(b) THE COMPOSITION AND NUTRITIVE VALUE OF FLOUR*

by H. M. SINCLAIR, M.A., D.M., B.SC., M.R.C.P.,
Vice-President, Magdalen College, Oxford;
Reader in Human Nutrition, University of Oxford

I—COMPOSITION OF FLOUR IN RELATION TO REQUIREMENTS

(*a*) Contribution to nutritional requirements

BREAD and flour are in many respects the most important constituents of the ordinary British diet. During the Second World War they provided the following approximate percentage requirements of aliments and nutrients in an adult diet (calculated from Sinclair[1], 1951):

> Calories, 35; protein, 47; carbohydrate, 48; fat, 5; iron, 71; calcium, 32; phosphorus, 52; thiamine, 65; nicotinic acid, 43; riboflavin, 24. Flour is devoid of vitamin A, carotene, vitamin D and ascorbic acid.

The proportion of an average person's approximate daily nutritional requirements met by bread and flour of 85 per cent. extraction with added $CaCO_3$ as compared with 70 per cent. extraction without $CaCO_3$, are as follows (*ibid.*):

* Read at a Sessional Meeting held at the Society's Headquarters on 6th March, 1957, under the Chairmanship of Prof. Harold Burrow, M.R.C.V.S., D.V.S.M., F.R.S.H. (Chairman of Council)

	85 per cent. with $CaCO_3$	70 per cent.
Calories	27	24
Protein	37	31
Carbohydrate	37	35
Fat	4	2
Iron	46	26
Calcium	21	8
Phosphorus	33	19
Vitamin A	0	0
Carotene	0	0
Vitamin D	0	0
Thiamine	49	13
Nicotinic acid	33	18
Riboflavin	19	7
Vitamin C	0	0

It is obvious therefore that although there is a slight difference in protein which might be of importance in view of the probable excellent biological value of wheat-germ protein, the most significant differences in the above nutrients if chalk is added to all flour are in iron and the three given vitamins of the B complex. Therefore, if these are added to flour of 70 per cent. extraction, it might be supposed that this should have a nutritional value similar to that of National flour.

Bread and flour provide rather higher percentage requirements of nicotinic acid than of riboflavin, the conference on the post-war loaf[2] decided the "token nutrients" should be iron, thiamine and nicotinic acid only, since after giving "careful thought to the question of riboflavin" they reached the reasonable decision that riboflavin should not be added.

(*b*) Other vitamins of the B Complex

A number of different compounds happen to be included in the vitamin B complex instead of having separate letters in the alphabet because they tend to occur together in foodstuffs. Chemically, vitamin B_1 is as distinct from vitamin B_{12} as it is from vitamin C; and since we do not know in detail how the last two vitamins act the same distinction may occur in the nature of their function. There is reason to suppose therefore that the difference in amounts of the three given members of the B complex found in National bread and bread of 70 per cent. extraction will extend to other known vitamins of the B complex. Such is found to be the case: high extraction flour has nearly three times as much pyridoxin, about twice as much pantothenic acid and folic acid, and nearly five times as much biotin as is found in white flour. Although we know very little about the requirements of pyridoxin, panthothenic acid, biotin, folic acid and vitamin B_{12}, we have reason to believe that they are needed by man. Although flour contains no vitamin B_{12}, some synthesis of this vitamin occurs in the intestine and the quality of flour could affect this.

Pyridoxin has been shown to relieve certain convulsions occurring in children [3, 4, 5]. It is apparently specific for relieving by inunction certain cases of seborrhœis dermatitis[6]. There have been many reports of successful use in hyperemesis gravidarum and radiation sickness; a biochemical lesion supporting deficiency of vitamin B_6 has been found in certain cases of the former[7], and there is experimental evidence that in mice, pyridoxin increases resistance to injury from X-rays[8]. Isonicotinic acid hydrazide combines with pyridoxal, and the neuropathy that accompanies therapy with this compound is caused by deficiency of the vitamin. There can be no doubt that pyridoxin is required by man, and this matter will be further considered below.

Pantothenic acid is also required by man[9], but as this vitamin is widely distributed (as its name implies) bread and flour may be unimportant sources. However, we know little about the nutritional requirements and dietary sources of the many known members of the vitamin B complex other than thiamine, nicotinic acid and riboflavin. It is probable also that other such vitamins remain to be discovered. This is a very strong reason for not discarding the most important single dietary source of vitamins of the B complex.

Further, there is evidence that there is a balance betwen vitamins of the B complex. This has been shown in man and in lower animals: increasing the dietary source of one vitamin may precipitate deficiency of another vitamin, as when a pellagrin is treated with nicotinic acid and the clinical signs of ariboflavinosis appear.

(*c*) Trace elements

It might be supposed that man would not become deficient in these since the amounts required are very small and man subsists upon a very varied diet. Yet two of the commonest nutritional deficiencies in this country are of iron and iodine; and some would make a case for including fluorine in this category.

Bread of high extraction has a much higher ash (1·70 per cent.) than white bread (0·37 per cent.). The former has about four times as much copper, but this is not of dietetic importance. However, we know very little about the nutritional needs and dietary sources of trace elements in man; manganese is almost certainly required and the fact that bread of high extraction contains about 70 times as much manganese as does white bread might be important.

II—COMPARISONS OF FLOURS EXPERIMENTALLY

There have been very many tests upon lower animals of the two types of flour, and it is acknowledged that rats grow better upon flour of high extraction than on "fortified" white flour. It could be maintained that these experiments upon growth of lower animals are not applicable to man.

Widdowson and McCance[10] compared flours of different extraction upon German children in two orphanages after the war. The children received the full German rations to which they were entitled except for German bread, which was replaced by unlimited amounts of one of five types of flour specially milled in England: (i) 100 per cent. extraction, (ii) 85 per cent., (iii) 70 per cent., (iv) 70 per cent. with added iron and three B vitamins restored to the 85 per cent. level, (v) as the last, but with the restorations to the 100 per cent. level; all contained added calcium. The children ate nutritious vegetable soups but had very little milk or other animal protein.

The children, who were undernourished at the start, grew very rapidly and almost equally on all the flours. This is not surprising for three reasons. First, aliments and all known nutrients, with the exception of riboflavin, appear from calculation to have been met by all the diets; animal protein was very low in all these but wheat protein is known to be of high biological value. Secondly, the experiment was of short duration. Thirdly, the 70 per cent. extraction flour used was unusually rich in certain nutrients and in some respects more nearly resembled the 80 per cent. than the 70 per cent. used in this country.

III—ESSENTIAL FATTY ACIDS, PYRIDOXIN AND VITAMIN E

(*a*) Nature and interconversion of essential fatty acids

The natural form of linoleic acid (*cis*-9, *cis*-12-octadecadienoic acid) is found in plant oils, some of which, such as wheat germ oil, are very rich. Unfortunately there are several reasons why this acid tends to be destroyed. The *cis-cis* isomer is the least stable and readily becomes converted into the other geometrical isomers. The unconjugated double bonds, interrupted by a methylene group one hydrogen of which is readily oxidized to form a hydroperoxide, can easily be lost by oxidation or hydrogenation (as in the formation of margarine) or by conversion to the more stable cojugated positional isomer. All such geometrical and positional isomers have no EFA-activity, and some at least increase the requirement of EFA since they act as antivitamins.

Oxidation of linoleic acid in air would occur extremely rapidly were it not for the presence of vitamin E, which is a powerful antioxidant. Wheat germ oil is unusually rich in vitamin E, containing 270 mg. tocopherols per 100 g. Corn oil and cottonseed oil, which have approximately the same concentration of linoleic acid as has wheat germ oil (about 50 per cent.), have only 110 mg. tocopherols per 100 g.; sunflower seed oil, which is richer in linoleic acid (63 per cent.), contains 70 mg. of tocopherols; olive oil is poor in linoelic acid (6 per cent.) and in tocopherols (7 mg. per 100 g.).

Linoleic acid is converted in the body into arachidonic acid, which appears to be the required essential fatty acid for most purposes, but which does not occur in plant sources. For the converison pyridoxio (vitamin B_6) is required. Effective deficiency of EFA can therefore occur if diets are low in arachidonic acid and pyridoxin, or in arachidonic acid and linoleic acid. Since arachidonic acid, which contains four unconjugated double bonds, is not contained in many foods and is extremely unstable in presence of oxygen, both pyridoxin and linoleic acid must be contained in diets to prevent EFA-deficiency; and vitamin E is needed to protect linoleic acid in the diet, in the intestine and in the body.

(*b*) Possible significance in human nutrition

This subject I have discussed elsewhere[11, 12]. The simplest hypothesis regarding the action of EFA in the animal organism is that they are required for structural purposes in combination with cholesterol and in phospholipids, both being incorporated into lipoproteins. All the plasms cholesterol is found in lipoproteins and the incorporation of cholesteryl esters depends upon the type of fatty acid in the ester. Normally, cholesterol is esterified with highly unsaturated fatty acids, but if these are not present it becomes esterified with more saturated fatty acids, such as stearic acid, which can be formed in the body. Such saturated esters of cholesterol are much less soluble than those containing unsaturated fatty acids, and it is the more saturated type which is found in low-density β-lipoproteins: this is the type of lipoprotein that is found to be higher in men as opposed to women, in old people, and in diseases, such as atherosclerosis, diabetes mellitus, nephritis and myxoedema; this type, unlike high-density β-lipoproteins, does not contain essential fatty acids. I believe that in atherosclerosis there are two factors to be taken into account regarding EFA, first, this question of solubility in carriage of cholesteryl esters and other compounds that normally contain EFA (batyl alcohol and phospholipids); and secondly, permeability of the capillary endothelium. We know that in EFA deficiency there is increased permeability and fragility of capillaries (Kramár and Levine[13], 1953). Myocardial infraction has two factors ætiologically related to EFA deficiency. First, atheroma must be present; secondly, there may be

increased coagulability of blood caused by an increase in plasma of phosphatidyl ethanolamine; a phospholipid which normally contains highly unsaturated fatty acids. I believe that this question of coagulability explains the deposition of cholesteryl esters that occurs in the intima of blood vessels, in the epidermis (where it can be sufficiently marked to consitute xanthoma), in the cornea as arcus senilis and in the lens of the eye as cataract. For instance, in diabetes mellitus, in which the requirement of EFA is greatly increased as judged by the alloxan-diabetic rat, deposition of esterified cholesterol occurs in all these sites. Further, the triopathy of diabetes can also be explained by EFA deficiency as follows.

Not only are EFA required for cell membranes (which accounts for the greatly increased permeability of the skin to water in EFA-deficiency) but they are also propably required for the bimolecular leaflets of lipid that form the endoplasmic reticulum of cells and the membrane of mitochondria with its invaginations to form the cristæ mitochondriales; these bimolecular leaflets of lipids also occur in myelin. Perhaps most important of all, it appears that EFA are required for the formation of mesenchymal ground substance. In the EFA-deficient rat this form of connective tissue is defective, as are other forms such as cartilage and bone. Evidence is beginning to appear to suggest that deficiency of EFA may be a factor in the collagen diseases and be responsible for the nephropathy of diabetes. The retinitis of diabetes can be similarly explained and the neuropathy could be related to the known occurrence of EFA in myelin and the axis cylinder. Defective connective tissue caused by EFA-deficiency can also explain dental caries, senile ostereoporosis and arthritis.

(*c*) Composition of flour in relation to EFA

Wholewheat flour contains about 1 g. of linoleic acid per 100 g. If therefore 100 oz. flour and bread are consumed weekly, about 4 g. linoleic acid would be obtained daily. The requirement of EFA for man is not known, but 4 g. would be a substantial amount: if, as is sometimes guessed, 1 per cent. of the total calories should be provided by EFA, about 3·3 g. daily would be required. White flour contains about half that present in wholewheat, which is a surprisingly large amount since the linoleic acid occurs in the germ. It should, however, be remembered that EFQ deficiency was not demonstrated in lower animals until Evans and Burr[14] introduced sucrose instead of purified starch as the carbohydrate constituent of diets and later it was found that pure starch adsorbs linoleic acid.

As mentioned above, wheat-germ oil contains large amounts of vitamin E. According to Engel[15], flours of 82 per cent. to 100 per cent. extraction contain 5·9 mg. of tocopherols per 100 g. whereas white flour contains only 1·7 mg. Nothing is known about the function of vitamin E as such in human nutrition, but reference has already been made to its important function in protecting EFA.

The Cohen Report[16] points out that 80 per cent. extraction flour provides 39 per cent. of the pyridoxin in the diet of this country; for a patent flour of 40 per cent. extraction the corresponding figure would be 19 per cent. It appears that the *per caput* consumption of pyridoxin is of the order of 1·7 mg. daily when national flour was almost universally being used (Hollingsworth and Mann[17], 1956), but this figure falls by about 27 per cent. to a *per caput* consumption of 1·2 mg. when, as at present, white flour replaces national. The requirement for pyridoxin for man is not known. Probably the best available guess is that derived by the balanced studies of Greenberg on monkeys, which put the requirement for man at about 4 mg. daily. A considerable reduction cannot therefore be viewed with equanimity.

Perhaps the most important factor of all regarding flour and EFA is the destruction that occurs by the use of the so-called flour " improvers ". Strong bleaching agents (agene, chlorine dioxide and benzoyl peroxide) are used to oxidize xanthophylls which are plant pigments. Most of the vitamin E in flour is destroyed and apparently considerable proportions of the linoleic acid as well. At the end of the war 90 per cent. of the flour used in this country was treated with agene, but as from September last this has become illegal. Chlorine dioxide is now mainly used and there are chemical grounds for believing that this not only oxidizes linoleic acid but adds chlorine to the double bonds. Nothing is known about the anti-EFA effect of halogenated linoleic acid.

" Improvers " are also used by bakers. One such is polyoxethylene stearate which has been forbidden in the U.S. for the past few years and is known to be toxic to rats and hamsters[18, 19].

IV—THE COHEN REPORT

A panel of five, under the Chairmanship of Lord Cohen of Birkenhead (then Sir Henry Cohen) was appointed in May, 1955, by the Secretary of State for Scotland, the Minister of Agriculture, Fisheries and Food, and the Minister of Health, to make an independent authoritative review on the scientific and medical evidence then available on the differences in composition and nutritive value of flour of varying extraction rates. The final paragraph of their report starts: " The conclusions reached by the Panel differ from those presented in their evidence by the Government's medical and scientific advisers and by the Medical Research Council ". The Panel summarized the views of these experts as follows: " Briefly, the Government's medical and scientific advisers and the Medical Research Council claim that, since bread contributes, on a national average, one-third of the total calories of the diet, National flour of 80 per cent. extraction makes it virtually certain that the diet as a whole will provide an adequate supply of protein, vitamin B, nicotinic acid and iron and that, in addition, such flour provides useful quantities of other essential nutrients for which there are less well defined criteria of adequacy. If the extraction rate were lowered to 70 per cent. there would be a loss of protein, vitamin B_1, nicotinic acid and iron, and, even if these two vitamins and iron were restored by enrichment, a reduced intake of other vitamins might in some circumstances be reflected in nutritional deficiencies."

No consideration was given by the Panel or the Medical Research Council in their reports to EFA or to vitamin E. Regarding pyridoxin, the Panel concluded correctly that human requirements were not known and information as to its distribution in foods and flours of various grades was far from complete. Some might have considered this a challenge to obtain the relevant information, but not so the Panel: " The Panel's review of the relevant literature leads them to believe that, in spite of weighty opinion to the contrary, a lowering of the extraction rate from 80 per cent. to 70 per cent. is very unlikely to lead to any nutritional disturbance from lack of these vitamins [pyridoxin, pantothenic acid, biotin and folic acid]." The Panel believed " that a policy of enrichment provides a realistic means of ensuring that the greatest nutritional benefit is derived from flour. . . . Taking into account all the circumstances, and bearing in mind particularly the needs of the vulnerable groups in the population, the Panel concludes 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 forseeable circumstances. They believe, however, that differences between low extraction flour enriched as specified and low extraction flour not so enriched are significant."

It would seem that the fundamental distinction between the attitude of the Panel and that of the scientists advising the Government is that the former felt sufficient information was at hand to reach a decision whereas the latter considered that future research might prove the existence of factors in flour other than those already known that would affect human nutrition and become deficient if low extraction flour were used. A physician is trained to take no chances with his patients but to foresee risks and avoid them. This training he retains when he enters the field of preventive medicine. He knows that there are unknown factors in diet that affect nutrition for he sees that dental caries—possibly the commonest nutritional disorder in civilized countries—is caused by some unknown defect in the diet of those countries. The attitude of a physician is to prevent any risk of harm occurring. Some laboratory scientists on the other hand consider a measure to be justifiable unless it has been proved dangerous. Therefore in their view it is permissible to remove nutrients from a natural food until these have been proved essential for the maintenance of health in man. I believe that research in the next year or two will prove that there is a widespread relative deficiency of essential fatty acids in the diets of the more highly civilized countries, particularly

those that use flours of low extraction to which bleaching agents have been added. Since low extraction flour demonstrably decreases the dietary content of linoleic acid, vitamin E and pyridoxin as compared with the use of National flour, and since there is no evidence that there is a widespread public demand for the latter, I deplore the policy advocated in the Cohen report which was subsequently adopted by the Government.

REFERENCES

[1] SINCLAIR, H. M. (1951). *In Aspects of Modern Science*, Ed. I. Geikie-Cobb. London: Low.
[2] MINISTRY OF FOOD (1945). H.M.S.O. Cmd. 6701.
[3] MOLONEY, C. J., and PARMELEE, A. H. (1954). *J. Amer. Med. Ass.*, **154**, 405.
[4] COUSIN, D. B. (1954). *J. Amer. Med. Ass.*, **154**, 406.
[5] HUNT, A. D., STOKES, J., MCCRORY, W. W., and STROUD, H. H. (1954). *Pediatr.*, **13**, 140.
[6] VILTER, L. W., and SCHREINER, W. (1952). *Nutr. Symp. Ser., Nat. Vit. Found.*, **5**, 104.
[7] MCGANITY, W. J., MCHENRY, E. W., VAN WYCK, H. B., and WATT, G. L. (1949). *J. biol. Chem.*, **178**, 511.
[8] GOLDFEDER, A., COHEN, L., MILLER, C., and SINGER, M. (1948). *Proc. Soc. exp. Biol.*, N.Y., **67**, 272.
[9] BEAN, W. B., and HODGES, R. E. (1954). *Proc. Soc. exp. Biol.*, N.Y., **86**, 693.
[10] WIDDOWSON, E. M., and MCCANCE, R. A. (1954). *Med. Res. Coun. Spec. Rep. Ser.*, 287.
[11] SINCLAIR, H. M. (1956). *Lancet*, **i**, 381.
[12] SINCLAIR, H. M. (1956). *Proc. 3rd. internat. Congr. on Lipids.* In press.
[13] KRAMÁR, J., and LEVINE, V. E. (1953). *J. Nutr.*, **50**, 149.
[14] EVANS, H. M., and BURR, G. O. (1928). *Proc. Soc. exp. Biol.*, N.Y., **25**, 390.
[15] ENGEL, R. A. (1943). *J. Nutrit.*, **25**, 441.
[16] COHEN, H. (1956). *Report of the Panel on Composition and Nutritive Value of Flour*, H.M.S.O. Cmd. 9757.
[17] HOLLINGSWORTH, D. F., VAUGHAN, M. C., and WARNOCK, G. M. (1956). *Proc. Nutrit. Soc.*, **15**, xvii.
[18] POLING, C. E., EAGLE, E., and RICE, E. E. (1956). *Food Res.*, **21**, 337.
[19] EAGLE, E., and POLING, C. E. (1956). *Food Res.*, **21**, 348.

DISCUSSION

Dr. T. Moore (Dunn Nutritional Laboratory, Cambridge) said that thanks were due to both the speakers for the trouble they had taken in preparing such comprehensive reviews on the important subject of the symposium. It had been shown that the protein, vitamin and mineral contents of flours were affected not only by the extraction rate, but also by the use of chemical improvers. Factors such as digestibility had also to be considered. The possible variations in the nutritive value of flour, therefore, presented a very complicated picture, and it had been discussed very adequately that afternoon.

Dr. Moore thought that one of the most important points in Professor Frazer's paper, also mentioned by Dr. Sinclair, was the value of bread as a source of protein. In the somewhat artificial classification of foods, according to whether they were " protective " or merely sources of energy, there had been a widespread tendency to place bread in the second class. Regarding the experiments on German children by Widdowson and McCance, however their finer points may be interpreted, at least they made them raise the estimate of the value of bread as a body-builder.

In telling of the production of coeliac disease through sensitivity to wheat protein, Professor Frazer had spoken as an eminent authority on that distressing complaint. It would be interesting to know whether wheat was the sole cause, or whether other etiological factors might also have been concerned.

In regard to the action of chlorine dioxide in destroying vitamin E in flour, the line drawn by Professor Frazer between the effect of that improver, and those of baking and storing, might well have been more distinct. In an investigation, reported in the current number of the *Journal of the Science of Food and Agriculture*, Dr. Moore's colleagues and he had certainly confirmed that vitamin E was partially lost during baking. That loss, however, was much less complete than the loss caused by chloride dioxide. Rats fed upon bread baked from untreated flour received a satisfactory intake of vitamin E. In contrast, rats which received flour which had been treated with chlorine dioxide, or bread which had been baked from it, developed plain signs of avitaminosis.

Concerning Professor Frazer's suggestion that margarine might be fortified with vitamin E, it must be remembered that that food was a good source of that vitamin as now available. In America it had been suggested that the estimation of vitamin E should be used to test the possible contamination of butter. Values above a certain maximum would indicate the presence of margarine, or of vegetable fat from some other source. It was interesting to reflect that the same intake of vitamin E might be obtained by eating bread made from untreated flour with butter, or bread made from flour treated with chlorine dioxide in conjunction with margarine. The two forms of food sophistication tended to neutralize each other in that particular direction.

In regard to the strictures by Dr. Sinclair on the recommendations of the Cohen Committee, Dr. Moore could only add his personal opinion in his support. The risks which were incurred by the reduc-

tion in low-extraction flour of its contents of pyridoxine, pantothenic acid, biotin and folic acid did not seem worth the dubious gain of greater whiteness. Losses in essential fatty acids, caused both by a lowered extraction rate and the use of chlorine dioxide, required further investigation. For the present, however, he would hesitate to endorse all the interesting speculations with which Dr. Sinclair had intrigued them in relation to the possible pathological effects of E.S.A. deficiency in man. Dr. Moore agreed with Professor Frazer that much more research was needed on many problems concerning the nutritive value of flour and bread.

To finish his remarks with a statement of his own tastes, Dr. Moore said that he regretted the disappearance of the National loaf, championed by the late Sir Jack Drummond, and made from slightly off-white flour. Unless they were fortunate in the range of breads supplied by the local baker they seemed to be left the choice of proprietary wholemeal breads and an insipid, spongy white bread. Bread of the latter type might, perhaps, be suitable for mopping up gravy after a plate of meat, but it did not appeal to his taste when eaten as a main component of a meal. Moreover, he was advised, by advertisements prominently displayed in the press, that bread of that kind was particularly beneficial when it was eaten fresh. He disliked fresh bread, and had always thought that it could cause indigestion. He asked whether Professor Frazer, or anyone else at the meeting, could tell them whether there was any scientific basis for that recommendation.

The Rt. Hon. Lord Douglas of Barloch, K.C.M.G. (London) said that the public was urged to eat fresh bread because most of that on sale became hard and mouldy so quickly that it could not be eaten stale. Large quantities were consigned to the dustbins every day. The composition of flour and bread was dictated by commercial, and not by dietetic reasons. The bran and the germ which contained vitamins, minerals and other essential factors were sold for animal feeding or for making processed vitamin and bran products for the public as a remedy for dietary deficiencies. The bleached flour took up more air and water in baking and so yielded a larger loaf. In 1927 the Departmental Committee on the Treatment of Flour with Chemical Substances gave a warning against the bleaching of flour with chlorine or with nitrogen trichloride (agene). The use of agene after many years had only recently been discontinued in this country, but chlorine dioxide was now being used despite that warning. Very few of the public knew the taste of bread made of unbleached flour or of genuine wholemeal, and properly baked. There was no "consumer preference" for bleached and depleted flour. But no compulsion should be employed to oblige the consumer to eat any particular kind of food or food additive. The public were entitled to know what they were buying. All flour and flour products sold for human consumption should be clearly labelled to show what processing they had sustained and what had been added to or subtracted from them.

Mr. R. B. D. Stocker (London), speaking as a dentist, said that physicians and others who had made a special study of dental caries knew that its great prevalence in civilized countries was due to the consumption of flour and sugar, which was retained, and fermented, on the teeth. There was experimental and other evidence that wholemeal bread was less harmful than white, and that was probably because its texture stimulated the natural cleansing of the mouth by the tongue, etc. White bread was poorly tolerated by many, causing constipation and possibly other diseases of the gut. The conflict between palatability and wholesomeness should be resolved by joint research into the factors determining both qualities, leading to the manufacture of such foods that the consumer's instinctive choice amongst them would automatically guide him to a good diet, as it guided primitive man and lower animals to the best diet available to them. Although fluorine was possibly not essential to man, a trace of it was generally recognized to be beneficial under civilized dietary conditions. The fluorine accidentally present in the *creta praeparata* added to National flour was in appreciable quantity and might have contributed to the decline in caries during the war. Deliberate enrichment of flour with fluorides might be a good method of preventing caries, either as supplementary to the fluoridation of water supplies, in order to ensure a more nearly uniform fluoride intake, or as an alternative, to meet the case of those who might object to what they mistakenly considered to be compulsory.

Dr. W. Alcock (Medical Officer of Health, Watford) felt that there was something fundamentally wrong with the present abstraction policy, with its attempt at partial replacement of nutritives by the addition of calcium and iron. Those who advocated a "back-to-nature" policy might, on this occasion, be nearer the mark. The chief objection to 100 per cent. extraction of flour appeared to be its high phytic acid and bran content. With regard to the latter, he asked Professor Frazer for the evidence that bran was poorly tolerated by some people. It was taught that "roughage" was an essential constituent of a good diet. He asked whether the objectionable calcium-fixing property of phytic acid in wholemeal flour could not be corrected by the addition to the flour of dried skim-milk powder.

Dr. A. E. Bender (Bovril Ltd.) said that the figure of 70 quoted as the biological value of white flour was too high, and it was misleading to suggest that a lysine supplement raised it to 100; that suggested that lysine was the only amino acid deficiency in flour.

For bread the biological value was 45; with lysine it was raised to 57, and with the further addition of threonine to 74; and with methionine to 80. Thus the addition of lysine alone did not produce a very large increase in biological value. For that reason lysine supplementation could not have much

Mr. E. Mitchell Learmonth (British Soya Products Ltd.) inquired what importance Dr. Sinclair attributed to the presence of vitamin E *per se*—alpha tocopherol—as opposed to other tocopherols. So far as he was aware, vitamin E had not yet been shown to have any specific importance as a vitamin for human beings, although it had been deemed the anti-sterility vitamin for rats. As an antioxidant for the protection of the essential fatty acids, vitamin E (alpha tocopherol) had been said to be much less effective than gamma tocopherol. Gamma tocopherol was present in high concentrations in soya, as Professor Frazer had pointed out, and soya was increasingly used as an ingredient in foodstuffs containing wheat flour. It seemed to him (Mr. Learmonth) that insistence on the preservation of vitamin E was rather wide of the mark if its value resided only in the preservation of essential fatty acids, and if that aim could be much better achieved by supplementing the flour with gamma tocopherol, for example, in the form of soya, which was increasingly used as a supplement for other purposes also.

That was also an answer to another speaker, who had asked what other foodstuffs could be used in conjunction with wheat flour to improve, for example, the eating qualities and keeping qualities of bread. The use of milk powder, which had been suggested, was accompanied by a number of technical difficulties in making bread of satisfactory appearance and texture, though its nutritional value was high. Soya, on the other hand, offered technical advantages in breadmaking and was also used as a nutritional supplement with advantage in appearance, eating qualities and staling resistance.

He wished also to reinforce the remarks of Dr. Bender about the nutritional quality of the protein of wheat flour. The upper figure mentioned by Professor Frazer seemed to him high; and Dr. Sinclair also had referred to its high biological value. Those statements were not wholly supported by literature on the subject. Mitchell, in 1947, had found a biological value for whole wheat of only 61 and for white flour only 52, as compared with 72 for soya and 75 for beef.

Dr. W. T. C. Berry (Ministry of Health) said that polyoxyethylenes were not on the proposed permitted list of emulsifiers published by the Food Standards Committee. Calcium fluoride in the solid state was poorly absorbed. He pointed out that some of Dr. Sinclair's hypotheses as to conditions caused in man by deficiency of E.F.A. were susceptible to test. He asked whether they had been tested in America and, if so, with what result.

Dr. K. O. A. Vickery (Medical Officer of Health, Eastbourne) referred to the requirements of vitamin B1 in connection with carbohydrate metabolism. In that connection, the Manual of Nutrition of the Ministry of Agriculture and Food, 1955, page 32, clearly illustrated that present whiter bread, and even National bread, contained only sufficient for its own metabolism. The average family consumed, in addition to bread, considerable quantities of sugar, cakes, biscuits, and refined cereal products, known to be deficient in vitamin B_1. He contended that, unless at least the daily bread was wholemeal, which was the only variety carrying an excess of vitamin B_1 over its own metabolistic requirements, there was almost certain to be a deficiency in the daily diet.

He noted that Professor Frazer had not placed much value on the fibrous element of cereal, which he stated was irritant and not digestive or absorbed. Dr. Vickery could not understand why only those parts of the food which were digested and absorbed were regarded as of physiological value. He referred in support of the contrary view to investigation by Hipsley (Hipsley, E. H. (1953), *Brit. Med. J.*, ii, 420), which demonstrated a relationship in favour of the prevention of toxaemia of pregnancy by diets with a high fibre content. War-time experience in Belgium and Holland supported that finding in relation to toxaemia of pregnancy. There was also the investigation by Reid (Reid, J. J. A. (1956), *Brit. Med. J.*, ii, 25), which revealed that over 17 per cent. of a group of school entrants and leavers took laxatives at least weekly.

It was the duty of the public health medical officer to take account of the findings of the experts and to implement them in health education programmes. His own interpretation was that whilst there was considerable evidence and experience in favour of benefits to health of high-extraction flours and some which appeared to show little difference between high and enriched low, no one, so far as he was aware, claimed any benefits for refined cereals other than alleged public preference. He therefore continued to advocate wholegrain cereals in all possible circumstances, and, having heard Dr. Sinclair's thoughtful contribution could not understand why he, too, did not go the whole way in his obvious leaning towards the high-extraction flours.

Reprint No. 38
Price - .10¢
by
The Royal Society of Health Journal
Vol. 77 No. 5 - May, 1957
Reprinted by
LEE FOUNDATION FOR NUTRITIONAL RESEARCH
Milwaukee 1, Wisconsin