

### High-cereal diets for man

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As previous speakers in the Symposium have made clear, the generally declining economic position of the UK and the generally rising world prices for foods both indicate that we should consider how we can maintain our nutritional standards while spending less on imports. This means studying how to manage on a diet high in cereals (and potatoes) and generally economic.

FAO has had a rough rule that a dietary pattern in which 0.40 of the energy (or more) comes from the cereals or other local staples can generally be regarded as unbalanced. Is this anything but an empirical observation with both 'high-cereals' and 'dietary shortage' being relatively independent factors each resulting from the comparative poverty of the population?

#### *Historical association of 'high-cereals' with malnutrition*

I will look first at one example of trouble that was associated with high-cereal diets, probably the first to receive intensive study. Pellagra, first described as 'scorbutic leprosy', was a major problem in Southern Europe in the first half of the nineteenth century. Its subsequent spread, and medical opinion about its causes, were recently summarized (Roe, 1973). Many features of the disease, including its seasonal disappearance and re-appearance, are still puzzling. In Italy, in particular, there was sustained controversy from which Harris (1919) reviewed more than a hundred papers. But the most widely held opinion was that set out quite early by the French investigator Roussel (1845): 'the immediate cause of the disease is the consumption of damaged maize but the principle predisposing cause is the diet being almost exclusively 'vegetable' so that the proportion of animal products needs to be substantially increased'.

The persistent idea that it was due to 'mouldy' maize presumably came from the unconscious assumption at that time that such a horrible disease must come from something positively malignant. The direct, and agreed, observation was that the disease was apparently prevented by a plentiful consumption of animal products. And C. Lombroso, the famous 19th century Italian physiologist, is quoted by Gillman & Gillman (1951) as writing: 'To tell the peasant that to protect himself against pellagra he has only to have a good diet is correct, but a cruel irony. He will continue to eat corn because he cannot afford better. If he could he would do so without the advice of a doctor'. Even Goldberger, the hero of later research into pellagra in the USA, is quoted (De Kruif, 1928) as saying in a depressed mood

towards the end of his life: 'After all, I'm only a doctor, and what can I do about the economic conditions of the South?'

One is immediately sympathetic to these comments but they were wrong, and this could have been realized at the time if people had gone back to where maize had been the staple food for centuries amongst people at least as poor, that is to say, in Mexico and Central America. There people ate (and eat) little animal products and have maize as their staple, but pellagra is not an endemic problem. The explanation seems to be the almost universal practice amongst the traditional American Indian corn-eaters of cooking their corn with alkali, either lime-water or an extract of wood ash (Laguna & Carpenter, 1951; Katz, Hediger & Valleroy, 1974). This has the effect of releasing the niacin it contains from an otherwise unavailable complex (Kodicek, 1960). Although other grains appear also to have their niacin in an unavailable form they contain sufficient tryptophan to act as a precursor for niacin and so meet the requirement for the vitamin indirectly. If it can be accepted that this inexpensive alkali-treatment is effective, then the failure of Europeans and later of people in the Southern USA to take advantage of the 'traditional wisdom' of a less technically developed culture was a tragic one responsible for something like half a million deaths and the suffering of many more.

Another moral for today from this experience seems to be that, although poverty is the main cause of malnutrition, and its correction must be regarded as the primary objective in international programmes aimed at nutritional improvement (cf. Joy, 1973), it is still worth while to investigate how the individual's lot may be improved even within the constraint of a very limited income. Although the chances of success may seem small, the cost of such work is usually also minute in relation to the benefit that would come from even partial success.

#### *Diets based on wheat*

The main temperate cereals, wheat, barley, rye and oats, have never been associated with a serious nutritional disorder in the way that maize has been associated with pellagra. Their protein is of higher tryptophan content and lysine, which is severely limiting in growth assays with young rats, is probably not required at such a high level in the protein of human diets (cf. Widdowson & McCance, 1954; FAO/WHO, 1973). Further, the other protein sources in a mixed diet are generally of fairly high lysine content and there is mutual supplementation between the proteins (cf. Carpenter, 1970; 1975).

The one disadvantage of wheat, and of most other cereals, as compared with yellow maize is their lack of vitamin A activity. McLaren (1963) has drawn attention to the extent of blindness amongst children in areas of poverty wherever a vitamin A-deficient staple is used and green food is either not appreciated or, in dry areas, difficult to come by.

The anti-nutrient in wheat is phytic acid, which forms insoluble complex salts with the heavier metals though its significance has been the subject of controversy. Where wheat is eaten as unleavened bread or chapattis there have been indications

that mineral deficiencies may result: iron and zinc deficiency in the Middle East (Prasad, Mial, Sandstead, Schubert & Darby, 1963; Reinhold, Amirhakimi, Ronaghy & Halstead, 1972) and rickets amongst Pakistani immigrants in the UK (Wills, Day, Phillips & Bateman, 1972). Fortunately the phytic acid is largely destroyed during the traditional yeast fermentation of bread-making in Western cultures (Widdowson, 1941) and there is no suggestion that the same problems occur with our type of leavened bread (Widdowson, 1975).

The classic example of a successful diet with over 0.7 of its energy coming from wheat is found in the work of Widdowson & McCance (1954) at two German orphanages. Here, for a year, children, 5–14 years old, received the frugal official rations available in 1948–9 together with unlimited wheaten bread, of which they ate 1.0–1.4 lb/d. They also received supplements of vitamins A, C and D and the wheat flours were enriched with calcium carbonate. Regardless of whether the bread was made with 70, 85 or 100% extraction flour the children remained healthy and grew well. Some of them went on for a further six months, receiving

Table 1. *Growth of Duisberg orphanage children with unrestricted bread and different milk rations (Widdowson & McCance, 1954)*

	Low milk	High milk
Protein intake (g/d):		
85% extr. bread	41.0	34.6
Other vegetable foods	11.5	11.5
Animal foods	8.8	26.5
Total	61.4	72.6
% of dietary energy from protein	11.7	13.9
Total energy (kcal/kg per d)	66.6	67.0
Mean results over 6 months		
Gain in height (cm)	2.9	2.9
Gain in wt (kg)	2.5	2.5
(Calculated daily gain of crude protein (N×6.25) (g))		(2.2)

Table 2. *Protein intakes in the high-wheat orphanage experiments (Widdowson & McCance, 1954) compared with the calculated requirements of children for 'ideal' protein (FAO/WHO, 1973)*

	Orphanage	
	Duisberg	Vohwinkel
Protein intake/d (g)	61.4	51.0
(% from wheat)	(67)	(49)
Mean wt of children (kg)	30.5	30.1
N intake (mg/kg per d)	322	271
Wt gain/d (g)	13.7	13.4
FAO/WHO calculations		
N gain (mg/kg per d)	13.9	13.8
Obligatory N loss	73	73
Theoretical minimum N need	87	87
Efficiency required of dietary N	27%	32%

the same high-wheat diet with or without a daily supplement of 400 ml milk, and they did equally well both with and without the extra milk. Some of the results are summarized in Table 1. It is seen that the level of animal products in the basic diet was extremely low. Nevertheless 0.117 of the energy came from protein and calculation indicates that it only had to be used with a net efficiency of 0.27 to meet the children's requirements (Table 2).

The results are striking evidence of how healthy and well-balanced a really high-cereal diet can be and they created something of a sensation, particularly as regards the children eating white bread. But balance studies for several minerals and vitamins confirmed that absorption and retention were at normal rates.

*The practicability of high-cereal diets in the UK*

The average Briton looks to meals as an important source of pleasure. What would a day on a high-cereal menu mean in practice? I will take, as an example, a day's weighed food consumption by myself after trying to change gradually to a diet that was still pleasant, but which met modern nutritional recommendations, required little preparation and was reasonably helpful to the balance-of-payments of both myself and my country. The menu (Table 3) was also intended to avoid

Table 3. *A specimen day's menu for a high-cereal diet*

Breakfast	Afternoon tea
Oatmeal+tinned plums (in syrup)+milk	Fruitcake (1 slice)
Bread* (2 slices)+soft margarine (thinly)+jam	Tea (1 cup)
Tea† (3 cups)	Supper
Mid-morning	Smoked mackerel fillet
Fruitcake (slice)	+potatoes (baked in skin)
Tea (1 cup)	+baked beans
Ploughman's lunch	Apple, nuts and raisins
Cheese, chutney, chopped carrot	Bread (1 slice)+margarine
Bread (3 slices)+margarine	Tea (3 cups)
Apple	

\*All bread wholemeal.

†All tea with milk.

eggs and other animal products produced by intensive factory farming, which I find repugnant. The nutrient content of the high-cereal menu, estimated from the standard US tables of food consumption (Watt & Merrill, 1963), is shown in Table 4. Essentially it meets all the US Recommended Dietary Allowances (1974), which carry high margins of safety. Vitamin C is present at a high level despite the absence of citrus fruit and leafy vegetables, and potatoes being eaten only once.

The menu has also been compared with the UK National average diet, using the most recent report of the National Food Survey Committee (1976) which gives data for 1974. Everyone wanting to work with the national data wrestles with the

Table 4. Calculated nutrient composition of the day's menu (Table 3) in absolute units and as proportions of the recommended daily allowances (RDA)

Nutrient	Quantity	RDA units*	Nutrient	Quantity	RDA units*
Energy†	11.0 MJ	1.10	Vitamin D	410 i.u.	—
Protein	92 g	1.64	Vitamin E	10 mg	0.98
Ca	1.1 g	1.43	Vitamin C	83 mg	1.85
P	2.0 g	2.47	Thiamine	2.0 mg	1.68
Mg	480 mg	1.37	Riboflavin	1.6 mg	1.05
Zn	18 mg	1.20	Niacin	24 mg	1.50
Fe	20 mg	2.00	Pyridoxine	2.5 mg	1.24
I	130 µg	1.16	Cobalamin	6.0 µg	1.98
Vitamin A	11 m.i.u.	2.20	Folacin	260 µg	1.30

\*These are the US values for a man over 50 years old.  
 †0.26 of the energy came from fat and 0.14 from protein.

same problems. One is that the supply of edible oils and fats (other than butter) appears to be double that of their estimated household consumption (Tables 263

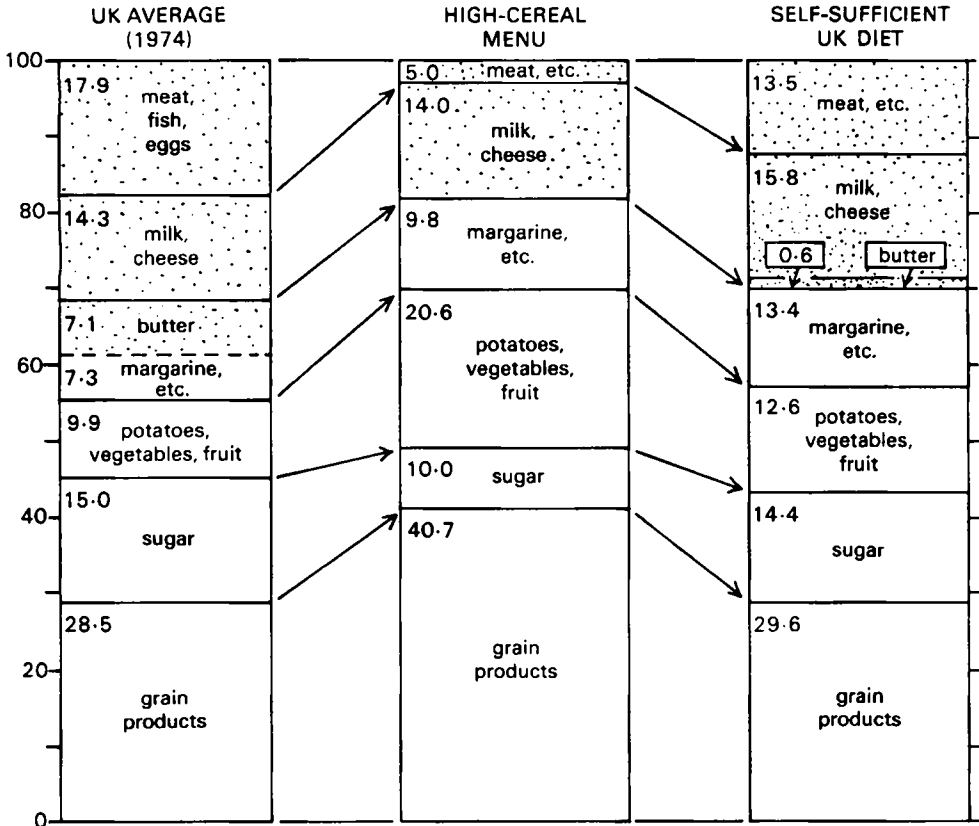


Fig. 1. The proportions of energy contributed by different groups of foods in the average UK diet, the specimen 'high-cereal' menu (see Table 3), and a suggestion (Blaxter, 1975) for a UK diet that would avoid the need for food imports.

and 268 of the *Annual Abstract of Statistics*; Central Statistical Office, 1976). Blaxter used the first figure in his 1975 paper and the second in 1976. I have chosen the second, lower figure, thinking that fat not purchased as such will largely have been bought in made-up foods (cakes, pork pies, etc.), though the proportion eaten out in fish-and-chips would not have been recorded. Secondly, a large proportion of the sugar that is consumed does not pass through the domestic kitchen and is outside the scope of the National Food Survey data. The estimate for confectionery (24 g sucrose/d) has been included in the 'average' calculations for Fig. 1, but that of 8 g sucrose/d in soft drinks has not, nor any estimate of that consumed in ice cream. These points may appear mere details, but taken together they can explain very large apparent discrepancies between different people's final tables.

However one calculates the average diet, the menu is considerably higher in fibre but lower in sucrose and fat content; the fat eaten also has a higher proportion of polyunsaturated fatty acids (Table 5). Although nutritionists give different weightings to these factors (e.g. Royal College of Physicians, 1976; Burkitt & Trowell, 1975; Yudkin, 1972; Walker, 1976), it would probably be agreed that changing to such a diet from the 'National average' would be generally advantageous, both as regards susceptibility to cardiovascular heart disease and other common disorders of middle age including obesity.

Table 5. *Criticized components of the UK diet and their level in the high-cereal menu*

	UK national average (1974) (g/d)	High-cereal menu‡ (g/d)
(A) Possibly excessive		
Sucrose	93*	80
Fat	121	76
Saturated fatty acids	58	25
Cholesterol	0.65	0.21
(B) Possibly insufficient		
Linoleic acid (per 100 g fat)	12 (10)	11 (14)
Crude fibre	4	12
Dietary fibre†	c. 20	56

\*In addition 24 g sucrose is eaten in confectionery.

†Calculated from Southgate, Bailey, Collinson & Walker (1976).

‡See Table 3.

In Table 6 the menu is broken down into its constituent foods. Although sugar as such was avoided, an estimated 67 g were used in making up the prepared food items (principally jam and cake). The additional sucrose (13 g) which brings the total estimated intake to 80 g comes from that naturally present in the fruit and vegetables eaten. In Fig. 1 the proportions of energy from each of the main food groups in the menu is compared with corresponding values for the national diet. We see that cereal grains provide just over 0.40 of the total energy in the menu,

Table 6. *Weights of items in the specimen day's menu (Table 3) with a breakdown of the prepared purchases*

	Wt (g)	Marga- rine	Sugar	Fresh fruit	Vege- tables	Dry grain	Eggs
Smoked mackerel	63						
Milk	280						
Cheese	32						
Margarine	19	19					
Potatoes	281						
Carrots	82				82		
Baked beans	98		6		27		
Apples	125			125			
Raisins	20						
Nuts	10						
Tinned plums	81		7	75			
Chutney	25		8		13		
Oatmeal (uncooked)	72					72	
Bread, wholemeal	279					195	
Fruitcake	80	14	14	14		27	14
Jam	54		32	95			
<b>Totals</b>		<b>33</b>	<b>67</b>	<b>309</b>	<b>122</b>	<b>294</b>	<b>14</b>

which is 1.43 times their contribution to the average diet. The corresponding reduction in animal (including fish) food is from 0.39 of the energy in the national diet to 0.19 in the menu. This represents a drop of about 500 'animal' kilocalories per day. Cépède (1975), writing for FAO, suggests that we should calculate the 'original' or 'vegetable calorie' cost of a diet, on the basis that one edible 'animal' calorie has required for its production the consumption of 7 'vegetable' calories. On that basis the UK dietary pattern (scaled to 2640 kcal) takes 8860 'original' kcal, while the menu takes 5650, and makes a saving of 3210 kcal.

In the menu the 'meat+fish' intake, 63 g, all comes from fish. The present supply of fish only allows an average consumption of 18–20 g/head. A proportion even of this is imported and it has not been suggested that 'home' yields of fish could be increased dramatically. Most people would, in any case, prefer some meat and approximately 45 g/d (the quantity needed to bring the total to 63 g/d) is probably obtained as a by-product of the dairy industry and from sheep employed to utilize grazing that would otherwise be unproductive. The very great saving with such a diet would come from intensively kept pigs and poultry, which at present provide well over half our meat but themselves live on cereals and specially imported feeding-stuffs.

Although the 'menu' represents a fairly drastic change from the typical diet, and in what most people regard as an abstemious direction, the saving in cost is quite modest. Expenditure on the UK 1974 diet was 44.3 p/head per d, providing 2320 kcal, so that the equivalent cost of supplying 2640 kcal would be 50.4 p. Calculated at the same (1974) prices, the 'menu' cost 42.0 p which represents a saving of 8.4 p or 0.17 of the 'average' cost. There is a hidden saving in the menu in that it required very little further time and fuel for cooking, the fish being smoked, the flour already baked into bread and the beans precooked. The raw ingredients

would have been cheaper. Thus one penny spent on white flour would have bought a quantity giving 260 kcal, but spent on white bread 140 kcal and on brown bread only about 95 kcal.

It has been a generalisation that people in poor countries ate very little fat because it was a more expensive source of energy than cereals. But this has not been the case in Britain in recent years. In 1974 the energy obtained for one penny was from butter 152 and margarine 173 kcal. The highest return was from sugar, giving 279 kcal. So, although the returns from a penny spent on meat, fish and eggs were only 15–30 kcal, brown bread was in the middle class and considerably more expensive as a source of energy than fat and sugar.

Even if the immediate saving for an average consumer who changed to our type of 'menu' is only modest, how does the degree of change compare with that required for Britain to become self-sufficient in food? Blaxter (1975) was asked to work out how we could manage if food imports had to be stopped altogether. He emphasizes that this must be considered rather an academic question when we still depend on the import of other resources to maintain high agricultural production in the country. However, he concluded that it would be theoretically possible with the dietary changes that are summarized in Fig. 1. The solution involves a reduction in sugar consumption similar to that in the menu and the virtual elimination of butter. But the proportion of energy from all animal products falls only to 30%, a much smaller change than that of the 'menu'. His calculations assume that the poultry industry can remain at its 1974 size because its products are home-produced. This is true in one sense but the 'original' calories on which it depends are largely imported. It would be paradoxical to allow cereals into the country only for consumption by animals and not by man. If feeding-stuff imports were cut off then we would have to come closer to the diet typified by the 'menu'.

Blaxter (1975) keeps margarine at its present level, but points out the difficulty of producing it without imported raw materials. At present its production depends largely on imported soya beans and tropical crops such as groundnuts and palm kernels. The only possibility of home production of vegetable oil on any scale seems to be from rapeseed, using varieties of low erucic acid content. Whether even this is practicable remains doubtful. It is obviously possible for Western people to eat a diet containing less fat than is present either in the 'menu' or in Blaxter's solution, and in one period of World War II the combined rations of butter and margarine were equivalent to only 16 g/d, but the more bread we eat, the more lubricant we crave to help it go down.

Allaby, Baldock & Blythe (1977) have examined what savings in imports could be made by less drastic modifications in the National diet that might occur as a result of movements in the price levels of different foods. In short, they suggest that 15% reductions in the consumption of sugar, fats and meat might all be tolerable. Allowing compensating increases in consumption of potatoes and vegetables by 15% and of cereals by 25–30%, the estimated net savings in imports would be about £500 million per year at 1974 prices, which is 11% of food imports and 2% of total imports.



It is dangerous, perhaps, to stray into the field of economic policy. But we know that the prices of different foods are already manipulated by means of selective subsidies. So it would seem reasonable for nutritionists first to debate amongst themselves and then, if they can agree, to point out to the Government which changes would tend to direct people to a more healthy diet. Further, if there are also changes that would reduce our dependence on imports, there would be an important second leg to the arguments.

But people are reluctant to change their dietary pattern. Having meals together is one of the important symbolic actions of our society, the sociologists tell us, a ceremony of identification with our group: 'we eat the same, therefore we *are* the same'. If someone says 'I am not going to eat your meal, but something totally different, out of my individual bag instead of the common pot' this is positively offensive, because the message comes over: 'what you are eating is not right, it is to be criticized'. We cannot laugh this out of existence; man is a social animal and the great achievements of civilization have depended on that fact. But I mention it to explain both the pressure of disapproval put on someone with an atypical lifestyle, particularly in eating, and the determination of the deviate to convert others to his point of view.

### *Conclusions*

To sum up, then, there seems no problem under UK conditions in choosing relatively high-cereal diets (i.e. with 40% of the energy from grain products) that meet all the established requirements for individual nutrients and are suitable for all but infants. Infant nutrition presents a separate and special problem, but in quantity their demands are small in relation to the over-all food budget of the population. High-fat, low-fibre diets are under suspicion and it is frequently asked whether eating the more usual type of Western diet, characterized by its low cereal content, is really compatible with having a good chance of remaining healthy through middle age, and whether a more 'primitive' type of high-cereal diet would be better. But is the evidence for this really sufficient for the Government, at the behest of a small group of enthusiasts, to make it difficult for people to eat what they like rather than to a more puritan pattern?

Food is, of course, a particularly emotive subject, giving scope for indulgence, generosity and hospitality or, on the other hand, abstinence and hoarding. And those of us with a scientific background can find rationalization for any course of action by picking out the appropriate facts or claims. Barkas (1975) for example, has demonstrated the complexity of what she calls 'the vegetarian frame of mind'. But to give one man's opinion, I am persuaded that I have a better chance of staying healthy if I remain on something more like the day's menu discussed above than on the average UK diet, and I intend to do so; but I do not feel that the present evidence justifies Government intervention except by disseminating information, promoting research and possibly by differential food subsidies.

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