DIETARY FIBRE

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1. INTRODUCTION

Dietary fibre may be broadly defined as "that part of food of plant origin which is not digested and absorbed". Other definitions which have been proposed include:

- "The indigenous components of plant materials which are resistant to digestion by enzymes produced by man". (1).
- "The sum of lignin and polysaccharides that are not hydrolysed by the indigenous secretions of the human digestive tract".
- "The structural materials of plant cells that are resistant to the digestive enzymes of human beings", (2).

The very existence of these three definitions illustrates the divergence of opinion and difficulty of analysing these materials.

The existence of dietary fibre has long been known. Its value as a component of human diet was controversial in former times. It is now universally recognised as beneficial, even essential for good health.

2. THE COMPOSITION AND MEASUREMENT OF DIEATARY FIBRE

The composition of dietary fibre is complex and therefore not easy to measure.

Dietary fibre is not a single entity but a group of substances including any or all of the following: cellulose, hemicelluloses, lignin, pentrosans and pectins (all of which are components of plant food), and also gums, mucilages, modified cellulose and certain polysaccharides (which may occur naturally or be present as components of processed food).

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Some of these substances are themselves composite. Hemicelluloses are polymers of certain sugars with sugar-acid residues attached and are not related to cellulose as the name suggests. Pentosans are polymers of pentose sugars, and may be loosely regarded as one of the subgroups of the hemicellulose group. Gums are complex polymers of sugars, deoxy-sugars and sugar acids. Pectins are complex polymers of sugars and esterified sugar acids. Pectins and gums differ from other forms of dietary fibre in that they are very soluble in water.

The relative proportions of the substances vary from one species of plant to another, and between different parts of an individual plant. Within an individual plant species these proportions may vary according to its variety, when it was harvested, how it was stored and how it was prepared for eating. These variations are significant because the different components do not exert equivalent effects.

Fibre was originally measured as that which remained after a food had been successfully extracted with ether, acid and alkali. This has been superseded by other methods. The two most widely used are:

(1) The AOAC enzymic-gravimetric method. This measures total dietary fibre in a way which simulates what happens to food in the digestive tract more closely than the early crude chemical methods did. It is a quick and simple method, convenient for the routine analysis of food for the purpose of labelling and quality control. It is officially recognised in some countries and is recommended as the method of choice by industry. Its value is limited in that it does not discriminate between the different components of fibre. This is significant for clinical investigations since it is known that the various (and variable) components of dietary fibre do not all have identical physiological effects.

(2) The Englyst method. This is a purely chemical method, which allows the various constituents of dietary fibre to be determined separately. It thus provides more information than the AOAC method and the extra information is nutritionally significant in some contexts. However, the utility of the method is limited because it is neither quick nor simple, and is therefore unsuitable for routine analysis.

3. DIETARY FIBRE AND HEALTH

A presumption that dietary fibre is necessary for health has long existed, based on the observation that human beings in their early stages of evolution subsisted on natural food rich in fibre. This presumption has been confirmed by scientific evidence. The main benefits claimed are the avoidance of constipation, irritable bowel syndrome, diverticular diseases, and cancer of the colon. Fibre assists the normal functioning of the bowels in several ways which together increase the bulk and soften the consistency of the faecal mass, promoting its frequent and fluent evacuation.

In addition to its role in assisting the functioning of the bowels, fibre has been claimed to:

(1) improve glucose tolerance to carbohydrates.

(2) Satisfy appetite without supplying energy (of benefit to the obese).
(3) Aid the regression of gallstones.
(4) Reduce the risk of peptic and duodenal ulcers.
(5) Lower serum cholesterol levels (potentially reducing the risk of heart disease).
(6) Protect against the potential adverse actions of toxins.

These benefits are accompanied by certain disadvantages, namely an impaired absorption of minerals, and, if consumption of fibre is excessive, the possibility of gastric and intestinal disturbances. The consensus of scientific opinion is that these disadvantages are far outweighed by the benefits.

The scientific community has however been reluctant to make claims which could be translated into detailed and quantified recommendations. This is because the precise effects of the individual components of fibre are not well enough understood; the relative proportions of these components in plant foods are not well enough known and the effects are in any case modified by other components of the total diet. Nonetheless, there is a consensus that industrialised societies would enjoy better health if they consumed more fibre than they do currently.

4. SOME PHYSIOLOGICAL EFFECTS OF FIBRE

4.1 *The effect on bowel functions:*

Fibre increases the bulk and softens the consistency of faeces by its water-holding capacity, its ion-exchange capacity (a feature which affects the concentration of salts in the contents of the bowels) and the extent to which it may be fermented by the gut flora.

The capacity to absorb water depends on the type of fibre (specifically its three-dimensional structure) and on its particle size.

Finely ground bran holds 26 % less water than unground bran (3).

Fibre absorbs cations (positively charged ions), with beneficial effect on bowel function, but with a risk of deprivation of minerals among those who consume grossly excessive amounts of fibre or whose diet is already poor in minerals (4). Different fibres absorb cations more or less strongly or more or less selectively, according to their nature. One study (5) found a difference between the ion-exchange characteristics of fibre from old and new potatoes.

The water-binding and ion-exchange capacities of different foods may vary not only according to the type of fibre but also, of course, to the amount of fibre contained in the food. Bran has nearly eight times the water-binding capacity of turnips or potatoes.

Some forms of fibre, particularly forms rich in pentosans, can be digested by the bacteria present in the human gut. (Bran fibre is not such a form). The resulting gaseous products, and the proliferation of the bacteria themselves beneficially increase the bulk and lower the density of the faecal mass.

4.2 *The effect on satiety*

Foods rich in fibre take longer to chew. This slows the rate of food intake, which may discourage overeating (it has been shown that high-fibre bread sates the appetite with a lower intake of calories than low-fibre bread (6)) Foods rich in fibre tend to slow gastric emptying. This is predominantly true of those polysaccharide fibres, e.g. pectin, which gel and swell in the stomach. When gastric emptying is delayed, the onset of hunger is also delayed.

Different components of fibre have different, sometimes opposite effects on the several individual enzymes involved in digestion. The significance of this (unlike the significance of longer chewing and gastric emptying times) is not yet well understood.

4.3 *The effect on serum cholesterol*

Foods rich in "soluble fibre" tend to lower the level of serum cholesterol, including "LDL-cholesterol" the form held to be a risk-factor in heart disease (7). Soluble fibre comprises pectins, some hemicelluloses, gums, mucilages and algal polysaccharides. Oatmeal and rice bran are rich in soluble fibre but wheat is not. Much of the research demonstrating the cholesterol-lowering effect of soluble fibre has been based on a comparison of the effects of oat-products and wheat products (8).

Although the cholesterol-lowering effect of soluble fibre is well established, it is not claimed to be more than a useful addition to all the other known ways of reducing the risk of heart disease (9).

Both soluble and insoluble fibre have an additional effect which may reduce the risk of heart disease. Both forms have the effect of reducing the level to which blood-glucose and blood-insulin rises following the eating of food which contains carbohydrate. High levels of blood-insulin have been associated indirectly with the propensity to heart disease.

4.4 *The effect on blood glucose*

The more soluble types of dietary fibre, pectins and gums tend to reduce the rate at which glucose enters the blood after eating a food containing carbohydrates, and spreads out the rise in blood glucose and the secretion of insulin over a longer period of time. Addition of 5-15 g of viscous, soluble fibre to a meal may have a profond effect on blood glucose and insulin concentrations after the meal. Some think this may have benefit in the treatment of non insulin dependent diabetes mellitus.

4.5 *Some other physiological effects*

The most important of these were enumerated in section 3. In some cases the evidence of benefit, though strongly suggestive, is less secure than it is for smooth bowel function, and the lowering of serum cholesterol, and the promotion of satiety.

In the case of diverticular disease much of the epidemiological evidence came from populations which differed in ways additional to fibre consumption, but intervention studies have confirmed this finding.

In the case of gallstones the evidence is largely circumstantial.

In the case of irritable bowel syndrome some of the evidence is inconsistent.

In the case of anti-toxic effects, the evidence is necessarily confined to animal trials.

Many studies indicate that specific components of fibre exert specific effects. Thus, a strong negative correlation has been found between bowel cancer and the intake of pentosans, but not with total fibre: pectin, but not cellulose or lignin has been shown to affect the "lithogenic index" (a measure of the propensity to gallstone formation); wheat-bran has been claimed to be especially effective in the treatment of constipation. Some other examples of specificity have already been quoted.

5. RECOMMENDED AND ACTUAL CONSUMPTION OF DIETARY FIBRE

Given that different forms of fibre have different effects, that those differences are not yet fully understood, that the relative proportions of the different forms in all the common plant foods is not yet unequivocally established and finally, that individuals differ in their response and requirements: it is clear that any dietary recommendations can only be made in general terms.

In 1987 the Life Sciences Office of the Federation of American Societies for Experimental Biology under contract to the Food and Drug Administration, recommended a daily intake of 20-35g/day for a healthy adult, and stipulated that this should be derived from "a wide variety of wholegrain products, fruit and vegetables". The average intake in the USA, at the time of writing, is 10-12g/day/person.

Authorities in the UK recommend a daily intake of 18g of non-starch polysaccharides/d/person which is equivalent to 20)25g/day of dietary fibre. The current consumption there is estimated to be 12g NSP/person (15-20g dietary fibre).

Germany recommends not less than 30g/day/person. Current consumption there is estimated to be 16,8g/day for women and 20,5g/day for men.

In less technologically developed societies the intake of dietary fibre is higher. For example, a nationwide survey in China found an average intake of 34g/day/person (with a range from 9 to 77g/day/person).

6. SOURCES OF DIETARY FIBRE

Sources are confined to food derived from plants, namely vegetables, cereals, fruit and nuts.

The total fibre content of such foods is listed in various tables, e.g. McCance & Widdowson's "The Composition of Foods".

A few typical values are given below

Table 1

Total dietary fibre in selected foods

	g/100g (wet weight)	g/100 kcal
Wholemeal bread	8,5	3,9
White bread	2,7	1,2
Cornflakes	11,0	3,0
Muesli	7,4	2,0
Boiled Spinach	6,3	27,0
Boiled cabbage	1,8	12,0
Boiled patotoes	2,0	2,6
Peanuts	8,1	1,4
Bananas	3,4	4,3
Strawberries	2,2	8,5

Such tables should be used with caution for several reasons. Analytical methods for measuring fibre are less well standardised than they are for most other food components. The quantity of a particular food likely to be eaten should be considered as well as its fibre content. (For example, spinach is much richer in fibre than potatoes, but since most people eat much more potato than spinach, potato contributes more fibre in their diet). Other food components may include the effects of fibre, (for example, although fibre tends to inhibit the absorption of minerals, any effect will be less with potato than with wheat since potato contains much less phytate and much more ascorbic acid than wheat). Finally, fibre differs in its detailed composition, and therefore effect, from one food to another.

Data on detailed composition are sparse. Some typical values are quoted in table 2 below

Table 2

	Cellulose	Hemicellulose	Lignin	Pectin
Apples	0,72	0,45	0,08	0,44
Oranges	0,60	0,08	0,02	0,57
Strawberries	0,50	0,21	0,23	0,36
Potatoes (cooked)	0,18	0,09	0,42	0,26
Tomatoes	0,35	0,08	0,19	0,21

It is worth noting that according to the publication from which these mean values were derived (10) the range found from different sources was sometimes wide. For example the lignin content of apples ranged from 0,005 to 0,12g/100g; the cellulose content of potatoes ranged from 0,09 to 0,27g/100g. Furthermore the values for total fibre, as the sum of cellulose, hemicellulose, lignin and pectin, do not agree with the values given in the compilation from which table 1 was derived.

Confectionery products and fine bakery wares generally contain relatively small amounts of dietary fibre which are of limited nutritional significance. This does not reduce the nutritional value of the products any more than the absence of dietary fibre in fish, meat and dairy products belittles the nutritional value of them. Rather, it reinforces the desirability of variety in the diet.

7. IOCCC Position

The IOCCC accepts that the recommended increase in the consumption of dietary fibre is likely to benefit certain aspects of health, and welcomes research and education directed to this end. Such education should emphasise the need for a widely varied diet.

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