

Talk given by Dr Peter Ashby to the Food & Drink Innovation Network Fibre Seminar.
30th March 2005. Daventry, Northamptonshire.

A personal view of the Technical and Regulatory issues associated with increasing the dietary fibre content of foods.

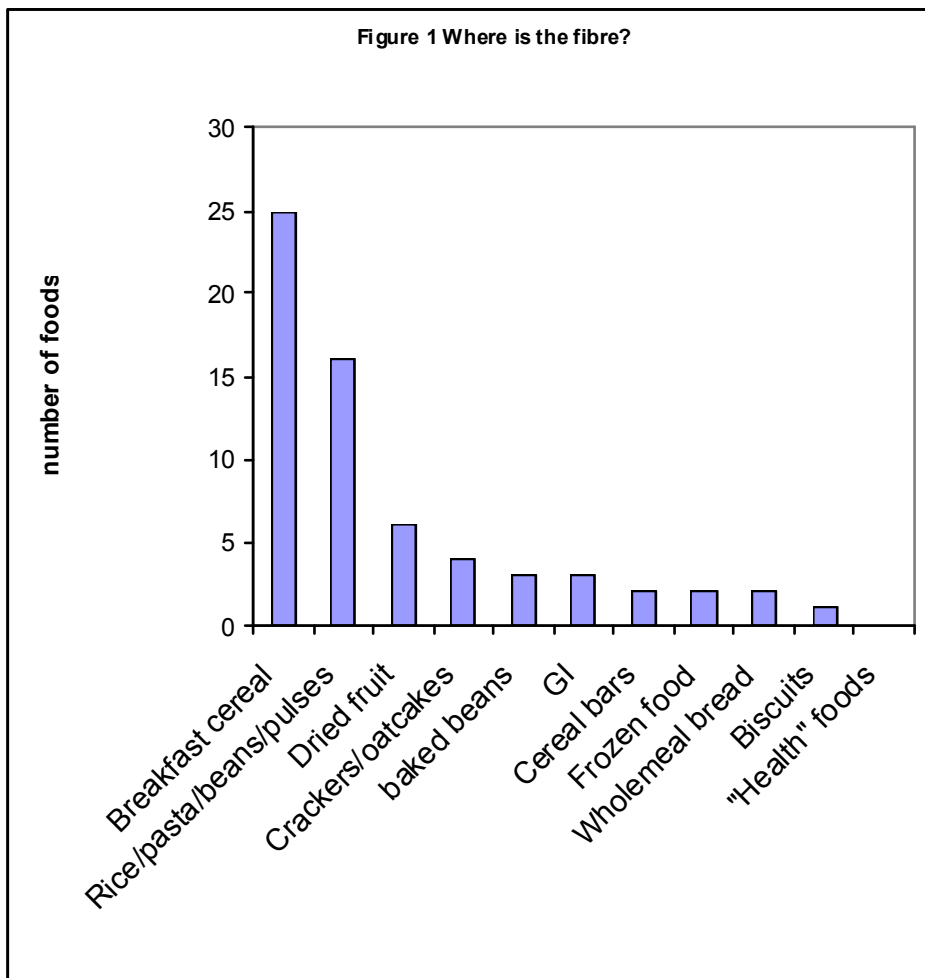
On 9 March 2005 the Department of Health published *Delivering Choosing Health: making healthier choices easier* and said “ a significant proportion of the population consumes less than the recommended amount of fruit and vegetables and fibre....”.

It seems likely that the Food Industry will be invited to help deliver this objective. I found it interesting that the DOH picked out two types of food (fruit and vegetable) and a nutrient (fibre). COMA (1) advised that the food sources for fibre in the British diet are vegetables (50%) and cereal grains (40%). So it will be interesting to see how the policy is translated into advice concerning food choices.

How might the food industry help deliver more fibre in the diet? What problems will product development managers have to consider?

The present marketplace

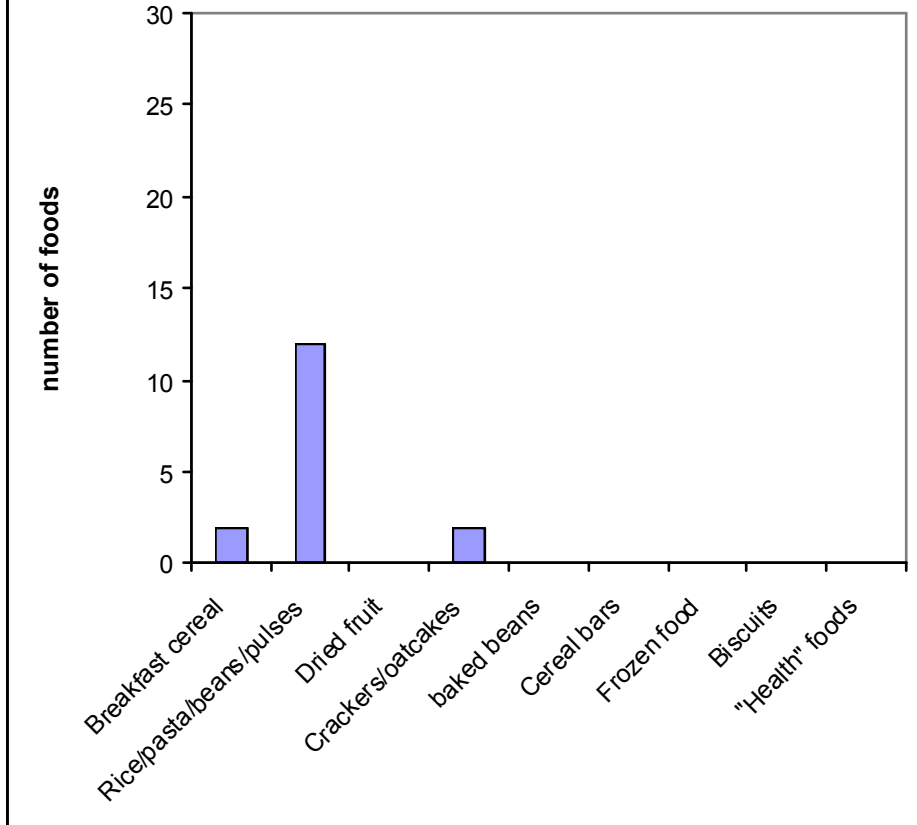
A good place to start is to look at what is presently offered. I went walkabout in a two large supermarkets to see what I could find as an informed consumer hunting fibre and its benefits. My findings are summarized in figure 1.



Breakfast cereal led the pack. At the other extreme the health food and supplements aisle no longer includes any fibre message offerings. Many foods contained enough fibre to make a “good source” claim but did not do so.

I next considered how the picture would look if I excluded foods high in salt or sugar as defined by the Food Standards Agency? That is: more than 0.5% salt or 10% sugar. (Figure 2).

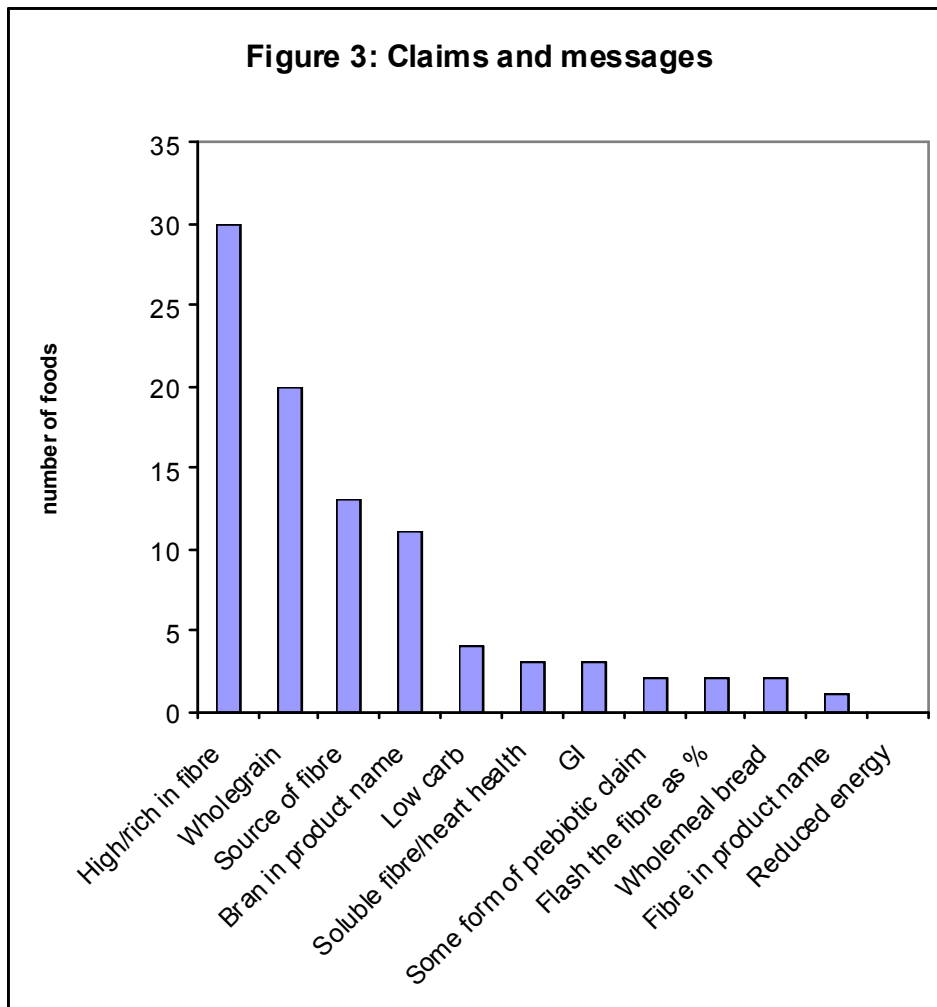
Figure 2: What happens if you eliminate foods judged high in salt or sugar by the criteria of the UK FSA?



Consumer choice becomes much more limited. The same is likely to be true under the traffic light proposals presently being debated.

How is the fibre presently communicated to consumers? I found 10 claims or messages communicating to the consumer that I considered related to fibre.

I'll review them, a few at length, and comment on any issues I see associated with them.



High or rich in fibre: The commonest communication about fibre at present. Most such foods are breakfast cereals so we have created a lot of choice around one meal occasion. For cereal we see products such as the Kellogg fibre franchise, which creates a range of choices for consumers actively seeking high fibre. Porridge can carry both high fibre and cholesterol reduction claims.

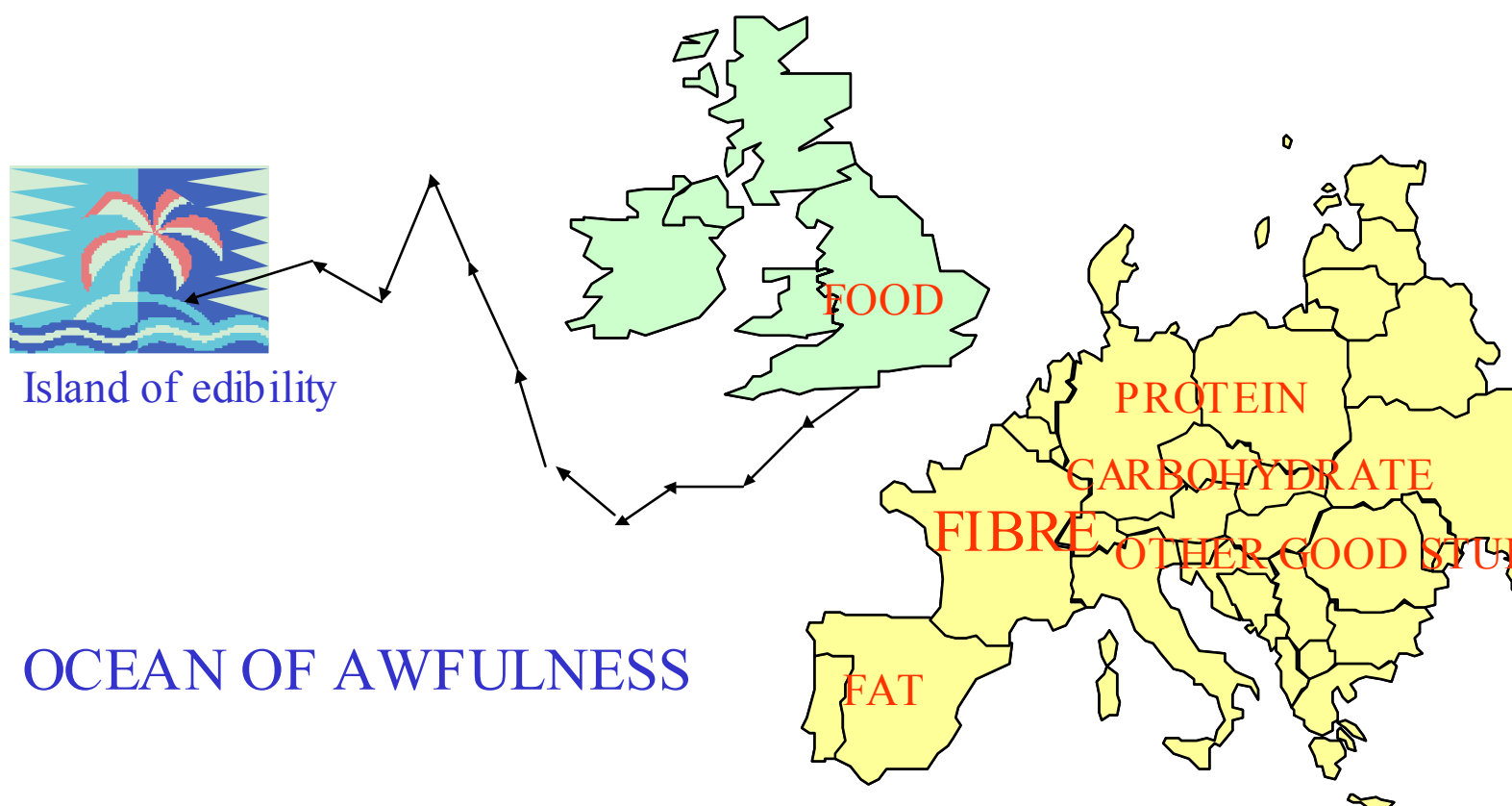
Source of fibre is pretty much the same story as for high fibre. It is a claim to draw the consumer's attention to the fact that there is fibre in the product.

I will discuss under the heading "Analysis of fibre" the justification of such claims and the difference between the UK and the rest of the EU concerning analysis methods.

"High fibre" does lead me to digress into the philosophy of product development. The traditional approach for fibre was to seek out ingredients very rich in fibre and use a lot of them to hit the requirement for the claim. Over the years I have evolved a metaphor for thinking about developments that spotlight nutrients in this way.

I think of myself as a citizen of food, an island off the coast of nutrition (figure 3). We are part of the same continent but there is a distinction. People eat food not nutrients. I notice that when visiting a nutrient for the purposes of a claim it can be considered impolite to mention the existence of other nutrients. Developing a single nutrient in this way is always worrying. It can lead to developers being sent out from the mainland of food to explore the ocean of awfulness in search of an island of edibility. You tend to end up in the Adult Niche archipelago.

Figure 3: a metaphor for the “hard” nutrition project. Any resemblance to any reality is co-incidental.



The high fibre products are a major segment but the niche is well filled. There is a range of choices but they seem to be most favoured by older members of the community. To increase the population average intake of fibre we need either major innovation in the

palatability of fibre or to incorporate lesser amounts of fibre into foods that appeal to other segments of the population. Which brings me to....

Wholegrain

I was interested to see that a declaration of wholegrain is the second most common message. The association of wholegrain with heart health is not made for all of these though the three largest manufacturers of breakfast cereal all make it for some of their products.

Looking back to COMA (1) they stated “Cereals, especially whole grain foods are a rich source of NSP”. However fibre is only a part of the story for wholegrain. There is the fibre benefit and also the additional benefits that are associated with the whole package of the grain. Some grains give more fibre some less. Wheat, maize and rice offer insoluble fibre, oats barley and rye have significant content of soluble fibre. Some grains give more germ, some less, oats has more oil than most cereals but it is very polyunsaturated. For a wholegrain heart health claim there is strict guidance as to the amount of wholegrain that must be present. I have appended a links to the JHCI claim (appendix 1) and the constraints that apply to the similar claim in the USA (appendix 2). If one does not make the claim then one may use lesser but credible amounts of wholegrain. What I believe to be significant about wholegrain is that with different rules and expectations than for “high fibre” one can create a different set of foods from and reach into new groups within the population. This is emphasized by the fact that Shreddies with 80% wholegrain (on a dry weight basis) and 9.8 % fibre and Cheerios with 66 % wholegrain and 6.6% fibre are very popular with children.

The recent growth in interest in wholegrain stemmed in part from a change in US law whereby food manufacturers were invited to petition for health claims if they had substantiating scientific evidence. The American FDA announced “These changes are intended to benefit public health by encouraging manufacturers to use health claims and nutrient content claims that will assist consumers in maintaining a healthy diet”. One could hope that the debate concerning the EU Health Claims Regulation will engender a similar spirit.

In 1999 General Mills successfully petitioned for a new health claim associating wholegrain with the health of the heart. Professor David Richardson created a dossier for CPMK that was approved by the JHCI in February 2002. From a technology perspective very little product development was required. Eighty per cent of CPMK volume was wholegrain. We did assure that we complied with the full FDA constraints for the claim (appendix 2). This meant reducing fat in some products by replacing some coconut with fruit.

The health benefits of wholegrain continue to unfold and earlier this year when the US dietary guidelines were updated there was increased emphasis on the importance of wholegrain in the diet. I believe we could usefully import this trend into the UK because wholegrain can offer fibre and other benefits on or near my mainland of food.

On March 16 of this year General Mills announced that henceforth all of their cereal would contain wholegrain. Their adult and all-family portfolio was already wholegrain. They have solved the problem of introducing wholegrain into their whole portfolio of children's cereal without loss of palatability. Obviously I can't tell you how they solved it. I can tell you that it will be a harder task to follow them in Europe because of the differences in ingredient supply and regulations over here.

Oats and heart health

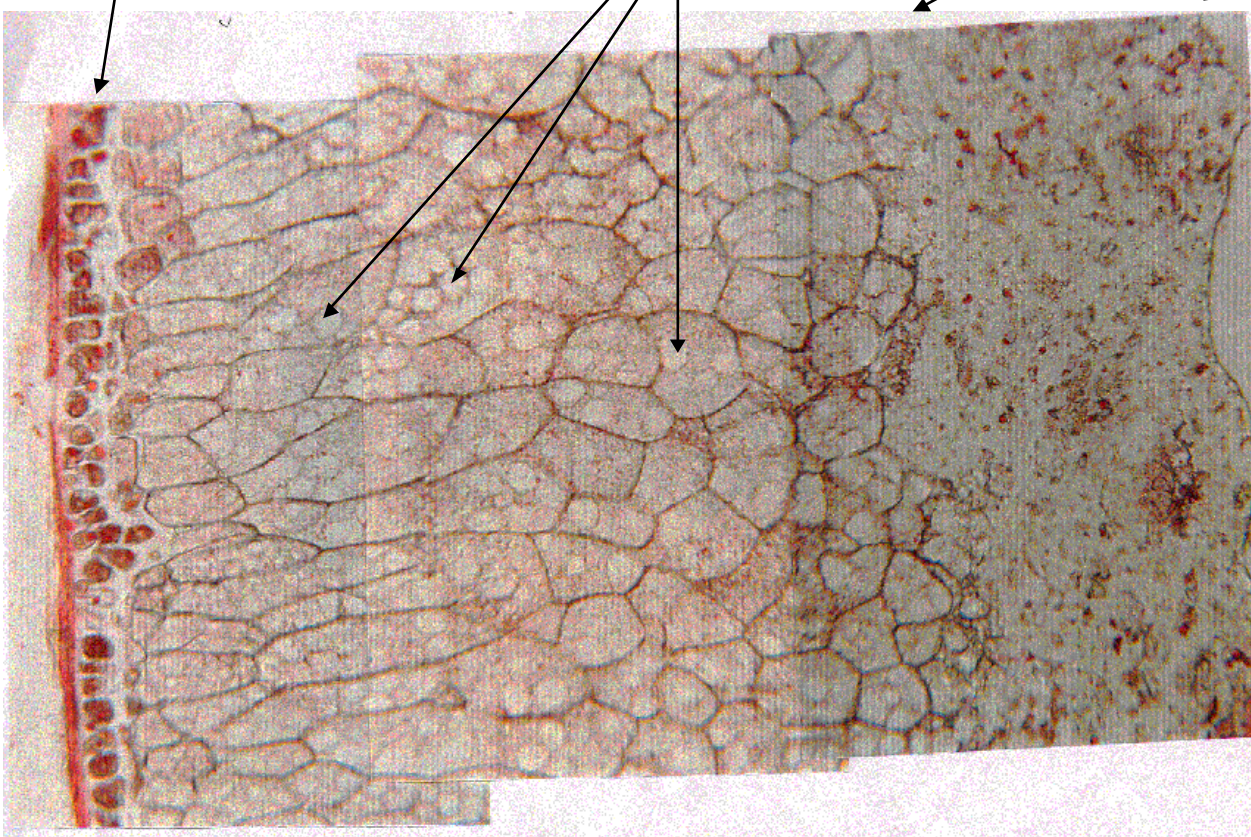
Oats offer a specific health claim that appeals to some consumers and there is now a JHCI approved claim closely modeled on that of the US FDA. (appendix 3) The measurable is no longer fibre as a whole; it is beta glucan. We are presently constrained for ingredients to oat bran, rolled oats and whole oat flour. Barley is in progress as a further source of beta glucan for the USA and potentially Europe or the UK could follow in the future.

We need to deliver 0.75 g of beta glucan per serving to sustain a claim. It is well to be aware that the physiological benefit does hinge on the viscosity of the fibre so if very high shear processes are used there is a need to check that the beta glucan has not been broken down. Suppliers are aware of this and some can help arrange testing

The other issue for oats is the oil content which is higher than for the other cereals and is not neatly located in a germ fraction. There is quite a bit of oil located as droplets in the bran (figure 4). So some attention to prevention of rancidity may be required when a new product is developed. I'll touch on this later under the heading "technological hurdles".

Figure 4 A cooked oat groat stained for lipids

Concentration of lipid droplets in cells below the bran. Starch granules in intact cells Continuous starch gel



The Glycaemic Index

If interest in the glycaemic index is sustained it could offer a new reason for people to eat more fibre. The full frontal way to tackle reduction of GI is to reduce the digestibility of starch. Your ingredient suppliers can tell you about resistant starch that can be purchased off the shelf.

I have seen suggestions that the low GI attributed to some foods could result from their structure. In effect that if the starch granules are swollen and converted but still intact and inside intact plant cell walls then the starch might be less accessible to the digestive enzymes. The micrograph (figure 4) illustrates the concept. You can see intact cells with swollen and gelatinized starch granules in this image of a cooked pinhead oat. It seemed reasonable that these would digest more slowly than starch present as a continuous gel outside cell walls.

We made some measurements on wheat products made by existing low shear processes that leave most of the starch granules cooked and intact. The fact that I'm talking about it tells you immediately the results were negative. The best-packaged starch was digested as quickly as the fully exposed starch. Score one for human evolution in development of a vigorous digestive process.

Prebiotic claims

Prebiotics are fibre. The prebiotic fibres seem to lend themselves better to foods that children in particular find easier to eat than heavy weight wheat fibre. For example Muddles from Kellogg and the prebiotic drinks.

The claims associated with prebiotics are being examined by the French and UK Food Standards agencies. The AFFSA report (appendix 4) is an interesting review.

Low Carb diets

The Atkins diet triggered a burst of interesting developments to fit the desires of LOW CARB dieters. Several of these products declare more than 20% in fibre perhaps present as resistant starch.

Low energy

In the past fibre has been viewed as a direct route to lower energy foods because an energy value of zero was assigned to fibre. Now that we know that fermentation of fibre does provide metabolisable calories to the body it may become harder to sustain a value of zero. Some have suggested that a value of 2 calories per gram may be more appropriate. If this happened it might help move public opinion away from a view of fibre as inert laxative and towards a wider perception of its active role in the body.

What is fibre and how is it measured?

There are three obvious ways for a food industry scientist to view fibre.

First the AACCC definition.

Dietary fibre is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine.

Dietary fibre includes polysaccharides, oligosaccharides, lignin and associated plant substances.

Dietary fibres promote beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation.

This tells us concisely what we eat, what we measure chemically and why we might choose to eat fibre.

The AOAC definition opens the door to purchased ingredients such as polydextrose as “analogous carbohydrates”.

Second the Ashby definition

There are three basic kinds of dietary fibre:

1. There is chemical fibre, which is what can be measured by analysis.
2. There is physiological fibre, which is associated with health benefits
3. There is legal fibre, which may lawfully be declared and which may lawfully be associated with claims.

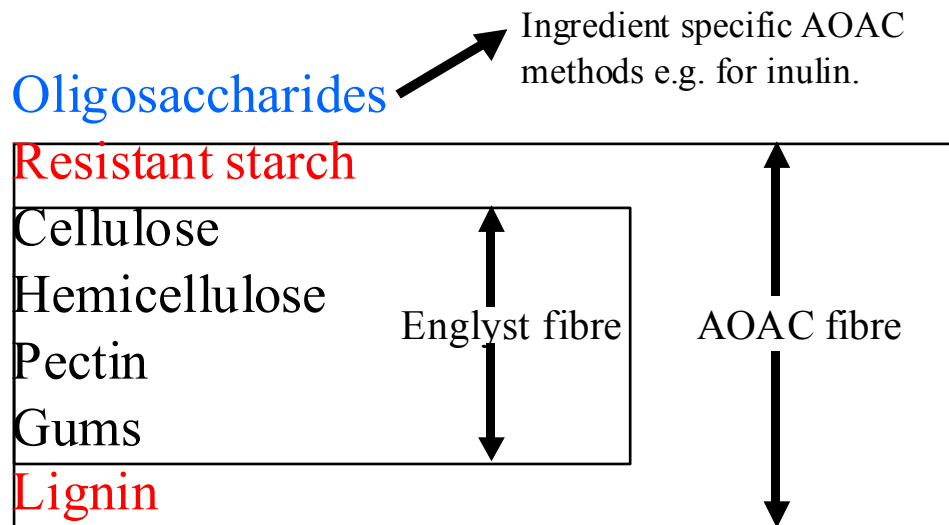
I am only willing to use the third kind of fibre in product development. Am I paranoid? Certainly. You only have to read the news about food to be sure that everyone is out to get you.

I always ask for written assurance that a more processed form of fibre is accepted as fibre and for an analysis result in terms of the appropriate official method for the country to which development is targeted. Nowadays all major suppliers provide the information from the start.

Third the analysts definition

Figure 5 is adapted from a work of Professor Asp and illustrates that two methods are in use and shows that they measure different sets of carbohydrates so they give rise to different answers.

Figure 5 Analysis of fibre for legal labelling



At present UK industry operates to a voluntary accord with the recommendations of the Food Advisory Committee. They advise that any claims relating to fibre should be based on the Englyst analysis for Non-Starch Polysaccharide. The UK Dietary Reference Value is 18g NSP per day.

The rest of Europe and most of the world works to the AOAC method for measuring fibre. There is a letter to industry from Rosemary Hignett, formerly of MAFF now of FSA which cites 24g of AOAC fibre as equivalent to 18g of Englyst fibre for the purpose of the DRV. This ratio does not hold for individual ingredients.

The general practice in the breakfast cereal industry is to declare AOAC fibre. We could otherwise be disadvantaged against cereal imported from mainland Europe. Shoppers using the on-pack declaration to select higher fibre foods would see higher values on imports than on comparable British products. If we make a claim for fibre we would commission and hold on file Englyst method analyses from an independent laboratory. I believe this is a common practice.

As to where we are going

- The Department of Health FAHAP objectives published earlier this month reiterate the 18g per day value and are presumably in terms of Englyst fibre.

- The draft EU regulation on nutrition and health claims includes conditions for claims on fibre. We assume that the regulation is in terms of the AOAC methods accepted everywhere except in the UK.

One hopes that the UK will harmonise with the rest of Europe when the regulation comes into force.

Practical problems associated with fibre analysis

Fibre analysis has generated more problems that reached my desk than any other macronutrient analysis. We sell products over the whole of Europe and this exposes us to many different laboratories. The between-laboratory variation for both the Englyst and AOAC method can exceed the tolerances normally accepted by Enforcement Authorities. Laboratories making single analyses on single samples of food sometimes generate results well outside the normal range. They invariably assume that we are in error rather than making a second test. I have on occasion had to commission analyses at several independent analysts to settle disputes with control laboratories. I don't have any other answer to this problem.

Disappearing fibre:

I am not best pleased to find that fibre can disappear between raw materials and finished product. One may consistently lose 25% between raw wheat and a particular wheat product. This annoys me.

- Not because we are losing value from ingredients.
- Not because we can't analyse the wheat then use a calculated figure for all the products in the factory.

What really annoys me is that I don't know where the stuff has gone. If anyone has an explanation I'd love to hear it later. *(We will test Mike Croghan's suggestion that the raw material contains resistant starch, which is lost in processing. If this is the answer we will consider why we see the phenomenon for some wheat but not other).* The message is: beware of calculation. For fibre it is always safest to analyse the finished product for the declaration.

Technical challenges to increasing fibre content of food.

I have listed below some challenges and issues that warrant a little "constructive worrying".

1) What to replace with fibre

We can increase fibre in two ways:

- Decrease the amount of non-grain constituents.
- Increase the amount of grain and fibre rich grain constituents.

You can't do one without the other but the starting point makes a difference to the way you approach the problem.

An obvious win-win would be to decrease sugar and replace it with grain. If this was easy it would have been done long ago; if only because sugar is the most expensive ingredient in most breakfast cereals. Cereals with no sugar or less than 10% sugar do exist and have a large space in the market place but they don't satisfy everyone. Some people want a sweeter cereal. How can we meet this need and provide more fibre?

The most obvious way to reduce sugar in breakfast cereal is to use intense sweeteners. Products with 75% sugar reduction exist in the USA. New sweeteners such as sucralose and developments with some of the established sweeteners allow the possibility for the sweetener to survive the high temperatures of our processes. The main hurdle in the path of development is that the Sweeteners Directive explicitly prohibits most breakfast cereal formulations from using sweeteners. If this hurdle could be overcome it will then come down to the consumer's trust in the alternative we offer. Europe is at present going through a period of great distrust in the products of technology.

2) Water management:

Fibre and especially high fibre ingredients are often like blotting paper. So a mix may need more water and the consistency may change with time as the fibre absorbs water. This may upset Operations staff using forming equipment and in mixed grain systems the competition for water may leave some ingredients uncooked. Using mixed grains is like cooking spaghetti *al dente* and rice *to tenderness with no excess water* but at the same time in the same pot. Fibre adds to the fun of this. Any competent product developer can solve these problems.

3) Oxidative rancidity

Rancidity is occasionally a hurdle. Problems are less common than was once the case as ingredient suppliers have improved heat treatments of part processed ingredients. Simply de-germing the grain removes most of the oils of the grain. For oats there is more of a hurdle because there is more oil in oats than in other grains and it is not neatly bundled in the germ (figure 4) The red spots in this image are the oil. Notice how it is concentrated in the cells under the bran layer. This can make oats and oat bran an issue at times. Ingredient suppliers can usually help by their pre-processing. However one should not take it for granted that heat treatments or partial de-fating of the raw material will always do the job. It may be necessary to do some process development to optimize shelf life.

For whole grains the germ remains with the grain. The germ contains healthy, unsaturated oils. The hurdle of rancidity is relatively easy to solve in some countries, which permit antioxidants in cereal. It can be harder to overcome in the EU where the most effective antioxidants are prohibited for our category.

4) Acrylamide.

It is generally known that acrylamide is formed when plant derived foods are cooked by any means other than boiling. It is less well known that asparagine; the amino acid precursor of acrylamide appears to be somewhat concentrated in bran (figure 6). One hopes that this will not become a reason for a return to refined grain foods!

Figure 6: Asparagine content of wheat and oat brans and flours.

Asparagine mg/kg	
Wheat bran	112.8
Wheat flour	10.5-18.9
Oat bran	70.8
Oat flour	49.6

5) Mycotoxins

The recent EU proposals for limits on the mycotoxin content of grain bear watching. The mycotoxins, natural fungal toxins are concentrated on the surface of crops. Very low limits could make it more difficult to make fibre rich foods.

The future:

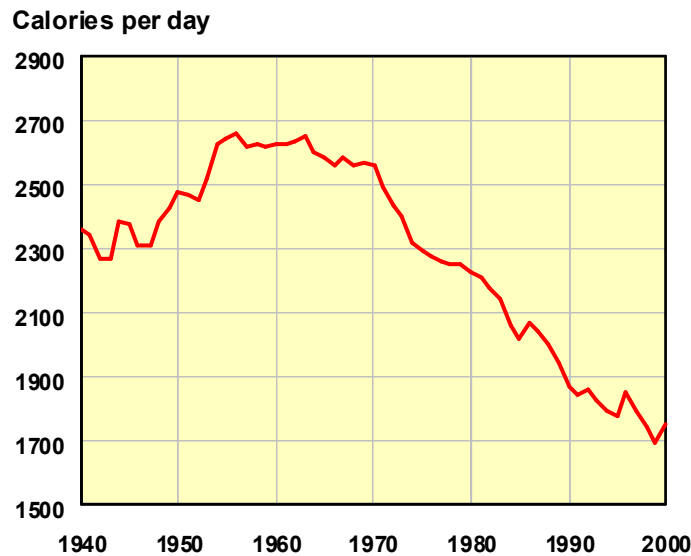
Other speakers discussed consumer behaviour. I think the heart of it is that there are many consumer behaviours. A single approach to fibre – say the “rich in fibre” claim - attracts a set of consumers. There is a need to appeal to other sets; in particular younger consumers. A hard health message and a dark brown, heavy food may not be appropriate for them. Promoting bran flakes on children’s TV is not the way forward!

We need other messages and more foods to attract the people who are not choosing the present fibre options. We need in particular messages that encourage a greater proportion of the public to eat foods with fibre. Encouraging manufacturers to provide even a little fibre where there was none before will, in my opinion, do more at a population level than trying to persuade all of the people to eat high fibre foods.

Do we need food technology and innovation to increase fibre consumption or is there is a simpler way? For example “returning to the natural virtues of diets in the past”. Our real history before agriculture became an industry was of recurring famine. The “natural virtues of the past” were not here for most people before 1800.

The National Food Survey records the energy consumption of the British population as an industrial society since 1940 (Figure 7). What I see from it is that we have never settled down into any stable pattern for even a fraction of a lifetime. We now want to fit more fibre into less food than our people have eaten in the history of the survey. That says to me that we do need some innovation. Education and that level of coercion acceptable in our democracy may have a beneficial effect. New choices of good tasting food can also play a role.

Figure 7 Shooting at a moving target
Food calorie intake for the British population since 1940



Source National Food Survey

References:

- 1) Report on Health and Social Subjects 41: Dietary reference values for food and nutrients in the United Kingdom. HMSO 1991.

Appendix 1



JHCI Generic Claims
wholegrainfoods & h

Appendix 2 Summary of FDA requirements for a wholegrain food heart health claim.
Note that summaries of regulatory constraints can become outdated.

Hurdle 1: To make ANY nutritional claim a food must not contain too much fat, saturated fat, cholesterol or sodium:

“Disqualifying Nutrient levels”

Any of the nutrients below if present in more than the stated quantity per reference amount customarily consumed, **per label serving size** or, when applicable, per 50g will disqualify the food

☐ 13g fat.

Over-riden by requirement that product be low in fat. See below. ☐ 4g saturated fat.

Over-riden by requirement that product be low in saturated fat. See below. ☐ 60mg cholesterol

Over-riden by requirement that product be low in cholesterol. See below.

- 480mg sodium Compliance mandatory.

Hurdle 2 To qualify for the wholegrain claim the food must qualify as "low fat", "low in saturated fat" and "low in cholesterol".

Whole Grain Foods: The food must meet the criteria for

“low fat” which are: $\leq 3g$ fat per reference amount customarily consumed (and per 50g if reference amount customarily consumed is 30g or less) **“low saturated fat”** which are: $\leq 1g$ sat fat per reference

amount customarily consumed and < 15% of calories from saturated fat “**low cholesterol**”” which are: contains ≤ 20 mg cholesterol per reference amount customarily consumed and contains ≤ 2 g saturated fat per reference amount customarily consumed.

Hurdle 3 The wholegrain itself

The food must contain all portions of the kernel The food must contain 51% whole grain ingredient(s) or more by weight [fiber level will be used to verify compliance]. It must also provide a minimum of 16 grams of whole grain per reference amount customarily consumed.

Cautionary comments:

Whole grain must be expressed as dry weight of the wholegrain as a percentage of final product. *The moisture content of the final product is included in its weight* So the hurdle is higher than if EU style QUID thinking were applied.

The condition "It must *also* provide a minimum of 16 grams of whole grain per reference amount customarily consumed," means that you actually need 53.33% wholegrain to qualify if the serving size is 30g ($16 \times 100 / 30 = 53.33\%$).

Appendix 3



JHCI Generic Claims ·
oats and reduction of

Appendix 4 Effects of probiotics and prebiotics on flora and immunity in adults.
AFFSA February 2005 The document is in French and in English.