Dietary fibre in health and disease: "How and how much dietary fibre should we eat?"

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Roughage or dietary fibre used to be regarded as physiologically inert, or even a troublesome component of food. Since the pioneering observations of Trowell and Burkitt about its potential health significance, the dietary fibre story has fired the interests of medical scientists and of the community.

It is time to take stock of where we are at, and especially to see whether we know how we should eat it, and how much we should eat.

Heterogeneity. It turns out that dietary fibre has considerable chemical complexity. Most dietary fibre is non-starch polysaccharide and a little is lignin, which is not a carbohydrate.

What allows the grouping of chemicals as "dietary fibre" is their lack of digestion in the human small intestine. Almost all starch is digested in the small intestine — we are now learning that a variable small quantity is not.

Sometimes, the non-starch polysaccharides are subdivided into those which are cellulosic and those which are not. For those that are non-cellulosic, there are hemicellulose, pectin, and storage polysaccharides (inulin and guar) and, also plant gums and mucilages.

The non-cellulosic, non-starch polysaccharides, are also sometimes divided into those which are water-soluble (pectin and ispaghula) and those which are water-soluble. The preferred analytical method for looking at dietary fibre fractions, that devised by Hans Englyst at Cambridge, assesses water solubility.

A modification of this method is the one that we are using in the Department of Human Nutrition at Deakin University for the analyses of dietary fibre in food for the new Australian food composition tables.

For total dietary fibre, a figure is obtained by the Englyst method which agrees very closely with a more direct method devised by Nils Asp, of the Department of Food Chemistry at Lund University in Sweden. We also use this method, now coming to be the agreed international method, when we only want a figure for total dietary fibre and not for its fractions.

However, it is important to appreciate that the spectrum of chemicals making up dietary fibre from a particular food is very different to that from another food. In time, this is bound to have important physiological and pathophysiological significance.

Food as a source. Dietary fibre is one of the important factors conferring structure on food, a property which is irretrievable once fibre is isolated from food. There are now various studies which indicate the importance of food structure insofar as digestion and absorption of nutrients is concerned.

For example, Heaton and colleagues, demonstrated different effects on carbohydrate metabolism with apple puree as opposed to intact apple; the only difference between the two test foods was structure. There were further differences with the removal of dietary fibre and associated components from puree as evidenced by a comparison of puree and apple juice.

O'Dea and colleagues have also demonstrated differences between carbohydrate responses to ground and unground rice. There are different degrees of nutrient malabsorption with peanuts according to particle size.

Physico-chemical properties which fibre confers on food, or has in isolation from food, are likely to include particle size, viscosity, and water retention. At present, these aspects of food composition are not addressed in tables of food composition.

When dietary fibre content of food is considered, the fact that this is only a statement of total content of several different chemicals should not be forgotten.

The effects of dietary fibre-rich foods may be mediated not only by the chemistry and physical chemistry of dietary fibre in the food, but also by other food components with which it is associated.

Examples of these would include amylase inhibitors, saponins (which may have cholesterol-lowering properties), phytates (which may decrease the bio-availability of elements like zinc), and lignans (like those converted to the animal lignans, enterolactone and enterodiol, and which appear to have anti-oestrogenic properties).

The need to obtain dietary fibre from a variety of food sources is therefore evident. The reasons are these:

- The chemical heterogeneity of dietary fibre.
- The physico-chemical heterogeneity of dietary fibre.
- The dissociation between different physiological effects of dietary fibre.
- Dietary fibre may serve as a marker for other nutritients and food components.
- Inadequate knowledge of the relationships between dietary fibre and health.

Recommended intakes. In a consideration of what might be desirable levels of dietary fibre intake, there must be some knowledge of the levels of dietary fibre intake at which certain disease problems emerge.

The broad disease categories requiring consideration are listed below but it should be stressed that the evidence for a relationship between dietary fibre intake and these various disease entities is not equally well established:

- Gastrointestinal disease (Constipation, Haemorrhoids, Diverticular disease, Colorectal cancer, and Chronic inflam-

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matory bowel disease (Crohn's disease).

- Metabolic disease (Obesity, Diabetes, Hyperlipidaemia).
- Cardiovascular disease (Hypertension and Atherosclerotic vascular disease).

Also, in considering relationships between dietary fibre intake and health outcomes, not only is it important to realise that dietary fibre might serve as a marker of desirable foods, rather than being the required component, but also that it is most likely that where it has a role in its own right, it will be one of several factors of consequence. Indeed, there is probably no disease process which has a unifactorial origin.

One of the best guides to desirable levels of dietary fibre intake comes from the study in the town of Zutphen in the Netherlands, reported in 1982. Zutphen formed the Dutch contribution to the famous seven countries study of diet and heart disease.

In 1960, food intake information was collected abut 871 middle-aged men. They were then followed up for 10 years. Mortality from coronary heart disease, cancer (mainly lung cancer), and all causes was least with the highest quintile of dietary fibre intake.

Dietary fibre intakes of at least 37 grams per day appeared protective against the patterns of chronic disease found in Western society. Thus, it would appear reasonable, and is certainly realistic, to aim at a total dietary fibre intake for adults of about 40 grams per day.

However, it should be remembered that, in the Zutphen study, the dietary fibre came from various kinds of plant food including bread, potatoes, fruits and vegetables.

It may, however, not be satisfactory to describe or recommend dietary fibre intakes for all age groups, and in regard to all functions of dietary fibre, in terms of mass of dietary fibre per day.

Possible alternatives are these: mass per day, mass per kilogram bodyweight per day, mass per kilojoule per day, and mass per mass of absorbable carbohydrate.

Another important associated finding which came out of both the Zutphen and the London study of Morris was that the greater the total food energy intake per day, the greater the life expectancy.

The implication of this is that the more physically active the individual, the greater the life expectancy; and it must be remembered that the preferred way of having more food energy appears to be from plant food.

Vic. studies. The quality of the diet with regard to dietary fibre can improve without any change in total dietary fibre intake.

An example of this comes from our own work at Alcoa in Geelong, Victoria, where Alison Stewart, Bob Oliphant, and I have sought to identify and then modify nutritionally coronary risk factors.

It so happened that it was possible in a confidential way to obtain information about alcohol intake and to counsel accordingly. As alcohol intake decreased over three and six months, total dietary fibre intake did not change; but the dietary fibre intake expressed in terms of energy intake improved significantly.

This would suggest that we must consider dietary fibre intake in regard to the total diet. It seems likely that the functional significance of the dietary fibre will alter as specific nutrient density for dietary fibre increases.

For children, dietary fibre intake may need to be expressed in terms of body weight. There seems little doubt that, even in pre-school children, whom we examined in the Latrobe Valley of Victoria (Wahlqvist *et al*, 1981), dietary fibre intake relates to health.

Pre-schoolers with the highest dietary fibre intakes had as little as a 0.2% prevalence of constipation, whereas those with the lowest dietary fibre intakes had a 12.3% prevalence of constipation. It would be necessary, of course, to see the effect of increasing dietary fibre intake on constipation in these children.

It would also be very desirable to follow such children up and look at the extent to which this dietary fibre intake and the associated constipation is a precursor of later gastrointestinal pathology. But in so doing, consideration must be given to the ways of expressing dietary fibre intake.

At the other end of life, we have found dietary fibre intakes to be less in those elderly people who are institutionalised, and less still in those in institutions who have a poorer functional status (Ngyuen, Flint, Prinsley & Wahlqvist, 1984).

Part of the problem will be that, with declining physical activity with advancing years, less total food is needed for energy requirements, and consequently, less dietary fibre consumed. Additionally, there are difficulties for some elderly people in the handling and mastication of dietary fibre-rich foods.

But with dietary fibre intakes down to about eight grams per day in those in institutions with the worst functional status, efforts are probably required to address the dietary fibre problem in its own right.

Dietary fibre intakes amongst community-based elderly people are in the region of 15 to 25 grams per day, rather like the rest of the apparently healthy Anglo-Australian population.

In elderly people, dietary fibre intake cannot be considered, however, in isolation from other nutrient considerations. For example, in institutions, low zinc status is not uncommonly seen, and an increase in dietary fibre intake which meant an increase in phytate intake, appears to compromise zinc nutrition in elderly people (Wahlqvist, Flint & Parish, 1983).

Whatever we say about desirable dietary fibre intakes, for the majority of people they will respond to the outcomes of changing dietary fibre intake on bowel function.

This was no more clearly in evidence than in the study by the Gastroenterological Society of Australia in the South Australian town of Strathalbyn. In that study, the effectiveness of a dietary fibre education program was monitored by the sales of laxatives in pharmacies.

The success of the program could be judged by the persistence of reduced laxatives sales well beyond the education period. The response with haemorrhoidal disease to dietary fibre supplements is also another example of the persuasive effect that dietary fibre supplements can have on the potential for long-term changes in intake (Hunt and Korman, 1982).

Physiological effects. The physiological effects of dietary fibre are likely to occur at all levels of the gastrointestinal tract and also, at least, in the splanchnic circulation.

The relevant sites would be these:

- The mouth in mastication and on dental hygiene.
- The oesophagus and stomach on motility and emptying (more research is needed in these areas).
- Small intestinal function (although no digestion of dietary fibre takes place in the small intestine, effects on other digestible and absorbable nutrients are seen; some of this effect will take place in the lumen, but effects on small intestinal morphology have also been seen in experimental animals fed large amounts of different kinds of dietary fibre).
- Colon.
- Liver.

Several components of dietary fibre serve as substrate for the colonic microflora. Indeed, whereas previously it was thought that water-retaining properties accounted

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for the increase in faecal bulk with dietary fibre, it is now clear that most of the faecal-bulking effect is attributable to an increase in bacterial mass.

The most important products of the bacterial metabolism of dietary fibre, apart from the increase in bacterial mass itself, are the production of intestinal gas and the release of volatile fatty acids (acetate, propionate and butyrate).

Fibre fermentation leads to the production of the odourless gases carbondioxide, methane, and hydrogen. It is worth noting that it is basically protein break-down which leads to the production of gas with odour.

It is probably in part the advent of an urban society, and the associated awkwardness that intestinal gas production meant socially, that stimulated use of increasingly refined and dietary fibre-poor foods.

The corollary is that, as an increase in dietary fibre intake is promoted, new ways of adjusting to increased intestinal gas production must be found. One of the simplest recommendations to make is that people be as physically active as possible and, at the very least, get up and walk around. Not to do so can be associated with abdominal distension and discomfort.

Volatile fatty acids (VFA) production is a most exciting area of contemporary research. These volatile fatty acids may play an important role in serving as fuels or substrates for the intestinal mucosa, which might be nourished not only from the blood, but also from the lumen of the gut.

Roediger and colleagues have suggested that this might be an important consideration in the pathogenesis of ulcerative colitis.

VFA are transported in the portal blood to the liver where they have potential for regulating splanchnic metabolism. Our own view is that this might have importance in the regulation of fasting blood glucose in diabetics. It means that, in the interval between meals, ongoing dietary fibre digestion from the colon, might have an important metabolic regulatory role.

Adverse effects. Reference has already been made to the way in which pharmacological doses of dietary fibre might adversely affect small intestinal morphology. It is not clear whether these effects occur in man, but they do in the rat. This might be one of several ways in which nutrient availability might be altered by dietary fibre.

The kinds of problems that might occur with increased fibre consumption could be categorised in the following way:

- Decreased nutrient availability — minerals (calcium, iron), trace elements (zinc), vitamins?
- Early satiety in PEM (Protein and Energy Malnutrition). This can be important for children in developing countries where food eaten is fairly exclusively of a high-fibre kind.
- Drug interactions — cardiac glycosides (digoxin, digitoxin), salicylates, nitrofurantion, tranquilisers? and antihypertensives?

Supplements as a source. The preferred way to have dietary fibre is from food. However, once particular roles for dietary fibre are defined, like those in regard to the gastrointestinal tract, particular fibre types can be isolated and used for those particular purposes.

It can also be that properties of dietary fibre not ordinarily seen at physiological intakes, might be seen at pharmacological intakes. This may well be the case as far as effects of pectin and guar on diabetic control are concerned, since the acute effects are not seen in the same way when the dietary fibre comes from food.

Dietary fibre from food seems to induce different kinds of effects on carbohydrate metabolism which take longer to emerge.

Thus, it is clear that one needs to distinguish between the pharmaceutical use of dietary fibre and the need to promote dietary change.

For some people, however, the use of a dietary fibre supplement in the short-term with evident effects, such as on bowel function, can convince them that long-term dietary change is worthwhile.

New manual on regulatory affairs

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Dr Buckley's book has been published by TIL Publications, London, as one of an international series, and will be available through SCRIP.

The Manual is intended for management and marketing personnel who must understand and operate within the system, and regulatory personnel who must operate the system.

There are 354 pages of discussions, checklists, tabulations, and figures presented in 12 sections, namely: Introduction, Historical perspective, Historical, philosophical and legal basis of medicines control in Australia, Guidelines for preparing applications, Commentaries on special subjects, Registration in Victoria, The Pharmaceutical Benefits Scheme, Federal regulatory agencies, Directory of state health authorities, Pharmaceutical industry associations, The paperwork of registration, Bibliography.

The comprehensive list of contents is designed as a check list on the subject matter of registrations. This feature combined with the loose-leaf format should assist the user personally to keep up-to-date and to continously update the manual.

(Copies may be purchased from Scrip Bookshop. Price in Europe F170, Australia $US270, Rest of World $US300 including postage.) Cheques (UK Sterling) should be made payable to SCRIP, drawn on a UK Bank and sent to, SCRIP, 18-22 Hill Rise, Richmond, Surrey TW106AU, U.K.

Wellcome to fund Aust. research

The first in a series of scientific research funding awards, worth more than $2 million over the next eight years, has been announced by the Wellcome Trust, Britain's largest medical charity, and sole shareholder of Wellcome Australia Limited.

The first two Australian Wellcome senior research fellows will be Dr. David Healy, 35, of the Prince Henry Hospital, Melbourne, who will work on hormone activity in pregnancy during his studies on endocrinology in obstetrics and gynaecology; and Dr. Keryn Williams, 34, who will be investigating the problems of rejection of corneal transplants at Flinders University, Adelaide.

They were selected from more than 30 applications following interviews of short-listed candidates by a committee of Australian medical scientists from the Royal Australian College of Physicians, augmented by Dr. P. O. Williams, director of the Wellcome Trust, and Professor W. S. Peart, one of its trustees.

The new scheme of five-year fellowships was designed to enable Australian research workers of proven high ability to continue