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Discussion

Dr. E. Kodicek (Dunn Nutritional Laboratory, Cambridge), joint opener: Before a few specific points are discussed, results will be presented, obtained in this laboratory on flours of varying extractions, most of which were kindly supplied by the Cereals Research Station of the Ministry of Food (Table 1). The values obtained for vitamin B_1

TABLE 1

VALUES FOR VITAMIN CONTENT OF CEREAL PRODUCTS AND OF FLOURS OF VARYING EXTRACTIONS OBTAINED AT THE DUNN NUTRITIONAL LABORATORY

Product	Vitamin B_1, fluorimetric method of Harris and Wang (1941) μg. per g.	Riboflavin			Nicotinic acid, chemical method μg. per g.
		Fluorimetric method μg. per g.	Microbiological method μg. per g.	Results of other authors* μg. per g.	
Flour 100 per cent. extraction	4·2 (3·0 to 5·1)	1·1 to 1·3	1·1	1·0 to 1·3	48·5 (35·5 to 60·0)
85 ,,	3·5	0·7	0·6	—	17·8
80 ,,	2·7	0·5	0·5	—	9·9
70 ,,	1·0	0·36	0·32	0·35 to 0·40	9·1
Wheat germ ..	19·0	7·6	—	—	51·9
Bran	11·0	3·6	—	—	235·0

* Andrews (1943); Andrews, Boyd and Terry (1942); Conner and Straub (1941); Munsell (1942); Swaminathan (1942).

and nicotinic acid agree well with those of the previous speakers. With decreasing extraction, the values for vitamin B_1 decrease from 4·2 μg. to 1·0 μg. per g. and for nicotinic acid from 50 μg. to 9 μg. per g. The high nicotinic acid content of bran, 235 μg. per g., though well known, is worth mentioning. The value of 11 μg. vitamin B_1 per g. in bran was found by Harris and Wang (1941) on various samples, but a recent sample contained only 4·2 μg. per g. which is comparable with the value reported by Moran (1945) for cleaned bran.

The riboflavin values obtained fluorimetrically and microbiologically decrease from 1·1 μg. to 0·7, 0·5 and 0·36 μg. per g. with decreasing extraction. These values are in good agreement with those of other

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authors, mostly in the U.S.A., listed in Table 1. Andrews, Boyd and Terry (1942) made especially extensive studies. They found a range of 1·0 to 1·3 μg. per g. in 24 samples of spring wheat, 15 samples of soft winter wheats, and 27 samples of various varieties of hard winter wheats. A similar range was found by Munsell (1942), Conner and Straub (1941), and Swaminathan (1942), using fluorimetric or microbiological methods. A wider range has been reported by Andrews (1943) from a collaborative study with 20 participants, but the average results were well within the range mentioned in Table 1. Our results are definitely lower than those given by the previous speakers and by Barton-Wright and Booth (1943) but the relative decrease with decreasing extraction is of the same order.

Figure 1 shows the percentage of the total vitamins present in whole

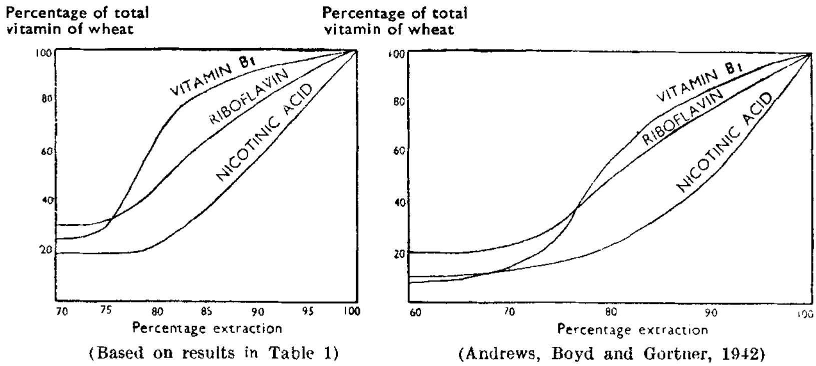

FIGURE 1.
DISTRIBUTION OF VITAMINS IN PRODUCTS OF WHEAT MILLING.

wheat which are retained at different extractions. The graph taken from the paper of Andrews, Boyd and Gortner (1942) shows good agreement with our results. For vitamin B_1 the decrease is small until 85 per cent. extraction is reached, but below the 80 per cent. level there is a sudden drop in concentration to 29 per cent. of that found in whole wheat. The behaviour of the curve for riboflavin is similar but less pronounced. The content of nicotinic acid, however, drops rapidly to a low value even in flour of 85 per cent. extraction. The graph illustrates clearly that the amount of one vitamin in a certain extraction is no guide to the amount of any other vitamin present.

Figure 2 shows graphically the relative contribution made by flours of different extractions towards satisfying the requirements of the three vitamins. The black columns in each case show the daily requirement, the white columns, the percentage of this contributed by 200 g. of the flours of different extractions. With flour of 100, 85 and 80 per cent. extraction, a daily intake of 200 g., taken as average (Widdowson and Alington, 1941; Special Joint Committee Set up by the Combined Food Board, 1944), contributes, respectively, 84, 70 and 54 per cent. to the vitamin B_1 requirement of 1 mg.; with 70 per cent. extraction flour there is a sudden drop to 20 per cent. of the daily requirement. With nicotinic acid, 87 per cent. of the assumed daily requirement of 12 mg. (Kodicek, 1942) may be supplied by flour of 100 per cent. extraction, but only 30 to 15 per cent. by flours of lower extractions. The possibility should be

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mentioned of the existence in wheat products of a nicotinic acid precursor (Andrews, Boyd and Gortner, 1942; Krehl and Strong, 1944; Krehl, Elvehjem and Strong, 1944), which is estimated by our methods but may not be of nutritional significance (Kodicek and Mackworth, unpublished results). Even if a requirement of riboflavin as low as 1·5 mg. per day as suggested by Williams, Mason, Cusick and Wilder (1943) is accepted, the contribution of 200 g. of flour to this requirement is very small, about 15 to 5 per cent. with decreasing extraction. It appears,

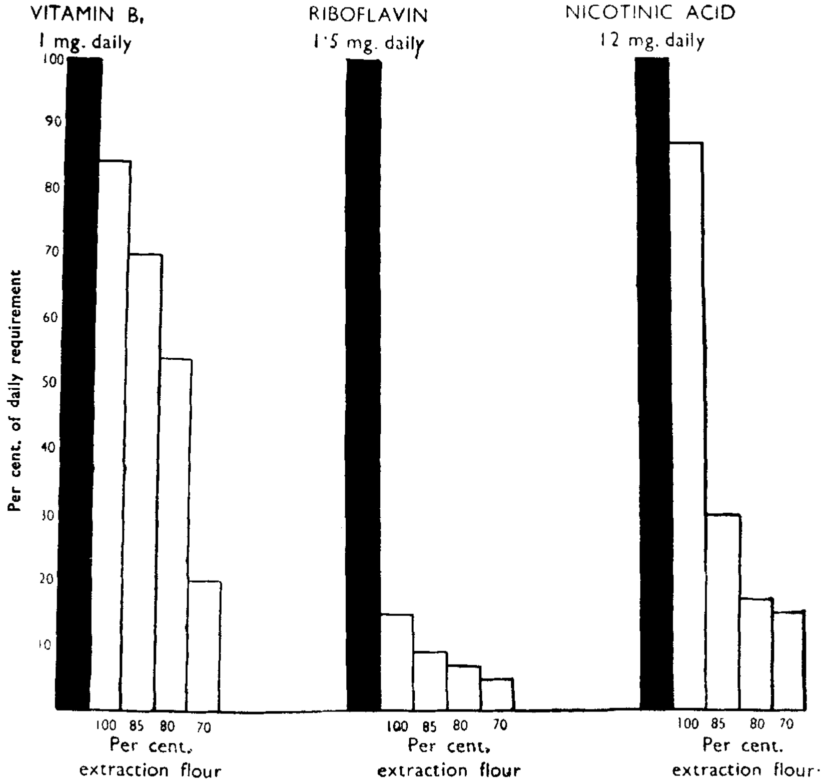

FIGURE 2.
CONTRIBUTION OF 200 g. OF FLOUR TO DAILY REQUIREMENTS OF B VITAMINS.

therefore, that the consumption of high extraction flour would satisfy an important part of the vitamin B_1 requirement, less of the nicotinic acid requirement and, of the riboflavin requirement, very little indeed.

There is a last point which it is desirable should be discussed. In the future, microbiological and chemical methods will certainly be used to a far greater extent than in the past. It would be an advantage to be able to distinguish at once whether results were obtained biologically or chemically, since it is to be expected that differences may arise through the nature of the tests. Biological methods may give higher results for certain foodstuffs by including derivatives of the vitamin not estimated

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chemically, or through the effect of non-specific substances, especially in microbiological tests. Such for example is the activity of "pseudo-pyridoxine" or pyridoxal (Snell, 1944), or the effect in vitamin tests of saturated and unsaturated fatty acids on *Lactobacillus helveticus* (Bauernfeind, Sotier and Boruff, 1942; Strong and Carpenter, 1942; Kodicek and Worden, 1944, 1945). The critical evaluation of the final result thus depends on the nature of the test, whether biological or chemical. In practice the differentiation is effected by repeated description which becomes difficult in compiling tables.

I would like to put it for discussion to the meeting that it should be agreed to express chemical results in weight units, and biological results in biological units, for vitamin B_1 in international units, and for riboflavin, nicotinic acid and other B vitamins in new biological units equivalent to say, 1 μg. for easy calculation.

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Mr. A. L. Bacharach (Glaxo Laboratories, Ltd., Greenford, Middlesex), joint opener: Some of the figures to which Dr. Kent-Jones and Dr. Kodicek have already alluded are illustrated in a slightly different way in Table 1, where I have followed the former in choosing for the daily requirements the amounts laid down as Recommended Allowances by the Committee on Food and Nutrition of the U.S.A. National Research Council (1941). Consequently this table shows contributions by bread to the daily requirements of vitamin B_1 less than those illustrated by Dr. Kodicek.

I consider it useless to argue about the merits and demerits of particular foods in a nutritional vacuum. Such questions can be decided only in relation to the daily diet of a population or group. A sound nutritional policy must have sufficient flexibility to allow for changes in dietaries and

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to be able to adjust the composition of particular foods accordingly. The work of Jessop and his colleagues in Dublin (Pringle, Reynolds and Jessop, 1943; Croasdaile, Collis, Pringle and Jessop, 1943; Fitzgerald, Sheehan, Collis, Pringle, Reynolds and Jessop, 1944), though by no means decisive as they are the first to admit, does suggest caution about sudden changes of extraction in flour without sufficient consideration of the other articles of diet. In the direction of reconciling the opposition of those who advocate a wholemeal loaf and those who support the use of

TABLE 1

PERCENTAGE OF RECOMMENDED DIETARY ALLOWANCES (RDA) SUPPLIED BY 200 g. OF FLOUR OF DIFFERENT EXTRACTION OR ENRICHMENT, IN A 2500 CALORIE DIET

Nutrient		RDA mg.	Percentage of RDA supplied by flour of 97 per cent. extraction	85	80	75	71	U.S.A. enriched flour* Minimum	Maximum
Vitamin B_1		1·5	60	41	34	21	14	60	75
Nicotinic acid		15	60	21	16	11	—	47	59
Riboflavin		2·2	18	11	9	7	4	24	30
Iron	Total	—	75	44	33	20	15	109	138
	Available	12	59	37	29	17	15	109	138

* Kent-Jones and Bacharach (1941).

low extraction flour, there is now a convergence of opinion, a British compromise, if you will, by the acceptance of flour with extraction somewhere in the range of 80 to 90 per cent. The adoption of an 80 per cent. "basic" flour, with such enrichment as might be prescribed from time to time in accordance with changing dietary needs, would be a possible way of making the best of both worlds.

The figures in Table 1 illustrate a number of points that have already been brought out in the papers presented this morning. They show clearly, in spite of their approximate nature, how rich bran is in iron and nicotinic acid and how, on the other hand, riboflavin is distributed more or less uniformly throughout the wheat grain. It is possibly fortunate that the two former nutrients are among the cheapest of those reduced in amount with falling extraction of flour. Whether or not bran contains any of the "X factors", to which occasional reference has been, and no doubt will again be, made during this discussion, is a matter that can best be left to each of those present to decide for himself on whatever basis he thinks suitable, but I am in agreement with Dr. Kent-Jones that there is nothing immoral, as such, in rejecting the outer layers of a food and eating the inner ones. I am equally satisfied that most of the stories about the ill effects of bran on human digestion are without scientific foundation. To cranks at both ends of the scale of flour extraction I most emphatically say "a plague on both your houses", and this meeting will have been fully justified if all it does is to indicate that such an attitude is shared by the responsible members of this Society.

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Sir Joseph Barcroft (Physiological Laboratory, Cambridge): I had hoped to hear today, and I have not heard it yet, though Dr. Kent-Jones did get near it, the answer to this question: if we took 70 or 75 per cent. extraction flour and added to it, if we could, all the things we know it to be deficient in, and then did a laboratory experiment such as we have heard about, could we find out whether the flour so manufactured is or is not more nourishing than wholemeal flour? What is the answer?

Mr. H. C. H. Graves (Research Laboratories, Vitamins, Ltd., 23 Upper Mall, Hammersmith, London, W.6): I should like to make three points about Dr. Chick's work on the biological value of wheat proteins (Chick, 1942).

Firstly, Dr. Chick used the *ad libitum* feeding technique, some of the disadvantages of which have been pointed out by Mitchell (1944) as well as by Dr. Chick herself (Chick, 1935).

Secondly, Dr. Chick omitted to allow in her calculations for the protein requirements of her animals for maintenance as distinct from the requirement for growth. If this is done most of the apparent differences can readily be reconciled.

Thirdly, as I have shown in more detail in a paper shortly to be published elsewhere (Graves, 1945), since the final weights of Dr. Chick's animals can be predicted in all cases from an equation of the type:

$$\text{Growth} = b \log (\text{net retained food}) - \kappa$$

irrespective of the protein source used, the tests described in her paper do not discriminate between the biological values of these protein sources.

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Dr. E. R. Dawson (Research Department, Distillers Co., Ltd., Great Burgh, Epsom): The food to be discussed today is bread. Most of the figures we have been given are for flour and the assumption has been made that the nutrients in flour are unchanged in breadmaking. This is not necessarily correct. It has been shown in both Britain and the U.S.A., that a considerable proportion, 20 to 30 per cent., of vitamin B_1 in flour is destroyed during the baking of bread. I should like to ask Miss Copping and Dr. Kodicek, if they have been able to confirm this loss.

Some of the effects of breadmaking may be favourable. Thus it has been shown that hydrolysis of phytic acid may occur during the fermentation of dough by yeast.

Miss A. M. Copping replied: Except for one recent comparison of the vitamin B_1 and riboflavin content of 85 per cent. extraction flour and of bread baked from it, no biological experiments have been made since the early ones of Copping and Roscoe (1937). These experiments did not indicate any serious loss of B vitamins from flour in the process of baking bread.

REFERENCE

Copping, A. M. and Roscoe, M. H. (1937). *Biochem. J.* **31**, 1879.

Dr. E. Kodicek replied: In the baking of bread there is a slight loss of vitamin B_1 as determined by the thiochrome method. The content of riboflavin and nicotinic acid of flour is not affected by baking, at least not in a degree detectable by chemical means. If, however, bicarbonate of soda is used in baking, there is an appreciable loss of vitamin B_1.

Dr. L. J. Harris (Dunn Nutritional Laboratory, Cambridge): Dr. Wang and I showed that when wheatmeal biscuits were baked with sodium bicarbonate, or with sodium bicarbonate and ammonium carbonate, according to the current procedure, the alkaline reaction caused a serious loss in vitamin B_1. We were able to rectify the trouble, which had some important practical bearings, by having the biscuits baked with ammonium carbonate alone, or better still with yeast, which last measure was apparently something of an innovation in biscuit making (Harris and Wang, 1941).

REFERENCE

Harris, L. J. and Wang, Y. L. (1941). *Biochem. J.* **35**, 1050.

Professor L. S. Fridericia (Institute of Hygiene, University of Copenhagen): The papers and discussion have given the impression that all civilized peoples eat wheat bread and that they like to have it white; some speakers have mentioned ill effects said to be connected with the eating of wholemeal bread. I come from Denmark and we consider ourselves fairly civilized. In Denmark we eat, and have done for thousands of years, brown rye bread, 100 per cent. wholemeal, more than 100 per cent. in fact as during the war even the 17 per cent. discarded from the wheat flour was added to the rye flour. If what has been said about brown bread is true, we should get rickets, and yet we have very little rickets in Denmark. Denmark has one of the lowest death rates of the world and, next to Holland, the lowest tuberculosis death rate in Europe. The Danish experience speaks decidedly against the supposition that the eating of large amounts of wholemeal rye bread involves any inconvenience whatever.

Mr. E. C. Wood (Virol, Ltd., Hanger Lane, London, W.5): Since reference has been made to the alleged association between the use in Eire of bread made from 100 per cent. extraction flour and an increased incidence of rickets in Dublin, I think it only right to draw attention to a letter by Dr. J. C. Saunders of the Cork Public Health Department to *The Lancet* (Saunders, 1944) in which he suggests that the cause of the increase in rickets may be, not the use of wholemeal bread, but the shortage of cod liver oil and other antirachitic preparations which, from December 1941 until December 1943, were completely unobtainable, and are still in very short supply, as are also butter, milk, eggs, and cheese. Moreover, the Cork Public Health Department recorded 16 cases of rickets in 1943 and 15 cases in the first 8 months of 1944 although, since

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December 13th 1943, the extraction of the flour used for bread making was lowered from 100 to 85 per cent. It should be obvious that where there have been gross changes in more than one factor over the period in which a certain phenomenon has been noticed, it is very unscientific without further investigation to attribute the phenomenon in question to one only of them.

REFERENCE

Saunders, J. C. (1944). *Lancet*, **247**, 580.

Dr. W. R. G. Atkins (Marine Biological Laboratory, Citadel Hill, Plymouth): I should like to urge the adoption of a more uniform system of presentation of numerical results. We get mg. per 100 g., mg. per lb., μg. per g. and so forth. It would be easier to remember, and give a better sense of proportion, if analyses were expressed in one system, such as parts per hundred, per thousand or per million.

What is the damage done to flour by infestation with insects or mites? The War Department chemist rejects flour on ground of insect infestation when actually mites only are present. In a specific instance about four-fifths of a consignment of about 1000 bags of flour had been made into good bread when the analyst's report came condemning it as "unfit for Army use". The unused portion was accordingly returned to the contractor. The important point is that flour should have not more than 11 to 13 per cent. moisture as mites are then unable to multiply.

Dr. J. Tosic (Dunn Nutritional Laboratory, Cambridge): We have studied the vitamin E content of bread cereals in the fractions obtained during the milling process. The samples of grain products have been kindly supplied by Dr. R. G. Booth, of the Cereals Research Station, to whom we are very grateful. The method of estimation (Moore and Tosic, 1943) was a modification of the $FeCl_3$ and $\alpha\alpha'$-dipyridyl procedure of Emmerie and Engel (1938), by which total $FeCl_3$ reducing substances are estimated in the unsaponifiable matter. We have shown, however, that in the case of wheat germ oil some 40 per cent. of these substances are biologically inactive at the level tested (Tosic and Moore, 1944); it is likely that this is true also for whole cereals, and that the data of Engel (1942) and our own are on the high side. In the tables, therefore, we have recorded the results as "vitamin E", indicating by inverted commas that they represent total $FeCl_3$ reducing substances; for convenience we have expressed them in terms of α-tocopherol.

The results obtained with various fractions of wheat are summarized in Table 1, and show that 70·90 per cent. extraction flour is a poorer source of vitamin E than the whole wheat flour or the offals, in which bran and scratch are the richest sources, being 6 to 7 times richer than the corresponding flour. A higher extraction of flour, therefore, would increase its "vitamin E" content and, in our control experiments, we found that freshly ground whole wheat was $2\frac{1}{2}$ times higher in "vitamin E" than 70·90 per cent. extraction flour obtained from the same sample of grain. These results are in good agreement with Engel's findings for wheat grain.

In a similar way we have examined the "vitamin E" content of other bread cereals, such as rye, barley and oats, and found that freshly ground rye and barley contain 5·50 and 5·39 mg. of "vitamin E" per

100 g., respectively, figures which are very near to those shown for wheat in Table 1, whilst oats contain less "vitamin E", namely, 3·56 mg. per 100 g. The distribution of the vitamin in the berry of rye and barley

TABLE 1

"VITAMIN E" CONTENT OF VARIOUS MILL PRODUCTS OF WHEAT

Mill product	Percentage of total grain	"Vitamin E" content mg. per 100 g.	Percentage "vitamin E" per 100 g. wheat
Flour	70·90	2·25	28·90
Offals, bran	13·90	13·76	34·45
coarse	4·80	5·86	5·05
"fine"	4·20	9·01	6·86
scratch	6·10	14·36	15·88
			91·14
Whole wheat (control) ..	100·00	5·54	

is rather similar to that shown for wheat in Table 1. A summary of figures showing the proportion of the vitamin found in flours, the corresponding offals and wholemeal cereals are given in Table 2.

TABLE 2

DISTRIBUTION OF "VITAMIN E" IN THE FLOURS AND OFFALS OF DIFFERENT CEREALS

Cereal product	Percentage of total grain	"Vitamin E" content mg. per 100 g.	Percentage "vitamin E" per 100 g. cereal
Wheat, flour	70·90	2·25	28·90
offals	29·00	11·90	62·30
wholemeal ..	100·00	5·54	
Rye, flour	72·15	1·93	25·25
offals	27·85	13:40	68·00
wholemeal ..	100·00	5·50	
Barley, flour	62·75	2·54	31·70
offals	37·25	9·85	67·90
wholemeal ..	100·00	5·39	
Oats, groats, flour, ..	73·20	2·00	41·10
wholemeal ..	100·00	3·56	

The values for wholemeal cereals are slightly higher than the total figures of all the mill products of the corresponding cereals. This is explained by the fact that the vitamin E content of mill products decreases on storage, and that samples were examined within two months of milling, whilst the wholemeal cereals were examined on the day of grinding.

The figures clearly indicate that "vitamin E" is situated mainly in the offals and that an increased extraction of the flour would increase its vitamin E content.

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