Labelling Review Recommendation 14 – Supporting Document 1

Practicality and feasibility of differentiating natural from total dietary fibre

Executive Summary

'Dietary fibre' covers a group of chemically and structurally diverse substances that are largely, but not exclusively, carbohydrates. The types of dietary fibre that are found naturally in foods, or added through minimally-processed ingredients such as bran, overlap in composition with those that can be added from refined sources. These refined fibres include fibres purified or concentrated from natural sources and those that have been synthesised.

Under Standard 1.2.8 of the Food Standards Code, declaration of dietary fibre content is not mandatory. If a declaration is made voluntarily, only the total dietary fibre content is required and must be determined by one of the methods of analysis specified in that Standard. In a recent Food Standard Australia New Zealand (FSANZ) survey of foods carrying label claims about their dietary fibre content, naturally-occurring dietary fibre was contributed by ingredients such as wholegrain cereals and wholemeal cereal flours, brans, nuts, seeds, dried fruit, vegetables, legumes, legume flours, resistant starch and BARLEYmax™ grain or flour. Sources of refined dietary fibre that appear to be most commonly added to foods were inulin/oligofructose, polydextrose, psyllium and soy fibre. Other than polydextrose, all of these refined dietary fibres can also be obtained naturally from foods through consumption of certain vegetables, psyllium husks or soy beans/flours. Food groups that contained refined dietary fibre included breakfast cereals and drinks, breads, muesli bars and yoghurts. Among the products identified that contained refined dietary fibre and made label claims about fibre content, almost all contained naturally occurring dietary fibre as well.

Although there are a range of methods of analysis that allow measurement of total dietary fibre with reasonable accuracy, these methods overlap in the fibre types they capture and there is no readily available method of analysis that clearly distinguishes and quantifies the naturally occurring dietary fibre separately from total dietary fibre where both natural and refined fibres are present. Although methods of analysis have been developed for some fibre types, including inulin, these methods do not identify whether the substances are naturally occurring or added, they are expensive and are specific only to those particular compounds. There are no such generally accepted equivalent tests for more complex refined fibres containing a mixture of fibre types, such as soy fibre.

At present the only feasible alternative to direct analysis, for estimating amounts of naturally occurring dietary fibre compared to total dietary fibre, is for manufacturers to estimate the amount of refined dietary fibre from the formulation of their product and to subtract this value from the total dietary fibre of their food. To do so the manufacturer needs to know the level of dietary fibre in their refined ingredient. National food composition tables and nutrition labelling tools for Australia and New Zealand do not contain the information required for manufacturers to use these information sources for these labelling purposes and would need to undergo substantial modification if a requirement to label naturally occurring dietary fibre separately from total dietary fibre were to be mandated.

The key physiological effects of dietary fibre are identified in the definition of dietary fibre used in Standard 1.2.8 of the Code – one or more of laxation, reduction in blood cholesterol and modulation of blood glucose. The refined dietary fibre types in common use as fibre sources all display at least one of these effects and therefore differences in physiological effects cannot be used as a way of distinguishing naturally occurring and refined dietary fibre. Dietary fibres may also affect the growth of specific gut bacteria and inulin and other oligosaccharides, in particular, appear to have this effect. However, this effect is not part of the regulatory definition of fibre at present.

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1. Purpose

This report has been prepared to address aspects of Recommendation 14 of the *Labelling Logic* report on food labelling law and policy (2011). The purpose of this report is to assess whether it is practical and feasible to differentiate the naturally occurring dietary fibre content of a food separate to its total dietary fibre content.

The following subject matters are considered:

- Types of dietary fibre
- The range of fibres used in the food supply
- Analytical techniques for measuring dietary fibre
- Alternative techniques for estimating levels of naturally occurring and total dietary fibre
- Physiological effects of dietary fibre, particularly refined dietary fibre.

In this report, naturally occurring dietary fibre is defined as dietary fibre that is intrinsic to a food or that has been contributed by ingredients that are not highly refined, purified or synthesised. In contrast, highly refined, purified or synthesised substances ('refined dietary fibre') means dietary fibre substances that meet appropriate specifications for identity and purity under Standard 1.3.4 of the Australia New Zealand Food Standards Code ('the Code'), or are otherwise supplied in a refined and/or concentrated form. Total dietary fibre is the sum of naturally occurring dietary fibre and refined dietary fibre.

This report is organised such that the content addresses each subject in turn. Each section contains a key points summary, showing the main messages from the research in that area.

2. What types of dietary fibre substances are naturally occurring in foods?

Key points

- The definition of dietary fibre in the *Australia New Zealand Food Standards Code* covers a wide range of substances, mostly carbohydrates. A large number of plant-derived naturally occurring and refined dietary fibre substances conform to the definition.
- Most foods do not contain a single type of dietary fibre. A range of different naturally occurring dietary fibres can be present in food, and ingredients containing some of these naturally occurring dietary fibres can be added to the food to further increase the dietary fibre content of the food.

2.1 Defining dietary fibre

Defining 'dietary fibre' has been a contentious issue over several decades because the term does not refer to a single chemical entity but to a range of substances of varying composition that have a common feature of resistance to digestion in the small intestine. Definitions of dietary fibre have evolved over time as analytical methods and understanding of the composition of foods has evolved (McCleary et al, 2012; Miller Jones, 2013; Philips, 2013).

The definition in the Code is similar to that of Codex Alimentarius. Standard 1.2.8 of the Code defines dietary fibre as meaning "that fraction of the edible part of plants or their extracts, or synthetic analogues that –

(a) are resistant to the digestion and absorption in the small intestine, usually with complete or partial fermentation in the large intestine; and
(b) promote one or more of the following beneficial physiological effects –
(i) laxation;
(ii) reduction in blood cholesterol;
(iii) modulation of blood glucose;

and includes polysaccharides, oligosaccharides (degree of polymerisation > 2) and lignins."

A wide range of substances are encompassed by this definition. Typically, these substances are carbohydrates but some other substances, such as lignin, waxes also meet the definition. Figure 1 provides a schematic of the major types of substances that meet the Code definition of dietary fibre.

The term 'degree of polymerisation' (DP) refers to the number of monomers (generally sugars) that are bound together to form a larger compound. Generally, when between three and 20 monomers are joined, the resultant substance is referred to as an oligosaccharide (Miller Jones, 2013) and sometimes described as being of 'low molecular weight'. Where more than 20 sugars are joined, the substance is termed a polysaccharide. The molecular weight of polysaccharides differs enormously but for purposes of analysis they are generally referred to as 'high molecular weight' polymers. Polysaccharides may contain hundreds or thousands of sugar units bound together in complex physical structures.

Different dietary fibres are sometimes also described as being 'soluble' or 'viscous' (typically includes glucans, gums, oligosaccharides and pectins) or 'insoluble' (includes cellulose).

By limiting the definition of dietary fibre to parts or extracts of plants, or their synthetic analogues, the Code definition does not capture substances that are derived from animal extracts that are not digested in the small intestine but do exhibit one or more of the physiological effects noted in the definition of dietary fibre (e.g. chitosan). The Code also does not limit the definition to carbohydrate substances.

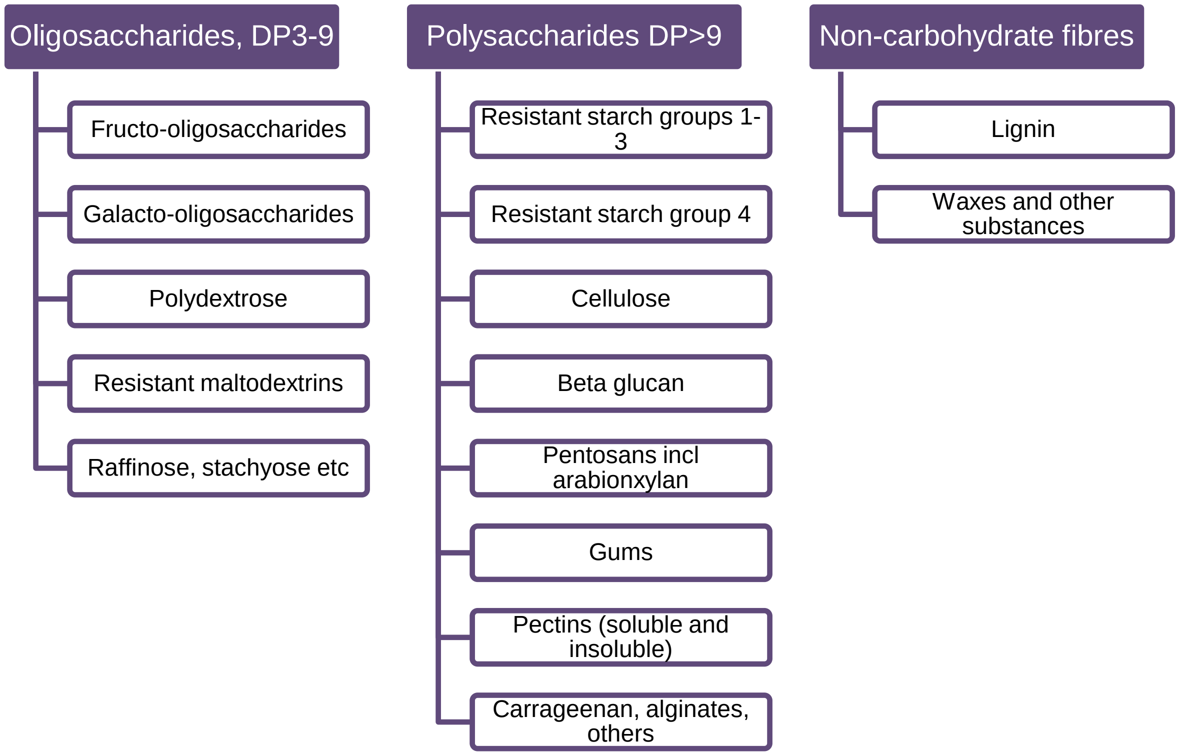


Figure 1. Major types of dietary fibres, by composition and size (based on Westenbrink et al 2013).

2.2 Types of dietary fibre in foods

Most dietary fibre substances are carbohydrates (compounds based on the elements carbon, oxygen and hydrogen) and most, but not all, are based on the monosaccharide glucose.

For carbohydrate-based dietary fibres, different types are characterised by differences in the number and types of monomers, the types of bonds that join these monomers and lead to straight or branched/twisted chain arrangements, and the presence of other non-carbohydrate compounds such as methyl groups and sulphur (Elleuch et al, 2011).

The major classes of dietary fibre derived from plant foods are:

- **Celluloses:** non-starch polysaccharides comprised of varying numbers of glucose units (up to 10,000) bonded in linear arrangements. It differs from starch in the way in which these glucose units are linked, making cellulose indigestible in the small intestine as humans do not produce the enzyme required to break down these links (Gray, 2006, IOM, 2005). It is the main structural component of plant cell walls (Viuda-Martos et al, 2010).

- **Hemicelluloses:** non-starch polysaccharides, but are composed of sugars other than or in addition to glucose. These sugars can be five-carbon sugars or ‘pentoses’ (including arabinose and xylose) or six carbon sugars (‘hexoses’, such as glucose, rhamnose and galactose). Hemicelluloses are generally found with cellulose in plant cell walls but can be branched as well as linear in structure and are generally smaller in size than cellulose (Gray, 2006, IOM, 2005). Arabinoxylan, which contains the sugars arabinose and xylose, is an example of a hemicellulose and is usually extracted from wheat bran and endosperm, (Bernstein et al, 2013, Lu et al., 2000).

- **Beta glucans**, which are typically extracted from oats and barley but also found in other plants including fungi, are also glucose-based hemicelluloses. They are smaller in size than cellulose and linear in structure (Bernstein et al, 2013; Gray, 2006, IOM, 2005) and have some different linkages between monomers. BARLEYmax™ is a cultivar of barley with altered starch synthesis, leading to a lower total starch content, a higher proportion of non-starch polysaccharides including beta glucans (Keogh et al, 2007).

- **Pectins:** a class of complex plant polysaccharides that may contain a number of sugar monomers including galacturonic acid, rhamnose, xylose and apiose in very complex arrangements (Onumpai et al, 2011). Pectins are found in a wide range of plants but certain fruits (e.g. apples) are rich in them. They can become viscous when mixed with water. Some authors consider pectins to be a class of hemicellulose (Bernstein et al, 2013).

- **Gums and mucilages**: carbohydrate-based substances that are generally found in seed coats (e.g. guar gum, which is predominantly glucomannan), plant exudates (e.g. gum arabic) and seaweeds (e.g. carrageenan), and which become viscous when mixed with water (Kristensen & Jensen, 2011). The term ‘mucilage’ generally refers to sticky extracts such as that from psyllium husk (Gray, 2006) or other seed coats (Viuda-Martos et al, 2010).

- **Oligosaccharides**: carbohydrate polymers that can be based solely on glucose (e.g. maltodextrins), or other sugars. Inulin is one type of oligosaccharide found naturally in plants such as onions, Jerusalem artichokes and chicory, with small amounts also reported in wheat and asparagus (Gray, 2006; Nair et al, 2010). Inulin is composed largely of fructose monomers, but does contain some glucose (Flamm et al, 2001). Many resistant dextrins are also oligosaccharides, and are produced by breaking down starch, which is glucose based, into smaller units using heat, acid and/or enzymes (IOM, 2005).

- **Resistant starches:** starches that are wholly or partly indigestible in the small intestine because of their natural physical structure (such as in raw bananas, some maize starches) or changes to their structure as a result of cooking, cooling, storage or processing (Gray, 2006; DeVries and Rader, 2005). Plant breeding techniques have enabled the production of cereal flours with a higher than usual resistant starch content, such as Hi-maize™ starch from a maize flour that was bred to contain more resistant starch than usual (Morita et al, 1997, Lunn & Buttriss, 2007).

- **Lignins**: substances based on highly branched phenol-compounds (IOM, 2005, Elleuch et al, 2007), and are not carbohydrate-based but often occur together with celluloses and other carbohydrate fibres (Gray, 2006). Waxes are lipid-based indigestible compounds.

Most, if not all of these types of dietary fibre can be extracted or purified from foods rich in them. For example, naturally occurring cellulose can be purified from cereals and supplied as a relatively pure ingredient that can be used for a range of functions in foods or other products such as paper (for example see http://purelignin.com/lignin).

Most foods that contain naturally occurring dietary fibre will contain more than one type of dietary fibre, even when no refined dietary fibre is added. For example wholemeal bread with added grains may contain cellulose from wheat endosperm, arabinoxylan from wheat bran, other non-starch polysaccharides from other cereal grains such as barley, lignins from added bran and wheat germ, and resistant starch that forms in the wheat flour during baking (Bernstein et al, 2013).

3. What are the technical and practical considerations when distinguishing natural dietary fibre from refined dietary fibre?

Key points

- There is no clear separation, either chemically or by function, between those dietary fibre substances that are naturally occurring and those that are refined dietary fibre.
- Those foods that contain refined dietary fibre can also contain naturally occurring dietary fibre, and some of this naturally occurring dietary fibre will be the same substance as the refined dietary fibre.

Dietary fibre levels can be boosted in foods through the addition of a range of ingredients derived from basic foods, along a continuum of purity. For example, wholemeal wheat flour can be added to white flour to boost fibre content during bread making. Alternatively, the wheat bran separated from the wholemeal wheat flour could be added back to the bread dough, or refined wheat endosperm containing high levels of fibrous material (e.g Vitacel®

wheat fibre) could be added. The point at which these fibre sources move from being ‘naturally occurring dietary fibre’ to ‘refined dietary fibre’ is not always clear cut. However in this report we have considered a fibre source to be refined dietary fibre when it is supplied in a form that contains very high fibre levels through extraction or purification from natural sources, or where it is synthesised or deliberately modified. Fibre sources that have specifications for identify and purity set out in Standard 1.3.4 of the Code, or are captured under the definition of food additive in Standard 1.3.1 of the Code[1], are also considered to be refined dietary fibre.

Some other fibres used in food processing that could be considered as either naturally or refined dietary fibre, depending on how refined they are and how they are used, include soy, pea, oat, linseed and lupin fibres, all of which could also be added as an intact food (e.g. as soy and other legume flours, oat flakes or linseed meal). Soy fibre is a mixture of types of fibre (including cellulose, hemicellulose, lignin and pectin) that is obtained from soy cotyledon as a by-product of tofu and soy milk production (Snyder, 2003; Chen et al, 2010). Pea fibre is obtained from the hulls of the field pea and contains hemicelluloses, cellulose, and pectins (Klosterbuer et al, 2011). Lupin fibre is derived from the endosperm of *Lupinus Angustifolius*, which appears to be composed primarily of pectin-like substances (Turnbull et al., 2005). The level of measured total dietary fibre within refined wheat, soy, lupin and pea fibres ranged from 46-90%, compared with purified cellulose that contained 97% fibre (Turnbull et al., 2005). Starches or flours containing highly concentrated resistant starch levels are now available (e.g. Netrition corn starch 260).

Psyllium is another example of the complexity of deciding when fibre becomes refined. Psyllium is the cleaned and dried seed husk of Plantago species, including *Plantago ovata* (US Pharmacopeia, 2006). It can be consumed directly as psyllium fibre but is also used as a food and pharmaceutical ingredient.

Of the synthesised and modified fibres, the most commonly used in food products are inulin/oligofructose, polydextrose and chemically modified starches and dextrins.

Although food-grade inulin is usually obtained by extraction from natural sources such as chicory, it can be synthesised from sugars, usually sucrose (a disaccharide of glucose and fructose). When extracted from a plant source, inulin may contain mixtures of oligo- and poly-saccharides with a DP of up to 60 (Hager et al, 2010; Nair et al, 2010) but refined inulin (commonly referred to as ‘oligofructose’) contains only oligosaccharides (DP of 2-8) (Alexiou & Frank, 2008, Klosterbuer et al, 2010). ‘Short-chain fructooligosaccharides’ refers to fructose-based oligosaccharides, produced by enzyme-induced condensation of sucrose or enzyme-induced breakdown of inulin, which have a DP of five or less (FSANZ, 2013).

Polydextroses and modified polydextroses are synthesised directly from carbohydrate monomers and do not occur naturally. Polydextrose is a non-digestible glucose polymer produced catalytically from glucose in the presence of sorbitol, with an average degree of polymerisation of 12, but ranging up to 100. It is a branched molecule with a range of bond types (Gray, 2006, Putaala, 2013).

Resistant (malto-)dextrins are produced by treating starch with heat and enzymes to produce smaller compounds with around 15 glucose units where the linkages between monomers have been changed so they are no longer able to be broken by intestinal enzymes (Viuda-Martos et al, 2010). Starches and cellulose can also be chemically modified to make them

[1] Standard 1.3.1 defines a food additive as being any substance not normally consumed as a food in itself and not normally used as an ingredient of food, but which is intentionally added to a food to achieve one or more of the technological functions specified in Schedule of that Standard. Food additives have specifications of identify or purity. However some food ingredients also have specifications of purity.

resistant to digestion and to provide other beneficial properties for food processing purposes (Gray, 2006). Soluble maize fibre is produced by hydrolysis of maize starch and contains a mixture of different bonds between glucose molecules (Timm et al, 2013).
For foods that contain refined dietary fibre, most will also contain naturally occurring dietary fibre and some of this naturally occurring dietary fibre can be the same substance as the refined dietary fibre. For example, strawberry jam will contain naturally occurring dietary fibre from the plant cell walls, including naturally occurring pectin, as well as additional refined pectin to enhance jam setting (refer to boxed text below); a breakfast cereal containing added oligofructose or psyllium would also contain natural fibres from the cereal ingredients.

Jam

Pectin, a dietary fibre substance, is required for jam to set. Pectin dissolves when fruit is boiled with sugar to make jam. Pectin forms into a jelly when the boiled jam cools.

Pectin is found naturally in fruits in varying amounts. Some fruits are high in pectin, such as apples and citrus skins, while others are not. The concentration of pectin is higher in unripe fruit because the process of ripening breaks down the pectin and softens the fruit.

Where pectin levels are naturally low in a fruit, e.g. strawberries, a source of pectin must be added to make such fruits into jam. Traditionally, strawberries would have been boiled together with some apples or perhaps lemon peel to make strawberry jam. It may have been difficult to produce a consistent jam through these cooking methods because the thickness of the jam depends on the amount of pectin present.

Pectin is available commercially in powdered or liquid forms to be used in jam making. Commercial pectin is produced by extracting it from natural sources like apples.

All jam contains pectin. Strawberry jam will contain pectin that has been added because strawberries are a low pectin fruit. Blackberry jam, by comparison, may or may not require added pectin, depending on how ripe the blackberries were that were used to make the jam. Firm blackberries may contain enough of their own pectin to enable them to be made into jam. Very ripe blackberries probably could not be made into jam unless pectin was added.

Therefore, depending upon how one chooses to define naturally occurring dietary fibre the fibre in jam from pectin may be there naturally, or it may not.

Table 1 identifies a range of refined dietary fibre substances that may be used in food to boost total dietary fibre content but also for a variety of other functions. These purposes may include gelling, thickening, stabilising, bulking, firming, emulsifying, as suspension agents, humectants, texturisers, anticaking agents or binding agents. Some have the potential to be used as fat replacers or prebiotics (Alexiou & Frank, 2008; Nair et al, 2010).

Table 1: Purity specifications for refined dietary fibre substances

Substance	Function	INS number	CAS number	Primary source(s): (a)(b)(c)[2]	Secondary source
Arabinogalactan or Larch Gum	Dietary fibre, humectant, stabiliser	409	9036-66-2	(c)	
Beta glucan from baker's yeast	Nutrient	-	-	(c)	
Carob bean gum (locust bean gum)	Thickener, stabiliser, emulsifier, gelling agent	410	9000-40-2	(b) and (c)	
Cellulose gum	Thickening agent, stabiliser, suspension agent	466	9004-32-4	(b) and (c)	
Cellulose, powdered (microcrystalline)	Anticaking agent; binding agent; bulking agent; dispersing agent; filter aid; texturizing agent; thickening agent	460ii	9004-34-6	(b) and (c)	WHO International Pharmacopoeia and Japan's Specifications & Standards for Food Additives
Cross-linked cellulose[3] gum	Tabletting agent	468		(b)	
Curdlan Beta-1,3-glucan	Firming agent, gelling agent, stabiliser, thickener	424	54724-00-4	(b) and (c)	
Dextrin[4] (roasted starch) (see modified starches)	Thickener, colloidal stabiliser, binder, surface-finishing agent	1400	9004-53-9	(b) and (c)	
Fructooligosaccharides, short chain (FOS)	Bulking agent, source of dietary fibre, sweetener, prebiotic	-	-	(c)	

[2] There are three primary sources under clause 2 of Standard 1.3.4 of the Code: **(a)** the Schedule to Standard 1.3.4; **(b)** the FAO JECFA Combined Compendium of Food Additive Specifications; and **(c)** the Food Chemicals Codex (8th edition).

[3] There are 20 additives with the key word 'cellulose' in their name in the JECFA Combined Compendium of Food Additive Specifications. They have INS numbers around 460. An incomplete list has been provided here for illustrative purposes only.

[4] There are ten additives that have 'dextrin' in their name in the JECFA Combined Compendium but none are identified therein as resistant dextrin.

Substance	Function	INS number	CAS number	Primary source(s): (a)(b)(c)[2]	Secondary source
Gellan Gum	Stabiliser, thickener	418	71010-52-1	(b) and (c)	Japan's Specifications & Standards for Food Additives
Guar gum[5]	Thickener, stabiliser, emulsifier	412	9000-30-0	(b) and (c)	Japan's Specifications & Standards for Food Additives
Inulin	Source of dietary fibre, binder, bulking agent, texturizer	-	9005-80-5	(c)	
Isomaltulose	Not stated	-	-	(a)	
Modified starches (n=16) (includes dextrin) (amyla-starches)	Thickener, stabiliser, binder, emulsifier	Several 1400-	9005-25-8	(b) and (c)	WHO International Pharmacopoeia
Pectins	Gelling agent, thickener, stabiliser, emulsifier	440	9000-69-5	(b) and (c)	Japan's Specifications & Standards for Food Additives
Polydextrose (modified polydextroses)	Bulking agent, humectant, texturiser (stabiliser, thickener)	1200	68424-04-4	(b) and (c)	
Polydextrose solution	Bulking agent, humectant, texturiser	-	-	(c)	
Psyllium husk	Not stated				United States Pharmacopeia
Resistant maltodextrins	Not stated	-	-	(a)	
Sugar Beet Fibre	Anticaking agent; binding agent; bulking agent; dispersing agent; source of dietary fibre; stabilising agent; texturising agent; thickening agent	-	-	(c)	

[5] There are 38 additives with 'gum' in their name in the JECFA Combined Compendium of Food Additive Specifications. A select few have been included in this table.

4. What New Zealand and Australian foods contain refined versus natural dietary fibres?

In order to identify the major types of dietary fibres added to foods, FSANZ undertook a small, qualitative survey of foods available in 2013 that carried claims or statements relating to their dietary fibre content.

Key points

- Among products that carried label claims relating to fibre, around half contained refined dietary fibre.
- Among products containing refined dietary fibre, very few contained only refined dietary fibre. Most foods that contained refined dietary fibre contained naturally occurring dietary fibre as well.

4.1 Methods

FSANZ staff surveyed the label information for over 100 foods available in a single outlet of a major Australian supermarket chain in September 2013, where those foods carried specific label statements about the fibre present in the food, including declaration 'fibre' as an ingredient. The survey identified the specific claims made, the declared total dietary fibre content per 100 g of the food, and the ingredients that could be contributing to total or refined dietary fibre content. The use of fibre claims by manufacturers is voluntary.

The survey ascertained specific information for foods where the label contained prominent statements (including nutrition content and health claims) in relation to fibre, but not foods whose only label reference to fibre was a declaration of dietary fibre content within the product's nutrition information panel (NIP). The survey also estimated the proportion of products within an overall category that were carrying dietary fibre content claims, using four qualitatively-assessed groups: none, 'low', 'around half' and 'high'. This qualitative assessment was based on the number of identified products in relation to the total number available adjacent to it in that category.

This survey is clearly a snapshot only and is not representative of all foods that make dietary fibre claims. However, FSANZ considers it is sufficient to identify major trends in this area.

The resultant data were grouped into three categories:

- foods whose fibre was solely derived from natural sources (including the addition of unpurified fibre rich ingredients such as whole oats, legume flours, brans and high resistant starch cereals)
- foods containing both naturally occurring and refined dietary fibre
- foods whose fibre was derived almost entirely from refined dietary fibre.

A refined dietary fibre ingredient was considered to be one of those ingredients identified in Table 1 (including psyllium husks), or one where the ingredient was named in the food's ingredient list as being 'fibre'. Because refined dietary fibre ingredients may be added to foods for purposes other than increasing fibre content, it is not always clear which particular technological function some ingredients were performing. Where products with fibre claims contained gums and starches, which could be contributing fibre, they also contained ingredients such as inulin or other fibre sources.

Although this snapshot survey was only carried out in Australia, it included products that are made and are available in both Australia and New Zealand.

4.2 Results

The full results of this qualitative survey are shown in Appendix 1.

Naturally occurring dietary fibre was contributed by ingredients such as wholegrain cereals and wholemeal cereal flours, brans, nuts, seeds, dried fruit, vegetables, legumes, legume flours, resistant starch and BARLEYmax^{TM}.

Among products that carried label claims relating to fibre, around half contained refined dietary fibre. The main types of refined dietary fibre added to foods were, in approximate descending order, inulin, polydextrose, soy fibre and psyllium. Inulin (including products declaring they contained oligofructose or vegetable fibre) was present in a range of product categories including a number of gluten free products. Polydextrose was largely used in products targeted towards weight reduction. Other refined fibres identified included 'wheat fibre', 'oat fibre', 'pea fibre', various gums, maltodextrin and pectin.

Among products containing refined dietary fibre, very few contained only refined dietary fibre. Most foods that contained refined dietary fibre contained naturally occurring dietary fibre as well.

Product categories where a substantial proportion of products carried fibre claims included breads, breakfast cereals and muesli style bars. In breads and bars, average total dietary fibre content was higher in products containing refined dietary fibre than similar ones without. In contrast in breakfast cereals, products without refined dietary fibre had a higher average total dietary fibre content, but these products were more likely to contain high proportions of wheat bran or to contain BARLEYmax^{TM}.

In some cereal-based product categories, where relatively few products carried claims relating to fibre, a number of products instead made claims relating to the wholegrain content of the food.

Product categories where no fibre claims were identified included fresh or shelf stable fruit and vegetable juices, fresh or shelf stable milks including milk alternatives, fresh or canned fruit, dips and sauces, meats and meat products, confectionery and cakes. Some of the foods in these product categories do contain fibre, while others do not.

5. Are there methods that can be used to estimate natural dietary fibre levels separate from refined dietary fibre levels in foods?

Key points

- There is no readily available method of analysis that clearly distinguishes naturally occurring dietary fibre from total dietary fibre unless the food contains no refined dietary fibre.
- Manufacturers could estimate the amount of refined dietary fibre from the formulation of their product and subtract this value from the total dietary fibre of their food to obtain a naturally occurring dietary fibre value.
- However, national food composition tables and nutrition labelling tools for Australia and New Zealand currently do not contain the information required for manufacturers to estimate natural dietary fibre by recipe. These composition tables and tools would need to undergo substantial modification if a requirement to label naturally occurring dietary fibre separately from total dietary fibre were to be mandated.

5.1 Direct laboratory analysis

Plant cell walls are often complex arrangements of different types of dietary fibre substances which can be difficult to separate (Chesson, 1995; Pena et al., 2001; Raninen et al., 2011). Measurement of dietary fibre levels in foods has been one of the most challenging and controversial areas of nutrient analysis for many years. In the early 1990s two different methods of quantifying total dietary fibre analysis were developed, one that measured non-starch polysaccharides only (and hence did not capture resistant starch, lignin or oligosaccharide fibres) and another that captured most polysaccharide fibre sources as well as non-carbohydrate fibres, but not oligosaccharide fibres. Proponents of the former method considered it gave a better estimate of fibre derived from plant foods, while proponents of the second method considered it was a better measure of all major sources of dietary fibre, including most (but not all) resistant starches (Westenbrink et al, 2013). The latter method (AOAC 985.29) was eventually adopted by Codex for determining dietary fibre content and is adopted in Standard 1.2.8, subclause 18(1).

Since that time, improvements to the methods of analysis for dietary fibre have been developed and incorporated into the Standard. Standard 1.2.8 now allows a range of methods that measure total dietary fibre and separately quantify some components of dietary fibre, including inulin and polydextrose (see Table 2). The permitted methods of analysis in Standard 1.2.8 are all methods established as ‘official methods’ of AOAC International, which is a globally recognised, independent association that develops consensus standards in the area of analytical chemistry.

Table 2: Methods of dietary fibre analysis permitted under Standard 1.2.8 for the purposes of nutrition labelling

Dietary Fibre	Method of analysis
Total dietary fibre	Section 985.29 of the AOAC, 18th Edition (2005), or Section 991.43 of the AOAC, 18th Edition (2005).
Total dietary fibre (including all resistant maltodextrins)	Section 2001.03 of the AOAC, 18th Edition (2005)
Inulin and fructooligosaccharide	Section 997.08 of the AOAC, 18th Edition (2005).
Inulin	Section 999.03 of the AOAC, 18th Edition (2005).
Polydextrose	Section 2000.11 of the AOAC, 18th Edition (2005)

At this time, the table to Standard 1.2.8 does not incorporate the most recently developed method of analysing total dietary fibre AOAC method 2009.01 (McCleary et al., 2012). This newer method captures non-starch polysaccharides, most resistant starches, fructo- and galacto-oligosaccharides, inulin, polydextrose and resistant maltodextrins. It therefore yields higher values than earlier methods for foods that contain some classes of resistant starches and low molecular weight substances such as inulin (Westenbrink et al, 2013, Brunt et al, 2013, Hollman et al, 2013). Other AOAC methods are available for measurement of trans-galacto-oligosaccharides (AOAC 2001.02) and resistant maltodextrins (AOAC 2001.03, McCleary et al., 2010).

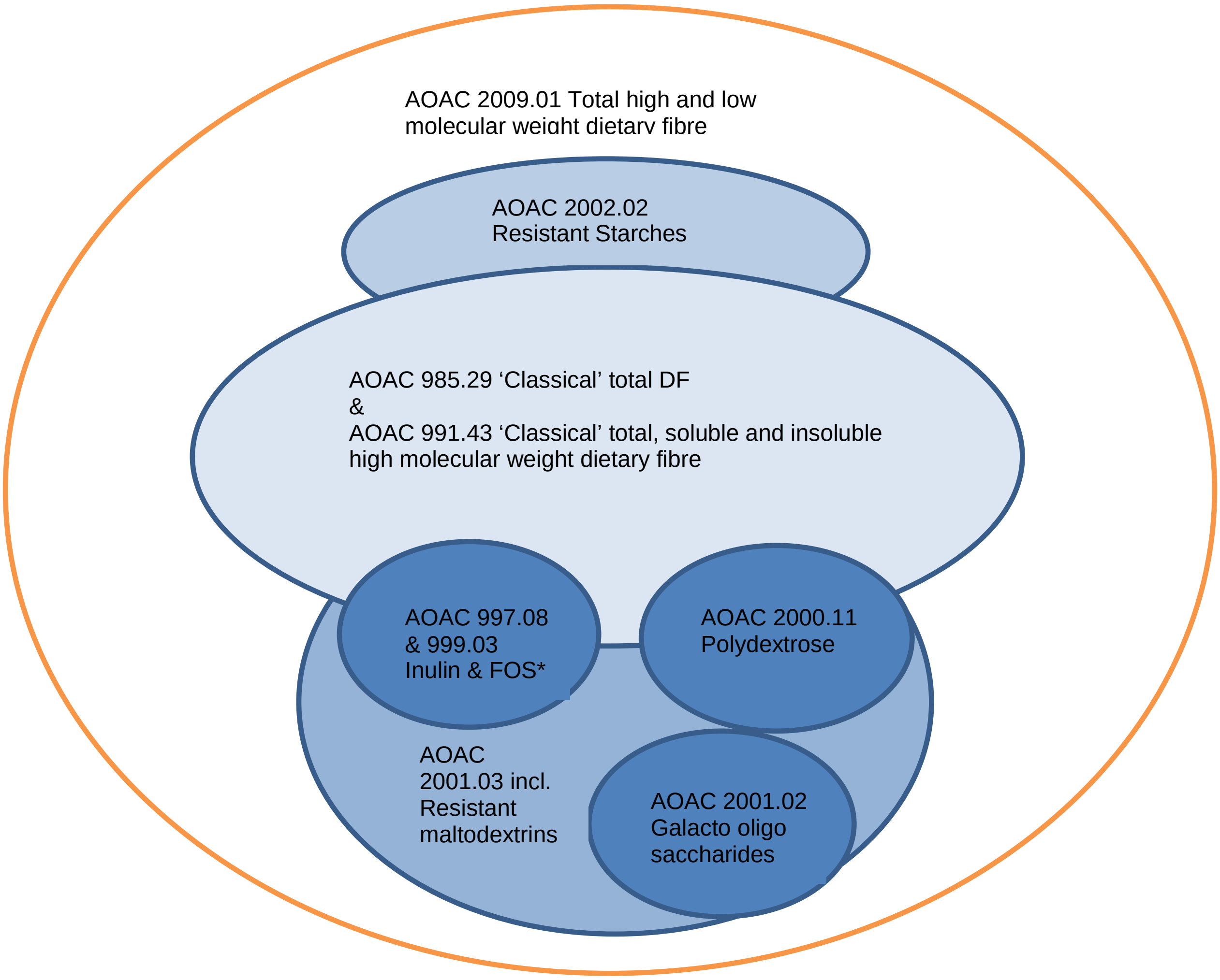
Although the different methods stipulated in the Code or available from AOAC appear to measure different types of dietary fibre, and specific components of fibre, in practice there is some overlap between methods so that the same fibre type may be captured more than once leading, potentially, to an incorrect estimate of dietary fibre content (Englyst et al, 2007). Figure 2 illustrates this potential for 'double counting' of dietary fibre by showing the overlap in captured substances with each method of analysis.

Unless a food contains no ingredients contributing naturally occurring dietary fibre, there is no readily available method of analysis that can determine, unambiguously, what fibre in a food is from natural sources and what is added in refined form (Westenbrink et al, 2013, DeVries and Rader, 2005), because both refined and naturally occurring dietary fibre may be the same substances and because current methods of analysis may capture closely-related substances. For example if a food contained both dried onion and added inulin, measurement of total inulin content would include both the inulin from the onion and added inulin.

For refined dietary fibre that is concentrated from a natural source, such as concentrated soy or wheat fibre, there is no single method available that would allow quantification of the complex mixtures of fibre they contain, separately from the mixtures of fibres present from other ingredients in a food.

Whichever method of analysis is selected, analysis costs for fibre analysis are high compared to other nutrients included in NIPs. For example, in a quote provided to FSANZ in 2013, the cost of total dietary fibre analysis (using AOAC 985.29) was five times that of protein and fat analysis, around three times that of sugars and almost double that of starch. Analysis of specific fibre types using one of the methods identified in Table 2, would lead to additional costs above that of measuring total dietary fibre alone.

In addition, when specific types of dietary fibre are present at low levels, measurement uncertainty can be too high to provide satisfactory results, particularly in foods containing high levels of starch and sugars, and low recovery of some fibre components can also occur, leading to inaccurate estimates of content (Englyst et al, 2013).



FOS = fructo oligosaccharides, AOAC refers to the internationally accepted analytical methods published by AOAC International
Methods 2001.01 and 999.03 are not specified in Standard 1.2.8.

Figure 2. Summary of the types of fibre measured using different methods of analysis (adapted from Westenbrink et al, 2013)

5.2 Estimation of dietary fibre levels using a recipe approach

Aside from direct laboratory analysis, there are two potentially-feasible alternative means available for quantifying amounts of naturally occurring and total dietary fibre in a food product:

- Use of data from published food composition tables
- Estimation based on proportion of ingoing ingredients.

Neither Australian (NUTTAB; FSANZ (2011)) nor New Zealand (FOODFiles) national food composition tables provide data on levels of naturally occurring dietary fibre. Both sets of tables provide data on total dietary fibre and the unabridged New Zealand tables also provide values for non-starch polysaccharides, soluble and insoluble fibres (S. Sivakumaran, personal communication, 2013). However as noted above, these measures do not distinguish between chemically-identical substances that are intrinsic to a food and those that are added as refined dietary fibre. Therefore at this time there is no readily available and comprehensive dataset of naturally occurring and total dietary fibre values that could be used for labelling purposes.

There are a number of labelling tools for the generation of NIP data using a recipe approach, such as FSANZ's online Nutrition Panel Calculator (NPC) (http://www.foodstandards.gov.au/industry/npc/Pages/Nutrition-Panel-Calculator-introduction.aspx) and New Zealand's NIP Database (http://www.foodcomposition.co.nz/nip-database). These products draw on national food composition datasets and therefore do not include separate values for levels of naturally occurring dietary fibre. The NPC does not currently include any fibre values at all as dietary fibre is not a mandatory nutrient for declaration in NIPs, and the New Zealand NIP database contains total dietary fibre only. Further, the NPC includes nutrient composition data for only a small number of ingredients that are refined dietary fibre and the New Zealand NIP Database does not include any. Therefore to include all forms of fibre both labelling tools would need to be updated to include all types of refined dietary fibre as ingredients.

A manufacturer could estimate the proportion of naturally occurring dietary fibre in a food product by using the determined value for total dietary fibre (determined by analysis, by use of food composition tables or similar methods) and adjusting all other nutrient values for the known proportion of the product that is refined dietary fibre. However to do this they would also have to have access to data on the levels of other fibre in their refined ingredient; such data may not always be available.

6. Do 'naturally occurring' and 'extracted' forms of dietary fibre have different impacts on the recognised physiological effects of dietary fibre?

Key points

- Refined and naturally occurring dietary fibre both display some or all of the physiological effects identified as defining dietary fibre, under Standard 1.2.8.
- There is little information available that would allow a definitive comparison of the health benefits of refined dietary fibre compared to naturally occurring dietary fibre.
- The information reviewed suggests that both naturally occurring and refined dietary fibre have the potential to contribute to some of the recognised health outcomes for dietary fibre.

In order to be considered as dietary fibre for food labelling purposes, the substance under consideration must be:

- Plant derived
- Indigestible in the small intestine.

Dietary fibres are indigestible in the small intestine because humans do not produce the enzymes required to break the bonds between adjacent sugar units (Bonsu et al, 2011, Flamm et al, 2001). When fibres reach the large intestine, they are able to be wholly or partially fermented by the bacteria present in the bowel resulting in the production of hydrogen, methane, carbon dioxide and short chain fatty acids. These short chain fatty acids are available for energy production (Flamm et al, 2001).

Beyond the requirement for plant origin and indigestibility, dietary fibre must, by definition, promote one or more of the following physiological effects:

- Laxation
- Reduction in blood cholesterol
- Modulation of blood glucose.

This review considers whether the main types of refined dietary fibre present in Australian and New Zealand foods display one or more of these physiological effects. The main fibre types that will be considered are those that are most widely used:

- Inulin/oligofructose
- Polydextrose
- Psyllium
- Soy fibre.

This consideration is a brief assessment of key information in this area and so a targeted literature search including publications in recent years in key electronic databases and of abstracts at two recent nutrition conferences were searched. The information it contains has not been identified, collated and presented in ways that meet the requirements of a full systematic review for health claims purposes.

6.1 Literature Review of the physiological effects of dietary fibre

6.1.1 Literature Search

The following databases were searched:

- Cochrane database of systematic reviews
- PubMed
- EBSCO Discovery

Search terms used included: fibre or fiber, psyllium, inulin, oligofructose, polydextrose, soy fibre (or fiber), wheat fibre (or fiber), cellulose, laxation, cholesterol, glucose.

Search dates were generally from 2005 onwards although some earlier papers were retrieved through checking reference lists of papers. Hand checking of the published abstracts of the 2013 International Congress of Nutrition and 2013 Proceedings of the Nutrition Society of Australia was also carried out.

Retrieved studies were limited to those on humans.

6.1.2 Findings – laxation

Laxation refers to the expulsion of waste material from the digestive tract as faeces. The ability of dietary fibres to promote laxation are typically assessed by parameters such as faecal transit time; stool weight, frequency and water content; gastrointestinal discomfort and laxative use (Yang et al, 2012). Dietary fibres may promote laxation as a result of a greater faecal mass, for example because of the presence of large amounts of cellulose, from greater mass of bowel bacteria or from greater water binding from viscous fibres (Yang et al, 2011, Flamm et al, 2001).
Inulin/oligofructose and polydextrose have been shown to increase faecal weight and stool frequency at doses of around 15-20 g/day (IOM, 2005; Raninen et al, 2011), although other studies (cited in Brownlee, 2009) contradict this. The increase in stool weight, which is not as great as found with fibres such as cellulose, is believed to be a result of an increased mass of bowel bacteria.

Polydextrose increases faecal mass, decreases transit time, improves stool consistency and ease of defecation and sometimes increases stool frequency (Putaala, 2013; IOM, 2005). In a recent randomised, placebo-controlled, double blind crossover trial, both polydextrose and soluble corn fibre, at a daily dose of 20 g, were found to improve a range of measures of laxation (stool weight, number of stools per day, stool softness - polydextrose only) compared to the control. Both test materials also caused increases in flatulence and borborygmi (stomach rumbling). Participants in this study had a mean age of 25 years and were healthy and of normal body weight (Timm et al, 2013). Similar results were reported by Hengst et al (2009) for healthy participants, ranging from 19-66 years, taking 8 g per day polydextrose. However this study did not find a beneficial effect on stool weight. This study was supported by the manufacturer of the polydextrose used. Jie et al (2000) also reported improvements in measures of laxation when polydextrose (4-12 g/day) was consumed.

Psyllium is the active ingredient in a range of non-prescription products aimed at reducing constipation or promoting regularity, such as *Metamucil*. There is extensive literature to show that consumption of psyllium, or proprietary products containing it, leads to improvements in a range of measures of laxation (including faecal weight and stool consistency) (IOM, 2005, Brownlee, 2009).

Vuksan et al (2008) studied the effect of consuming breakfast cereal fortified with 13% psyllium, with viscous soluble fibres (guar and xanthan gums), with added corn fibre or with extra wheat bran on measures of laxation (faecal bulk, transit time, stool frequency and stool water content), compared to a low fibre control diet. Participants were free-living, healthy male and female adults (mean age 35 years). All breakfast cereals had positive effects on laxation compared to the control diet. The psyllium-fortified cereal had a greater beneficial effect on stool water than other cereals. This study was supported by the Kellogg Company.

As noted earlier, soy fibre is a mixture of different types of fibre, including cellulose and pectins. While soy fibre would be expected to display the same physiological effects as its component fibre types, studies on the effect of soy fibre on laxation were not identified.

In terms of other refined dietary fibre, added cellulose, but not added pectin or lignin, increased stool weight and faecal transit time (IOM, 2005). Brownlee (2009) reported that consumption of β-glucan rich oat hull fibre did not affect transit time but did increase stool weight. Gums appear to have minimal effect on faecal mass (Lunn & Buttriss, 2007).

In summary, inulin/oligofructose, polydextrose and psyllium have effects on laxation, as does one of the main components of soy fibre (cellulose). Another component of soy fibre, pectin, does not appear to affect laxation. There were no studies in the identified literature set that reported contrary findings on laxation for these fibres.

6.1.3 Findings – reduction in blood cholesterol

Several mechanisms have been proposed by which consumption of dietary fibre may lead to reductions in blood cholesterol. Soluble or viscous fibres appear to bind bile acids in the small intestine, which facilitates their excretion in the faeces (Anderson et al, 2009). This encourages increased production of bile acids by the liver and, as bile acids contain cholesterol, leads in turn to reduced blood cholesterol (Brownlee, 2009).

Inulin has shown variable effects on blood cholesterol levels. Raninen et al (2011) summarised six studies from 1997 to 2000 in which only one demonstrated reduced levels of total cholesterol following consumption of inulin; no studies found inulin reduced LDL or raised HDL cholesterol. They also summarised three studies of polydextrose and found no effects on total or LDL cholesterol and conflicting results on HDL cholesterol. More recently, Kaminskas et al (2013) reported that daily consumption of 5 g inulin, added to a 125 g tub of yoghurt, reduced LDL-cholesterol, but not total cholesterol, among 25 patients with metabolic syndrome. Forcheron & Beylot (2007) found that, after 6 months of inulin consumption at 10 g/day on top of habitual diet, there were no beneficial effects on cholesterol levels.

Contradictory findings have been reported for polydextrose, with some studies finding no effect on blood cholesterol, and others finding reductions in total and LDL-cholesterol levels, but not HDL cholesterol levels, at doses in the range 10-20 g/day (Putaala, 2013; IOM, 2005). Schwab et al (2006) found that neither polydextrose nor sugar beet fibre, consumed in a drink at a dose of 16 g/day, influenced serum lipid profile in overweight middle aged subjects.

A range of studies have shown that doses of 7 g psyllium per day, or more, lead to modest (up to around 10%) reductions in total and LDL cholesterol in a dose dependent manner. Anderson et al (2000) conducted a meta analysis of eight experimental studies examining psyllium intake (as Metamucil fibre supplement) and serum lipids in participants already following low fat diets. They found that consumption of 10.2 g psyllium/day lowered serum total cholesterol by 4% ($P < 0.0001$) and LDL cholesterol by 7% ($P < 0.0001$) but did not affect HDL cholesterol levels.

While many studies of psyllium and blood cholesterol have used therapeutic formulations, some have been conducted with psyllium-enriched breakfast cereals. Wei et al (2009) reviewed studies in which adult participants had mild to moderate hypercholesterolemia and consumed between 3 and 24 g/day psyllium fibre, consumed as a supplement or added to breakfast cereal or other foods. They found dose dependent reductions in both total- and LDL-cholesterol, with similar effects found regardless of whether the psyllium was incorporated into a food or consumed as a supplement.

Soy fibre would be expected to display the same range of physiological effects as its component fibre types, but specific studies on the effect of soy fibre on cholesterol were not identified.

Among other types of refined dietary fibre, cellulose does not affect blood cholesterol but pectins appear to do so, although this is likely to depend on the source and type of pectin (Brouns et al (2012) and the amount consumed (at least 6 g/day is likely to be required; EFSA, 2010). Guar gum has been shown to reduce blood cholesterol, by around 10-15%, but at doses of up to around 20 g per day, which is a level considerably higher than is likely to be derived from addition of refined gum to foods (IOM, 2005).

There are a range of studies available on the influence of β-glucans on blood cholesterol levels, and a food health relationship for this is accepted in Standard 1.2.7 Nutrition, Health & Related Claims, of the Food Standards Code.[6] For example, the ability of oat β-glucans to reduce LDL cholesterol levels was shown by Wolever et al (2010) in a multi-centre (including Australia), randomised, blinded, placebo-controlled trial of 367 male and female adults with increased total blood cholesterol but without evidence of impaired glucose metabolism. These researchers also found that the extent of cholesterol lowering is influenced by the molecular weight of the glucans present, which in turn affects the viscosity of these glucans in the intestines. Participants consumed two servings per day of a control (wheat bran based cereal) or an oat bran based cereal containing high, medium or low molecular weight β-glucans. Consuming the low molecular weight β-glucans did not reduce LDL cholesterol, whereas the medium and high molecular weight β-glucans did reduce LDL cholesterol by around 5% compared to consumption of a wheat bran cereal.

In summary, neither inulin/oligofructose nor polydextrose are likely to affect blood cholesterol levels to any clinically significant extent. Consumption of psyllium does appear to reduce blood cholesterol. Of the two main components of soy fibre that were investigated, cellulose does not appear to help reduce blood cholesterol but pectins may, although it is unlikely that sufficient pectins would be consumed through added soy fibre to achieve cholesterol lowering.

6.1.4 Findings – modulation of blood glucose

Fibres can affect blood glucose levels by influencing the amount of glucose available from the food and by affecting glucose absorption or release (Putaala, 2013). A Panel of the European Food Safety Authority recently concluded that consumption of foods or beverages containing non-digestible carbohydrates instead of sugar results in reduced post-prandial blood glucose (and insulinaemic) responses compared with the consumption of sugars on a weight-by-weight basis (EFSA 2014).

A recent systematic review of studies on inulin and other fructans, and blood glucose concentration did not find a relationship between fructan intake and blood glucose levels (Bonsu et al., 2011).

Little information is available about the effect of polydextrose on blood glucose although there are some studies that indicate it is likely to modulate blood glucose rise after meals (Putaala, 2013). Schwab et al (2006) found that neither polydextrose nor sugar beet fibre, consumed in a drink at a dose of 16 g/day, influenced fasting or postprandial plasma glucose concentrations in overweight subjects with abnormal glucose metabolism. Similarly, Jie et al (2000) found no effect of consuming 4 g/day of polydextrose on post prandial blood glucose response, although there was a modest reduction in the area under the curve after consumption of 8 or 12 g; there were no effects on fasting blood glucose levels.

Similar doses of psyllium as used in studies of blood cholesterol have been shown to have modest effects on blood glucose rises after eating. For example, Rigaud et al (1998) demonstrated that a 7.4 g dose of psyllium, administered as a fibre supplement, led to a smaller postprandial increase in blood glucose than consumption of a placebo product. This study was a randomised, placebo-controlled, crossover study of 14 normal weight individuals aged 18-50 years.

[6] The accepted relationship is Beta glucan reduces blood cholesterol, with the conditions of use being that the food must contain at least 1 g β-glucan per serve derived from the presence of oat bran, wholegrain oats or wholegrain barley

Soy fibre would be expected to display the same range of physiological effects as its component fibre types. However Librenti et al (1992) found that 7 g soy fibre had a greater effect on post-prandial glucose response to a test meal than the same amount of cellulose; participants in this small (n=8) study were older (mean age 54 years), overweight (mean BMI = 27.8 kg/m^2) type 2 diabetics. The greater effect of soy fibre compared to cellulose may be a result of the other types of fibre it contains, such as pectins. Other authors have reported that cellulose does not affect blood glucose. However a number of studies have shown that viscous fibres such as pectins help to control the increase in blood glucose levels that occurs after meals (IOM, 2005).

Lu et al (2000) reported that arabinoxylan-rich fibre extracted from wheat endosperm and added to bread in a test meal, lowered postprandial blood glucose response and insulin response in a dose dependent manner. At the maximum dose tested (12 g), glucose response (measured as Incremental Area Under the Curve) was reduced by around 40% compared to participants who had bread without arabinoxylan-rich fibre. In this small study (15 participants), participants were normal body weight, healthy adults with normal glucose responses. Garcia et al (2007) reported similar findings in overweight or obese adults with impaired glucose tolerance.

In summary, inulin/oligofructose does not appear to modulate blood glucose levels. It is unclear whether polydextrose and psyllium modulate blood glucose levels, Soy fibre has been found in one study to modulate postprandial blood glucose, in comparison to cellulose, which appears to have no effect. The other component of soy fibre investigated, pectins, are likely to modulate blood glucose to some extent.

6.1.5 Findings – other physiological effects

The current definition of dietary fibre does not cover all identified or potential physiological effects of fibre. For example, inulin and similar oligosaccharides are believed to influence the bowel microflora, encouraging growth of beneficial microorganisms (‘probiotics’) (Flamm et al, 2001). Inulin is sometimes referred to as a ‘prebiotic’ for this reason. Addition of inulin-derived substances and fructo-oligosaccharides to infant formula under Standard 2.9.1 recognises that these substances can have beneficial effects on bowel microflora and stool softness (FSANZ, 2008, FSANZ, 2013). The effect of fibres on bowel microflora appears to be a growing area of research at this time.

Fibres may also influence the short chain fatty acid (e.g. butyric acid) composition of the large bowel in ways that are postulated to be beneficial for health outcomes such as reduced risk of colorectal cancer (Lunn & Buttriss, 2007).

Fibre, overall, does not appear to influence satiation to any great extent although there are some inconsistent results. Clark and Slavin (2013) found that certain fibres, including both natural (wheat bran, wholegrain wheat mixed with corn bran, resistant starches) and refined dietary fibre (psyllium), did not enhance satiety while others, again including both natural (rye bran, wholegrain rye, various fruits and vegetables) and refined dietary fibre (lupin kernel fibre, β glucans), had a modest effect on improving the sensation of satisfaction after eating. Kristensen & Jensen (2011) report that viscous fibres enhance satiation as their water holding ability leads to delayed gastric emptying and prolonged small intestine transit time.

There is growing recognition that some shorter chain, poorly digested carbohydrates (e.g. certain unavailable oligosaccharides) contribute to irritable bowel syndrome, by distending the intestinal lumen through increased water and gas in the bowel (Gibson, 2013).

6.1.6 Conclusion

Different types of added dietary fibres display different effects in the human body but of those types of refined dietary fibre commonly used in Australia and New Zealand, all display at least one of the required physiological effects of dietary fibre, identified in Standard 1.2.8 and therefore naturally occurring and refined dietary fibre cannot be differentiated on this basis. Table 3 summarises the physiological effects displayed by different fibre types.

Table 3: Summary of physiological effects displayed by different types of dietary fibres commonly added to foods in Australia and New Zealand*

Fibre type	Indigestible in small intestine?	Laxation?	Reduction in blood cholesterol?	Modulation of blood glucose?
Inulin and oligofructose	Yes	Yes	Unlikely	No
Polydextrose	Yes	Yes	Unlikely	No
Psyllium	Yes	Yes	Yes	Probably
Soy fibre	Yes	No evidence	No evidence	Yes
- Cellulose	Yes	Yes	No	No
- Pectins	Yes	No	Yes	Yes

** Note that this assessment of evidence is indicative and does not fulfil the requirements established for the substantiation of food health relationships for health claims purposes*

6.2 Health effects of dietary fibre

The range of physiological effects displayed by different types of dietary fibre suggests that fibres could also influence broader health outcomes. However the evidence for assessing dietary fibres' roles on health outcomes is generally derived from observational studies that have used imperfect measures of fibre consumption (e.g. food frequency questionnaires, varying fibre definitions and fibre values based on different analytical methods). Types of dietary fibre consumed by participants in such studies would be likely to cover the range of fibre types outlined earlier and to include at least some refined dietary fibre. These observational studies generally do not allow unambiguous determination that a reported outcome is from the fibre present in consumed foods, or from other components also found in such foods (Brownlee, 2009, Zhang et al, 2013, Threapleton et al, 2013). As with all observational studies of diet and disease risk, control for potential confounders can be challenging. In the case of dietary fibre, those who consume large amounts of fibre are also more likely to follow other risk-reducing practices, such as exercising and controlling body weight. Residual confounding (remaining after controlling for major known factors such as body weight) may lead to overestimates of the strength of some associations (Threapleton et al, 2013; Dong et al, 2011; Ye et al, 2012).

Post et al (2012) reviewed the effect of increased fibre intake on risk of type 2 diabetes, drawing on randomised controlled trials that reported fasting blood glucose levels and levels of glycosylated haemoglobin. Included studies had used interventions covering a range of refined dietary fibre including guar gum, psyllium, arabinoxylan and purified wheat and beet fibre, as well as naturally occurring dietary fibre (through inclusion of fibre rich foods such as wholegrain breads). Reductions in both outcome measures were observed in most included studies, suggesting that both naturally occurring and refined dietary fibre may have a role in reducing risk of type 2 diabetes.

Some observational studies have shown an association of dietary fibre on obesity levels. For example, Anderson et al (2009) cite two large cross-sectional studies and four prospective cohort studies (i.e. observational studies) that together indicate a strong negative association between dietary fibre intake and obesity. In contrast, a systematic review by Wanders et al (2011) of experimental studies found that dietary fibre, regardless of type, had only small effects on energy intake and body weight, but there were some effects on appetite (assessed subjectively, most commonly as feelings of hunger). Appetite was reduced more by consumption of viscous fibres such as refined pectins, pectin-rich mixed fibres, β-glucans and guar gum than of other non-viscous fibres. The fibre types used in the studies included in this systematic review were predominantly refined dietary fibre.

A number of studies have suggested that consumption of high fibre foods, such as wholegrain cereals, fruits and vegetables may reduce risk of cardiovascular disease. This finding would be consistent with the effects demonstrated on specific types of fibre on blood cholesterol and blood glucose rise. The literature search did not, however, identify any studies that examined refined dietary fibre and cardiovascular disease risk.

The laxation effects of fibre, together with influences of some fibre types on levels of short chain fatty acids, and certain gut bacteria, could potentially influence rates of digestive system cancers. The World Cancer Research Fund (2007) concludes there is probable evidence for an association between foods containing dietary fibre (including both naturally occurring and added dietary fibre) and reduced risk of colorectal cancer (RR per 10 g per day: 0.90 (0.84–0.97), and limited suggestive evidence of an association with oesophageal cancer. However they note that no plausible mechanism by which fibre affects oesophageal cancer risk has been identified.

Although use of high fibre foods or fibre-rich dietary supplements is often recommended for management of a variety of gastrointestinal disorders (including chronic constipation, reflux disease, irritable bowel syndrome and diverticular disease), there is limited evidence available to support this use (Anderson et al, 2009). Ruepert et al (2011), in a systematic review, found no benefit of fibrous bulking agents on a range of scores for irritable bowel syndrome. Suares & Ford (2011) found conflicting evidence that insoluble fibres (wheat bran and wholegrain bread) improved chronic idiopathic constipation and some weak evidence that soluble fibres (psyllium and a combination of maltodextrin/inulin) had a beneficial effect. The soluble fibres studied would be considered as refined dietary fibre, as defined in this paper, and the insoluble fibres studied as naturally occurring dietary fibre. Studies included in this review were generally not high quality. For children (aged 5-17 years), a systematic review by Horvath et al (2012) found that supplemental fibres (psyllium, corn fibre, glucomannan) did not improve functional gastrointestinal problems including abdominal pain; the authors noted the poor overall quality of included studies.

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Appendix 1

Table 2A. Products with label fibre claims, where all fibre is likely to be derived from natural sources

Product group	Category share (compared to entire product group)*	Types of claims	Dietary fibre content grams per 100 g (mean and/or range)**	Ingredients contributing natural fibre (% stated where known)	Example products
Sweet biscuits	Low	Source of fibre Goodness of fibre	3.5 - 8.7	Wheat flour, other cereals such as oats, nuts, dried fruit, brans	Belvita Honey & Nut, Arnotts Shredded Wheatmeal
Savoury biscuits, crackers and snacks	Low	Good source of fibre Source of fibre High in fibre 'X% dietary fibre'	5.3 - 11.4	Wholegrain cereals including wheat, maize, oats, rye, seeds, added bran, soy grits, linseed	Real Foods Corn Thins, Arnotts Vita Weat (range), RW Garcia Flax organic tortilla chips
Pasta, flour & grains	Low	High in fibre 'Fibre' in product name Source of fibre Source of beta glucan – over a third of your recommended daily intake of fibre Natural source of dietary fibre Dietary fibre	2.4 - 15.5	Wholemeal wheat flour, soy flour, brown rice, BARLEYmax, maize meal	San Remo wholemeal pasta, San Remo soyaroni twists, Sunrice Rice & Barley Fibre, Sunrice organic brown rice, Sostanza polenta, Jimmy's Atta flour (wholemeal)
Muesli bars, nut bars, breakfast cereal bars, fruit filled snack bars	Around half	Excellent source of fibre High in fibre Source of fibre Fibre from bran	5.6 (4.6-6.6)	Wholegrain cereals, nuts, seeds, dried fruits	Coles nut delight bars, Nature Valley crunchy, Weight Watchers muesli Bars, Frontelle mini-meal, Carmen's classic, Carmen's dark choc & yoghurt, Be Natural nut delight, Uncle Toby's chewy muesli bars

Product group	Category share (compared to entire product group)*	Types of claims	Dietary fibre content grams per 100 g (mean and/or range)**	Ingredients contributing natural fibre (% stated where known)	Example products
Breads, wraps	Around half	High in fibre Source of fibre Packed full of fibre Blest with natural fibre Rich in fibre Wholegrain fibre for your heart's wellbeing Protein & fibre – our special combination to satisfy hunger Soluble fibre slows digestion to maximise nutrient absorption Insoluble fibre to help keep you regular 2xFibre	6.2 (4.9-10.8)	Flours and whole grains (includes wheat, rye, triticale, maize, oats, barley), seeds, high amylose maize starch (Hi-Maize) Hi-Maize 2.7% Oat bran 6%	True Foods wraps plus, Wattle Valley sourdough soft wraps, Bazaar wholemeal Pide pockets, Wonder Wholemeal muffins, Tip Top Sunblest soft wholemeal, van der Muelen pumpernickel, Burgen Wholegrain & Oats for Heart Health, Burgen Wholemeal & Seeds for Weight Management, Burgen Rye for Digestive Balance, Old El Paso wholegrain wraps
Breakfast cereals	Around half	Very high in fibre Very high in dietary fibre High in fibre Excellent source of fibre Excellent fibre source – 55% of your recommended daily intake Source of fibre Source of dietary fibre More than 20% of your daily fibre needs 24% of your daily fibre 'Fibre' (in product name)	16.1 (6.9-31.8)	Wheat flour, wheat bran, rice bran, wheat fibre, dried fruits, nuts, seeds, oats, maize, rice, corn bran, BARLEYmax	Kellogg's All Bran Original, Kellogg's Sultana Bran, Kellogg's Just Right Original, Uncle Toby's Bran plus, Uncle Toby's Vita Brits Weeties, Uncle Toby's Fruit Bites, Uncle Toby's Oats, Uncle Toby's Swiss Muesli; Sanitarium Weet Bix Hi Bran, NuVit Original muesli gluten free, Freelicious fibre up flakes, Goodness Superfoods Digestive
Dried fruits & nuts	Low	'Fibre' in product name Good source of dietary fibre Natural source of fibre High in fibre	7.6 - 11.0	Nuts, seeds, dried fruit	Lucky Smart Snax fibre mix, Coles Trail Mix, Fruit for Life dried blueberries

Product group	Category share (compared to entire product group)*	Types of claims	Dietary fibre content grams per 100 g (mean and/or range)**	Ingredients contributing natural fibre (% stated where known)	Example products
Breakfast drinks	None				No products identified
Dairy foods	None				No products identified
Vegetables and legumes	Low	High in fibre Vegetables are naturally high in fibre A natural source of fibre	3.0 - 7.0	Chick peas Vegetables	Coles canned chick peas Heinz frozen broad beans, Birds Eye frozen field fresh peas, McCains sliced beans
Vegetarian products	Low	Excellent source of fibre Source of dietary fibre Good source of fibre High in fibre Containing plenty of natural fibre Rich in dietary fibre	3.8 - 6.5	Oats, flour, legumes, soy beans, seeds, vegetables	Sanitarium Smokey BBQ Burgers, Falafel mix, Nutrisoy tempeh, Eatwell Vegie Burgers, Heinz baked beans
Special purpose foods – weight control	None				No products identified
Other	Low	Source of fibre Source of dietary fibre High in fibre ‘Fibre’ in product name	1.2 - 27.0	Vegetables, wheat flour, rice, dried fruits, coconut, BARLEYmax, legumes, vegetables	Latina low fat lasagne, Paxton’s rice cream, , Golden Days apricot coconut slice, Goodness Superfoods Fibre Boost Sprinkles, Weight Watchers frozen Hawaiian pizza, Moroccan fixe (fresh ready meal)

* Low – less than a quarter of products in this category made a label statement about fibre and contained only natural fibre sources, High – around two thirds or more of products made a label statement about fibre, and contained only natural fibre sources

** Mean values calculated only when at least 6 products were identified and all were similar in formulation

Table 2B. Products with label fibre claims, where fibre is derived from both natural (see Table 2A) and refined sources

Product group	Category share (compared to entire product group)*	Types of claims	Dietary fibre content grams per 100 g (mean and/or range)**	Refined fibre ingredients as declared (includes ingredients that may be considered refined in some cases)	Example products
Sweet biscuits	Low	Product name contains ‘fibre’ Source of fibre	5.1 - 6.6	Inulin, vegetable fibre	Belvita Fruit n Fibre, Arnotts Snack Right fruit pillows
Savoury biscuits, crackers and snacks	Low	Source of fibre and wholegrain Multifibre (product name) High fibre	8.0 - 22.0	Inulin Dietary fibre - inulin	Sakata wholegrain rice crackers (several flavours), Taylors Multifibre Snacks
Pasta, flour & grains	Low	Fibre enriched 50% more fibre	5.2	Wheat starch	Healthy Baker self raising flour
Muesli bars, nut bars, breakfast cereal bars, fruit filled snack bars	Around half	Very high in fibre High in fibre Source of fibre ¼ of your daily fibre needs	11.8 (4.9 - 25.4)	Psyllium, vegetable fibre (chicory), vegetable fibre (inulin), dietary fibre (inulin), inulin, chicory extract (inulin), modified starch 1412 (distarch phosphate)	Carmen’s roasted nut bars (macadamia), Be Natural Four range, Be Natural Trail bars, Kelloggs Special K apricot bar, Uncle Toby’s Bodywise Digestive balance, Crunchy Choc chip bar, Freedom Foods Free Oats chewy bars, Go Natural Fruit & nut delight snack bars, Coles Simply Less fruit filled bars (range), Weight Watchers fruit filled bars (range), Uncle Toby’s fruit fix

Product group	Category share (compared to entire product group)*	Types of claims	Dietary fibre content grams per 100 g (mean and/or range)**	Refined fibre ingredients as declared (includes ingredients that may be considered refined in some cases)	Example products
Breads, wraps	Low	Wholemeal, high in fibre High in fibre High fibre	8.5 (7.0 - 11.8)	Guar gum, gums, soy fibre, soy fibre 5%, wheat fibre, psyllium, sugar beet fibre, vegetable gum (415)	Australia's Own Organic wraps, Golden Mills white high-fibre sandwich thins, Wattle Valley lite wraps soft wraps, Coles hi-fibre sandwich bread range, Tip Top The One wholemeal, Tip Top Wonderwhite Hi Fibre Plus, Pure Bred Bakery Gluten Free wholemeal rolls, Old El Paso light white wraps
Breakfast cereals	Low	Soluble fibre helps lower cholesterol reabsorption - Contains psyllium High in fibre High fibre More than 20% of your daily fibre needs Fruit & fibre (product name) High fibre Fibre to help you feel satisfied	11.9 (5.7 - 21.8) Note: Oat beta glucan is 18% of total fibre in Healthwise	Psyllium, Psyllium 12%, Beta glucan, resistant starch, oat fibre, oat fibre 4%, pectin, oligofructose, inulin, gelling agent, linseed fibre 6%, modified starch (1422)	Kellogg's Guardian, Kellogg's Special K Advantage, UncleToby's Healthwise for Heart Wellbeing, UncleToby's Plus Fibre, UncleToby's Hi-fibre Oats, UncleToby's Oats Weightwise Original, Food for Health Fruit Free clusters with Chia, Freedom Foods Berry Good Morning, Freedom Crunchola Clusters with Berries, Coles Right Start Fruit & Fibre, Flavoured Oats, Be Natural 5 Wholegrain Flakes

Product group	Category share (compared to entire product group)*	Types of claims	Dietary fibre content grams per 100 g (mean and/or range)**	Refined fibre ingredients as declared (includes ingredients that may be considered refined in some cases)	Example products
Dried fruits, nuts	None				No products identified
Breakfast drinks	Around half	High fibre High in fibre Fibre 5 g	1.4 – 1.6	Inulin, prebiotic fibre (inulin), dietary fibre (inulin), wheat maltodextrin, cereal flours & fibres	Sanitarium Up & Go, Sanitarium Up & Go energise, Sanitarium Up & Go Vive, Devondale Fast Start
Dairy foods	Low	Ingredient list declaration High fibre Source of fibre	1.1 - 2.4	Inulin dietary fibre Polydextrose Locust or carob bean gums, pectin & modified starch (as thickeners)	Vaalia Breakfast to go Swiss Muesli with Yoghurt, Vaalia breakfast yoghurt (contains fruit) Yoplait Forme Greek berry yoghurt
Vegetables and legumes	None				No products identified
Vegetarian products	Low	Good source of fibre High in fibre	4.2 - 8.0	Vegetable gum Vegetable gums (methylcellulose, carrageenan), gelling agent (401), pea fibre	Sanitarium Chick pea & couscous falafel, Sanitarium Lentil patties, Quorn BBQ sausages
Special purpose foods – weight control	High	Excellent source of fibre Good source of fibre More fibre than a cup of oats	7.5 - 25.5 Note: in one product, 76% of fibre is from polydextrose	Polydextrose Inulin	Body Trim Lo carb Choc Nut Delight bar, Optifast berry crunch bar, Bioglan Superfoods whole food smoothie
Other	Low	Fibre cleanse High in dietary fibre	42.3	Psyllium	Nature First premium breakfast booster

* Low – less than a quarter of products in this category made a label statement about fibre and contained both natural & refined fibre sources, High – around two thirds or more of products made a label statement about fibre, and contained both natural & refined fibre sources
** Mean values calculated only when at least 6 products were identified and all were similar in formulation

Table 2C. Products with fibre claims, where at least 90% of fibre is derived only from refined sources

Product group	**Category share (compared to entire product group)***	**Types of claims**	**Dietary fibre content grams per 100 g (mean and/or range)****	**Ingredients contributing refined fibre (representing at least 90% of total fibre, where this is known)**	**Example products**
Breakfast drinks	Around half	High in fibre High fibre	1.7 - 1.8	Inulin, powdered cellulose, carboxymethyl cellulose (stabilisers), carrageenan	Kellogg's Coco Pops, Kellogg's Nutrigrain Breakfast fuel
Dairy foods	Low	Ingredient list declaration		Polydextrose (note that fruit portion of these products is around 5-6%)	Vaalia breakfast yoghurt (contains fruit) Yoplait Forme Greek berry yoghurt
Special purpose foods – weight control	High	Excellent source of fibre High fibre High in fibre Good source of fibre	2.4 – 12.2 Note: polydextrose represents 90-99% of declared fibre content)	Inulin dietary fibre plus thickeners (alginates, guar, xanthan gums), Polydextrose	Coles Simply Less meal shake powder, Celebrity Slim choc caramel crunch bar, Protein FX Lo Carb Brekkie bar, Optislim Rapid Tone Low carb protein bites, Slim Secrets Mintabolism boost bar

* High – around two thirds or more of products made a label statement about fibre, and contained refined fibre sources but no naturally occurring dietary fibre.