Institute of Food Science & Technology Trust Fund

Dietary Fibre

The Institute of Food Science & Technology, through its Public Affairs and Technical & Legislative Committees, has authorised the following Information Statement, dated April 2007, updating that of February 2007.

SUMMARY

Dietary fibre is now defined as food material, particularly plant material, that is not hydrolysed by enzymes secreted by the human digestive tract but that may be digested by microflora in the gut. Plant components that fall within this definition include non-starch polysaccharides (NSP) such as celluloses, some hemi-celluloses, gums and pectins, as well as lignin, resistant dextrins and resistant starches. However, along with the current Codex definition, a proposal to limit the definition to "intrinsic plant cell wall polysaccharides" will be considered at the relevant Codex meeting in November 2007.

Sources of dietary fibre include vegetables, wheat and most other grains. Foods rich in soluble fibre include fruits, oats, barley and beans.

Extensive research has been carried out into the physiological effects of dietary fibre and there is evidence that a low intake may be associated with a number of diseases.

The determination of dietary fibre in food is therefore important, not only to support clinical programmes, but also to provide and validate data for legal requirements such as food labelling. Methods of analysis developed over the years have usually concentrated on groups of components within the dietary fibre complex and the results of the analyses have not been directly comparable.

However, in 1999 the UK approved methodology that is in general use elsewhere and which provides the basis for agreement in international trade.

It must nevertheless be accepted that since dietary fibre is a complex mixture of materials, some with very different characteristics, and that the mixture varies with source, no method of analysis can correlate precisely with any specific physiological function.

THE MEANING OF DIETARY FIBRE (DF)

DF has been defined in a variety of ways, one of the earliest being 'the sum of celluloses, hemicelluloses and lignins'. DF was defined by Trowell (1974) as 'the skeletal remains of

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plant cells that are resistant to hydrolysis by the enzymes of man'. A similar definition was given in the Codex guidelines on nutrition labelling (as 'edible plant or animal material not hydrolysed by the endogenous enzymes of the human digestive tract' (Codex, 1998). However, animal material is not a significant factor in the consideration of dietary fibre.

At its 27th session in May 2006, the Codex Committee on Nutrition and Foods for Special Dietary Uses (CCCNFSDU) made further progress on moving towards an agreed definition for fibre (considering this within the discussions on the *Guidelines for the Use of Nutrition Claims: Draft Table of Conditions for Nutrient Contents*).The latest definition, which was returned to Step 6 for further comment and discussions at the next session of the Committee, states that:

> *"Dietary fibre means carbohydrate polymers with a degree of polymerisation (DP) not lower than 3 which are neither digested nor absorbed in the small intestine. A degree of polymerisation not lower than 3 is intended to exclude mono- and disaccharides. It is not intended to reflect the average DP of a mixture. Dietary fibre consists of one or more of:*
> - *Edible carbohydrate polymers naturally occurring in the food as consumed,*
> - *carbohydrate polymers, which have been obtained from food raw material by physical, enzymatic or chemical means,*
> - *synthetic carbohydrate polymers."*

Article 1, paragraph 4 of the EU Directive 90/496/EEC on Nutrition Labelling for Foodstuffs provides definitions for a number of nutrients that are used in nutrition labelling. In paragraph 4(j), it is noted that 'fibre' means the material to be defined according to Standing Committee procedure and measured by the method of analysis to be determined in accordance with that procedure. In May 2006, in its Discussion Paper on Revision of Technical Issues under the Standing Committee procedure, the Health and Consumer Protection Directorate, quoted the above Codex proposed definition and posed the question,

> "Are the current Codex discussions a suitable basis for setting down a definition of fibre in the Nutrition Labelling Directive?"

The types of plant material that are included within the definitions of DF may be divided into two forms, based on their water solubility

- Insoluble dietary fibre (IDF) which includes celluloses, some hemicelluloses and lignin;
- Soluble dietary fibre (SDF) which includes β-glucans, pectins, gums, mucilages and some hemicelluloses.

The IDF and SDF compounds, apart from lignin, are known collectively as non-starch polysaccharides (NSP), which was one of the earlier definitions of DF. However, the Codex definition recognises that there are other materials that are not hydrolysed within the human digestive tract, the principal class of these being the resistant starches and lignin.

There are three forms of resistant starches – (a) protected starch molecules, (b) unswollen granules, e.g. potato starch and (c) retrograded starch. Like the IDF and SDF compounds,

they are resistant to digestion in the upper reaches of the alimentary canal and arrive intact in the colon where they are digested by the microflora of the gut**,** a defining characteristic of DF.

Fructans, which contain β-1-2 linkages between fructose molecules, also now fall within the definition of DF, since they are not attacked by gastro-intestinal enzymes but are digested by the microflora of the gut. The principal fructan is inulin, and the oligomers are fructo-oligosaccharides, which are formed either by the hydrolysis of inulin or by enzymic synthesis from sucrose.

Synthetic oligosaccharides based on galactose, maltose and other sugars, so-called resistant oligosaccharides, and polydextrose would, under the recent proposed Codex definition be classified as DF.

Micro components of plant structures such as waxes, cutin and suberin also fall within the definition of DF.

WHO/FAO commissioned 40 experts to consider the definition of dietary fibre, and in January 2007 a Codex Circular Letter 2006/50-NFSDU contained the consensus recommendation of those experts that the definition should be "Dietary fibre consists of intrinsic plant cell wall polysaccharides".

The rationale given for that proposal is that "the established epidemiological support for the health benefits of dietary fibre is based on diets that contain fruits, vegetables and wholegrain cereal foods, which have the characteristic of containing plant cell walls. It is this food component that should form the basis of a dietary fibre definition as it provides a consistent indicator of the plant foods promoted in guidelines, intake of which has been used to establish population reference values for dietary fibre. Using this approach, dietary fibre is defined as a natural food component and no further criteria are required.

The structural polysaccharides are the major part of plant cell walls and, by determining this characteristic component, it is possible to indicate the presence of other beneficial substances, such as micronutrients and phytochemicals that are present in the plant. This approach is preferable to the determination of all the individual parts of plant cell wall material, which is both impractical and would not add to the nutritional message that is provided by focusing on the polysaccharides of the plant cell wall. Therefore, lignin and other substances are not included in the definition. Other carbohydrates share the feature of resisting digestion in the small intestine, but these do not provide a consistent indicator of plant rich diets, and they can be affected by food processing or may be added to food. Until recently, there has not been wide-scale use of fibre-like ingredients as supplements, and the current epidemiological evidence base for dietary fibre rich foods cannot be extrapolated to diets containing such preparations. To include them within a dietary fibre definition would clearly represent a conflict with reference intake values and health claims, which are derived mainly from these population studies. The suggestion to have inclusion criteria based on the demonstration of specified physiological properties is neither appropriate nor manageable within a dietary fibre definition. Instead, resistant starch, oligosaccharides and fibre supplements should be researched and, if shown to be beneficial to health, be promoted in their own right. Considering the variation in chemical and physiological properties involved,

the best approach is to validate and if appropriate, establish health claims on an individual basis."

This WHO/FAO proposed definition/rationale and the existing Codex definition have been referred to the next CCNFSDU Session in November 2007.

ANALYSIS OF DIETARY FIBRE

A number of methods of analysis for DF has been used in the UK over the years for the purpose of food nutrition labelling and these methods have changed as the definition of DF has evolved.

The Southgate method (1969) was used for many years and the results are included in standard works on nutrition information such as *McCance and Widdowson*. A method developed by Englyst et al (1992), which determined NSP only, was accepted by MAFF and it remained the recommended UK method for nutrition and labelling purposes until 1999. Englyst results also appear in *McCance and Widdowson*.

In August 1999, the Joint Food Safety and Standards Group (JFSSG - the precursor of the Food Standards Agency) accepted the role of resistant starch and lignin in DF and recommended the adoption of AOAC method 991.43 as the official UK method for DF. The further method, AOAC 997.08, determines fructans since these are also accepted as DF components (Hignett, 1999). This was confirmed in 2000 by a Food Standards Agency Guidance note.

In November 2005 the Institute of Grocery Distribution published a new Table of Guideline Daily Amounts (GDAs) for nutrients, in which the GDA for dietary fibre was 24g, and this Table carried the endorsement of the FSA.

The UK is now in line with the United States and continental Europe in the methodology for the analysis of DF.

However, the methods previously in use in the UK gave rise to different results and the user of these results must be aware of the differences. For example, Englyst determines NSP and can be split into insoluble and soluble DF. Southgate figures are normally higher than Englyst, particularly in the case of starchy foods. The AOAC method, which includes resistant starches, will also give results higher than Englyst.

The AOAC method (991.43) requires enzymic digestion of protein and non-resistant starch, followed by precipitation of soluble fibre with 95% alcohol and weighing. Inulin present should be removed using inulinase so as to avoid it being determined (in part) in method 991.43 and fully in method 997.08.

Method 997.08 for fructans (Hoebregs,1997) depends upon extraction with boiling water, hydrolysis with amylase and inulinase, then determination of sugars using anion exchange chromatography with pulsed amperometric detection. Correction is made for non-fructan sugars present.

Method AOAC 2000.11covers Polydextrose in Foods; method AOAC 2001.02 covers the Determination of trans-galactooligosaccharides (TGOS) in Selected Food Products; and method AOAC 2001.03 covers Total Dietary Fiber in Foods Containing Resistant Maltodextrin (AOAC, 2000)

LEVEL OF DIETARY FIBRE IN FOODS

A comparison of DF found in food using the AOAC and the Englyst methods is given in the following table:

Product	AOAC (g/100g)*	Englyst (g/100g)
Apples (with skin)	2.0	1.6
Bananas	1.9	1.1
Carrots (boiled)	3.1	2.5
Baked Beans	4.2	3.7
Cabbage	2.0	1.8
White Bread	2.0	1.5
Brown Bread	4.5	3.5
Wholemeal Bread	7.4	5.8

*excludes fructans

(Source – AOAC values *CRC Handbook of Dietary Fibre in Human Nutrition*, 2nd Edition (1993). Englyst NSP values *The Composition of Foods* McCance and Widdowson, 5th Edition (1991).

In the case of some processed cereal products, the differences between DF (AOAC) and DF (Englyst) could be greater than those shown above, due to the presence of variable amounts of resistant starch.

The differences in this table explain the recommendation by the JFSSG in August 1999 that the RDA for Dietary Fibre as determined by the AOAC method should be 24g, replacing the previous value of 18g based on determination by the Englyst method.

This recommendation was superseded by a Guidance Note from the Food Standards Agency dated 22 September 2000. In this Note, the recommended reference procedure for the analysis of Dietary Fibre is an AOAC International method e.g. AOAC 16th Ed.1996 method 991.43 ; AOAC 17th Ed. 2000 method 997.08 (fructans)

This FSA Guidance Note gives no Dietary Reference Value (DRV) for DF determined by the AOAC method but states that the value of 18g (which is based on analysis by the Englyst method) should not be used. A DRV related to the AOAC method is not proposed but will form part of harmonised EC legislation for nutrient claims (see above).

The effect of the FSA Note is that nutrient claims for Dietary Fibre based on an AOAC analysis can not currently be made although the declaration of dietary fibre (AOAC) in the statement of Nutrition Information is permitted. Nutrient claims based on an Englyst analysis

(as indicated in a JFSSG letter dated 26 November 1999) are still valid. These claims for dietary fibre are as follows:

Source of Dietary Fibre
The food must contain at least 3g DF per 100g or per 100ml or 'the reasonably expected daily intake of the food'.

Increased Dietary Fibre
The food must contain at least 25% more than similar food for which no claim is made and must meet the criterion for a **source** claim

High in Dietary Fibre
The food must contain at least 6g DF per 100g or per 100ml or 'the reasonably expected daily intake of the food'.

In January 2007, a Corrigendum to EU Regulation (EC) No 1924/2006 (OJ 409 p9 30.12.2006 on nutrition and health claims made on foods was published, taking effect from 1 July 2007.
http://eurex.europa.eu/LexUriServ/site/en/oj/2007/l_012/l_01220070118en00030018.pdf

This specifies:

Source of Fibre
A claim that a food is a source of fibre, and any claim likely to have the same meaning for the consumer, may only be made where the product contains at least 3g of fibre per 100g or at least 1.5g of fibre per 100kcal.

High Fibre
A claim that a food is high in fibre, and any claim likely to have the same meaning for the consumer, may only be made where the product contains at least 6g of fibre per 100g or at least 3g of fibre per 100kcal.

NUTRITIONAL AND HEALTH EFFECTS

Sources of dietary fibre include vegetables, wheat and most other grains. Foods rich in soluble fibre include fruits, oats, barley and beans.

The nutritional and health benefits of DF continue to be the subject of much study and have been reviewed by many authors, including O'Sullivan (1998) and WHO/FAO (2003).

High fibre foods, because of their consistency, encourage mastication and stimulate the secretion of digestive juices. The soluble components of DF cause an increase in the viscosity of the stomach contents, thereby retarding gastric emptying (Leclere et al, 1994). This then affects the rate of digestion and the uptake of nutrients and creates a feeling of satiety.

Soluble fibre has also been shown to lower selectively serum LDL cholesterol and to improve glucose metabolism and insulin response (Glore et al, 1994).

In the colon, DF tends to increase faecal bulking due to increased water retention and the IDF reduces transit time. This is particularly important since the conversion of sterols to carcinogenic polycyclic aromatic hydrocarbons is known to occur with time. Epidemiological evidence suggests that low faecal weights are associated with an increased risk of cancer of the colon (Burkitt et al, 1972), (Cummings et al, 1982). DF may also bind toxins, bile acids and carcinogens (Reddy, 1980).

In vitro studies have shown that NSP, probably through the carboxyl groups of the uronic acids, can bind divalent cations such as calcium, iron, copper and zinc (Eastwood and Mitchell, 1976), (James et al, 1978). Phytate has also been implicated in this binding action (Davies, 1978). However, *in vivo* studies in humans have shown little effect on the mineral balance except where the levels of phytate are also high (Kelsay, 1978 and 1986). The UK Dept. of Health Report on Health and Social Subjects No. 41 states "Any direct adverse effects of high NSP diets are therefore more likely to be seen in those members of the population whose diet is marginal with respect to mineral content ……"

There is much epidemiological evidence of the role of DF in disease prevention (Ahmed, 1995). Inverse relationships between fibre intake and the incidence of obesity, heart disease, cancers (of the colon and breast) (Bingham et al, 2003), Park et al, 2005), diabetes and gastrointestinal disorders have been reported.

The laxative effects of DF have been long observed and the relief of constipation in the elderly, the pregnant and the young has been documented.

DF may be beneficial in weight reduction (Anderson and Tietyen-Clark, 1986 and WHO/FAO, 2003) and in the control of diseases such as hypolipidaemia and diabetes (Anderson, 1986).

The concept of prebiotics is topical in food development at this time. Essentially, it consists of using food ingredients which are not metabolised by enzymes in the alimentary tract but are fermented by specific microflora of the colon to produce short chain fatty acids, which may have beneficial effects. Prebiotic compounds, unlike dietary fibre, can also encourage the development of micro-organisms such as *Bifidobacter* and *lactobacilli* at the expense of pathogenic species.

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