

qualitative and quantitative relationship to each other and the total calorie intake affect the incidence of diabetes.

### *Example of the well-trained diabetic*

Well-trained diabetics might do much in imparting their practical knowledge of food values to the rest of the community to bring about an economic level of good nutrition such as we experienced in Britain during the war. The regulation of a balanced diet in an affluent society needs self-control and it is not going too far to say that the diabetic's diet should be considered the normal arrangement and not a special diet at all.

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## Patterns and trends in carbohydrate consumption and their relation to disease

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It is generally held that, for the greater part of the million or more years of his existence, man was a hunter and forager; his diet was largely the bodies of animals he killed or found as carrion, with relatively small amounts of leaves, fruits and roots. Being omnivorous, he could of course sustain himself if necessary with a lower proportion of meat, and a higher proportion of vegetable foods, but by and large his diet was relatively poor in carbohydrate.

With the discovery and development of agriculture some 8 thousand or 10 thousand years ago, the ease of production of carbohydrate-rich foods such as cereals resulted in his diet with few exceptions becoming predominantly carbohydrate, with little fat and with small and often minimal amounts of protein. The only exceptions are

small pockets of people mostly in parts of Africa and in the Arctic Circle, who have retained a hunting economy until recently, or in some instances up to today; their diets are still rich in protein, moderately rich in fat, and relatively low in carbohydrate.

When circumstances allow—usually economic circumstances—there is a considerable increase in the protein and fat intake. This is seen both in the wealthier members of the poorer countries, and also in the average diet of the wealthier countries as compared with the poorer. It is commonly believed that this is accompanied by a fall in carbohydrate intake with increasing wealth. In fact, however, the absolute amount of carbohydrate consumed is very much the same in most countries, except in the poorest.

*Diet in relation to income*

The effect of increasing national income on the intake of protein, fat and carbohydrate is shown in Fig. 1, for the thirty-four countries for which relevant infor-

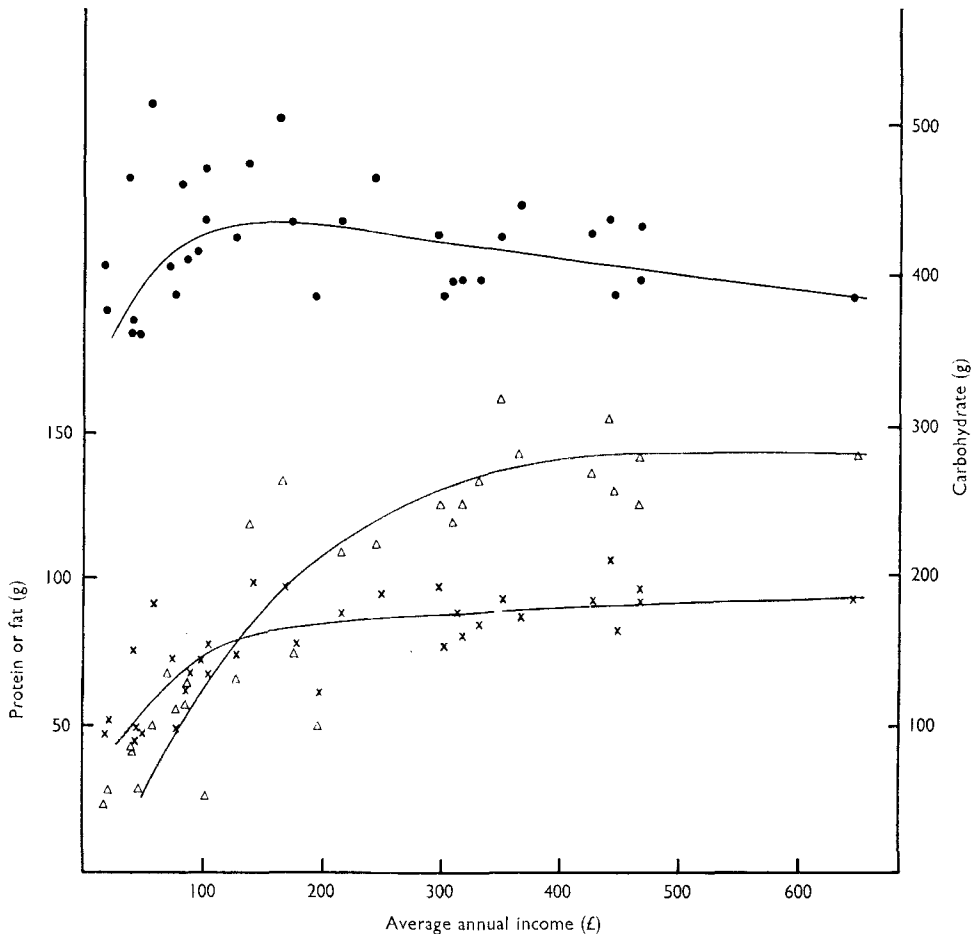


Fig. 1. Consumption of protein, fat and carbohydrate in thirty-four countries related to average national income. Sources: FAO (1963); Unilever (1964; information kindly supplied by Economics and Statistics Division, Unilever Ltd, London). ●, carbohydrate; △, fat; ×, protein.

mation was available. As income rises, there is a very steep rise in fat intake, and a less steep rise in protein intake; there seems to be no lower limit to fat intake, but there is of course a lower limit to protein intake below which life cannot be sustained. Moreover, fat intake is higher than protein intake in the wealthiest countries, as well as being lower in the poorest countries.

Carbohydrate intake is lowest in the poorest countries, where the diet is meagre in all its constituents. With decreasing poverty, carbohydrate consumption somewhat rises, but it falls off very little with increasing affluence.

Superficially, it may seem surprising that the wealthiest countries consume almost as much carbohydrate as most of the poorer countries, since the intake of such carbohydrate-rich foods as cereals is much lower. The reason however is that increasing wealth is accompanied by increasing intake of sugar, which almost exactly makes up for the decreasing intake of starch.

Table 1. *Effect of average national income on intake of calories, protein, fat, total carbohydrate and sugar*

| Annual income (£) | No. of countries | Daily intake    |         |             |                  |           |                           |
|-------------------|------------------|-----------------|---------|-------------|------------------|-----------|---------------------------|
|                   |                  | Calories (kcal) | Fat (g) | Protein (g) | Carbohydrate (g) | Sugar (g) | Sugar (% of carbohydrate) |
| Up to 50          | 6                | 2060            | 34      | 52          | 394              | 35        | 9                         |
| 51 - 100          | 6                | 2500            | 61      | 68          | 437              | 59        | 13.5                      |
| 101 - 200         | 7                | 2700            | 73      | 78          | 456              | 86        | 19                        |
| 210 - 350         | 7                | 2970            | 118     | 86          | 419              | 102       | 24                        |
| More than 350     | 8                | 3200            | 140     | 92          | 422              | 139       | 33                        |

Values for groups of countries not weighted for population.

Sources: FAO (1963); Unilever (1964; information kindly supplied by Economics and Statistics Division, Unilever Ltd, London); Viton & Pignalosa (1961).

Table 1 shows the intake of protein, fat and carbohydrate as in Fig. 1, but with the countries grouped according to income, and with sugar given as a separate item. From the poorest to the wealthiest group, average calorie intake increases by about 50%, protein by about 80% and fat by 300%. Total carbohydrate intake changes very little; the highest is in the relatively poor countries with average annual incomes between £100 and £200, but it is only 15% more than in the poorest. But, although the intake of carbohydrate is relatively constant, there is hidden in it a considerable increase in sugar with increasing income, which like the increase in fat is of the order of 300%. There is in fact a striking similarity not only in the relative increase in intake of fat and sugar, but in their absolute amounts. This is shown in Fig. 2, in which the diagonal represents an exact one-to-one relationship between the intakes of fat and of sugar.

Though the precise one-to-one relationship is fortuitous, the general relationship is not. Many of our sugar-containing foods—cakes, biscuits, puddings, chocolates, ice-cream—contain both sugar and fat, so that their levels of intake within a total diet tend to be interdependent. I shall have more to say on this point later.

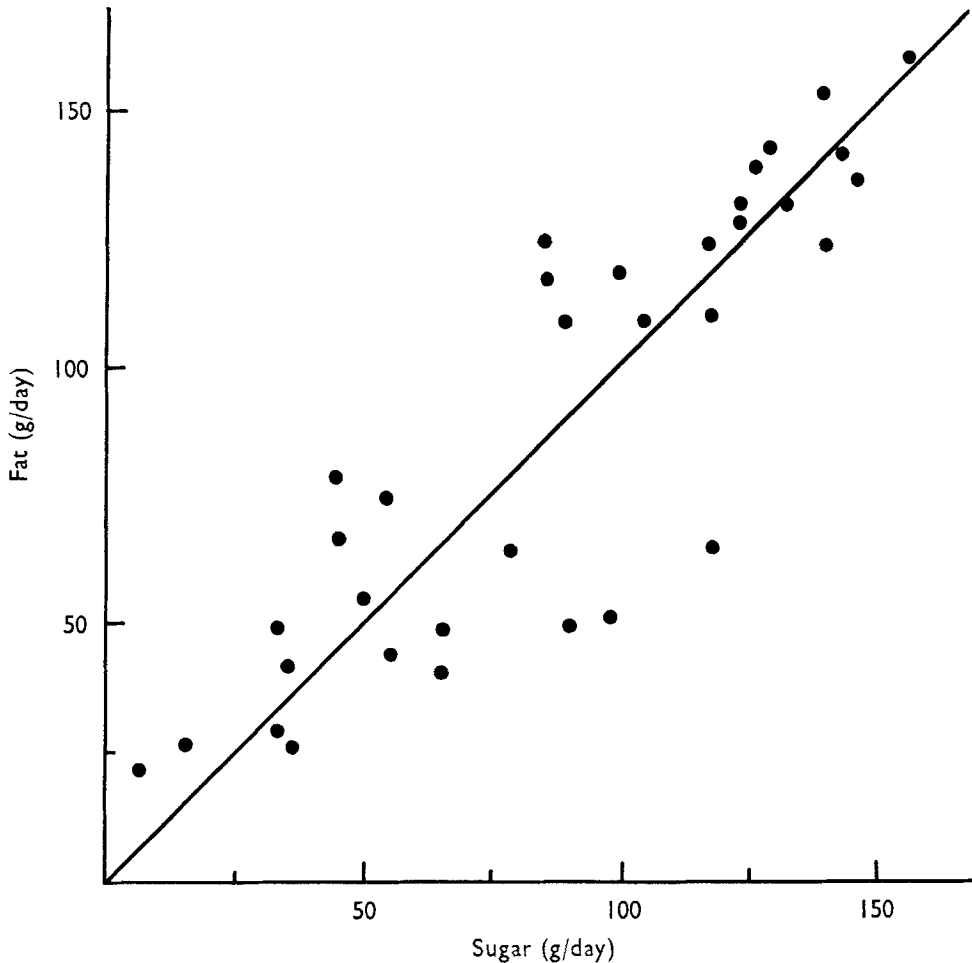


Fig. 2. Relationship between fat intake and sugar intake in thirty-four countries. Sources: FAO (1963); Viton & Pignalosa (1961).

In the poorest countries, sugar amounts to less than 10% of the total carbohydrate intake and contributes 145 kcal daily, or 7% of the low intake of calories; in the wealthiest countries, sugar amounts to 33% of the total carbohydrate intake and contributes 540 kcal daily, or 17% of the much higher intake of calories. In the United Kingdom, we obtain about 570 kcal daily from sugar, which is very little less than the 610 kcal we obtain from the carbohydrate in our bread.

#### *Increase in sugar consumption*

Total world production of sugar is increasing more rapidly than that of most other food commodities (Fig. 3). The increase is far greater than the growth of population—the average consumption has increased nearly threefold since the beginning of the century (Table 2). The proportionate increase is, in general, much greater for the poorer regions (Table 3). The exception is in the Far East, where,

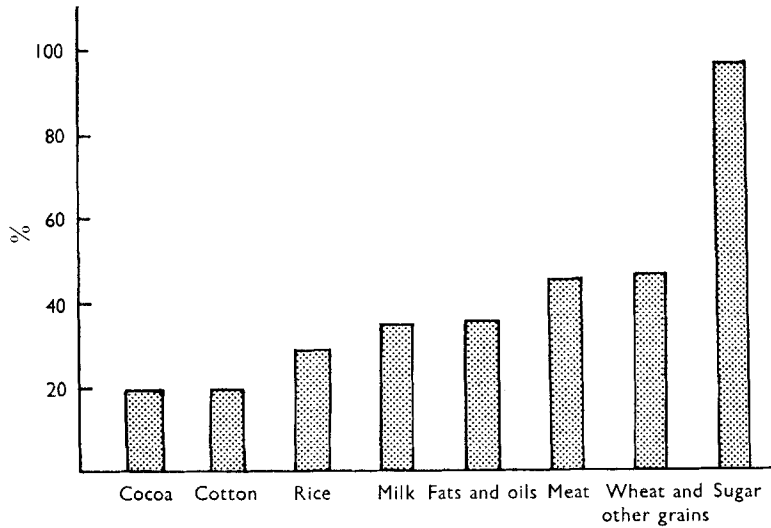


Fig. 3. Percentage increase in 1958 over prewar production of some agricultural commodities. Source: Viton & Pignalosa (1961).

Table 2. *Yearly world sugar consumption*

| Year | Consumption |       |
|------|-------------|-------|
|      | kg/head     | Index |
| 1899 | 5.5         | 100   |
| 1909 | 7.5         | 135   |
| 1924 | 10.2        | 185   |
| 1929 | 12.4        | 225   |
| 1938 | 12.0        | 218   |
| 1949 | 11.8        | 215   |
| 1957 | 15.5        | 282   |

Source: Viton & Pignalosa (1961).

Table 3. *Regional increase in yearly sugar consumption (kg/head)*

| Region                | Consumption |      | Increase (%) |
|-----------------------|-------------|------|--------------|
|                       | Prewar      | 1957 |              |
| Far East*             | 4.7         | 6.6  | 40           |
| Near East             | 4.9         | 12.4 | 145          |
| Africa                | 5.0         | 10.0 | 100          |
| Eastern Europe + USSR | 12.9        | 25.8 | 100          |
| Central America       | 16.6        | 28.3 | 70           |
| South America         | 16.8        | 29.1 | 73           |
| Western Europe        | 25.2        | 32.4 | 27           |
| Oceania               | 43.3        | 45.4 | 5            |
| North America         | 46.5        | 46.1 | -1           |

Source: Viton & Pignalosa (1961).

\*Excluding China.

however, consumption had fallen considerably during and after the war. By 1951, it had fallen to only two-thirds of its prewar amount, but since then it has increased faster than in any other region.

The rate of increase in sugar consumption in some individual countries is shown in Fig. 4. Only in the United States and perhaps in Australia does it look as if consumption has not changed, or perhaps even fallen off slightly, compared with

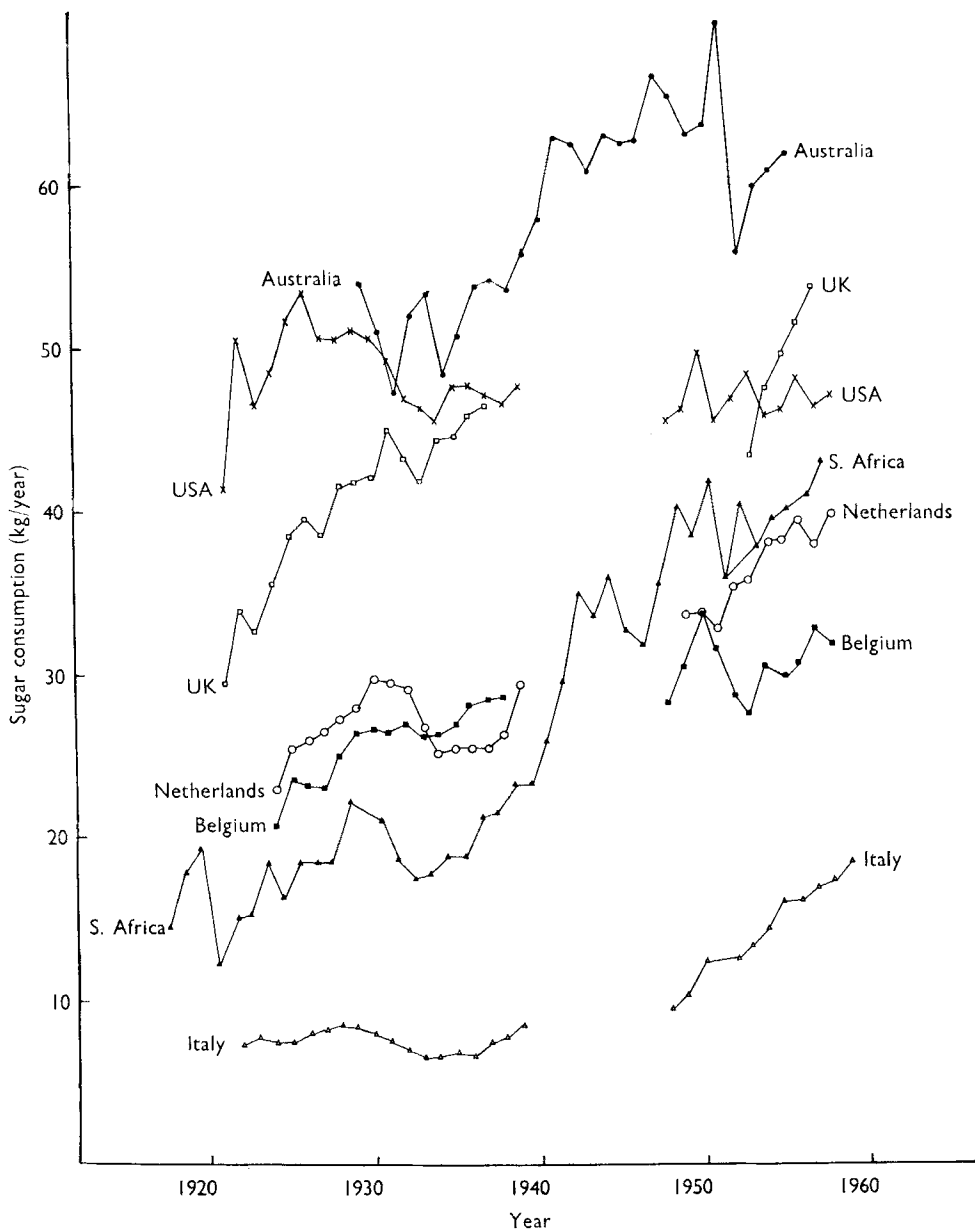


Fig. 4. Changing sugar consumption in some selected countries. Source: Viton & Pignalosa (1961).

Table 4. *Sugar used in manufacture as a percentage of total sugar consumption*

| Country      | Year   | Sugar used in manufacture |
|--------------|--------|---------------------------|
| South Africa | 1956-7 | 20                        |
| West Germany | 1956-7 | 40                        |
| France       | 1956-7 | 42                        |
| UK           | 1958   | 49                        |
| USA          | 1957   | 51                        |
| Australia    | 1955-6 | 55                        |

Source: Viton & Pignalosa (1961).

prewar. On the other hand, the increase is proportionately greatest in Italy, which had (and has) the lowest consumption in this group.

#### *Forms of sugar consumed*

Sugar is purchased either directly as such (as household sugar) or in the form of manufactured sugar-containing foods (industrial sugar). In the latter form it occurs in such foods as cakes, biscuits and confectionery. The proportion bought as industrial sugar increases with increasing income. This can be seen when one compares different countries (Table 4). In some countries, the proportion of manufactured sugar has increased also with time, as they became wealthier (Fig. 5).

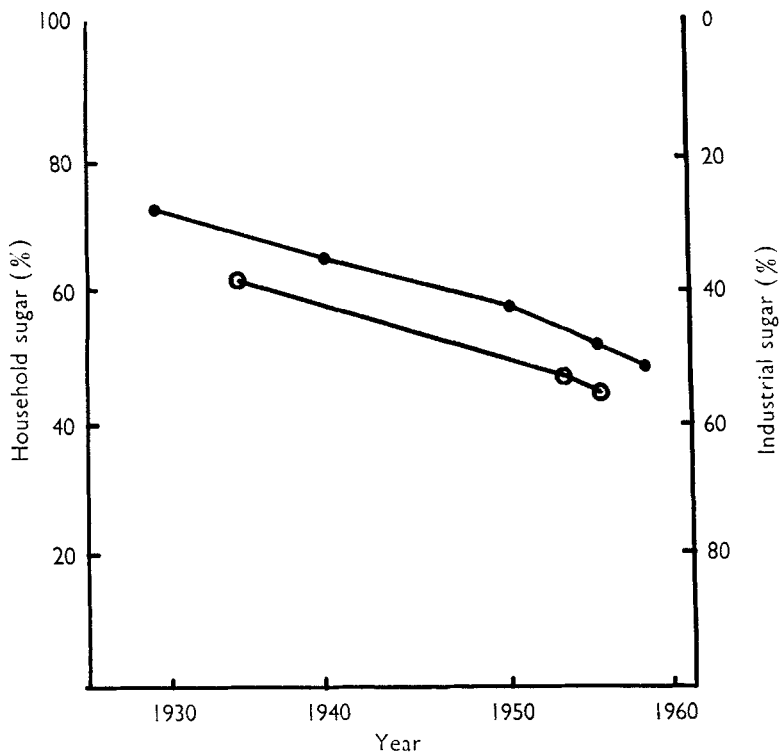


Fig. 5. Fall in proportion of sugar used in households in USA and Australia. Source: Viton & Pignalosa (1961). ●—●, USA; ○—○, Australia.

In individual countries the amount of sugar consumed in manufactured foods is proportional to income. This can also be demonstrated indirectly by examining the cost of a unit amount of sugar, since clearly sugar-containing manufactured foods cost more than the sugar they contain. Both in Ireland and in the rural and urban areas of the USA, the wealthier families pay twice as much for a kg of sugar as the poorer families, no doubt because they are buying more, and more expensive, manufactured sugar-containing foods (Figs. 6, 7, 8).

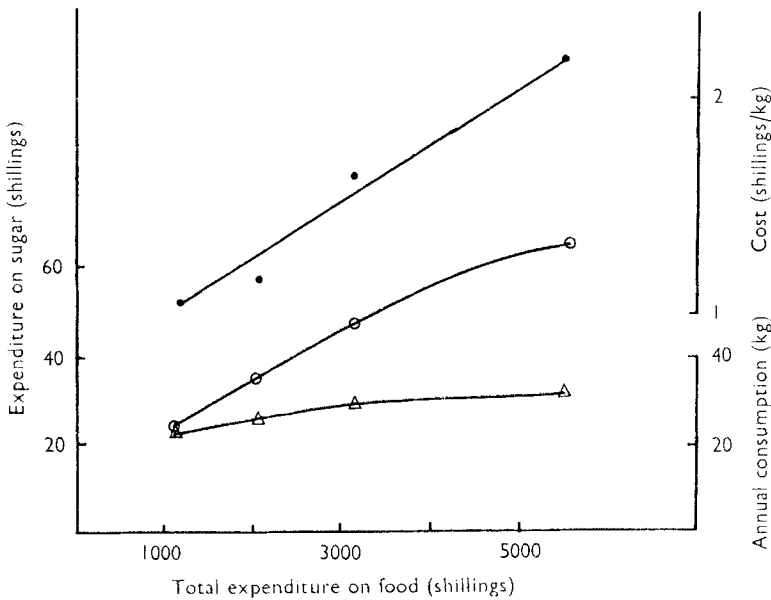


Fig. 6. Average annual sugar consumption and cost, related to total annual expenditure on food per head: Ireland 1951-2. Source: Viton & Pignalosa (1961). ●, cost; ○, expenditure; △, consumption.

These manufactured foods contain in addition to sugar other calorific constituents, such as flour, fat and chocolate. I believe that this has a bearing on the consumption of other foods. For we sometimes forget that, unlike with other consumer goods, there are fairly narrow limits to the amounts of food we can consume (Yudkin, 1964). The poorest people may buy virtually no clothes at all; the wealthiest may buy 2 dozen shirts and three or four suits in a year. The poorest may live in a mud hut; the wealthiest may have a large town house, a country home and, nowadays, a cottage abroad. But there is a lower limit to the amount of food, below which we cannot live; and an upper limit of not more than perhaps twice this level, above which the most gluttonous cannot reach. Thus, a significant increase or decrease in the amount consumed of one food might well produce a decrease or increase in one or more of the other foods, though it is not easy to predict where this reciprocal change might occur (Yudkin, 1964).

The average calorie intake in the wealthiest countries does not seem to have changed significantly in the last three or four decades. In fact, one might perhaps



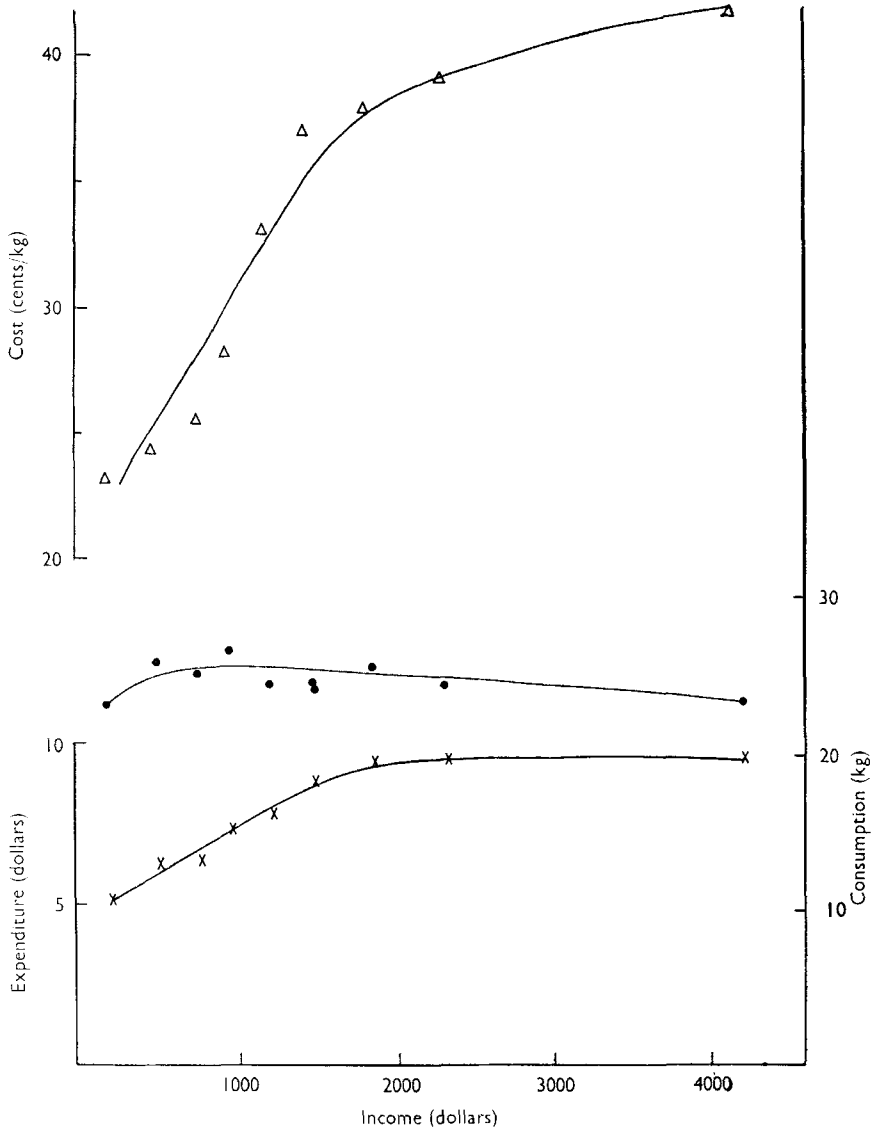


Fig. 7. Annual sugar consumption per head and cost, related to income: USA urban families 1955. Source: Viton & Pignalosa (1961). Δ, cost; ●, consumption; ×, expenditure.

have expected something of a fall because of the increase in mechanization at work and in the home, and the general increase in sedentariness.

*Interaction of consumption levels*

If then the wealthiest groups in the wealthiest countries are buying more sugar-containing manufactured foods, deriving calories both from the sugar and from the other constituents, then one must expect an increase in the prevalence of obesity, or

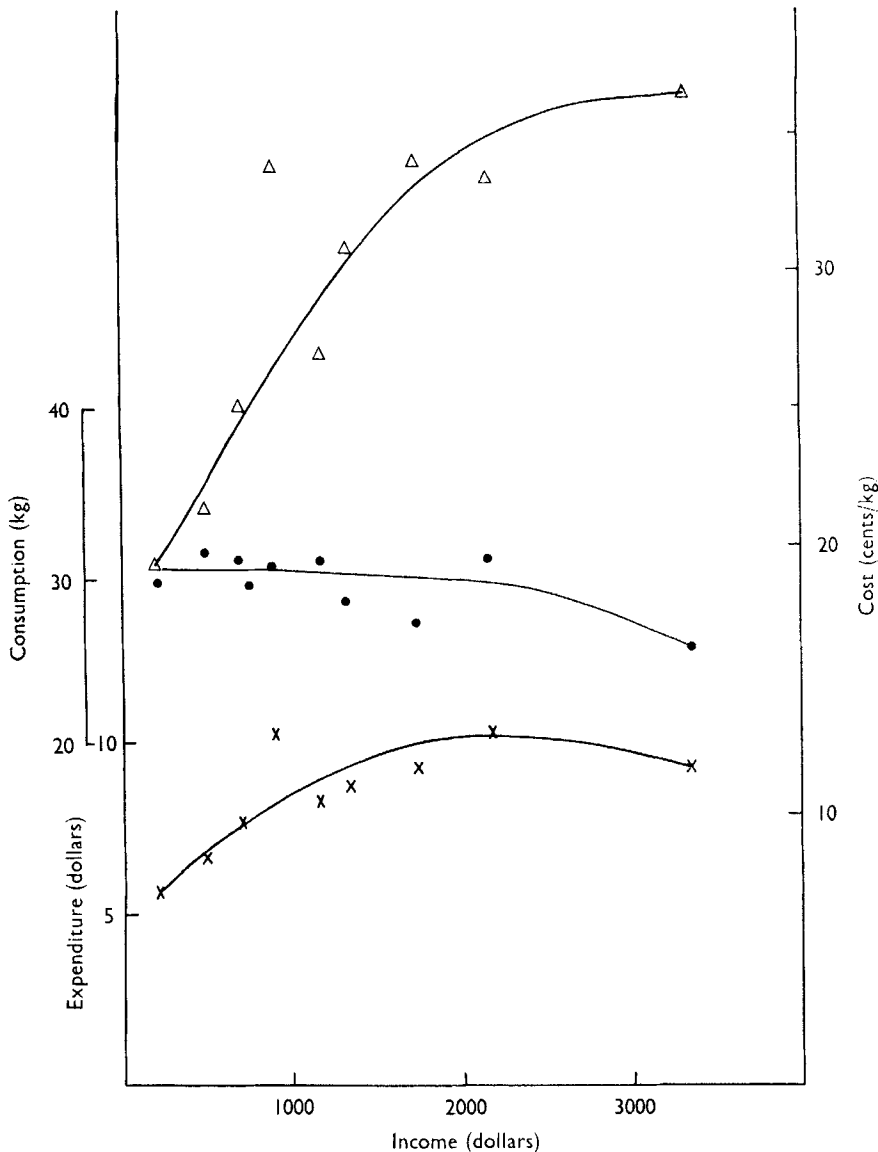


Fig. 8. Annual sugar consumption per head and cost, related to income: USA rural non-farm families 1955. Source: Viton & Pignalosa (1961).  $\Delta$ , cost;  $\bullet$ , consumption;  $\times$ , expenditure.

a reduced consumption of other foods, or both. It is said that there has been a three-fold increase in the proportion of obese persons in the United States since the beginning of the century. The proportion of overweight people amongst the wealthiest section of the population, though high, is, however, lower than in the poorer sections (Hundley, 1955). We might then expect to find that especially in the wealthier section there is a decrease in the consumption of other foods, to make up for the increase in manufactured sugar-containing foods, though the decrease might not be easily detectable if it were over a wide range of foods.

I believe that we can in fact detect two examples of decrease, both in what are usually regarded as nutritionally desirable foods. McKenzie and I have calculated that in this country there has been a fall in the amount of meat consumed by the wealthiest members of the population (Table 5). The figures for meat consumption

Table 5. *Weekly UK meat consumption (oz/head) related to income, and percentage of population in each income class*

| Income class | Consumption |      |            | Population |      |
|--------------|-------------|------|------------|------------|------|
|              | 1936        | 1960 | Change (%) | 1936       | 1960 |
| Lower        | 32          | 35   | +10        | 50         | 52   |
| Middle       | 43          | 36   | -16        | 40         | 38   |
| Upper        | 49          | 38   | -22        | 10         | 10   |

Sources: Orr (1936); Ministry of Agriculture, Fisheries and Food: National Food Survey Committee (1962).

per head imply that there has been an overall fall of 6% since before the war, whereas there has in fact been a rise of some 5%. It is likely, however, that Table 5 gives a reasonably accurate indication of the relative consumption per head of different groups in 1936 and in 1960; if we now adjust the figures to introduce an overall 5% increase without altering the relative group values, we still find that there has been a fall in meat consumption per head of 7% in the middle-income classes, and of 14% in the upper. We have similarly found evidence of a fall in consumption of fruit by the wealthiest section in America (Table 6).

Table 6. *Weekly US fruit consumption (lb/head) related to income, and percentage of population in each income class*

| Income class | Consumption |      |            | Population |      |
|--------------|-------------|------|------------|------------|------|
|              | 1942        | 1956 | Change (%) | 1942       | 1956 |
| Lowest       | 2.5         | 3.0  | +20        | 30         | 30   |
| Highest      | 5.6         | 4.7  | -16        | 19         | 20   |

Sources: United States Department of Agriculture (1944, 1956).

We believe that these two examples make it no longer possible to accept the frequently expressed belief that increasing income is invariably accompanied by increasing consumption of meat, fruit and other nutritionally desirable foods. Thus, Baines, Hollingsworth & Leitch (1963), speaking of the changes of the diets in the United Kingdom since before the Second World War, say 'The levelling effect of the war and post-war years was in all important respects upwards'. In fact, as we have seen, in at least some foods the levelling has been downwards from the high levels of consumption of people with the highest incomes, as well as upwards from the low levels of people with the lowest incomes.

*Carbohydrate consumption and disease*

I have shown that the main patterns and trends relate to sugar in particular rather than to carbohydrate in general. I believe that the trends have already had a detectable effect on the incidence of disease, in both the poorer and the wealthier countries.

In the poorer countries there has been increasing anxiety expressed concerning the competition between sugar-containing foods and the much-needed protein-rich foods (Burgess & Dean, 1962; Yudkin & McKenzie, 1964). Especially in the rapidly growing towns of some of these countries, there is a tendency for the poorest people to buy, especially for their children, sweet foods and fizzy drinks when they might be buying milk. Even the addition of sugar to cereal foods for infants, or the purchase of some proprietary infant foods containing sugar, can reduce the intake of protein to levels which cause kwashiorkor.

It has been reported that the quarter of the world's population with the lowest food consumption had even less to eat in 1954 than prewar; the fall was greatest for milk and meat (Blau, 1956). During the same period, its sugar consumption had increased by more than 50%.

The situation has improved only little since 1954. I have made calculations for 1958 for the nine low-income countries, Brazil, Ceylon, Chile, Egypt, Greece, India, Pakistan, Philippines and Yugoslavia, with a total population of some 650 millions. Compared with the prewar period, the average calorie intake in 1958 had increased by 9%, but meat consumption had fallen by 9% and animal protein intake by 7%. At the same time, sugar consumption had increased by 105%.

In the wealthier countries, the intake of highly palatable sweetened food and drinks, of which the sugar alone contributes over 500 kcal/head a day, is undoubtedly a potent contribution to the high prevalence of obesity, both in adults and in children. And, as we all know, obesity is a contributory factor in a long list of diseases, diseases of the joints, gall-bladder, kidneys and heart, all adding up to an increase in mortality. For a middle-aged man or woman weighing 25% above the average, this means a decreased expectation of life of some 4 years.

In addition, as I have said elsewhere, I believe that as well as contributing excessive calories, sugar may specifically be a factor in the causation of other diseases. Amongst these, I include dental caries, diabetes mellitus, dyspepsia and peptic ulceration, and myocardial infarction.

Cohen (1963) has produced evidence that the increased prevalence of diabetes and of myocardial infarction amongst immigrant Yemenis, as their period of residence in Israel increased, is most closely related to their consumption of sugar. This is supported by his experimental studies and, for myocardial infarction, by the investigations of Albrink (1962).

The most interesting of these recent contributions are, to my mind, those that underline the association between diabetes and myocardial infarction. It has long been known that atherosclerosis and myocardial infarction are common complications of diabetes. More recently, it has been shown that individuals with a history of ischaemic heart disease frequently have an impaired glucose tolerance. Cohen &

Teitelbaum (1964) have shown that this impairment can be brought about in rats by diets rich in sugar. Moreover, K. J. Kingsbury (1964, personal communication) finds that patients who have arterial disease show a diminished glucose tolerance more frequently than an elevated serum cholesterol.

The close relationship which I have shown to exist between sugar consumption and fat consumption removes the difficulty to which Himsworth (1949) drew attention, when he summarized his views on the role of diet in the aetiology of diabetes.

At first, he points out, he believed that the prevalence of diabetes was somehow associated with the amount, or the proportion, of total dietary carbohydrate. Like most workers up to the present time, he did not distinguish between forms of dietary carbohydrate. Later, however, he concluded that the evidence from epidemiology indicated that 'the dietary factor which parallels these changes [in mortality and prevalence of diabetes] most closely is the consumption of fat, and this correlation is surprisingly consistent'. He continues, 'We are thus left with the paradox that, though the consumption of fat has no deleterious influence on sugar tolerance, and fat diets actually reduce the susceptibility of animals to diabetogenic agents, the incidence of human diabetes is correlated with the amount of fat consumed'.

We can say that the paradox is now resolved, and that the association of diabetes with the dietary level of fat is quite fortuitous. It is simply indicative of a relationship with the dietary level of sugar, for the intakes of fat and of sugar are so closely allied.

I believe that the widely publicized relationship between fat intake and myocardial infarction is similarly fortuitous, and that the intake of fat is only a coincidental index of the intake of sugar. The aetiology of myocardial infarction is almost certainly multifactorial; the important dietary factor is likely to prove to be the level of sugar. Perhaps I may be permitted to recall that in 1957 I showed that the incidence of deaths due to myocardial infarction in different countries was better related to the consumption of sugar than to the consumption of total fat, or of any particular sort of fat (Yudkin, 1957).

Today's symposium on carbohydrate is a reflection of the increasing interest which nutritionists are beginning to show in this very neglected field. For my part I believe that we should pay much more attention to the sugar moiety of our dietary carbohydrate, especially since its rate of increase has been far and away greater than that of any other dietary component.

#### *Summary*

1. The diet of early man contained little carbohydrate. With the discovery of agriculture, the amount of carbohydrate increased, and the amounts of protein and fat decreased.

2. The ease and cheapness of production of carbohydrate-rich foods tend to keep diets low in protein and fat, except when economic circumstances allow.

3. When national diets are compared with national incomes, one finds that increasing incomes are associated with moderate increases in calories and in protein, considerable increases in fat, and little change in carbohydrate.

4. Higher national incomes are associated also with considerable increases in the sugar moiety of the carbohydrate. In the wealthiest countries, sugar contributes nearly 20% of the total calories. The average intake of sugar in each country is very similar to its intake of fat.

5. Increasing prosperity, both between countries and within a country, leads to an increasing proportion of sugar being bought in manufactured foods, rather than as household sugar. It is suggested that the effect of this is that wealthier countries, and the wealthier section of a national population, tend to have a higher intake of calories from the accompanying flour, chocolate, fat and other ingredients of these manufactured foods.

6. There is now evidence that one of the effects of this contribution of calories from sugar-containing foods is to reduce the consumption of nutritionally desirable foods, such as fruit and meat.

7. In the poorer countries, the consumption of sugar and sugar-containing foods may be responsible for malnutrition, especially for protein deficiency in children.

8. In the wealthier countries, there is evidence that sugar and sugar-containing foods contribute to several diseases, including obesity, dental caries, diabetes mellitus and myocardial infarction.

9. It is suggested that the known association of the prevalence of diabetes and of myocardial infarction with the level of fat intake is fortuitous and secondary. It is more likely that the primary association is with levels of sugar intake, which I have shown are, in turn, closely related to levels of fat intake.

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