Department of Health and Social Security

Report on Health and Social Subjects

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Report of the Panel on Bread, Flour and other Cereal Products
Committee on Medical Aspects of Food Policy

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Preface

For thousands of years bread has been a staple food of man and, although there has been a decline in consumption during this century, bread still has a major part to play in the diet of British people. Recently, there has been an increasing interest in the significance of fibre and the importance of trace elements in the diet. In 1978, an expert panel of the Committee on Medical Aspects of Food Policy was set up to reconsider the nutritional aspects of bread, flour and cereals in the light of present knowledge.

The Panel has deliberated very carefully before coming to the conclusion that, in the context of the present-day British diet, there is no longer any nutritional necessity for the mandatory addition of calcium, thiamin, nicotinic acid or iron to flour. The Panel also concluded that there would be nutritional advantage to many people if they adjusted their diet to include more bread, whether white, brown or wholemeal. The Panel members were unanimous in their decisions. The Note of Reservation by Professor Morris expresses his views about what should be done to increase consumption of brown and wholemeal bread. The findings of the National Food Survey show that, since 1975, there have been increased purchases of brown and wholemeal bread, although total bread consumption has continued to decrease.

Our thanks are due to the members of the Panel and particularly to the original Chairman, Professor Sir Frank Young, who was a member of the 1960 Joint Nutrition Panel on Bread and Flour and Chairman of the 1972 Advisory Panel on Bread and Flour. Our special thanks are also due to Dr John Cummings who was a member of the Panel and took over the Chairmanship in January 1980 when Sir Frank resigned because of ill-health. We are most grateful to all those who have given so generously of their time and expert knowledge in an important subject.

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Chairman of the Committee on the Medical Aspects of Food Policy

Committee on Medical Aspects of Food Policy

Panel on Bread, Flour and other Cereal Products

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Dr J H Cummings (from January 1980)	Dunn Clinical Nutrition Centre, University of Cambridge and Medical Research Council

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1. Introduction

1.1 Bread has been a staple food of the British people for centuries but, over the past few decades, the amount of bread eaten in Britain and the contribution of bread and flour to the nutrient content of the total diet have decreased.

1.2 Since 1942, all wheat flour except wholemeal has been fortified with calcium carbonate, and thiamin was added to white flour during 1940-42. Following the recommendation of the Conference on the Post-War Loaf (Ministry of Food, 1945), thiamin, nicotinic acid and iron have been restored to white flour since 1953 when the ban on the milling of this flour was lifted.

1.3 Recently there has been increased interest in the importance of trace elements in the diet and in the nutritional aspects of dietary fibre. In 1974 members of the milling industry asked advice of the Committee on Medical Aspects of Food Policy about the function and desirability of the fibre in bread.

1.4 The need for the continued addition of certain nutrients to bread has been examined by expert Advisory Committees in 1956, 1960 and 1972 (Ministry of Agriculture, Fisheries and Food and Ministry of Health, 1956; Ministry of Agriculture, Fisheries and Food, 1960 and 1974). A further review seemed opportune and, in 1978, the Committee on Medical Aspects of Food Policy set up a Panel of experts for this purpose under the Chairmanship of Professor Sir Frank Young. Because of ill-health Sir Frank resigned the chair in December 1979 and was succeeded in January 1980 by Dr J H Cummings. The Panel met for the first time in June 1978, held seven meetings and had the benefit of discussion with a number of professional people and with representatives from industry (acknowledgements p.vii).

1.5 The Terms of Reference of the Panel were:—
In the light of the available medical and scientific evidence,

a. to consider the nutritive value of bread, flour and other cereal products and their importance in the diet, and
b. to make any appropriate recommendations.

1.6 This report is concerned almost entirely with the nutritional aspects of wheat flour and of bread made from such flour. Other cereal products have not been considered in detail. Questions which relate to food additives or to contaminants and toxicity are matters for the Food Standards Committee[1], the

[1] The Food Standards Committee advises the Minister of Agriculture, Fisheries and Food, the Secretary of State for Social Services, the Secretary of State for Scotland, the Secretary of State for Wales and the Head of the Department of Health and Social Services for Northern Ireland on the exercise of their powers under the Food and Drugs Act, 1955 and the corresponding enactments relating to Scotland and Northern Ireland, to control the composition and description of food.

Food Additives and Contaminants Committee [1], and the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment[2] and are outside the terms of reference of the present Panel.

1.7 Early in 1978 the Council of the Royal College of Physicians of London set up a Working Party under the Chairmanship of the President of the Royal College of Physicians, Sir Douglas Black, to study and report on the medical aspects of dietary fibre. Among the members of this Working Party who were also members of the present Panel were Professor J N Morris and Dr D A T Southgate. The medical secretary of the Panel, Dr S R Fine, was the observer from the Department of Health and Social Security. An exchange of information about dietary fibre between the two Committees was therefore facilitated. The report of the Royal College of Physicians on "Medical Aspects of Dietary Fibre" was published in October 1980.

[1] The Food Additives and Contaminants Committee advises the Minister of Agriculture, Fisheries and Food, the Secretary of State for Social Services, the Secretary of State for Scotland, the Secretary of State for Wales and the Head of the Department of Health and Social Services for Northern Ireland on matters referred to them by Ministers in relation to food contaminants, additives and similar substances which are or may be present in food or used in its preparation.

[2] The Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment advises, on request, on the hazards to health including toxicological and carcinogenic risks, which result from the use of or presence of additives, contaminants or pesticides in food and in the environment.

2. Historical background

2.1 Wheat and other cereals have been significant constituents of man's diet since pre-historic times. Before the discovery of fermentation, attributed to the Egyptians about 2600 BC, ground cereal was probably used for making unleavened cakes or porridge. Bread was a staple part of the diet of the Greeks and Romans, and wheat gradually became established as the main cereal crop of southern Europe.

2.2 In Britain, oats, barley and rye were grown in the north and wheat in the south and east of the country. The more prosperous people and those in southern and eastern countries consumed wheaten bread and, as cultivation methods improved, wheat became the largest grain crop. White bread was considerably more expensive than the darker breads until the mid-eighteenth century and the consumption of white bread was for long confined to noble or wealthy households.

2.3 By the late 19th century, the development and gradual adoption by the milling industry of the steel roller mill and its ancillary equipment enabled a more effective separation of the constituent parts of the grain. The roller mill was also better adapted to milling hard wheats from North America and elsewhere. These changes, together with an increasing demand in the animal feed market for the bran produced by milling, resulted in flour which consisted of about 70% of the wheat grain becoming widely available. Apart from the imposition, for economic reasons, of a compulsory minimum extraction of flour from the wheat grain during and immediately following the first world war, the extraction rate[1] for flour remained at around 70% until 1939.

2.4 During the thirties, there was a growing recognition of the part played in the diet by vitamins. In particular it was noted by scientific authorities that white flour was relatively deficient in the B vitamins, especially thiamin (vitamin B_1), when compared with the whole grain. The bulk of the thiamin is located in the scutellum[2] of the grain and this is largely removed during the production of white flour. In the late 1930s, Professor (Sir Charles) Dodds suggested to the British milling industry that white flour should be supplemented by the addition of synthetic thiamin which had just begun to be produced on a commercial scale (Horder, Dodds and Moran, 1954, page 160). The outbreak of war in September 1939 diverted the industry's plans to implement this suggestion but, because of the possibly serious consequences to the nation of a dietary shortage

[1] The extraction rate is the percentage by weight of flour milled from the cleaned grain.

[2] The scutellum is a shield-like structure which represents that part of the single cotyledon of grains which is adjacent to the embryo and lies between it and the endosperm (Figure 3.1).

of thiamin, in July 1940 the Government announced that 200 mg of thiamin would be added to each 280 lb sack of white flour.

2.5 By mid-1940 shipping space was at a premium and considerable importance was therefore attached to the need to make available for human food a greater proportion of the wheat grain than had been customary. In August 1940, the Accessory Food Factors Committee of the Medical Research Council issued a memorandum which contained four main recommendations to improve the nutritive value of flour and bread (Medical Research Council Accessory Food Factors Committee, 1940). The first was that the minimum extraction rate for flour should be 80-85%. Two other recommendations concerned restrictions in the use of bleaching agents and of alkaline baking powders and the fourth was a proposal that calcium salts should be added to flour during its manufacture. This last recommendation followed, in part, from what appeared to be strong evidence that the absorption of calcium was affected by "toxamins" present in certain foods. McCance and Widdowson (1942a) had shown that phytic acid which is present in wheat cereals reduced, in the short term at least, the absorption of calcium from the gut. It was known, moreover, that there was more phytate in flours of high extraction rate. Probably a more pressing reason for the addition of calcium was that during wartime those foods rich in calcium such as milk and cheese were expected to be in short supply. It was therefore appropriate to increase the calcium content of a food which would still feature prominently in the nation's diet. The addition of chalk to flour at a rate of 7 oz calcium carbonate per 280 lb of flour, which was half that recommended for 85% extraction in a second memorandum (Medical Research Council Accessory Food Factors Committee, 1941), began in 1942 and became compulsory in 1943. In August 1946, after the extraction rate had been raised to 90% in the previous May and the phytate content of flour increased, legislation was introduced which required that the amount of added chalk be increased from 7 to 14 oz per 280 lb of flour.

2.6 In September 1939, the Government introduced legislation which laid down that in the manufacture of flour the minimum rate of extraction of the wheat grain should be 70%. In October 1939, this minimum rate of extraction was raised to 73% and in April 1941 to 75%, the flour produced being still almost white. In March 1942, the minimum extraction rate for all flour had been raised to 85% to save shipping space and millers were urged to include as much of the wheatgerm as possible and to exclude the coarse bran. With the increased extraction rate, the addition of thiamin was no longer considered necessary (Ministry of Food, 1945, paragraphs 9-14, pages 166-168).

2.7 In January 1945, the Ministry of Food convened a Conference on the Post-War Loaf which was attended by representatives of the milling and baking industries as well as Government advisers (Ministry of Food, 1945). The Conference concluded that, since the health of those living in the United Kingdom during the war had been good despite a great reduction in the variety of available food, the amounts of certain nutrients present in the wartime diet represented a satisfactory standard for the maintenance of health.

The nutrients selected for special consideration were thiamin, riboflavin, nicotinic acid and iron. The Conference did not recommend that riboflavin be added to flour but agreed that all flour should contain no less than certain specified quantities of the three so-called "token nutrients", namely 0.24 mg thiamin, 1.6 mg nicotinic acid and 1.65 mg of iron per 100 g of flour. These amounts were the minimum amounts known to be present in flour of 80% extraction rate.

2.8 The official medical and scientific members of the Conference strongly held the view that the three token nutrients were only part of an organic complex which included other substances, some of which were known to be physiologically active though knowledge of them was still imperfect. There was disagreement at the Conference on the question of whether the nutritional value of white flour could be made equal to that of an 80% extraction flour by the addition of only the three token nutrients.

2.9 In the post-war period therefore, the question was not whether high extraction flour was better than white, but whether white flour, to which the thiamin, nicotinic acid and iron removed by milling had been restored, was nutritionally as good as higher extraction flour. To determine this, Widdowson and McCance (1954) studied the effect of feeding breads made from flour of various extraction rates on the growth and health of undernourished children in Germany. The children were stunted in height and underweight at the outset of the feeding trials in 1947. The results of these studies showed that the children all grew rapidly and equally well when they obtained 75% of their food energy from any of the breads made from five different types of flour. The flours were wholemeal, brown flour of 85% and white flour of 70% extraction without added nutrients except calcium, and 70% extraction flour to which thiamin, riboflavin, nicotinic acid and iron had been added to restore the amounts to what was naturally present in 100% and in 85% extraction flours. All flours contained added calcium carbonate.

2.10 Widdowson and McCance's conclusions were as follows:—

"Probably the most important finding concerns the high nutritive value of wheat in any of the forms customarily consumed by man. Thus it has been shown that diets in which 75% of the calories were derived from wheat flour and 21% from vegetables, and which contained only 8 g of animal protein a day, provided undernourished children aged 5-15 years with all the nutrients required for a high rate of growth and development for a period of 18 months. The addition of 500 ml of reconstituted full-cream dried milk per day over a period of 6 months caused no apparent improvement in the growth or health of the children. It is evident that diets containing much bread and little animal protein can be made highly satisfactory and, that a balanced diet, adequate in all its nutritional aspects, can be provided with minimal amounts of milk and meat, if plenty of wheat and vegetables are available".

2.11 When the milling industry was finally decontrolled in 1953, a Flour Order was made (Statutory Rules and Orders, 1953) which allowed the

extraction rate to fall below 80% provided that the flour contained the minimum amounts of thiamin, nicotinic acid and iron recommended by the Conference on the Post-War Loaf (Ministry of Food, 1945). In addition the requirement to add chalk at the rate of 14 oz per 280 lb was continued. Bread made from National flour[1] of 80% extraction rate was subsidized until 1956 but the millers were free to produce flour of a lower extraction rate to which the required nutrients had been added.

2.12 However, the debate continued about the nutritional value of 80% extraction flour compared with that of flour of a lower extraction to which the token nutrients had been added. An independent Panel, under the chairmanship of Sir Henry Cohen, was appointed in 1955. The Panel concluded in its report (Ministry of Agriculture, Fisheries and Food and Ministry of Health, 1956, paragraph 10.11, page 26) that "the available evidence does not reveal any ascertainable difference between National flour as defined in the Flour Order, 1953, and flours of extraction rate less than National flour, to which vitamin B_1 nicotinic acid and iron have been restored in the amounts specified in the Flour Order, 1953, which would significantly affect the health of the population in any foreseeable circumstances. They believe, however, that differences between low extraction flour enriched as specified and low extraction flour not so enriched are significant".

2.13 A Report on Bread and Flour by the Food Standards Committee (Ministry of Agriculture, Fisheries and Food, 1960) contained a statement by a Joint Nutrition Panel on Bread and Flour which included representatives of the Food Standards Committee and of the Committee on Medical Aspects of Food Policy (COMA) under the chairmanship of Professor (Sir Derrick) Dunlop. No changes were recommended in the amounts of thiamin, nicotinic acid, iron and calcium beyond the current statutory requirements, and the addition of riboflavin and of pyridoxine was not recommended. The Panel thought that the evidence for the continued addition of calcium was not firmly established and recommended that the matter should be assessed again when there had been time for any adverse effects of a reduction in the vitamin D content of infant cereals, National Dried Milk and Cod Liver Oil to be revealed. The reduction in the vitamin D content of these foods was to minimise the risk of hypercalcaemia which could result from the ingestion of excess vitamin D by young children (Ministry of Health, Department of Health for Scotland, 1957). The recommendations of the Dunlop Committee in the Food Standards Report of 1960 became mandatory in the Bread and Flour Regulations, 1963 (Statutory Instrument, 1963).

2.14 The form in which iron should be added to flour became of concern after Elwood (1963) found that the powdered iron of the kind which was added to the flour used for breadmaking was poorly absorbed from the gut. The Bread and Flour Regulations, 1963 stipulated that the addition of iron to flour, where such an addition was required, should be in the form of ferric ammonium citrate or of reduced iron prepared by the action of hydrogen upon ferric oxide. The

[1] National flour was defined in the Flour Order, 1953.

Ministry of Health set up an Advisory Panel on Iron in Flour which reported in 1968, giving details of further experiments (Ministry of Health 1968). Studies of the absorption of iron from bread which contained different forms of radioactively labelled iron and iron compounds showed that powdered iron was least well-absorbed, ferrous sulphate was the best absorbed and that the iron in ferric ammonium citrate was better absorbed than that from freshly reduced iron.

2.15 In April 1969, the Committee on Medical Aspects of Food Policy was invited by the Food Standards Committee to assist in a review of the 1963 Regulations, and an Advisory Panel on Bread and Flour, chaired by Professor Sir Frank Young, reported in 1972 (Ministry of Agriculture, Fisheries and Food 1974). The Panel recommended the continued addition of calcium as the carbonate to flour, on the grounds that until further evidence about the possible link between hard water and cardiovascular disease was available, a reduction in calcium intake should not be recommended. The Panel accepted the possibility of the use of other non-toxic calcium salts as permitted additives to flour, recommended the inclusion of ferrous sulphate as a source of iron and made no change in the amount of thiamin to be added to white flour. The Panel concluded that there was no longer any need for the continued addition of nicotinic acid to flour, firstly because the contribution of flour to dietary nicotinic acid was small since nicotinic acid in cereals is mainly in a bound form which is not absorbed from the gut (Das and Guha, 1960; Kodicek, 1962; Clegg, 1963), and secondly because there was good evidence that nicotinic acid was formed in the body from the tryptophan of dietary protein. The addition of riboflavin, pyridoxine or any other vitamins was not recommended. The Bread and Flour (Amendment) Regulations, 1972 (Statutory Instrument, 1972) permitted the use of ferrous sulphate and ferric ammonium citrate as sources of iron and specified the particle size and solubility in dilute hydrochloric acid of iron powder when this was intended for addition to flour, but did not delete the requirement to add nicotinic acid to flour.

2.16 Cleave (1956) was among the first to draw attention to the possibility of adverse effects on health of including in the diet so-called purified foods such as sucrose and white flour. Since the early 1970s, nutritional interest in dietary fibre has increased. Burkitt (1971), Trowell (1972, 1973), Walker, Walker, Richardson and Woolford (1973) and others have put forward the hypothesis, based on their epidemiological studies in Africa, that the amount of dietary fibre eaten may be related to the prevalence of certain diseases, particularly those which affect the large bowel (section 6). This hypothesis, together with increasing knowledge about trace elements, has a direct bearing on the importance of bread and flour products in the average diet in the United Kingdom (paragraph 1.3).

2.17 The brief historical account which is set out in the above paragraphs illustrates the developments that have led to the present review of the nutritional composition of bread and flour and of the importance of these foods in the diet.

3. Composition of bread and flour

3.1 Introduction

3.1.1 Most of the bread which is eaten in the United Kingdom is baked from wheat flour although bread can be made from other cereals such as rye. In this report, bread and flour refer to wheat products unless otherwise stated.

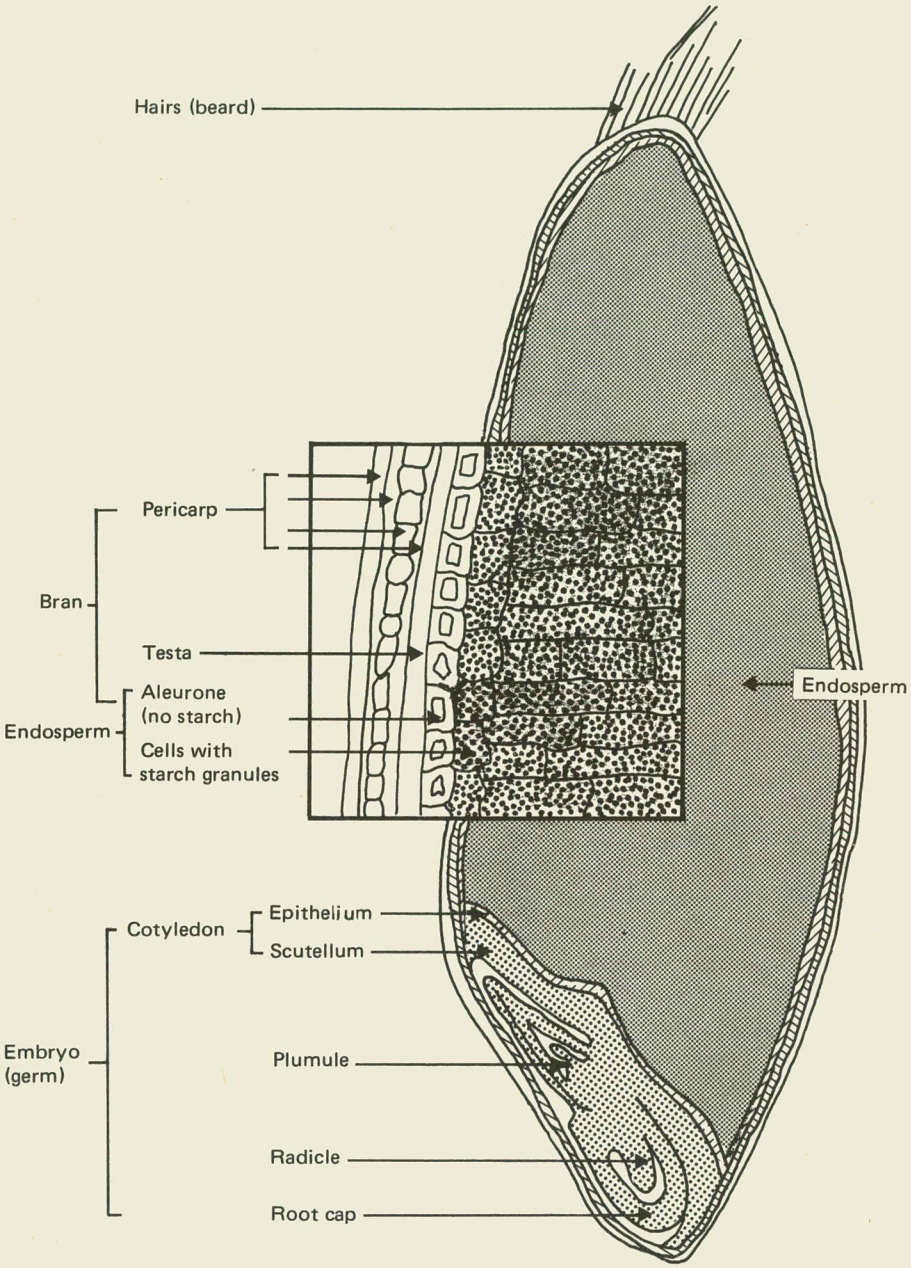
3.1.2 *Anatomy of the wheat grain.* The wheat grain, like that of other cereals, consists of the pericarp and testa which cover the endosperm and the germ or embryo (Figure 3.1). The outer layers, including the aleurone layer of the endosperm, form bran which constitutes about 12 to 15% of the grain. The scutellum, which lies between the embryo and the endosperm, is rich in thiamin and the germ or embryo, which contains a greater concentration of protein, fat and vitamin E than the rest of the grain, makes up approximately 2 to 3% of its weight. The remainder is endosperm which contains protein and the starchy material that goes into flour.

3.1.3 *Extraction rates.* Flour for breadmaking is produced in a range of extraction rates. Wholemeal flour (100% extraction) contains all the material derived from the cleaned wheat grain as a result of milling, whereas white flour (of approximately 72% extraction) is derived mainly from the endosperm. The bran and germ, which are removed in milling white flour, are known as 'offals'.

3.1.4 White flour can be obtained at extraction rates of up to 75%, according to the quality of the wheat and the efficiency of the milling equipment. Flours of extraction rates between that of white flour and 100% can be produced by adding to white flour a proportion of the ground offals, until the desired extraction rate is reached. As milling proceeds, the flour fractions and the offals comprise a number of distinct streams. A series of flours, all the same nominal extraction rate, can be made by mixing the appropriate flour fractions with the available offal streams.

3.1.5 Thus the extraction rate is not necessarily an accurate guide to the composition of flour. In addition, the composition of flour (even if of 100% extraction) varies according to the variety of wheat used. In practice a mixture of different varieties is selected as the 'grist' so that the milling and the baking properties of the resultant flour are those required for the particular product, including the type of bread, to be made.

Figure 3.1. *Diagrammatic longitudinal section of wheat grain through the crease and germ.*



Source: Adapted from a drawing by E.E. McDermott in "The Technology of Cereals" by N.L. Kent, 1975. Oxford, Pergamon Press.

3.2 Constituents of bread and flour

3.2.1 The popular view of the nutritional role of bread in the diet is that it provides only carbohydrate. This view is incorrect in that bread is also a source of protein, fat, some vitamins and minerals, including some of the trace elements, as well as dietary fibre. However, there are many different types of flour and bread and the composition of these commodities differs one from another.

3.2.2 The composition of flour is largely determined by the varieties of wheat which are included in the grist and by the proportion of the grain which becomes flour whereas the composition of bread is determined by the flour from which it is baked and by the amounts of other ingredients which are added during the baking process. Bread-making involves the addition of water and a small loss of carbohydrate as a result of fermentation by added yeast. Differences between the composition of flours and the corresponding breads are chiefly due to the larger moisture content of bread. Table 3.1 shows the average composition of white, brown and wholemeal flours commonly used in the United Kingdom and of the corresponding breads.

3.3 Carbohydrates

3.3.1 About 2% of wholemeal flour is a mixture of simple sugars, about 57% is starch and about 10% is other carbohydrate which is derived from cell walls and is called dietary fibre.[1] White flour of about 72% extraction contains approximately 1-2% sugars, 67% starch and a smaller amount (about 3%) of dietary fibre. Flours of intermediate extraction rates contain less starch and more dietary fibre than white flour.

3.3.2 *Sugars.* Most flours contain 1-2% of a mixture of glucose, fructose, maltose, raffinose and a gluco-fructan polysaccharide complex known as 'levosin', which is the major component. The amounts of simple sugars are increased if the grain has been stored at a moisture content that has allowed enzymatic activity.

3.3.3 *Starch.* Starch is present in granules which fill the endosperm cells. Structurally, starch is composed of approximately 26% of a straight chain $\alpha(1\text{-}4)$ polymer of glucose called amylose, and most of the remainder is a branched $\alpha(1\text{-}4)$, $\alpha(1\text{-}6)$ polymer called amylopectin. In addition there is a small amount of an intermediate polymer with both straight and branched chain configurations.

3.3.4 *Dietary fibre.* Wheat fibre is derived from the cell wall material of the 3 different types of tissue within the grain. The undifferentiated walls of the

[1] Dietary fibre in cereals is derived principally from the plant cell walls and can best be defined analytically as lignin and non-starch polysaccharide. This includes all polysaccharides other than α-linked glucose polymers.

embryo and the thin walls of the endosperm cells contain polysaccharides of which about a quarter are cellulose (long chain β-D-glucans) and the remainder are non-cellulosic polysaccharides. The cell walls of the pericarp (Figure 3.1) and the seed coat are thicker and the external layers are partially lignified so that they contain about 10% lignin (which is not a carbohydrate) in addition to cellulose (about 25%) and non-cellulosic polysaccharides (about 65%). About 75% of the dietary fibre is in the bran and about 25% in the endosperm. Thus all flours and breads contain dietary fibre but the amounts and composition of the fibre vary according to the proportion of bran present. Wholemeal bread contains 8-9 g dietary fibre/100 g bread, brown bread contains 5-6 g/100 g and white bread contains 2-3 g dietary fibre/100 g bread.

3.4 Protein

3.4.1 The amount of protein in a wheat flour depends on both the extraction rate (high extraction flours contain more protein) and on the type of wheat from which the flour was milled. The protein content of a given wheat variety can, to a limited extent, vary with the fertiliser treatment that the crop has received but, in general, North American wheats are richer in protein than English wheats. In practice, the mixture of wheats which are used in the grist ensures that the protein content of bread varies over only a narrow range. Wheats are classified as 'hard' or 'soft' according to their milling qualities, and as 'strong' or 'weak' according to their baking strength. Hard wheats contain a mixture of proteins that give flour the required physical property of trapping gas during bread-making to give the desired crumb structure. Only some of the soft wheats have similar 'strong' bread-making characteristics.

3.4.2 The distribution of proteins within the wheat grain is reflected in the essential amino acid composition of flours of different extraction rates (Table 3.2). The proteins in higher extraction flours tend to be slightly richer in lysine than those of white flour, but minor variations in amino acid composition between flours of different extraction rates, and any slight losses on baking, are of little or no significance for the United Kingdom diet which contains more protein than is needed to meet physiological requirements.

3.5 Fat

3.5.1 The wheat grain contains a relatively small amount of lipid, the greatest concentration of which is in the embryo. Wholemeal and brown flours therefore contain more fat than white flour.

3.5.2 In bread-making, a small amount of fat is usually added to flour and the type of added fat alters the composition of the fat in bread. Table 3.3 shows the average composition of fat in white, brown and wholemeal flours and the corresponding breads, and demonstrates that the amount of fat/100 g flour or bread is small.

3.6 Vitamins

3.6.1 The wheat grain contains vitamins of the B complex which are chiefly found in the aleurone layer of the endosperm and in the embryo so that high extraction flours contain larger concentrations of vitamins. Average figures for the vitamin content of breads and flours are shown in Table 3.4. At present, thiamin and nicotinic acid are added to white flour in amounts which accord with the Bread and Flour Regulations, 1963 so that flour contains not less than 0.24 mg thiamin and not less than 1.6 mg nicotinic acid/100 g flour.

3.6.2 *Thiamin.* Wholemeal flour contains 0.46 mg thiamin/100 g compared with about 0.1 mg in white flour of 72% extraction to which no thiamin has been added.

3.6.3 *Nicotinic acid.* Wholemeal flour contains 5.6 mg nicotinic acid/100 g and white flour without the addition of nicotinic acid contains only 0.7 mg/100 g. However, most of the nicotinic acid in wheat flour is bound to protein and is unavailable, that is to say, not readily absorbed (Das and Guha, 1960; Kodicek, 1962; Mason, Gibson, and Kodicek, 1973). In the body, nicotinic acid is synthesised from tryptophan, and because the tryptophan content of white, brown and wholemeal flours is about the same, the nicotinic acid equivalents which are calculated on the basis that 60 mg tryptophan give rise to 1 mg of nicotinic acid, are also similar for the three types of flour. The addition of nicotinic acid to flour, other than wholemeal, therefore causes the total available amount of the vitamin added plus that from tryptophan to be greater in white and brown flours than in wholemeal flour (Holman, 1954).

3.7 Inorganic Constituents

3.7.1 Table 3.5 shows the average amounts of the inorganic nutrients in flour and bread. The distribution of inorganic constituents within the wheat grain is such that high extraction flours tend to contain larger concentrations of most minerals.

3.7.2 *Sodium.* Salt is usually added during bread-making for reasons of palatability and this increases the sodium concentration from 3-4 mg/100 g flour to over 500 mg/100 g bread.

3.7.3 *Potassium.* Wholemeal flour contains about 3 times as much potassium as white flour. Small amounts of potassium are added in the form of potassium bromate used as an oxidising agent in flours other than wholemeal.

3.7.4 *Calcium.* Calcium as chalk (calcium carbonate or creta praeparata) is required to be added to all flour, except wholemeal and self-raising flours with a calcium content not less than 0.2%, in the range of 235-390 mg calcium carbonate/100 g flour. This contributes about 94-156 mg calcium/100 g flour (paragraph 5.1.2).

3.7.5 *Magnesium.* Magnesium is concentrated in the bran and germ of the wheat grain, and wholemeal flour contains nearly 4 times as much magnesium as white flour.

3.7.6 *Phosphate.* The larger concentration of phosphate in the bran and germ of the grain is reflected in the concentration present in brown and wholemeal flour. A substantial proportion is present as the magnesium and potassium salts of phytic acid (inositol hexaphosphate) in high extraction flours. Although some phytate is destroyed during fermentation and baking, the concentration in wholemeal bread is much greater than in white bread (paragraph 7.1.4.).

3.7.7. *Iron.* Iron is added where necessary to all flours except wholemeal in amounts which ensure that at least 1.65 mg iron per 100 g flour is present. The iron is usually added as iron powder of a defined specification. Ferrous sulphate and ferric ammonium citrate are also permitted according to the Bread and Flour (Amendment) Regulations, 1972.

3.7.8 *Copper and Zinc.* The concentration of copper and zinc, like that of many other inorganic constituents, is greater in high extraction flours.

3.7.9 *Other trace elements.* Many other trace elements, for example manganese and chromium, are present in much greater concentrations in the bran and germ of the wheat grain and are, therefore, found at greater concentrations in high extraction flours. The selenium content, in particular, is known to be influenced by the concentration of selenium in the soil in which the wheat crop was grown.

Table 3.1: *Average nutrient composition/100g of white, brown and wholemeal flours and of breads baked from such flours*

		Flour[1]			Bread		
		White	Brown	Wholemeal	White	Brown	Wholemeal
Water	g	14.5	14.0	14.0	39.0	39.0	40.0
Protein (N × 5.7)	g	11.3	12.8	13.2	7.8	8.9	8.8
Fat	g	1.2	2.0	2.0	1.7	2.2	2.7
Sugars	g	1.5	1.9	2.3	1.8	1.8	2.1
Starch	g	67	60	57	43	39	36
Dietary fibre	g	3.0	7.5	9.6	2.7	5.1	8.5
Phytic acid[(2)]	mg	100	527	806	4	202	360
Total food energy	kcal	337	327	318	233	223	216
	MJ	1.43	1.39	1.35	0.99	0.95	0.92

Source: Paul and Southgate, 1978.

[1]White, brown and wholemeal flours correspond to flours of approximately 72%, 85% and 100% extraction rates.

[2]Data of DGH Daniels and N Fisher, Flour Milling and Baking Research Association (private communication).

Table 3.2: *Average amounts (expressed as mg/100g) of essential amino acids in white, brown and wholemeal flour and in breads baked from such flours*

Amino acids	Flour[1]			Bread		
	White	Brown	Wholemeal	White	Brown	Wholemeal
Isoleucine	480	470	480	340	330	320
Leucine	870	950	950	620	660	630
Lysine	240	320	340	170	220	230
Methionine	200	230	230	140	160	150
*Cystine	320	360	360	220	250	240
Phenylalanine	590	630	630	420	440	420
*Tyrosine	320	430	430	220	300	290
Threonine	340	380	380	240	270	260
Tryptophan	140	160	160	98	110	110
Valine	540	610	630	380	420	420

Source: Paul, Southgate and Russell, 1980.

[1]as for Table 3.1.

*Included because of their sparing action on methionine and phenylalanine requirements.

Table 3.3: *Average amounts (expressed as g/100g) of some fatty acids in white, brown and wholemeal flours and in breads baked from such flours*

Fatty acids	Flour[1]			Bread[2]		
	White	Brown	Wholemeal	White	Brown	Wholemeal
Saturated						
palmitic	0.16	0.26	0.26	0.31	0.34	0.41
stearic	Tr	0.01	0.01	0.07	0.07	0.09
Mono-unsaturated						
oleic	0.13	0.21	0.21	0.24	0.30	0.37
Polyunsaturated						
linoleic	0.50	0.83	0.83	0.62	0.88	1.08
linolenic	0.03	0.06	0.06	0.04	0.06	0.08

Source: Paul, Southgate and Russell 1980.

Tr = trace.

[1]as for Table 3.1.

[2]The fatty acids in bread are derived, to some extent, from fat added in bread-making.

Table 3.4: *Average vitamin content/100g of white, brown and wholemeal flours and of breads baked from such flours*

		Flour[1]			Bread		
		White	Brown	Wholemeal	White	Brown	Wholemeal
Thiamin — total	mg	0.30	0.42	0.46	0.18	0.24	0.26
— before restoration	mg	0.10	0.30	0.46			
Riboflavin	mg	0.03	0.06	0.08	0.03	0.06	0.06
Nicotinic acid							
unavailable	mg	0.7	1.7	5.6	1.4	2.9	3.9
added	mg	1.3	2.5	nil			nil
Nicotinic acid equivalents							
from tryptophan	mg	2.3	2.6	2.5	1.6	1.8	1.7
total available	mg	3.6	5.1	2.5	1.76	1.86	1.7
Folic acid							
free	μg	14	23	25	6	21	22
total	μg	31	51	57	27	36	39
Pantothenic acid	mg	0.3	0.4*	0.8	0.3	0.3	0.6
Biotin	μg	1	3*	7	1	3	6
Vitamin E	mg	Tr	Tr	1.0	Tr	Tr	0.2*

Source: Paul and Southgate, 1978.

Tr = trace.

[1]as for Table 3.1.

*estimated values.

Table 3.5: *Average amounts (expressed as mg/100g) of some minerals and trace elements in white, brown and wholemeal flours and in breads baked from such flours*

	Flour[1]			Bread		
	White	Brown	Wholemeal	White	Brown	Wholemeal
Sodium	3	4	3	540	550	540
Potassium	130	280	360	100	210	220
Calcium — total	140	150	35	100	100	23
— before fortification	15	20				
Magnesium	36	110	140	26	75	93
Phosphorus	130	270	340	97	190	230
Iron — total	2.2	3.6	4.0	1.7	2.5	2.5
— before restoration	1.5	2.5				
Copper	0.22	0.35	0.40	0.15	0.23	0.27
Zinc	0.9	2.4	3.0	0.8	1.6	2.0
Chromium	0.009	NA	0.017	0.026	NA	0.06
Manganese	0.73	2.43	4.4	0.42	1.71	4.0
Molybdenum	0.03	0.04	0.05	0.028	NA	NA
Selenium	0.037	0.017	0.05	0.041	0.067	0.067

Source: Paul and Southgate, 1978.
Values for chromium, manganese, molybdenum and selenium are provided by Kent, 1980 (private communication).

[1]as for Table 3.1.

NA = not available.

4. Bread-making, types of bread and cereal products and their contribution to the diet.

4.1 Bread-making processes in the United Kingdom

4.1.1 The attainment of good quality bread depends largely on the characteristics of the flour used for baking. The dough made from flour, yeast and water is brought to a condition of optimum spring and elasticity ("ripeness") by chemical and physical means prior to baking.

4.1.2 *Carbohydrates in bread-making.* During the preparation of bread the starch granules in the flour absorb water, swell and are hydrolysed in part by yeast amylases to produce glucose, maltose, maltotorise and dextrins. Glucose, fructose and sucrose, which are either present as such or are derived from levosin breakdown, are fermented preferentially by yeast to produce carbon dioxide gas which expands the dough. Maltose is further hydrolysed by yeast maltase to glucose. In the traditional long fermentation baking process, up to 2% of the flour carbohydrate may be lost in the dough. A smaller loss of flour carbohydrate occurs during fermentation by the Chorleywood process (paragraph 4.1.5).

4.1.3 In baking, the first stage is the formation of a crust in which intact starch granules are present. In the body of the dough the gas expands and for a short time there is increased enzymatic activity and fermentation. The baking process results in some irreversible dextrinisation of the starch and in Maillard reactions between the carbohydrate and protein which cause some loss of available lysine and give a darker colour to the crust. Staling involves crystallisation of the starch fraction and also some redistribution of water between starch and gluten, the net effect being a firming of the crumb.

4.1.4 *Long Fermentation Process.* Until twenty years ago, most bread in the United Kingdom was made by mixing the ingredients mechanically to a warm dough and allowing the yeast to ferment the dough in bulk for about three hours. A light re-mixing ("knock-back" or kneading) was occasionally inserted into the fermentation period. Further fermentation periods ("proving") up to a total of one and a half hours were allowed after division and moulding of pieces of dough into shapes ready for baking. Thus after a total fermentation period of four and a half hours the dough was in the correct state of "ripeness" to be baked in an oven for about half an hour. Approximately 15% of bread, including most wholemeal bread, is still made by this method or variations of it.

4.1.5 *Short Fermentation Process.* About twenty years ago at Chorleywood, processes were developed that eliminated the time-consuming and space-requiring bulk fermentation stage, though not the "proving" stages. In these processes, the physical and chemical effects of bulk fermentation for three hours could be reproduced by high-speed mixing of the dough for about three minutes in the presence of mixtures of ascorbic acid and potassium bromate[1] to a total of 75 mg/kg flour. More recently a fast-acting improver azodicarbonamide[2] has been included by some bakers together with ascorbic acid and potassium bromate. Compared with the long fermentation process, almost twice as much yeast is added and 3.5% more water (based on flour weight) since less flour is fermented to carbon dioxide and alcohol because of the shorter time. Good results can be obtained with flours which contain about 10% less protein than is needed for the long fermentation process. This has helped to facilitate the increased use of home grown wheat in milling. Approximately 75% of all bread in the United Kingdom is now made by the Chorleywood Bread Process.

4.1.6 *Activated Dough Development.* For those not possessing or wishing to purchase the special mixers required for the Chorleywood Bread Process, the bulk fermentation stage can be eliminated or considerably reduced by the use of low speed mixers and addition of the naturally occurring amino acid L-cysteine to the dough as well as ascorbic acid and potassium bromate to a total of 125 mg/kg flour. About 10% of bread is now made in this way.

4.1.7 *Chilled doughs and partly-baked bread.* In commercial circumstances it is sometimes convenient to delay fermentation by temporarily chilling the dough. Dough pieces may be frozen and transported to shops for baking. Bread can also be marketed in a partly-baked condition.

4.2 Types of bread, flour and flour products

4.2.1 White bread is made from white flour of approximately 72% extraction to which a number of ingredients may be added. Some ingredients (water and yeast) are basic for bread-making, others are needed to improve palatability, crumb-texture, colour and keeping qualities. The permitted optional ingredients are listed in the Bread and Flour Regulations, 1963 (Statutory Instrument, 1963) and are discussed later in this report (paragraphs 7.5.1-7.5.6).

4.2.2 Bread which is described as brown bread is made from flour of approximately 85% extraction and is required to contain at least 0.6% crude

[1]Ascorbic acid and potassium bromate are included in the list of permitted improving agents under the Bread and Flour Regulations, 1963.

[2]Azodicarbonamide was the subject of a report in 1965 (Ministry of Agriculture, Fisheries and Food, 1968) and was included as a permitted additive in the Bread and Flour (Amendment) Regulations, 1972.

fibre[1] calculated by weight on the dry matter of the bread. In practice brown flours are often made by the addition of the appropriate amount of 'offals' to white flour. Wheatgerm bread is required to contain not less than 10% of added processed wheatgerm but no specified amount of crude fibre. Brown bread may contain caramel and any or all of the listed optional ingredients. In the Bread and Flour Regulations, 1963 the term 'wheatmeal' is used as an alternative to brown bread. The possible confusion of this term with the description 'wholemeal' is discussed in paragraph 7.6.3.

4.2.3 Wholemeal bread is baked from wholemeal flour (100% extraction). The list of permitted ingredients is more restricted than for other breads (paragraph 7.5.2).

4.2.4 Flours of various extraction rates can be bought for domestic use, and a wide variety is available of flour products such as biscuits, cakes, pastry, pasta, buns and scones.

4.3 Consumption of bread, flour and flour products

4.3.1 The consumption of bread is diminishing in many developed areas of the world. Reliable statistics for bread are not universally available but Table 4.1 shows the consumption of wheat flour in a number of countries between 1960 and 1975.

4.3.2 Information about the consumption of foods in Great Britain is available from the results of the National Food Survey. This survey records continuously, except during the Christmas period, for a sample of some 7-8,000 households each year, the amount and cost of foods purchased for domestic consumption over a period of one week. The survey provides information about the quantity of food which enters each household, and not the amounts of foods eaten by each person within the household. Food which is home grown or received as a gift is recorded. Certain foods such as alcoholic beverages, sweets and some ice-cream and soft drinks are not included. The figures are expressed as weights of food/person/week and as total food energy and nutrients/person/day. When comparisons are made with recommended daily amounts of energy and nutrients (Department of Health and Social Security, 1979a) allowance is made for meals eaten away from home and for food wastage.

4.3.3 The National Food Survey reveals regional differences in the consumption of various foods. More bread is obtained by households in Wales, Scotland and the West Midlands than by those in South East England and East Anglia, and when bread and flour are considered together, households in the conurbation of London and in provincial conurbations obtain rather more than the national average (Ministry of Agriculture, Fisheries and Food, 1977).

[1]Crude fibre is the insoluble residue left after digesting a weighed dry sample successively with boiling acid and boiling alkali.

4.3.4 National Food Survey figures at 5 yearly intervals over the period 1955 to 1975 and for 1979 show a decline in the consumption of white bread (Table 4.2). During 1965 to 1975 there was no consistent trend in the consumption of brown, wholemeal and other breads. However, since 1975 there has been a gradual increase in purchases of brown and other breads, and in 1979 and 1980 (Ministry of Agriculture, Fisheries and Food, 1980a) purchases of wholemeal bread also increased although total bread consumption has continued to decline. Consumption of bread outside the home is not included in the National Food Survey but can be roughly estimated from the amount of bread-making flour supplied by the millers to bakeries. Allowing for wastage, the figures indicate that non-domestic consumption of bread in, for example, restaurants and canteens may constitute about an extra 15% over that bought for use in the home (N. Chamberlain, personal communication).

4.3.5 Tables 4.3, 4.4, and 4.5 show that, on average, households with small incomes and those which include 4 or more children purchase more white bread and less brown and wholemeal bread than other households. Total bread consumption is greatest in large, low income households.

4.4 Contribution of bread, flour and flour products to the nutrient content of the diet

4.4.1 In spite of the decline in the consumption of bread and flour, National Food Survey results show that these foods provide, at present, about one-sixth of the total food energy and of the total protein, and even without the present mandatory addition of nutrients to flour, one fifth of the iron, one-seventh of the thiamin and one-eleventh of the total nicotinic acid equivalents of the average household diet in Great Britain (Table 4.6). Bread and flour are of special nutritional importance in households in which there are 4 or more children, since a larger proportion of the total food energy and of nutrients shown in Table 4.7 is obtained from these commodities than is obtained by the average household (Table 4.6).

4.4.2 In parts of the world other than the United Kingdom, rice, maize (corn), oats, rye and barley may be staple cereals but with the exception of rice for certain groups of Asian immigrants these are not major sources of nourishment for many people in Britain. These cereals are eaten mainly as speciality items such as corn flakes, porridge, rye bread and pearl barley. The average consumption of these products is very low, as shown in Table 4.8.

4.4.3 Comparison of the average daily consumption of dietary energy and some nutrients in 1979 (Ministry of Agriculture, Fisheries and Food, 1981) with the recommended amounts for these nutrients (Department of Health and Social Security, 1979a) shows a figure of at least 100% in average households (Table 4.6) and, except for energy and iron, in households with 4 or more children (Table 4.7). However, National Food Survey findings do not include all foods which are sources of energy, for example, sweets and alcohol, and the diet

in this country does not supply enough iron to meet the needs of some women of child-bearing age (paragraph 5.2.8).

4.5 Contribution of bread, flour and other cereal products to the fibre content of the diet

4.5.1 Bread, flour and other cereal products are substantial sources of fibre in the British diet. Dietary surveys (Southgate, Bingham and Robertson, 1978; Bingham, Cummings and McNeil, 1979) show that the mean total fibre intake is about 20 g/day with a range of 8 to 32 g/day. The intake of dietary fibre by vegetarians is larger (Gear, Ware, Fursdon, Mann, Nolan, Brodribb and Nessey, 1979). One third of total dietary fibre intake is derived from cereals, mostly bread. Breakfast cereals, particularly those made from bran or wholewheat, are also rich sources of fibre. The rest comes mainly from fruit and vegetables.

4.5.2 During this century, fibre consumption has diminished slightly, Cereal fibre intakes, however, have declined by a greater amount so that this type of dietary fibre now contributes proportionately much less to the total fibre intake. Information about the total food supplies for the population shows that there was a decrease in cereal fibre intake from 10.9 g/day in 1909 to 8.1 g/day in 1970 (Southgate, Bingham, and Robertson, 1978). During the years 1942 to 1953 total fibre increased sharply to about 40 g/day with intake from cereals rising to 19-24 g/day. This was due largely to greater bread consumption and the use of National flour.

Table 4.1: *Amounts of wheat flour (expressed as kg/person/year) available for human consumption in some countries*

Country	1955	1960	1965	1970	1975	Percentage change 1955 to 1975
Belgium/Luxembourg	93.8	88.5	82.9	77.1	71.5	−26
Canada	63.1	60.0	59.3	60.6	61.6	−2
Denmark	44.2	43.3	41.6	40.4	39.9	−10
France	101.2	97.3	87.0	75.0	71.5	−29
Ireland	121.7	103.4	92.6	84.4	81.5	−33
Italy*	120.9	120.0	121.2	127.0	121.6	+1
Netherlands	76.6	71.2	64.0	56.6	56.0	−27
United Kingdom	82.0	75.7	70.1	65.8	67.5	−18
United States of America	57.1	54.7	53.9	51.2	48.4	−15
West Germany	62.7	56.2	50.6	47.1	45.0	−28

Source: Organisation for Economic Co-operation and Development: Food Consumption Statistics, 1968, 1970 and 1978.

*In Italy a large proportion of wheat flour is consumed as pasta rather than as bread, biscuits or cakes.

Table 4.2: *The amounts of bread and flour (expressed as g/person/week) available for domestic consumption in Great Britain as recorded by the National Food Survey from 1955 to 1979*

	Year					
	1955	1960	1965	1970	1975	1979
White bread	10	1040	975	915	785	655
Brown bread	1430*	70	80	70	75	105
Wholemeal bread	50	25	20	15	20	30
Other bread	75	155	80	85	75	95
Total bread	1565	1290	1155	1080	955	890
Flour for domestic use	245	190	175	160	145	165

* National bread.
Source: Ministry of Agriculture, Fisheries and Food, 1957, 1962, 1967, 1972, 1977 and 1981.

Table 4.3: *Average amounts of bread and flour (expressed in g/person/week) obtained by households for domestic consumption in relation to the income of the head of the household (National Food Survey 1979)*

	Income Grade*				
	A1	A2	B	C	D
White bread	450	500	620	740	820
Brown bread	130	95	95	100	95
Wholemeal bread	35	45	35	25	25
Other bread	95	100	90	95	90
Total bread	715	745	840	955	1030
Flour	125	130	160	145	155

Source: Ministry of Agriculture, Fisheries and Food, 1981.

*Defined in terms of the gross weekly income of the head of the household as follows:
A1 — £200 and over.
A2 — £145 and under £200.
B — £90 and under £145.
C — £56 and under £90.
D — less than £56.

Table 4.4: *Amounts of bread and flour (expressed as g/person/week) obtained for domestic consumption by households with 2 adults and different numbers of children in 1979 (National Food Survey 1979)*

	Number of children				
	None	One	Two	Three	Four or more
White bread	595	655	610	680	855
Brown bread	155	95	70	65	45
Wholemeal bread	55	25	25	15	10
Other bread	125	95	80	80	60
Total bread	930	870	785	840	970
Flour	230	115	135	105	225

Source: Ministry of Agriculture, Fisheries and Food, 1981.

Table 4.5: *Amounts of bread (expressed as g/person/week) obtained by households for domestic consumption according to the number of persons and income of the head of household (National Food Survey 1979)*

Size of household	Income grade			
	A1 + A2	B	C	D + E2*
Adults only	785	930	1010	1005
2 adults plus:				
One child	845	820	915	955
Two children	670	765	850	1005
Three children	765	815	870	990
Four or more children	930	915	985	1085

Source: Ministry of Agriculture, Fisheries and Food, 1981.

*Income grade E2: households with no earner, and income of less than £56 per week.

Other income grades are defined in the footnote to Table 4.3.

Table 4.6: *Amounts of food energy and of certain nutrients present in all foods and in bread and flour obtained for domestic consumption by the average household in Great Britain, expressed as amounts/person/day (column A), as a percentage of the total intake (column B) or as a percentage of the Recommended Daily Amounts (column C) (National Food Survey, 1979).*

		Total for all foods		In bread		In flour		In bread and flour together	
		(A)	(C)	(A)	(B)	(A)	(B)	(A)	(B)
a. with flour as at present									
Energy	kcal	2254	100	306	13.6	78	3.5	384	17.1
	MJ	9.47		1.30		0.33		1.63	
Protein	g	73.4	130	10.6	14.3	2.3	3.1	12.9	17.4
Calcium	mg	964	174	116	12.0	53	5.5	169	17.5
Iron	mg	11.0	102	2.2	19.6	0.5	4.7	2.7	24.3
Thiamin	mg	1.22	132	0.25	20.8	0.06	4.7	0.31	25.5
Nicotinic acid equivalent	mg	30.6	195	2.9	9.3	0.7	2.1	3.6	11.4
b. if nutrients were not added to flour									
Calcium	mg	800	144	10	1.3	23	2.9	33	4.1
Iron	mg	10.1	94	1.6	15.8	0.4	4.0	2.0	19.8
Thiamin	mg	1.01	110	0.12	11.9	0.03	3.0	0.15	14.9
Nicotinic acid equivalent	mg	29.6	189	2.2	7.4	0.5	1.7	2.7	9.1

Source: Ministry of Agriculture, Fisheries and Food, 1981.

Table 4.7: *Amounts of food energy and of certain nutrients present in all foods and bread and flour obtained for domestic consumption by households with 2 adults and four or more children in Great Britain, expressed as amounts/person/day (column A), as a percentage of the total intake (column B) and as a percentage of the Recommended Daily Amounts (column C) (National Food Survey, 1979).*

		Total for all foods		In bread		In flour		In bread and flour together	
		(A)	(C)	(A)	(B)	(A)	(B)	(A)	(B)
a. with flour as at present									
Energy	kcal	2008	93	336	16.7	107	5.3	443	22.1
	MJ	8.44		1.43		0.46		1.89	
Protein	g	62.5	115	11.4	18.2	3.2	5.1	14.5	23.2
Calcium	mg	839	141	130	15.5	72	8.6	202	24.1
Iron	mg	10.1	94	2.2	21.8	0.7	6.9	2.9	28.7
Thiamin	mg	1.16	133	0.27	23.3	0.08	6.9	0.35	30.2
Nicotinic acid equivalent	mg	25.9	182	3.1	12.0	0.9	3.5	4.0	15.4
b. if nutrients were not added to flour									
Calcium	mg	654	110	11	1.7	32	4.9	43	6.6
Iron	mg	9.1	85	1.6	17.6	0.5	5.5	2.0	22.0
Thiamin	mg	0.94	108	0.12	12.8	0.04	4.3	0.15	16.0
Nicotinic acid equivalent	mg	24.7	174	2.3	9.3	0.7	2.8	3.0	12.1

Source: Ministry of Agriculture, Fisheries and Food, 1981.

Table 4.8: *Contribution of selected cereals (expressed in amount/person/week and nutrient/person/day) to average intake in Great Britain (National Food Survey 1979)*

	Amount	Energy	Protein	Thiamin	Nicotinic acid equivalents
	g	kcal	g	mg	mg
All bread	890	306	10.6	0.25	2.9
Rye bread	10	4	0.1	Tr	Tr
Rice	20	11	0.2	Tr	0.1
Oatmeal and Oat products	15	7	0.2	0.01	Tr
*Cornflakes	35	19	0.4	0.08	1.0
Pearl Barley	< 5	Tr	Tr	Tr	Tr

Source: Ministry of Agriculture, Fisheries and Food, 1981.

Tr = Trace.

*Some brands of cornflakes are fortified with certain nutrients.

5. Nutrients Added to Flour

5.1 Calcium

5.1.1 Wheat flour, as milled, contains only small amounts of calcium but, because bread is eaten by the majority of the population, it was decided in the early 1940s to make flour the vehicle for the addition of creta praeparata (calcium carbonate) as a means of providing more calcium in the diet (paragraph 2.5). There were two reasons: first, milk and cheese, the main sources of calcium in the diet, were likely to be scarce; and second, the extraction rate of flour for bread-making had been raised to 85%. This flour contained more phytate than the pre-war white flour of about 70% extraction, and phytate had been shown to hinder absorption of calcium from the intestine (McCance and Widdowson, 1942a). In May 1946, the extraction rate of flour had been raised to 90% and therefore in August 1946 the mandatory addition of calcium carbonate to flour was increased from 7 oz to 14 oz/280 lb of flour.

5.1.2 In 1950 the permitted extraction rate of flour was reduced to 80%, and in 1953 legislative control of the extraction rate ceased. The Flour Order, 1953 (Statutory Rules and Orders, 1953) required that all flour, except wholemeal, should continue to contain 14 oz creta praeparata/280 lb flour. In May 1956, the Cohen Committee in its Report on the Composition and Nutritive Value of Flour noted that the continued addition of creta praeparata to white flour provided "a valuable addition to calcium intakes in amounts which would ensure an adequate supply". (Ministry of Agriculture, Fisheries and Food and Ministry of Health, 1956, paragraph 6.2.4 page 12). Subsequently because of the difficulty of achieving uniform addition of calcium carbonate, the Flour Composition Regulations, 1956 (Statutory Instrument, 1956) altered the requirement for added calcium to 235-390 mg calcium carbonate/100 g flour which is equivalent to 94-156 mg calcium/100 g flour, and is on average 14 oz calcium carbonate/280 lb flour.

5.1.3 The Report of a Joint Panel of the Committee on Medical and Nutritional Aspects of Food Policy and the Food Standards Committee on Bread and Flour (Ministry of Agriculture, Fisheries and Food, 1960) again recommended the continued fortification of flour with creta praeparata. The report stated in paragraph 13(3), page 24 that "although the signs and symptoms of a specific dietary calcium deficiency in man are matters for discussion, nevertheless inadequacy of dietary calcium may be a factor in diseases such as rickets and osteomalacia." An Advisory Sub-Committee on Welfare Foods (Ministry of Health, Department of Health for Scotland, 1957) had recommended a reduction in the vitamin D content of certain foods (paragraph 2.14) in order to minimise the risk of infantile hypercalcaemia, a

condition thought to have resulted from too great an intake of vitamin D. The Joint Panel recognised that the recommendations concerning vitamin D were made with the knowledge that flour was fortified with calcium, and advised that addition of calcium should be reviewed after a suitable lapse of time during which adverse effects, if any, as a result of the change of vitamin D fortification would be revealed. The Bread and Flour Regulations, 1963 (Statutory Instrument, 1963) therefore retained the mandatory addition of chalk to flour. There were no adverse effects from the changes in the vitamin D content of Welfare Foods in 1957 and this reason for the continued addition of calcium to flour was therefore not upheld.

5.1.4 In the Food Standard Committee's Second Report on Bread and Flour (Ministry of Agriculture, Fisheries and Food, 1974), the Advisory Panel on Bread and Flour of the Committee on Medical Aspects of Food Policy concluded that the original and subsequent reasons for adding calcium carbonate to flour had become invalid. The Panel asked two questions, "Is an intake of calcium significantly above that recommended likely to be detrimental to health?" and "Would any nutritional disadvantage be likely to follow a cessation of the addition to flour of chalk or any other calcium salt?". The Panel answered these two questions as follows, "We have found no evidence that the present relatively high intake of calcium by the people of Great Britain, which is at present not far short of double that recommended in the 1969 Report on Recommended Intakes of Nutrients,[1] is harmful to health. We have also found no evidence that any nutritional disadvantage could attach to the fall in intake of calcium that would result from a discontinuation of the addition of chalk to flour" (paragraph 3.1.4 page 86). Thus there seemed no reason to recommend the continued fortification of flour with calcium carbonate. However, at that time, consideration was being given to the epidemiological evidence that mortality from cardiovascular disease was greater where the domestic water supply was soft than in areas which were supplied with hard water. A reduction in dietary calcium was therefore thought to be unwise. The conclusion of the Panel about the addition of calcium was couched in negative terms: "We therefore do not recommend that chalk be no longer added to flour" (paragraph 3.1.6 page 87).

5.1.5. A recent publication of a comparison of cardiovascular mortality in several areas of Great Britain with the degree of hardness of the domestic water supply in these areas (Pocock, Shaper, Cook, Packham, Lacey, Powell and Russell, 1980) confirmed a statistical relationship between decreased mortality from coronary heart disease and increased hardness of water. However, the authors stress that there is no new evidence which would implicate calcium in domestic water as the protective factor against heart attacks.

5.1.6 The present Panel agrees that the original reasons, and all the subsequent reasons, for the addition of calcium to flour that have been put forward over the years, are no longer valid.

[1]Department of Health and Social Security, 1969.

5.1.7 Before making a decision to recommend that calcium be no longer added to any flour, wholemeal and brown must be considered. Somewhat larger amounts of bread made from these flours are being eaten now than a few years ago, so the possibility that phytate may interfere with the absorption of calcium by those eating these breads has to be borne in mind. Wholemeal flour, which contains most phytate, has never been fortified with calcium. However, the phytate content of all breads is less than that of the corresponding flours because some of the phytate is destroyed during fermentation and baking. There is also evidence that, over a period of time, adaptation to an increased phytate intake occurs and faecal calcium losses decrease (Walker, Fox and Irving, 1948).

5.1.8 After consideration of all these matters the Panel concluded that there is no longer any nutritional justification for the compulsory addition of calcium to flour.

5.2 Iron

5.2.1 Iron was one of the nutrients to which special consideration was given by the Conference on the Post-War Loaf (Ministry of Food, 1945). The Conference noted that, despite a diminution in the variety of foods eaten during the war, a high standard of health had been maintained and the amounts of the selected nutrients provided by the wartime diet presumably represented a satisfactory standard for the maintenance of health.

5.2.2 When legislative control of the extraction rate of flour ceased, the Flour Order 1953 required a desirable minimum standard for the nutrient content of flour by the mandatory addition, where necessary, of three "token nutrients" (paragraph 2.7) to all flour of less than 100% extraction rate. Iron was to be added so that the flour contained 1.65 mg iron/100 g flour which is the minimum amount present in flour of 80% extraction. The mandatory addition of iron to flour was therefore nutrient restoration. There was no suggestion by the Conference on the Post-War Loaf in 1945, or by any subsequent Committee or Panel, that iron should be added to flour in excess of that which was naturally present. The amount of iron to be added to flour has remained unchanged in all regulations subsequent to those of 1953.

5.2.3 At present between one-third and one-half of the iron content of white flour is artificially added, and calculations from National Food Survey findings show that on average, about 10% of the domestic consumption[1] of iron is derived from iron which has been added to flour.

5.2.4 There have been several studies of the absorption of iron from bread. Among the earliest are those of Mackay, Dobbs and Bingham (1945) in which

[1]Domestic consumption, in this context, means bought for domestic use (see paragraph 4.3.2), and is not identical with food eaten.

groups of nursery children were given 14-20 mg iron daily in bread as ferrous carbonate with no evidence of any increase in mean haemoglobin. The study of undernourished children in Germany by Widdowson and McCance (1954) also showed that the mean haemoglobin and haematocrit of the groups of children who ate bread which was enriched with iron were no different, after one year, from the values for children who ate bread not so enriched. Elwood (1963) found no statistically significant effect on haemoglobin in hospital patients who were given about 80 mg iron daily, for six months, as powdered iron baked into bread. In 1964, studies were made in which different iron preparations were labelled with radio-active iron isotopes Fe^{59} and Fe^{55} and baked into bread which was fed to healthy subjects as part of a breakfast thought to be typical of that eaten by many people. Iron absorption was measured by whole body counting and showed that powdered iron, which was then used for the mandatory addition of iron to flour, was virtually unabsorbed (Ministry of Health, 1968).

5.2.5 Thus there is evidence that the powdered iron used to restore the iron content of white flour to that of 80% extraction flour is poorly absorbed from bread. The Bread and Flour Regulations,1963 state that "reduced iron shall be obtained by the action of hydrogen upon ferric oxide . . . shall be insoluble in water and alcohol and completely soluble in dilute hydrochloric acid". The Bread and Flour (Amendment) Regulations, 1972 (Statutory Instrument, 1972) specified the particle size and complete solubility in dilute hydrochloric acid of iron powder but not the method by which the powder was to be prepared. Although there have been no studies to assess the absorption from bread of added iron which complies with the 1972 Regulations, the assumption can be made that the iron powder now added to flour is unlikely to be much, if any, better absorbed than the powder which was used before the amended Regulations came into force (paragraph 5.2.4).

5.2.6 Nevertheless, the Bread and Flour (Amendment) Regulations 1972 also permit, as forms of iron which could be added to flour, the use of ferrous sulphate BP in addition to ferric ammonium citrate BP or BPC which was already permitted in 1963. These salts are known to be absorbed if given in tablet form. Neither of these salts has ever been added to flour to any significant extent on a commercial scale because there are technical disadvantages, such as the liability to develop rancidity, when the flour is stored. Field trials in which ferric ammonium citrate was baked into bread failed to show any increase in haemoglobin or any evidence of symptomatic benefit to subjects who had presumptive evidence of iron deficiency (Elwood, Waters and Sweetnam, 1971). Similar studies of elderly subjects in Boston (Gershoff, Brusis, Nino and Huber, 1977) and of school children in Yugoslavia (Buzina, unpublished), in which iron in a form known to be absorbed by human subjects was baked into bread, have also failed to show any effect on haemoglobin or any symptomatic benefit to health.

5.2.7 The requirement of individuals for iron, like all nutrient requirements, varies from one person to another. Furthermore, the absorption of iron from a

food depends not only on the type of iron present but also upon the other foods which make up the diet. For example, about 30% of haem iron from animal sources is absorbed compared with about 5% of non-haem iron from vegetable sources (Björn-Rasmussen, Hallberg, Isaksson and Arvidsson, 1974; Cook, 1977). The absorption of non-haem iron from vegetable foods is improved by the presence in the meal of vitamin C and of animal tissues such as pork, lamb, beef, chicken and fish but not by eggs and dairy products (Cook, 1977). At all ages, iron absorption depends on the needs of the individual and varies from one individual to another. The iron requirements of infants and young children can be met by foods other than bread and cereals.

5.2.8 The Recommended Daily Amount for iron is an average which applies only to groups of healthy individuals (Department of Health and Social Security, 1979a). The amount is based on a number of assumptions and it is accepted that a diet which would supply the energy requirements of a group of women of child bearing age would not provide enough iron to satisfy the needs of the 10% of women who have large menstrual losses. Similarly the average United Kingdom diet would not provide enough iron to supply the needs of any individuals who were suffering a pathological loss of blood.

5.2.9 If the addition of iron to flour and bread were no longer required, the average consumption of iron would be smaller than at present. However "consumption" figures are not identical with dietary intakes or with the amount of iron absorbed, and since the powdered iron added to bread is poorly absorbed, a diminished figure for iron consumption could not be interpreted as indicating any substantial decrease in absorbed iron.

5.2.10 In Britain there is little evidence of ill-health due to dietary iron deficiency except in association with debilitating disease, for example in some elderly people (Department of Health and Social Security, 1979b). Although iron deficiency does occur there is no evidence that it is a widespread problem and, where it is of sufficient severity to be a likely threat to health, it is usually the result of excessive blood loss or some other pathological process. The Panel agrees that, for such individuals, iron deficiency is best investigated clinically and treated medically. The fact that some individuals become iron-deficient due to clinical disease is not a basis for a national policy of adding iron to flour.

5.2.11 After due consideration therefore, the Panel finds no nutritional advantage in the continued addition of iron to flour.

5.3 Thiamin

5.3.1 Thiamin was first added to flour in 1940 after it had been observed that much of the thiamin present in the whole grain was removed during the milling of white flour (paragraph 2.4). In 1942, when the extraction rate was raised to 85% for the production of National Flour, the addition of thiamin became unnecessary and it was discontinued. The Conference on the Post-War Loaf

(Ministry of Food, 1945) concluded that a desirable target for average daily intakes of thiamin was 1.78 mg and recommended that thiamin should be added to flour to achieve a minimum amount of 0.24 mg thiamin/100 g flour. This minimum amount was calculated from the figures for bread consumption of large, low income families and approximated to that found in flour of 80% extraction. When in 1953 the Flour Order permitted flour of less than 80% extraction to be milled, the mandatory addition of thiamin ensured restoration of the amount of thiamin in white flour to that present in 80% extraction flour.

5.3.2 The addition of thiamin to flour was not based on the observation that thiamin deficiency was common in the United Kingdom and the Panels on Bread and Flour in 1960 and 1974 noted the rarity of thiamin deficiency in the community. Today clinical thiamin deficiency is virtually unknown except in some cases of severe alcoholism. The clinical significance of so-called biochemical deficiency is uncertain. When thiamin intakes are reduced experimentally in man, erythrocyte transketolase activity decreases (Brin, 1962) and this decrease is commonly believed to be a suitable biochemical indicator of thiamin deficiency. In a recent survey of elderly people in the United Kingdom few subjects had abnormal erythrocyte transketolase activities and none had clinical evidence of deficiency (Department of Health and Social Security, 1979b).

5.3.3 The biochemical basis for recommended amounts in the diet is probably better understood for thiamin than for other nutrients which are at present added to flour. Thiamin needs are closely related to carbohydrate intake and, allowing for individual variation, intakes of 0.4 mg/1,000 kcal are recommended for the United Kingdom (Department of Health and Social Security 1979a). Although thiamin consumption has diminished somewhat since 1960, there has been a concomitant reduction in the intake of food energy and particularly of carbohydrate over the same period (Hollingsworth, 1978). National Food Survey findings show that thiamin consumption has increased from 0.48 mg/1,000 kcal in 1960 to 0.54 mg/1,000 kcal in 1979. At present, average thiamin consumption as recorded in the National Food Survey is in excess of the recommended daily amount (Table 4.6) even in large families (Table 4.7), and would still be above these recommended amounts were thiamin not added to flour.

5.3.4 The addition of thiamin to flour dates from a time when bread and flour formed a greater part of the diet than at present and the loss of thiamin during milling was thought to be a cause for concern. Later Advisory Panels on Bread and Flour (Ministry of Agriculture, Fisheries and Food and Ministry of Health, 1956; Ministry of Agriculture, Fisheries and Food, 1974) were concerned that a large proportion of carbohydrate intake was in the form of sugar, which contains no thiamin. The intake of sugar has declined in recent years and bread is by no means the only source of dietary thiamin.

5.3.5 The Panel therefore concluded that there is no nutritional reason to add thiamin to flour.

5.4 Nicotinic Acid

5.4.1 Nicotinic acid is now known to be naturally present in cereals mainly in a bound form which is not absorbed from the diet and therefore not available to the body (Das and Guha, 1960; Kodicek, 1962; Clegg, 1963; Mason, Gibson and Kodicek, 1973). There is general agreement that tryptophan present in dietary protein can in part be transformed into nicotinic acid by the body and that 60 mg of dietary tryptophan yields approximately 1 mg of nicotinic acid in the body.

5.4.2 The contribution of bread and flour to the total dietary consumption of nicotinic acid recorded by the National Food Survey in 1979 was 11% and would be reduced to 9% if nicotinic acid were not added to flour (Table 4.6). Even without the addition, total nicotinic acid including that derived from tryptophan (Tables 4.6 and 4.7) would still be considerably above the amount recommended (Department of Health and Social Security (1979a). There is no evidence that nicotinic acid deficiency is a problem in this country. The Panel therefore endorses the view stated by the Advisory Panel to the Food Standards Committee in the Second Report on Bread and Flour (Ministry of Agriculture, Fisheries and Food, 1974) that there is no nutritional advantage in the continued addition of nicotinic acid to flour.

5.5 Other Vitamins and Minerals

5.5.1 In the absence of evidence of any vitamin or mineral deficiency disease in the general population, of such proportions that government action is indicated, the Panel did not suggest the addition of any other nutrient to flour.

6. Dietary Fibre

6.1 The dietary fibre hypothesis

Dietary fibre is present in all plant foods. Much of what has been published about fibre refers to fibre from cereals but many other forms exist and each has distinctive properties (para 6.3). Although the effects which fibre has on bowel habit have been known for centuries, hence its designation as "roughage", only in the last decade have the wider implications for bowel disease and the importance of dietary fibre for other aspects of nutrition come to light. In the short term, fibre is not an essential nutrient since infants grow well without it and adults can be sustained on a fibre-free diet for many months. However the hypothesis has been proposed (paragraph 2.16) that in the long term the amount of fibre in the diet may be related to the prevalence of diseases of the large bowel and other disorders. Evidence for this hypothesis is derived from epidemiology, physiological studies and clinical (therapeutic) trials.

6.2 Epidemiology

6.2.1 The epidemiological evidence for the hypothesis is largely based on the observations of Burkitt, Trowell and Walker. These workers have pointed out that bowel cancer (Burkitt, 1971), diverticular disease (Painter and Burkitt, 1971), appendicitis (Walker, Walker, Richardson and Woolford, 1973; Burkitt, 1975), haemorrhoids (Burkitt and Graham-Stewart, 1974), constipation (Burkitt, Walker and Painter, 1972), heart disease (Trowell, 1972, 1973) and diabetes (Trowell, 1973, 1978) are less common in rural Africa and other largely non-industrialised communities than in the United Kingdom and in similar western societies. Burkitt, Trowell and Walker have also observed that the intakes of dietary fibre are much larger in Africa and have suggested that this has a protective effect against the diseases mentioned above. These observations however are largely unquantified.

6.2.2 Few measurements of dietary fibre intake have been reported, chiefly because of methodological difficulties. In studies where these difficulties have been overcome, the reported values range from 20-150 g/day. Intakes in Western Europe, Britain and the United States of America are at the lower end of this range while those in rural Africa are the highest currently known (Bingham and Cummings, 1980). Suggestions have been made that the increase, during this century, in the prevalence of disease said to be due to fibre deficiency has been associated with a fall in intakes of fibre. However, Southgate, Bingham and Robertson (1978) have found that total dietary fibre intakes have changed little over the past 80 years, but the proportion of dietary

fibre derived from cereals has become smaller except during 1942-53 (paragraph 4.5.2). An association has been reported between greater intakes of dietary fibre and a low incidence of large bowel cancer (International Agency for Research on Cancer Intestinal Microecology Group, 1977), between cereal fibre intake and protection from ischaemic heart disease (Morris, Marr and Clayton, 1977; 1978) and between cereal fibre intake and protection from diverticular disease (Gear, Ware, Fursdon, Mann, Nolan, Brodribb and Nessey, 1979). However, there is at present insufficient evidence for the intake of cereal fibre to be accepted as an important factor in the aetiology of these diseases.

6.2.3 A more serious criticism of the dietary fibre hypothesis is that major differences in diet and in other aspects of lifestyle exist between the populations in question, and these differences might account for the observed contrasts in disease patterns. In addition, there are many sorts of fibre, which differ in composition and in their effects in man, and this needs to be taken into account when interpreting population studies. The epidemiological evidence for the prevention of the so-called "diseases of western civilisation" points to a need for change in lifestyle. A change in the intake of dietary fibre alone cannot be singled out at the present time as the sole means of prevention of these diseases.

6.3 Physiological studies

6.3.1 Much stronger evidence for the importance of all types of dietary fibre in human nutrition comes from physiological studies, in which either purified cell-wall material or fibre-containing foods have been fed to man. The most detailed research has been on the effect of dietary fibre on absorption of nutrients, on metabolism and on colonic function. These studies have shown fibre to increase stool output, dilute colonic contents, speed up the rate of passage of digesta through the gut, increase stool frequency, stimulate microbial growth, alter salt and water metabolism and, because of bacterial fermentation in the colon, increase the production of short chain fatty acids, hydrogen and carbon dioxide (Cowgill and Anderson, 1932; Williams and Olmsted, 1936; Eastwood, Kirkpatrick, Mitchell, Bone and Hamilton, 1973; Meyer and Calloway, 1977; Cummings, Southgate, Branch, Houston, Jenkins and James, 1978; Tadesse and Eastwood, 1978; Bond and Levitt, 1978; Stephen and Cummings, 1980). These effects are modified by alterations in both the physical and chemical composition of fibre and by cooking. Present evidence suggests that fibre from wheat, as opposed to that from other sources, has distinctive properties in the colon and is the most effective food source of fibre so far examined in increasing stool weight and shortening transit time. A typical British diet in which cereal fibre is increased from 6 g to 14-16 g/day produces, on average, a 50% increase in stool output. Unlike other sorts of fibre which are extensively degraded in the gut by colonic microflora, fibre from cereals, especially the lignified cell walls of bran, largely survives digestion and is excreted unchanged in the faeces (Southgate, Branch, Hill, Drasar, Walters, Davies and Baird, 1976; Cummings, Southgate, Branch, Wiggins, Houston, Jenkins, Jivraj and Hill,

1979; Dintzis, McBrien, Baker, Inglett, Jacob, Munoz, Klevay, Sandstead and Shuey, 1979; Stephen and Cummings, 1980).

6.3.2 Other effects of fibre on digestion and absorption are less clear. Fibre may have a satiating effect and thus limit energy intake but the evidence is conflicting at present (Haber, Heaton, Murphy and Burroughs, 1977; Bryson, Dore and Garrow, 1980). The glucose and insulin response to test meals is reduced by fibre, but this effect is seen mainly with gel-forming polysaccharides (Jenkins, Leeds, Gassull, Cochet and Alberti, 1977; Jenkins, Wolever, Leeds, Gassull, Haisman, Dilawari, Goff, Metz and Alberti, 1978). Wheat fibre has little, if any, effect. The influence of fibre on protein and lipid absorption is largely unknown but faecal fat and nitrogen excretion increase on high fibre diets (Macrae, Hutchinson, Irwin, Bacon and McDougal, 1942; McCance and Walsham, 1948; Southgate and Durnin, 1970; Southgate, Branch, Hill, Drasar, Walters, Davies and Baird, 1976; Kelsay, Behall and Prather, 1978). The mechanism by which this occurs is unclear and may represent a combination of increased bacterial mass and unabsorbed dietary nutrients. The changes are not nutritionally significant in the context of the United Kingdom diet. The effect of cereal fibre, as opposed to other types of fibre, on sterol metabolism seems to be small.

6.3.3 A possible disadvantage of foods which contain wheat fibre is the greater excretion of minerals and trace elements which they may induce. Fibre has been shown to bind minerals such as calcium and zinc in vitro (Reinhold, Ismail-Beigi and Faradji, 1975; Ismail-Beigi, Faradji and Reinhold, 1977; James, Branch and Southgate, 1978), and to increase mineral excretion (Ismail-Beigi, Reinhold, Faradji and Abadi, 1977). Whether such effects result from the binding to phytic acid which is associated with the fibre in bran, or to the fibre itself, is unresolved but these effects are unlikely to be of nutritional significance in the context of a mixed diet.

6.3.4 In summary, physiological studies show that dietary fibre, especially wheat fibre, has pronounced effects on large bowel function which are compatible with those predicted from epidemiological studies. These effects are likely to be of benefit in protecting against colonic disease according to current theories. At present, insufficient evidence is available to enable a clear understanding of other effects of dietary fibre in relation to health.

6.4 Clinical studies

6.4.1 As a result of information derived from epidemiological and physiological studies and from clinical observations, dietary fibre is now used in the treatment of a number of medical disorders. Constipation can be treated successfully with fibre from wheat (Dimock, 1936; Olmsted, Williams and Bauerlein, 1936; Streicher and Quirk, 1943) as can diverticular disease (Painter, Almeida and Colebourne, 1972; Brodribb, 1977); 6-10 g of wheat fibre a day significantly improves symptoms in the majority of subjects with

these conditions. Other forms of fibre are less effective. At present the value of cereal fibre in the treatment of irritable bowel syndrome and haemorrhoids is uncertain. No satisfactory trials are reported for the use of cereal fibre in the treatment of heart disease, gallstones or diabetes. Some success has been reported in the treatment of diabetes with bread supplemented with cellulose (Miranda and Horwitz, 1978) or crisp-bread supplemented with guar gum (Jenkins, Wolever, Nineham, Taylor, Metz, Bacon and Hockaday, 1978) but Anderson and Ward (1979) have emphasised that a high carbohydrate diet, of which bread forms a major part, and not necessarily a high fibre diet, is optimal for the control of this disease.

6.4.2 Only 2 studies of the role of cereal fibre in the prevention of disease have been reported. A preliminary report suggests a protective role in diverticular disease following surgery (Smith, Kirwan and Shariff, 1974) and a prospective study also indicates that there may be a protective effect by cereal fibre in ischaemic heart disease (Morris, Marr and Clayton, 1977 and 1978). Overall, therefore, as is concluded in the report of the Royal College of Physicians on Medical Aspects of Dietary Fibre (1980), there is clinical evidence of the value of dietary fibre in the treatment of some bowel disorders and of complex carbohydrates in the management of diabetes. However, the Panel noted that factors important in the cure of symptoms might be quite different from those responsible for the development of the disease. In addition, many clinical studies have used purified sources of fibre such as pectin or materials like bran rather than foods like bread, which are cooked before eating. Results from studies with pectin or bran as the source of fibre may not apply to dietary fibre in foods as they are usually eaten.

6.5 Conclusions

6.5.1 Although much that is claimed for dietary fibre remains to be proved, the evidence that fibre is a physiologically important component of the diet is strong. The effect of cereal dietary fibre on colonic function has been clearly documented. Evidence from epidemiological and clinical studies suggests that an increase in the intake of cereal dietary fibre would lead to decreased morbidity and mortality from some diseases of the large bowel and would relieve constipation. There may be other benefits (Royal College of Physicians, 1980).

6.5.2 To achieve an effective increase in cereal dietary fibre intake from bread, the average intake of bread would need to be doubled and part of this intake would have to come from bread made with flour of higher extraction rates. An increase in the intake of wholewheat breakfast cereals would further add to the increase. However, excessive consumption of uncooked bran from whatever source may give rise to difficulty in the assimilation of certain essential inorganic nutrients such as zinc (paragraphs 7.1.1-7.1.6).

7. Other matters of current concern

7.1 Phytic Acid

7.1.1 Phytic acid (inositol hexaphosphoric acid) is present in all grains, mainly as potassium and magnesium salts, and is concentrated in the aleurone layer of the endosperm (figure 3.1). There are small differences in the phytate content of flours milled from different varieties of wheat but wholemeal flour usually contains about eight times as much phytate as white flour (Table 3.1). Phytic acid readily forms insoluble complexes with divalent cations, such as calcium, magnesium and zinc, and because of this is able to inhibit the absorption of these ions from the human gut.

7.1.2 When sodium phytate is fed to healthy human subjects a negative calcium balance can occur (McCance and Widdowson, 1942a; Reinhold, Nasr, Lahimgarzadeh and Hedayati, 1973). Similarly, when unleavened bread, in which phytate has not been destroyed by yeast phytase, forms a major part of the diet, mineral absorption can be impaired (Reinhold, Nasr, Lahimgarzadeh and Hedayati, 1973; Campbell, Reinhold, Cannell and Nourmand, 1976). McCance and Widdowson (1942a, b) found that bread made from 69% extraction flour had no effect on calcium absorption over a 2-3 week period, but bread made from 92% extraction flour increased the loss of calcium in the faeces of all subjects. In these studies bread contributed more than half the dietary energy and so the intake of phytate was greatly in excess of that today. Furthermore, long-term studies, also in man (Walker, Fox and Irving, 1948) showed that, although excessive faecal loss of calcium occurred when the diet included a large amount of wholemeal cereals, over a period of time adaptation to the increased cereal intake took place and calcium losses diminished. In addition, Widdowson and McCance (1954) found that children grew equally well over a period of one year on diets in which 75% of energy intake was from either wholemeal or white bread. Both breads contained added calcium carbonate and the children absorbed and retained sufficient calcium, magnesium and phosphorus for growth whichever of the two breads was eaten. Another study, in which bread containing bran provided a smaller part of the energy intake, also failed to show adverse effects on mineral balance (Sandstead, Muñoz, Jacob, Klevay, Reck, Logan, Dintzis, Inglett and Shuey, 1978).

7.1.3 Although wholewheat products are rich sources of trace elements, absorption of some of these nutrients may be affected by the phytate content of the cereal. Experiments with rats have shown that, when the ratio of phytate to zinc (by weight) in the diet exceeds 100, the retention of zinc is reduced and growth is affected (Davies, 1979). The phytate-zinc ratios in wholemeal and

white flours are 330:1 and 150:1 respectively and in wholemeal and white breads are 222:1 and 8:1 respectively on a weight basis (C. F. Mills, personal communication). However the nutritional significance of this ratio with regard to the amount of zinc available for absorption depends on the composition of the diet overall and on the phytate-zinc ratio of the other foods eaten.

7.1.4 Wheat contains a small amount of natural phytase which, together with the larger amount of added phytase in yeast, breaks down phytate during bread making. Virtually all the small amount of phytate present in white flour is lost during baking, while two-thirds of the greater amount present in wholemeal flour remains. The amount of phytate destroyed differs according to the different bread-making processes used. If wholemeal bread is made by the long fermentation process, which was, at one time, the commonest way of making bread, the phytate content is reduced by 54% of that present in the original flour. If baked by the Chorleywood bread process the amount of phytate is reduced to about 67% (D G H Daniels and N Fisher, unpublished data), probably because the leavening time is considerably shorter in the Chorleywood process. These differences are small and are probably unimportant when compared with differences in the phytate content of breads made from flours of different extraction rates.

7.1.5 The absorption of zinc from the diet is reduced in the presence of whole cereals (Reinhold, Nasr, Lahimgarzadeh and Hedayati, 1973; Davies, Hristic and Flett, 1977) but the efficiency of zinc absorption from the gut is strongly influenced by the amount of protein in the diet (Sandstrom, Arvidsson, Cederblad and Björn-Rasmussen, 1980). One study, in which a high protein intake was maintained, showed that zinc balance can remain satisfactory despite a high intake of cereal (Sandstead, Muñoz, Jacob, Klevay, Reck, Logan, Dintzis, Inglett and Shuey, 1978).

7.1.6 The amount of protein in the average United Kingdom diet is sufficient and there is no evidence that the inclusion in the diet of bread made from high extraction flours prevents adequate absorption of minerals and trace elements from the gut. Nevertheless, comparatively little information is available and more is needed about the interaction of phytate and dietary fibre with minerals and trace elements in the gut of man, and of the effect of other foods in the diet on absorption of these nutrients.

7.2 Trace elements

7.2.1 Trace elements in the diet may be defined as elements which are present at a concentration of less than 100 parts per million. Some of these are known to be essential to life. Trace elements were not considered by members of the Conference on the Post-War Loaf in 1945, or by members of the Cohen Committee which reported in 1956, or by the Advisory Panel which reported in 1972, because there was too little information available about them. Since the early 1970s the importance of these nutrients has been increasingly well-

recognised. In 1973, a World Health Organization Expert Committee reported that 14 trace elements were believed to be important for animal life: iron, copper, zinc, manganese, chromium, cobalt, molybdenum, selenium, nickel, tin, silicon, iodine, fluorine and vanadium. Others may yet be found to be essential for human health.

7.2.2 Estimated figures for the average consumption of essential trace elements are tentative. Flour and bread contribute on average almost half the total consumption of selenium, between 7 and 15% of copper, zinc, manganese and chromium and much less of other essential trace elements (Table 7.1). Several of the essential trace elements are concentrated in bran and hence brown and wholemeal flour and breads usually have a higher content of these nutrients than white flour or bread. In wholemeal flour the concentration of copper and zinc may be two to three times, and of manganese six times, that in white flour (Table 3.5), but the effectiveness with which these elements are utilized from wholemeal flour may be less because of the presence of phytate (paragraphs 7.1.3-7.1.6).

Table 7.1: *The average contribution of trace elements (expressed as* μg/person/day) from bread and flour to the total consumption of trace elements in the United Kingdom

Trace element	Bread[1]			Flour	Estimated[2] total daily consumption	Percentage from bread and flour
	White	Brown	Wholemeal			
Chromium	5.8	0.9	0.3	1.9	60 130	7 15
Copper	141	28	10	45	1510 2020	11 15
Fluorine	45	6	1	14	NA	NA
Iodine	1.3	0.4	0.2	0.4	165	1
Manganese	469	194	75	150	4660	19
Molybdenum	18	3	1	6	166	17
Nickel	16	2	1	5	360	7
Selenium	24	1	1	8	60	57
Silicon	90	280	121	37	NA	NA
Zinc	642	181	56	206	9100 11100	10 12

Source: C.F. Mills, 1980 (personal communication).

NA = not available.

[1] Although the concentration of trace elements in brown and wholemeal bread is greater than in white bread (Table 3.5), white bread contributes more of the trace elements to the average United Kingdom diet because most of the bread which is consumed is white.

[2] Where more than one figure is given, estimates of consumption are derived from both the National Food Survey and the Ministry of Agriculture, Fisheries and Food Total Diet Survey.

7.2.3 Little is known about the requirements of the individual for the different

trace elements. Absorption of trace elements from food is known to vary and may be affected by the phytate content of the diet. Iron and zinc, for example, are less readily absorbed from cereal foods than from meat, but chromium is well absorbed from cereals.

7.2.4 There is at present no evidence to indicate a need for the addition of trace elements to flour.

7.3 Value of bread in the diet

7.3.1 Since 1954, when food rationing ended in the United Kingdom, a wide choice of foods has become available and important dietary changes have taken place. Total food energy intakes have decreased, with a greater proportion derived from fatty foods, from foods sweetened with sucrose and from alcoholic beverages, and less from the complex carbohydrate (starchy) foods. Over the same period, certain diseases such as coronary heart disease and cancer of the large bowel have become increasingly prevalent.

7.3.2 Both for the United Kingdom (Department of Health and Social Security, 1978) and for many other industrialised countries, a more prudent diet has been recommended, in which complex carbohydrate foods, such as bread and potatoes, replace some of the fat, sugar and alcohol. Bread has the merit not only of contributing food energy from starch but also supplying other nutrients and cereal dietary fibre. The importance of cereal fibre for health has been discussed in section 6. An increased consumption of white bread would be beneficial, and some bread from higher extraction flour could be of additional benefit to health. There is already some evidence of a recent increase in the consumption of brown and wholemeal breads (paragraph 4.3.4).

7.3.3 Many people already consume a prudent diet, and changes in dietary habits cannot be imposed except, for example, in a national emergency when food rationing can be introduced. In peacetime, food intake patterns are less easily modified, although changes have occurred since 1945. Some food preferences are probably formed early in life as a result of economic and cultural factors whilst in adult life further modification may occur as a result of lifestyle and of changing beliefs about the health value of foods. Any effect of nutrition education in promoting a more prudent diet is likely to be slow, but education which is based on sound facts becomes of great importance if members of the public are to make a wise choice in favour of a diet which is conducive to good health. At present insufficient effort is made to provide such factual education, particularly by means of radio, television and the press.

7.4 Choice and availability of breads

7.4.1 The consumer is understandably often confused about the significance of the differences between the various types of bread and by the profusion of

breads which are available for purchase. Naming and labelling of breads is intended to aid the customer. Some breads are named according to accepted shapes or after places where the shapes originated, and some indicate that the dough has been enriched by the addition of, for example, protein, wheatgerm, gluten, malted wheat, milk or bran. Soda-bread is made from flour, sodium bicarbonate and water but may contain yeast and any of the permitted ingredients. The consumer can select, from a wide variety in bakers' shops and supermarkets, the bread which will suit the taste and needs of the family. Among the factors which may influence the consumer's choice are texture, keeping qualities, price and availability.

7.4.2 The *texture* of bread depends to some extent on the skill of the baker, the kind of flour and the use of permitted ingredients. Wholemeal bread often tends to be dense in texture and to crumble when cut, with some separation of the crust. Many bakers think that the addition to wholemeal flour of some of the improving agents now permitted for white and brown flours would enable a lighter, spongier wholemeal loaf to be baked. Such a wholemeal loaf would, when cut, provide a slice which would keep longer and would therefore be more acceptable to many people.

7.4.3 Bread made from a proportion of flour milled from the hard Canadian and North American wheats will, other things being equal, be larger in volume, softer and finer in texture than that prepared entirely fom home-grown wheat flour. Wholemeal bread of similar characteristics needs proportionately more of the harder wheats than does white bread.

7.4.4 *Keeping qualities* vary with the method of presentation of the loaf to the consumer. Uncut, unwrapped bread stales more rapidly than sliced, wrapped bread but a single slice of bread stales more quickly in the air than a crusted loaf. Deep-frozen, wrapped bread keeps well for several months but staling occurs in a few days at room temperature and even more rapidly in an ordinary domestic refrigerator.

7.4.5 One of the factors which may influence the choice of bread is its *price.* Wholemeal bread nearly always cost more than brown or white bread but the price difference between white and brown bread, especially the large sliced loaves sold in supermarkets, is often small or non-existent (S Bingham, personal communication). National Food Survey published information provides evidence that the average cost per unit weight of wholemeal and brown bread is greater than that of large white loaves but less than that of small white loaves. If the demand for wholemeal bread were to increase, the differences in price would be likely to diminish. If improvers were permitted in wholemeal bread (paragraph 7.5.5), more home-grown wheat could be included. Although the importation of wheat from outside the European Economic Community is subject to a levy which increases by about 50% the price of such imported hard wheat, this accounts for only one additional penny in the price of a wholemeal loaf compared with that of white bread (personal communication, Ministry of Agriculture, Fisheries and Food).

7.4.6 In most canteens, hospitals, schools, cafés and restaurants, at present only white bread is readily *available*. The Panel thinks that all who are responsible for public catering should take the lead in offering consumers a wider choice of white, brown or wholemeal breads.

7.5 Additional ingredients

7.5.1 The Bread and Flour Regulations, 1963 provide that white bread shall be composed of dough made from flour, yeast and water, which has been fermented and subsequently baked. The regulations also specify categories of additional ingredients such as bleaching or improving agents which white bread may contain. Similar provisions in the regulations allow for the use, in brown bread, of all or any of the ingredients allowed in white bread and, in addition, require brown bread to contain not less than 0.6% of crude fibre, calculated by weight on the dry matter of the bread. Brown bread may also contain caramel.

7.5.2 Wholemeal bread must be made exclusively from wholemeal flour and may contain caramel and all or any of the additional ingredients allowed in white and brown bread except milk, milk products, rice flour, soya bean flour, prepared wheat gluten, additional wheat germ, cracked oat grain, oatmeal, oatflakes or any bleaching or improving agent. Chalk (calcium carbonate) is not required to be added to wholemeal flour.

7.5.3 These provisions apply to bread which is described as white, brown, or wholemeal, and bread described solely as bread may not contain any ingredient not allowed in these types of bread. However, other ingredients are allowed if bread is described as "bread with or containing x", x being the other ingredient, or alternatively as "x-bread" in which the presence of the other ingredient imparts a specific character to the bread (for example, currants or malt). New labelling regulations to implement the European Economic Community Directive on Labelling of Foods, 1980 have been proposed and these will provide that the descriptions white bread, brown bread etc must be used as a name for bread which complies with the compositional requirements for white bread, brown bread, etc.

7.5.4 The Food Standards Committee, in its Second Report on Bread and Flour (Ministry of Agriculture, Fisheries and Food, 1974), understood that the restrictions on the additional ingredients in wholemeal bread were made in deference to the views of those consumers who purchase wholemeal bread because of a preference for natural foods. However, the Committee pointed out that while wholemeal flour must contain no additional ingredients, wholemeal bread may contain all the yeast-stimulating preparations, rope inhibitors, preservatives, emulsifiers and stabilisers permitted in white bread. The Committee received representations that flour improvers should be allowed for the commercial baking of wholemeal bread. The Food Additives and Contaminants Committee was consulted and saw no objection to the proposals. The Food Standards Committee recommended in its Report that ascorbic acid

and L-cysteine hydrochloride should be permitted additives in the preparation of wholemeal bread and in wholemeal flour sold to a baker when such flour is to be used in making wholemeal bread, but this recommendation has not yet been implemented.

7.5.5 The Panel would like to see an increase in consumption of breads including those made from high extraction flours (paragraph 7.3.2). Wholemeal bread can be made more acceptable to many people by the use of certain improvers which are at present prohibited and the use of these substances would enable wholemeal bread to be manufactured on a scale which could enable a reduction in price to be considered (paragraph 7.4.5). The Panel recommends therefore that those flour improvers which are already allowed as additional ingredients in white bread and brown bread should also be allowed in wholemeal bread and, where necessary to achieve this, wholemeal flour used for commercial bread-making. The addition of the improvers concerned has been accepted by the Food Additives and Contaminants Committee and these compounds are regarded as safe in use. The fact that the use of certain ingredients is allowed does not mean that they will be used. Where wholemeal bread is made without the use of flour improvers, the Panel recommends that this should be made clear so that consumers can, if they wish, choose such bread.

7.5.6 In order to maintain wholemeal flour as a commodity which is acceptable to those who are concerned that their diet should comprise, as far as possible, only natural foods, the Panel recommends that the present controls which prohibit the use of additional ingredients to wholemeal flour should be maintained when the flour is intended for retail sale. Housewives and caterers in institutions who bake their own bread could then, if they wish, obtain 100% wholemeal flour free from any other ingredient.

7.6 Labelling of bread

7.6.1 There is considerable confusion, which is likely to be misleading to the customer, about the different kinds of brown bread available on the market at present. For example a brown loaf could be brown, wheatmeal, wheatgerm or wholemeal bread (paragraph 4.2.2). Each kind of bread must comply with regulations as to composition but the difference in composition is not made clear to the consumer by labelling. This difficulty should be resolved under the provisions of the new proposed regulations to implement the European Economic Community Directive on Labelling of Foods, 1980.

7.6.2 Dietary fibre is a constituent of flour and bread which is important for health. Were the consumer to be informed of the dietary fibre content of bread, confusion about brown breads would be diminished. At the present time there is a lack of agreement about what constitutes the best method of measuring dietary fibre but current research (James and Theander, 1981) indicates that rapid progress is being made towards adequate methodology. Alternatively, or

in addition, to know the nominal extraction rate of the flour from which the bread is baked would give the customer some information about the composition of the loaf (paragraph 3.1.5). The Panel agrees that the public will wish to be able to differentiate breads in the whole range from white to wholemeal and therefore recommends more explicit labelling.

7.6.3 The Food Standards Committee in its Second Report on Food Labelling (Ministry of Agriculture, Fisheries and Food, 1980b) notes that the term 'wheatmeal' is often confused by the public with 'wholemeal' although a wheatmeal loaf will not be baked from 100% extraction flour. The Panel endorses the views of the Food Standards Committee that the term 'wheatmeal' should be abolished as a description for bread.

7.7 Salt in bread

7.7.1 During bread-making salt (sodium chloride) is added to flour so that it comprises 1-2% of the final loaf. Flour, other than self-raising flour, contains virtually no sodium (less than 5 mg/100 g). The addition of salt is said to be to make bread more palatable and not because it is needed for the baking process.

7.7.2 There is now evidence, from epidemiological studies and both animal and human experiments, to link the development of hypertension in some susceptible individuals with dietary salt intakes (Freis, 1976). Hypertension is an important cause of ill-health and death in the United Kingdom. Although large intakes of salt in the diet are statistically related to hypertension when comparisons are made between countries, studies within populations do not confirm this association (Miall, 1959; Bing, Thurston and Swales, 1979; Dawber, Kannel, Kagan, Donabedian, McNamara and Pearson, 1967). The lack of correlation within populations is said to be due to differences in genetic susceptibility to hypertension induced by salt (Dahl, 1967 and 1972; Garany and Meyer, 1979). Moreover, other factors may also be involved in the pathogenesis of hypertension. These include obesity, stress and possibly dietary fat intake (Iacono, Marshall, Dougherty, Wheeler, Mackin and Canary, 1975; Burstyn and Firth, 1975). At present, there is therefore only circumstantial evidence of an association between the development of hypertension and salt intake.

7.7.3 Dietary salt intake is difficult to determine accurately but can be estimated from urinary loss since this is a major route for salt excretion. Although no systematic attempts have been made to measure the salt output of a nationally representative sample of the United Kingdom population, estimates indicate a range of intake of about 8-12 g/day (Miall, 1959; Dauncey and Widdowson, 1972; Bing, Thurston and Swales, 1979). Salt intakes in other countries may vary from 1-27 g/day. Bread is not a major source of dietary salt since it provides only about 2 g/day. In some countries, for example Belgium, legislation has been introduced to reduce the amount of salt in bread but, on the basis of the evidence at present available, the Panel agrees that such action

would not be appropriate for the United Kingdom. A reduction in the amount of salt in bread sufficient to affect salt intakes significantly might reduce palatability and discourage consumption. Furthermore, to single out bread from the diet as a means of reducing salt intake when large quantities of salt are added to other foods during cooking and at table by most families would be unreasonable. If however, more evidence of a relationship between salt intake and hypertension, or any other disease, becomes available, the amount of salt in food including bread, and its contribution to total salt intake, should be reviewed.

8. Summary and conclusions

8.1 Introduction

8.1.1 Over the centuries bread has been a staple item of the diet in the United Kingdom, although preference was given in some parts of Ireland to the potato and in Scotland to oats. Surveys over the past twenty-five years have shown that purchases of bread for domestic use have diminished, but recent research into dietary fibre and trace elements has reawakened an interest in bread and flour and the nutritional importance of these foods.

8.1.2 The present Advisory Panel was convened to consider the nutritive value of bread and flour and their importance in the diet and to make appropriate recommendations. The nutritional significance of dietary fibre (and of trace elements) was an aspect of bread not considered in any detail by previous Advisory Panels. Concurrently with the work of this Panel, the Royal College of Physicians has reviewed the medical aspects of dietary fibre (Royal College of Physicians, 1980).

8.2 Historical background

8.2.1 During the period from 1940 until the end of food rationing in Britain in 1954, legislation was introduced to enforce the milling of flour up to 80% extraction and at times to an even higher extraction rate in order to make full use of the nutritional value of the wheat grain and so to save shipping space in the importation of wheat (paragraphs 2.5 and 2.6). The National flour of this period contained more of the bran and germ than white flour although less than is present in wholemeal flour. The resulting loaf was darker in colour than the white loaf obtained when all the bran and germ are removed, but lighter than bread made from wholemeal flour. A history of the controversy about the relative nutritional merits of white and brown bread has been fully recorded by McCance and Widdowson (1956). Public opinion about the bread made from National flour varied but, in 1953 when the ban on the milling of white flour was lifted, industry was convinced that a majority of the population preferred white bread. This has been borne out by experience (Table 4.2) although recently purchases of brown and wholemeal bread have increased.

8.2.2 Flour was used as a vehicle for the introduction of calcium into the diet in 1942 (paragraph 2.5) at a time when a possible shortage of dietary calcium was foreshadowed as a result of the restriction in imports of dairy products. Bread made from higher extraction flours was also known to contain more phytic acid and this had been shown to interfere with calcium absorption.

8.2.3 As a result of the 1945 Conference on the Post-War Loaf, when the ban on the milling of white flour was lifted in 1953 and bread could again be made from flour of approximately 70% extraction rate, the restoration of nutrients removed by milling was required in order to maintain the nutritional value of a staple article of food. A compromise was effected in that the nutrient composition was restored by the addition of three 'token' nutrients, iron, thiamin and nicotinic acid (paragraph 2.7), in amounts which corresponded to the minima found in flour of 80% extraction rate. The millers were encouraged to include as much of the wheatgerm as possible since this part of the grain was richest in nutrients. Experience has shown that such wartime flour had provided a nutritionally satisfactory type of bread.

8.2.4 In 1956 and 1960, Advisory Panels reviewed the regulations for the composition of bread and flour and advised the continued addition of the four nutrients for reasons concerned with the public health. In 1972, an Advisory Panel of the Committee on Medical Aspects of Food Policy recommended that nicotinic acid no longer need be added and was less convinced of the need for the addition of calcium carbonate than previous advisory committees had been. Part of the work of the present Panel in considering the nutritional value of bread and flour (paragraph 1.4) was to review the need for the continued addition of the four nutrients.

8.3 Composition of bread and flour

8.3.1 Although bread can be made from cereals other than wheat, in this report, bread and flour refer to wheat products. Contrary to popular belief, flour and bread are not solely starch (a carbohydrate) but contain, in addition, protein, a small amount of fat, certain vitamins of the B complex and inorganic nutrients including the trace elements. All flours and breads also contain cereal dietary fibre. Misunderstandings about the nutritional importance of bread should be corrected by nutrition education.

8.3.2 The average composition of white, brown and wholemeal flour is set out in section 3. Differences in composition of flours of different extraction rates are mainly due to the differing amounts of bran and germ present in the flour. In general, wholemeal flour contains most and white flour least dietary fibre. Wholemeal flour is also naturally richer in most of the nutrients than white or brown flours. Calcium, iron, thiamin and nicotinic acid are added to white flour. These added nutrients are also present in brown flours which are made by adding, to white flour, some of the offals, that is to say, the bran and germ which are removed in milling white flour.

8.3.3 The composition of different kinds of bread is determined by the flour used for baking and by the amounts of yeast, water and other permitted additives which are used in the different baking processes.

8.4 Contribution of bread and flour to the British diet

8.4.1 National Food Survey findings show that most of the bread purchased is white, and that over the period 1955 to 1979 there has been a steady decline in the total amount of bread purchased. Domestic consumption of brown and wholemeal bread has always been comparatively small without any noticeable trend until the past few years when the figures indicate increased purchases of these breads (section 4.3).

8.4.2 Bread is a nutritious food and, in spite of the decline in consumption, bread and flour products provide about one-sixth of the total food energy and of the total protein consumption for the average British household. Bread and flour are of special nutritional importance in households with several children and National Food Survey findings show that a larger proportion of total food energy and of nutrients is derived from these foods in households with four or more children than in the average household (section 4.4).

8.4.3 Bread and flour products are also substantial sources of dietary fibre (section 4.5). One third of total dietary fibre intake is derived from cereals, mostly bread. Consumption of fibre has changed very little over the past 80 years but the intake of cereal fibre has declined compared with that of vegetable and fruit fibre, and now contributes proportionately less to the total fibre intake. Between 1942 and 1953, cereal fibre intake increased sharply. This was largely due to increased consumption of bread made from National flour which was of higher extraction rate than white flour.

8.4.4 Although brown and wholemeal bread contribute more dietary fibre, and wholemeal bread and flour are richer in most nutrients when compared with the brown or white commodities, any kind of bread is a nutritious food. In the context of the present day British diet, which comprises a mixture of foods, the nutritional value of any bread should be stressed in nutrition education rather than too much emphasis being placed on a comparison between white, brown and wholemeal breads. Those who are concerned with improving health are aware that many people would benefit by eating less sugar, fat and alcohol. These foods are sources of food energy and would need to be replaced by complex carbohydrate foods which would contribute not only energy but nutrients to the daily intake.Bread is one such food (section 7.3).

8.5 Dietary fibre

8.5.1 Those who are concerned with improving health are also aware that many people would benefit from an increased intake of dietary fibre. There is evidence from epidemiological, physiological and clinical studies (section 6) that cereal fibre is an important component of the diet although much that is claimed for dietary fibre still remains to be proved (paragraph 6.5.1). Cereal fibre, especially from wheat, has beneficial effects on bowel function in the

prevention of constipation and, according to present theories, in protection against disease of the colon (paragraph 6.4.1).

8.5.2 An increase in dietary fibre intake would be achieved by eating more bread, especially bread made from flour of higher extraction rates. Too much uncooked bran may be associated with some impairment in the absorption of essential inorganic nutrients (paragraph 6.5.2).

8.6 Nutrients added to flour

8.6.1 *Calcium*

8.6.1.1 The need to add calcium to flour in order to increase dietary calcium intakes was questioned in the Food Standards Committee Report on Bread and Flour (1974). The original reasons for the addition of calcium to flour were to ensure enough for the diet when the supply of dairy products was in question, and because phytate in wheat flour had been shown to reduce absorption of calcium from the gut. Other reasons which had been put forward to support the continued fortification of flour with calcium were concern that intakes of calcium should be sufficient when fortification of infant foods with vitamin D was reduced in the late 1950s (paragraphs 5.1.1 — 5.1.3), and that calcium in domestic water might protect against heart disease (paragraphs 5.1.4 and 5.1.5), since hard water areas are associated with lower mortality from cardiovascular disease than areas with soft water. All these reasons are now no longer valid.

8.6.1.2 If calcium were not added to flour, mean calcium intakes, as assessed by National Food Survey records of food purchased for domestic consumption and as measured in individual dietary surveys, would remain above the amounts recommended for population groups. There is also no evidence of calcium deficiency in the United Kingdom population, or in populations in other countries where calcium intakes are considerably less than in Britain, or in those countries where calcium is not added to flour. For all these reasons the Panel agreed that there is no longer any need for the fortification of flour with calcium carbonate (chalk) and recommends that the mandatory addition of calcium carbonate be no longer required (paragraph 5.1.8).

8.6.2 *Iron*

8.6.2.1 The addition of iron to flour, like the addition of the other "token nutrients" thiamin and nicotinic acid (paragraph 2.7), became mandatory in 1953 in order to restore what had been removed by milling white flour (paragraph 2.12) to the minimal amounts of these nutrients present in 80% extraction flour. There was never any question of fortification, that is to say, adding more of these nutrients than was naturally present in flour. The restoration of iron, and of the other two nutrients, to flour was suggested in the post-war period because during the war a good standard of health had been

maintained and the only bread available was made from flour of about 80% or, at times, a higher extraction rate (paragraphs 5.2.1 and 5.2.2).

8.6.2.2 Several studies on the absorption of iron from bread have shown that added iron is not well absorbed even when present as iron salts which are known to be therapeutically effective if prescribed in tablet form. Powdered iron added by manufacturers according to specifications of the Bread and Flour Regulations, 1963 is almost certainly poorly absorbed (paragraphs 5.2.4 — 5.2.6).

8.6.2.3 There is little evidence in Britain that dietary iron deficiency is a cause of ill-health and, although iron deficiency anaemia occurs, it is usually in association with blood loss or other pathological conditions (paragraph 5.2.10). The average diet which in Britain would supply the energy requirements of a group of women of child-bearing age would not provide enough iron to satisfy the 10% who have a large menstrual loss (paragraph 5.2.8). The Panel agreed that any problem of iron deficiency should be resolved by clinical investigation and medical treatment of the individual concerned.

8.6.2.4 The mandatory addition of iron to flour was a matter of restoring a nutrient which had been removed by milling and was never intended as a means of either preventing or treating iron deficiency anaemia. Since the added iron is known to be poorly absorbed (paragraphs 5.2.4 and 5.2.5) and to have no haematinic effect (paragraph 5.2.6), the Panel decided that there was no nutritional advantage in the continued compulsory addition of iron to flour (paragraph 5.2.11).

8.6.3 *Thiamin*

8.6.3.1 The decision to add thiamin to flour was not based on an observation that thiamin deficiency is a public health problem in the United Kingdom. Thiamin deficiency is rare and, when seen, is usually associated with chronic and severe alcoholism (paragraph 5.3.2).

8.6.3.2 Thiamin is needed for the metabolism of carbohydrate and a recommended amount of 0.4 mg thiamin/1000 kcal allows for individual variation in requirements and for an additional margin of safety. Calculations from the findings of the National Food Survey indicate that the average thiamin consumption in terms of food purchases for domestic use has increased from 0.48 mg thiamin/1000 kcal in 1960 to 0.54 mg/1000 kcal in 1979. If thiamin were not added to flour the figure for 1979 would be 0.45 mg thiamin/1000 kcal (paragraphs 5.3.3 and 5.3.4). The Panel concluded that, if thiamin were not added to flour, there would be no likelihood of a resulting deficiency of this vitamin, and agreed to recommend that the mandatory addition of thiamin to flour no longer be required.

8.6.4 *Nicotinic acid*

8.6.4.1 The Panel endorsed the decision made by the previous COMA Advisory Panel on Bread and Flour in 1972 that nicotinic acid need no longer be added to flour. Nicotinic acid, as naturally present in cereals, is largely unavailable for absorption from the gut and there is general agreement that this nutrient can be synthesised in the body from the amino acid tryptophan. Since the protein content and consequently the tryptophan content of the average British diet is more than adequate, the Panel agrees that there is no sound reason for the mandatory addition of nicotinic acid to flour.

8.6.5 *Conclusions about the addition of nutrients to flour.*

8.6.5.1 The addition of calcium, iron, thiamin and nicotinic acid was made mandatory at a time when the malnutrition which was common in Britain in the 1930s was well-remembered. For some years, committees of experts have considered the nutritional contribution of bread and especially of the added nutrients to the national diet. Certainly no harm has resulted from their addition. In the present state of knowledge there appears to be no good reason why the four nutrients should continue to be added and there is no reason to expect that any harm would result if they were not added. The Panel recommends therefore that the addition of calcium, iron, thiamin, and nicotinic acid to flour no longer be mandatory.

8.6.5.2 The Panel considered that, in the absence of any public health problem of deficiency, there were no nutritional reasons for the addition to flour of other vitamins such as riboflavin, pyridoxine, pantothenic acid or folate and that at present there is no evidence which would indicate a nutritional need for the addition of the trace elements or of any other inorganic salts to flour (paragraphs 5.5.1 and 7.2.4).

8.7 Phytic acid and trace elements

8.7.1 Phytic acid is present in all grains chiefly as the potassium and magnesium salts and wholemeal flour contains about eight times as much phytate as white flour. Phytic acid readily forms complexes with calcium, magnesium and zinc and is therefore able to inhibit the absorption of certain minerals and trace elements from the gut.

8.7.2 Virtually all the small amount of phytate present in white flour is destroyed by the action of enzymes in the yeast which is added during the baking of bread. Depending on the length of time allowed for yeast fermentation, about one-third to one-half of the phytate in wholemeal flour is similarly destroyed.

8.7.3 Although there is evidence that, in the short term, absorption of calcium in decreased and faecal loss of calcium is increased when cereal phytate is

introduced into the diet, in the long term, adaptation occurs and calcium losses decrease. The absorption of zinc is also reduced in the presence of whole cereals, but this effect is nullified if the diet is rich in protein. On average, the amount of protein in the United Kingdom diet is more than sufficient for requirements and there is no evidence that the inclusion of brown or wholemeal bread in the diet has an adverse effect on the absorption of minerals and trace elements or that there is any need to add any of these nutrients to flour.

8.8 Salt in bread

8.8.1 Bread contains one to two percent of sodium chloride (salt) which is added during the baking for reasons of taste. Salt is not necessary for the baking process. The contribution of bread to total salt intake is small compared with the amount of salt which, on average, is added in cooking, in the processing of some foods and at table. Although epidemiological studies have shown a statistical association between salt intake and blood pressure, there are probably genetic factors which lead to differences in susceptibility to hypertension induced by salt (paragraphs 7.7.1 and 7.7.2). The evidence for the relationship is not considered to be sufficient, at present, to recommend a reduction in the amount of salt in bread. To do so might reduce palatability and discourage consumption and would be unreasonable since bread is not a major source of dietary salt. In the future, if a relationship between salt intake and raised blood pressure is confirmed, the possible advantages of changing the salt content of foods, including bread, would need to be assessed (paragraph 7.7.3).

8.9 Additional ingredients

8.9.1 The Bread and Flour Regulations, 1963 permit the addition of certain ingredients in the baking of white and brown bread. These ingredients are for reasons of crumb texture, palatability and keeping qualities.

8.9.2 Wholemeal bread, made from 100% extraction flour, is said by many people to be less palatable and to keep for a shorter period of time than white bread. These characteristics may, in part, be due to the fact that the present Bread and Flour Regulations 1963 do not permit the addition of those optional ingredients that are claimed by bakers to be necessary for baking a wholemeal loaf with a texture, crumb, crust and other features to suit all consumer tastes (paragraph 7.5.2). The Food Standards Committee and the Food Additives and Contaminants Committee recommended in 1974 that flour improvers should be allowed for the commercial baking of wholemeal bread (paragraph 7.5.4). The Panel supports this decision and recommends that the addition of improvers be permitted for baking wholemeal bread in the hope that the resulting loaf will be more acceptable to the consumer (paragraph 7.5.5).

8.9.3 The Panel is aware that 'natural' foods are held by some people to have advantages over processed foods. Members of the Panel respect the right of

individuals to hold such a view, and recommend that the presence of additional ingredients in wholemeal flour intended for retail sale should continue to be prohibited (paragraph 7.5.6).

8.10 Labelling of bread

8.10.1 At present the consumer is unable to distinguish easily between different kinds of bread and particularly between the different kinds of brown bread. The Panel recommends that consideration be given to some simple labelling so that the differences in composition including the dietary fibre content can easily be assessed, albeit approximately, by the consumer. This could be achieved if bread were labelled either according to the approximate extraction rate of the flour from which it has been baked or to the dietary fibre content (paragraph 7.6.1).

8.10.2 The term 'wheatmeal' has been used for some time as an alternative designation for brown bread but has been questioned by the Food Standards Committee in reports published in 1960 and 1974. The Panel endorses the view of the Food Standards Committee that this term is easily confused by the consumer with the term 'wholemeal', and recommends that the use of the term 'wheatmeal' should be abandoned (paragraph 7.6.2).

8.11 Choice and availability

8.11.1 Statistics on bread consumption in the United Kingdom indicate a consumer preference for white bread (Table 4.2) but, over the past few years, consumer preference seems to be changing and there has been an increase in the consumption of brown and wholemeal bread (paragraph 4.3.4). The reasons for choosing any particular kind of bread are not known but may include taste, price, availability, keeping qualities, convenience and habit (paragraphs 7.4.1 — 7.4.6). The effect on consumer choice of the longstanding dispute about the relative merits of brown and white bread, variously supported by members of the scientific, medical and industrial community, is unknown.

8.11.2 Bread is a food which contributes many nutrients to the diet. The Panel agrees that the nutritional advantage of the additional nutrients, trace elements and dietary fibre in breads made from high extraction flours is clear although some of these differences are less striking when considered in the context of the mixed diet usually eaten in Britain. Most retail outlets offer a wide choice of bread, but institutional caterers such as hospitals, office and works canteens and schools often provide only white bread. The Panel would like to see a wider choice of bread available in these places in order to encourage greater consumption of all breads including brown and wholemeal.

8.11.3 The price of bread is likely to be a factor in consumer choice. Wholemeal, wheatgerm and speciality breads are usually costlier than white or

brown, and this may be one reason for their smaller consumption. The recommendation to allow certain improvers in the baking of wholemeal bread may make wholemeal loaves more acceptable, lead to increased consumption and consequently to a reduction in price (paragraph 7.4.5). The price difference between white and brown bread is much less than that between white and wholemeal and in some supermarkets is already negligible.

8.12 Research

8.12.1 The Panel agrees that more knowledge is needed about the nutritional importance of dietary fibre, trace elements and phytate, and recommends that research should continue and should include an examination of the long-term effects of these dietary components.

8.12.2 In addition, long-term surveillance of the nutritional status of the population should continue, and would serve to assess the effects, if any, of the changes recommended by the Panel. These recommendations should be reviewed in the light of any new knowledge which results from further research.

8.12.3 Little is known about the factors governing food choice, consumer preferences and the reasons for long-term changes in dietary habits. The recommendation to eat more bread implies that certain current trends in food intake may be changed and it would be of interest for research to be made into how these changes occur and can be influenced.

8.12.4 The paucity of information about the amounts of bread and of other foods actually eaten indicates that studies are needed of the food intake of individuals within the population.

9. Recommendations

The Panel recommends that:

1. the consumption of bread, whether it be white, brown or wholemeal, should be promoted and bread should replace some of the fat and sugar in the diet;

2. nutrition education should stress the value of bread as a source of nutrients and of cereal fibre in the diet;

3. an increase in the cereal fibre content of the diet would be beneficial and this could best be achieved by eating some bread baked from high extraction flours;

4. in places where bread is sold or eaten, those responsible should make wholemeal and brown bread available in addition to white bread;

5. the addition of those flour improvers which are already permitted for the baking of brown and white bread should be allowed for the baking of wholemeal bread;

6. the presence of additional ingredients in wholemeal flour intended for retail sale should continue to be prohibited;

7. the addition of calcium carbonate (chalk) to any flour be no longer mandatory;

8. the restoration of iron, thiamin and nicotine acid to flour be no longer mandatory;

9. information relating to the extraction rate of the flour used for bread-making and of the cereal dietary fibre content of bread should be made available to the consumer by an agreed form of labelling;

10. the term "wheatmeal" as applied to brown bread, should not be used as a description for bread;

11. further research be promoted on the nutritional importance of dietary fibre and of trace elements, on factors determining food choice and food habits and on individual intakes of foods including breads;

12. long-term surveillance of the nutritional status of the population should continue, and

13. further reviews of the nutritional aspects of flour and bread should be made in the light of new knowledge.

Note of reservation by Professor J N Morris

While I am in complete agreement with our Report, I wish to add a further Recommendation —

that over a period of a few years Government makes the necessary arrangements with industry and trade so that the price of a standard "brown" and a standard "wholemeal" loaf is lowered to that of a standard white loaf.

Any recommendation on national diet — for example, to eat more bread but also, in particular, more brown and wholemeal bread — has to be seen in context of the priority accepted by Government for the promotion of health and for prevention.[1-3]

The Report refers to the need to improve the availability and acceptability of breads of higher extraction. How important a factor price is in food choice is little understood, as said, so it is only prudent to assume that the higher cost of brown and wholemeal bread *is* a disincentive, particularly among the poorer and less healthy sections of the population, and the larger families, who at present buy them less.[4] On average, the public early in 1980 were spending a little more than 4p extra on a lb of brown, and nearly 5p more on a lb of wholemeal bread than on white,[5] the differences being greatest of course with the most widely eaten large sliced white loaf. Recently, there have been welcome signs of the cost of brown, though not of wholemeal, bread falling, and for greater variety to be offered to the public.

Moreover, while I share Government's views on personal (and parental) responsibility for healthier behaviour, it has to be recognised that there is little the individual can do to lower the price of brown and wholemeal bread — and so allow genuine freedom of choice. The reasons these breads cost more lie in the discounting practices of bakers and supermarkets, the Common Agricultural Policy, the economics of milling white flour and its by-products, and baking regulations as seen. The relatively small quantity of brown and wholemeal bread purchased is also a factor, of course, and this must take time to rectify.

There are practical measures that Government, and Government alone, can take to enable — not to say encourage — people to change their habits.[6] Subsidy is one method of lowering prices, and a first estimate indicates that over a year this would cost about £10m, for a penny reduction per small loaf of brown/wholemeal bread, at early 1980 levels of consumption. But for obvious reasons other methods of lowering prices, in particular through improved marketing, should urgently be sought. Public taste across the income classes is showing signs of a shift towards these better breads and, indeed, they may have a major part in the general rehabilitation of bread and the reversal of its decline which is our primary recommendation. There is an opportunity now for Government to strengthen this trend to healthier living.

London School of Hygiene and Tropical Medicine. 14.1.81.

[1] *Prevention and Health.* Cmnd. 7047. Dec., 1977.

[2] Rt. Hon. Patrick Jenkin, MP, reported in *Health Education News,* July/Aug., 1979.

[3] *Eating for Health.* Health Departments/HMSO, 1979.

[4] *Inequalities in Health.* Report of a Research Working Group, DHSS, 1980.

[5] National Food Survey, April-June 1980, *Food Facts No. 10,* November 24, 1980.

[6] J N Morris: Are health services important to the people's health? *British Medical Journal,* 19 Jan., 1980.

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