Editorial

Dietary fibre and diabetes revisited

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Dietary guidelines for people with diabetes appear to change from time to time and advice from various apparently authoritative sources differs—to the extent that those who have not carefully followed the reasoning behind the recommendations might be forgiven for being somewhat dismissive regarding the extent to which dietary treatment can influence glycaemic control and risk factor management. The recently revised ‘Recommendations for the nutritional management of patients with diabetes mellitus’ prepared by the Diabetes and Nutrition Study Group (DNSG) of the European Association for the Study of Diabetes (EASD) help to place in perspective apparent discrepancies between advice emanating from groups of researchers or expert committees (Diabetes and Nutrition Study Group, 2000). They explain that several different dietary patterns can often produce similar impressive improvements in glycaemic control and levels of cardiovascular risk factors. For example, diets low in saturated fats and moderately high in *cis*-unsaturated fatty acids are associated with comparable results to those achieved on a diet in which vegetables, fruits, wholegrain cereals and other appropriate carbohydrate-containing foods provide replacement energy for saturated fatty acids. However one issue which continues to cause some confusion relates to the most appropriate method for determining optimal carbohydrate-containing foods. What is the role of dietary fibre? Should the glycaemic index be the main determinant of carbohydrate-containing foods recommended as being particularly suitable for people with diabetes?

The potential role for dietary fibre in diabetes was first promoted more than 30 y ago by Trowell on the basis of his experience in East Africa where he noted a virtual absence of what is now known as type 2 diabetes in association with the consumption of traditional diets which were extremely high in ‘lightly processed’ cereal foods (Mann, 1985). Uncontrolled clinical studies from Anderson’s group in Kentucky followed. They demonstrated, in a relatively small number of insulin-treated patients (probably with type 2 diabetes), that introduction of a high carbohydrate—high fibre diet was associated with a dramatic

improvement in glycaemic control and reduction in insulin dose (Kiehlm *et al*, 1976). In fact such observations were not entirely new, similar observations having been made many years earlier by Kempner using his rice diet (Kempner *et al*, 1958). Inspired by the work of Anderson and also by the studies of Stone and Connor (1963), who drew attention to the potential of the low carbohydrate—high fat diet, then in widespread use, to increase cardiovascular risk, our own group in Oxford, England embarked on a series of carefully controlled studies which helped to further understand the role of dietary fibre (Simpson *et al*, 1979a; Simpson *et al*, 1979b; Simpson *et al*, 1981; Simpson *et al*, 1982; Lousley *et al*, 1984; Geekie *et al*, 1986; Mann, 1984). Each of the studies involved a cross-over design in which patients with type 1 and type 2 diabetes were randomised to receive advice regarding the standard diabetic diet of the time, relatively low in carbohydrate and dietary fibre, or an experimental high carbohydrate diet. After 6 weeks on the first diet participants crossed over to the alternative diet for a similar length of time. The patients were all free-living and meals were prepared at home under the close supervision of research dietitians. A range of measures of glycaemic control and lipoprotein-related cardiovascular risk factors were the principal outcome measures.

Our studies clearly showed improved glycaemic control and reduced total and LDL cholesterol on a diet relatively low in fat and in which readily obtainable fibre-rich foods accounted for the increased intake of carbohydrate (Simpson *et al*, 1979a; Simpson *et al*, 1979b; Simpson *et al*, 1981; Lousley *et al*, 1984). The improvement was particularly striking when foods rich in soluble fibre were encouraged (Simpson *et al*, 1981). The early studies were criticised on the grounds that we could not distinguish between the beneficial effects of carbohydrates *per se* and dietary fibre, but later studies in which carbohydrate alone was increased left little doubt that in order to achieve improved glycaemic control and reduced LDL without any increase in VLDL and triglycerides or reduction in HDL it was essential to increase dietary fibre, especially soluble fibre (Simpson *et al*, 1982). We were also able to show that it was possible to achieve beneficial effects with more acceptable amounts of dietary fibre than had been used in our earlier studies (Lousley *et al*, 1984). Other groups publishing at around the same time or

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shortly afterwards produced broadly comparable results (Rivellese *et al*, 1980; Riccardi *et al*, 1984). Those who were unable to duplicate these findings may have used foods which were not sufficiently rich in soluble fibre (Hollenbeck *et al*, 1988).

At the same time as our studies using whole foods were being started, Jenkins and his colleagues, also working in Oxford, were undertaking studies with guar gum and other soluble forms of dietary fibre (Jenkins *et al*, 1976; Jenkins *et al*, 1977). They demonstrated that the addition of these preparations as supplements to carbohydrate-containing meals reduced the glycaemic excursion following such meals. This work initiated by Jenkins and Wolever has been duplicated by researchers throughout the world using a range of purified or semi-purified gums, mucilages and other forms of soluble fibre (Smith *et al*, 1982; Smith & Holm 1982). In addition to the acute effects, some studies showed an overall improvement in glycaemic control when these fibres were incorporated into foods or used as supplements (Aro *et al*, 1981), but the improvements were usually less marked than those achieved with the use of fibre-rich whole foods. Furthermore it seems that for technological reasons it was difficult to incorporate such fibres into palatable food products and their use in diabetes management has thus far been limited in most countries.

Jenkins, Wolever and colleagues were also responsible for the introduction of the concept of glycaemic index (GI) of carbohydrate-containing foods, ie the glycaemic excursion (measured as area under the blood glucose response curve in mmol/min/l) following ingestion of a standard amount of food (usually 50 or 100 g) expressed as a percentage of the glycaemic excursion following an equivalent amount of a carbohydrate standard (50 or 100 g of glucose or white bread) (Jenkins *et al*, 1981; Wolever & Jenkins, 1986). Slowly absorbed carbohydrate-containing foods (eg various cooked dried beans such as lentils and chick peas, brown spaghetti and parboiled rice) have lower GIs than those containing rapidly absorbed carbohydrates (eg breakfast cereals such as cornflakes, ripe bananas and mashed potato) (Foster-Powell & Brand Miller, 1995). Although the term glycaemic index came to be widely used in the early 1980s, the idea that similar amounts of carbohydrate in different foods resulted in varying glycaemic responses had been suggested several years earlier by researchers in several different countries (Truswell, 1992). The GI of foods depends upon several different attributes, including the nature of the carbohydrate component, the cooking or food processing, and other food components eaten at the same time (FAO/WHO, 1998; Brand *et al*, 1985).

A diet in which low GI foods provide a high proportion of all dietary carbohydrate improves long-term glycaemic control and plasma lipids (Wolever *et al*, 1992). Innumerable publications from many research groups in different countries have now reported GI values for locally available foods and in some countries the GI concept has become the means of identifying the most appropriate carbohydrate-containing foods for people with diabetes. While some low GI foods are high in soluble forms of dietary fibre (eg

lentils, chickpeas, other dried beans), this is not invariably the case.

After a hiatus of several years during which little new information emerged, several recent publications have helped to clarify the extent to which knowledge of glycaemic index and dietary fibre content of carbohydrate-containing foods are useful when prescribing diets for people with diabetes. Jarvi and colleagues undertook a landmark controlled study in which individuals with type 2 diabetes were provided with fairly similar meals which, through use of skilled food technology, differed only in glycaemic index (Jarvi *et al*, 1999). Macronutrient composition and dietary fibre content were identical on the two diets. After 24 days, the low glycaemic index diet was associated with improved glycaemic control, reduced total and LDL cholesterol and reduced levels of plasminogen activator inhibitor-I (PAI-I) when compared with the high glycaemic index diet, thus confirming the ability of low GI foods to confer benefit, independent of dietary fibre, in terms not only of blood glucose control and lipoprotein mediated cardiovascular risk reduction, but also a reduction in thrombogenic risk (reduced PAI-I).

Chandalia *et al* have reexamined the role of dietary fibre in type 2 diabetes comparing average (24 g/day total, 8 g soluble) and high (50 g/day total, 25 g soluble) fibre diets using an experimental design similar to that which we used in our early studies, ie a 6 week randomised crossover design (Chandalia *et al*, 2000). However there were several important differences. The experimental diets were identical in macronutrient composition, reduced in total and low in saturated fatty acids (30 and 7% total energy) and average in total carbohydrate and protein content (55 and 15% total energy). Furthermore dietary intake was more carefully controlled by providing the participants with all their meals. Reductions in plasma glucose and insulin and urinary glucose excretion throughout a 24 h period on the high, compared with the average fibre diet, were virtually identical to those we observed nearly 20 y ago, as were the improvements in lipids and lipoproteins. The increase in soluble fibre was achieved by increasing a range of unfortified foods, vegetables, fruit and wholegrain cereals (eg cantaloupe, grapefruit, orange, papaya, raisins, lima beans, okra, sweet potato, winter squash, zucchini, granola, oatbran) and no fibre supplements. Glycaemic index data are not presented for these foods or the meals as a whole but from published data it would seem that, while some do indeed have a low GI (eg lima beans), most others would be defined as having an intermediate index (eg sweet potato, oatbran, granola, orange and papaya). Additional recent support for the usefulness of dietary fibre in type 1 diabetes comes from the EURODIAB study, which suggested better glycaemic control and reduced episodes of ketoacidosis in those with highest intakes (Buyken *et al*, 1998).

Thus it would seem to be inappropriate to dismiss the usefulness of soluble dietary fibre in the management of patients with types 1 and 2 diabetes in favour of the exclusive use of GI. High soluble fibre-containing foods and low GI foods improve diabetes control at least in part

as a result of delayed glucose absorption. In type 2 diabetes, given the diminished first-phase insulin response, there is a better match between the maximum blood glucose concentration after a carbohydrate-containing meal and the delayed insulin response. Other mechanisms by which low GI and high fibre foods achieve reduced postprandial hypoglycaemia are more speculative but it is important to emphasise that the benefits of increased fibre intake result principally from the greater consumption of soluble forms. While insoluble forms of dietary fibre may confer benefit in terms of maintaining gastrointestinal health, such fibres appear to have a smaller effect on carbohydrate and lipid metabolism. Unfortunately the methodology presently available for measuring these subtypes of dietary fibre are imperfect and the WHO/FAO Expert Consultation on Carbohydrates has suggested the measurement of non-starch polysaccharides rather than dietary fibre, with specification regarding the type of polysaccharide, eg gums, pectins, mucilages. This is impractical for clinical use. Until methodology has been further improved it may be best to advise patients with diabetes to select carbohydrate-containing foods from lists of those rich in appropriate dietary fibres and which are regionally available, rather than to suggest amounts of soluble fibre which must be consumed. Indeed the same advice may be applied to choices based on glycaemic index. Although glycaemic index is, in theory, easy to determine, there is considerable individual variation in this biological index, even when measured under standardised conditions. Low GI foods (those with a GI below 55) and intermediate GI foods (GI 55–70) which are also rich in soluble fibre represent the most appropriate choices of carbohydrate-containing foods.

Perhaps the most important message to emerge from this discussion is the reminder of the extent to which dietary management can contribute to diabetes management in types 1 and 2 diabetes. A new drug which could reproduce the range of benefits associated with soluble fibre rich or low GI foods would be heralded as a major breakthrough and rapidly become a best seller. Dietary modification would seem to be a far better option.

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