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FLOUR AND BREAD

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Wheat and bread. A historical introduction

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Historical

Although the wheat plant (*Triticum*) is nowhere found in the wild state, it has been cultivated for human food from the earliest times of which we have record. The origin is held to have been in south-west Asia, in Mesopotamia. When Abraham (about 2000 B.C.) was visited by three angels unawares, he commanded Sarah to 'make ready quickly three measures of fine meal, knead it, and make cakes upon the hearth' (*Genesis*, 18,6). The word 'knead' suggests the formation of a dough and the mention of leaven when Lot made a feast hurriedly for the two angels who met him in the gate of Sodom and 'did bake unleavened bread' (*Genesis*, 19,3) is evidence that the meal used was wheaten meal. These instances suggest that wheaten bread was a common food in the basin of the Euphrates and Tigris, including Ur of the Chaldees, for which there is confirmatory evidence from modern archaeological researches.

From Mesopotamia cultivation of wheat spread eastward to China and westward to Europe. Grains of a primitive species of wheat (*Triticum monococcum*) have been identified in the calcined remnants of food found in the ruins of the Swiss lake-dwellers of the later Stone Age. The ancient Egyptians were skilled in the art of bread baking and, although barley and millet (*Sorghum*) were largely consumed, white bread made from fine wheaten flour was available for those who could afford it.

The urge of most Europeans to choose wheat as a staple food in preference to other cereals has been evident throughout the ages. In the Greek and Roman civilizations wheat was imported to provide bread for the large cities. By simple methods of shaking, sieving and bolting the stone-milled product, various grades of flour were obtained and the finest and whitest of the products was highly esteemed as a luxury to be enjoyed by the rich citizen whereas dark bread carried something of a social stigma. At the same time, bread made from wholemeal flour was the usual food of country dwellers.

In our islands where only the more southern districts were suited for wheat growing, barley, rye and oats were largely used in the past, both alone and mixed with wheat to economize the inadequate supplies. All through the centuries there can be traced the tendency to choose wheat flour for bread making whenever possible. Bread made from rye, which possesses a fair proportion of gluten in its protein mixture, presents a reasonably light loaf when risen with yeast and is still consumed to a large extent in northern and eastern Europe. Barley meal is a poor breadmaker and oatmeal can be eaten only as porridge or unleavened cakes.

In mediaeval England the grain brought by the farmer was ground by the miller who was paid in kind for his work. Many were the complaints of his dishonesty in keeping back more than his authorized share or in mixing inferior meal with the flour returned to the grower. The bad reputation of the miller is recorded by Chaucer and his unpopularity is preserved in the traditional song of the Miller of Dee who declared: 'I care for nobody, no, not I, And nobody cares for me'.

The separation and grading of the flour were usually done by the housewife or baker, by the simple methods of sieving and bolting. The whitest bread, made from the finest flour and pale cream in colour, was much dearer than 'household' bread which contained more of the 'offals', and in the cheapest and coarsest bread, known as 'wheaten', there was presumably a good proportion of bran. From time to time the prices for these different grades were fixed by law. As in classical times, to eat the whitest bread marked a class distinction; it was a sign of wealth and refinement and as such was the object of a natural ambition. Nevertheless, throughout the centuries, unconventional voices have declared the advantage for health and strength of the wholemeal and darker bread of the country folk and peasants. The view was doubtless linked with the accepted desirability of a 'return to nature', in view of the better health and vigour enjoyed by country people compared with city dwellers, for there could then have been no reasonable arguments to show that wholemeal had any greater nutritive value than white flour. The knowledge did not then exist and, moreover, the coarser texture and darker colour of the peasants' bread was often due to admixture with rye or barley or even peas or beans and not to inclusion of additional fractions of the wheat berry. It was not until the 18th century that improvement in agricultural practice enabled enough wheat to be grown and ripened to feed most of the people of England with wheaten bread, but oats remained the staple cereal in the north and in Scotland.

At the beginning of the 19th century the Napoleonic wars stopped the import of European wheat which had become necessary to feed the increased population on these islands. Prices rose and, when peace came and prices fell, the Corn Laws were passed in 1815 to restore agricultural prosperity. Cheap wheat for all was not achieved until the repeal of the Corn Laws in 1846. The refined white flour of that period must have been more nutritious than that of our own day because, in the stone-milling of those times, the separation from the flour of the germ and aleurone layer must have been far from complete. The introduction into this country, in the mid 19th century, of roller-milling practice from Hungary, where it was first applied, marks an important dividing line between the old ways and the new. Separation of the grain into its parts was more complete and, in particular, removal of the wheat germ became possible through its flattening by, and adherence to, the rollers. The result was a loss in nutritive value of the bread but pleased the millers because of the improvement in the keeping qualities of the flour. By the end of the 19th century bread made from fine white flour, representing about 70% by weight of the grain, was the common food of our people although there were still some authorities who contended for the better food value of brown or wholemeal bread.

Ashley (1928), Drummond & Wilbraham (1939), the Encyclopaedia Brittanica, 11th ed. (1910), McCance & Widdowson (1956) and Trevelyan (1942) give fuller information about these historical aspects.

Proteins in the wheat grain

Scientific study of the wheat grain and of the nutritive value of its different parts took shape from about the middle of the last century. Most of the earlier work was concerned with the chemical and physical properties of its proteins, more especially of the gluten, as the most characteristic member of the mixture because of its importance in breadmaking (see Bailey, 1944). Among the more important researches were those of Rubner (1883) and Girard (1884), which included physiological tests as well as elaborate chemical analyses. Girard's work in particular, with its meticulous study of fractions of the grain separated by hand, has borne well comparison with that of many later investigators. Special interest lies in the careful study he made of the outer tissues of the grain, called by him the 'enveloppe' which included the germ, the pericarp and the aleurone layer; the last, although it belongs morphologically to the endosperm, adheres to the pericarp and is separated with it. The aleurone tissue, he showed, though consisting of one layer of cells and accounting for only 9% of the grain by weight, provided 16% of the total protein: corresponding figures for the germ were 1·5% and 4%. For analysis and study of the germ Girard records that more than 1000 were separated by hand from the grains. The aleurone layer and the germ were therefore the portions of the grain by far the richest in protein. Girard further made tests in vitro and on himself to determine the digestibility of the protein in the 'enveloppe'. Rubner's work on similar lines was concerned to examine the claims of the recently formed London Bread Reform League, one of the societies then zealously advocating wholemeal bread in place of the fashionable white loaf. Girard, whose personal tests were made on uncooked bran, concluded that the nitrogen of the 'enveloppe' was not absorbed to a significant extent by the human subject. Rubner found otherwise, and later workers have shown that from 80 to 90% of the nitrogen in wheat bran is available (Borgström, 1941; Macrae, Hutchinson, Irwin, Bacon & McDougall, 1942; Eckstein & Vogel, 1942). The work of Girard and Rubner was extended and crowned by the well-known investigations of Osborne and his colleagues from 1900 to 1919 (Osborne & Mendel, 1919).

In protein value, the aleurone is the most important single item in the grain and the higher nutritive value, now well established, of the protein mixture in wholemeal flour compared with that in white flour (Chick, 1942; Chick & Slack, 1948–9) depends not only on the inclusion of the germ but also on the much larger contribution made by the aleurone cells. It is unfortunate that the aleurone is so firmly attached to the pericarp that it has not proved possible to obtain enough of a sufficiently pure specimen for investigation of its protein value by animal feeding. Nevertheless, animal trials with mixtures of white flour and bran have shown that the proteins in the mixture are markedly superior to those in white flour (Osborne & Mendel, 1919; Murphy & Jones, 1926; Hove, Carpenter & Harrel, 1945; Chick, Cutting, Martin & Slack, 1948). The proteins of wheat bran are richer than those of white flour in the essential amino-acids, tryptophan and lysine (Jones & Gersdorff, 1925; Barton-Wright & Moran, 1946; Hutchinson, Moran & Pace, 1956), and thus are complementary to the proteins of white flour which are relatively poor in those amino-acids.

Distribution of vitamins in the wheat grain

About the period of the First World War the discovery was made that essential nutrients other than proteins were distributed unevenly in the wheat grain and were for the most part concentrated chiefly in the outer layers. Researches on the cause of beriberi among rice eaters had revealed the serious consequences of removing the cortical layers in the milling of rice. The presence of a protective substance, an antiberiberi vitamin now known as thiamine, was demonstrated in rice bran and rice polishings, and it soon became clear that the same substance was present in the offals and bran of wheat and was lacking in white flour. The diagnosis of beriberi among Commonwealth troops serving in the Middle East, whose diet had consisted mainly of white bread and tinned meat, led to some extensive work, roughly quantitative in type, on the distribution of the antiberiberi substance in the wheat grain. It was found to be concentrated in the germs of both wheat and rice, and white wheaten flour and white polished rice were found to be equally lacking of protective action against polyneuritis of birds, the accepted analogue of human beriberi (Chick & Hume, 1917; Hinton, 1944). Other members of the water-soluble B group of vitamins which have been identified in more recent times have also been found present chiefly in the germ and outer layers of the wheat grain. Among them are riboflavin, pyridoxine, pantothenic acid and nicotinic acid (Copping, 1943; Moran & Drummond, 1945; McCance, Widdowson, Moran, Pringle & Macrae, 1945; Chick, Copping & Slack, 1946; Heathcote, Hinton & Shaw, 1952).

National bread in the Second World War

After the outbreak of war in 1939 the attention of the Government was directed to the problem of wheat supplies and of the type of bread which would be both economical and nutritious. Much of the information contained in the preceding paragraphs was available and additional *ad hoc* research was undertaken. The results were closely studied by physiologists, millers and bakers. In accordance with the recommendations of the Accessory Food Factors Committee of the Lister Institute and Medical Research Council (Medical Research Council, 1940, 1941), a flour was adopted which contained '85% of the clean wheat' and included 'the maximum amount of the germ and aleurone layer and the minimum of the pericarp, as shown by the fibre content'. With the assistance of the Research Institute of the British Flour-Millers, a 'straight-run' flour conforming to that specification was achieved and an acceptable loaf, off-white in colour, was produced. This National flour was a satisfactory compromise between the somewhat more nutritious wholemeal (100% extraction of the grain) and the less nutritious white flour (70–73% extraction). In nutritive qualities it was rather nearer to the former and in its low fibre content nearer to the latter. The specification further required that the flour should contain not less than 1 i.u. vitamin B_1/g and have a fibre content of less than 0·9%. For the control of these points trustworthy methods of analysis were needed and were produced by a large series of special co-operative tests (Medical Research Council and Lister Institute: Vitamin B_1 Sub-committee of the Accessory Food Factors Committee, 1943).

The designation 'straight-run' was important, for it involved an arrangement of the milling machinery to yield a final mill stream of the required composition. Less nutritious flours, also representing 85% of the grain, could be obtained by suitable admixture of a white flour with bran.

The value for support of growth of wheat flours of different degrees of extraction of the grain is shown in Fig. 1 and Table 1, which contain the results of an unpublished experiment of the author. Groups of litter-mate weanling rats were reared on diets of which 92% was provided by wheat flours derived from the same grist of 70, 80, 85, and 100% extraction, respectively. The rest of the ration was made up of cod-liver oil 1, salt mixture 2 and arachis oil 4%. The flours were thus the only source of B vitamins and of protein (N × 5·7), which varied from 12·5% on dry weight in the flour of 70% extraction to 13·6% in the wholemeal.

The gain in weight of the animals receiving the wholemeal was about twice that of those receiving the 70% extraction flour; that of the other two groups was intermediate. In the utilization for weight gain of food and of protein eaten there was also a graded rise in efficiency as the degree of extraction increased. The performance of the animals receiving the 85% extraction flour was near to that of those receiving the wholemeal. There was little difference between the groups having the 80 and 70% extraction flours.

Table 1. *Nutritive value of wheat flours of different extraction rates determined with groups of weanling rats*

(Time, 6 weeks)

Extraction rate (%)	No. of rats/group	Mean body-weight (g)		Mean weight increase	
		Initial	Final	g/100 g dry food eaten	g/g protein (N × 5·7) eaten
70	4	49·8	81	12·7	1·08
80	4	49·2	92	11·7	0·97
85	8	50·2	105·5	17·1	1·34
100	8	49·1	111	18·4	1·46

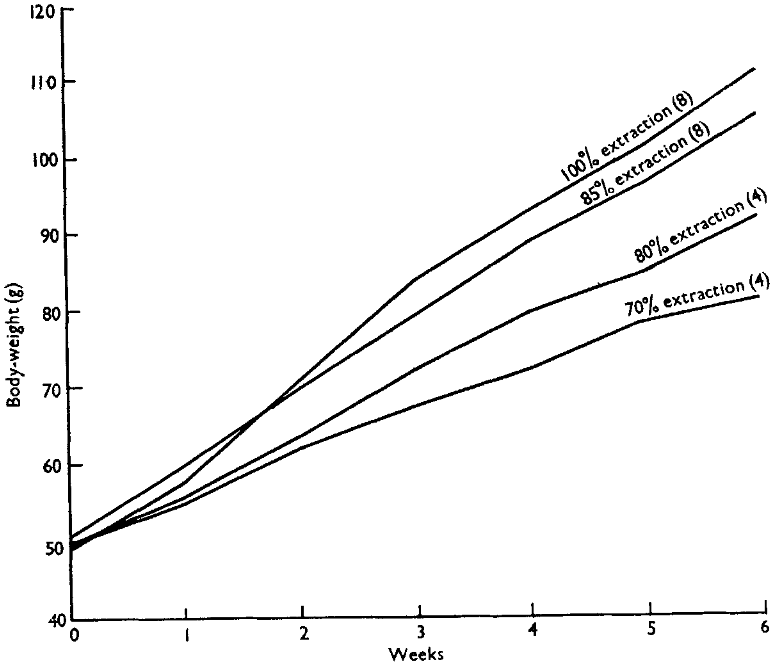

Fig. 1. Growth of groups of litter-mate weanling rats on diets with flour of different degrees of extraction. The diet was composed as follows: flour 92, arachis oil 4, salts 2 and cod-liver oil 1%. Figures in parentheses are the numbers of rats in a group.

There is little doubt that the National bread of the war years played a significant part in assuring the satisfactory state of nutrition and health enjoyed by the population of these islands. At the same time there was an important saving in our national economy in the reduction of the shipping space needed for the importation of wheat to this country from overseas.

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The essentials of the flour-milling process

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Technology

Fundamentally, two main divisions of the flour-milling process must be recognized: breaking and reduction. With wheat, the relative toughness of the bran and friability of the endosperm facilitate the separation of these materials by processes of crushing followed by sifting. On the other hand, the grain is awkwardly shaped and the endosperm is relatively firmly attached to its envelope. The grain must therefore be opened up initially and the contents spilled or released. They may then be separated from the unfurled bran coats, by means of sieves (known as scalpers), for subsequent crushing. The opening-up operation (termed 'breaking') requires a combination of pressure and shear, but shattering of the bran must be minimized since the extent to which bran fragments may be separated from endosperm after breaking varies inversely with the particle size of the mixture: for the same reason, the endosperm is desirably released mainly in the form of large particles.

Breaking process. The most effective means yet found for meeting the above requirements is a number of successive graduated treatments of the grain between pairs of spirally fluted chilled-iron rolls driven at different speeds. The rolls are progressively set closer together and more finely fluted throughout the four or five breaks usual in this country.

The scalping sieve through which the release is separated from the bran coats (or, better, break tails) becomes finer as the breaks proceed, ranging from a 1 mm aperture at the first break to 0·5–0·6 mm at the last. Basically the material passing over (overtailing) the last sieve is bran but it is perhaps better described as 'last break tails' because, to meet market requirements, it is generally sifted before sale.