frying and lard and dripping for shallow frying. Margarine and butter are not suitable for frying purposes.

Sugar.

The chemical nature and food value of the different sugars have already been described in Chapter II. The sugar we are concerned with here is the ordinary sugar we buy from the grocer. This is the sucrose derived from either sugar cane or sugar beet.

Sucrose is obtained from sugar canes by crushing them and then extracting with water. By heating, adding lime and bubbling carbon dioxide through the liquid, various impurities separate out and are skimmed off. The remaining liquid is then evaporated until concentrated enough to crystallise. The crystals are impure *brown sugar* and the liquid left is *molasses or treacle*.

Brown sugar is refined by dissolving it in water, filtering through bone charcoal and bleaching the solution with sulphur dioxide. The liquid is then concentrated in special vacuum pans until it crystallises. The crystals are now pure *white sugar* and the liquid left is golden syrup.

Sucrose is obtained from sugar beet in a very similar manner but the molasses from sugar beet is too impure to be used as human food.

The refined sugars from sugar cane and sugar beet are identical. They consist of approximately 99.5 per cent. pure sucrose and are exactly alike in appearance and sweetness.

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Cane sugar has been known for more than 2,000 years and has been used in this country for over 600 years. Beet sugar has only been in use since the middle of the last century. As will be seen from the map the sugar cane grows in countries with a tropical or sub-tropical climate while sugar beet grows in countries with a temperate climate. Sugar beet is grown in this country.

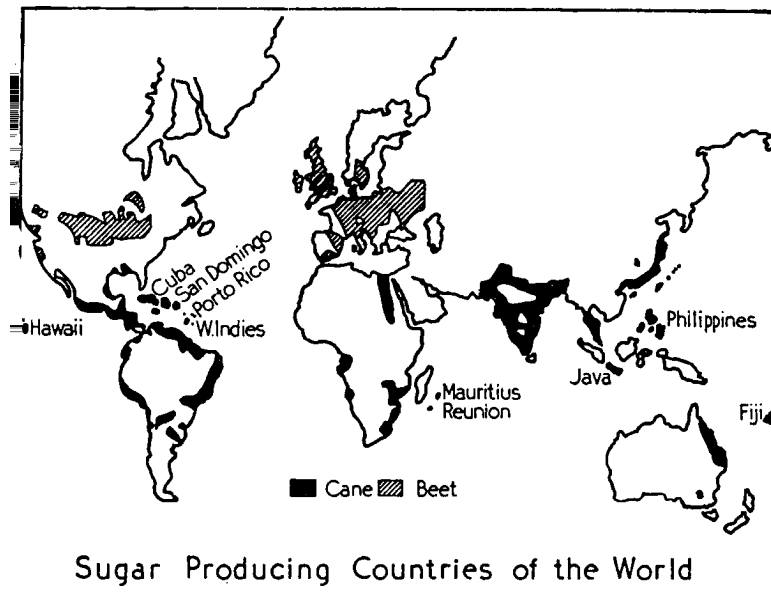


FIG. 41.

Forms of Sugar.

The most important processed forms of sugar in general use are granulated, cube or lump, castor, icing and demarara. *Granulated sugar* is in the form of small cubic crystals and is the commonest form of all. *Cube or lump sugar* is granulated sugar that has been caked into a hard mass and then cut into cubes by machinery. *Castor and icing sugars* are prepared from granulated sugar by milling to a fine powder and then sifting through silk

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sieves. The particles too big to pass through the silk form castor sugar; those fine enough to pass through form the icing sugar. *Demarara sugar* is an unrefined brown sugar.

Sugar Derivatives.

SUGAR CANDY.

This is prepared by suspending thin strings in a hot concentrated sugar solution. The sugar slowly crystallises on the strings in the form of large cubic crystals.

BARLEY SUGAR.

When sugar is heated it melts at about 215-220° F. If a little water is previously added it melts at a slightly lower temperature. The melted sugar becomes straw-coloured and, if allowed to cool at this stage, sets to a hard brittle mass of barley sugar. When prepared by confectioners it is either poured into moulds or on to a greased slab and, while still fairly plastic, cut with a sharp knife into strips which are then twisted between the finger and thumb.

CARAMEL.

On further heating, sugar darkens in colour and, at about 350° F., is converted into a dark brown substance known as caramel. This has the smell and taste of burnt sugar and is much used as a colouring and flavouring in gravy browning, sauces, "artificial" vinegar, rich cakes, beer and stout.

FONDANTS.

Fondants are really of two types—those used by sugar boilers as sweets and those used by confectioners for cake decorations. The principles underlying their preparation are, however, the same in both cases and consist in the formation of a sugar syrup which sets hard on cooling without crystallising. In other words, it sets hard without going sugary or crumbly as does an ordinary sugar syrup. This "cutting of the grain", as it is called, is accomplished either by adding some glucose to the cane sugar or converting some of the cane sugar (sucrose) into glucose and fructose by heating it with an acid substance, e.g., cream of tartar, tartaric or

FATS AND SUGARS

citric acid or vinegar. The presence of even a small amount of glucose in a cane sugar syrup prevents the sugar from crystallising, i.e., going crumbly, on cooling or keeping. The conversion of the double sugar, sucrose, into the single sugars, glucose and fructose, is known as "inversion". The cane sugar is said to be "inverted" and the mixture of glucose and fructose is known as "invert sugar".

It will be found that all fondant and toffee recipes include either glucose itself or treacle or golden syrup, both of which contain glucose, or, alternatively, small amounts of such acid substances as cream of tartar, tartaric acid, lemon juice, acetic acid or vinegar are included. During the boiling of sugar syrup the acid substance inverts sufficient cane sugar to glucose to prevent crystallisation and the fondant or toffee sets hard. The same kind of inversion takes place in jam making due to the acid of the fruit.

The preparation of fondant can be illustrated in the following way. Heat 2 lb. of sugar with $\frac{1}{2}$ pint of water in a copper or enamelled saucepan and add either 4 oz. glucose or a little cream of tartar, tartaric acid, lemon juice, acetic acid or vinegar. Gradually raise the temperature to 245° F. (soft ball degree on a sugar boiler's thermometer). Pour the syrup into a glazed earthenware basin and allow it to cool to about 100° F. Stir the syrup with a wooden spoon. The syrup becomes more and more viscous and also less transparent and more creamy in appearance. When the sugar becomes too stiff to be stirred with the spoon, knead it with the hands until a smooth creamy mass is obtained. This is fondant such as is used for icing cakes and in sweetmeats.

If the sugar syrup had been poured out on to a greased slab and while still hot and plastic had been held in the two hands and thrown over a hook in the wall and pulled and twisted a number of times it would have gone fibrous and shiny and set to "rock". This pulling and folding, for which confectioners use a special machine, causes a partial crystallisation of the sugar but the crystals are too small to cause the rock to go sugary and crumbly.

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TOFFEES AND SWEETS.

We have seen that when sugar is heated it first of all melts and on continued heating turns dark brown to caramel. On still further heating it turns black to form sugar charcoal or carbon and finally burns completely away. In actual fact there are a large number of gradual changes in the sugar between melting and caramelisation which are not easy to distinguish except by the experienced eye. An expert sugar boiler can recognise ten different and distinct stages or "degrees" as follows:—

Syrup	215–220°F.
"Thread" degree ...	225°F.
"Pearl" degree ...	230°F.
"Blow" degree ...	235°F.
"Feather" degree ...	240°F.
"Soft ball" degree ...	245°F.
"Hard ball" degree ...	250°F.
"Soft crack" degree ...	280°F.
"Hard crack" degree ...	310°F.
Caramel	350°F.

These various "degrees" can be determined best by the use of a sugar boiler's thermometer on which they are marked or, in skilled hands, by the shape and consistency of a sample of the syrup poured into water. For ordinary purposes only four of these degrees are of any real importance. They are:—

- Thread degree (225°F.) for boiled icing.
- Soft ball degree (245°F.) for fondants.
- Crack degree (310°F.) for toffee.
- Caramel (350°F.) for colouring and flavouring.

If a thermometer is not available the following tests can be used:—

Thread Degree.

A little of the syrup is dropped from a wooden spoon into cold water. A thread is formed when the syrup is squeezed between finger and thumb and then separated.

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Soft Ball Degree

A sample is dropped into cold water from a wooden spoon and when worked between the finger and thumb forms a soft ball.

Crack Degree.

At this stage a sample poured into cold water will crackle and when taken out will be hard and brittle.

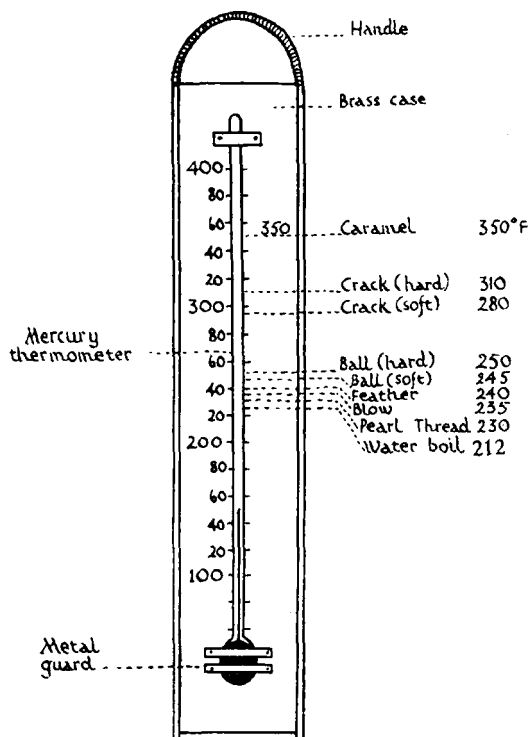


FIG. 42. Diagram of Sugar-Boiler's Thermometer.

Caramel.

The sugar begins to darken rapidly in colour and the smell of burnt sugar becomes noticeable.

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The preparation of toffee can be illustrated in the following way. Place 2 ozs. butter, $\frac{1}{2}$ lb. treacle, $\frac{1}{2}$ lb. cane sugar and a little lemon juice or vinegar in a clean saucepan. Bring to a boil and continue boiling until "crack" degree is reached. (Use a sugar boiler's thermometer or pour a sample into cold water.) Pour into a greased tin and stand in a cool place until set.

The butter in the recipe provides flavour and increases the food value, the treacle supplies glucose and the lemon juice or vinegar "inverts" some of the cane sugar during the boiling and so "cuts the grain." Such a toffee sets hard and does not go crumbly on keeping. The tin into which the toffee is poured is greased so that there will be a film of oil between the hot syrup and the tin. This prevents the toffee from sticking to the tin and it is easily removed.

Honey.

Honey is deposited by bees in the cells of wax combs and is obtained by them from the nectar of flowers. The sugar of nectar is cane sugar (sucrose) but as it passes through the bodies of the bees it is "inverted" and honey consists of about 75 per cent. of invert sugar (glucose and fructose). The flavour and aroma of honey are due to the scents derived from the flowers the bees have visited. The two main flavours are those of heather and clover.

Genuine honey is sometimes blended with artificial invert sugar but the fact must be stated on the label for such a mixture cannot legally be described as honey.

Honey is a very attractive and palatable energy food. During ancient and mediæval times it was the chief source of sweetening materials. It was also fermented into a drink known as mead.

Treacle and Golden Syrup.

We have already seen that these are by-products of the manufacture of granulated sugar. They remain syrups because of the invert sugar (glucose and fructose) which they contain in addition to cane sugar. Both are energy foods but treacle contains, in addition to sugars, useful amounts of calcium and iron.

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Chocolate.

Chocolate is made from ground cocoa nibs, cocoa butter, cane sugar and flavourings. Milk chocolate has milk powder added to it. Chocolate is an acceptable energy food because of its sugar and fat. It contains useful amounts of iron derived from the cocoa nibs. Milk chocolate, because of its milk, contains valuable calcium and vitamin A.

Jams and dried fruits, which are usually classed as energy foods, are discussed in the chapter on the preservation of foods, page 162.

Chapter IX

FRUITS, VEGETABLES, PULSES AND NUTS

Fruits.

To the botanist a fruit is the complete structure formed by the ovary of a flower after its ovules have been fertilised by pollen. It contains the seeds which must be dispersed if the life cycle is to be completed. Various methods of dispersal are adopted by different plants. Some seeds are dispersed by wind, some by water and others by mechanical means. Many plants envelop their seeds with succulent pulpy flesh with an attractive flavour and conspicuous colour. Birds, animals and human beings are tempted to eat these fruits and the hard, indigestible seeds they contain are liberated and dispersed. It is these succulent fruits which we call, in common parlance, "fruits." To the botanist, the dandelion "clock," the coconut, the pea pod, thistle "down" and the rose hip are just as much fruits as are the orange, tomato, apple or plum. Apples, apricots, bananas, blackberries, cherries, black, red and white currants, plums, damsons, greengages, lemons, loganberries, melons, oranges, peaches, pears, pineapples, raspberries, strawberries and tangerines are examples of succulent fruits. The tomato is a succulent fruit which is usually eaten as a vegetable. Rhubarb is eaten as a fruit but is, of course, a leaf stalk.

The general composition of ripe fresh fruit is approximately: —

Water	...	...	85-90 per cent.
Protein	...	...	0.5 per cent.
Fat	...	...	0.5 per cent.
Carbohydrate	...	...	5.5-10.5 per cent.
Cellulose	...	...	2.5 per cent.
Minerals	...	...	0.5 per cent.

It will be seen from this table that we eat fruit more for its sweetness and flavour than for actual nourishment. There is always a very considerable amount of waste and a very large amount of water. The quantities of protein and fat are so small

FRUITS, VEGETABLES, PULSES AND NUTS

as to be negligible. Olives and Avocado pears, which contain a large proportion of fat are exceptions. In unripe fruits the carbohydrate is mainly starch but as the fruits ripen the enzymes and acids they contain gradually change the starch into sucrose (cane sugar) and the sucrose into fructose and glucose. The "unavailable" carbohydrates consist chiefly of cellulose and pectin and are of no food value since they are indigestible. The cellulose serves a useful purpose in acting as roughage and the pectin is important in helping the fruit to set to a jelly in jam-making. The amounts of cellulose and pectin vary greatly in different fruits. They are always less in cultivated fruits than in the corresponding wild fruits, e.g., crab apples contain much more than cultivated apples. The amounts also diminish during the ripening of fruit.

The minerals in fruit are chiefly the potassium salts of various acids usually called "fruit acids." They are tartaric, citric and malic acids. These give fruits their agreeable acid flavours. They increase the laxative action of fruits by stimulating the peristaltic action of the intestines. During the ripening of fruits the amounts of these "acids" diminish while the amounts of sugar increase. This alteration in the balance of fruit acid and sweet flavouring accounts for the difference in taste between unripe and ripe fruit. It is important to realise that the "fruit acids" are oxidised in the body to alkalis and render the blood more alkaline and the urine less acid. It is in this sense that fruits "purify the blood" which is apt to become less alkaline as a result of the oxidation of proteins and carbohydrates. Fruit acids are also necessary, along with sugar, to cause pectin to set to a jelly in jam making. Reasonable amounts of iron are found in a few fruits, e.g., black and red currants, loganberries and raspberries.

Fresh fruits, with the exceptions of apples, pears, plums and cherries, are important sources of ascorbic acid, while the yellow fruits, apricots, peaches and oranges contain some carotene and so do tomatoes. In the case of tomatoes the yellow colour of the carotene is masked by a red pigment. In spite of its lack of ascorbic acid, the apple is a valuable fruit. Its hardness helps to teach children to chew and cleans their teeth after meals.

The smell and flavour of fruits are due to the presence of very small quantities of essential oils, esters and ethers. Like the extractives of meat they have no food value in themselves but stimulate the appetite and so promote digestion.

It will thus be seen that fresh fruits are mainly valuable for their ascorbic acid content. They are protective foods and the most valuable fruits are those which contain most ascorbic acid. These, as we have previously seen, are *the summer fruits*, blackcurrants, gooseberries, strawberries, raspberries and tomatoes and *the imported citrus fruits*, oranges, lemons and grape fruits. Because of the fact that they can be eaten practically all the year round tomatoes and oranges are especially valuable. The other fruits not mentioned are not so valuable as green vegetables as sources of ascorbic acid and are mainly to be regarded as providing pleasant taste, attractiveness to meals and variety in the diet. Because of the destructive action of heat upon ascorbic acid fruit should preferably be eaten raw. The acidity of the fruit and its skin both help to preserve the ascorbic acid during storage. Care should be taken not to bruise or damage fruit since ascorbic acid is destroyed when the cells containing it are ruptured and their enzymes liberated to attack the vitamin.

Fruit drinks are refreshing and when made from fresh fruit rich in ascorbic acid, e.g., lemons, oranges and blackcurrants, can be a good source of this vitamin. To obtain the maximum amount of the vitamin, the skin as well as the juice of the fruit should be used in the preparation of the drink. Manufactured drinks such as mineral waters, lemonade and fruit cordials contain at most only a negligible amount of ascorbic acid. Rose hip syrup and concentrated orange juice are extremely valuable sources of ascorbic acid and consequently are strongly recommended for young children.

Vegetables.

A great variety of plants and of different parts of them are eaten as vegetables. A rough classification of the vegetables used in this country is as follows:—

FRUITS, VEGETABLES, PULSES AND NUTS

- (1) *Green leaves.*
Lettuce, watercress, cabbage, sprouts, spinach, broccoli, mustard and cress, turnip tops, kale, savoys, parsley.
- (2) *Leaf stalks.*
Celery and rhubarb.
- (3) *Stems.*
Asparagus, sea-kale.
- (4) *Roots.*
Carrot, parsnip, beetroot, swede, turnip, radish.
- (5) *Tubers.*
Potato, Jerusalem artichoke.
- (6) *Bulbs.*
Onion, leek, garlic.
- (7) *Inflorescences (Flower buds).*
Cauliflower, broccoli, globe artichoke.
- (8) *Fruits and Seeds.*
Cucumber, marrow, tomato, pulses (peas, beans), mushrooms.

This long list can be grouped into two main types: —

- (a) The green leafy vegetables. (b) Bulbs, roots and tubers.

GREEN, LEAFY VEGETABLES.

The green vegetables are those whose leaves are used as food. The leaves of a plant act as the factories for the production of sugar and starch which are then carried away to other parts of the plant either to be used at once or stored up for future use.

The thin layer of the leaf in between the upper and lower skins consists, for the most part, of living cells in which is contained the green chlorophyll enclosed in compartments of cellulose. Chlorophyll has the power of abstracting energy from sunlight which the living stuff of the cells (protoplasm) uses to convert carbon dioxide obtained from the air and water from the soil into sugar. Vitamins, minerals and enzymes are agents in bringing about this chemical change and are particularly abundant and active in leaves.

ELEMENTARY SCIENCE OF FOOD

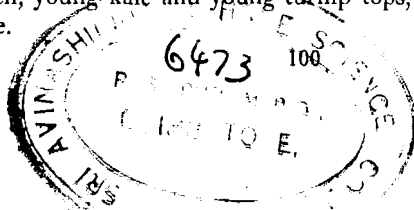
Leaves are not storage organs and consequently contain very little protein, fat or carbohydrate. Their value in the diet depends upon the vitamins and minerals they contain. Like fresh fruits they are neither body-building nor energy foods. They provide little in the way of amino-acids or Calories, but they are valuable protective foods.

The most important minerals in vegetables are calcium and iron. Unlike the other minerals present—sodium, potassium, magnesium, phosphorus and chlorine—they are not dissolved out when green vegetables are cooked but the amounts in an average helping are not large and, as previously mentioned, are not always fully "available."

It is chiefly as sources of vitamins that the green leafy vegetables are of such importance in the diet. They are all rich sources of carotene from which the body can make vitamin A. The greener and leafier the vegetable the greater is the amount of carotene. Thus the outside leaves of cabbage and lettuce, which are often discarded, contain more carotene than the white hearts. In the fresh raw state, most leafy vegetables are rich sources of ascorbic acid and this is their greatest merit. It has already been emphasised that a loss of ascorbic acid occurs when green vegetables are stored, especially if bruised or damaged, and a further loss when cooked. For this reason green leafy vegetables should always be eaten as fresh as possible, and frequently eaten raw in the form of salads. Raw salads are as good, if not better, sources of ascorbic acid than fresh fruit and one or the other or both should be eaten daily all the year round. A good salad is not merely a lot of lettuce leaves with a few radishes, but a mixture of all kinds of raw vegetables in season. With a little ingenuity it is possible to devise attractive and nutritious salads all the year round.

Suitable ingredients for salads include:—

(1) *Green leafy vegetables* such as cabbage, savoy, sprouts, spinach, young kale and young turnip tops, watercress, lettuce and endive.



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(2) *Root vegetables* such as raw or cooked beetroot, turnip, carrot, swede and parsnip.

(3) *Other vegetables* such as cooked potatoes, raw radishes, cucumber, leeks, onions; cooked or raw peas, cooked french or runner beans, celery, cauliflower, broccoli and cooked broad beans.

(4) *Flavourings* such as green herbs, chives, mint, parsley, spring onions, young celery leaves, nasturtium and dandelion leaves, mustard and cress.

(5) *Fruit* of any kind, fresh or dried.

(6) *Eggs*, either fresh or dried, served scrambled or hard-boiled.

(7) *Cheese* either grated or cut in cubes or slices.

(8) *Meat and fish*, cooked or canned.

Such salads can be served as a small helping with hot meat, fish or other savoury dish, or as a filling for sandwiches or rolls. Alternatively, the salad could be served as the main dish of a meal with meat, fish, cheese or eggs and bread or potatoes; as a substitute for the sweet course or at the beginning of a meal in place of soup. For those who like it a creamy salad dressing adds to the flavour and supplies fat.

Green leafy vegetables are not particularly good sources of the B group of vitamins. There is little likelihood of destruction of vitamin B (thiamine) at the temperatures used in cooking unless bicarbonate of soda is added to preserve the green colour of the vegetables. A good deal, however, passes into the soaking and cooking water since the thiamine is very soluble.

As in the case of fruits and the husks of cereals, the indigestible cellulose of green leafy vegetables increases the bulk of the diet, acts as roughage and stimulates the peristaltic action of the intestines which is so frequently necessary in the highly concentrated and refined diets so commonly taken today.

Finally, green leafy vegetables add flavour and variety to the diet and form an excellent medium for the addition of other nutrients, e.g., the fat and milk used in the sauces frequently served with them.

BULBS, ROOTS AND TUBERS.

Unlike the green leafy parts of vegetables, bulbs, roots and tubers are storage organs in which the sugars and starch manufactured by the leaves are collected for future use by the plant. The roots, bulbs and tubers we eat are those of plants which require two years for complete growth. They are biennials which spend the first season of growth storing up food for use in their second season when they form their flowers and seeds. When cultivated for food they are, of course, only grown for one season, i.e., they are grown as annuals.

Roots, tubers and bulbs are thus quite distinct from green leafy vegetables and serve a different purpose in the diet. In spite of the large amounts of water and cellulose they contain, many of them are valuable energy foods because of their starch and sugar and some contain a small amount of valuable protein, minerals and vitamins.

The potato is a tuber and is the most valuable of this type of vegetable. After the cereals, it is, in fact, the most important plant food. It contains a comparatively large amount of starch so that it is a valuable source of Calories, and a small amount of protein especially just below the skin. It is not rich in mineral salts but it has substantial amounts of ascorbic acid, some thiamine, and a little carotene. The fact that there is a loss of ascorbic acid when potatoes are stored and a further loss when cooked, particularly when mashed or kept hot for long periods after cooking, has previously been stated. All the same, potatoes are eaten so regularly and in such large amounts compared with other vegetables that they make an important contribution to our supplies of ascorbic acid. Potatoes have the further merit of a very mild flavour so that we do not quickly tire of them and they form an admirable medium for mixing with a great variety of other foodstuffs such as milk, meat, fish and eggs.

The roots, such as carrot, swede, parsnip and beetroot, contain more water and less starch than the potato and have, consequently, less energy value. They contain varying amounts of ascorbic acid.

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swedes and turnips being the richest sources among the root vegetables. They have little of the B group of vitamins and, with the notable exception of the carrot, very little carotene.

The chief bulb vegetable is *the onion* which is especially rich in sugar. The essential oil the onion contains gives it its pungency which is so useful in the flavouring of many otherwise insipid dishes.

Green peas and broad beans contain more carbohydrate and protein than other vegetables. They also contain some ascorbic acid and, in the case of green peas, carotene as well. French and runner beans are useful for both carotene and ascorbic acid.

Other vegetables such as celery, cucumber and marrow are eaten so infrequently and contain so little nutriment that they can only be regarded as pleasant adjuncts to the diet.

Pulses.

By the term pulses we usually mean dried peas, beans and lentils which are the seeds formed in the pods or shells of leguminous plants, but the term can conveniently be extended to include the seeds of other leguminous plants used as human food such as the soya bean and the peanut (monkey nut or ground nut). You will remember that leguminous plants are those which are able, with the help of bacteria in nodules on their roots, to form their protein from the nitrogen of the air. One of the characteristics of the pulses is the relatively large amount of protein they contain, which, though not quite first-class, is nevertheless a valuable supplement to the high grade protein of meat, fish and eggs. This is their chief value. They are a cheap protein supplement. It should be realised, however, that the protein of pulses, legumin, is inferior to that of the cereals and that, in this country, pulses are not normally eaten in large amounts except by vegetarians.

In addition to their protein, the pulses in general have a high starch and sugar content and consequently a high Calorie value. They are rich in calcium, phosphorus, iron and vitamins of the B group. Peas, beans and lentils are deficient in fat and it is a

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good plan to serve them along with fatty protein foods such as pork and bacon.

Dried pulses need to be soaked before cooking. It is best to cover them with boiling water and soak overnight. The boiling precipitates calcium carbonate from hard water which would otherwise be absorbed by the pulses and contribute to their hardening. If the water is very hard, or the pulses very old and hard, bicarbonate of soda may be used to soften the water and the tissues of the pulses. During the soaking the pulses take up a considerable amount of water with consequent increase in weight and bulk. This reduces their Calorie value and makes their food value as eaten much less than might be supposed from an examination of food tables showing the composition of dried pulses. Besides long soaking, pulses also need long cooking unless finely divided as in pea flour, otherwise they are apt to be indigestible and cause flatulence. Probably most of the vitamin B (thiamine) of the pulses is lost or destroyed during the soaking and cooking with bicarbonate of soda so that they lose any protective value they might possess. It is doubtful if much of the iron they contain is "available." There is no ascorbic acid in dried pulses but it can be developed in them by steeping them in cold water and allowing them to stand until germination begins. This method is excellent with dried peas. The amount of carotene in dried pulses is negligible.

The soya bean is a native of Eastern Asia and one of the oldest crops grown by man. It has probably been cultivated in China for more than 5,000 years. In China, Japan and neighbouring countries the soya bean is one of the most important articles of diet. For the poorer classes it forms one of the principal sources of protein. It is described as "the meat without bones." The beans can be picked green and cooked or served raw in salads or the dried beans can be soaked in salt water and then roasted. A vegetable milk is made from the crushed beans as a substitute for animal milk.

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In recent years its use has spread to other countries and attempts have been made to cultivate it in many parts of the world. The soya bean has been successfully grown in America and is used in breakfast foods, beverages and soup powders; the oil crushed from the beans is used in margarine, cooking oils and salad oils. In this country its cultivation has not yet proved successful but increasing amounts are imported for the preparation of soya bean flour which can be used in soups, meat loaves, gravies, sauces, stews, pastes, sandwich spreads, puddings and custards.

Soya flour does not thicken when cooked as do wheat flour and cornflour because of the smaller amount of carbohydrate it contains. Consequently, for thickening sauces, stews and gravies, it can only be used in combination with wheat flour or cornflour. Since it contains a large proportion of fat and no gluten it cannot be used alone in making cakes, biscuits or pastry. They would be too heavy to be palatable. Soya flour does not bind well and will not rise. By using soya flour in the proportion of one part of soya to seven parts of wheat flour excellent bread, cakes, biscuits, pastry and so on can be made and their food value enhanced. Soya flour is also used in this country in sausages and sold in a form suitable for making milk puddings.

The soya bean differs from peas, beans and lentils in having a large proportion of fat and, therefore, a much higher energy value. It also contains rather more protein, more of the B group of vitamins and more calcium and iron. The amount of carbohydrate is correspondingly less.

THE PEANUT.

The peanut, earthnut, groundnut or monkey nut is the fruit of a sub tropical annual plant. The fruit matures in the ground and the kernel grows inside pods like peas—hence its alternative names.

The peanut has a high protein and fat content. The protein, like that of the soya bean, is not of the highest biological value.

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Some of the essential amino-acids are missing. The fat, which amounts to more than 40 per cent., is crushed out of the peanuts and used very extensively in the preparation of margarine, cooking fat, and the peanut butter used by vegetarians.

Nuts.

Nuts are highly nutritious foods because of their protein, fat and mineral salts. They have, however, a large proportion of waste and owing to their fat and the tough fibrous framework of cellulose are rather indigestible. For this reason, nuts should always be well chewed, minced or crushed to flour. Alternatively, they can be cooked before eating. Almonds and walnuts contain vitamin B (thiamine). There are no vitamins in any of the other nuts. With the exception of the chestnut the amounts of carbohydrates are low. The chestnut contains much less fat than other nuts.

The protein of nuts is of low biological value but vegetarians rely very largely upon them for their supply of protein and fat. Provided they are taken in conjunction with milk, cheese and eggs they will serve this purpose adequately. The calcium and iron of nuts is probably not all "available" because of the presence of phytic acid. The fat of nuts is quite exceptional in amount for vegetable foods and gives them a high Calorie value. These vegetable fats are lacking in vitamins A and D but are used in very large quantities in the preparation of margarine.

Non-vegetarians use nuts merely as a dessert and they play only a small part in their diet. In view of their high Calorie and food values this seems a pity. The chestnut and almond appear to be the most valuable of the nuts and their more frequent use would be advantageous. Chestnuts can be used as a flour for cake-making or they can be boiled for use in savouries and soups. Almonds can be ground into a highly nutritious flour which can be used for almond paste and so on.

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Fungi.

The edible fungi—mushrooms and truffles—are of little importance in the diet. Their food value is negligible and they are difficult to digest. Their flavour is their only recommendation. They are condiments rather than foods.

The preservation of fruits and vegetables is discussed in Chapter XIV, and their cooking in Chapter XV.

Chapter X

MILK

Milk is the creamy yellow liquid formed by all female mammals for feeding their young. Cow's milk is the one most commonly used in this country but the milks of ewes, goats, mares, asses and reindeer are used as human food in various parts of the world. The milks of different animals are very similar to one another and contain the same food materials but with slight differences in composition and in proportions.

Milk is often spoken of as "Nature's most perfect food." This expression may, perhaps, give an exaggerated idea of its qualities but it is true to say that milk is the most complete single food we know. Since cow's milk is the only food of the young calf, it must necessarily contain all the food ingredients needed for its life and growth. While not a complete food for human beings, cow's milk is, nevertheless, of the very greatest value at all stages of human life and particularly to children, adolescents, expectant and nursing mothers, invalids and old people.

Milk contains every type of nutrient, i.e., carbohydrate, fat, protein, minerals and vitamins. Its proteins are first-class proteins of high biological value. It is exceptionally rich in calcium and phosphorus, and has a generous supply of vitamin A and riboflavine along with useful amounts of the other members of the vitamin B complex. Cow's milk contains ascorbic acid, vitamin D and iron but not in sufficient amounts even for a young child. As previously mentioned, infants fed entirely on cow's milk, need additional amounts of ascorbic acid and vitamin D and, after six months of age, additional iron.

A pint of milk supplies a child of five years with about three-quarters of the calcium, nearly half of the protein, three-quarters of the riboflavine and a third of the vitamin A and thiamine required daily. For an average man, a pint of milk supplies seven-eighths of the calcium required daily, a quarter of the protein, a third of the riboflavine and one-fifth of the vitamin

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A and thiamine. In view of these remarkable facts it is not surprising that a pint of milk is so often recommended as the basis of our daily diet, that additional milk is provided for children at school, and that young children and expectant and nursing mothers are given priority in milk supplies during times of scarcity.

The exact composition of milk varies somewhat with the particular breed of cow, the length of time since it had a calf, the nature of the food it has eaten and the season of the year. The variations in the amounts of protein, calcium and phosphorus are not large, but the amounts of vitamin A vary considerably with the cow's food, the amounts of vitamin D with the season, and the

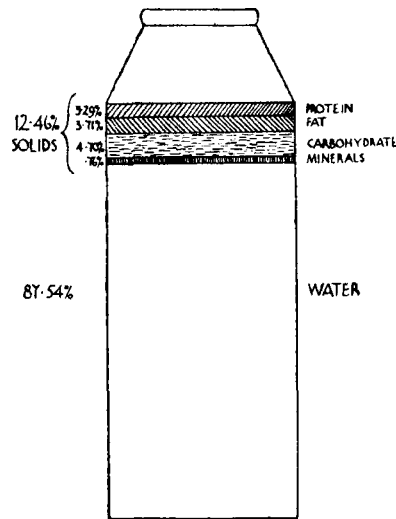


FIG. 43. Percentage Composition of Milk.

amounts of ascorbic acid with the state of the milk, i.e., whether it is raw, pasteurised, sterilised, or boiled, and whether or not it has been left exposed to light. The following composition is an average one based on thousands of analyses.

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Water	87.54 per cent
Protein	3.29 per cent.
Fat	3.71 per cent.
Carbohydrate	4.70 per cent.
Minerals ... ..	.76 per cent.
	—
	100.00 per cent.
	—

Total Solids = 12.46 per cent.

Total Solids (not fat) = 8.75 per cent.

Milk Proteins.

The chief protein in milk is known as *caseinogen*. It is a very valuable body-building material containing phosphorus which is needed for the nervous tissues. With it are smaller amounts of two other proteins known as *lactalbumin* and *lactoglobulin*. Caseinogen is similar to the vitellin of egg yolk, while lactalbumin and lactoglobulin are similar to the proteins of white of egg.

When milk is turned sour by bacteria on keeping, its sugar, lactose, is converted into lactic acid and the milk becomes so acid that the caseinogen is rendered insoluble in the water of the milk and is precipitated as a curd. We say the milk has curdled. Other acids, such as vinegar, lemon juice, cream of tartar, and tartaric acid produce a similar effect.

In our stomachs we have a substance, *rennin*, which causes the caseinogen of milk to coagulate or clot. The caseinogen is changed to casein which combines with calcium of the milk to form a clot. This clot shrinks, becomes entangled with the fat of the milk, thus forming a curd and subsequently expresses a yellowish liquid called whey. There is thus a distinction between the acid curdling and rennin clotting of milk. An extract of rennin, known as *rennet*, which is obtained from a calf's stomach can be bought from the chemist's. It is used to make milk into junket and cheese. When rennet is used the milk has to be warmed to blood-heat (98.4°F.) since this is the temperature at which rennin is accustomed to working in our stomachs and those of calves.

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When milk is poured into a strong infusion of tea, it is clotted by the tannin, the harsh taste of which is consequently reduced. Hence the use of milk in tea.

The lactalbumin and lactoglobulin of milk are not curdled by bacteria or acids or clotted by rennet but when milk is heated they set (coagulate) and form a skin on the surface at about 160°F. It is the collection of air bubbles and steam under this skin which causes milk to boil over so easily when it is heated above this temperature. Caseinogen does not ordinarily coagulate with heat unless the milk is nearly sour.

All three proteins of milk are first-class proteins of the highest biological value. As we would expect, they contain all the essential amino-acids, in a proper balance, and are extremely valuable body-building materials. In addition, they have the further merit of being easily digested and of greatly increasing the value of any second-class plant proteins eaten along with them at the same meal. This supplementing of second-class plant proteins occurs when milk is used with flour in making bread, scones, teacakes, buns and cakes, and with cereals such as oatmeal in porridge and rice in puddings.

Milk Fats.

The fat of fresh milk is in the form of tiny globules dispersed throughout the water of the milk. Such a mixture of fat and water is called an emulsion. (Fat and water do not, of course, ordinarily mix.) The globules of fat can be clearly seen under a microscope. They give milk its "milky" opalescent appearance. When milk is allowed to stand, these globules of fat, being lighter than the rest of the milk, gradually rise to the surface and run together to form cream.

The fatty acids in milk fats are chiefly oleic acid and butyric acid with smaller amounts of many other fatty acids. These fatty acids, especially butyric acid, in combination with glycerin, form fats which are pleasant in smell and taste. Because of this and also being finely divided, milk fats are the most palatable and

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most easily digested of all fats. In addition, they contain vitamins A and D and so are valuable protective as well as energy foods.

Milk Sugar.

(Milk sugar or lactose is a double sugar, i.e., disaccharide. It is the only carbohydrate in milk and is the only known animal sugar.) It has very little sweetness compared with cane sugar. This is probably an advantage since we would tire quickly of milk if it had a strong taste. There is no difference in their Calorie values.

The bacteria which turn milk sour are known as lactic acid bacteria. They feed upon the lactose of milk and change it into lactic acid which curdles the caseinogen. The milk goes sour and separates into curds and whey.

Even for infants the proportion of carbohydrate in cow's milk is too small to be ideal and it is usual to add lactose or glucose to the milk of bottle-fed infants. Cane sugar is not suitable and should not be used, for it cannot be easily digested by very young children. Milk puddings, in which a large proportion of starchy carbohydrate, e.g., rice, sago, tapioca, is added to milk and sweetened with sugar, make a more correctly balanced food for children and adults. Custards, made with starchy custard powder and milk, or milk and biscuits, serve the same purpose.

Milk Minerals.

Milk contains all the minerals necessary for the growth of the young animal. The important ones are calcium and phosphorus, which are essential for the formation of sound bones and teeth. Milk is the best source of these two food minerals.

It has already been emphasised that milk is deficient in iron so that young infants fed on milk require additional iron after six months of age if they are not to become anæmic. This can be given as "iron" medicines or in small quantities of egg yolk, finely minced liver or sieved green vegetables.

Milk Vitamins.

All the commoner vitamins are present in milk in varying amounts. Vitamin A is present in considerable amounts in the

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milk fats. The actual amount depends largely on the cow's food and is greater in summer when the cows graze on quickly growing herbage than in winter when they are fed on hay and other winter fodder. Vitamin D is also present in the milk fats but the amount is small and variable. Like vitamin A it is greatest in milk during the summer when the cows are out in the sunshine and in the field. Bottle-fed babies should get additional supplies of vitamins A and D by taking halibut liver oil or cod liver oil.

Milk is a good source of riboflavine throughout the year although some of it is destroyed if the milk is left exposed to ordinary daylight or, still more, to bright sunlight. Thiamine and nicotinic acid are present in small amounts; the variation in amounts between summer and winter milk is but slight.

Ascorbic acid is found in milk in small amounts only but this is remarkably constant as the milk leaves the cow. It is afterwards that the amount of ascorbic acid decreases according to the treatment the milk receives. Thus, a bottle of milk left on the doorstep in daylight or, worse still, direct sunlight, soon loses much of its ascorbic acid. The pasteurisation of milk causes some destruction of the vitamin and sterilisation or boiling is still more destructive. These facts emphasise the need of bottle-fed infants for the supplement of orange juice previously mentioned (page 64).

Water of Milk.

Milk contains much more water than anything else. Seven-eighths of milk is water and only one-eighth solids. Of these solids, the fats are dispersed in the water as an emulsion and the rest are dissolved. By itself milk is thus a very dilute and bulky form of food for everybody except infants. It is apt to be regarded wrongly as a beverage instead of as a food.

Bacteria in Milk.

Milk is not only a splendid food for animals and human beings but also, unfortunately, for bacteria. It contains all the essential nutrients, it is a liquid and it is handled a good deal. All these factors make milk particularly liable to infection by bacteria and

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for their rapid growth when once they have been introduced. Freshly drawn from a healthy and perfectly clean cow, milk is practically free from bacteria. On the other hand, milk from unhealthy cows is liable to contain disease bacteria. Tuberculosis and undulant fever can be passed on from cows to human beings in this way. It is more common, however, for bacteria to be introduced into milk after it has been withdrawn. This is possible in a great many ways. Dirty milk literally teems with bacteria. Dirt and bacteria may enter the milk from the cow's body, from dust and dirt in the cowshed, from the milker, from the milking apparatus and utensils, during transit to the consumer and in the home. The great majority of them are harmless to health and will do nothing worse to the milk than turn it sour, but serious outbreaks of scarlet fever, diphtheria, septic sore throat, and typhoid have frequently been traced to milk infected by some carrier of these diseases. A pure milk supply is thus of the very greatest importance to the health of the nation. There are two methods of tackling the problem. The first is to ensure that the cows in the dairy herd are perfectly healthy, are milked under conditions of perfect cleanliness and the milk is cooled and bottled immediately on the farm. The second method is to destroy by heat any disease bacteria in milk, i.e., by sterilisation or pasteurisation. The first is the more ideal method but the second is the more practicable at the present time. The conviction is growing that even the purest milk should be pasteurised and that we should no more think of drinking raw milk than we would think of eating raw meat.

Sterilised Milk has been heated to 230°F., for some time. This treatment destroys the bacteria but also alters the taste of the milk. The ascorbic acid is destroyed, the lactalbumin and lactoglobulin coagulated, and the fine emulsion of fat broken up. This type of milk has never become very popular but it keeps for a long time.

Pasteurised Milk (so-called after Pasteur) has been heat treated to provide safe milk of good keeping quality without altering the taste or destroying the cream line as occurs with sterilisation.

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The resistance of bacteria to destruction by heat depends not only on the temperature to which they are subjected but also on the time for which it is applied. The tubercle bacillus is the most resistant to heat of all common pathogenic organisms found in milk. Thus a time-temperature treatment sufficient to kill this organism will ensure destruction of all the other less resistant pathogenic organisms.

There are two official methods of pasteurisation:—

(1) *The Holder Method.*

This method requires that milk shall be “retained at a temperature of not less than 145°F., and not more than 150°F., for at least 30 minutes and be immediately cooled to a temperature of not more than 55°F.”

At 145°F., the tubercle bacillus is killed in 6 minutes and at 150°F., in 2 minutes; thus it will be seen that this method allows a very wide margin of safety. Immediate cooling is required to ensure maximum effect from the treatment. Growth of the surviving (all non-pathogenic) organisms is checked and keeping quality consequently further promoted. Such cooling is also important for the maximum restoration of the cream line.

(2) *H.T.S.T. (High Temperature Short-Time) Method.*

Since 1941 this second method of pasteurisation has been steadily replacing the Holder method. It requires that “the milk shall be maintained at a temperature of not less than 162°F., for at least 15 seconds and shall be immediately cooled to a temperature of not more than 55°F.”

Only milk heated and cooled by one of these methods receives a licence to be sold as pasteurised.

A frequent criticism is that pasteurisation destroys the nutritive properties of milk. Before considering evidence as to the falsity of such statements, the effect of heat on the nutritive value must be understood. Milk, when heated, undergoes changes which are influenced by the time during which it is exposed to the heating agent and the temperature attained during processing. The changes

which occur in milk heated to high temperatures do not occur in efficiently pasteurised milk, e.g., at 150°F. 5 per cent. of the albumin is precipitated but at 145°F. the albumin is not affected. Approximately 5 per cent. of the calcium and phosphate salts are precipitated in insoluble form. The cream line may be slightly reduced. The vitamin content of milk is altered to a varying degree. Vitamins A, B₂, D and E are not affected by pasteurisation. Vitamin B₁ may be reduced by 10 to 20 per cent. Vitamin C is heat sensitive to a greater or less extent depending upon previous exposure to light, especially sunshine, and the degree of oxidation which has taken place. Usually the loss ranges from 20 per cent. to 40 per cent. of the vitamin C present in the raw milk prior to treatment. It should be realised that the quantity of vitamin C in raw milk is not large, certainly not sufficient to satisfy human requirements, and this deficiency must, in any case, be made good by foods other than milk.

“ Designated ” Milk.

The milk from farms where special care is taken with regard to its cleanliness and the number of bacteria it contains is known as “ designated ” milk. Under the Government’s Milk (Special Designation) Order, 1936, such milk is divided into the following grades: —

- (a) *Tuberculin-tested.*
- (b) *Accredited.*
- (c) *Tuberculin-tested (pasteurised).*
- (d) *Pasteurised.*

Tuberculin-tested Milk is from cows that are tested for tuberculosis every six months. If the milk is bottled and sealed immediately on the farm the word “ certified ” may be added to its description.

Accredited Milk is from cows which were tested for tuberculosis before being included in the herd and examined by a veterinary surgeon every three months, though not actually tested for tuberculosis.

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Tuberculin-tested (Pasteurised) is the same as tuberculin-tested except that it has been pasteurised.

Pasteurised Milk is any milk, graded or ungraded, which has been pasteurised.

According to the Milk (Special Designations) Act, 1949, the use of special designations is compulsory in the case of the sale of milk by retail *in specified areas*. The use of the designation "Accredited" will no longer be permitted in such areas after 1st October, 1954, and after 1st October, 1957, the special designation "Tuberculin Tested" may only be used in respect of milk from a herd which is on the "Register of Attested Herds" maintained by the Ministry of Agriculture and Fisheries.

TREATMENT OF MILK IN THE HOME.

It is no use buying tuberculin-tested milk or pasteurised milk unless it receives proper care in the home. The following points about the care of milk in the home are all too frequently overlooked:—

- (1) Never leave the milk on the doorstep exposed to sunlight.
- (2) Keep in a cool dark place—in the refrigerator if you are fortunate enough to possess one.

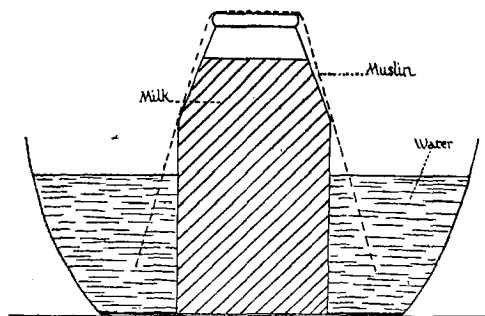


FIG. 44. A Simple Milk Cooler.

- (3) In hot weather stand the bottle in a basin of cold water—with a piece of muslin over the top with the edges dipping in the

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water. If the basin can be stood in a draught so much the better. The muslin soaks up water which slowly evaporates. Heat is withdrawn from the milk to help this evaporation and the milk is thus kept cool.

(4) Do not pour the milk into jugs until required for use and see that the jugs are perfectly clean. Milk jugs should be washed in cold water, then in very hot water and finally rinsed in cold water. The jugs should be turned upside down to drain. The inside should not be dried with a teacloth. This may introduce bacteria.

(5) When in the jug, keep milk covered to protect it against dust and flies. Both may infect milk with bacteria.

(6) Never place milk near a sink or near foods with a strong smell, e.g., onions. The mild taste of milk is easily spoilt by the absorption of such smells.

(7) Never mix new milk with old milk unless it is to be used immediately; otherwise the bacteria in the old milk will quickly infect the new.

(8) If your milk is raw ungraded milk delivered from an open milk kit it is safest to boil or scald it. Boiling will alter the taste but if scalding is done carefully in a double saucepan and the milk quickly cooled afterwards by standing in a basin of cold water, there is very little change in taste.

MILK PRODUCTS

Cream.

We have seen that when milk is allowed to stand the fat globules rise to the surface and run together to form a layer of cream. This cream layer can be removed either by skimming off or, more efficiently, by means of a cream separator.

Cream contains not only fat but also water and small amounts of protein and milk sugar. Skimmed cream contains about 20 per cent. fat and separated cream about 50 per cent. fat. Separated cream is thus more concentrated. It also keeps better because it can be made from fresh milk. In the case of skimmed cream, the

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milk has first to be allowed to stand and bacteria have time to multiply and to attack the cream.

At one time it was customary to add preservatives and thickening materials to cream but this has been made illegal. It is to be hoped that some legal standard for cream, e.g., 40 to 50 per cent. fat, will be adopted. The "single cream" sold before 1939 contained 20-35 per cent. fat and "double cream" 30-50 per cent. fat.

Because its fats are so finely divided cream is a very palatable and easily digested energy food. It also contains the vitamins A and D of the milk dissolved in it and is thus a protective food. It is a particularly suitable form of fat for invalids and convalescents.

Devonshire, Cornish or clotted cream is made by allowing milk to stand for twelve hours, then scalding it and allowing it to stand again before separating. Besides cream it contains most of the protein and sugar of the milk and resembles a very soft cream cheese.

Whipped cream can be best made from cream which is slightly sour. Fresh cream is not sufficiently acid for the emulsion of fat to break down easily during whipping. On the other hand, older cream, if too acid, is liable to whip to butter.

"*Reconstituted cream*", which differs very little in appearance or taste from fresh cream, is made by emulsifying together salt-free butter and milk. Special machines are on sale for home use for this purpose.

"*Synthetic or Artificial cream*", used for filling cakes and buns, is made by emulsifying together a mixture of unsalted butter or margarine, milk powder and water.

"*Ice cream*", as sold in this country, is not frozen cream but a synthetic product made from milk powder, unsalted margarine, sugar and gelatin. When properly prepared under hygienic conditions it is an excellent food.

Butter.

Butter is made by churning separated cream after it has "ripened". The ripening is a souring brought about by lactic acid bacteria. They form lactic acid which improves the flavour and breaks down the emulsion, thus helping the fat globules to stick together into a solid mass of butter. The solid lumps of butter are collected and moulded into shape after the addition of a little salt and colouring matter.

Butter contains about 85 per cent. fat. The rest is water with small amounts of salt and caseinogen. The presence of water and caseinogen favours the growth of bacteria which turn butter rancid. The salt helps to prevent this as well as giving flavour.

Butter is a very palatable and easily digested fat containing the vitamins A and D of the original milk. It is one of our most valuable foods for Calories. The volatile fats in butter, chiefly butyric, give it its pleasant smell and taste. Its distinctive flavour is imparted to any cakes or other baked goods in which it is used.

Margarine.

Margarine is not a milk product but it is convenient to discuss it here. It is made from a great variety of fats and oils such as beef fat, lard, olive, ground nut, cotton seed, palm kernel, sunflower and soya bean oils. Whale oils and fish oils and some vegetable oils, which were previously unsuitable for human food on account of their objectionable smell and taste, can now be refined and converted into palatable solid fats by a process of hydrogenation. This consists in passing hydrogen gas through them under special conditions. These hydrogenated fats and oils are now largely used in margarine and in cooking and frying fats.

The fats and oils are melted together so as to give a mixture with about the same melting point as butter and then emulsified with soured skim milk. The mixture is then rapidly frozen, allowed to mature for a short time and then kneaded to the correct consistency, salt and colouring matter being added.

Modern margarines contain about the same amount of fat as butter and have about the same Calorie value. The vitamins A

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and D which are absent from most of the fats and oils used in margarine are added to it during manufacture to make it equivalent in this respect to the best summer butter. Margarine does not contain the butyrin found in butter and thus lacks its pleasant smell and taste.

Cheese.

Cheese consists chiefly of the casein and fat of milk. It is prepared by clotting the milk with rennet or by an acid such as vinegar or by souring by bacteria. The whey is strained from the curd and the curd then salted and pressed to remove as much as possible of the remaining whey. Finally, it is set aside in a cool place to "ripen". The flavour and character of the cheese are developed during this stage by the action of bacteria and moulds.

The variations in taste, texture and appearance between different types of cheese are due to:—

(1) *The type of milk used, e.g.:*

Cheshire and Cheddar from whole cows' milk.

Stilton and Gorgonzola from milk to which additional cream has been added.

Dutch cheese (Edam and Gouda) from separated milk.

Parmesan from goats' milk.

Roquefort from ewe's milk.

(2) *The amount of pressing.*

Hard cheeses such as Cheshire, Cheddar and Lancashire have been pressed in cheese presses.

Soft cheeses such as Stilton and Gorgonzola have been subjected only to the pressure of their own weight.

(3) *The amount and kind of ripening.*

The particular flavour of a cheese depends upon the type of bacteria used in the ripening and the length of time it is allowed to proceed. Special green moulds are used in the ripening of such cheeses as Stilton and Gorgonzola.

"Processed cheeses" are made by grinding cheese to

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a fine powder, melting it with pasteurised milk, allowing it to solidify and then wrapping it in lacquered tin foil.

Generally speaking, cheese consists of approximately one-third protein, one-third fat and one-third water. In addition, it contains calcium and vitamin A from the milk and the salt which is added during manufacture. It is thus an excellent body-building, energy and protective food and has the additional merit of being relatively cheap. The fact that its fat and protein are so intimately mixed together makes it rather difficult to digest. For this reason cheese should be chewed well and in the case of young children, finely shredded or grated. If cheese is cooked it should not be overheated, otherwise the protein will be over-coagulated and made more difficult to digest. Cheese should be eaten along with carbohydrate foods, e.g. bread and biscuits. In this way the fat of the cheese is more completely oxidised in the body and its protein increases the value of the protein in the bread and biscuits.

Skimmed and Separated Milks.

Skimmed and separated milks are the liquids left after the cream has been skimmed off or separated. They still contain the other ingredients of milk and are valuable foods, particularly for their first-class protein and calcium. They should on no account be wasted. Such milks are very useful in making bread, cakes and scones. Large quantities were imported into this country during World War II in a dried form known as "Household milk". Skimmed and separated milks are not suitable foods for infants on account of their lack of fat.

Buttermilk.

Buttermilk is the waste product of butter manufacture. It contains the constituents of the original milk, except the fat, and is distinctly acid due to the action of lactic acid bacteria. It is useful in making scones. The food value of the scones is increased, and the lactic acid releases carbon dioxide from the bicarbonate of soda used in the scones and thus aerates them. Dried buttermilk powders are sold for use in breadmaking.

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Whey.

Whey is the liquid left after the removal of the curd when milk has been curdled by rennet or by souring with an acid such as vinegar, or by bacteria. The casein and fat are removed in the curd and the whey contains only small amounts of food material, chiefly the proteins, lactalbumin and lactoglobulin, and milk sugar. It is usually used for feeding farm animals although a dried whey powder can be bought for confectionery purposes.

Condensed Milk.

{ Condensed milk is made by evaporating away about two-thirds of the water from either full cream or separated milk. The evaporation is carried out in special closed pans, known as vacuum pans, under reduced pressure. The temperature does not rise above 150° F.) In this way, the lactalbumin and lactoglobulin are prevented from coagulating and giving the condensed milk a cooked flavour. { The condensed milk may be sweetened or left unsweetened.) The addition of sugar improves the flavour, increases the food value and checks bacterial action. { Whether full cream, separated, sweetened or unsweetened the condensed milk is hermetically sealed in sterilized tins) The tins must have a label attached giving a clear description of the contents.

{ Condensed milks, as a result of their heat treatment and storage in sealed tins, contain fewer bacteria than fresh milk and are less likely to spread infectious diseases.) Provided they are kept sealed they will keep indefinitely. Their use for infants is open, however, to certain objections. Condensed skimmed milks, sweetened or unsweetened, are deficient in fat and quite unsuitable for infants. Sweetened condensed full cream milk contains too much sugar which is liable to upset an infant's digestion. Mixing this type of condensed milk with water to give a more correct proportion of sugar makes the protein and fat deficient. The most suitable form of condensed milk for infant feeding is an unsweetened full cream milk. This would need supplementing by orange juice, cod liver oil and iron as previously mentioned. { Condensed milks are most useful as emergency supplies.)

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COMPOSITION OF TYPICAL CONDENSED MILKS

Percentage	Whole, Sweetened	Whole, Unsweetened	Skimmed, Sweetened
Protein ...	8.2	8.5	9.5
Fat ...	9.2	9.2	.5
Carbohydrate	49.6	11.5	55.8
Calcium ...	.3	.3	.3
Water			

Milk Powders.

These are prepared by the removal of practically the whole of the water of milk. They are produced from both whole milk and separated milk. The milk is first homogenised, i.e., its constituents are thoroughly mixed mechanically so that they will not separate out. It is then dried by either the roller process or the spray process.

In the roller process the milk is allowed to fall on to hot revolving rollers. The water evaporates rapidly leaving a thin film of powder on the rollers which is automatically scraped off. This type of dried milk does not readily "reconstitute". It tends to cling in flakes and go lumpy when mixed with water.

In the spray process the homogenised milk is pumped through a fine jet as a spray into a chamber through which hot air is circulated. The fine droplets of milk quickly lose their water by evaporation and fall to the floor of the chamber as a fine powder. The temperature of the hot air is carefully regulated so as not to coagulate the proteins and give the milk powder a cooked flavour. Because of its finely divided state this type of dried milk is readily reconstituted by mixing with water.

Provided they are kept dry in airtight containers, milk powders will keep indefinitely. The fat of dried whole milk is liable to go rancid on exposure to air. Dried whole milk powder contains all the ingredients of milk in a concentrated form. Dried skimmed milk (household milk) contains no fat and consequently no vitamin A or vitamin D but contains the whole of the protein,

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calcium and riboflavine of the milk. It is valuable in cooking and baking.

Patent Baby-Foods.

Dried whole milk is made the basis of patent baby foods. It is frequently modified in some way, e.g., by adding sugar, removing fat, adding vitamins and iron, to make it more closely resemble human milk in composition. It is then said to be "humanised".

COMPOSITION OF TYPICAL MILK POWDERS

Percentage	Whole milk powder	Skimmed milk powder
Protein	25.6	35.8
Fat	26.7	.7
Carbohydrate	35.6	47.9
Calcium ... ..	.9	1.2

Fermented Milks.

The process of fermentation is one of the oldest methods known of preserving or improving the nutritive constituents of milk. In spite of the fact that modern methods have made fermentation of milk unnecessary, there is a growing demand for fermented milks, principally because of the claims put forward as to their exceptional health-giving properties. The principal types of fermented milks are Kephyr, Koumiss and Yoghourt, the last being the commonest in this country. Yoghourt is a thick, curdled milk which is decidedly acid. It is a nourishing and refreshing food which is easily digested. Milk is converted into Yoghourt by curdling it with special bacterial cultures. The acidity of Yoghourt is due to the formation of lactic acid from lactose, and the digestibility to the partial peptonisation of the casein.

CHAPTER XI

MEAT, FISH AND EGGS

Meat.

The term "meat" includes the flesh and some of the internal organs (offal) of animals and birds. The chief animals used in this country as sources of meat are the bullock (beef), sheep (lamb and mutton), pig (pork) and rabbit. The chief birds are domestic poultry, such as chickens, ducks, geese and turkeys, and game birds such as the pheasant, partridge and grouse.

Flesh, or lean meat, consists of muscle tissue which is built up of microscopic fibres. These fibres are arranged in bundles which are held together by connective tissue of a gristle-like nature. These bundles are again grouped into bigger bundles surrounded by connective tissue and the whole muscle surrounded by a sheath of connective tissue which merges at each end into gristle or tendons joining the muscle to bone. Dispersed throughout the fibres are nerves and bloodvessels and embedded in the connective tissue between the fibres is a certain amount of fat.

Muscle fibres vary considerably in length and thickness and in the amounts of connective tissue, gristle and fat they contain. It is upon these variations that the tenderness of meat very largely depends. In the flesh of older animals the muscle fibres are thick and long and have a large amount of connective tissue and gristle. It is thus tougher than the flesh of younger animals with thinner, shorter fibres, less connective tissue and less gristle. Even in the same animal the muscles which have had most work to do are stronger and tougher and have more connective tissue and gristle than muscles from other parts of its body which have had less work to do. This explains, for instance, why shin beef, which is the leg muscle of the bullock, is tougher than sirloin which comes from the muscles of its back. In the same way, chicken leg is tougher than the breast.

The amount of fat embedded in the connective tissue varies with the kind of animal and between animals of the same kind

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according to their age and food. Most forms of game contain very little fat. Beef contains more than veal while pork contains more than beef or mutton. Water birds such as duck and geese contain more fat in their muscle fibres than land birds such as

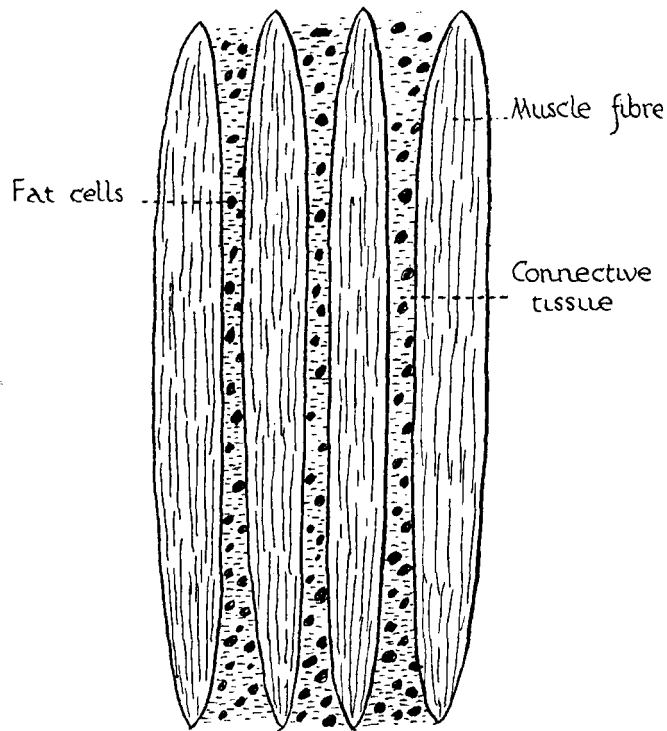


FIG. 45. Diagram of Muscle Fibres, etc.

chickens and turkeys. A large amount of fat tends to make the meat less easily digested by preventing the digestive juices coming into contact with the fibres. It should be made clear that the fat referred to here is not the fat deposited under the animal's skin

and round its internal organs such as the kidneys. It is sometimes called "invisible" fat because it cannot be seen with the naked eye.

Each microscopic muscle fibre contains water in which are dissolved, proteins, mineral salts and substances known as "extractives". The chief protein is *myosinogen* which clots into *myosin* when the animal is killed and its body cools. This causes the muscle fibres to go hard and accounts for the stiffening after death known as *rigor mortis*. In this condition the meat is very tough and must be hung until the rigor mortis has passed off. Gradually, the coagulated myosin liquefies because of the formation of acids and the action of enzymes in the fibres. The meat thus becomes tender and the acids improve the flavour and help to break down the connective tissue. In the case of game, the hanging is carried out until it is "high", that is, until it has begun to putrefy. These effects are sometimes imitated artificially by soaking tough meat in vinegar and water for a short time.

The mineral salts in the muscle fibres are chiefly phosphates. There is iron in the haemoglobin of any blood left in the meat but not much of it is "available". In digestion muscle fibres contain very little calcium.

The extractives are so called because they can be extracted from meat by boiling water. It is these substances which give meat its flavour and the variation in taste between different kinds of meat is due largely to differences in the kind and amount of extractives they contain. The extractives powerfully stimulate the flow of digestive juices and thus help in the digestion of meat. They have no actual food value.

Connective tissue is composed of a protein known as *collagen*. The walls of the muscle fibres are composed of a protein known as *elastin*. Both are quite different from the protein, myosin. Elastin is insoluble in water and very tough. Collagen is also insoluble in water but moist heat converts it into *gelatin*. This conversion takes place during the cooking of meat. The meat is thus made more tender and the digestive juices are better able to

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come into contact with the myosin of the muscle fibres. The pounding of beef steak with a stick before cooking breaks open the sheaths of connective tissue and produces a similar effect. For the same reason, meat should be carved across the length of the fibres and not along them.

The vitamins in lean meat are chiefly those of the B group, particularly riboflavine and nicotinic acid. Lean meat is not a rich source of thiamine, although lean pork, bacon and ham are exceptions. This is probably due to the fact that the food of foreign pigs (maize) contains more thiamine than that of cattle and sheep. Lean meat contains some vitamin A in its "invisible" fat, but very little ascorbic acid is found in meat.

Offal.

The internal organs are usually referred to as "offal". The main offal foods are liver, kidneys and tripe.

Liver and kidneys are more compact and have less connective tissue than lean meat. They consist chiefly of proteins with a little fat. Their proteins are different from those of lean meat. They are called nucleo-proteins and are liable to form uric acid on digestion. For this reason, these foods should be avoided by persons suffering from gout, rheumatism or kidney trouble. Both of them, and particularly liver, contain large amounts of vitamin A and iron. Both are valuable protective foods.

Tripe is prepared from the stomach and intestines of cattle and sheep. It contains a large amount of connective tissue which is changed into gelatin during the long slow cooking it undergoes. The fact that it contains no extractives makes it lacking in flavour but it can be made palatable by serving with sauce or, better still, with milk and onions. Tripe is a valuable and easily digested food. In addition to protein, it contains an appreciable quantity of calcium from the lime used in its preparation.

Meat Extracts.

Meat extracts are made by treating fresh meat with boiling water to dissolve out its soluble ingredients. These include

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minerals, extractives and the vitamins, nicotinic acid and riboflavine. The extract is concentrated to give the thick brown material with a strong "meaty" smell which we all know.

Because of the minerals and extractives they contain, soups and beverages made from meat extracts give flavour and help digestion by stimulating the flow of digestive juices. They contain no protein and no fat and so are neither body-builders nor energy foods and it is an exaggeration to say that they contain all the goodness of meat in a concentrated form. They do, however, contain a large amount of nicotinic acid and a fairly large amount of riboflavine. It is in these two vitamins that their main food value lies.

Soups and Beef Tea.

It will now be realised that the water in which meat has been cooked will contain minerals, extractives, nicotinic acid and riboflavine. Soups and beef tea will thus contain all these materials and if the meat itself is added the soup or beef tea will provide protein. Any vegetables or cereals added will also increase the food value but long heating will destroy any ascorbic acid the vegetables might contain. The real value of soups is as stimulants to the appetite and as aids to digestion by increasing the flow of digestive juices. This is why it is customary to take soup at the beginning of dinner.

Characteristics of Fresh Meat.

If meat is fresh it will have the following characteristics: —

- (1) It will be firm and elastic to the touch.
- (2) The colour will be bright.
- (3) It will be moist but not wet.
- (4) The flesh will be mottled with fat.
- (5) The fat will be pale yellow in colour and of firm texture.

For the cooking of meat see Chapter XV. For the preservation of meat see Chapter XIV.

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Fish.

As with meat, the chief food materials in fish are protein and fat. Compared with meat, fish contains very much more waste material in the form of skin, head and bones and a larger amount of water. The connective tissue of fish contains collagen only without any of the tough elastin. This collagen is easily converted into gelatin during the cooking of fish. This explains why fish is more tender than meat and more easily cooked. The fat in fish is found entirely dispersed among the muscle fibres: there is no separate fatty tissue as there is in meat. The amounts of minerals and extractives are much less than in meat and this accounts for their comparative lack of flavour. As a result, fish eaten too frequently is apt to become insipid and monotonous unless attractively cooked and served. Well-made sauces, vinegar, pepper and salt are valuable aids in making fish more appetising.

The flesh, i.e., the muscle of fish, is divided into flakes between the bones. In some fish, e.g., cod, the flakes are large and easily separated from the bones, while in others, e.g., herrings, they are small and difficult to remove. The proteins of the muscle fibres are similar to those of meat. They contain the essential amino-acids and are of high biological value.

The amount of fat in fish varies very considerably with the type of fish and the time of the year. Herrings, mackerel, pilchards, sardines and salmon contain up to 20 per cent, and are known as *fat fish*. The actual amount of fat in fish alters with the time of year because it depends upon the fish's food and the nearness of spawning. Herrings contain most fat during the summer months when they are feeding intensively and least in spring and autumn when they are spawning. The salmon is at its best when it first leaves the sea to go upstream to breed. During the breeding season the fat is used up and the flesh becomes pale and watery.

Fish which never contain much fat are known as *white fish*. They include cod, halibut, haddock, plaice, sole, hake, turbot and whiting.

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The mineral salts in fish consist chiefly of calcium and phosphorus. These are provided in largest amounts when we eat the bones of such fish as sardines, sprats and whitebait. Sea fish contain valuable traces of iodine but there is very little iron in fish except in sardines and sprats. Fat fish contain the fat-soluble vitamins A and D. In fact, herrings, sardines, mackerel and salmon are among the few good food sources of vitamin D. White fish contain only a small amount of vitamin A and no vitamin D at all except that stored up in the liver. Fish liver oils, particularly those of halibut and cod, contain exceptionally large amounts of both vitamins. There are small amounts of the B vitamins in most fish; fat fish containing more than white. Fat fish are thus very valuable body-building, energy and protective foods while white fish are body-building foods only.

Because of the short fibres and small amount of connective tissue the flesh of white fish is amongst our most valuable and easily digested animal foods. Fat fish, as we have seen, are even more nutritious but their fat makes them less easy to digest, particularly for invalids. For normal healthy persons leading an active life herrings, and other fat fish, are amongst our finest and cheapest foods for protein, fat and vitamins A and D. Their frequent use in the diet cannot be too highly recommended.

Fish Offals.

The only offal of fish which is ordinarily eaten is the *roe*. "Hard roe", in which the eggs are easily visible, is the ovary of the female fish. "Soft roe", or milt, is the corresponding organ in the male fish. Both consist largely of protein with small amounts of fat. *Caviare* is the salted roe of the sturgeon.

Shell Fish.

Included under this heading are the *crustaceans*, crab and lobster, and the *molluscs*, oysters, mussels, winkles and cockles.

The flesh of lobster and crab is found in the claws and tail. The body consists mainly of liver. The flesh is dense and coarse with thick fibre walls which make it rather indigestible. Their

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food value consists in their protein and fat. Prawns and shrimps are similar.

The use of vinegar with these shell fish helps to soften the muscle fibres besides adding to the flavour.

Oysters, mussels, winkles and cockles contain small amounts of protein, fat and minerals, including iodine and iron.

In both crustaceans and molluscs there is always a very large amount of waste on account of the shell. They are best regarded as occasional tasty delicacies.

Fish goes bad very quickly and for this reason should be very fresh and cooked as soon as possible. Whether fish is purchased whole, or in fillets or steaks, the flesh should be firm and without disagreeable smell. In the case of whole fish, the gills should be examined to see if they are bright and clear and the eyes should be bright and full and not dull and sunken.

For the cooking of fish see Chapter XV. For the preservation of fish see Chapter XIV.

Eggs.

By the term eggs we ordinarily mean those of the domestic fowl but these are not the only edible eggs. The eggs of such domestic birds as ducks, geese and turkeys as well as those of such wild birds as the plover, gull and heron can also be used as human food. Other eggs used for food are those of the turtle and many varieties of fish, e.g., herring (roe) and sturgeon (caviare). For our purpose we shall confine ourselves to the hen's egg which constitutes the chief source of our supply of eggs.

We shall better understand the value of an egg as food if we realise that it is a living organism. It contains an undeveloped chick, or embryo, with its store of food enclosed in a protective shell. The fact that the living chicken steps out of the egg shell when the egg hatches after twenty-one days sitting or incubation shows us that the egg must contain every type of food material necessary for its rapid growth and development. We should expect to find that it contains proteins and minerals for building the flesh and bones of the rapidly growing embryo and fat to supply energy.

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Fat is a more compact fuel than carbohydrate and thus more suitable for storing in a confined space such as an egg. The vitamins we should expect to find will be vitamins A and D since these are the ones most closely concerned with growth. All these expectations are borne out in fact.

The shell consists chiefly of chalk (calcium carbonate) with small amounts of calcium phosphate. It is not a solid shell forming a hermetic seal but is pitted with tiny holes. In other words, it is porous. This allows air to pass into the interior of the egg for the living embryo to breathe in oxygen. The carbon dioxide it breathes out passes outwards through the pores of the shell. Unfortunately, the porous character of the shell allows bacteria to enter the egg and moisture to escape. When eggs are stored the contents are liable to go bad through the action of these bacteria and to shrink owing to the loss of moisture.

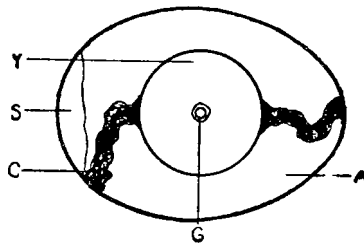


FIG. 46. Diagram of a fowl's egg. A. albumin or egg white. C. chalaza. G. germinal disc or embryo. S. air space. Y. yolk.

Underneath the shell is a thin parchment-like *shell-membrane* which divides at the broad end of the egg into two layers to form an *air chamber*. Inside the shell membrane are the *white* and the *yolk*. The white is a thick sticky liquid surrounding the yolk. The yolk is roughly spherical in shape and is surrounded by a thin elastic membrane. Underneath this *yolk membrane* is the *living embryo* which can be seen as a small circular disc. Attached to the yolk are two fibrous twisted cords, known as *chalazas* or *balancers* which hold the yolk in position and prevent injury to the embryo by acting as "shock-absorbers" when the egg is moved.

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The white consists essentially of a solution in water of a protein known as *egg albumin* or *ovalbumin*. It also contains some riboflavine. Unlike the protein of meat and fish, that of eggs is not in the form of muscle fibres and is not surrounded by tough connective tissue. It is in a cellular structure and is thus easily digested, and consequently, particularly suitable for young children, invalids and convalescents.

The yolk is the chief storehouse of food for the young chick. It is very much richer and more complex than the white. It contains less water, more protein and a large proportion of fat and minerals. In addition to ovalbumin, the yolk contains two other proteins, *vitellin*, which contains phosphorus, and *livetin*. The fats in egg yolk are highly emulsified and, consequently, easily digested. A fat-like substance *lecithin*, which contains phosphorus, is also present. The minerals include valuable calcium, iron and sulphur in addition to the phosphorus already mentioned. The vitamins include vitamins A and D in the fats with some thiamine and riboflavine. The yolk is thus an exceptionally fine food with its first-class protein, its easily digested fat, its valuable calcium, iron, sulphur and phosphorus, and its vitamins.

Eggs are highly nutritious foods which are also easily digested and absorbed and are widely used in baking and cooking. Unfortunately, their cost is high in spite of the small amount of waste compared with meat and fish.

The average weight of a hen's egg is about two ounces and its approximate composition is as follows:—

Shell and membrane	10.1 per cent.
White	59.7 per cent.
Yolk	30.2 per cent.

Without the shell the proportions of white and yolk work out at:—

White	66.4 per cent.
Yolk	33.6 per cent.

so that there is almost exactly twice as much white as yolk.

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Because of its sticky glutinous nature the white of egg can be beaten or whisked into a froth which is almost permanent. Bubbles of air become entangled in its substance and are unable to escape. Thus whisked eggs introduce air into any sponge or cake mixture in which they are used and act as aerating agents. The yolk of egg contains too much fat to whisk separately but nevertheless is a valuable ingredient in baked goods. It improves their colour, flavour and food value and its fat has a "shortening" and moistening action. The best results are obtained by using the whole egg for baking purposes. As a general rule, whole egg can aerate an equal weight of flour, i.e., 8 eggs to 1 lb. flour. If less than this proportion is used baking powder or self-raising flour will be needed.

In addition to their use directly as foods, and as aerating and enriching agents in sponge and cake mixtures, eggs are used in omelettes, custards, and Yorkshire and other puddings. Egg whites are used separately in meringues, macaroons, dessert biscuits and royal icing.

When eggs are heated their proteins set or coagulate. This coagulation begins at about 60°C. (140°F.) so that fully boiling water (100°C., 212°F.) is not essential to the "boiling" of an egg. The same coagulation takes place in other methods of cooking eggs, e.g., frying, scrambling and poaching. As a result of the coagulation of the proteins the whole egg solidifies. The white becomes a soft, tough mass but the yolk, because of its fat, breaks up into a powder. The higher the temperature and the longer the time of cooking the tougher and more solid the eggs become and, therefore, more difficult to digest. Thus, fried eggs are harder to digest than poached or scrambled eggs, and hard-boiled eggs more difficult to digest than lightly-boiled ones.

This same coagulation of the proteins takes place when mixtures containing eggs are cooked or baked. In sponge and cake mixtures it helps to fix the sponge or cake in shape during baking. In sauces, egg custards and lemon cheese it helps the stiffening which takes place on cooling. In the case of these articles care

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must be taken to mix the ingredients thoroughly and not to heat them too strongly or the proteins will harden into lumps and "curdle" the mixture. The mixture should, therefore, not be permitted to boil after the egg is added. The use of a double pan is advisable.

The use of eggs for binding mixtures together is explained in the same way. When the proteins coagulate on heating they bind together the loose or dry ingredients, e.g., in rissoles and croquettes. The use of eggs on the outside of fried foods which might fall apart in cooking is also due to the same action. The proteins set on the outside during the cooking and prevent the foods from breaking, and also prevent too much fat being soaked up by the mixture. Bread crumbs are used after the egg has been applied to give a crisp brown appearance.

When eggs are to be kept for some time they should be placed in a suitable tray with the blunt ends, containing the air-chamber, uppermost. In this way the yolk is kept in its proper position completely surrounded by the white. The white is less likely to deteriorate into the condition known as "watery" white. Of the two parts of an egg the white is less easily attacked by bacteria than the yolk with its richer food store and, when it completely surrounds the yolk, the white exerts a protective influence upon it. The eggs should be placed in a cool dry place away from any strong smelling foods. Eggs readily absorb odours and their taste is thus spoiled.

Their high nutritive qualities make eggs an excellent medium for the rapid multiplication of bacteria which putrefy the food contents. The sulphur compounds of the proteins give sulphuretted hydrogen on decomposition and it is this gas which gives the unpleasant smell to a rotten egg. Another cause which renders eggs unsuitable for human food is the partial growth of the embryo due to irregular collection or accidental incubation. Since the contents of the egg are enclosed in a mineral shell it is impossible to know by looking at it whether the egg is fresh or bad until the shell is broken, when it is sometimes only too obvious that

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things are not as they should be. Some simple method of testing the quality and freshness of a whole egg is obviously desirable, and two methods are in common use. These tests are the brine test and the candling test.

The brine test consists in placing the egg in a 10 per cent. salt solution (2 ounces of salt in 1 pint of water) in a tall jar, and is a simple and infallible test. A newly laid egg will sink in such a solution and lie flat at the bottom of the jar. An older egg will have lost weight by evaporation of water through its porous shell, and the consequent drying and shrinking of the contents will have enlarged the air chamber. As a result, the egg will become lighter and more buoyant with age. A two-day-old egg will float near the bottom of the solution with its broad end upwards. A three-day-old egg will float about half way up the solution, and one five days' old or more will float on the surface. Thus the older the egg the nearer the surface it will float. While it is not always possible to judge the age of an egg by this method, it is easy to decide whether an egg is fresh or not.

The candling test is dependent upon the transparency of eggs to light and not upon their buoyancy. It is a quicker method and more suitable for use in egg-packing stations than the brine test but requires skill and experience to obtain reliable results. The apparatus consists of a lamp surrounded by a metal shade bored with a hole. The egg to be tested is placed against the hole, slowly turned between finger and thumb, and the transparency of the egg observed. As the contents of the egg dry and shrink with age they become more and more opaque. For home use a simple form of candling lamp can be improvised by cutting a hole in a sheet of stiff cardboard, placing the egg against the hole and holding the cardboard up to some source of light. Alternatively, an electric bulb can be placed in a cardboard box and the egg placed on a hole in the lid. It is not sufficient merely to hold the egg near some source of light, since light can pass round the egg and obscure the test. Only light actually passing through the egg must reach the eye of the observer. When a new laid egg is tested by this method the white appears clear and homogeneous,

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the air chamber is small and the yolk is a rose-tinted circle in the middle of the egg. In an older egg the white appears cloudy, the air chamber is enlarged and the yolk is of a reddish tint. A rotten egg is opaque under this "X-ray" test.

We have already seen that the use of eggs in baking is chiefly as aerators and that the white of egg is the part which whips up into a froth and entangles air bubbles in its sticky glutinous substance. These air bubbles are retained in the cake or sponge mixture until they are baked and so make it light, i.e., aerate them. Many cheap *egg substitutes* are manufactured which simulate the aerating power of white of egg. These substitutes generally contain starch, bicarbonate of soda, tartaric acid and some glutinous substance such as gelatine. The mixture is given an egg-like appearance by the addition to it of some yellow colouring. The mixture is similar to baking powder and when mixed with water carbon dioxide is given off which is retained by the glutinous substance and the mixture beats up in a similar way to genuine egg. Such substitutes are, however, very much inferior to eggs as aerating and strengthening agents and are in no way comparable with eggs in food value. Their only merit is their cheapness.

Custard powders may be similar in composition to egg substitutes as given above, or may merely consist of cornflour, or other form of starch, coloured to resemble egg and flavoured, usually with vanilla. When mixed with a little cold milk to a paste, then stirred with boiling milk the custard powder sets on cooling owing to the formation of a thick starch paste. They do not compare in food value with genuine egg custard made from eggs and milk but have the merit of the milk used in their preparation.

The preservation of eggs is discussed in Chapter XIV.

In concluding this important chapter there is one other point about meat, fish and eggs which we wish to point out. These three foods contain little or no carbohydrates. It is for this reason that they are normally eaten with some food rich in starch, e.g., potatoes, bread and flour. In this way they are made more complete foods.

CHAPTER XII

BEVERAGES

We have already seen in Chapter V that nearly three-quarters of the body consists of water and that water is essential for the digestion and absorption of our food and for its transport throughout the body. We have seen, too, that water is continually being lost from the body through the skin in perspiration, the lungs as water vapour in expired air, the kidneys in urine and the bowels in faeces. This daily loss amounts to an average of about four and a quarter pints which must be made good. We may replace this lost water as drink, in foods, or by the water formed by the oxidation of foods in the body. It was stated on page 47 that the average amount of water required as drink is about two and a half pints. This includes, in addition to water itself, such fluids as tea, coffee, cocoa, mineral waters, alcoholic beverages and so on.

Water.

Water itself is the best and most natural drink and the finest thirst quencher. What little taste water possesses is due to the presence in it of dissolved oxygen and carbon dioxide and dissolved mineral salts such as calcium bicarbonate and calcium and magnesium sulphates. The effect of dissolved oxygen and carbon dioxide is easily realised when well-aerated water is contrasted with boiled water from which the dissolved gases have been expelled by heat. Of the dissolved mineral salts, the calcium bicarbonate of temporarily hard water gives a pleasanter taste than the calcium and magnesium sulphates of permanently hard water. Very soft water has less taste than harder water with its dissolved mineral salts and is more likely to dissolve small amounts of lead from lead piping and may thus be harmful to health. It may even taste acid or peaty if coming off moorland gathering grounds. Hard water supplies quite a useful amount of calcium to the diet.

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Natural Mineral Waters.

The waters from natural springs in many parts of the world, e.g., Apollinaris, Perrier, Seltzer and Vichy, contain comparatively large amounts of dissolved carbon dioxide and various mineral salts such as salt, bicarbonates of soda, lime and magnesia. In the past, exaggerated claims have been made for their medicinal value in the cure of gout, rheumatoid arthritis and other diseases. The Victorian cult of visiting various "spas" to "drink the waters" appears almost to have died out. Most of these waters are sparkling because of their carbon dioxide and slightly alkaline because of their dissolved carbonates. It is probably true to say that the carbon dioxide will stimulate the flow of gastric juice and the alkalinity will partly neutralise the acidity of gastric juice but not much more than that can be said of them.

Artificial Mineral Waters.

Artificial imitations of natural mineral waters can be purchased which consist of solutions of various carbonates in spring water or distilled water. For example, soda water contains a little bicarbonate of soda, magnesia water, magnesium carbonate, and seltzer water, common salt, bicarbonate of soda, magnesium carbonate and hydrochloric acid and is heavily charged with carbon dioxide. Much so-called "soda" water is merely water containing carbon dioxide dissolved under pressure. It is really "carbonated" water and contains no soda whatever.

Sweetened and flavoured mineral waters comprise lemonade, orangeade, "ginger beer", and so on. These consist of water sweetened with sugar, made tart, by the addition of an acid such as acetic, citric or phosphoric, flavoured to resemble the material after which they are named and finally charged with carbon dioxide under pressure to make them effervesce. It is unusual for them to contain the natural fruit acids, citric and tartaric, or the natural fruit flavourings. Genuine fermented ginger beer is an exception and does contain natural ginger and, as a result of fermentation, some alcohol too.

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Fruit Juices.

Juices expressed from fruits by specially designed machines and bottled and pasteurised are pleasant to drink and contain the sugar and acids of the original fruits as well as a small proportion of ascorbic acid. These are very different from the artificial lemonade, orangeade and so on and are definitely beneficial. Large amounts are drunk in the U.S.A. and their use in this country is increasing.

Tea.

Tea has been used as a beverage in China at least since 2,700 B.C. It was introduced into this country early in the Stuart period but it was not until 1660 that it came to the notice of Pepys.

Tea consists of the dried leaves of a shrub, *Camellia thea*, grown in China, India, Ceylon, Java and Japan. Originally all the tea in this country came from China but we now import most of our tea from India and Ceylon and very little from China.

The tea plant is a hardy evergreen which is kept down by severe pruning to a low shrub of convenient height for hand plucking. The leaves are plucked at intervals during the season. The size of the leaf varies according to age and position on the twig and determines the grade of tea. The smaller, younger leaves and buds at the top of the twigs are the finest grade and the larger, older, tougher leaves lower down the lowest grade.

The process of manufacture is briefly as follows: —

(1) *Withering.*

The leaves are spread on hessian mats for several hours until about half the water is dried out.

(2) *Rolling.*

The leaves are rolled by machine or hand to break open the cells to release the juice and bring about the twist in the leaves.

(3) *Fermentation.*

The rolled leaves are spread for several hours on cement tables

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with free access of cool air to ferment or oxidise. Oxidation of some of the tannin and development of the essential oils are responsible for the flavour. The colour of the leaves changes to a bright coppery shade during fermentation. Light fermentation gives flavour and pungency; longer fermentation gives strength and body. If fermented too long, tea becomes sour. Green tea is not fermented.

(4) *Firing.*

Fermentation is stopped by drying the leaves in currents of hot air.

Tea is generally imported into this country as "originals" or unblended tea and afterwards blended by professional tea tasters to suit the needs of various districts dependent mainly upon the hardness or softness of the local drinking water. Hard water tends to make a thin tea and soft water to make it more coloured.

Apart from a small amount of mineral salts and riboflavine, tea has little food value other than that of the cream or milk and sugar taken with it. The caffeine it contains is a mild nervous stimulant with no harmful after effects. It is speedily dissolved in boiling water. The tannin of tea is an astringent which exercises an inhibitory action on the intestinal tract, and coagulates protein and so checks digestion. Tannin is not readily soluble in boiling water but is extracted on standing and imparts a bitter flavour to tea. The essential oils of tea give it its aroma and pungency. China tea has the most delicate flavour, most caffeine and least tannin. Indian and Ceylon teas have more body, colour and tannin.

In the correct brewing of tea the maximum amount of caffeine and essential oil should be extracted and the minimum amount of tannin. This is best achieved by the following method:—

- (1) Pour hot water into the teapot and leave to stand until thoroughly hot.
- (2) Pour off this water and put in the tea, allowing two level teaspoons for each half-pint of water.

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- (3) Bring the water to the boil and pour *immediately* over the tea. Water which has been long boiled loses its dissolved gases and gives a flat, insipid tea.
- (4) Allow the tea to stand (infuse) for three to four minutes only. Stir well before pouring out. This length of time is sufficient to extract the caffeine and essential oils. Long infusion extracts the tannin and gives a bitter taste.
- (5) Serve at once.
- (6) If a second cup per person is required, pour fresh boiling water on the tea leaves and infuse again. This second brewing will be weaker and inferior in flavour.
- (7) The milk or cream should be poured into the cups before the tea. The milk helps to precipitate any tannin present.

Coffee.

Coffee was introduced into this country in 1652 and quickly became the vogue in "coffee houses". In most parts of the world, except the United Kingdom, coffee is the most popular beverage.

The coffee plant is an evergreen shrub grown in the moist tropics, chiefly Arabia, British East Africa, Abyssinia, India, Ceylon, Java, Jamaica and Brazil. The fruit or coffee cherry consists of an outer skin, a pulp, and a "stone" with a parchment skin enclosing two seeds ("beans" or "berries"). The stone is dried, the husk removed and the berries roasted before use. The roasting makes the berries brittle and easily ground, caramelises some of the sugar and develops aroma and flavour. As soon as roasted, the berries should be quickly cooled and afterwards kept in an air-tight container. Roasting should be done frequently, even daily, and preferably followed by immediate grinding. The aroma and flavour quickly disappear after grinding, particularly if the ground coffee is not kept enclosed, because of the very volatile character of the essential oils.

To make coffee in the home the simplest way is to use an earthenware jug with a lip for pouring and a lid. The method is as follows:—

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- (1) Warm the jug with boiling water. When thoroughly hot, pour out the water and put in at least one ounce of coffee for every pint of liquor required.
- (2) Pour in freshly boiling water and stir well with a wooden spoon.
- (3) Allow to infuse in a warm place for about ten minutes
- (4) Strain and serve very hot.
- (5) Milk, when used with coffee, should be hot but not boiling.

Alternative methods of making coffee involve the use of special drip coffee pots, vacuum coffee pots or coffee percolators. It is doubtful if the resulting coffee is in any way superior to, or even as good as, that produced in a jug by the method outlined above. In any case, the coffee drunk in this country seldom equals that made on the Continent. What is frequently called "coffee" in this country is really café-au-lait—hot milk flavoured with coffee.

Coffee contains a much smaller amount of caffeine than tea but more tannin. It acts upon the nervous system which it stimulates, so causing wakefulness. It may also have an aperient action by stimulating the muscles of the intestines, hence its place at the end of dinner.

Coffee is frequently adulterated with chicory which is the dried powdery root of the wild endive. Roasted chicory contains no caffeine but contains easily soluble colouring matters, including caramel.

Cocoa.

Cocoa first came to this country about 1650. It is obtained from a small evergreen tree, *Cacao theobroma*. The fruits resemble the marrow or cucumber and have a similar soft pulpy case in which the seeds are embedded. The seeds are removed from the fruit and roasted and the roasted seeds separated into two parts known as cocoa nibs. The nibs are ground between hot rollers to form a semi-liquid mass from which the greater part of the fat is extracted as cocoa butter. The remaining cocoa is run into

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moulds to cool and set as cocoa cake which is further ground and sifted to form cocoa powder.

The stimulant in cocoa is theobromine which is similar to the caffeine of tea and coffee but much milder in its action on the nervous system. In addition, cocoa contains some tannin, fat, starch, protein, B vitamins and mineral salts so that cocoa has some food value. The small amounts of cocoa used daily, however, do not make any significant addition to the diet. It is as a substance which makes palatable the drinking of hot water or milk that cocoa is justified as a beverage. Because of its mild stimulant and the food value of the added milk and sugar, it is the most suitable of the common beverages for children.

Cocoa is best made as follows:—

- (1) Allow two level teaspoons of cocoa for half a pint of milk or milk and water. Add sugar to taste.
- (2) Mix cocoa, sugar and some of the cold liquid to a smooth paste.
- (3) Boil the remaining liquid and pour into the cocoa and sugar.
- (4) Return the mixture to the pan and boil for one or two minutes before serving. This second boiling cooks the starch in the cocoa and greatly improves the flavour.

Although they are food-drinks rather than beverages, it is convenient to mention here such proprietary articles as Ovaltine and Bournvita which consist of malt extract, milk, eggs, and cocoa. They are highly nutritious and easily digested and particularly suitable for invalids, convalescents and children.

Alcoholic Beverages.

Alcoholic beverages are those which are made by the fermentation of glucose into alcohol and carbon dioxide together with small amounts of other by-products such as acids and esters which affect the flavour and body of the beverage. Different beverages are produced according to the foodstuff fermented by the yeast, e.g., wine from grapes, cider from apples and beer from malt.

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The amount of alcohol in such beverages depends mainly upon the amount of fermentable sugar present in the original foodstuff. The amounts of alcohol in spirits such as whisky, brandy, rum and gin are increased by distillation and in liqueurs the spirits are sweetened with sugar and flavoured with various herbs and fruit peels. Fortified wines such as port have spirit added to them.

Beers.

The starting point in the production of beer is the preparation of a "mash" of malt in water. Malt is made by soaking barley grains in water and then spreading them on the floor of a malt house and keeping them at a moderate temperature. Under these conditions the barley grains germinate and the diastase formed by the embryos transforms some of the starch of the endosperms into dextrins and maltose (malt sugar). The sprouted grains are then dried in a malt kiln. The dried malt is ground and a mash made of it with water. The dextrins and maltose and small amounts of other soluble substances from the malt pass into solution. The liquid or wort is strained from the malt, boiled with hops which have a flavouring and antiseptic action, cooled and then fermented by specially cultivated yeasts in large vats. After fermentation the yeast is skimmed off and the beer pumped into barrels. Slow fermentation continues in the barrels and the beer becomes aerated since the carbon dioxide formed is unable to escape.

Porter and stout are also made from malt and hops but the malt is first roasted in cylinders. This results in the conversion of some of the maltose into caramel and gives these beverages their darker colour and special flavour.

Beer, porter and stout contain from 3-6 per cent. alcohol, some dextrins and sugars, riboflavine and nicotinic acid. Consequently, these beverages have a certain amount of food value.

Wines.

In the preparation of wines the grapes are pressed either by their own weight, by treading or by putting them through wine presses. The grape juice, or "must", is poured into wooden vats

where it is allowed to ferment under the influence of the yeast cells present on the skins of the grapes. The fermentation stops when the alcohol reaches a maximum of about 16 per cent. because at this concentration the alcohol poisons the yeast cells. After fermentation, the wine is purified and casked.

For red wines the skins of the grapes are fermented along with the juice. For white wines the skins are removed before fermentation. Natural wines, e.g., claret, contain only as much alcohol as has been produced by fermentation from the sugar of the grape juice. Fortified wines, such as port, sherry and madeira, have spirit added to them. Champagne is a sparkling wine because it has been allowed to undergo a secondary fermentation in the bottle and is thus aerated with carbon dioxide. Cider and perry are prepared in a similar way to wines from apples and pears respectively. Home-made wines can be made by adding yeast to a syrup of fruit juice and sugar. The usual home-made wines are those of dandelion, damson, cherry, elderberry and blackberry. Natural wines contain roughly 10 per cent. alcohol and fortified wines some 20 per cent.

Spirits and Liqueurs.

Spirits are fermented liquids which have been distilled to increase the concentration of the alcohol and other volatile substances. Whisky is distilled from fermented barley malt mash or a fermented mash of barley, rye, maize and malt. Rum is distilled from fermented molasses or the fermented juice of sugar cane. Genuine brandy is distilled wine. Gin is distilled from a fermented mash of rye and malt afterwards flavoured with juniper berries. Liqueurs are spirits sweetened with cane sugar and flavoured with herbs and essences. Spirits contain about 40 per cent. alcohol and liqueurs about the same amount of alcohol with about 30 per cent. sugar in addition.

Uses of Alcoholic Beverages.

The use of alcoholic beverages has always been a much disputed question but we are not concerned here with the moral or economic aspects.

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The use of alcohol as a medicine has greatly decreased in recent years. Other drugs can produce the same results without harmful after effects. Alcohol is a narcotic drug and never a stimulant. It has a sedative action on different parts of the central nervous system and thus deadens pain and relieves worry and anxiety.

Alcohol is an energy food of limited value. It is more rapidly absorbed than any other food since it can pass directly through the walls of the stomach and intestines into the blood stream, but it is not quickly oxidised.

Alcohol dilates the surface blood vessels and so causes an extra flow of blood to the skin. This gives an illusory feeling of warmth but this is only temporary and is followed by an increased loss of heat so the final result is a chilling and not a warming.

Alcohol is quite unable to cure any disease, infectious or otherwise, or increase bodily strength, as is often supposed.

CHAPTER XIII

FLAVOURING AND COLOURING MATERIALS

Foods are frequently made more attractive in taste, flavour and appearance by the addition of a wide range of spices, herbs, condiments, flavouring and colouring agents. There is no doubt that the taste, flavour and appearance of foods have considerable influence upon appetite and the flow of digestive juices and consequently upon digestion. In this sense, the use of flavouring and colouring materials, in moderation, is beneficial.

Particular flavourings are associated with particular foods, e.g., mustard with roast beef, mint sauce with lamb, sage and onion with pork and fowl, lemon juice with fillets of fish, and vinegar with crab and oysters. Pepper and salt have a universal application in the kitchen and at the dining table. Sauces and chutneys are real assistants in the eating of cold and insipid meats. Incidentally, sauces, chutneys and salad creams, unlike the majority of flavouring materials, have appreciable food value. Sauces and chutneys contain fruit, vinegar and sugar, while salad creams contain fat, vinegar and egg yolk. Among individual flavouring materials, mint and parsley provide some vitamin C (ascorbic acid) while the onion and leek are regarded as foods as much as flavourings.

The aroma and taste of flowers, fruits, leaves and other parts of plants used as flavouring agents are due mainly to the essential oils they contain. These essential oils must be distinguished from mineral oils, such as paraffin, on the one hand, and food oils, such as olive oil, on the other. Generally, essential oils are colourless liquids when pure and have strong odours and tastes. They are very volatile and some of them are easily destroyed by exposure to air. Consequently, extracts of essential oils used as flavourings should be kept in well stoppered bottles to prevent loss by evaporation and loss of flavour by oxidation. Essential oils are not usually soluble in water but dissolve easily in alcohol. Flavouring essences or extracts are solutions of essential oils in alcohol.

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Spices and condiments are now much less important and used in much smaller quantities than in Mediæval times or even fifty years ago. In the Middle Ages pastures were poor and root crops for the winter feeding of farm animals unknown. With the approach of winter the greater part of the herd had to be slaughtered and the only method of preservation was by salting. By the end of the winter the meat was tough and unpalatable or even repulsive because of decay. The use of large quantities of spices, herbs and condiments was essential to give some variety to the monotonous salty flavour or to hide the unpleasant taste and flavour of half-rotten meat. Even fifty years ago the housewife's equipment included a comprehensive range of spices. Spices were the grocers' most important wares. In France the grocer is still called "l'épicier"—the spice dealer. Not only were spices and herbs used as flavourings but also as ingredients of medicines, salves and ointments. Nowadays, instead of being necessities, spices and herbs have become merely pleasant adjuncts to foods.

Spices.

Spices were probably first brought to Europe by Arab merchants and Arabia was regarded as the home of spices although, in actual fact, most of them came from Southern India and the Moluccas, or Spice Islands. During the Middle Ages most of the spice trade was carried out by the Venetians and the glories of Venice and its empire of the seas were built upon it. By the end of the fifteenth century the trade had passed to the Portuguese. It is sometimes suggested that the voyages of Vasco da Gama and Columbus were originally planned to discover new routes to the spice islands of the East. From the Portuguese the spice trade passed to the Dutch and their East Indies Empire. To-day, most of the tropical and sub-tropical spice-producing countries and islands, such as India, Ceylon, Jamaica, British East and West Africa, Zanzibar, Grenada and Straits Settlement are all in the British Commonwealth.

Spices can be classified according to the parts of plants from which they are derived, e.g.:—

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- (a) *Fruit Spices.*
Pepper, capsicums, chillies, paprika, pimento, vanilla.
- (b) *Seed Spices.*
Mustard, mace, nutmeg, cardamom, fenugreek, caraway and coriander.
- (c) *Flower Spices.*
Cloves, saffron, capers.
- (d) *Bark Spices.*
Cinnamon, cassia.
- (e) *Root Spices.*
Ginger, turmeric.

FRUIT SPICES.

Pepper is the most important of the spices and has the widest use. Whole black pepper is the unripe fruit or berry of a tropical perennial creeper or vine. White pepper is a product of the same plant with the seeds in a riper state and with the outside skin removed. Peppers are grown chiefly in the Isle of Banka and Java. Singapore and Sarawak are the chief places from which pepper is exported.

The bulk of domestic pepper is in the form of ground pepper. For table use, white pepper is usually preferred because of its appearance when sprinkled on food but for kitchen use black pepper has the advantage in aroma and pungency. The aroma and pungency of pepper are due to an essential oil which stimulates the flow of saliva and gastric juice.

Capsicums and chillies are the fruits of various tropical perennials. The fruits vary considerably in shape, size, colour and taste. The large fruits are the capsicums and the small ones the chillies. Chillies are much the more pungent. Both types are widely grown in tropical countries. Capsicums are exported mainly from India and chillies from Japan and Nigeria. The main use of capsicums and chillies is in pickling spices.

Cayenne pepper is the name given to ground capsicums and chillies. Its colour varies from a bright red to a yellowish brown,

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according to the varieties and qualities of capsicums and chillies used in its preparation. It is not a substitute for ground black or white pepper. Its flavour is quite different. Because of its pungency, cayenne pepper is a common constituent of curry powders, chutneys, sauces, pickles and savouries.

Paprika or Hungarian pepper is the red pepper made from the dried ripe fruit of a capsicum grown in Hungary and Spain. It has only a slight pungency and is mainly valuable as a colouring and garnishing in gravies, stews, hashes, ketchups and sauces.

Pimento or Allspice is the dried unripe fruit of a tropical evergreen myrtle grown in the West Indies. The berries are nearly globular in shape and of a light brown colour. The alternative name of allspice is derived from the supposed resemblance of its flavour to a mixture of cinnamon, nutmeg, and cloves. It is also sometimes called Jamaica pepper. Pimento is much used, either whole or ground, in mixed spice, pickles, sauces, sausages and potted meats.

SEED SPICES.

Mustard is made by grinding the seeds of the black mustard and white mustard plants. In this country we use a mixture of the two types along with turmeric to give colour and wheat flour to absorb the essential oils and retard fermentation. White mustard seed is grown in East Anglia and is three times the size of the black seed but has less pungency and aroma. When mixed with cold water, vinegar or oil, the enzymes in the ground mustard flour produce the volatile mustard oil with its pungent smell and taste. The use of hot water or milk would destroy the enzymes and result in a mustard lacking in flavour. Mustard flour is used as a table condiment with cold meats. It assists digestion by promoting the flow of digestive juices. Whole mustard seeds are used in pickles and chutneys.

Mace and Nutmeg are both derived from the fruit of the nutmeg tree grown extensively in the East and West Indies. The fruit resembles an apricot. Mace is the finely ground dried red husk

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surrounding the kernel and is used in the kitchen for flavouring. The nutmeg is the kernel itself and is used as a garnishing and flavouring in custards and jurets.

Cardamoms are the small dark brown seeds of the cardamom plant grown in Ceylon, India, Java and Jamaica. The seeds are rich in an essential oil and are used for flavouring soups, sauces and cordials or "soft drinks."

Fenugreek consists of small yellowish-brown seeds of a plant grown chiefly in Morocco and Tunis. It is a common ingredient of curry powders to which it imparts colour, aroma and flavour.

Coriander is the globular seed of a plant grown extensively in India and French Morocco. When ripe the seeds are very fragrant and have a pleasant, warm, pungent taste. They are important ingredients in curry powders, mixed spice and fancy breads and confectionery.

Caraway is the aromatic seed of a plant grown in Holland and other European countries. Caraway seeds are used in flavouring cakes and baked fruits.

Celery Seed is the seed of the celery plant grown in this country. It is useful as a flavouring when celery is out of season.

FLOWER SPICES.

Cloves are the dried unopened flower buds of a tropical evergreen tree grown chiefly in the Moluccas Islands, the Amboyna Islands, Zanzibar and Madagascar. They are strongly aromatic, with a very characteristic odour and hot taste. Cloves are used in stews, steamed puddings, pickles, chutneys, and baked or stewed apples.

Saffron consists of the dried stigmas and tops of the styles of the saffron crocus which is grown chiefly in Spain. The town of Saffron Waldron in Essex is supposed to have derived its name from the fact that the saffron crocus was grown there in large quantities in the sixteenth century. Saffron has a very characteristic odour and a rather bitter taste. It is used in the saffron cakes popular in Cornwall and the West Country.

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Capers are the flower buds of a tropical creeping shrub which are pickled in salt and vinegar and then dried. They are used in pickling spices and sauces.

BARK SPICES.

Cinnamon is the product of an evergreen aromatic laurel which grows wild and is cultivated in Ceylon. The Chinese, who discovered it when trading with Ceylon in the thirteenth century, found it was superior to their own cassia. The Portuguese occupied the island for the sake of its cinnamon after their discovery of the route via the Cape of Good Hope at the end of the fifteenth century. The Dutch captured the island in the seventeenth century and began the cultivation of the cinnamon tree. The island later became part of the British Commonwealth.

The cultivated trees are kept as shrubs by severe pruning. After cutting the shoots, the twigs and leaves are removed and the bark slit down on both sides. The bark is then carefully removed, left for a few days to ferment and dry and finally cut into quills.

Cinnamon is one of the most pleasant flavouring spices and is excellent for flavouring cakes and puddings as well as pickles and chutneys.

Cassia, like cinnamon, is the product of an evergreen aromatic laurel. It is grown chiefly in China and is cheaper than cinnamon but inferior in flavour. Cassia is largely used in mixed spice.

ROOT SPICES.

Ginger was one of the earliest oriental spices to be brought to Europe. It appears to have been used in China and India as a spice and medicine from the very earliest times. Its cultivation in Jamaica was started by the Spaniards in the sixteenth century. Jamaica still grows the finest ginger.

Ginger is prepared from the underground stem or rhizome of a tropical herbaceous perennial. The rhizomes are dug up, carefully peeled and dried. The dried rhizomes can be ground to a

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powder or preserved in syrup. Ginger is used by mineral water manufacturers and by the housewife as a flavouring.

Turmeric or Indian Saffron is obtained from the rhizome of a plant similar to the ginger plant. It is grown chiefly in India. The dried powdered rhizome is not very aromatic but, because of its rich yellow colour, is used to colour curry powder and mustard pickles. Its acrid taste makes it unsuitable for use in cakes.

Curry Powder is a mixture of ground spices such as coriander, turmeric, ginger, pepper, cardamoms, chillies, pimento, fenugreek and nutmeg. In this country it is used chiefly in mulligatawny soup and stews.

Herbs.

The sweet herbs used in the kitchen are the dried parts of plants—leaves, roots, fruits and seeds—which, because of the pungency and fragrance of their essential oils, give flavour to soups, stews, salads and so on.

Most of the herbs are native to the dry sunny soils of the Mediterranean countries. They were introduced to this country first by the Romans and later by the various orders of monks. Herb gardens were a characteristic feature of monasteries in Mediæval times. The only vegetables grown were onions and leeks and these were used as flavourings rather than as foods. Herbs, like the more pungent oriental spices, were used to mask the flavour of the salted meat in stuffings and stews.

The herbs used included balm, basil, sage, marjoram, rosemary, mint, thyme, parsley, dill, fennel, angelica, aniseed, rue, borage, sweet bay, chevril, chive, garlic, horse-radish and tarragon. Those most commonly used today are parsley, mint, sage and thyme.

Parsley is grown largely for its leaves, which serve as garnishing and flavouring. It can be used fresh or dried and powdered.

Mint is made into sauce or jelly and eaten with lamb which it makes more digestible by stimulating the digestive glands. A few

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sprigs added to the water in which potatoes, peas or carrots are being boiled, improve their flavour.

Sage leaves are used as flavouring and seasoning in soups and in stuffings with onion for ducks, geese and pork.

Thyme is the cultivated form of the wild thyme of the Mediterranean coast and is used in stuffings and salad dressings.

Common Salt.

Although used in very large quantities as a condiment, salt is quite different in character from the spices and herbs. Unlike them, it is a mineral salt and is an essential food since it is a constituent of the blood. The hydrochloric acid of gastric juice is formed from it.

Most of the salt used in this country is obtained from Cheshire where it is pumped up out of bore holes in the form of brine which is evaporated until the salt crystallises out. In hot countries salt is prepared by the evaporation of sea water in shallow ponds or salterns. In very cold countries the tide is trapped in shallow lagoons and allowed to freeze. The ice formed contains no salt and consequently the liquid below the ice contains an increased amount. This "concentrated" sea water is evaporated in pans over fires.

Even in this country during the Middle Ages salt was largely obtained by the evaporation of sea water run into shallow salterns. Traces of these may still be found in the neighbourhood of Portsmouth, Lymington and Poole. From the centres of this sea-salt industry and from the naturally-occurring brine springs at Droitwich and Northwich, ancient tracks, the saltways, carried a considerable traffic in salt throughout the country. In those days, as we have seen, salt had a very extensive use as a preservative of meat, fowl and fish.

Besides its use at the table for adding flavour to under-seasoned food, salt has many uses in the kitchen. It is used as a preservative, either as dry salt or as brine (page 178). The addition of salt to the water in which fish or vegetables are cooked helps to

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prevent the loss of their natural mineral salts and so preserves their flavour. Salt is used in breadmaking as a flavouring and also to strengthen the gluten and moderate the fermentation.

Some brands of table salt have a little rice powder or sodium phosphate added to them to prevent impurities in the salt absorbing moisture from the air and so becoming damp or caking in lumps. Iodised table salts have small amounts of iodine compounds added to them. They are recommended for use in districts where the drinking water and vegetables are deficient in iodine and goitre is consequently prevalent (page 44).

Vinegar.

Vinegar, or "sour wine," is formed when light alcoholic beverages such as weak wines, cider and ale are left exposed to the air. The alcohol they contain is oxidised to acetic acid by acetic acid bacteria. The alcoholic taste is changed to the sharp sour taste of vinegar. Strong alcoholic beverages such as port wine and whisky cannot be fermented to vinegar by these bacteria.

Genuine vinegars are made from poor quality wine, cider or malt liquor by fermentation with acetic acid bacteria. In this country, malt liquor is mainly used. The malt liquor is first fermented by yeast to convert the glucose of the malt into alcohol and then fermented by acetic acid bacteria to convert the alcohol into acetic acid and so produce malt vinegar.

Cheap artificial vinegars are made by diluting industrial acetic acid with water and adding a little caramel to colour it. Such vinegars have a harshness and pungency lacking in fermented vinegars.

The sharp sour flavour of vinegar makes it a useful condiment with fish, crabs, oysters and salads. The acetic acid of vinegar acts as a preservative in pickles and chutneys.

Flavouring Essences or Extracts.

Genuine fruit essences or extracts are solutions in alcohol of the essential oils and esters of fruits which flavour any confectionery

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in which they are used. With a few exceptions, such as vanilla, lemon, orange and almond, it is impossible to extract the distinctive flavours from fruits in sufficient quantity and of sufficient strength for flavouring purposes. For this reason the majority of fruit essences are artificial products prepared by mixing artificial essential oils and esters with alcohol. The aroma and flavour of such artificial essences are seldom as delicate or as fragrant as the natural product they attempt to imitate. Occasionally, an artificial essence contains only a single substance dissolved in alcohol, e.g., amyl acetate (pear drops), but more usually several substances are used in varying proportions before a close approximation to the natural product is achieved.

In certain cases, better results are obtained by using the actual source of the flavouring rather than the essence. Thus finely cut orange and lemon peels mixed in cakes give a superior flavour to that obtained with the essences.

VANILLA ESSENCE.

The flavour of vanilla is due to a substance called vanillin. The vanilla pods from which the vanillin is extracted are the fruits of a tropical climbing orchid. The pods or beans, which are greenish-yellow in colour when gathered before they are fully ripe, are allowed to ferment. The flavouring material, vanillin, is formed in the beans and appears as white crystals on the outside of the beans. After drying in the sun, the beans have a dark brown wrinkled surface and a waxy feel. They are about eight inches long and about one-quarter of an inch thick in the middle. They are tied into bundles for export.

The pods may be crushed to a powder and mixed with nine times their weight of castor sugar and used in this dry form, or the pods may be broken into small pieces and steeped in alcohol for several months to form vanilla essence.

Artificial vanilla essence is prepared by dissolving synthetic vanillin in alcohol. It is inferior to the natural product.

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LEMON AND ORANGE ESSENCES.

The essential oils of these two citrus fruits occur in small glands in the rinds from which they are extracted by pressure. On the large scale, screw presses are used but the finest quality oils are produced by hand. One hand method is the sponge and bowl process in which the peel is cut into halves and the oil expressed by turning them inside out and then wiping off the oil with a sponge and squeezing the sponge in a bowl. In another hand process the rind is rotated rapidly in a round metal bowl studded with sharp spikes which burst the glands containing the oil. The extracted oil collects in a receptacle at the bottom of the bowl.

These oils are produced mainly in Sicily and Southern Italy and, more recently, in California. They are pale yellow in colour with characteristic aromas and bitter aromatic tastes. The extracts or essences are prepared by diluting the oils with alcohol.

ALMOND ESSENCE.

There are two types of almonds—sweet almonds and bitter almonds. Sweet almonds are used, either whole or ground, for marzipan, almond paste and dessert. It is the bitter almond whose kernel is used for the extraction of almond oil. The essential oil of bitter almonds is benzaldehyde and artificial almond essence is simply a solution of artificial benzaldehyde in alcohol.

Before concluding this section we ought to point out that although sugar is a valuable energy food and is commonly regarded as such, it is, nevertheless, the most widely used of all flavouring agents. Like the others, when used in moderation, it stimulates the appetite and the flow of digestive juices.

Colouring Materials.

Not only are foods made more palatable to the taste by the use of flavouring materials but their appearance is sometimes made more pleasing to the eye by the addition of colouring materials. The colours used are natural animal or vegetable products such as cochineal, turmeric and annatto, and artificial coal-tar dyes such as are used in textile dyeing. Of the two types the artificial dyes, on

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account of their very wide range in colour, are the more important. We shall confine ourselves to the natural dyes except to say that artificial dyes which are poisonous are prohibited in foods by Public Health Regulations.

COCHINEAL OR CARMINE.

Cochineal is prepared from the female insect (*coccina*) which feeds upon a variety of cactus native to Mexico and Peru and cultivated in Guatemala and the Canary Islands. The female insects are collected and killed by dropping them into hot water and then dried in the sun. Alternatively, the insects may be placed in bags and dried in stoves without previously killing in hot water. The essential colouring matter in cochineal is carminic acid.

ANNATTO.

Annatto is prepared from the fermented seeds of a tropical plant cultivated in the West Indies and Ceylon. The dye is sold as an orange paste and is used in colouring butter, margarine and cheese.

Turmeric and Saffron which are used as both flavouring and colouring materials have already been described.

PART THREE

CHAPTER XIV

THE PRESERVATION OF FOODS

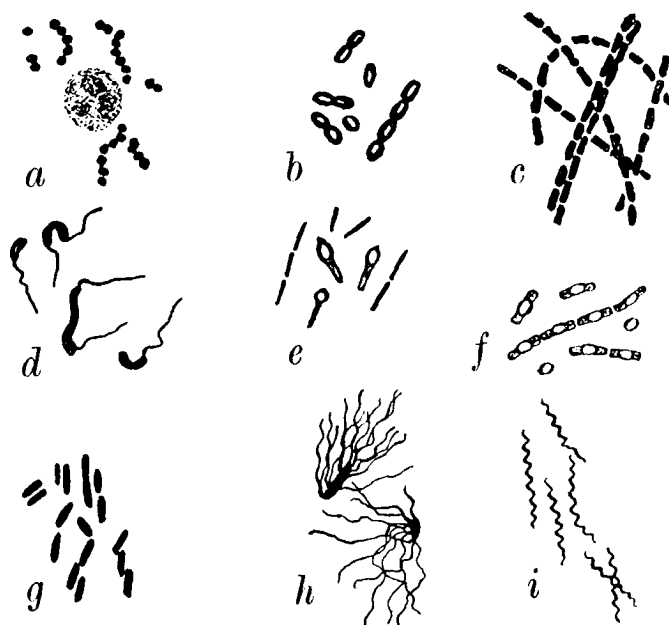
No food will keep indefinitely in its natural form. All natural foods are "alive" and, like all other living materials, are subject to processes of deterioration and decay. These gradual changes in fresh foods are due, in the first place, to substances known as enzymes in the living protoplasm of the foods themselves and secondly, to enzymes formed by minute living organisms which get into the foods from outside. Meat, fish and eggs go putrid, fats go rancid, milk goes sour, fruits go mouldy or ferment, vegetables wilt and rot, cereals go musty or germinate, because of the action of enzymes. All natural foods are slowly and continually changing in character and composition. Their appearance, smell, flavour and food value are gradually being altered. The preservation of food consists in the stopping or slowing down of these changes.

These changes are not always harmful or undesirable. We have seen that cream is "ripened" before it is churned into butter, that cheese is allowed to "ripen" to develop flavour, and that meat is "hung" to make it more digestible. But there comes a stage in the decay of most foods when they become obnoxious or harmful and even, in some cases, poisonous.

It is obviously desirable to eat fresh foods whenever we can but this is not always possible. Such a large proportion of the world's population lives in large towns and cities away from farms and gardens that food has to be transported great distances and kept in good condition for long periods. Some countries produce more food than they can consume themselves while every country produces surpluses of such foods as fruits, vegetables and eggs at certain seasons of the year. Modern civilisation could not exist without the use of preserved foods. But for the use of methods of preservation much of the world's food would be wasted and our diets would be much less varied than they are. Preserved foods usually require less preparation and less cooking than raw fresh foods and so have the merit of convenience. Their flavours are

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frequently altered but there is little loss of food value except for some loss of vitamins, particularly ascorbic acid and the B vitamins. Provided this is realised and fresh foods eaten to make up for this loss there is no harm in the increased use of preserved foods.



By courtesy of Cambridge University Press.

FIG. 47. Bacteria. a, Streptococci from pus (showing a blood corpuscle); b, *Pneumococcus* (pneumonia); c, *Bacillus anthracis* (anthrax) showing bacilli in chains; f, *B. anthracis* showing the formation of a single spore inside each bacterial cell; d, cholera spirillum showing flagellate cells; e, *Clostridium tetani* (tetanus) showing cells with and without spores; g, h, *Bacillus typhosus* (typhoid) with and without flagella; i, *Spirochaeta pallida*—a protozoon.

The minute living organisms which attack foods are simple forms of plant life. They are of three types:—bacteria, yeasts, and moulds. To understand how food is preserved we must know something about the needs and habits of these organisms.

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Bacteria.

Bacteria are minute plants consisting of single cells of great diversity of shape. They are the simplest and smallest of all living things. Bacteria increase by the simplest method of reproduction, that of division. The cell divides into two and each part grows until it is mature and then divides again in a similar way. Under suitable conditions bacteria can multiply very rapidly indeed. Under unfavourable conditions the bacteria cell changes into a spore which is much more resistant and more difficult to destroy.

Bacteria require suitable food, ample moisture, warmth and oxygen. (Some bacteria can live without oxygen.) Acids, low temperatures and strong solutions of sugar and salt prevent their growth while very high temperatures destroy them outright.

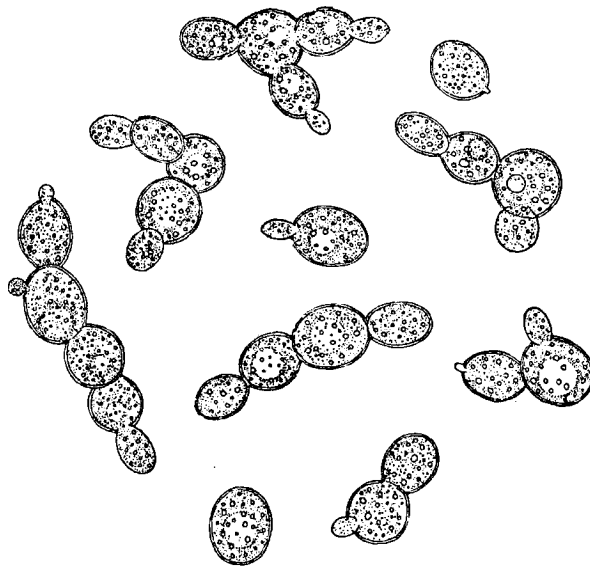


FIG. 48. Yeast Cells and Budding.

Yeasts.

Like bacteria, these are small single-celled plants. They are oval in shape and measure about 1/2000th part of an inch across,

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which is much bigger than most bacteria. The cells consist of protoplasm with a denser part in the middle called the nucleus. They multiply by the process of budding. A small bud appears on the side of the yeast cell, grows larger and eventually splits off as an independent yeast cell. Yeast cells can change to resistant spores under unfavourable conditions in a similar way to bacteria.

Yeasts need less moisture than bacteria and can tolerate a greater degree of acidity and a higher concentration of sugar. They flourish in dilute sugar solutions and ferment sugar syrups, jam and fruit juices. Heat and cold affect yeasts in the same way as they affect bacteria.

Moulds

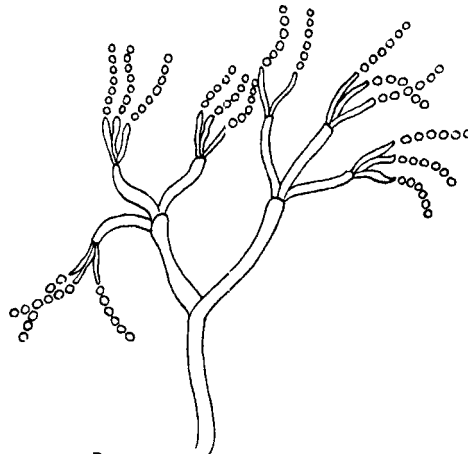
Moulds are simple plants consisting of a network of branching threads which spread in all directions through the food. The threads are known as hyphae and the tangled mass as a mycelium. Here and there the hyphae develop stalks, known as filaments, which rise above the food and develop thousands of minute spores corresponding to the seeds of higher forms of plant life. In the group of moulds known as *Penicillium*, the spores are developed in chains from the tips of branched hyphae. In the genus *Aspergillus* the spores are developed in chains which radiate from the swollen tip of a hypha. In the genus *Mucor*, a large number of spores are produced in a spore case which is developed at the tip of a hypha. By means of spores, moulds are spread over the food or are carried in the dust of the air to other foods.

Moulds require less moisture than either bacteria or yeasts and are not as much affected by acids, sugar and salt.

Thus we see that, for their growth, bacteria, yeasts and moulds require moisture, oxygen, suitable temperature and suitable food. They are affected by high concentrations of acids, sugar and salt. The various methods of preservation of foods consist in the destruction of the micro-organisms they contain, the removal of one or more of the conditions necessary for their growth, or the addition of sugar, salt or acids to make the foods unsuitable for them.

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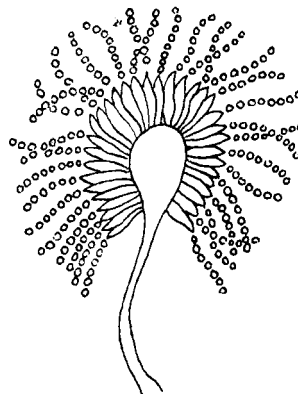
It so happens that the methods of destroying or checking the growth of micro-organisms in foods also destroy or check the enzymes of the foods themselves.



Penicillium



Mucor



Aspergillus

FIG. 49.

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The chief methods of preservation are thus:—

- (1) *By drying* (removal of the necessary water).
- (2) *By cold* (micro-organisms require warmth if they are to grow).
- (3) *By heat* (yeasts and moulds are easily destroyed at 150° F., bacteria at 160-180° F., while spores require higher temperatures and longer heating).
- (4) *By the addition of sugar, salt, acids or chemical preservatives* (e.g., jam, bacon and pickled onions).

Preservation by Drying or Dehydration.

This is one of the oldest, simplest and most effective methods of preserving foods. Micro-organisms cannot grow in dried foods and enzyme action is completely stopped. In addition, drying concentrates the soluble ingredients in foods and this high concentration prevents the growth of bacteria, yeasts and moulds. The concentration of sugars in dried fruits is a good example of this action. Dried foods quickly deteriorate if allowed to become moist again.

MEAT.

Dried meat is not much used in this country but beef has been dried by the natives of North America, South America and South Africa for centuries, where it is known respectively as pemmican, charqui and biltong. Dried beef has been used in recent times by Polar explorers and by soldiers as part of their "iron ration". Such meat not only keeps well but occupies very little space compared with fresh meat or meat preserved by other methods.

The meat is sliced and cooked until brown in the minimum amount of water. It is then minced and spread on trays and dried in a current of warm air. Finally, it is packed in air-tight tins with nitrogen in place of air to prevent oxidation of the fat. Except for some loss of vitamin B (thiamine) its nutritive value is similar to that of fresh beef.

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FISH.

Fish is still sun-dried, as it has been for centuries, in the Scandinavian countries, Canada, Newfoundland, India and all round the Mediterranean coasts. In this country, fish is roller dried like milk and eggs. Alternatively, it is filleted, minced and cooked for 30 minutes, then spread on trays and dehydrated in a current of warm air. Herrings are the fish most frequently dried here because, although the herring fishing season only lasts 20 weeks, such vast quantities are caught they cannot all be eaten fresh. The dehydrated herring is in the form of crumbly grey-brown pellets which can be reconstituted with milk, water, or water and vinegar for use in fish cakes and sandwich fillings.

EGGS.

Liquid eggs can be dried by the roller process or the spray process used for drying milk (p. 124). The same precautions must be taken to prevent the coagulation of the proteins by keeping the temperature below coagulation point. Otherwise the dried egg will not reconstitute properly when mixed with water. Even then there is some denaturing of the proteins and dried eggs are not as good aerating agents as the same amount of fresh eggs. The addition of sugar to the liquid egg before drying gives the reconstituted egg improved aerating qualities. Except for some loss of thiamine there is little alteration of food value. Dried egg keeps well, particularly if sealed in air-tight containers with nitrogen in place of air to prevent oxidation of the fat. It is easily transported and convenient in use. Dried egg has occasionally been found to contain Salmonella bacteria (p. 190).

MILK.

The drying of milk by the roller process and the spray process has already been described (p. 124).

FRUITS.

Fruits have been dried from time immemorial and are, at the present time, the most popular of all dried foods. The old method, which is still used in hot countries, is to dry the fruit in the sun

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on fibre mats spread out on the ground. In England artificial heat is necessary and, on a commercial scale, is carried out by means of a current of warm air. On the small scale, in the home, fruits may be dried by placing them in a moderately warm oven on wire trays or wooden frames covered with muslin or cheese cloth. Most, however, of our dried fruits are imported from foreign countries in which they are sun dried. They include currants, sultanas, raisins, apples, pears, apricots, prunes, dates and figs.

Currants, sultanas and raisins are produced from special varieties of grapes grown for the purpose. Apples and pears are peeled, cored and cut into discs before drying. Apricots have their stones removed. Prunes are dried plums.

Because of the concentration of their sugars due to the removal of water, dried fruits such as currants, sultanas, raisins, dates and figs are valuable energy foods. Dried apples, pears, apricots and prunes are reconstituted by soaking in water before cooking and then closely resemble the original fresh fruits in flavour and food value except for the loss of ascorbic acid.

VEGETABLES.

Green leafy vegetables, such as cabbage, are first shredded and then "blanched" by dipping them into water containing sulphite (sulphur dioxide) and then scalding them in steam. This treatment destroys the enzymes which decompose ascorbic acid and also helps to prevent the cabbage becoming discoloured during dehydration. Without this preliminary treatment there is considerable loss of ascorbic acid and much discolouration. The cabbage is then spread on trays and quickly dried at 200° F. until it contains only 5 per cent. water. It is packed in sealed cans to prevent absorption of moisture from the air and if it is to be stored for a long time should have the air in the tin replaced by nitrogen.

Carrots are dehydrated in a similar way and there is little loss of the valuable carotene they contain. Dried carrot, however, develops a smell of violets, due to oxidation of carotene, if exposed to the air for any length of time. For this reason it must be packed in sealed tins filled with nitrogen.

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Potatoes can be sliced, "blanched" and dried in the same way as cabbage and carrots and it is claimed that 50 per cent. of the original ascorbic acid is retained. Another method is to cook and mash the potatoes before drying. The dried powder is granulated and consists of unbroken starch cells which reconstitute with water to give an excellent mash. If the starch cells were burst, then a sticky paste would be formed with water.

Herbs can be preserved by washing, tying in bundles, covering with a piece of muslin to keep out dust and hanging up to dry. Those with large leaves may have the leaves plucked from the stalks, blanched in boiling water and dried in a cool oven until crisp. They may then be crushed to a powder and stored in tins or sealed jars.

CEREALS AND PULSES.

Cereals and pulses are already dried by nature. They are dried plants in miniature with a dried food supply which they can only convert into soluble forms when they obtain the necessary water and begin to germinate. The preservation of cereals and pulses, and the meals and flours made from them, is merely a matter of keeping them dry.

Preservation by Cold.

Although it has been known for a long time that the deterioration of foods can be delayed by low temperatures it is only within the last seventy years or so that widespread use of this principle has been possible following the invention of the refrigerator. Refrigeration is applied to foods either to chill them or actually to freeze them. In chilling, the food is kept at a temperature just above freezing point and is used with foods which do not recover their natural state after thawing.

Refrigeration is only a temporary method of preservation. Micro-organisms are not destroyed by subjecting them to even very low temperatures. They are merely held in check and prevented from multiplying. The bacteria, yeasts and moulds are

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liable to become active and set up decomposition when the food is thawed out and restored to normal temperatures.

MEAT.

Mutton and lamb can be frozen solid and this is the usual method of preservation for this type of meat. It has made possible the shipping of thousands of tons of mutton and lamb to this country from Australia and New Zealand.

Freezing is not suitable for the larger carcasses of beef. Beef carcasses take longer to freeze than do those of mutton and lamb. In consequence the crystals of ice formed in the fibres of the beef are sufficiently large to burst them open. When thawed, such meat is wet, loses a good deal of juice as "drip" and is altered in texture.

By means of chilling it has been possible to import beef from Argentina—a journey of about three weeks. The journey from Australia—about six weeks—is too long for beef which has simply been chilled. By pumping carbon dioxide, to a concentration of 10 per cent., into the refrigerated holds of the ships, the activity of micro-organisms is further retarded and by this "gas storage" beef can now be imported from Australia.

FISH.

Fish is a more delicate flesh than beef or mutton and, unless quickly frozen at a very low temperature so that very small ice crystals are formed, is liable to be spoilt in texture on thawing and cooking. By freezing fish in brine a temperature of 20 degrees below freezing point is reached. This is sometimes done on the fishing trawlers themselves.

For the transport of fish from the big fishing ports such as Hull, Grimsby, Fleetwood and Aberdeen, fish is placed in boxes with ice and salt and carried to all parts of the country by express fish trains in vans containing solid carbon dioxide (dry ice).

Herrings have recently been "quick-frozen" by the "Birds-eye method" in which they are packed ungutted into trays, placed between cold plates and there frozen solid. In this form they

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are packed in special cartons and placed in cold store. In another method, known as the "airblast method", the herrings are packed ungutted and then passed into a tunnel through which currents of cold air blast the fish until they are frozen and then stored at -25° F.

In both methods there is the shortest possible time between landing the fish and processing it so that decay and bacterial growth are reduced to a minimum.

EGGS.

Freezing is not a suitable method for preserving shell eggs, the shell is apt to break and the membrane surrounding the yolk to burst. Consequently imported shell eggs are chilled instead of frozen. In addition, the humidity of the air is carefully regulated to prevent mould growths. Alternatively, the eggs are stored in a high concentration of carbon dioxide which prevents mould growth and bacterial development. This latter method is known as "gas storage". Canned liquid eggs can be frozen. Such eggs are used by confectioners for baking.

MILK.

There is not much large scale use made of freezing or chilling as methods of preserving milk. It is possible, however, to serve fresh milk on board ship by storing it at 32° F. Milk will keep fresh for long periods in a home refrigerator. Butter and cheese can also be chilled but both must be wrapped to exclude air and prevent the growth of moulds and oxidation of the fat.

FRUITS.

The preservation of fruit during transport and storage is governed by the fact that the fruit is a living organism and as such is constantly changing. These changes can be slowed down by low temperatures but great care has to be taken not to cause unpleasant flavours, loss of colour and rupture of the cells which allows juice to be lost and the fruit to become soft.

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Freezing in syrup prevents browning during storage provided the fruit is completely immersed. Raspberries, gooseberries and red currants can be successfully frozen in this way. Plums and cherries are liable to discolour when thawed out after being frozen in syrup.

Many fruits are chilled but certain precautions must be taken not to over-chill so as not to damage or kill the fruit. Apples, for example, must be wrapped in oiled paper to prevent the disease known as "scald". Different fruits, and even different varieties of the same fruit, must be chilled to different temperatures. Some fruits, such as tomatoes and bananas, are picked green and allowed to ripen during the journey and in warehouses on arrival.

The use of gas storage along with chilling delays the ripening of fruit still further and is being increasingly used for home-grown fruit. The concentration of carbon dioxide used is round about 5 per cent.

In the modern "frozen pack", "frosted food", or "Birdseye method", the fruit is placed in containers, covered with syrup and frozen quickly at -30 to -40° F., and stored between 0° F. and -10° F. This quick-freezing process is particularly suitable for strawberries, raspberries, gooseberries and currants.

VEGETABLES.

Asparagus, green peas, runner beans and broad beans have been successfully preserved by the quick-freeze method. They are first scalded to prevent enzyme actions which go on in raw vegetables even at low temperatures and then quickly frozen at -30° to -40° F. and stored at 0° to -10° F.

Preservation by Heat.

Bacteria, yeasts and moulds are all destroyed by heat and so are the natural enzymes of food. A temperature of 150° F. is sufficient to kill the cell forms of the micro-organisms but greater heat (260° F.) is necessary to destroy their spores. By destroying micro-organisms and enzymes in food by heat and then placing

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it in a sealed container to prevent the access of air and other micro-organisms the food should keep indefinitely. This is the principle underlying the canning and bottling of foods.

This method of preservation was invented by a French chef, Nicolas Appert, in 1810, as a result of the offer of a prize by the French Government, for improved methods of preserving foods during the Napoleonic Wars. It is interesting to note that margarine was invented by Mège-Mouries in 1870 in a similar competition organised by the French Government during the Franco-German War.

Appert used glass bottles in which he covered the food with water and cooked it for several hours before sealing them with special waxed corks which were wired on to the bottles. Since Appert's time there have been great advances made but his principles were sound and the improvements have been in technique and detail rather than in new principles. Glass bottles have been replaced by cans. At first these were hand-made and then machine-made. The first type had a hole in the lid which had to be sealed with solder. The hole allowed steam to escape during cooking which drove out the air and by sealing while hot a vacuum was produced in the tin. The open-top or "sanitary" can is sealed by machinery and no solder is needed. The lid is fixed while the food is hot by bending the edges of the top of the can and the flange of the lid by a double seamer machine to give an airtight seal.

The sheet steel used in the manufacture of cans is coated with a layer of tin to prevent chemical action between the food and the can. The cans used for such acid-containing foods as fruits and vegetables are also lacquered or enamelled to give additional protection. The heating or processing of the foods is now done by superheated steam in a vacuum (vacuum pans) instead of in open pans such as Appert used. In this way, higher temperatures can be used to destroy micro-organisms without spoiling the appearance, flavour and food value, particularly the vitamin value, of foods. Chemical preservatives are now seldom used in canned foods. They are unnecessary.

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Because of these improvements in methods of manufacture, decomposition of canned foods is rare but if a tin bulges outwards it is a sign of the production of gas inside the tin by the decomposition of the food. Should a canned food show by its appearance or smell the least sign of decomposition it should be discarded.

MEAT.

Beef is the meat most commonly canned. It is first cut up into small pieces and scalded in boiling water for 15 minutes. The fat is skimmed off the liquid which is then concentrated in vacuum pans to produce meat extracts such as Oxo and Bovril. The scalded meat is pickled in a solution of common salt and sodium nitrate or sodium nitrite. The latter changes the unappetising colour of the boiled beef to a more attractive pink colour. The pickling solution is drained off, the meat packed into cans and then sterilised at high temperature in the cans in which it is packed. The product is corned beef. Other forms of meat, e.g., mutton, pork and poultry are canned in a similar way.

FISH.

Fish such as salmon are cleaned, cut into suitable portions and parboiled after packing into cans. The cans are sealed, while still hot, and processed.

Sardines, which are immature fish of the pilchard family, are first fried in oil and then canned in oil or tomato sauce before processing.

EGGS.

Shell eggs are not suitable for canning and processing. Canned liquid eggs are used by confectioners for baking purposes. The eggs are broken into cans, and the cans sealed. They are not cooked or processed in any way.

MILK.

The preparation of evaporated or condensed milk has already been described (page 123).

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FRUITS.

The cans are packed with fresh graded fruit and filled with boiling water or sugar syrup. The lid is sealed on while still hot so that air will have been driven out by the steam. The sealed cans are then processed so as to sterilise and cook the fruit.

Although home-canning outfits can be bought, the usual domestic method of preserving fruit by heat is that of bottling. The principles involved are, of course, similar to those of canning but the following points should be noted.

(a) *The Fruit.* Soft fruits, except gooseberries, should be of good colour, ripe and firm. Gooseberries should be bottled when green and slightly under-ripe. Most stone-fruits should be firm-ripe. The fruit should be picked while dry and bottled as fresh as possible. It is advisable to grade the fruit according to size and ripeness for the time necessary for cooking will depend to some extent on the size and ripeness of the fruit. The fruit should be packed as tightly as possible and the bottles well filled.

(b) *The Bottles.* Before use the bottles should be perfectly cleaned in order to sterilise them thoroughly. The two commonest types of bottle in use for the preservation of fruit are clip bottles, e.g., Snap Closure and screw band bottles, e.g., Kilner.

Clip bottles have lacquered tin lids fitted with rubber bands. During sterilisation they are held in position by metal spring clips. While the fruit is being heated the pressure inside the bottles increases sufficiently to lift the lids slightly and allow steam and air to escape. During cooling, the spring clip holds the lids firmly in position while the steam inside the bottles condenses to water and so creates a partial vacuum.

Screw band bottles have lacquered tin bands to hold the glass lids in position on the rubber bands placed round the rims of the bottles. During the heating the screw bands are fitted loosely so as to allow the escape of steam and air. During cooling the bands are screwed down tightly so as to hold the lids in position until a vacuum is formed when the steam condenses.

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(c) *The Sterilisation.* Having packed the fruit properly into suitable bottles it should now be covered with either water or sugar syrup. Of the two, sugar syrup is preferable as the sugar impregnates the fruit during sterilisation and storing, and helps to preserve the fresh fruit flavour. The most suitable strength of sugar syrup is one containing 8-12 ounces per pint of water.

The rubber rings, lids and clips or screw bands are now placed in position and the fruit sterilised. Various methods can be used. The bottles can be placed on a false bottom of wood or cloth in a deep pan, zinc bath or bucket and completely covered with water. The water is heated slowly to simmering point in about $1\frac{1}{4}$ hours and retained at this temperature for 15 minutes. Alternatively, the bottles can be heated on an asbestos mat, sheet of cardboard or wood in a very moderate oven (about 240°F.) for $\frac{3}{4}$ hour to 1 hour. In this oven method the water or sugar syrup can be added either before the heating or as boiling water or boiling sugar syrup after the heating.

(d) *Testing the seal.* After 24 hours remove the spring clip or screw band and lift the bottle by its lid. If the lid comes off the seal is imperfect and the fruit should be re-sterilised or eaten within a few days. If properly sealed, the difference between the atmospheric pressure outside the bottle and the small pressure of the partial vacuum inside the bottle will be great enough to hold the lid in position.

While vacuum bottles of the spring clip or screw band type give the best results, ordinary wide-necked bottles or jam jars may be used if care is taken to seal them well enough to prevent the access of air and micro-organisms. Acid fruits such as plums, damsons and gooseberries which are easily sterilised are most suitable when vacuum bottles are not available. The bottles or jars can be sealed in several ways. One method is to pour over them a layer of olive oil, medicinal paraffin or clarified beef or mutton fat and tie a piece of paper over the top to keep out dust. If a sufficiently tight-fitting cork is available this can be used but it should be covered with melted wax or kept moist and swollen by storing the bottle on its side to ensure its remaining airtight. Pieces

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of white calico can be painted over with a melted mixture of 1 oz. beeswax, 1 oz. vaseline and 8 ozs. resin or several layers of paper pasted over the neck of the bottle with paste or gum. Synthetic skins, such as Porosan, are also useful for sealing bottled fruit.

VEGETABLES.

Vegetables are washed, cut up into suitable sizes, and then scalded or blanched. They are then packed into cans, covered with boiling water, sealed while still hot so as to produce a partial vacuum, and finally processed.

The home bottling of vegetables is not very common because it is a lengthy process requiring high temperatures and the use of a pressure cooker for sterilisation.

Preservation by Sugar, Salt, Acids and Other Chemical Substances.

Micro-organisms are killed and the action of enzymes prevented by the use of high concentrations of sugar, salt and acids such as vinegar. Certain chemical substances such as boric acid, borax, sodium benzoate, sodium salicylate and formalin are poisonous to micro-organisms in even minute quantities. They were largely used as food preservatives until their use was made illegal by the Public Health Authorities in 1925 because of their harmful effect upon the health of people eating foods preserved in this way. The only preservatives of this type permitted by the Regulations are sulphur dioxide and benzoic acid. Even these can only be used in restricted amounts and in certain foods such as sausages, meat pastes and dehydrated vegetables. If a food contains either of these chemical preservatives the fact and the amount must be stated on the label.

MEAT.

In the past the salting of meat was the usual method of preserving it. The meat was either rubbed with dry salt or pickled in salt solution (brine). At the present time pork is the only form of meat extensively salted. The rolled or unrolled sides of the pig, after removal of the ribs, form bacon, while the back

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legs form hams. The old-fashioned method still used in farm-houses is the dry-salting one in which dry salt is rubbed into the pork. The bacon or ham is afterwards hung, with or without smoking. Modern mild-cured bacon and ham are cured in brine and do not keep anything like as long as dry-salted bacon and ham. In addition to common salt, a little sodium nitrate or potassium nitrate (saltpetre) is used. It acts as a preservative and gives the bacon or ham an attractive red colour.

Micro-organisms cannot grow in the high concentrations of salt in bacon and ham and, in addition, the salt absorbs water from the meat and so partly dries it. The keeping qualities are still further enhanced by smoking. Sawdusts of hard woods such as oak and beech are used. The meat absorbs substances from the smoke which have an antiseptic action. It is also altered in flavour and dried still further.

FISH.

Salt is very frequently used to preserve fish. Cod is salted in large quantities in Newfoundland, Iceland and Greenland. In this country, fish is both salted and smoked. The kipper is herring which has been split and salted before smoking for one night. Bloaters are similar to kippers but have more salt added. Red herrings have a further addition of salt and are smoked for ten days. Haddocks were first cured at Findon, a small fishing village near Aberdeen, from which the name Finnon Haddock is derived. Salmon which has been salted and smoked is eaten without further cooking.

EGGS.

We have already seen that liquid eggs are canned with chemical preservatives and used for confectionery purposes.

Chemical preservatives used for shell eggs act in a different way. Micro-organisms can be prevented from attacking the food materials in the egg by blocking up the pores in the shell. This can be done by "pickling" them in solutions of water-glass (sodium silicate), lime or borax. Alternatively, the eggs can be sealed by coating them with melted paraffin wax or special varnishes such as Oteg.

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Pickling is the most suitable domestic method of preserving eggs. The eggs can be pickled when they are plentiful and used when they are scarce. A "pickled" egg will remain fit for use for 12 months. When a pickled egg is boiled the shell almost invariably cracks because the pores of the shell are sealed and the expansion of the air-chamber during heating causes a sufficient internal pressure to break the shell. This can be prevented by making a small hole through the broad end of the egg into the air-chamber by means of a pin or needle.

MILK.

The use of chemical preservatives of any type in liquid milk or cream is prohibited by Public Health Regulations. Condensed milk (p. 123) can be sweetened and its keeping qualities enhanced by the addition of sugar.

The salt added to butter, margarine and cheese not merely gives flavour but acts as a preservative as well. Although very little salt is used, the amount of water in butter, margarine and cheese is so small that a concentrated salt solution is produced. It should be realised that, in a sense, butter and cheese are preserved forms of milk. Both keep much better than the milk from which they are prepared.

FRUIT.

Very large amounts of fruit are preserved by means of sugar in the form of jams, jellies, marmalades, candied peels, and glacé or crystallised fruits. By producing a high concentration of sugar in and around the fruit the growth of moulds and yeasts is prevented.

JAM.

Fresh fruit contains fibre, water, sugars, fruit-acids and a gum-like substance known as pectin. This pectin is of great importance in jam-making because it is to pectin that the setting of jam is due. Successful "gel" formation depends upon the extraction of as much pectin as possible from the fruit and fruit acids are necessary to do this.

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Fruits such as plums, damsons, currants and gooseberries are easily made into jam because they contain large proportions of both pectin and fruit acids. On the other hand, strawberries, pears, rhubarb, and marrow, contain very little pectin or acid and are consequently difficult to make into jam. Acid substances such as lemon juice, tartaric acid, cream of tartar, citric acid, gooseberry juice or red currant juice are frequently added to such fruits. The presence of acid in the fruit improves the colour and flavour of the jam and also prevents "graining" or crystallisation of the sugar in the jam when it is stored. This graining is prevented by the "inversion" of some of the cane sugar to invert sugar (glucose and fructose) during the boiling of the jam. Strawberries, cherries and rhubarb, can be made to form excellent jam by the addition of pectin from other fruits. This can be done by making the jam of two fruits, e.g., strawberry and apple, or by adding home-made pectin or commercial pectin preparations.

Home-made pectin stock can be prepared from such pectin-rich fruits as apples, red currants or gooseberries, by simmering three pounds of fruit with a pint of water until tender. The fruit is then mashed and strained through a scalded jelly bag and left to drain. After draining, the pulp in the jelly bag is again simmered for about an hour and finally strained. The two extracts thus obtained are then mixed. The mixture can be tested for pectin by pouring a sample into methylated spirits. Pectin is insoluble in alcohol and is precipitated as a jelly-like clot. If only a poor clot is obtained the extract should be further concentrated. Finally the extract is bottled and stored for use with fruit poor in pectin.

There are a number of commercial pectin preparations such as Certo, Zett and Pexicon. When these are used for jam-making the time of boiling is very much reduced, the yield of jam is greater, the fresh fruit colour and flavour are more readily preserved and a well set jam is ensured. Such concentrated pectin preparations should, however, be used with care and the enclosed directions accurately followed. Otherwise the jam will be too stiff or the delicate fruit flavour ruined.

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The fruit used for jam-making should be perfectly fresh and firm ripe. It is at this stage that fruits are richest in pectin and acid. Over-ripe fruits contain a diminishing amount of pectin and acid and are liable to mould growth and loss of colour and flavour.

After cleaning, the fruit should be cooked for some time before the sugar is added. The length of time for this cooking varies according to the fruit used: from 10-15 minutes with such fruits as raspberries, to 30-45 minutes, with addition of water, in the case of plums, damsons and blackcurrants. It is during this preliminary cooking that the pectin is extracted and in the case of fruits deficient in fruit acids it is at this stage that additional acid should be added.

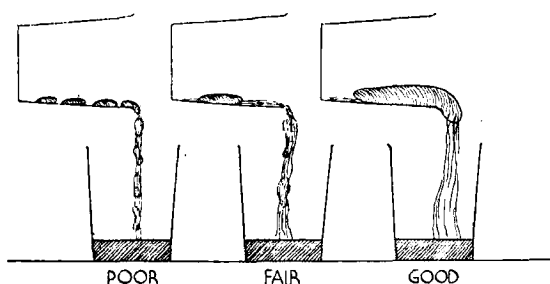


FIG. 50. Pectin Clots.

The fruit is sufficiently cooked when a good pectin clot is obtained with the following test. A teaspoonful of jam free from seeds and skins is placed in a tumbler or cup and three teaspoonfuls of methylated spirits added to it. The mixture is shaken gently and left for a minute. If the fruit contains sufficient pectin a transparent jelly-like clot of pectin will be formed and, when poured into another tumbler or cup, will remain in one piece. A poor clot may divide into two or three lumps and a very poor clot into numerous small pieces.

Having obtained a good pectin clot by this test, the fruit is now ready for the addition of sugar. The most suitable type is a good quality granulated sugar. As a general rule 1 lb. of

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sugar should be added for each lb. of fruit. The mixture should be stirred until all the sugar has dissolved and then boiled as rapidly as possible without stirring as air bubbles and scum may get mixed up with the jam and spoil its appearance.

This boiling period will vary from about three to twenty minutes according to the kind and quantity of fruit and the shape and size of the pan. The object is to reduce this period of boiling with sugar to a minimum in order to produce a jam with a fresh fruit flavour, good colour and firm set. Boiling too long will weaken the setting qualities of the pectin and some of the sugar may be caramelised and so spoil the flavour and colour of the finished jam. On the other hand, if the jam is not boiled long enough an insufficient amount of sugar will be inverted to prevent the jam going sugary on keeping.

The following tests may be made, to find when the jam has reached setting point:—

(1) *Cold Plate Test.*

A sample of the jam is poured from a wooden spoon on to a cold plate. When the jam has reached setting point the surface of the sample should set quickly and crinkle when pushed with the finger.

(2) *Flake Test.*

A sample of the jam is taken out on a wooden spoon and turned horizontally until the sample is partly cooled. The jam is then allowed to drop from the edge of the spoon. If the drops run together into flakes which break off cleanly, setting point is reached.

(3) *Temperature Test.*

Provided a sugar-boiler's thermometer is available, this is the most reliable test. When the jam boils at 220° F. it will set on cooling.

(4) *Weight Test.*

This test consists in weighing the pan and its contents (without spoon) on a suitable spring balance until the weight of added sugar forms 60 per cent. of the weight of the jam. Thus, if the recipe

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contains 6 lb. of sugar, setting point is reached when the weight of jam reaches $\frac{6}{1} \times \frac{100}{60} = 10$ lb. It must be remembered, of course, that the weight of the jam does not include the weight of the pan.

When setting point is reached, the jam should be removed from the source of heat and any scum quickly skimmed off. The jam should then be quickly poured into clean, dry, warm jars which should be filled quite up to the top to allow for considerable shrinkage on cooling. Wax discs, waxed side downwards, should be placed on the surface of the jam to prevent it absorbing moisture from the air and so giving moulds and yeasts a chance to grow. Finally, the jars should be tied down with jam covers to prevent the access of moulds and yeasts and stored in a cool dry airy place.

A really good jam should be well set but not too stiff. It should be clear and bright in colour and have a distinct fruity flavour. It should be capable of storage without fermenting or going either mouldy or sugary. Finally, the fruit should be soft of flesh and tender of skin and should be evenly distributed throughout the jars.

The following are the chief faults found in jams.

(a) *Mould on Jam.*

Jam may go mouldy because of any of the following: —

- (1) Too little sugar has been used.
- (2) Storage in a damp warm place.
- (3) The use of wet or inferior fruit.
- (4) A wet summer which predisposes fruit to mould growth.
- (5) Incomplete destruction of mould spores during boiling.

(b) *Fermentation of Jam.*

This is caused by yeasts converting some of the sugar into alcohol. Jams may ferment because: —

- (1) Too little sugar has been used.
- (2) Underboiling has resulted in too large a yield of jam. If 3 lb. of sugar are used the yield of jam should not be more than 5 lb.

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(c) *Graining of Jam.*

Some of the sugar may crystallise out and the jam go sugary because: —

- (1) Too much sugar has been used.
- (2) Too little of the sugar has been inverted. This may be because the jam was not boiled long enough to allow the acids of the fruit to invert sufficient of the sugar or the fruit may have contained too little acid to bring about sufficient inversion.

(d) *Other Faults.*

- (1) The fruit may have risen to the top of the jar. This is particularly common with strawberry jam and marmalade. It can be avoided by allowing the fruit to cool slightly until it begins to stiffen and then stirring it gently before pouring it into jars.
- (2) The jam may be dull and cloudy in appearance and lacking in fresh fruit flavour. This may be due to stirring during the boiling with sugar or to overboiling and caramelisation of some of the sugar, or because the scum of coagulated proteins from the fruit has not been removed.

FRUIT JELLIES.

The preparation of fruit jellies depends upon the same principles as those of jam. With the exception of strawberries, cherries, and pears, which are deficient in pectin and acid, all the common fruits can be made into jellies. The most suitable are currants, gooseberries, loganberries and quinces and such wild fruits as elderberries, bilberries, blackberries, sloes and crab apples. The wild berries set better if mixed with cooking apples.

The fresh firm-ripe fruit is first washed but it is unnecessary to remove stalks, leaves, etc., as they will be removed during straining. Large fruits, such as apples and plums, should be cut into small pieces. The fruit is then cooked in water, the amount

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of water depending upon the type of fruit. The cooking should be slow and the fruit simmered until tender when the maximum amount of pectin and acid will be extracted. The test for pectin is the same as with jam and when a good clot is obtained the pulp is strained through a scalded jelly bag.

The juice is now heated and skimmed and sugar added at the rate of one pound per pint of juice. The juice is stirred until all the sugar is dissolved and then boiled as rapidly as possible without stirring. The jelly will set, as in the case of jam, when the added sugar content has reached 60 per cent. The same test for setting point can be used as with jam (except the weight test). When setting point is reached the hot jelly is immediately poured into clean dry warm jars until completely filled. Wax circles are placed on the surface of the jelly while still hot and the jars tied down after cooling. The jars should then be stored in a cool, dry, airy place.

This type of fruit jelly should not be confused with the commercial type made of gelatin, coloured and flavoured to resemble some particular fruit.

MARMALADE.

The preparation of marmalade from such citrus fruits as oranges, lemons, grape fruits and limes is so similar in method and principles to jams and jellies that the following details only need be mentioned.

The thick rinds of citrus fruits require boiling for at least two hours and the addition of water is essential during the cooking. It is important that the white inner skin or "pith" and pips should be cooked along with the rest of the fruit since most of the pectin is in them and not in the juice. If considered desirable, the pith and pips can be placed in a muslin bag and cooked along with the marmalade and then taken out before the sugar is added. In this way the valuable pectin is extracted without spoiling the appearance of the marmalade by the presence of white pith in it.

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COMPOSITION OF JAMS.

The composition of jam varies but the following table gives a general average composition.

Water	...	...	28 per cent.
Sucrose	...	...	36 per cent.
Invert Sugar	...	...	33 per cent.
Fruit Acids	...	...	0.75 per cent.
Pectin	...	...	0.5-0.75 per cent.
Seeds and Fibres	...	...	1-2 per cent.
(exclusive of stones)			

Although there are no legal requirements for commercial jams, the Food Manufacturers' Association have agreed on a minimum fruit content and a minimum soluble solids content (68.5 per cent.) i.e., added sugar together with the small amount of sugar from the fruit. The standards prescribed ensure jams of good quality and jams are not now adulterated with vegetables and cheap varieties of fruit. Jam must not contain any fruit other than that named on the label. It must consist only of the named fruits, sugar, pectin and water. There are three recognised standards for each variety of commercial jam: Full Fruit, Fresh Fruit and Lower Fruit standards. The first two standards both contain 30-42 per cent. of fruit according to the variety but, while fruit pulp and colouring matter can be used in "Full Fruit," only fresh fruit can be used in the other. "Lower Fruit" standard jams contain a minimum of 20 per cent. of fruit.

CANDIED PEELS, GLACE AND CRYSTALLISED FRUITS AND FLOWERS.

The chief candied peels are those of the lemon, orange, citron, grapefruit and lime. The fruits are cut in two and the pulp removed. The "caps" are soaked in brine to soften them and then washed in water to remove the salt. They are placed in tanks of weak sugar syrup and absorb some of the sugar. By passing into stronger and stronger sugar syrups the caps become saturated with sugar. Finally, they are drained, dried and candied by heating for several hours. The heating sets the sugar and hardens the caps.

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Glacé or crystallised fruits, such as cherries, first of all have their stones removed and then they are cooked in weak sugar syrup until soft and finally rolled in melted sugar.

Crystallised ginger is made from the underground stem (rhizome) of the ginger plant by first cleaning and then cooking it in weak sugar syrup. The much more common ground ginger is made by grinding the dried rhizome.

Angelica and Sweet Parma violets and rose petals are crystallised in a similar way and used for decorative purposes in confectionery.

Preservation by Chemical Substances.

It is legal to preserve fruit by means of sulphur dioxide and this method is used by jam manufacturers to preserve fruit pulp so that they can make jams all the year round instead of seasonally.

Special fruit preserving tablets, known as "Campden Fruit Preserving Tablets" can be bought from chemists for home use. They contain a chemical substance (potassium bisulphite) which contains sulphur dioxide. In contact with the acid of fruit this sulphur dioxide is slowly released and preserves the fruit. These tablets are most suitable for use with plums and damsons.

The fruit is packed in jars or bottles and a cold solution of the tablets in the required amount of water poured over the fruit until covered. The jars or bottles are then sealed so as to be airtight. The fruit can be stewed or used in puddings or pies or for making jam. The liquid will smell strongly of sulphur dioxide and the colour of the fruit may be bleached. Before use the fruit and liquid should be boiled in an open pan until the smell of sulphur dioxide has disappeared and the fruit has returned to something like its original colour.

VEGETABLES.

Kidney beans and runner beans can be preserved by storing them between layers of salt but the usual chemical preservative for vegetables is vinegar. The sharp sour taste of vinegar is due to the

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presence of acetic acid and it is this acid which prevents the activities of micro-organisms in pickled vegetables.

The vinegar is first boiled with spices and salt and after cooling, is poured over the onions or walnuts. Piccalilli contains cauliflower and other vegetables. Mustard and ginger are used as well as vinegar, salt and spices. Chutneys of fruits and vegetables are made with sugar, vinegar and salt as preservatives, and ginger and spices as flavourings.

In concluding this important chapter we would point out that, although not regarded as preservation in the strict sense of the term, the keeping of food fresh as long as possible by proper storage in the home is really a form of temporary preservation. Full use should be made of refrigerators whenever available for such foods as milk, meat, fish, eggs, butter, margarine and fats. Other simple methods of keeping milk fresh have already been given (page 117). Similar methods can be used for butter, margarine and fats. Cheese should be kept cool and dry. Bread should be kept wrapped in a clean cloth on an airy shelf or in a clean dry ventilated bin. New bread should be quite cold before being put away. Green vegetables should be kept away from the air in an air-tight container, e.g., a large saucepan with the lid on. Root vegetables and potatoes should be kept cool and moist. Cereals, pulses and flour should be kept perfectly dry, preferably in glass or metal containers with lids.

CHAPTER XV
THE PREPARATION OF FOOD

Cleanliness of Food.

We have seen that foods putrefy and decay because of the action upon them of micro-organisms such as bacteria, yeasts and moulds. While the majority of these micro-organisms do no more than lead to the waste of valuable food there are some which can cause serious outbreaks of food poisoning and disease.

Most cases of food poisoning are caused by bacteria of the Salmonella group, so called after their discoverer, Salmon. Unfortunately, food affected by these bacteria is not altered in appearance or taste to any great extent. The bacteria multiply in the digestive tract of persons who have eaten infected food and form their poisons (toxins) there. The poisons cause severe pain, sickness and diarrhoea. Serious cases may result in death. Cooking the food will destroy bacteria of the Salmonella group.

A more serious, but much rarer type of food poisoning, is botulism. The name is derived from the Latin word for sausage. The spores of the bacteria which cause botulism occur in soil and dust and occasionally find their way into made-up foods such as sausages, meat pastes and canned goods such as vegetables. They can live without oxygen and produce their toxins in the interior of the food itself which may not be sufficiently altered in appearance, smell or taste for its infection to be noticeable. The toxin is destroyed by the temperatures of ordinary cooking but the spores are more heat-resistant and are not killed until the temperature reaches 250°F. Food poisoning of this type is usually fatal.

Pathogenic (disease-causing) bacteria may find their way into food through the agency of human disease carriers handling the food. Typhoid fever, scarlet fever, undulant fever, tuberculosis and diphtheria have all been known to spread in this way, particularly in milk and drinking water and fresh or made-up meat. Oysters have been known to cause typhoid fever when the oyster beds have been polluted with sewage water. Steps are now taken

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to prevent this. Flies, cockroaches and crickets are notorious as conveyors of putrefactive and pathogenic bacteria and rats and mice have also been held accountable for the infection of foods. In addition, certain animal parasites, e.g., tape worm, round worm, and trichina, may be found in meat.

Public Health Authorities employ inspectors to examine meat and other foods, and places where food is prepared and sold in order to prevent the sale of foods unfit for human consumption. For example, home-killed meat can be inspected at all stages from the slaughter house to the butcher's shop. Imported meat is inspected before it leaves the exporting country and again on arrival here. Persons known to be typhoid carriers should not be allowed to handle food of any kind. The most scrupulous cleanliness is essential in all abattoirs, bakeries, food factories, markets, shops, hotels, restaurants and, not least, the home, to prevent infection of food by rats, mice, flies, cockroaches and crickets. Persons handling food should invariably wash their hands after visiting the toilet.

Although great advances have been made in our methods of handling food at all stages there is still much room for further improvements and an informed public opinion can do much to bring them about.

Cooking of Food.

The practice of cooking meat and other foods has grown up with civilisation and the general advance in refinement of taste. Primitive man depended upon uncooked raw food. Civilised man is the only living creature that does not eat his food raw.

The purposes of cooking food can be summarised as follows: —

- (1) To improve its appearance.
- (2) To develop new flavours and so stimulate appetite and the flow of digestive juices.
- (3) To make the food more digestible.
- (4) To destroy micro-organisms and parasites and so make the food keep longer.

The following methods of cooking are usually distinguished: — stewing, boiling, braising, baking, roasting, grilling, frying and

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steaming. All of them, of course, involve the use of heat which may be applied to the food in three different ways.

(1) Dry heat applied directly to the food in roasting, baking, grilling and braising.

(2) Moist heat applied by means of hot water or steam in stewing, boiling and steaming.

(3) High temperatures applied by means of hot fat in frying.

Before dealing separately with each method of cooking we must first discuss the action of heat upon the nutrients of food, carbohydrates, fats, proteins, minerals and vitamins.

CARBOHYDRATES.

Cooking is essential if starch is to be digested. Uncooked starch in flour, potatoes, rice, oatmeal and so on is in the form of cells or granules with an outside skin of cellulose which our digestive juices cannot penetrate. With moist heat the starch cells swell up and burst and the starch is said to be gelatinised. In this form it can easily be converted by our digestive juices into glucose and completely absorbed. Gelatinisation of starch takes place when bread is baked, potatoes boiled, custard powder made into custards with boiling milk and so on. With dry heat starch is converted into dextrin which is easily digested.

Cane sugar in acid solutions as in stewed fruits and jams is inverted into invert sugar (glucose and fructose). The formation of caramel by the action of heat on sugar alters the flavour and colour of many foods during cooking.

FATS.

Unless fats are heated to very high temperatures the only changes which take place are that they melt to oils and lose any moisture they may contain. Butter may lose some of its more volatile fats and thus lose its superior flavour and become harder and more tallowy. At very high temperatures, such as in frying, some of the fat may be decomposed into fatty acids and glycerin and even some of the glycerin decomposed into acrolein which has an irritating effect on the digestive organs.

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PROTEINS.

Proteins are "set" or coagulated by heat. This is most easily seen in the white of a boiled egg. In addition, proteins shrink on heating. This is seen in the shrinkage of meat during roasting owing to the contraction of the protein of the muscle fibres. Lightly coagulated protein is more digestible than raw protein, e.g., a lightly-boiled egg is more digestible than a raw egg, but over-coagulation makes protein less digestible and reduces its food value.

MINERALS.

Dry heat has little effect upon the minerals of food. Boiling may result in the loss of some of the soluble magnesium, potassium and sodium salts but this is of little consequence because we get plenty of these minerals in our diet. The more valuable calcium and iron are practically unaffected by boiling. In fact, their amounts in foods are sometimes increased by the absorption of calcium from hard water and iron from the utensils.

VITAMINS.

Vitamins A and D are insoluble in water and can withstand the temperatures of ordinary methods of cooking so that cooked foods contain as much of these vitamins as the raw foods.

Some of the vitamin B (thiamine) may be lost in cooking water since it is very soluble. It is destroyed at very high temperatures particularly in the presence of bicarbonate of soda. Riboflavine and nicotinic acid are not much affected by ordinary methods of cooking in spite of the fact that they are soluble in water and destroyed at high temperatures. Pressure cooking and the corning of beef are likely to cause some loss of both these vitamins.

Vitamin C (ascorbic acid) is the vitamin most easily dissolved out of foods and destroyed by heat. As previously pointed out (page 65), this loss is greatest if the heating is prolonged, or takes place in the presence of air, or if the vegetables are grated, or the boiling started from the cold. By careful cooking the loss of ascorbic acid in vegetables can be reduced to a minimum.

Methods of cooking.**1. MEAT.**

The objects of cooking meat are to remove its raw appearance without overcoagulating the proteins or removing the minerals and extractives which give it its flavour.

Roasting or Baking is cooking quickly in a closed oven by direct radiation. It is suitable for fairly large joints of meat which must, however, be tender. Otherwise the meat is likely to become tough and dry. Besides beef, mutton and pork, poultry, game and rabbits can be roasted or baked.

The meat for roasting should be trimmed, and, when necessary, boned, tied and skewered into a suitable shape. It is then put into a tin with a little dripping and placed in a very hot oven (500° F.).

The meat quickly turns a brown colour owing to the destruction of the red colouring matter, haemoglobin. The proteins of the muscle fibres shrink and juice is squeezed out on to the surface of the meat. A small amount of the juice falls to the bottom of the tin as drip but much more evaporates as steam and leaves the minerals and extractives on the surface. In this way the outside layers of roasted meat get their additional flavour. The evaporation of water from the meat is the chief cause of the very marked loss in weight which occurs in roasting. As the meat becomes hotter the proteins on the outside coagulate and slow down the loss of juice from inside the joint. After this sealing process the heat should be reduced or the meat moved to a cooler part of the oven (350° F.), otherwise the proteins will be over-coagulated on the outside of the joint before the heat has penetrated to the interior because meat is a very bad conductor of heat. The dripping will melt as well as some of the fat of the meat and these, together with the drip from the meat, form the gravy. Sometimes, during the roasting, the meat is basted with the hot fat in order to prevent the outside of the joint becoming dry and hard and also to assist in the cooking. The meat may be turned over in order to cook it evenly but, if this is done, the fork should be stuck into the fat rather than the lean part of the joint so as not to allow juice to escape.

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If an open tin is used, the draught in a gas oven causes a greater loss in weight by evaporation and consequent drying of the meat than in an electric, coke or coal oven. There is less evaporation and drying in any type of oven if a closed tin is used. Consequently there is more drip and more of the minerals and extractives pass into the gravy. Thus, roasting in a closed tin gives juicier meat and richer gravy while an open tin gives a drier, better flavoured joint but poorer gravy.

Grilling is really very quick small-scale roasting. It is only suitable for small pieces of meat, e.g., chops, which should be tender and of the best quality. The meat is placed on a gridiron, heated very strongly and frequently turned as the proteins coagulate. The juice squeezed out during shrinkage evaporates very quickly in the great heat and leaves the minerals and extractives on the surface so that grilled meat has an excellent flavour.

The grillers on gas and electric ovens can be used for bacon, ham and sausages as well as for browning the surfaces of puddings and savouries.

Braising. In braising, the meat is first fried in shallow fat and then stewed in water or stock. Because of the high temperature of the hot fat the proteins are very quickly coagulated and this is apt to make the meat tough and indigestible.

Stewing. In stewing, the meat is cut up into small pieces, placed in a small amount of water or stock in a closely covered pan to avoid loss of steam, and the liquid gently heated so as not to reach a temperature of more than 180° F. Much so-called stewing is really simmering or slow-boiling at 212° F. At the lower temperature the cooking takes place more slowly and there is little danger of over-coagulation of the proteins. A good deal of the minerals and extractives are dissolved out from the small pieces of meat. This makes them rather tasteless but this does not matter very much because the richly-flavoured cooking liquid is served along with the meat. The prolonged action of heat and moisture converts much of the collagen of the connective tissues of the meat into gelatin so that the muscle fibres easily fall apart and

the meat becomes tender. Stewing is thus a suitable method of cooking the cheaper, tougher cuts of meat unsuitable for roasting. Although stewing is usually started from the cold, it has been found to make no difference to the final result whether the meat is placed in cold water or hot water.

Stewing is an economical method of cooking, not only because it can be used for the cheaper cuts of meat, but also because there is no waste, as well as a saving of fuel and cooking space since potatoes and other vegetables can be cooked along with the meat as is done in Irish stew and Lancashire hot pot.

Boiling. In boiling, the meat is placed in one piece in water or stock and kept at boiling point (212° F.) until cooked. It is suitable for large pieces of meat which require thorough cooking but which are not tender enough for roasting. There is the same destruction of haemoglobin and consequent change in colour as in other methods of cooking. At 140° F. some of the juice is squeezed out owing to the shrinkage of the proteins of the muscle fibres and the minerals and extractives pass into the cooking water which should be used for soup or stock. The heat penetrates slowly into the interior of the meat and the proteins are coagulated. There is less danger of over-coagulation of the outside layers than in roasting and grilling but the meat is not so well-flavoured. It makes no difference to the amount of minerals and extractives lost or, to the amount of shrinkage, whether the meat is started in cold or boiling water or whether the water is just boiling or boiling vigorously.

Steaming is cooking in the steam from boiling water in a steamer which fits tightly on to a saucepan and has a tight-fitting lid to prevent loss of steam. The temperature is the same as that of boiling water (212° F.) and the results similar to boiling except that there is less loss of minerals and extractives though more than in roasting, grilling or frying.

Suet puddings and Christmas puddings are better steamed than boiled. They are less likely to become sodden with water and rise more easily.

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Frying. We have already seen (p. 88) that the smoking temperatures to which fats are heated for frying are much higher than the temperature of boiling water; 360-400° F. compared with 212° F. At these higher temperatures there is very rapid evaporation of water, and shrinkage and coagulation of the proteins. Practically all the minerals and extractives are left behind. There is less loss than with roasting or grilling and much less than with boiling or stewing. Fried foods are thus well flavoured.

The proteins are coagulated so rapidly that only small pieces of food should be fried. With large pieces there is a danger that the outer layers may be over-coagulated while the interior is still uncooked. To prevent over-coagulation of the outside proteins and the absorption of too much fat, many foods are coated with batter, egg and breadcrumbs or flour and milk, before frying.

It is usual to distinguish two types of frying—shallow or dry frying, and deep fat frying. In shallow frying the food is cooked in a frying pan with very little fat. It is really baking rather than frying, the amount of fat used merely preventing the food sticking to the pan. Shallow frying is suitable for foods which already contain a good deal of fat, e.g., ham, bacon and sausage.

In deep fat frying, a deep heavy pan is necessary which should contain sufficient fat to cover the food completely. A frying basket or perforated ladle is required to lower the food gently into the smoking fat and to lift it out all together. Too much food should not be put into the fat at a time as this reduces the temperature of the fat and the food will not cook properly. After frying, the food should be placed on clean kitchen paper to absorb some of the grease and so keep the food crisp. Fried foods should be served quickly and eaten hot.

2. FISH.

Fish is more easily cooked than meat. There is no need to adopt a particular method of cooking suitable for a particular cut as there is with meat. The flesh of fish is of much more even quality than meat and since it is usually cooked in small pieces the difficulties caused by the poor heat conductivity of large pieces of meat do not arise.

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The changes that take place during the cooking of fish are similar to those of meat except that there is not the same marked change in colour. There is a similar evaporation of water and shrinkage and coagulation of protein causing the flesh to become firm. Fish muscle has much less connective tissue than meat and, for this reason, more easily divides up into flakes during cooking. In the case of fat fish, such as herrings, some of the fat slowly oozes away. There are less minerals and extractives in fish than in meat. Consequently, boiling and steaming, while making fish easily digestible and suitable for invalids, are apt to make it insipid in taste because of the loss of these flavouring agents. Baked, grilled or fried fish are more tasty because of the smaller losses of minerals and extractives.

Small fat fish—herrings, kippers and smoked haddock—may be grilled or shallow fried; filets of larger fish may be deep fried; small pieces of large white fish boiled, steamed or fried. Sometimes large fish, such as salmon, are cooked whole.

3. EGGS.

Eggs differ from meat and fish in that there is much less evaporation and no shrinkage on cooking. The proteins coagulate at 160° F. which is much below the boiling point of water (212° F.), so that it is not necessary to have boiling water to "boil" an egg. If heated above 160° F. for any length of time the proteins are apt to become tough, hard and indigestible. Whether boiled, poached, or scrambled, eggs should be only lightly cooked. The high temperature of the hot fat used in frying eggs is apt to over-coagulate the proteins—we do not coat eggs with a protective batter as we do fish. Fried eggs are not suitable for invalids and young children.

of time

4. FRUITS.

Sweet fruits are best eaten uncooked but green gooseberries, black currants, red currants, damsons, cooking apples and cooking pears are improved if stewed with sugar. The skins are made tender and the cellulose softened. Some of the soluble ingredients

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and vitamins of the fruit pass into the cooking water and some of the sugar is absorbed by the fruit. Since we consume the cooking water as well as the fruit this is no detriment. Because of the acids in the fruit the losses of vitamin B and vitamin C are less than would otherwise be the case. It is more economical to add the sugar at the end of the stewing than at the beginning because the acids of the fruit invert some of the cane sugar to invert sugar which is less sweet. The use of bicarbonate of soda to reduce the amount of sugar needed by neutralising the acids is not recommended as it increases the amounts of vitamins B and C destroyed.

5. VEGETABLES.

The chief reasons for cooking vegetables are to soften the cellulose framework and to gelatinise the starch grains. The proteins of vegetables are coagulated in exactly the same way as those of animal foods. Unlike meat and fish, vegetables usually become bulkier after cooking. There is a danger that the cooking of vegetables may result in a loss of some of their mineral salts but, fortunately, the important ones, calcium and iron, are the least affected. Carotene is not likely to be lost by cooking since it is fairly stable to heat and is not soluble in water. Vitamin B is not much affected by the temperatures of cooking but is very soluble in water so that much of it is likely to be lost in the cooking water. The use of bicarbonate of soda to preserve the green colour of vegetables causes destruction of this vitamin and is not advisable. Some vitamin C (ascorbic acid) is destroyed by the heat and a great deal is dissolved out in the cooking water. The amount of this vitamin in vegetables decreases rapidly on storing and consequently all vegetables should be eaten as fresh as possible.

Green leafy vegetables owe their value in the diet to the ascorbic acid they contain. Because of the ease with which this vitamin is destroyed by heat and dissolved out by water, the best method of cooking these vegetables is not to cook them at all. In other words they are best eaten raw in salads. When they are cooked we should make sure that the cooking reduces the inevitable loss of ascorbic acid to a minimum. This can be done by cooking

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in a little fat or boiling rapidly in the minimum amount of water for the shortest possible time.

In the first method, sufficient fat to cover the bottom is melted in a saucepan. When the fat is hot, but not smoking, the vegetables are added and the lid placed on the saucepan. The vegetables are cooked gently until tender (10-20 minutes) and served with the liquid in the pan.

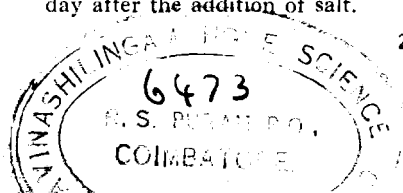
In boiling, the vegetables should first be thoroughly washed and soaked as little as possible in salted water. Root vegetables should be sliced and green vegetables shredded in order to reduce the time of cooking. Only sufficient water to prevent burning should be used and salt added to it. The pan should have a tightly fitting lid so that the vegetables are "steam-boiled". The boiling should only take 10-15 minutes and the pan should be given an occasional shake. The cooking liquor should be used for soups, stews and gravies.

Root vegetables can be cooked by either of these two methods, and there is the same need to reduce the cooking time to a minimum. Potatoes, beetroot and onions can be baked in the oven. Potatoes can be fried in deep fat and root vegetables in shallow fat. It is worth while baking, and even boiling, potatoes unpeeled since the skin helps to prevent loss of ascorbic acid.

Steaming is not recommended as a method of cooking vegetables. Because it is a slow method it results in very considerable loss of ascorbic acid. Finally, cooked vegetables should never be kept hot for long periods before serving. The destruction of ascorbic acid is very rapid under such conditions.

6. CEREALS.

Cereals are improved in flavour and made more digestible by the softening of their cellulose and the bursting and gelatinisation of their starch grains during cooking. Rice, tapioca and sago can be baked in a slow oven (250-350° F.) with milk and sugar to form milk puddings. Because of the large amount of cellulose, oatmeal should be soaked over-night and boiled for 15-20 minutes next day after the addition of salt.



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Breadmaking.

Bread may be described as the product formed by baking a mixture of flour, water and salt which is made porous by the use of yeast or some other means of aeration. By whatever method the bread is aerated it is made lighter and spongier in texture and its attractiveness and digestibility very considerably increased. If we compare the sodden "damper" baked by the squatter in the ashes of his camp fire, ship's biscuits or the "hard tack" of the army, with well-made bread we can easily realise the advantages obtained by aeration.

METHODS OF AERATION.

(1) *Leaven.*

The earliest method of aeration consisted in leaving a small portion of dough from one baking to the next. This left-over dough or leaven was quickly infected with micro-organisms from the dust of the air and when mixed with the next batch of dough contained sufficient yeast cells to lighten or leaven it. The bread produced was much inferior to a modern one but was, no doubt, superior to the more primitive bread made in earlier times by covering a round pasty mass of coarsely ground grain and water with red hot ashes and scraping away the ashes when they became cold.

Bread which has not been aerated is known as unleavened bread and is still eaten by Jews at the Feast of the Passover to commemorate the hurried departure of the Israelites from Egypt. Except for this ceremonial use, modern bread is aerated, at any rate in civilised countries.

Modern methods of aeration can be divided into three main types—mechanical, chemical and fermentation.

(2) *Mechanical.*

(a) The aerated bread sold in A.B.C. shops in London and many continental towns is made by placing flour with the necessary salt in a strong iron vessel fitted with a mechanical stirrer. Water saturated with carbon dioxide under pressure (similar to soda water) is then added and thoroughly incorporated with the flour

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by the mechanical stirrer. The dough is eventually forced out of the iron vessel by the pressure of the gas, moulded into loaves and quickly transferred to the oven. The expansion of the gas by the heat of the oven produces the spongy texture of aerated bread.

(b) A second example of mechanical aeration is that involving the use of white of egg. When beaten or whisked the sticky glutinous white of egg forms a froth which is almost permanent owing to the bubbles of air which become entangled in it. When added to cake or sponge mixtures sufficient air is introduced to make them light and spongy.

(3) *Chemical.*

There are two kinds of chemical aeration. In the first kind a single chemical substance is used which decomposes on heating with the production of gas which causes the goods to rise during baking. Bicarbonate of soda (baking soda) is the most important substance used in this way. In the second type of chemical aeration an acid substance and bicarbonate of soda are used together as a baking powder. In the presence of moisture, the acid and the bicarbonate of soda combine together to form a salt, water and carbon dioxide. The salt remains behind in the goods when they are baked while the carbon dioxide causes them to rise. Many different acid substances can be used but cream of tartar is regarded as the best.

Bicarbonate of soda is a pure white powder which contains a great deal of carbon dioxide. Half of this gas is released by heat, and the bicarbonate of soda converted into carbonate of soda (washing soda), steam and carbon dioxide. When used in baked goods the carbon dioxide produces aeration during baking in the oven. The carbonate of soda is left behind in the goods. The presence of large quantities may spoil the flavour of the goods and also make yellow stains in them. Consequently, as little bicarbonate of soda as possible should be used and it should be thoroughly sifted into the flour. With goods such as parkin, which have a strong taste and colour of their own, larger quantities of bicarbonate of soda can be safely used.

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Baking powders contain an acid substance and bicarbonate of soda which combine together in the presence of water to form a salt, water and carbon dioxide. Acids release the whole of the carbon dioxide of bicarbonate of soda instead of only half as is the case with heat and instead of washing soda being left in the goods, a salt is left behind. If cream of tartar is the acid substance in the baking powder the salt formed is known as Rochelle salt. Since this salt is white and almost tasteless it is unlikely, in small quantities, to affect either the taste or the appearance of the goods in which it is formed.

Bicarbonate of soda can only combine with a definite amount of cream of tartar. For this reason it is important that the two substances should be mixed in the correct proportions in the baking powder. Otherwise the excess bicarbonate of soda or cream of tartar will have a bad effect upon the colour and taste of the goods in which the baking powder is used. The correct proportions are two parts by weight of cream of tartar to one of bicarbonate of soda.

The cream of tartar and bicarbonate of soda can only act upon one another in the presence of water. Provided they are kept dry in a closed tin they will keep indefinitely. If stored in paper packets in a damp place, the baking powder will lose "strength" because of interaction between the cream of tartar and bicarbonate of soda and consequent release of some of the carbon dioxide of the bicarbonate of soda.

Commercial baking powders frequently contain a third ingredient as a "filler". This is usually some form of starch such as rice flour or cornflour which will help to keep the baking powder dry by absorbing any small amounts of moisture with which it may come into contact. Home-made baking powders do not need this added starch provided they are properly stored.

It sometimes happens that a recipe contains an acid substance other than cream of tartar which will release carbon dioxide from bicarbonate of soda. Examples are sour milk, jam, treacle, golden syrup and vinegar.

(4) *Fermentation.*

Fermentation methods of aeration are those involving the use of yeast. We have seen that yeast is a minute plant whose chief food is sugar. It converts this sugar into alcohol and carbon dioxide. It is this change which is known as fermentation. When grape juice is fermented by yeast, the sugar it contains is changed into alcohol and the grape juice becomes wine. When malt liquor is fermented by yeast it becomes beer. Bakers make use of the carbon dioxide formed by yeast inside dough to aerate it into bread.

THE BAKING OF BREAD.

The primary ingredients of bread are flour, yeast, water and salt. Other ingredients are usually added such as milk, fat and sugar.

The flour is first of all weighed out and transferred to an earthenware bowl which has previously been warmed. An earthenware bowl is best because it is a bad conductor of heat and it is warmed because yeast ferments best when warm. The salt is next mixed thoroughly into the flour. The salt gives flavour to the bread, strengthens the gluten and acts as a yeast food. The thorough mixing of the salt with the flour is necessary to prevent too great a concentration coming into contact with the yeast and poisoning it. Three and a half pounds of flour require three teaspoonfuls of salt to produce the necessary flavour and stabilisation of the gluten. The required amount of yeast is now weighed out (1 oz. to 3½ lb. of flour) and mixed with warm water to which a little sugar may be added. The use of warm water is needed to make the yeast more active. Generally speaking the temperature of the water should be between 90° F. and 100° F. (blood heat). The object is to produce a dough temperature of between 80° F. and 83° F. and the water is cooled slightly when it is mixed with the colder flour. Yeast ferments best at a temperature of 80-83° F. A hollow is next made in the flour into which the mixture of warm water, yeast and sugar is poured until sufficient is added to convert the flour into dough. The dough is then thoroughly kneaded to ensure an intimate mixing of all the

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ingredients and complete absorption of water by the gluten. The bowl is afterwards covered with a cloth to prevent contact with draughts and consequent chilling of the yeast and placed in front of the fire to rise or "prove". The yeast ferments the added sugar and by means of its enzymes converts some of the starch of the flour into sugar as well. The carbon dioxide bubbles formed in this way are held inside the dough by the elastic gluten and the dough rises to about double its original bulk in some one and a half hours. It is then turned on a board previously dusted with dry flour to prevent the dough sticking to the board or the hands. Pieces of the dough are cut off and moulded into the required size and shape. If tins are to be used they should have been warmed and greased. The warming will prevent the dough being chilled and the greasing will make it easy to remove the bread from the tin after baking. The tins should be about half full. Because the dough is greatly distended by the carbon dioxide gas and the gluten under a great strain, the dough should be very carefully handled at this stage. After placing in the tins the dough is again lightly kneaded to bring the yeast cells into contact with fresh food supplies and again placed before the fire to rise still further. This second proving gives the dough a chance to recover from the handling to which it has been subjected, which, no matter how carefully carried out, results in some loss of gas and dropping of the dough. When the dough has risen to the tops of the tins they are placed in the oven to bake. The normal temperature for bread is 400-450° F. and the time for baking about 50 minutes.

For the first few minutes in the oven the higher temperature results in increased yeast activity and expansion of the gas bubbles and the dough rises rapidly above the top of the tin ("oven spring"). After ten or fifteen minutes the temperature becomes too high for the yeast and it is killed. All fermentation is thus stopped and the loaf is sterilised. The gluten is coagulated and the loaf "set" and fixed in shape even though the carbon dioxide escapes. The alcohol formed by the yeast is driven out by the heat and a good deal of the water of the dough converted into steam. The starch cells are burst and gelatinised, particularly those

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near the outside of the loaf, because of the greater heat. The outside layers of the loaf are dried and converted into a crust in which some of the starch is changed into dextrin and even sugar and caramel.

When withdrawn from the oven, the loaf cools and the solid crust contracts with the formation of small cracks through which steam can escape from the loaf.

The use of milk or fat in breadmaking has a considerable influence on the appearance, flavour and keeping qualities of the bread apart from the obvious increase in food value. The bread has a smoother texture, a softer crumb and a glossier crust and does not go stale quickly.

Bread is one of our most important foods. In the amounts normally eaten it provides us with something like one-fifth of our Calories and one-fifth of our proteins. Its starch provides our main source of carbohydrates. It is a cheap and palatable food. Bread made from 80 per cent. extraction flour supplies nearly half our requirements of vitamin B₁. Its deficiency in fat is compensated for by eating it with butter or margarine. Its large amount of carbohydrate makes it an excellent food to be eaten along with foods rich in animal protein and fat, e.g., cheese, eggs, meat and fish, since its protein is not first-class.

Cakes.

The primary ingredients of the various types of cakes are flour, sugar, eggs, fat and fruit.

The flour used for cake making should be a "soft" flour i.e., it should not contain too much gluten. A "strong" flour is apt to make the cake go dry quickly when it is cut and exposed to the air. Soft flour gives a softer mixing which rises evenly when baked and is less likely to rise too much in the centre.

Sugar improves the flavour and food value of a cake. It also improves its texture and appearance and helps to keep it moist. Too little sugar is likely to result in a harsh crumb while too much sugar will weaken the gluten and so cause the cake

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to sink in the middle during baking. The best type of sugar to use is castor because it easily dissolves and creams well. Coarse grained granulated sugar may not be completely dissolved and so cause specks in the cake during baking. The amount of sugar used should be between one-fifth and one quarter of the weight of the other ingredients, excluding the fruit.

Many types of fat are used in cake-making but the best is undoubtedly butter because of its superior flavour and because it creams up readily and lightly. The fat forms a film round the particles of starch and gluten in the flour thus preventing them sticking together and enabling them to expand more easily when baked. The mixture becomes more friable or "short" so that the cake crumbles readily in the mouth. Not only is the food value and texture of the cake improved by the use of fat but it also retains its moisture for a much longer period and consequently does not go stale and dry as quickly as would otherwise be the case.

Eggs are used in cakes as aerating, enriching, moistening and colouring agents. An egg should aerate its own weight of flour and in rich cakes sufficient eggs should be used to make the use of baking powder unnecessary. It is the white of the egg which acts as the aerater. The yolk increases the food value of the cake, improves its colour and supplies additional fat to act as shortening. If sufficient eggs are used for aeration there will be sufficient for moistening the mixture. Otherwise, milk will be needed as an additional moistening agent.

Fruit makes a cake more attractive in appearance and taste. Only the best quality fruit should be used and care taken to so balance the ingredients of the cake as to allow the mixture to support the fruit. Too soft a mixture allows the cherries or other fruit to sink to the bottom and so spoil the texture. The syrup should be washed off cherries and the cherries dried again before using and rubbed in flour. This prevents the syrup melting during baking and the cherries dropping as the syrup runs down the cake.

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PROPORTIONS OF INGREDIENTS.

The balancing of the ingredients is a most important factor in successful cake-making. Below are given a few examples showing the usual proportions of the various ingredients. The proportions are by weight—an egg is taken as weighing 2 ounces.

Type of cake	Flour	Sugar	Eggs	Butter	Fruit	B.P.	Milk
Plain cake ...	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	†	†
Cherry cake ...	1	1	1	1	$\frac{3}{4}$	—	—
Rich cake ...	$1\frac{1}{2}$	1	1	1	1	†	†
Birthday cake ...	$1\frac{1}{2}$	1	$1\frac{1}{2}$	1	3	—	—
Christmas cake ...	$1\frac{1}{2}$	1	$1\frac{1}{2}$	1	4	—	—
Wedding cake ...	1	1	1	1	4	—	—

† As necessary.

From an examination of these proportions the following points should be clear:—

1. The weight of sugar should not be more than the weight of flour but should be between one-fifth and one-quarter of the weight of all the ingredients, except the fruit.

2. The weight of eggs should be about equal to the weight of the flour; where this is not the case, e.g., plain cakes, baking powder is necessary for aeration and milk for mixing.

3. The weight of eggs should not be more than one and a half times the weight of the butter.

It is an interesting exercise to compare these proportions with the recipes given in your cookery book. Here are three examples.

1. *Plain Fruit Cake Recipe.*

Flour	Sugar	Eggs	Butter	Fruit	B.P.	Milk
8 oz.	3 oz.	2 oz.	3 oz.	3 oz.	1 tsp.	1 gill

We see that:—

(a) The weight of sugar is less than the weight of flour and also less than one-fifth of the weight of all the ingredients, except the fruit.

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- (b) The weight of eggs is less than the weight of flour so that baking powder and milk are needed for aeration and mixing.
- (c) The weight of eggs is less than the weight of butter.

2. *Moderately Rich Cake Recipe.*

Flour	Sugar	Eggs	Butter	Fruit	B.P.	Milk
8 oz.	4 oz.	4 oz.	4 oz.	6 oz.	$\frac{1}{2}$ tsp.	If necessary

Again we see that:—

- (a) The weight of sugar is less than the weight of flour but is now equal to one-fifth of the weight of all the ingredients except the fruit.
- (b) The weight of eggs is less than the weight of flour but twice as great as in the previous recipe so less baking powder and milk are necessary.
- (c) The weight of eggs is equal to the weight of butter.

3. *Rich Fruit Cake Recipe.*

Flour	Sugar	Eggs	Butter	Fruit	B.P.	Milk
8 oz.	6 oz.	8 oz.	6 oz.	8 oz.	None	None

Here we see that:—

- (a) The weight of sugar is less than the weight of the flour and between one-fifth and one-quarter of the weight of all the ingredients, except the fruit.
- (b) The weight of eggs is equal to the weight of flour so that baking powder is unnecessary for aeration and milk unnecessary for mixing.
- (c) The weight of eggs is greater than the weight of butter.

CAKE MAKING METHODS.

1. *Plain Cakes.*

The flour is sifted in a dry basin and salt and baking powder added. The fat is rubbed into the flour with the tips of the fingers until the mixture looks like fine bread crumbs. The sugar, fruit and other dry ingredients are next added and well mixed.

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The eggs are well beaten and poured into the mixture. If any milk is necessary it should now be stirred in gradually until the right consistency is obtained. If tins are to be used the mixture should be soft enough to drop from a spoon. If to be baked on a baking sheet the mixture should be stiff enough to be handled and moulded into shape. Baking should be done in a moderately hot oven (400-450° F.).

2. *Rich Cakes.*

The larger proportion of fat and sugar in rich cakes makes it necessary to adopt a different method of mixing from that used in plain cakes. The fat and sugar are creamed together very thoroughly by first softening the fat slightly and then beating in the sugar until the mixture is smooth, light and fluffy and looks like whipped cream. The eggs are beaten separately until thick and then stirred into the creamed mixture. The flour and baking powder are now added after being sifted. If any milk is necessary to produce the right consistency it should be added at this stage. The consistency should be thick but soft enough to pour from the mixing bowl into the tin. All the ingredients are stirred in with a circular motion until smoothly blended. Last of all, the fruit is added and stirred in gently.

The cake tins are greased and lined with greaseproof paper to prevent burning. The tins are filled about two-thirds full to allow for rising and a depression made in the middle so that the cake will be flat when risen. The cakes are baked in a moderate oven (350-400° F.)—the richer the cake the cooler the oven. When the cakes are baked they will shrink slightly from the sides of the tins and a steel knitting needle pushed into them will come out clean without any unbaked cake sticking to it. The cakes should be allowed to cool for a few minutes before removing from the tins and then carefully placed on a wire cake tray to allow steam to escape from the bottom as well as the top and sides. When perfectly cool, the cakes should be placed in dry airtight tins. Large rich cakes should be wrapped in greaseproof paper.

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CAKE FAULTS.

A perfect cake should have a smooth top and be baked an even brown all round, above and below. It should be well-risen with the top slightly rounded but not dome-shaped or cracked. Finally it should have a smooth even texture with no large holes or tunnels.

The common faults and their possible causes are given below.

1. *Cake sinking in the middle during or after baking.*
 - (a) Using too much baking powder.
 - (b) Too much butter and sugar in proportion to flour.
 - (c) Too cool an oven.
 - (d) Moving the cake before it is set.
2. *Fruit sinking to the bottom.*
 - (a) Mixture too soft.
 - (b) Damp fruit.
 - (c) Syrup in cherries, or cherries not properly dried after washing.
 - (d) Too much aerating agent.
 - (e) Opening the oven door before the cake is set.
3. *Cake cracking during baking.*
 - (a) Lack of steam in the oven.
 - (b) Tins not sufficiently lined.
 - (c) Opening the oven door before the cake is set.
4. *A dry cake which goes stale quickly.*
 - (a) Too cool an oven and too long baking time.
 - (b) Too stiff a mixture.
 - (c) The use of too much baking powder.
 - (d) Too little fat, sugar and eggs.
5. *Open texture.*
 - (a) Too much baking powder.
 - (b) Too cool an oven.
 - (c) Insufficient creaming of fat and sugar
 - (d) Careless mixing.

6. *Tunnels in cake.*

- (a) Too hot an oven.
- (b) Too much baking powder.
- (c) Mixing the ingredients too much after adding the flour.

7. *Cake too heavy.*

- (a) Too large a proportion of fat.
- (b) Mixing the ingredients too long after adding the flour.
- (c) Too much liquid.
- (d) Baking at too low a temperature or not baking long enough.

Sponges.

Sponge mixtures are similar to cake mixtures except that they contain flour, sugar, eggs and flavouring only. The same principles are involved in both mixing and baking.

Pastry.

Pastry is a mixture of flour and fat which gives a crisp and slightly risen article. It is used for giving a case or covering for both sweet and savoury mixtures. The flour used should be dry and of good quality. Butter, lard, dripping, margarine, suet or mixtures of these fats may be used as shortening. Baking powder or self-raising flour is only necessary when the proportion of fat is less than half that of the flour.

There are a number of different types of pastry according to the method used for mixing the fat and the flour, e.g.:—

Short Crust.—The fat is rubbed into the flour ($\frac{1}{2}$ lb. fat to 1 lb. of flour).

Suet Crust.—The suet is chopped or shredded finely and mixed with the flour ($\frac{1}{2}$ lb. fat to 1 lb. flour).

Flaky.—The fat is spread over the flour and rolled in ($\frac{3}{4}$ lb. fat to 1 lb. flour).

Rough Puff.—The fat is mixed with the flour and water in small pieces and rolled in ($\frac{1}{2}$ lb. fat to 1 lb. flour).

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Puff.—The fat is enclosed in the paste and rolled in (1 lb. fat to 1 lb. flour).

Raised pie-crust or hot water pastry.—The fat is melted with warm milk or water and mixed with the flour ($\frac{1}{4}$ lb. fat to 1 lb. flour).

GENERAL DIRECTIONS.

Except in the case of raised pie-crust pastry, cold water should be used for mixing and only sufficient used to bind the flour together. Too much water makes the pastry difficult to handle and the pastry is likely to bake hard. The hands and all utensils used should also be cold and the mixture handled very lightly with the tips of the fingers only in order to prevent the fat from melting, otherwise the pastry will be hard and difficult to make up. As air is the aerating agent the flour should be sifted and the pastry lightly handled. It is most important that the fat should be thoroughly mixed with the flour whichever method is adopted. Unless baking powder is being used, the pastry will be lighter and less likely to shrink when baked if it is allowed to stand for some time in a cool place before baking.

The temperature of the oven is also of great importance in pastry-making. Whatever type is being made the temperature of the oven should be high at the beginning (450-500° F.). This is necessary to expand the air bubbles and burst the starch cells quickly so that the melted fat can be quickly absorbed. Too low a temperature causes the fat to melt and run out before sufficient starch cells have been burst to absorb it. Such pastry is tough, greasy, heavy and indigestible. Too hot an oven may cause the gluten to coagulate on the outside and form a thin crust before the entrapped air has had time to expand. Such pastry is hard instead of being crisp and light. If the pastry is to be eaten cold it should be cooled slowly or it will be heavy.

CHAPTER XVI

THE KITCHEN AND ITS EQUIPMENT

In the past the planning and equipment of the kitchen were regarded as of little importance. Not infrequently the "domestic offices" were basement kitchens banished discreetly out of sight. The comfort and convenience of the housewife and the efficiency of the kitchen equipment received scant consideration. Today it is recognised that the kitchen is of primary importance and that its equipment and furnishing should come before that of any other room in the house. The housewife spends many hours each day in the kitchen. It is, in fact, the workshop of the home and, as such, should be pleasant to work in and planned for maximum efficiency and convenience.



FIG. 51. Kitchen of 100 years ago.

Crown Copyright. From a diorama in the Science Museum, South Kensington.

Types of Kitchen.

It is convenient to divide kitchens into two types:—living-room kitchens and workshop kitchens.

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For many years the kitchens of working-class houses—in other words, the vast majority—have acted as dining rooms, and living rooms as well as kitchens and washhouses. The sitting room has been a place set apart for occasional use only. The modern tendency is to design a kitchen apart from the living room and to make it a workshop only with no facilities for anything else. While both types have obvious advantages and disadvantages we shall confine ourselves here to the workshop type of kitchen devoted entirely to the preparation and cooking of food.

Size of Kitchen.

Except for the fortunate few who are planning new homes the size of the kitchen is already decided for us but we can at least see that the equipment is so placed as to give the best appearance

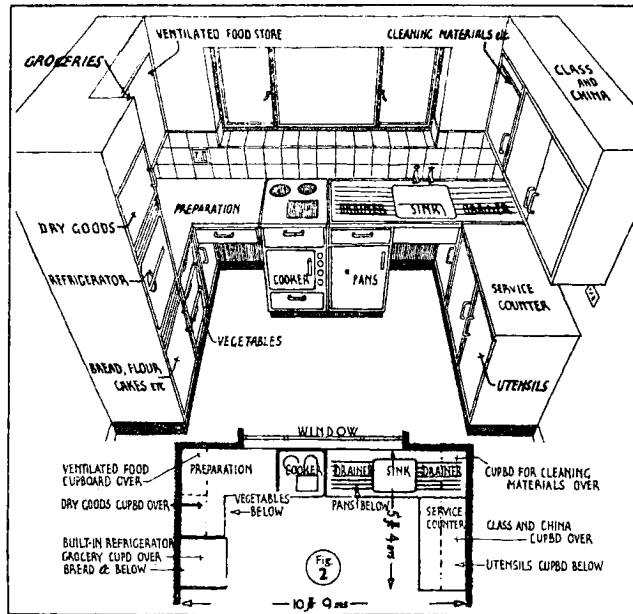


FIG. 52. Layout of a modern kitchen.

By courtesy of the British Electrical Development Association.

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and the greatest convenience. Too large a room is time-wasting and tiring; too small a room is uncomfortable to work in. The workshop-kitchen for the average household should have a floor space of about 80 to 100 square feet. With efficient planning and correct placing of equipment, this area will allow the housewife sufficient room to work in and also save her legs.

In addition, the kitchen should be situated near the back door where the food enters the house and either adjoin the dining-room or be provided with a hatch connection to it.

Shape of Kitchen.

There are three main shapes in the design of modern workshop-kitchens in which the basic requirements of working table or counter, cooker, sink and storage accommodation are placed conveniently near each other. They are:—



FIG. 53. Corner kitchen.

By courtesy of the Council of Industrial Design.

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1. CORNER KITCHEN.

This is the usual arrangement in a small square kitchen. The sink and working table are placed on one wall and the cooker on an adjoining wall. This arrangement leaves a convenient floor space for working in.



FIG. 54. Passage kitchen.

By courtesy of the Council of Industrial Design.

2. PASSAGE KITCHEN.

In the small narrow working-kitchen all the equipment can be placed along one wall. Storage fittings can be placed along the opposite wall provided a free floor space of at least $3\frac{1}{2}$ feet across is left to work in. Such an arrangement saves time and energy and is very convenient unless too much traffic passes through it to impede the housewife while she is working.

3. BAY KITCHEN.

Provided doors and windows are conveniently placed this type of kitchen can have the sink on one wall and the cooker on the opposite wall with the working table placed between them. One disadvantage of this arrangement is that it is difficult to watch the cooking while working at the sink.

Aspect.

It is preferable that the kitchen window should not face either due south or due north. In the first case, the kitchen would be too hot in summer and, in the second case, the kitchen would be cold and cheerless. South-east is the most suitable aspect so that the kitchen gets the morning sun and yet is not too hot in the afternoon and evening when the sun is setting.

If the kitchen has a larder it is important that its window should face north or north-east so that food may be kept cool and in good condition.

Walls.

The two great enemies of kitchen walls are steam and grease which can only be kept in check by regular cleaning. Consequently, kitchen walls should be resistant to steam and grease and able to withstand frequent cleaning with soap and water. The ideal finish for the kitchen walls would thus appear to be porcelain tiles, opaque glass, laminated plastic or glazed asbestos. These materials have smooth surfaces and are easily cleaned but, unfortunately, are very expensive. They might, however, be afforded behind the cooker and sink where they would be specially useful. A good enamel paint or a good varnished oil paint is easily cleaned and reasonably durable. A cheaper material still is washable distemper which is hygienic and easily applied but not very durable. An alternative suggestion is to use linoleum as a dado round the lower part of the wall with the upper part enamelled, painted or distempered.

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Woodwork.

All woodwork in the workshop-kitchen should be as plain as possible to eliminate ledges which collect dust. For the same reason, all doors should be plain "flush" doors. Enamel or varnished oil paint are the most suitable finishes for all kitchen woodwork.

Floors.

The floor of the kitchen has to withstand more wear than any other floor in the house. The ideal floor would be easily cleaned, would not absorb dirt and grease, would not take up permanent marks or stains, would be durable, resilient and comfortable to stand on, warm and non-slippery. It would also be sufficiently heat-resisting to remain unaffected by the heat from the cooking stove. Finally, it would be inexpensive. Such an ideal flooring material has not yet been produced although recent plastic linoleums with asbestos backings are very promising.

For the majority of kitchens the floor covering will be linoleum. This should be inlaid and should have a mottled finish (*jaspé*) so as not to show every mark as a plain linoleum does. In a small kitchen a large pattern on the linoleum should be avoided. If the floor is not provided with a damp course the linoleum will eventually rot unless fixed to the floor by a waterproof adhesive. The linoleum will last much longer if it has an underlay of paper-felt or even a good thick layer of newspapers. All linoleum should be fed regularly with a good polish to prevent it becoming dry and brittle. The linoleum will eventually wear round the cooker where it becomes brittle with the heat and in front of the sink where it rots through getting wet. The use of tiles under and round the cooker and sink is a great advantage.

Of the alternatives to linoleum, tiles are hard-wearing but expensive. They show every footmark and thus need constant cleaning. In addition, they are cold and noisy and tiring to the feet. Rubber floor coverings are damaged by grease and become

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tacky in course of time. Jointless composition floorings are not so cold or tiring as tiles and can be laid with a curved skirting to facilitate cleaning. The most suitable composition for kitchen flooring appears to be pitchmastic but the heat from cookers is apt to cause them to sink into it so that they should be placed on a tiled surface with the pitchmastic as a central inset on the same level.

Ceilings.

Ceilings should be painted white with a good quality flat-white paint in order to reflect as much light as possible.

Lighting.

A kitchen should be well lighted both naturally and artificially. Under ideal conditions the housewife should be able to see easily into the oven, cupboard or refrigerator at any time of the day and should never have to stand in her own light or in shadow while working in the kitchen. The light should be, as far as possible, of uniform intensity over the whole of the working space, cooker and sink.

For natural lighting, the window should be of adequate size and not placed too high up. The artificial lighting is best provided by an electric light from or near the ceiling. Instead of a glaring bulb and a dangling flex, the electric lamp can be totally enclosed in an opal glass globe suspended from the ceiling by a rod or fitted flush with the ceiling, according to the height of the kitchen. In this way, glare is avoided and the collection of dust prevented. The lighting should always be more than is generally regarded as adequate. Even though the workshop-kitchen is small it is false economy to use a lamp of less than 100 watts. White ceilings and light-coloured walls reflect the greater part of the light falling upon them while dark-coloured walls absorb much of the light.

If one ceiling light is insufficient, then extra lighting fittings of smaller power may be necessary at such important points as the sink or cooker. For safety's sake the light over the sink should

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have remote control, e.g., by a cord, but in the case of the cooker it is convenient to have the switch close at hand.

Fluorescent lighting of the "warm white" type is suitable for the kitchen because it is practically shadowless. The initial cost of installation is higher than with ordinary fittings but it is cheaper to run.

Ventilation.

The ventilation of the kitchen requires careful consideration. Good ventilation reduces the condensation of steam which is so detrimental to the walls, prevents cooking odours penetrating into the rest of the house and keeps the kitchen cool. It is often inconvenient to have the kitchen window open but, if it is a sash window, a piece of wood about eight inches wide and the exact width of the window can be placed on the window sill under the bottom sash and the window lowered on to it. A current of cold air will enter where the two sashes overlap. If the top sash is lowered slightly the hot air and steam of the kitchen will quickly escape.

Where ventilation difficulties are encountered an electric extractor fan can be installed.

Curtains.

Curtains in the kitchen should be bright and cheerful but not with much or too big a pattern if the room is small. The colour should be fast and the fabric of the curtains hardwearing and easily washed. The new plastic or oil silk materials can easily be wiped clean but sometimes perforate and split when seamed. They are liable to make the kitchen stuffy when tightly drawn as air is unable to pass through them. Of the ordinary fabrics, gingham is probably best.

Colour Scheme.

In a small room such as the workshop-kitchen it is important that the colours of walls, woodwork, equipment and so on should

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match each other or it will look smaller still. Large surfaces such as walls, cupboards and other large pieces of equipment should be light in tone so that the housewife does not tire of them. Stronger colours can be used in curtains, handles to doors and drawers, and shelf coverings to give a cheerful and more homely touch.

Kitchen Equipment.

The work carried out in the workshop-kitchen includes the storage and preparation of food, the cooking and serving of the food, washing-up and the storage of china and utensils. These processes take place several times a day and demand good lay-out, efficient appliances and convenient storage accommodation. To carry them out the housewife's main items of equipment will be:—

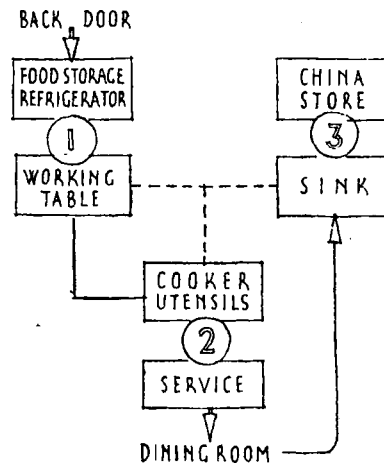


FIG. 55. Routine of food preparation, cooking and serving.
By courtesy of the British Electrical Development Association.

1. FOOD STORAGE AND PREPARATION.

Perishable food store, vegetable store, dry goods store, working table or counter with drawer and/or cupboard for knives, forks, spoons, rolling pin, baking tins, etc.

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2. COOKING AND SERVICE.

Cooking stove and storage for cooking utensils, etc.

3. WASHING-UP AND CHINA STORAGE.

Sink, draining boards, recess or shelf for soap and scouring materials, means for drying tea cloths, refuse container, cupboards for china and glass and drawers for linen and cutlery.

To make the routine work as easy as possible the equipment and storage accommodation related to each process should be grouped together in the most convenient way. Unfortunately in small kitchens it is not always possible to arrange clear-cut groupings and a compromise may have to be made. Ideally, the large pieces of kitchen equipment should be placed so as to follow the normal sequence of work in preparing, cooking and serving a meal. This would mean that the food storage and refrigerator would be near the back door where the food enters the kitchen. Next in sequence would come working table or counter, followed in rotation by cooking stove and utensil storage, sink and china storage. In particular, the principal kitchen fittings—cooking stove, sink and working surface—should be arranged as near to one another as possible.

After the meal is over, the return journey is in exactly the reverse direction—from kitchen table to sink and china cupboard or larder and refrigerator.

Working Space.

The old-fashioned large kitchen usually had a large kitchen table placed in the middle of the floor where it could easily be reached from all sides. In the modern small workshop-kitchen this arrangement would take up too much valuable space. Economy in space can be effected by using unit fittings which provide generous surface space to work on as well as ample storage space in the form of drawers and cupboards below. Modern kitchen units are made to a standard height of 36 inches and can be placed on either side of the cooker or sink and so provide usable

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working space ranged round the walls. The units are made of enamelled steel, stainless steel, plated aluminium or painted wood.

If space permits, a small table or counter in addition to the tops of unit fittings is a great advantage. The height of the table or counter should be 30 inches instead of the 36 inches of the unit fittings as for some purposes this lower height is more convenient. If there is insufficient room for a table or counter, an adjustable flap fixed to the wall may be a possibility. If space allows, the length of the kitchen table or counter should be at least three feet and its surface easily cleaned, but not easily stained, chipped or roughened. Hard wood, stainless steel, vitreous enamel or good quality linoleum all give suitable surfaces. Soft wood, such as deal, needs constant scrubbing and this roughens the surface and makes it absorbent. It should be possible to fix a mincer to the edge of the table. A chair or stool which can be placed under the table or counter is a valuable piece of kitchen furniture and not a luxury.

If a counter is used and the space underneath filled with a cupboard it should be so placed as to leave at least two inches space from the floor for the housewife's toes so that she can stand conveniently close to her work and avoid back strain. The depth of the counter top should be at least 21 inches.

Storage Space.

Storage space will consist of cupboards, shelves and drawers. They should be so arranged as to provide adequate storage space at each of the three working points, i.e., table, cooking stove and sink. Thus groceries and cooking tools should be within easy reach of the table, pots and pans near the cooking stove and cleaning materials near the sink.

A cupboard or unit fitting that stands against a wall should either be the correct height to serve as a table top or should go right up to the ceiling. If the top is to be used as a table there should be a toe recess beneath it. A cupboard or unit fitting reaching to the ceiling more than doubles the storage space and is a boon

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in a small kitchen. Articles in constant use should be arranged on shelves or in drawers easy to reach, i.e., between two feet and five feet nine inches from the floor. Less frequently used articles and reserve stores can be placed in the upper part of the cupboard or unit fitting.

Cupboards or unit fittings standing on the floor should be either flush with the floor to cut out cleaning underneath or should be high enough from the floor to enable the space underneath to be easily cleaned.

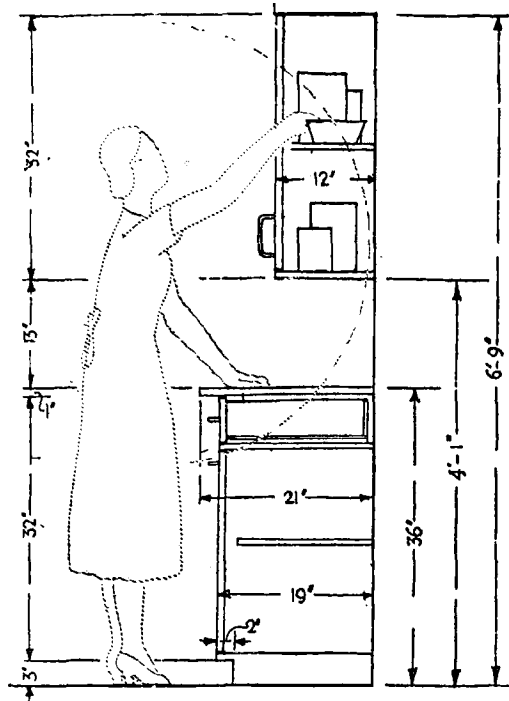


FIG. 56. Cupboard accommodation.

*By courtesy of the British Electrical
Development Association*

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Shelves should preferably be narrow and adjustable for height and should fit firmly but be easily removable for cleaning. Their surfaces should be easy to clean and strong enough to stand up to frequent cleaning. A gap of half an inch at the back greatly facilitates cleaning. Shelves for pots and pans are best made of strong metal mesh which allows the pans to dry off thoroughly. In the very small kitchen, sliding doors are convenient. They do not get in the way as doors which open outwards are liable to do when space is limited.

Wall cupboards fitted over a table or counter or fixed to a unit fitting with table top should be at least 15 inches above them or the working space will be practically useless. In addition, the depth of the cupboard should be sufficiently small compared with the working space below to allow freedom of movement while at work. Thus, if the depth of the working space is 21 inches that of the cupboard above it should be no more than 12 inches.

Drawers for cooking utensils should be shallow, otherwise valuable space is wasted and the utensils are apt to pile on top of one another and cause rummaging and damage. Drawers for kitchen cloths should be deeper as cloths can be kept in neat piles.

If larder space is provided it should be cool, dark, airy and flyproof for the storage of perishable goods. Kitchens without larders or refrigerators can utilise a food safe fitted on an outside wall facing east or north. Milk and butter coolers are useful in summer where there is no larder or refrigerator. They are made of porous unglazed earthenware which readily absorbs water. Before being placed over the milk or butter they should be soaked in cold water. The water in them will evaporate and, in so doing, will absorb heat from the surroundings and so keep the food cool. The most efficient kind are those with double walls between which water is poured.

Refrigerators.

Larders are seldom efficient in storing and preserving perishable foods and a refrigerator for these purposes is desirable. It

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not only prevents waste but allows much greater variety in the menu. Unfortunately, refrigerators are still too expensive for the majority of housewives but the day will come when every working-kitchen will be fitted with its refrigerator. Those able to afford a refrigerator should make sure that it is big enough for their needs and should look after it carefully by keeping the door shut and "defrosting" it regularly. A refrigerator of ample size—one cubic foot of storage space for each member of the household—a smaller cupboard on the wall and a vegetable cupboard under a counter top make a larder unnecessary.

Electric and gas refrigerators are made but both work upon the same basic principles and only differ in details. A liquid boils when its vapour pressure is equal to that of the surrounding atmosphere. Thus, water boils when it is heated to 212° F. because at that temperature its vapour pressure becomes equal to that of the atmosphere. Alternatively, a liquid may be made to boil by reducing the external pressure until it is equal to the vapour pressure of the liquid. In order to evaporate at this reduced pressure the liquid absorbs heat from its surroundings. In this way, intense cold can be produced by the rapid evaporation of a liquid under reduced pressure. This is precisely what takes place in a refrigerator.

Refrigerators are of two types:—the compression type and the absorption type. Those worked by electricity are usually compression refrigerators and those worked by gas, usually of the absorption type.

The compression refrigerator has four main parts:—the food-storage chamber, the compressor, the condenser, and the evaporator or "freezer." These components are usually assembled in one cabinet with the food-storage chamber surrounded by insulating material, such as granulated cork or slag wool, to prevent heat passing through from the outside. Some chemical substance which is easily liquefied by pressure, e.g., sulphur dioxide, methyl chloride or dichloro-difluoromethane is used as the refrigerant.

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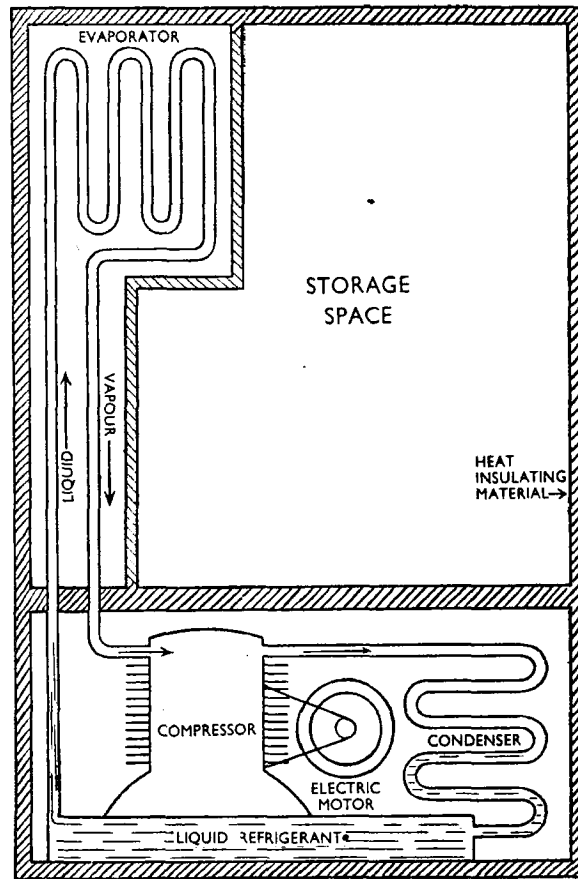


FIG. 57. The working of an electrical refrigerator.

The continuous cycle of operations, which is controlled by a thermostat, is briefly as follows. The compressor, which is driven by a small electric motor, exerts pressure upon the gaseous refrigerant which at the same time is cooled in the condenser by a current of air produced by a fan operated by the electric motor. The

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refrigerant is thus liquefied and in this form passes in small amounts to the evaporator where it expands and evaporates. In its evaporation it absorbs heat from the food-storage chamber which is thus cooled. The gaseous refrigerant is then drawn into the compressor again and reliquefied. This cycle of operations is continuous and heat is abstracted from the storage chamber at each cycle. The controlling thermostat is in the form of bellows which contain a gas. The expansion and contraction of this gas with rise and fall in temperature switches the electric motor on or off when suitable minimum and maximum temperatures are reached. The minimum temperature is usually 32°F., and the maximum 50°F. Most foods keep best within this range of temperature.

The absorption refrigerator has a solution of ammonia gas in water as its refrigerant. The ammonia gas is liberated from its solution in water by a small gas flame, electric element, oil burner or even a "bottled" gas burner, under the boiler. The ammonia gas then passes to the condenser where it is liquefied by means of water or air circulating round it. The liquefied ammonia is led into the evaporator with some hydrogen where it expands and changes to ammonia gas with the absorption of heat from the food storage chamber which is thus cooled. The gases produced are then led to the absorber and the ammonia gas re-dissolved in water. The ammonia solution is then conveyed back to the boiler while the hydrogen gas, which is not absorbed, is led into the evaporator. Thus the whole cycle of operations is completed.

In the absorption refrigerator, refrigeration is produced by heating only. There is no compressor as in the compression refrigerator and consequently no electric motor is necessary. The absorption refrigerator is consequently completely silent in operation. A water supply is, however, needed if the condenser is cooled by water instead of by air. Refrigeration is produced continuously as long as heat is applied to the boiler. The amount of heating is automatically controlled by a thermostat inside the refrigerator.

When using a refrigerator, foods should not be so crowded together as to prevent free circulation of air. The foods should

be covered to prevent drying out and the transfer of odours from strong-smelling foods to other foods. The door of the refrigerator should be kept tightly closed and only opened when necessary. Finally, the refrigerator should always be kept clean, inside and out, and defrosted, i.e., excessive ice removed from the evaporator or "freezer" at regular intervals.

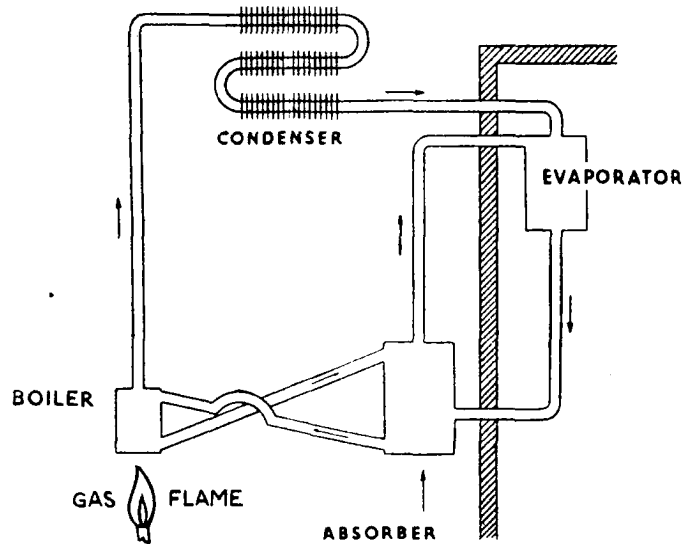


FIG. 58. The working of a gas refrigerator.
By courtesy of the Gas Council.

Cooking Stoves.

The cooking stove may be heated by solid fuel, gas, electricity or oil. Modern cooking stoves, whether solid-fuel, gas, electricity or oil heated, are now so efficient and reliable that any poor results obtained with them should be put down to the faulty adjustment of the stoves or the housewife's mismanagement of them. Each type of cooking stove has its own particular advantages and disadvantages and the choice between them becomes largely a question of cost, convenience, services available, and personal preference. Whichever is chosen it should be able to deal easily with all

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the cooking required, easily controlled, easily cleared, quickly heated and attractive in appearance.

SOLID FUEL COOKERS.

Solid fuels include the different varieties of coal, such as ordinary bituminous coal and the smokeless Welsh steam coal and anthracite, as well as coke and patent smokeless fuels.



FIG. 59. Preparing the midday meal in the farmhouse kitchen.
Copyright. C.O.I.

By courtesy of the Central Office of Information

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The old-fashioned coal range has largely been superseded by gas, electric or heat-storage cookers, but many people have of necessity to use one. Such ranges take up a lot of space, are very wasteful of fuel and make the room very dirty because of dust and smoke. They entail a great deal of work in keeping them clean and in lighting, stoking and cleaning out. In summer time they make the kitchen uncomfortably hot; on the other hand, they can be used to supply the household with hot water, and warm the room as well as cooking food. Some housewives are quite prepared to put up with the inconvenience and work of the coal range for the sake of a cheerful blaze in the kitchen.

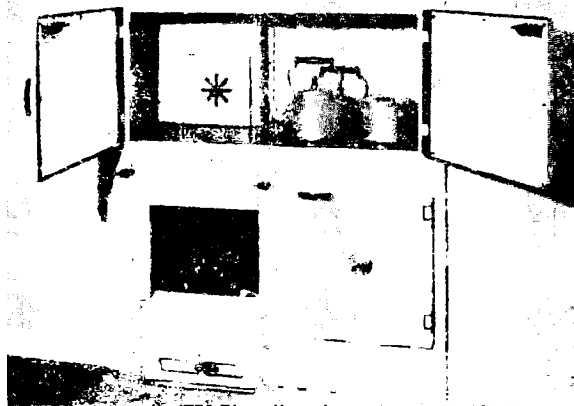


FIG. 60. Modern coal range.
Women's Advisory Council on Solid Fuel.

Nowadays there are improved kitchen ranges and combination grates in vitreous enamel which are modern in appearance, much more easily cleaned and burn fuel more economically and with less dirt and smoke.

In addition to the open coal range there are two types of solid-fuel continuously-burning cookers. They are the fully insulated heat-storage cooker and the semi-insulated cooker.

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In the *heat-storage cooker*, the fuel is burned continuously at the same rate in a fire-box totally enclosed in the centre of the cooker. Considerable wastage of heat occurs during periods when the ordinary solid-fuel range is not actually in use but in the heat-storage cooker this heat is stored in a heavy iron block above the

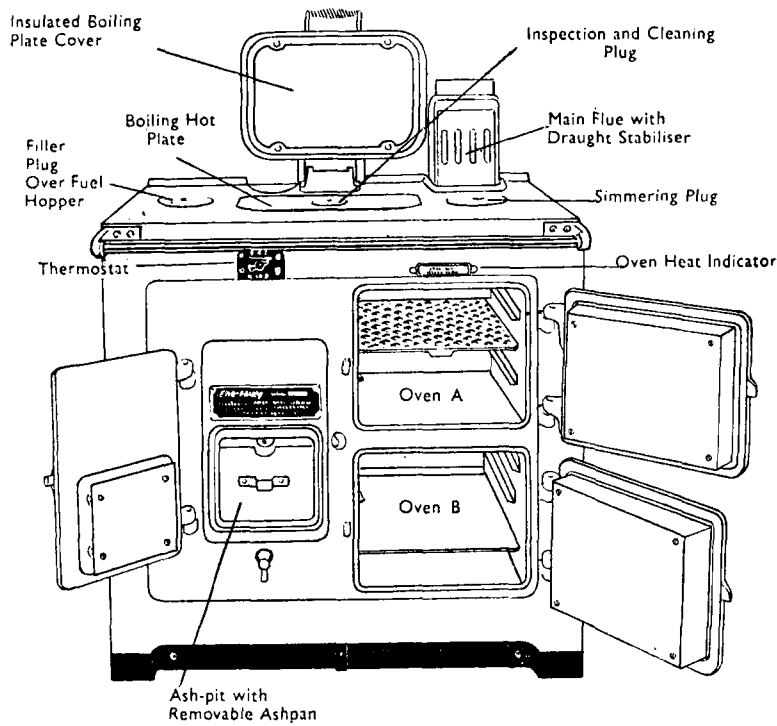


FIG. 61 The Esse cooker.

By courtesy of Smith & Wellstood.

fire (the hotplate) and in the heavy castings surrounding the ovens. The hot-plate is fitted with an insulated hinged cover to prevent the loss of heat when the hot-plate is not in use. The ovens and hot-plate are thus always at working temperatures. A typical

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design for the ordinary small household has a hot roasting oven on the right-hand side with a temperature of 400—450° F., a medium-heat oven under the fire-door with a temperature of 300—350° F, and a simmering oven with a temperature of about 200° F. Some types have a hot water boiler fitted. The usual fuels for the heat-storage cooker are coke or anthracite.

The *semi-insulated solid-fuel cooker* is cheaper than the heat-storage cooker and more flexible in use but less economical in fuel. With the semi-insulated cooker the rate of combustion of the fuel can be varied by air and damper controls to boost up the fire when cooking. Unlike the heat-storage cooker its fire can be opened and used to warm the kitchen. One type is made in two parts which are built back-to-back in one wall so that the oven half can be in the kitchen and the fire part in the dining room.

The great advantages of the continuous-burning solid-fuel cookers are their attractive appearance and their cleanliness and labour saving, since there is no smoke and very little dust. Their fuel consumption being very low they require very little stoking and are cheap to run. Their continuous burning gives convenient, immediately available service and a balanced range of cooking temperatures suitable for all purposes. Their disadvantages are that they are expensive to buy and need a flue pipe. Ground-based pans should be used to make good contact with the hot-plate and so heat more rapidly. They give best service with the particular fuel for which they are designed.

GAS COOKERS.

In gas cookers the heat comes from open flames and the cooking is done by heat which flows round the saucepans or through the oven and then escapes either directly into the air or through suitable vents. Unlike the closed ovens of the solid-fuel, electric or oil types, the gas oven is open below to admit air to burn the gas and consequently convection currents are much stronger.

In recent years great advances have been made in the technical efficiency of the gas cooker. Its vitreous enamel finish gives it an

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attractive appearance and makes it easy to clean. Insulation of the sides helps to retain the heat, reduces gas consumption and keeps the kitchen cool. The Regulo thermostatic control makes the

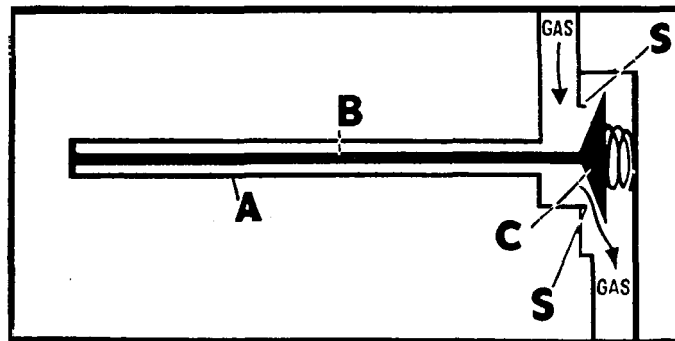


FIG. 62. The thermostat.

The thermostat is a simple device for controlling the temperature in cooker ovens and some water heaters. Its action depends upon the fact that some metals expand more than others when heated.

The brass tube A in the diagram encloses a rod B, made of special steel, to which is attached a valve C. The valve C regulates the amount of gas flowing to the burner.

When the gas is burning, the brass tube becomes heated and as it expands it carries with it the inner rod B, which expands very little, and brings the valve head C closer to its seating S, thus reducing the flow of gas. Should the air in the oven or the water heater cool down, the brass tube becomes less hot, contracts a little, and moves the valve C slightly away from its seating and so allows more gas to pass to the burner until once again the proper temperature is reached.

By courtesy of the Gas Council.

gas oven extremely easy to use, corrects for the chilling effect of placing cold food in the oven, cuts down the gas as the food becomes hot, adjusts automatically for any variation in gas pressure and maintains a constant cooking temperature.

In the modern gas cooker the oven and hot-plate sections are built as separate units, carried in a light structural frame from which either unit can be withdrawn. The outside casing is easily demountable. Extensive use is made of vitreous enamelled sheet

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steel, cast iron being used where direct flame contact or very hot gases are encountered, e.g., burners, hot-plate pan supports and burner chamber nozzle, and where structural strength is necessary, e.g., the top back plate and the gas rail. New vitreous enamels have been used for the hot-plate top and pan supports where heat resistance, corrosion resistance and a smooth finish are important.

The whole oven is designed to economise in gas and to be

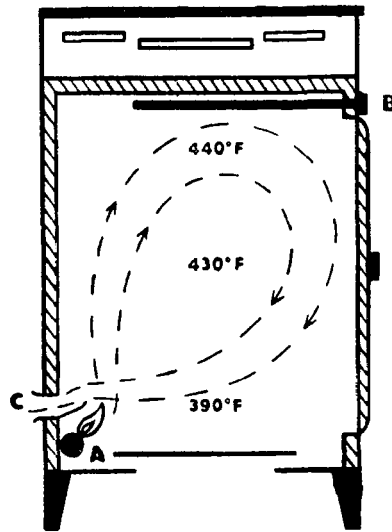


FIG. 63. The working of the gas cooker.

The drawing shows a side view of a popular type gas cooker, with gas pipes omitted. When burner A is lighted the heat rises (as shown by arrows), causes thermostat B to expand (automatically controlling the gas supply) and then flows round the oven and out of vent C.

With the thermostat at a medium setting, the temperature in the upper part of the oven is about 440° F.; in the middle of the oven it is 430° F. but about 390° F. at the bottom (temperatures measured with special thermometers). The upper two-thirds of the lighted oven are therefore hotter than the third at the bottom. This enables dishes requiring different temperatures to be cooked in the oven at the same time.

By courtesy of the Gas Council.

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easily cleaned. The oven shell, which is made in one piece, is secured to the front frame by four insulated bolts. The oven is thus suspended in air. This and the lagging of the oven with a blanket of glass wool covered with aluminium foil reduce the loss of heat by conduction to the frame to a minimum. The oven door beds on a springy strip of metal and the latching works on the cam principle so that when the door is closed the oven is effectively sealed. The oven burner is enclosed in a box finished in heat-resisting enamel and the hot gases directed into the oven in the best path.

Gas cookers have the advantages of labour saving. No fuel has to be carried and they do not need stoking. Since there are no flues, dust or smoke, they are easily kept clean. They are extremely flexible in use. Heating by gas to exact times and temperatures is easy because of the immediate response to any adjustment in fuel supply. The gas oven reaches the required temperature, say for roasting, more quickly than the electric or any other type of oven, and is thus faster in cooking and saves time. The gas oven is relatively cheap to hire or purchase and is inexpensive to use since the exact amount of fuel only need be consumed.

The disadvantages of gas cookers are that they cannot be used to heat a water supply nor to heat the kitchen. They cannot be installed in districts without a gas supply although they can be used with "bottled" gas, such as Calor gas, Butane gas or Propagas, supplied in cylinders.

ELECTRIC COOKERS.

The framework of a modern electric cooker is of cast iron with sides and back of enamelled steel plate. The oven is totally enclosed and well lagged with insulating material such as slag wool. The maximum amount of heat from the heating elements is thus retained for the longest possible time—in fact, much can be cooked after the oven switch has been turned off.

The illustration on page 238 shows an electric cooker suitable for a family of up to six people. The two boiling plates, grill boiler, hot cupboard, oven and separately heated warming drawer can be seen clearly. Electric cookers, with smooth surfaces and

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rounded corners, are usually supplied in white, cream, or mottled grey, but other colours can be had. All parts of the cooker can be used separately, or two or more parts can be used simultaneously if required. *The boiling plates* are controlled by an infinitely variable control or *simmerstat*. By this means, any degree of heat from the slowest simmer to fast boiling can be obtained as desired.

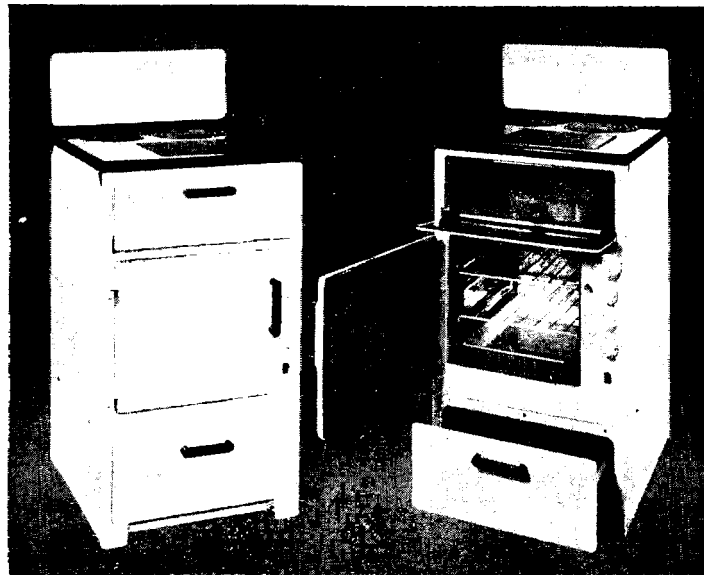


FIG. 64. Electric cooker.

By courtesy of the British Electrical Development Association.

The grill boiler is controlled by a three-heat switch. The large grill pan slides on runners into position under the even heat of the grill. Vegetables, sweets, coffee, or anything else required, can be cooked on the top during the grilling process. When the plate is to be used for boiling only, or drop scones, etc., a shiny deflector plate, placed below, directs the heat upwards, thus making another boiling plate. Several pans can be kept boiling at the

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same time on each of the plates. An electric kettle can be plugged into the separately controlled socket on the cooker control unit.

The oven is well insulated so that the heat is kept, where it should be, inside. The oven is controlled by a thermostat, i.e., an automatic switch. The dial is set to the required degree of heat and a red light shows. When the heat is reached, the light and the current are cut off automatically. The current will switch on and off automatically to keep this degree of heat as long as required.

The advantages of the electric cooker are that it is easy to use, and labour saving since it requires no fuel-carrying or stoking. It gives a very even heat, produces no smell, dust or smoke, is easily cleaned and is not expensive if used intelligently. For example a well-insulated oven will finish cooking a joint if the current is switched off when the desired temperature is reached. An electric oven can be placed practically anywhere in the kitchen—there is no restriction in the siting of the oven since the fixing of a flue or the problem of draughts do not arise.

Its disadvantages are that it does not heat the water supply, cannot be used to warm the kitchen, takes some time to reach the desired temperature and can only be used in districts where there is an electricity supply.

OIL COOKERS.

Oil cookers are much more efficient than is generally recognised. The larger models usually have a portable oven to fit over one or two of the burners. The oven can be set aside when all the burners are required for boiling. If the cooker uses a circular wick, its efficiency and clear burning will depend upon the cleanliness of the wick and burner. Oil cookers with burners fitted with asbestos collars (called kindlers) instead of wicks, give a particularly clean hot flame but are not as flexible. The pressure type of cooker is quicker still but the jets must be regularly cleaned and occasionally renewed. The pressure type requires care and intelligence in use. All types of oil cookers should be protected from draughts.

Oil cookers have the advantage of being usable where gas and electricity are not available. They are easily managed,

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economical and portable. The oven placed over the burners is at a height which saves stooping to put food into it, and is fitted with vitreous enamel lining for easy cleaning.

Their disadvantages are that they are smelly if not kept perfectly clean and the fuel is inflammable. Since they are not insulated, the ovens of oil cookers cool quickly when the flames

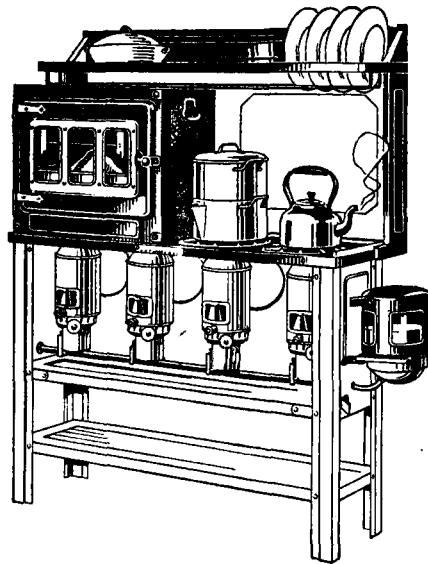


FIG. 65. The Valor oil cooker.
By courtesy of the Esso Petroleum Company, Ltd.

are extinguished, but are constructed with a double wall to reduce loss of heat.

Sinks.

The sink is usually fixed on an outside wall below a window to reduce plumbing costs and to allow work at the sink to be done in a good light. The wall round the sink should be of some smooth, easily-cleaned material, e.g., tiles, enamel or oil paint. The floor immediately beneath the sink should be of some smooth,

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easily-cleaned waterproof material, the best of which is tiles. The hardness and coldness of tiles can be avoided by standing on a slatted wooden board. The height of the sink should be 36 inches for the average person and a toe recess should be left below if the sink is fitted with a cupboard underneath.

Stone and fireclay were formerly used for sinks but these materials are difficult to keep clean and have now been replaced by glazed earthenware, sheet steel finished with vitreous enamel, stainless steel, aluminium or an alloy of nickel and copper, known as Monel metal, which neither rusts nor tarnishes. All materials used for sinks should be able to stand up to heavy usage. Metal sinks and draining boards can be made in one piece by pressing a single sheet of the metal. This is a great advantage.

The length and breadth of the sink will vary according to the size of the kitchen and the amount of work to be done in it but the depth should never be less than 9 inches. All sinks should be fitted with a rubber plug and chain and the waste pipe should have a grating. All sinks should have an overflow grating and pipe. Even if space is limited it is a great advantage to have a draining board on each side of the sink. They should slope slightly towards the sink and be grooved to enable water to drain away easily, but not so steeply sloped as to allow plates to slide. If not moulded with the sink, they should be easily removable for cleaning and should slightly overlap the sink. The joints with both sink and wall should be greaseproof and waterproof. If wooden draining boards are used, they should be made of hard, non-absorbent wood such as teak. Failing teak, home-grown sycamore or Dutch elm are suitable alternatives.

The taps should be correctly placed so that the spouts are at least 12 inches from the inside bottom of the sink. A bucket or large jug can then be conveniently placed inside the sink for filling. The pillar type single tap with one spout for hot and cold water is particularly convenient for the kitchen sink. Since kitchen taps are given very hard use they should be so constructed as to make it easy to renew worn out washers. Kitchen taps should preferably be of plated metal to reduce cleaning.

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A plate rack which holds the crocks firmly and drains them effectively is a useful adjunct to the sink. Such a rack may be of wood, rustless metal or plastics. It should be easily cleaned and simple in design. It is best fixed above a draining board and should have a detachable tray on which the plates and dishes can drip.

Small Equipment.

KETTLES.

For the average small household a three-pint kettle is the most convenient size. For gas and oil cookers a good quality aluminium kettle is most suitable. Time and fuel will be saved if the kettle has a finned base. Tin kettles do not last long and copper kettles take time to polish. For electric cookers of the hot-plate type an immersion-heated electric kettle is needed to save fuel. With solid-fuel cookers, close contact with hot-plate is essential for quick boiling. A heavy aluminium kettle with a machined bottom or ground base is most suitable.

All kettles should have spouts which pour cleanly without dripping. The handle should be insulated and firmly riveted. It should be so shaped as to allow it to be grasped without the hand getting into the direct line of steam when the lid is off for refilling. The lid should fit well and have a strong edge to withstand hard wear. The knob should be insulated and securely fixed. A small vent in the lid to allow steam to escape prevents the lid from rattling and the water from bubbling over when the kettle boils.

SAUCEPANS.

For the average small household the essential minimum is three lidded saucepans of different sizes and a "milk" saucepan with a lip. Aluminium saucepans should be of good thick quality and have machined bottoms, otherwise they will be liable to buckle, cook unevenly and cause the food to stick and burn. Cast aluminium and cast iron saucepans are hard wearing and quickly take up the heat. Enamel saucepans should be of the best quality, otherwise enamel will quickly chip and the pan "burn." For

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electric or solid-fuel hot-plates it is essential that the saucepans should be absolutely flat based so as to make complete contact with the hot-plate and thus heat quickly. All handles should be insulated and sealed at the ends. They should be comfortable to grip and well riveted to the pan. The lids should be strong and well-fitting with insulated knobs or handles and no unnecessary grooves or ridges to make cleaning difficult. Finally, the whole saucepan should be well balanced.

FRYING PANS.

Only one frying pan is needed for the small family. An eight-inch pan is most suitable. As with other pans it should be thick and heavy. Thin pans easily buckle and fry unevenly with the result that in some spots the food is burnt and in others uncooked. The handle should be insulated, sealed and firmly riveted. The whole pan should be well balanced.

For deep fat frying the pan should be deep but not too wide and should be fitted with a strainer.

STEAMERS.

Steamers can be purchased which fit several sizes of saucepans but with large saucepans they are liable to sink so far in as to leave little room for cooking anything underneath. With tiered steamers it is possible to cook a whole dinner on one burner or hot-plate. Steamer handles and the knob on the lid should be insulated.

CASSEROLES.

At least two casseroles with lids are advisable. Casseroles hold the heat well and can be used on the table and so save dishing and washing up. They may be made of earthenware, glass or metal with various finishes. The best types are those with a lid that can be used as a separate dish when required. Casseroles made of special heat-resisting glasses, such as Pyrex and Phoenix, are particularly suitable. In addition to the silicates of which ordinary glass is composed, they contain borates which enable them to with-

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stand very high temperatures without softening. Their coefficient of expansion is lower than that of ordinary glass. Consequently they can be quickly cooled without danger of cracking.

ROASTING TINS, BAKING TINS, CAKE TINS.

One roasting tin, one baking tray, one cake tin (6 inches), two sandwich tins (8 inches), two bun tins to hold twelve buns each and one deep plate will probably meet average requirements. All should be of good heavy quality so as not to buckle or cause food to burn. Cakes baked in thin tins will rise and brown unevenly. Tins with rolled edges do not cut the hands, are stronger and keep their shape better than those with unrolled edges. In addition, liquids and grease are prevented from falling into the oven. The tins may be made of non-rusting tin-plate or aluminium. Roasting tins and baking trays should fit comfortably into the oven and leave at least 2 inches all round to allow free circulation of hot air.

CUTTING TOOLS.

A sharp pointed vegetable knife and a good medium-sized cook's knife for chopping are essential. Other knives, e.g., a saw knife for slicing tomatoes and vegetables and a saw-edged bread knife are also useful. All kitchen knives should be made of hard steel and preferably stainless with the blade well riveted. A broad-bladed flexible palette knife with rounded end can be put to many uses in the kitchen. So also can a stout pair of easily handled scissors. A knife sharpener of the hard steel disc type can be used for both stainless and ordinary steel blades and does not mark or scratch the blade. The familiar "steel" can be used for ordinary steel knives and so can carborundum sharpeners. The kitchen step is not intended to be a knife sharpener!

Many people prefer a potato peeler to a knife. It is quicker and more economical in use. A can-opener of the "handle into jaws" or rotary type and a few forks, are other essential small items of kitchen equipment. A two-pronged fork is useful for dishing and so on.

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SPOONS.

The following metal spoons will be needed:—a tablespoon, dessert spoon, teaspoon, cook's perforated spoon and a soup ladle. The last two should have handles of wood or other insulating material. All spoons should be simple in design, well-shaped, comfortable to hold and robust without being clumsy. A set of measuring spoons is of great assistance in cooking (p. 246).

Two or three wooden spoons of varying sizes are needed for stirring sauces, batters, jam and so on. They should be of hard, close-grained wood so as not to splinter or lose their smooth finish. Their shape should be such as to make contact with the bottom and corners of pans possible. Rounded wooden spoons are better than oval but the best spoons are level at the bottom.

WHISKS.

Whisks may be of the hand type or rotary type. The hand type is preferable for whisking small quantities and the rotary type for larger quantities of eggs.

PASTRY BOARDS AND ROLLING PINS.

A pastry board is unnecessary if the table or counter has a hardwood, aluminium or enamelled top. A piece of American cloth will serve the same purpose. If a pastry board is used it may be of wood or pottery. Wooden boards should be made of evenly grained hard wood, free from knots. Pottery boards give a cool surface which is easy to keep perfectly clean.

Whether made of hardwood, glass, china, plastic or aluminium, the rolling pin should be straight, smooth and fairly heavy. If the handles are loose it is easier to roll lightly.

The pastry board should not be used as a chopping board. A separate hard wood board should be used for this.

A pastry brush is useful and should have its bristles firmly secured to the handle since it has to stand up to cleaning in very hot water.

STRAINERS, SIEVES AND COLANDERS.

It is best to have a coffee strainer, a pointed strainer and a round strainer. They should have a hook on the rim opposite

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the handle to fit over the vessel into which the liquid is being strained. The wire mesh should be strong and should fit perfectly into the rim.

Sieves are made of wire or hair and have meshes of various sizes. The wire or hair should be lightly and firmly fixed into the frame. Wooden frames are more durable than all-metal ones.

Colanders may be of enamelled iron, aluminium, or plastic and can be purchased with or without handles. The usual size has a diameter of 10 inches. The holes should be smoothly finished, the surface rustless and the colander should stand firmly on its base.

GRATERS.

Two-way graters with the teeth set in alternate rows, one row facing downwards and the next upwards, are most suitable for grating raw vegetables, cheese and breadcrumbs, since they give continuous grating with both upward and downward movements of the hand. Wire mesh graters serve the same purpose and have the advantage of not grating the fingers. Graters of both types should be so shaped as either to stand up in a bowl or to hook on to the bowl without slipping.

Graters may be coarse, medium or fine. Coarse graters are used for suet and vegetables, medium for breadcrumbs and fine for nutmegs. The three types can be combined in round or three screen graters. All graters should be rustless and easy to clean. If it can be afforded, a rotary mill is excellent for nuts and cheese.

SCALES AND MEASURING CUPS AND SPOONS.

Good kitchen scales are a necessity if reliable results are to be obtained. The two main types are the beam type with separate weights and the spring balance type which shows the weight on a dial. The beam type is more accurate and lasts longer. Whichever type is chosen it should be sufficiently sensitive to weigh small amounts accurately. The 5 lb. size will be big enough for the small family. The weights of the beam scale should be Government-stamped. The pan may be plain or enamelled metal

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or plastic. It should rest firmly and evenly on the scales. Scoop-shaped pans make for easier pouring than round ones.

Measuring cups and spoons are obtainable for use with recipes where cupfuls and spoonfuls are given instead of pounds or pints. The cups may be half pint size with smaller quantities clearly marked or a nest of cups, one for each quantity. Lipped cups for liquids and unlined cups for dry goods can be purchased. The measuring spoons are circular to make them more accurate.

BOWLS, BASINS AND JUGS.

Mixing bowls should be of a good size, say 12 inches, as beating and mixing are more easily done in a large bowl than a small one. The sides should be slightly curved to prevent food from being scattered during beating.

pudding basins should have well-moulded rims to allow paper or cloth to be tied to them easily and securely.

Jugs should have wide level bases so that they are not easily knocked over and wide mouths so that they can easily be cleaned. The spouts should enable pouring to be done without dripping. The handles should be easy to grasp and without ornamentation which collects dirt and makes cleaning difficult.

The glaze of all earthenware should be even, hard and leadless.

STORAGE JARS, TINS AND BINS.

Glass storage jars with rustless screw-top lids are excellent for storing cereals, pulses and other dry food. It is easy to see how the foods are keeping and when they need replenishing. Pottery jars are good and aluminium containers are light and rustless. Tea, coffee and spices should be stored in air-tight containers to avoid loss of aroma and flavour. Baking powder should be kept dry in a sealed tin. Salt should preferably be stored in a glass container. Enamelled bins and tins are necessary for flour, bread, cakes, biscuits and so on.

KITCHEN CLOTHS.

Tea towels are best made of linen or a mixture of linen and cotton. They wear longer and absorb moisture more easily than

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cotton. Dish cloths are woven from strong coarse cotton which does not easily fluff and clog the drain. An oven cloth of canvas, hessian or other strong material should always be kept handy. Facilities for drying kitchen cloths are a necessity and special rails can be purchased for the purpose. A sink shelf for the smaller sink accessories is a handy piece of equipment.

VEGETABLE RACKS.

A vegetable rack near the sink where the vegetables are to be washed is a great convenience. All vegetables remain fresh longer if they are kept cool. Root vegetables are best stored in a rack which allows cold air to circulate freely round them. The shelves may be perforated or of strong wire mesh. The vegetable rack should be simply constructed of rustless material and easily cleaned. Salad greens, provided they are dry, are best kept in a cool airtight container, e.g. pan with a lid. Greens of the cabbage type need air in storing.

GARBAGE BINS.

Bins for food scraps should be of rustless metal, have tight-fitting lids to keep out flies, and should be easily cleaned.

BRUSHES.

Brushes specifically for kitchen work will include a short-bristled saucepan brush with a straight handle, a bottle brush and a small stiff brush, about 4 inches long, for scrubbing potatoes and other vegetables.

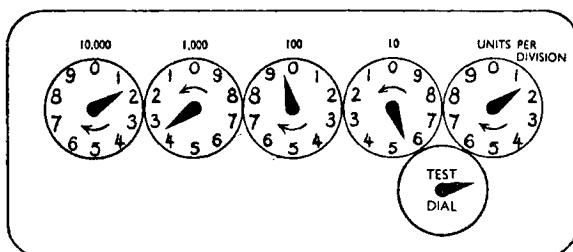
METERS.

If a gas or electric cooker is installed, a meter will also be fitted. This should be placed in a position where it can easily be cleaned and the dial easily seen.

In reading an electricity meter, ignore the small test dial below. Write down the readings of the dials from left to right. When a pointer is between two figures write down the smaller one. (If the pointer is between 9 and 0 write down 9.) When a pointer is on a figure write down one less except when the hand on the next dial to the right has just passed 0. Read the meter at the

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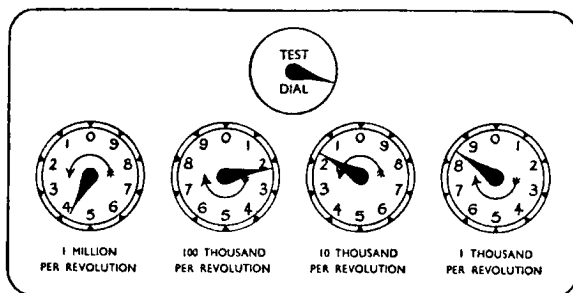
same time on the same day each week. To find how many units have been used in the week subtract last week's reading from this week's.



The Meter Reading is 13951

FIG. 66. Reading an electric meter.

In reading a gas meter, ignore the small test dial at the top. Write down the readings of the dials from left to right as with an electricity meter. Since the readings will be in hundreds of cubic feet your total figure must be multiplied by 100, i.e., 00 must be added to it. Read your meter at the same time on the same



The Meter Reading is 421800

FIG. 67. Reading a gas meter.

day each week. To find out how many cubic feet of gas you have used in the week subtract last week's reading from this week's with 00 added in each case.

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CLOCK.

The best type of kitchen clock is one which has a clear face which can easily be seen from all parts of the kitchen. It is best fitted into or on a wall. Since good cooking depends largely on accurate timing a good kitchen clock cannot be regarded as a luxury.

SUGAR BOILER'S THERMOMETER.

If it can be afforded a sugar-boiler's thermometer is a useful piece of kitchen apparatus for use in the making of icing, sweets and jams and for deep fat frying.

MISCELLANEOUS.

A mincer, corkscrew and bottle opener, lemon squeezer, fish slice, funnel, flour dredger, pastry cutters, jelly moulds, wire cake rack, grape fruit knife, icing tubes and bags are other small items which will find a place in a completely equipped kitchen.

Haybox Cooker.

A haybox cooker is an effective means of saving fuel and is of great advantage where long slow cooking is required. It works upon the same principle as the thermos flask, i.e., heat is conserved by insulation. The hot food is completely surrounded by hay or other materials which are bad conductors of heat. The heat is prevented from escaping and the food is slowly and thoroughly cooked.

The haybox consists of a strong wooden box with a hinged lid which fits tightly with a clasp. For a small household a box measuring 18 inches by 21 inches by 15 inches is sufficient. The whole box and the inside of the lid are lined with at least eight layers of newspaper, covered with brown paper and held in place with American cloth fixed by tacks or glue. The box is packed tightly with hay and a well made in it to hold the saucepan or casserole. A cushion of old blanket stuffed with hay until it is at

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least 4 inches thick is made to cover the well and should fit the haybox exactly.

The saucepan or casserole should be without handles and should have a tight-fitting lid. When placed in the well and the lid of the haybox closed, the saucepan or casserole should be completely surrounded by a minimum thickness of 4 inches of hay. The food should be cooked for about one third of the time

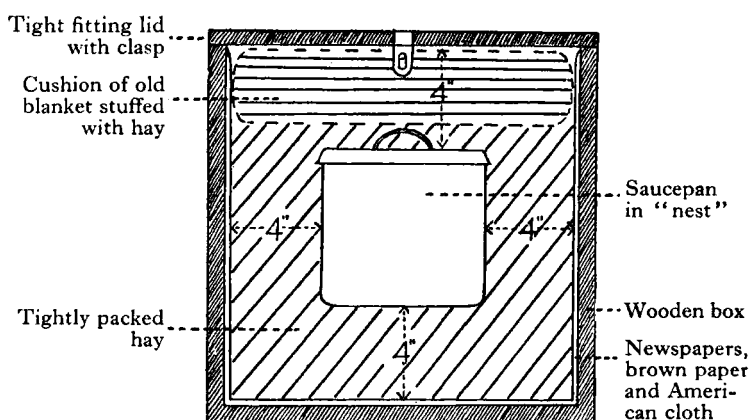


FIG. 68. A haybox cooker.

normally taken before placing in the haybox and left there for about three times the normal cooking time. Once the food is in the haybox, the lid should not be lifted until the food is required. The food should be boiling when placed in the haybox and may need a short re-heating before serving.

Because of the long slow cooking, the haybox is particularly suitable for stews, soups, pulses, porridge, cereals, dried fruits and root vegetables. It is especially useful for cooking the cheaper tougher cuts of meat and old fowls which are made remarkably tender. Green vegetables, potatoes and fresh fruits should not be cooked by this method because of the destruction of their vitamin C during the long slow cooking.

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Pressure Cookers.

Cooking under pressure has been known for a long time but it is only recently that it has become widely used. There are two main types of pressure cookers on the market. The larger and more robust type, e.g., Easiwork, is fitted with clock pressure and temperature gauge, safety valve and pressure regulator or "whistle." Any type of cooking, whether it be steaming, roasting, baking or deep fat frying, can be quickly carried out in these cookers, as well as the making of preserves and the bottling of fruits and vegetables. These cookers can be adjusted to cook at



FIG. 69. A pressure cooker.

By courtesy of Easiwork, Ltd.

pressures from 10 to 40 pounds per square inch by means of the whistle pressure regulator which must always be in perfect working order.

The smaller, cheaper and simpler type, such as the Prestige, Universal and Tempo, consists of a deep aluminium saucepan with a lid that locks on tightly and is fitted with a safety valve to release excess pressure. This type of pressure cooker works at a usual pressure of 15 pounds per square inch, but a 10 lb. pressure is better for jam making, and an even lower pressure (5 lb.) for bottling fruit.

Despite the variations in size and design, the cooking principles are the same in all cases. They are based on the fact that the lid is completely sealed or locked on the pan so that no steam can escape until a steam pressure of approximately 15 pounds per square inch above that of the atmosphere is reached. With increase in pressure there is a proportionate increase in temperature. The steam in the pressure cooker reaches a temperature of between 240 and 280° F., compared with the 212° F. of steam under ordinary atmospheric pressure.

Under these conditions the food cooks more quickly than by

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other methods. The saving in cooking time is, in fact, considerable. It naturally varies with different foods but is obviously greatest with those foods which normally require long slow cooking. On the average, cooking times are reduced by about two-thirds and occasionally by three-quarters or even more. Detailed instructions are issued with each cooker and all cooking times must be strictly followed or the food will quickly be overcooked. The time taken for cooking is always reckoned after cooking pressure is reached. The time taken to expel air and build up the steam pressure varies according to whether the pressure cooker is heated on a gas, electric, oil or heat-storage cooker, or on a kitchen range. An average time is 6—8 minutes. Once the cooking pressure is reached, the heat can be reduced to simmering point for the rest of the cooking time so that as well as economy in time there is considerable economy of fuel.

It is unnecessary to go into details here about the use of pressure cookers since these differ very slightly with different

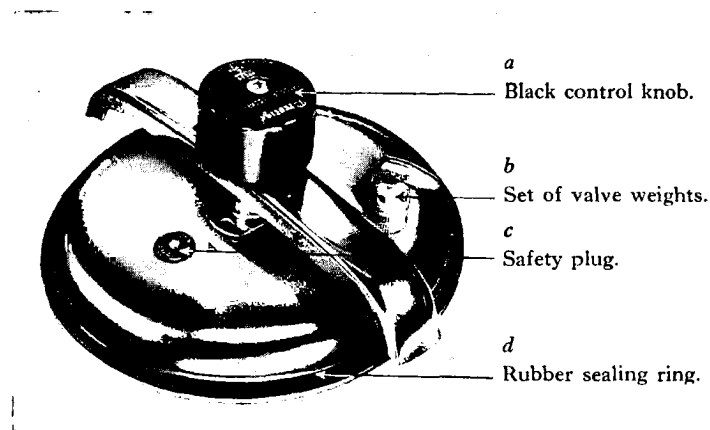


FIG. 70. A pressure saucepan lid.
By courtesy of Platers and Stampers, Ltd.

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makes. The manufacturers' directions for each cooker should be closely followed. These general points which apply to all types of pressure saucepans should be noted: —

1. It is essential to put $\frac{1}{2}$ to 1 cup of water in the cooker to form steam.

2. The small rack or false base provided should be used for all cooking except soups and stews.

3. Although the pressure saucepans are strong and durable and can withstand much higher pressures than the normal 15 pounds per square inch, the pressure control device needs careful attention. If this device becomes clogged up so that steam cannot escape, the cooker may become overheated and the safety plug may be blown out. Thus, the cleaning of the cooker after use is an important routine proceeding.

4. As soon as the cooking time has expired the cooker should be taken off the heat, and with the exception of a few foods such as soups, stews or meat, cooled under the cold water tap for a few seconds. This immediately reduces the pressure and prevents overcooking of the food. When this has been done, the pressure control lever or other device should be lifted and the pressure released. In some cookers it is impossible to take off the lid until the pressure has been completely reduced while with others it is not comfortable or safe to do so because of the escaping steam.

5. The cooker should not be filled too full or surplus steam may not be able to escape through the pressure control device. Two-thirds full is sufficient for solids and only half-full for liquids.

6. Food should not be left on the rubber band which helps to make the seal. The rubber band may be damaged and so cause a leak.

7. The small type pressure cookers are not suitable for preserving vegetables, meat or fish because of their smallness and because the 15 pounds pressure claimed by the manufacturers is only approximate.

THE KITCHEN AND ITS EQUIPMENT

It is impossible to speak authoritatively about the effect of pressure cooking on nutritive values until further tests have been carried out. It seems obvious, however, that the natural flavours of all foods will be more completely retained than by any other method of cooking. No aroma can escape during cooking and salt and seasonings should be added in only very small quantities. It is also clear that, provided it is not overcooked, the colour of meat is retained and bones used for stock are softened and presumably make the stock richer in calcium. Mineral salts will probably be leached out less than in ordinary methods of cooking, because of the small amount of water used and the short time of cooking. Vitamins A and D will not be affected by pressure cooking. Vitamin B, and vitamin C are the two nutrients most likely to be affected. Recent experiments suggest that the detrimental effect of the high temperature of pressure cooking is more than counterbalanced by the very short time of cooking with very little water and in the absence of air. It seems safe to say that pressure cooking of vegetables is unlikely to lead to greater destruction of vitamin C than ordinary methods of cooking and that there is less loss of vitamin B.

It is interesting to note that the pressure cooker provides the only means of cooking at high altitudes, and was consequently of considerable value to the 1953 Mount Everest Expedition. (See Fig. 71.) In Sir John Hunt's book, "The Ascent of Everest" (published 1953, Hodder & Stoughton Ltd.), Dr. L. G. C. Pugh in Appendix VI writes:

"At high altitude the cooking of fresh meat, rice and potatoes is extremely slow and expensive of fuel (at 21,000 feet water boils at 185°F. compared with 212°F. at sea level). The problem has been solved by the use of pressure cookers."

These cookers now form an indispensable part of the equipment taken on such expeditions and will be used on Sir Edmund Hillary's forthcoming expedition to Nepal, the British North Greenland Expedition and others.

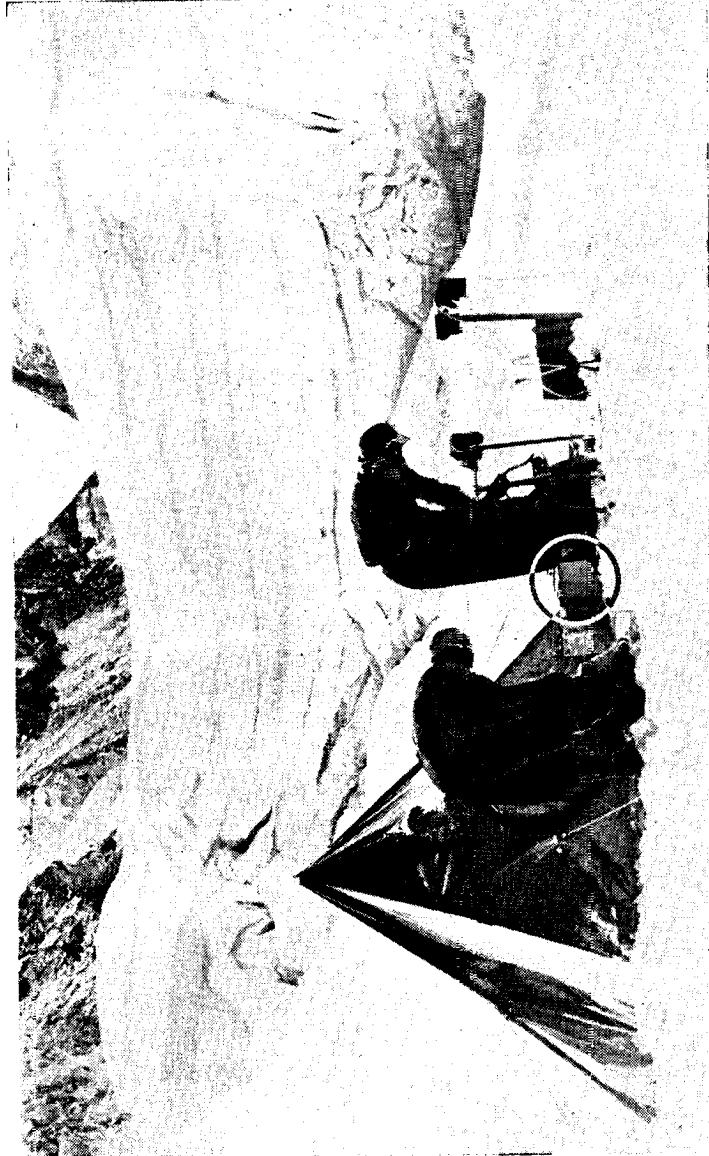


FIG. 71. Pressure Cooking on Everest. Hillary and Da Namgyal at Camp III.

CHAPTER XVII

THE PLANNING OF MEALS

We must begin this chapter by a recapitulation of the main facts given in Chapter I. We saw there that an adequate diet should provide (i) the necessary Calories to supply the required energy, (ii) proteins and minerals for building and repair, and (iii) vitamins and minerals to supply protective materials. We saw, too, that the body derives its energy mainly from fats and carbohydrates such as butter, margarine, suet, lard, dripping, cereals, pulses, sugar, treacle, jam, syrup, cheese, bacon and ham; its body-building materials from milk, eggs, meat, fish and cheese supplemented by pulses and nuts; and its protective materials from the minerals and vitamins of milk, cream, butter, eggs, cheese, summer fruits, foreign citrus fruits, vegetables, particularly salad vegetables, fat fish and liver.

It was also pointed out that it was unnecessary for the housewife to calculate the number of Calories, the amounts of protein, this particular vitamin, or that particular mineral she was supplying in the daily diet of her family. We suggested that a diet made up of the following foods would provide all the necessary nutrients:

- 1—*Milk*. At least a pint daily and more for children and expectant and nursing mothers.
- 2—*Eggs, cheese and pulses*. At least 3 or 4 times per week.
- 3—*Meat, fish or poultry*. Once daily.
- 4—*Fruit*. Orange, grapefruit or tomato at least once daily.
- 5—*Vegetables*. Two kinds daily in addition to potatoes and including one salad or green vegetable.
- 6—*Fat*. Butter or vitaminised margarine
- 7—*Cereals*. Wholemeal bread and oatmeal are the most valuable.
- 8—*Sugar*. Including jam, treacle, syrup and sweets.
- 9—*Water*. About $2\frac{1}{2}$ pints of fluids daily.

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Then eat any other foods you like in order to satisfy your appetite. In other words, you should eat what you want after you have eaten what you should.

The housewife's problem is to arrange these foods in the form of meals in such a way as not only to provide the necessary Calories, protein, minerals, vitamins, roughage and water, but to do so in such a way as to make them attractive, palatable, satisfying, digestible and economical.

The following rules may be helpful in planning the menu:

- 1—The whole day, or better still, the whole week, should be regarded as the unit rather than each individual meal. Any deficiencies in one meal can be made up in the others.
- 2—The same foods should not be served more than once in the same day without varying the form in which they are served. This does not apply to such staple foods as milk, bread, butter and margarine.
- 3—The same food should not be served twice in the same meal even in different form.
- 4—The colour, form and texture of different courses should be varied as much as possible to avoid monotony. A soft food should be alternated with a crisp food that needs chewing; a bland food with a highly seasoned one; cooked food with raw food and so on.
- 5—No meal should contain too great a concentration of any one type of nutrient, i.e., no meal should be predominantly protein or fat or carbohydrate in character. As previously pointed out, it is particularly important that both protein and fat should be accompanied by carbohydrate at the same meal.
- 6—Serve the animal proteins—milk, eggs, meat, cheese and fish—in small quantities at each meal rather than concentrate them in one meal. In this way the body makes better use of their building material particularly if accompanied by vegetable or cereal protein, e.g., pulses and oatmeal.

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7—Decide upon the protein ingredients of the meal first; next consider the protective materials such as the dairy foods, fruits and vegetables; and finally, supply energy foods such as bread, cereals, fats and sugar to satisfy appetite.

Let us now examine the following typical schedule of meals.

Breakfast.

Porridge or other cereal, or fruit, with milk and sugar.

Bacon, or egg, or fish, or sausage, with fried potatoes or fried bread.

National or wholemeal bread with butter or margarine.

Marmalade or jam.

Tea or coffee. Cocoa or milk for children.

Mid-Morning Snack.

Adolescents and men and women doing heavy manual work should have a mid-morning snack consisting of body-building material such as cheese, eggs, meat or fish and a protective food in the form of fruit or raw vegetable, e.g., cheese and watercress sandwiches, sardine and parsley sandwiches, or meat pasty with tomatoes.

Milk for children and expectant and nursing mothers.

Dinner.

Soup, if desired.

Meat or cheese or fish or eggs.

Potatoes.

Fresh vegetables (root or green or both).

Pudding or fruit with milk or custard.

Water to drink.

Tea.

Main dish of cheese or fish or egg or meat.

Raw vegetable salad or fruit and cream or custard.

Bread and butter or margarine.

Cakes, pastry, scones or biscuits.

Jam, syrup or honey if desired.

Tea. Milk for children.

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Supper.

Hot milk and biscuits.

In addition, young children and expectant and nursing mothers should have orange juice before breakfast and cod liver oil after meals.

Plenty of water should be drunk daily.

Each of these meals will be found to contain body-building material, protective material and energy material. For example:—

BREAKFAST.

Body-building material. First-class protein of milk, bacon, eggs, fish or sausage supplemented by second-class protein of oatmeal and bread.

Protective minerals and vitamins. Mainly from milk, butter, margarine, oatmeal, wholemeal bread, bacon, egg and fish.

Energy material. Mainly from oatmeal, bread, sugar, marmalade and jam.

MID-MORNING SNACK.

Body-building material. First-class protein from cheese, eggs, meat or fish.

Protective material. From fruit or raw vegetables.

DINNER.

Stimulation of appetite and flow of digestive juices from soup.

Body-building material. First-class protein from milk or custard, meat, fish, cheese, or eggs, supplemented by second-class protein from potatoes and vegetables and flour or cereal in pudding.

Protective minerals and vitamins. Mainly from meat, cheese, fish or eggs, potatoes, vegetables and milk (fresh or in custard).

Energy material. Mainly from potatoes, root vegetables, and cereals, fat and sugar in pudding and custard.

TEA.

Body-building material. First-class protein from cheese or fish or egg or meat supplemented by second-class protein from flour of bread, cakes, scones, pastry, biscuits and so on.

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Protective minerals and vitamins. Mainly from cheese, fish, egg or meat, raw vegetable or fruit, butter or margarine, and milk.

Energy material. Mainly from bread, butter or margarine, cakes, scones, pastry, biscuits and so on, jam, syrup or honey.

SUPPER.

Body-building material. First-class protein from milk supplemented by second-class protein of flour of biscuits.

Protective minerals and vitamins. From milk.

Energy material. From biscuits.

The additional calcium, vitamins A and D and vitamin C required by young children, expectant and nursing mothers will be supplied respectively by the extra milk, cod liver oil and orange juice they take.

The Feeding of Infants and Young Children.

There is no doubt that breast feeding is the best method of feeding a young baby. His mother's milk contains the exact materials he requires and in the correct proportions. If, for any reason, the mother is unable to breast-feed her baby he must be bottle-fed on cow's milk, either in the form of boiled whole milk, dried milk powder which may be "humanised" to make it more closely resemble human milk, or condensed milk. Dried skimmed milk, condensed skimmed milk and sweetened condensed milk, skimmed or unskimmed, are unsuitable for feeding infants. The skimmed milks are deficient in fat and the sweetened condensed milks contain too large a proportion of cane sugar.

At about the age of six months the baby will require protective and energy materials in addition to those supplied by his mother's milk. He should be trained to take orange juice, rose hip syrup or black currant pureé and cod liver oil from a spoon to supply vitamins C and A and D. The bottle-fed baby should be given orange juice and cod liver oil from birth.

Having been taught to take liquids from a spoon the next stage is to teach the baby to take some solid food from a spoon.

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He can be gradually introduced to bread and other cereals, mashed potatoes, sieved green vegetables, mashed hard-boiled egg yolk, minced meat, particularly liver, and fish. From the eighth month onwards the use of fruits and vegetables should be extended and jam, treacle, dripping and butter added to the baby's diet. The sieved greens, egg yolk and minced liver are especially important, because milk contains very little iron and by this time the baby will have used up the supply of iron stored up in his liver at birth.

The period from one to two years of age is an important transition stage during which the young child should be taught to use his teeth by being made to chew ripe fruit, fairy toast and rusks. It is during this transition from a milk diet to a mixed solid diet that likes and dislikes and habits of diet are largely formed. These may persist throughout life and great care must be taken by the mother to inculcate a liking for the right kinds of food.

By the time he is three years of age the child should be ready and willing to eat any of the usual foods of an adult in, of course, smaller quantities and with a preponderance of protective mineral and vitamin foods and body-building proteins. Young children can only take small amounts of food at each meal and it is essential that all they eat is of high nutritive value. A pint of milk daily should still be the foundation of the diet along with cheese, butter, vitaminised margarine, fresh fruit and vegetables, and fat fish. Bread toast, plain cake, biscuits, cereals, steamed puddings and jam should be the main energy suppliers.

The Feeding of Older Children.

From early childhood to adolescence the principles of diet remain the same but there is a gradual increase in the amounts required. Appetite can normally be relied upon to decide the amounts required but the mere satisfaction of appetite by the energy foods should never be allowed to take place at the expense of the body-building and protective foods.

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During adolescence the appetites of both boys and girls increase enormously and should be satisfied but again, not at the expense of the body-building and protective foods since growth of flesh and bone are very rapid at this stage. The iron-containing foods—green vegetables, eggs and liver—are especially important to girls during puberty and care should be taken to ensure their getting sufficient of them. The energy requirements of boys and girls between the ages of fourteen and twenty-one are greater than those of the average adult and can only be met by their receiving an increased amount of energy foods.

The Feeding of Adults.

According as to whether a man is a manual worker or a sedentary worker his output of energy will be greater or less and his intake of energy-producing foods must correspond. Contrary to generally accepted belief, heavy manual workers do not require additional protein foods. As previously stated, the father of the family should not get more of the meat than his rapidly growing son or daughter. The extra Calories needed by manual workers should be provided mainly by fats and carbohydrate foods. This will increase the requirements of vitamin B₁ (thiamine) but if National or wholemeal flour is used this will probably be already provided.

The sedentary worker has as much need of body-building and protective foods as the manual worker but has less need of the purely energy-producing foods. His food should be easily digested and given in smaller amounts at more frequent intervals. Carbohydrates, particularly sugar, should be less than for the manual worker and salads and fruits given in their place.

A woman's energy output is less than a man's and she normally requires less food. In the case of the protective foods, particularly the iron-containing foods, her needs are, however, almost certainly greater than those of a man. Many housewives make the mistake of ensuring an adequate diet for their husbands and children at the sacrifice of their own which all too frequently consists too largely of tea, bread, cakes and so on.

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Expectant and nursing mothers should obviously pay special attention to their diets. The body-building and protective foods will need to be increased in amount. In addition to extra protein and vitamins there will be an increased need of calcium and iron. This increase in the body-building and protective foods should take place gradually from the earliest stages of pregnancy and not be concentrated into the last few months as is frequently done.

Expectant and nursing mothers should have two pints of milk daily and increased servings of green vegetables, root vegetables, fruit, particularly citrus fruit, eggs, cheese, meat and butter as well as cod liver oil and orange juice. They should also drink three pints of water daily.

There is little scientific evidence respecting any special nutritional needs of old people. It is, however, reasonable to assume that their energy output will decrease with advancing age and their food requirements consequently diminish. Their digestive powers will almost certainly be less than they formerly were. Consequently old people should take food fairly frequently in small amounts at a time and in an easily digestible form.

There is no reliable evidence that old people require less protein than younger adults while their need for calcium, phosphorus and vitamin D will probably be as great as that of younger adults in view of their susceptibility to bone injury due to the gradual demineralisation which takes place in bones with advancing age. Anaemia is uncommon in old people and the iron requirements during old age are probably less than those of younger adults. So far as the vitamins are concerned the most we can say is that since old people require less Calories they will need less carbohydrates and consequently less of the B-vitamins. Vitamin C will probably be needed in larger amounts than by younger adults, particularly if the diet is restricted and monotonous as it frequently is in old age. Vitamins A and D will probably be needed in as large amounts as for younger adults.

It must be admitted that there is still a great deal to be learned about the nutritional needs of old people. There is no

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doubt, however, that a healthy old age is very largely a result of good nutrition in earlier life.

The Feeding of Invalids and Convalescents.

The feeding of invalids and convalescents is an important factor in their recovery and should receive very careful attention.

In the case of certain diseases, such as diabetes, anaemia, scarlet fever and typhoid fever, the doctor will prescribe what the patient should eat and his instructions should be rigidly followed. Quite apart from such special cases the mere fact that the patient is no longer leading a normal active life will necessitate changes in diet whether or not the illness affects the digestive system.

In the early stages of diseases marked by a rise in temperature solid foods should not be given. Instead, a liquid diet consisting of milk and milk foods such as arrowroot and milk jelly or beef tea will be sufficient. When the patient's temperature is down to normal a light diet may be given. This should be of an easily digested nature and served in small quantities only. In addition to milk and milk foods, eggs in the form of custards, meat broths, white fish, citrus fruits, toast and biscuits may be given. During convalescence the diet becomes of the greatest importance. It should be increased in amount and should be such as to build up strength and wasted tissues especially after a long and wasting illness. The more easily digested protein foods such as milk, eggs, white fish and poultry are of the greatest value for this purpose unless any of them are forbidden by the doctor. These foods should be given in their most digestible form, e.g., fish steamed, meat stewed or minced, and eggs scrambled or coddled.

The diet of an invalid or convalescent should contain plenty of foods rich in vitamin C. This can be given in the form of fruit, especially oranges, lemons and grapefruits, and fresh green vegetables. One green vegetable cooked so as to preserve the maximum amount of vitamin C should be given daily along with potatoes. Whenever possible a serving of raw vegetable as a salad, in sandwiches or as a garnish to a hot dish should be

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included daily. If cooked or raw vegetables cannot be taken, the patient should be given the necessary daily dose of vitamin C in the form of rose-hip syrup, blackcurrant purée or concentrated orange juice.

Indigestible greasy foods should not be given at any stage of an illness. This precludes pork, ham, sausages, pastry, all fried foods, hot buttered toast. New bread, and highly flavoured sauces, pickles and spices are also unsuitable. Foods such as beef tea, meat extracts and jellies may help to stimulate the patient's appetite but it should always be realised that they have very little food value and should form only a minor part of the invalid's diet.

Patients are frequently finicky about their food and their appetites need to be tempted. This can be done by serving absolutely fresh food of the finest quality: by varying the food and the method of cooking as much as possible to avoid monotony; by serving small helpings in a dainty and attractive way since nothing is more likely to upset the patient's appetite than the sight of too much food badly served; by being punctual with meals and by never preparing food or leaving food behind in the sickroom.

The correct feeding of invalids and convalescents is frequently an arduous and trying task requiring both skill and patience but, once the patient is convalescent, carefully chosen food properly cooked can often do more than anything else to ensure a speedy recovery.

The Oslo Meal or Oslo Breakfast.

The Oslo meal was so-called because it was first given to schoolchildren in Oslo by Professor Schiøtz who realised that the meals provided in schools there were similar in type to the home diets of the children and had the same nutritional deficiencies. Professor Schiøtz planned to give the children one meal a day which contained all the essential body-building and protective materials to meet their daily requirements. Having had this meal it mattered little what the rest of the children's meals might contain so long as they satisfied appetite.

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The original meal consisted of wholemeal rolls, butter or vitaminised margarine, milk, cheese or cooked fish and a salad or fruit depending on the season. It required little or no cooking and could easily be served.

The effect upon the children receiving this meal was remarkable. They grew more rapidly than the children receiving the ordinary type of meal, while their rosy cheeks, clear skins, general vitality and lack of minor ailments were eloquent testimony to the health-giving properties of this type of meal.

Such a meal would go a long way to make up the deficiencies in the diets of many people in this country. Probably the best time to have it would be at tea-time since many teas consist very largely of starchy and sugary foods and would be greatly improved by the addition of body-building and protective materials such as the Oslo meal provides. Meals of this type are very suitable as packed meals for picnickers, workers without canteen facilities and so on.

Vegetarian Diet.

Strictly speaking a vegetarian diet is one which is completely confined to food derived from plant life. Not only are meat, fish and poultry excluded but also milk, butter, eggs and cheese since these also are derived from animals. Such a diet is very limited in choice, monotonous, unattractive and very bulky. It is difficult to introduce much variety into meals consisting only of cereals, vegetables, fruits, nuts, honey, sugar and treacle. However, there are in the world a few races and religious sects which subsist upon such a diet. They include high caste Hindus and Trappist Monks. It is very doubtful if the human digestive system is adapted to the strictly vegetarian diet.

Apart from its lack of variety such a diet presents great difficulty in supplying the body with the essential amino-acids found in first-class animal proteins, the fat-soluble vitamins A and D and the minerals, calcium, phosphorus and iron. The best sources of protein for the strict vegetarian are the legumes, peas, beans, lentils and soya, and nuts but their proteins are not of such high

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biological value as those of animal foods nor are they as easily digested. The other plant foods—green vegetables, root vegetables, fruits, honey, sugar and treacle, are of little or no value as sources of proteins. Carbohydrate starch and sugar to supply energy would be easily provided in such a diet by the cereals, legumes, root vegetables, tubers, honey, sugar and treacle. Fat would mainly come from nuts and soya but large amounts would need to be eaten. Of the vitamins there would be no lack of vitamin C since such a large amount of fruit and vegetables would be consumed. The B-vitamins would also be well represented in the whole-grain cereals. Vitamin A, in the form of carotene, would be obtained from carrots, watercress, parsley, lettuce and turnip tops but, again, large amounts would have to be eaten to meet the body's requirements, while vitamin D would be still more difficult to acquire. The important minerals, calcium, phosphorus and iron would be difficult to supply in sufficient amounts since the legumes are the only plant foods supplying anything but negligible quantities. We are thus driven to the conclusion that the exclusive use of plant foods has no scientific justification.

Many so-called vegetarian diets include milk, butter, cheese and eggs. They are merely diets which do not include flesh foods. With these additions there is no difficulty in supplying the first-class proteins, vitamins A and D and the minerals calcium, phosphorus and iron. The difficulty of introducing variety and attractiveness into meals would still remain but to a much smaller degree and the diet would not be so bulky. Nevertheless, great skill and care would be needed to ensure that the same foods are not served too frequently and the dishes do not become monotonous and uninteresting.

While the strictly vegetarian diet is cheaper than the normal mixed diet, the addition of milk, butter, cheese and eggs in the necessary quantities is apt to make the non-flesh diet rather expensive. There can be no doubt that the use of meat, fish and poultry makes the preparation of attractive, appetising meals much easier and the provision of the necessary nutrients more certain.

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As in the case of the strictly vegetarian diet, there is no scientific justification for the non-flesh diet for the normal healthy person.

Economy in Diet.

True economy in diet means the provision of the necessary nutrients in adequate amounts at the lowest price without making the diet monotonous and unappetising. No matter how cheap it may be, no diet is really economical which does not supply the necessary Calories, protein, minerals and vitamins. On the other hand, the fact that a large amount of money is being spent on food does not necessarily guarantee a sound diet.

The cheapest sources of first-class proteins are cheese and herrings. The cheapest sources of Calories are bread and margarine. Such a combination would also supply calcium, phosphorus, vitamin A and, if the bread be made from National flour, some iron and B-vitamins. It would be lacking in vitamin C which could be most cheaply provided by raw cabbage, and vitamin D which could be cheaply supplied by a teaspoonful of cod liver oil. Theoretically, at any rate, it would be possible to subsist on such a diet but even the poorest person in the land would quickly tire of its monotony. Obviously, variety would have to be introduced and it is here that the diet can easily become uneconomical.

Meat and white fish are more expensive body-building foods than cheese and herrings which provide valuable calcium, phosphorus and vitamin A and Calories in addition to first-class proteins. Milk is a relatively dear food but is indispensable on account of its body-building and protective materials. Salmon and sardines are excellent foods but the same proteins, calcium, phosphorus, iodine, vitamins A and D can be more cheaply provided by herrings. Bacon is an economical body-building food because it supplies Calories as well as proteins. Eggs, in spite of their calcium, phosphorus, iron, vitamins A and D are, unfortunately, dear sources of proteins and Calories.

Of the fats, vitaminised margarine and suet are the cheapest. Even at its high price butter is an economical food because of its Calories and vitamin A.

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The greatest economy in diet can be made in the carbohydrate energy foods since they form the largest part of the diet and show the greatest variations in price. The cereals, potatoes, pulses and dried fruits are the cheapest of the carbohydrate foods. Sugar is a cheap energy food but supplies nothing else.

Green vegetables and fresh fruits must be judged as sources of vitamin C and minerals and the cabbage is easily the cheapest, followed by tomatoes and oranges. All green vegetables and fresh fruits are dear for Calories but their vitamins and minerals make them indispensable.

To sum up we may say that the diet may be made more economical but no less nutriticnally satisfactory by an increased use of cheese, herrings, vitaminised margarine, whole-grain cereals, potatoes, pulses and dried fruits. Milk, green vegetables and fresh fruit are essential and it is unwise to economise in their use in spite of their relatively high cost. To be economical the amounts of meat, white fish and eggs in the diet should be reduced.

CHAPTER XVIII

THE DIGESTION, ABSORPTION AND METABOLISM OF FOOD DIGESTION

We have seen that food supplies the body with heat and energy, with material for growth and repair, and with substances which regulate the mechanism of the body. With very few exceptions, foods as eaten are not in a suitable form to be utilised by the body for any of these purposes. The majority of foods must be broken down into simple soluble substances before they can be absorbed into the body through the walls of the digestive tract. It is only then that the body can utilise them. This breakdown process is carried out by the mechanical action of the teeth and other parts of the digestive tract but chiefly by the chemical action of various digestive juices. The whole breakdown process is known as *digestion*.

The Digestive Tract.

The digestive tract, or alimentary canal, consists essentially of a long tube open at both ends, the mouth and the anus. Although this tube passes through the body it is, in a sense, external to it and while food remains in this tube or "gut" it is really outside the body. It is only when food passes through the walls of the gut into the blood stream that it has actually passed into the body.

The main parts of the digestive tract are the mouth, gullet, stomach, small intestine and large intestine. In the adult, the small intestine is over 20 feet long and the large intestine about 6 feet in length. Various glands, such as the salivary glands of the mouth, the gastric glands of the stomach, the liver and pancreas, secrete digestive juices into the gut which break down the food by chemical action into simpler and soluble substances which can be absorbed into the blood.

The digestion of food is carried out in stages in separate parts of the digestive tract—the mouth, stomach and intestines—by

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digestive juices containing specialised enzymes. In the mouth, the salivary glands secrete saliva containing the enzyme, ptyalin,

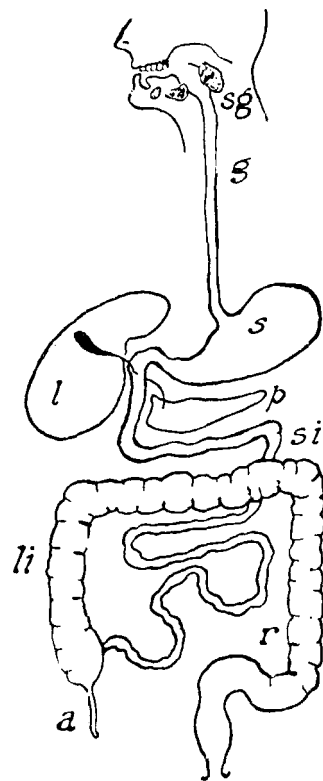


FIG. 72.

- Sg Salivary gland.
- G Gullet or œsophagus.
- S Stomach.
- L Liver.
- P Pancreas.
- Si Small intestine (20 feet).
- Li Large intestine.
- a Appendix.
- r Rectum.

which converts starch into soluble forms of carbohydrate. In the stomach, the gastric glands secrete gastric juice containing the enzyme, pepsin, which, in the presence of hydrochloric acid, converts proteins into simpler substances known as peptones. In the small intestine, food comes into contact with pancreatic juice from the pancreas, bile from the liver and intestinal juice from the small intestine itself. Pancreatic juice contains three distinct enzymes: (a) trypsin, which breaks down proteins and peptones into their constituent amino-acids, (b) amylase, which changes polysaccharides, such as starch, and disaccharides, such as maltose, into monosaccharides, chiefly glucose, (c) lipase, which splits up fats into their component fatty acids and glycerol. The bile from the liver contains alkaline bile salts which emulsify fats. Intestinal juice from the small intestine completes the conversion of disaccharides into glucose and of proteins and peptones into amino-acids.

The absorption of food into the blood stream takes place almost entirely in the small intestine.

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Very little food is absorbed through the lining of the inside of the mouth. Small quantities of alcohol, sugar, soluble mineral salts, soluble vitamins, i.e., B vitamins and vitamin C, and water may be absorbed through the walls of the stomach. Carbohydrates, proteins, fats, minerals, vitamins and water are practically completely absorbed in the small intestine. The main function of the large intestine is the absorption of water from the indigestible residue of foodstuffs and the residue of the digestive juices which form the faeces which are passed out of the body.

Such, briefly, is the sequence of the processes of digestion and absorption which will now be considered in greater detail.

DIGESTION IN THE MOUTH.

The process of reducing food to physical and chemical states suitable for absorption is started in the mouth. During mastication the teeth cut and grind the food to a small size and the tongue and the mouth muscles by their movements mix up the food with the saliva secreted by the salivary glands. The act of mastication stimulates the salivary glands but the secretion of saliva is more of a reflex action in response to the stimulus of taste and, to a less extent, of smell. Salivation is also closely linked with the emotions. The mere thought of food, particularly when one is hungry, is often sufficient to "make the mouth water." On the other hand, fear, excitement or worry may stop secretion. Pleasant surroundings, good company and cheerful conversation are all conducive to increased flow of saliva and hence to improved digestion.

Saliva acts as a moistener and lubricator so as to allow the soft bolus of food to pass easily down the gullet or oesophagus. Ptyalin has the power of converting starch into maltose and dextrin but only when the solution is alkaline and when the cellulose covering of the starch grains has been broken open by cooking. The majority of people, instead of chewing their food properly, swallow it almost as quickly as eaten and ptyalin has practically no opportunity of effecting any chemical change in the mouth. The

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action of ptyalin, however, continues for a time in the stomach until the hydrochloric acid of the stomach neutralises the alkalinity of the saliva. When starch grains are cooked with fat, as in pastry, fried potatoes or batter, the digestive action of ptyalin is considerably hindered and indigestion may be experienced.

DIGESTION IN THE STOMACH.

The chief purpose of the stomach is not really as a digestive organ but as a reservoir dealing out its contents in conveniently manageable quantities to the first part of the small intestine—the duodenum. Another useful function is to bring foods of different temperatures all to the temperature of the body (98.4° F.) and to melt fats. The stomach's extraordinarily rich supply of blood-vessels make it well adapted to these purposes. The hydrochloric acid secreted in the stomach acts as a powerful antiseptic: a fact doubtless of great importance in the case of the chance raw food of the savage, and not wholly without significance in the food of civilised man.

The pepsin of gastric juice, in association with hydrochloric acid, brings about a certain amount of digestion of proteins into peptones. Its main purpose, however, is probably to produce such semi-digested substances as will stimulate the secretion of further enzymes required for fuller digestion in the succeeding portion of the gut—the duodenum. Gastric juice probably also contains the enzyme, rennin, which curdles milk in readiness for digestion in the small intestine.

The stimulation of the flow of gastric juice in readiness for the digestion of protein foods depends partly upon the chemical nature of the food passing into the stomach and partly upon psychological factors. The dextrin produced by the partial digestion of starch in the mouth and the water in the saliva both excite the gastric glands. Hence the justification for the nibbling at a roll before taking soup. The extractives of meat, especially as concentrated in several proprietary articles, are powerful stimulants of the gastric glands. Ordinary soups act in the same manner;

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hence their place at the beginning of the ordinary dinner menu. The psychological factors of smell, sound and sight, and so on, which promote the flow of saliva also increase the flow of gastric juice. The flow is checked by worry, excitement or anger, and digestion thus hindered.

The mechanical action of the powerful muscles in the walls of the stomach in the churning of food is not now considered to be of as great importance as was previously thought. Nevertheless the movements of the stomach serve to bring the food into close contact with the gastric juice and reduce it to a more liquid consistency as "chyme."

DIGESTION IN THE SMALL INTESTINE.

Chyme, on becoming thoroughly impregnated with the acid gastric juice, causes the valve (pylorus) between the stomach and the first portion of the small intestine to relax and, in small quantities at a time, it passes into the duodenum. The reaction of the small intestine is alkaline and one of the first results of the admission of acid is the stimulation of the flow of pancreatic juice from the pancreas and the flow of bile from the liver. Pancreatic juice is the most powerful of the digestive juices. It contains three enzymes—trypsin, amylase and lipase. Trypsin continues the work of pepsin and changes proteins into peptones and finally amino-acids. Amylase continues the work of ptyalin on starch which is broken down into disaccharide, maltose. Lipase splits up fats into their constituent fatty acids and glycerol after they have been emulsified by the alkaline salts of bile. The final breakdown of proteins into amino acids and of disaccharides into glucose is brought about by the enzymes, erepsin, maltase, lactase and invertase, in the intestinal juice formed by the small intestine itself. Thus, as the food, or chyle as it is now called, is moved along the length of the small intestine by the peristaltic action of its muscles, all of it that is digestible is converted into simple and soluble substances which can pass through into the surrounding blood capillaries and lacteals to be utilised by the body.

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DIGESTION IN THE LARGE INTESTINE.

The large intestine contains no digestive juices but is rich in bacteria. By the time the mass reaches it all the digestible food has been absorbed. The material left is largely cellulose which is indigestible in man, the residue of digestive juices and bacteria. Water is absorbed from it all along the large intestine so that it reaches the rectum in a semi-solid or solid form. This more or less solid consistency exerts a pressure on the muscles of the rectum which leads to its expulsion from the body as faeces.

The bacteria in the large intestine produce certain of the B-group of vitamins and, in this way, supplement the body's supply.

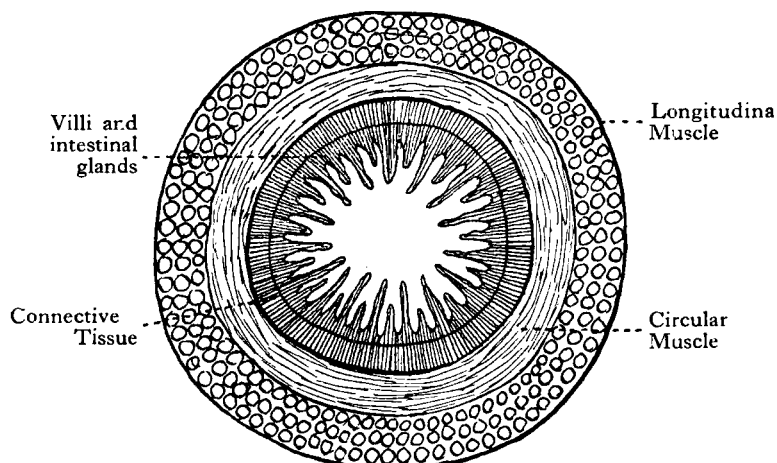


FIG. 73. Diagram of cross-section of small intestine.

Absorption.

Absorption is the term applied to the passage of the products of digestion through the walls of the digestive tract. The small intestine is the part of the digestive tract through which practically the whole of the absorption of foods into the blood stream takes

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place. The lining mucous membrane of the small intestine is especially adapted for the purpose by being thrown into permanent folds throughout which are tiny projections known as "villi."

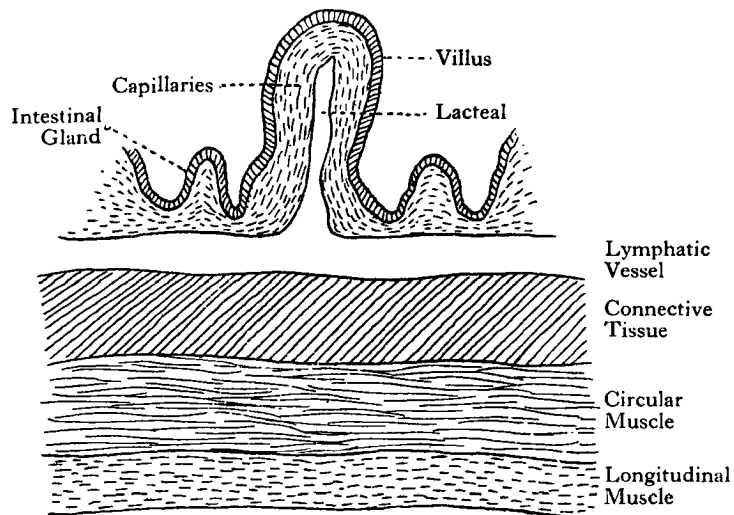


FIG. 74. Section through wall of small intestine.

Each villus is provided with a small lymph vessel, called a lacteal, and a network of capillary bloodvessels. During digestion, these villi are surrounded by chyle and the breakdown soluble substances diffuse through into the lacteals and capillaries. Glucose, the final digestive form of the various food carbohydrates, diffuses into the capillaries of the villi and ultimately passes by way of the portal vein into the liver.

The amino-acids derived from the protein foods also pass into the capillaries and, by way of the portal system, through the liver and thence into the general circulation.

The products of the digestion of fats—fatty acids and glycerol—in addition to some finely emulsified undissociated fats, pass into

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the lacteals of the villi where they are immediately reconstituted as fats characteristic of the body. The lacteals lead into the thoracic duct from which the milky emulsion of fat enters the blood stream without first passing through the liver.

Metabolism.

Metabolism is the term used for the many different chemical processes which take place in the tissues and cells of the body. Distinction is commonly made between those concerned with the building up of the various substances provided by food into the substances characteristic of the tissues and cells (anabolism), and those concerned with the liberation of energy and the production of final breakdown waste products such as carbon dioxide, water and urea (katabolism).

Glucose is normally found in the blood in fairly steady concentration. It is the more immediate supply of energy for cells and tissues. Used-up glucose is quickly replaced by the conversion of the stored carbohydrate, glycogen, in the liver being changed into glucose. The liberation of the available energy of this "blood sugar" is a complicated process, involving the absorption of oxygen from the blood stream and the liberation of carbon dioxide and water as breakdown waste products. The energy appears in various forms; as heat, as muscular work and as chemical energy in a great variety of compounds associated with the living stuff of cells and tissues.

Glucose absorbed in excess of body requirements is stored in the liver and muscles as animal starch (glycogen) or, when reduced to fat, is retained as depôt fat throughout the body, but chiefly in the abdomen. This reserve food supply can be drawn upon when required, being first re-converted into glucose by partial oxidation.

The complete oxidation of fat in the body is a more difficult process than that of glucose. When completely oxidised, fat yields simply carbon dioxide and water, but incomplete oxidation results in the formation of ketones which give rise to ketosis or biliousness.

DIGESTION, ABSORPTION AND METABOLISM

This condition can usually be relieved by adding sugar to the diet and largely prevented by a diet in which fats are well balanced by carbohydrates.

The essential compounds for the building up of the many different cell proteins are the amino-acids. These are taken in the necessary amount and variety from the blood stream so that the cells and tissues can grow and develop and wastage be made good. Amino-acids available to the body in the food which are in excess of the body's needs or are unwanted, are carried to the liver where they are disintegrated into carbohydrate or fat residues and nitrogen residues. The nitrogen residues are ultimately excreted from the system as urea, or similar substances, in urine. The carbohydrate residues are available for the production of heat and energy. The use of excess protein as fuel instead of as building and repair substance is uneconomic. Wastage of protein in this manner can be largely avoided by the practice of mixed carbohydrate and protein meals.

SUMMARIES

DIGESTION

- (a) *In the Mouth. (Alkaline.)*
 - (1) Food broken up, moistened and lubricated.
 - (2) A small amount of cooked starch changed into maltose.
- (b) *In the Stomach. (Acid.)*
 - (1) More mixing and mechanical breakdown of food.
 - (2) For a time, more cooked starch changed into maltose.
 - (3) Conversion of proteins into peptones started.
 - (4) Milk is curdled.
- (c) *In the Small Intestine. (Alkaline.)*
 - (1) Carbohydrates converted into glucose.
 - (2) Proteins and peptones converted into amino-acids.
 - (3) Fats emulsified and split into fatty acids and glycerol.
- (d) *In the Large Intestine.*
 - Some of the B vitamins formed.

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ABSORPTION

- (a) *In the Mouth.*
Very little.
- (b) *In the Stomach.*
Small quantities of alcohol, sugar, soluble mineral salts and soluble vitamins (B and C) and water.
- (c) *In the Small Intestine.*
Practically the whole of the absorption of carbohydrates, proteins, fats, minerals, vitamins and water.
- (d) *In the Large Intestine.*
Water and some B vitamins.

METABOLISM

- (a) *Carbohydrates.*
 - (1) Glucose oxidised to carbon dioxide and water with production of heat and energy.
 - (2) Excess glucose stored as glycogen or fat.
- (b) *Fats.*
 - (1) Oxidised to carbon dioxide and water with production of heat and energy.
 - (2) Stored in the body's fat depôts.
- (c) *Proteins.*
 - (1) Amino-acids used by tissues for building and repair.
 - (2) Oxidised for production of heat and energy.

DIGESTIVE JUICES

<i>Juice</i>	<i>Enzyme</i>	<i>Action</i>
Saliva	Ptyalin	Starch into maltose.
Gastric juice	Pepsin (hydrochloric acid)	Proteins into peptones.
Bile	(Alkaline salts)	Fats emulsified.

DIGESTION, ABSORPTION AND METABOLISM

<i>Juice</i>	<i>Enzyme</i>	<i>Action</i>
Pancreatic	(a) Trypsin	Proteins and peptones into amino-acids.
	(b) Amylase	Starch and maltose into glucose.
	(c) Lipase	Fats into fatty acids and glycerol.
Intestinal	(a) Erepsin	Peptones into amino-acids.
	(b) Maltase	Disaccharides to glucose (maltose, lactose, cane sugar).
	Lactase	
	Invertase	

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