Reprinted from FOOD TECHNOLOGY IN AUSTRALIA
Vol. 33, No. 2, February 1981, pp 50-54

The role of dietary fibre in human health

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There is now little doubt that the presence of non absorbable carbohydrate (NAC) in food confers health benefit. Much of the initial interest in NAC was with regard to gastrointestinal disease, but more recently its role in the prevention or amelioration of ischaemic heart disease (IHD) and of diabetes mellitus have come under scrutiny. Little, if any, epidemiological data to link dietary fibre intake to disease have been available in Australia. The authors have recently shown, however, by dietary pattern analysis, that the greater the intake of foods rich in dietary fibre, the less the prevalence of constipation in pre-school children in the Latrobe Valley of Victoria. English men with a higher intake of dietary fibre from cereals have been shown prospectively to have less IHD. Several studies now indicate that diets high in absorbable carbohydrate (AC) and NAC lead to lower fasting and post-prandial blood glucose concentrations. However, the relative importance of AC and NAC and of different types of NAC remain to be determined. Various NACs appear to reduce the reactive hypoglycaemia seen with refined carbohydrate, and this may have implications for appetite control. For the moment, it would seem prudent to recommend to Australians an increase in a variety of dietary fibres from whole grain cereals, fruits and vegetables.

The principal health problems of industrialised societies are atherosclerotic vascular disease, including ischaemic heart disease, neoplastic disease, principally of lung, breast and large bowel, maturity onset diabetes mellitus and alcohol abuse. The dietary pattern which distinguishes affluent from underdeveloped countries is one which is high in the intake of red meat and alcohol and low in the intake of vegetables, fruits and wholegrain cereals. One of the proposed links between some of these health problems and the dietary pattern is dietary fibre deficiency (Mendeloff 1977, Trowell 1978) (Table 1). Dietary fibre deficiency may or may not be causal as far as the health problems are concerned; it may in some cases, however, be a valuable marker for other nutritional problems. Dietary fibre embraces several compounds divergent in their physicochemical properties and biological effects (Crosby 1978). The remarkable convergence of dietary fibre as far as human health problems are concerned derives from its failure to be digested in the small bowel and, therefore, until recent times to be appreciated as a group of nutrients of physiological consequence. A new era in nutritional thinking has opened up as a consequence of the recognition of dietary fibre as a group of nutrients.

Gastrointestinal disorders

Since the pioneering work of Burkitt (Spiller & Shipley 1977, Trowell 1978), with confirmation by other workers (Spiller & Shipley 1977) it has become clear that the higher the dietary fibre intake, the greater the daily stool weight and the shorter the intestinal transit time. The implications of these findings for the management of constipation are already known to many individuals in the western world. But, further definition of the relationship between dietary fibre intake and bowel habits has been required with special reference to groups such as children and the elderly in Australia. Using records of all food consumed over a period of three days, we have recently shown for preschool children in the Latrobe Valley of Victoria that the more often foods of higher dietary fibre content are consumed, the less the prevalence of constipation (Table 2) (Duncan & Jones 1980). The period of observation of food intake and bowel habits for 366 pre-school children was three days, including week-ends and week-days. Constipation was defined as either no bowel movement during the period of observation or none for two days with pain or discomfort in the remaining period when a stool was passed; hardness of stools in the remaining period was also taken as evidence for constipation. The 'fibre score'

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Table 1. Diseases probably related to dietary fibre deficiency

Gastrointestinal	Cardiovascular	Metabolic
Constipation	Ischaemic heart disease	Obesity
Diverticulosis/itis	Hypertension	Diabetes mellitus
Chronic inflammatory bowel disease	Varicose veins	Hyperlipidaemia
Colorectal cancer		

Table 2. Constipation and dietary fibre score in 366 Australian pre-school children (under 5 years)

Fibre score	5–15	16–19	20–36
Frequency of constipation (%)	12.3	5.6	0.2*
Numbers of children	122	125	119

*χ^2 *evaluation indicates that frequency of constipation is significantly different according to fibre score with a* $P<0.01$ ($\chi^2 = 10.75$).

0015-6647/81/33/0050/04

used to describe the food intake patterns of the children was the number of times with which foods with dietary fibre concentrations greater than 2 g/100 g were consumed during the study period.

Recent work by Dr R. Willing on behalf of the Gastroenterological Society of Australia, in the South Australian town of Strathalbyn, indicates that following the introduction of a nutrition education program to promote the intake of dietary fibre-rich foods, the sales of laxatives in the town have dropped markedly. Moreover, beyond the period when the education program has ceased, laxative sales have continued to drop, suggesting that there is a spread of the educational message by those who have found a beneficial effect of altering their diet. The lines of evidence linking dietary fibre deficiency with irritable bowel syndrome and/or diverticular disease include descriptive epidemiology of diet and disease, studies of colonic intraluminal pressures at different diets (Cumming 1978, Eastwood *et al.* 1978), and the effects of different diets on the complication rates of diverticular disease (Hyland & Taylor 1980). Double blind studies are few and some of the evidence is conflicting, but overall a protective effect of dietary fibre against irritable bowel syndromes and diverticular disease is evident. Hunt and Korman (pers. comm.) at Prince Henry's Hospital in Melbourne have shown that ispaghula husk, after six weeks, ameliorates symptoms of haemorrhoids, reduces rectal bleeding associated with haemorrhoids and makes them less apparent on examination. The study was double blind.

As far as colorectal cancer is concerned, although it appears to be less likely to emerge where there is a high intake of vegetables, fruits and wholegrain cereals and a low intake of meat and alcohol, the specific dietary components or interactions which account for this association remain to be elucidated (Correa & Haenszel 1978, MacLennan *et al.* 1978). In this sense, dietary fibre may only serve as a marker of a prudent diet. Recent analyses of apparent food consumption data in 20 industrialised countries indicate that amongst the intake of cholesterol, saturated and polyunsaturated fat and dietary fibre, cholesterol intake has the most predictive value as far as the risk for large bowel cancer is concerned (Liu *et al.* 1979).

There is now interest in the role of dietary fibre in the pathogenesis (Thornton, Emmett & Heaton 1979) and management (Heaton, Thornton & Emmett 1979) of Crohn's disease, a chronic inflammatory bowel disease. It appears that patients with ulcerative colitis are not disadvantaged by a high fibre diet and that it may reduce the relapse rate (Davies & Rhodes 1978).

Cardiovascular disease

By analysis of the dietary records of 337 London men followed for 10–20 years, Morris (Morris, Marr & Clayton 1977) found that the higher the intake of dietary fibre from cereals the less the morbidity and mortality from coronary heart disease. However, cereal fibre does not appear to have any plasma cholesterol lowering effect so that if it has a protective effect against ischaemic heart disease it is presumably by another mechanism. The principal risk factors for ischaemic heart disease are hypercholesterolaemia, smoking and hypertension. There is now some evidence that a high intake of dietary fibre lowers blood pressure (Wright, Burstyn & Gibney 1979). Varicose veins have, on inter-country epidemiological grounds been associated with a low intake of dietary fibre (Mendeloff 1977, Trowell 1978).

Metabolic disease

A view has grown up that an increased intake of dietary fibre is protective against the emergence of obesity, which is to say a body weight in excess of 120% of desirable body weight (Albrink 1978, Van Itallie 1978). The proposed mechanisms for such an effect of dietary fibre include:

- earlier satiety by way of a bulking effect. Better methods for the measurement of appetite and satiety are required to evaluate this aspect.

- negative energy balance by way of increased faecal energy output. Overall, any effect on energy balance is small and unlikely to be of biological consequence.
- altered metabolic response to food intake, especially in regard to insulin secretion.

Insulin secretion can sometimes be inappropriate for the carbohydrate load so that hypoglycaemia occurs and appetite is stimulated. This does appear to be less of a problem where fibre is present (Haber *et al.* 1977). Glucose intolerance, which characterises diabetes mellitus, may be more evident with refined than unrefined carbohydrates (Wahlqvist, McDonald & Flint 1979, Wahlqvist 1980). It is not commonly appreciated that an increase in absorbable carbohydrate improves insulin sensitivity (Wahlqvist *et al.* 1979). Because of the effects of absorbable carbohydrate, it has not always been easy to assess the effects of non-absorbable carbohydrate or dietary fibre from natural foods on glucose handling. It is now clear that the addition of particular dietary fibre types to a standard load of ingested absorbable carbohydrate will lead to lesser rises in blood glucose and to lesser insulin responses. These effects have been seen with the non-cellulosic polysaccharides pectin and guar (Jenkins *et al.* 1977a,b) and with bran (Brodribb & Humphreys 1976). However, the mechanisms whereby fibre rich foods improve glucose tolerance are only partly clarified. For guar, it appears that it retards glucose absorption through its viscous properties. The physical characteristics of the food conferred by dietary fibre may also be important (O'Dea, Nestel & Antonoff 1980). It is also possible that dietary fibre serves as a marker for other factors in foods, such as amylase inhibitors (Puls & Keup 1973) and glucose tolerance factor (Mertz 1976), which themselves influence glucose digestion, absorption or metabolism.

Another area of growing interest is the effects which non-absorbable carbohydrate may have on the secretion of gut-related hormones. One such hormone which appears particularly important in regard to insulin secretion is gastric inhibitory polypeptide (Dupré *et al.* 1973). We have recently found that the gastrointestinal hormone, gastrin, reaches higher levels in blood following a carbohydrate meal (50 g) enriched with bran (10 g) than it does with a meal enriched with pectin (10 g) ($P<0.05$ in the third hour) or with guar (15 g) ($P<0.01$ in the third hour) (Fig. 1). In the case of pancreatic polypeptide, whose function in man remains to be elucidated, blood levels in response to a meal of carbohydrate ordinarily rise briskly and remain elevated for several hours. When guar (15 g) is added to the carbohydrate meal, pancreatic polypeptide secretion is significantly suppressed by the third hour ($P<0.05$) (Fig. 2). Although the physiological importance of these findings requires further investigation, it is clear that components of food, heretofore regarded as inert, can have considerable effects on hormonal and metabolic profiles.

The administration of certain dietary fibres notably pectin and those derived from Bengal gram and alfalfa, have cholesterol lowering properties (Anderson & Chen 1979, Kritchevsky 1978). Some dietary fibre rich foods which have cholesterol-lowering properties are rich in saponins and these may account for the observed effects (Topping *et al.* 1980). High-carbohydrate, high dietary-fibre foods can also lead to a reduction in plasma triglyceride levels, although it is not easy to separate out the effect of dietary fibre itself from the other dietary changes in the reported studies (Anderson & Chen 1979).

Possible adverse effects of dietary fibre

As recommendations are developed for diets with a higher dietary fibre content, it is necessary to be aware that the availability of certain nutrients may be decreased. These include iron, magnesium, zinc, calcium and folic acid (Brown, Kelleher & Losowsky 1976). In addition, a change in dietary fibre intake may alter the availability of various medications, such as cardiac glycosides, analgesics, anti-hypertensives and tranquillisers.

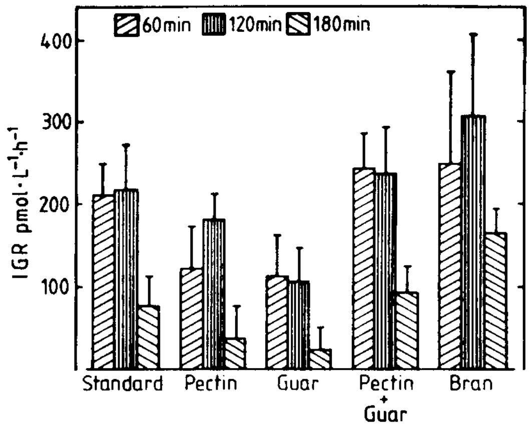

Figure 1. Effects of added dietary fibres to a 50 g glucose test meal on gastrin responses [immunoreactive gastrin (IGR) on the ordinate] in the first, second and third hours (60, 120 and 180 min after the meal). With bran (10 g), the gastrin responses in the third hour were significantly greater than with pectin (10 g) ($P<0.05$) or with guar (15 g) ($P<0.01$).

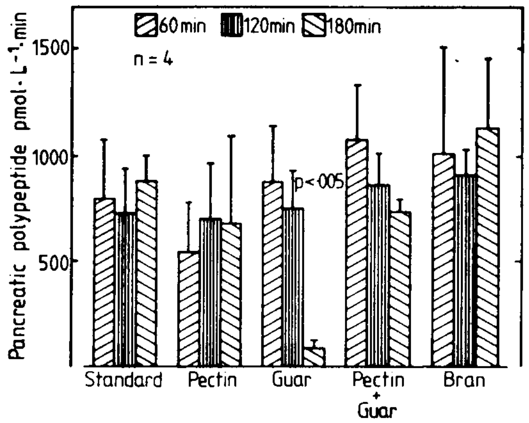

Figure 2. Effect of added dietary fibres (amounts as for Fig. 1) on the pancreatic polypeptide (ordinate) response to a 50 g glucose load. With guar, in the third hour after the meal, pancreatic polypeptide response was signficantly suppressed ($P<0.05$).

Conclusions

A move towards a diet with a variety of dietary fibres from wholegrain cereals, fruit and vegetables and away from one high in meat and alcohol is likely to be beneficial for Australians. The present average daily intake of dietary fibre by adult Australians is between 15 and 20 g and this could be doubled readily. Any adverse effects which might result are unlikely to be of consequence and can be allowed for if appreciated.

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