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Creation of a database for the estimation of cereal fibre content in foods

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Abstract

Food composition data provides a useful tool to calculate nutrient intake based on reported dietary consumption. This intake data may then be analysed for associations with health outcomes. Despite evidence for favourable health outcomes associated with cereal fibre intake, there is no existing quantification of cereal fibre within the vast majority of food databases. This study aimed to expand an existing Australian food database, the AUSNUT 2011-13, to include cereal fibre content of all foods and food products (n = 5741). Cereal fibre content (g) per 100 g was calculated using a systematic recipe-based approach, a food label-based approach and input from manufacturers. Overall 1918 foods were identified as containing ≫ > 0.1% cereal fibre, spanning 19 of 24 major food groups. While the Cereal based products and dishes group contained the majority (47.2%) of these foods, the vast range of contributing food groups indicates the presence of cereal fibre in small amounts in a wide variety of food products. This paper describes methods that can be adapted for use within databases outside Australia. The database may allow assessment of cereal fibre intake within any Australian group that can then be applied in determining associations of cereal fibre intake with health outcomes.

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Original Research Article

Creation of a database for the estimation of cereal fibre content in foods

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Abstract:

Food composition data provides a useful tool to calculate nutrient intake based on reported dietary consumption. This intake data may then be analysed for associations with health outcomes. Despite evidence for favourable health outcomes associated with cereal fibre intake, there is no existing quantification of cereal fibre within the vast majority of food databases. This study aimed to expand an existing Australian food database, the AUSNUT 2011-13, to include cereal fibre content of all foods and food products (n = 5741). Cereal fibre content (g) per 100 g was calculated using a systematic recipe-based approach, a food label-based approach and input from manufacturers. Overall 1918 foods were identified as containing >0.1% cereal fibre, spanning 19 of 24 major food groups. While the *Cereal based products and dishes* group contained the majority (47.2%) of these foods, the vast range of contributing food groups indicates the presence of cereal fibre in small amounts in a wide variety of food products. This paper describes methods that can be adapted for use within databases outside Australia. The database may allow assessment of cereal fibre intake within any Australian group that can then be applied in determining associations of cereal fibre intake with health outcomes.

Keywords: Australia; AUSNUT 2011-13; cereal fibre; food composition; food analysis; survey database; food products; food industry.

1. Introduction

The term ‘cereal fibre’ refers to fibre originating from grains, including barley, maize, millet, oats, rice, rye, sorghum, teff, triticale, and wheat varieties. Previous research has found numerous health benefits associated with dietary fibre consumption can be strongly linked specifically to cereal fibre consumption (Huang et al., 2015, Kim and Je, 2014 and Pereira et al., 2004). These findings are reflected within international dietary guidelines, including those for Australia, which recommend that Australians consume approximately 4-6 servings of cereal foods each day, with most of these servings from whole grain or high cereal fibre sources (National Health and Medical Research Council, 2013). Despite these findings and recommendations, there is no readily available data within Australia, nor internationally, to quantify total cereal fibre intake within a nationally representative sample. Current estimates of fibre intake from cereals are based primarily on foods categorised wholly as cereal foods such as bread and breakfast cereals. Mixed foods and those with small amounts of cereals used for thickening or as a minor ingredient are not included.

In order to quantify cereal fibre intake within a population, a database comprising cereal fibre content of all foods eaten is needed, as well as current dietary intake data. When considering this within an Australian context, the 2011-12 National Nutrition and Physical Activity Survey (NNPAS), a subcomponent of the 2011-13 Australian Health Survey (AHS), provides the most recent dietary intake data, based on a nationally representative survey of 12,153 Australians (Australian Bureau of Statistics, 2013). A national food composition survey database, the AUSNUT 2011-13 Food, Supplement and Nutrient database (FSANZ, 2013a), was developed to include all foods and beverages reported and the associated nutrients within the 2011-12 NNPAS.

64 The extent to which the current AUSNUT 2011-13 database facilitates analysis of reported
65 cereal fibre consumption is limited. The AUSNUT database categorises foods using a nested
66 hierarchical grouping system broadly using 2-digit codes for major and 5 digit codes sub-
67 major food groups (FSANZ, 2013b), which allows basic analysis of reported fibre intakes
68 from cereal foods. For example, *Cereals and cereal products* and *Cereal-based products and*
69 *dishes* are two major food groups. Then within the *Cereals and cereal products* food group
70 there are sub-major groups such as *Regular bread, and bread rolls*. While this grouping
71 system allows estimation of dietary fibre from cereal foods and cereal food dishes, some
72 foods within these categories, such as mixed dishes, contribute a number of sources of fibre.
73 In addition, many potential sources of cereal fibre are found in food groups classified in other
74 major food groups such as *Meat, poultry and game products and dishes* due to crumbed
75 products and mixed dishes. This system for Australian foods is analogous to many food and
76 nutrient databases available internationally.
77
78 Therefore, in order to quantify total cereal fibre consumption, a complete cereal fibre analysis
79 must take place, including mixed foods. In Australia, it is relevant to utilise the AUSNUT
80 2011-13 database as the most recent food composition database for Australian foods, and
81 expand this to include the cereal fibre content for all foods. This expanded database can then
82 be applied in future studies to the 2011-12 NNPAS to more accurately assess the reported
83 cereal fibre consumption of an Australian population, or can be applied to any studies
84 utilising Australian foods. Similar methods could be applied to other national databases.
85

86 **2. Materials and methods**

87 Expansion of the Australian food composition survey database, AUSNUT 2011-13, to
88 include the cereal fibre content of all foods involved a systematic method using primarily a

recipe-based approach informed by previous research (Galea et al., 2016) and a food label-based approach using commercial product packaging, as well as input from food manufacturers and standard recipes.

All data contained within the AUSNUT 2011-13 database was stored and managed within a Microsoft Excel (Version 14.0.0, 2011, Microsoft Corporation, North Ryde, NSW, Australia) spreadsheet.

2.1 Identification of cereal fibre-containing foods and food products

Cereal fibre is interpreted as fibre that is sourced from cereals grains and pseudo cereal grains, whether intact or processed within food products. Cereals grains include barley, maize, millet, oats, rice, rye, sorghum, teff, triticale, and wheat (all varieties including burghul, durum, einkorn, farro, freekeh, Khorasan and spelt). Pseudo cereal grains include amaranth, buckwheat and quinoa. The expanded database included pseudo cereal grains. The decision to include pseudo cereal grains as a source of cereal fibre was due to their similar nutrition profiles, preparation and uses (Van der Kamp et al., 2014).

Fibres considered for inclusion in the AUSNUT database met the Food Standards Australia New Zealand (FSANZ) definition (FSANZ, 2016) which includes fibre that is both intrinsic and extrinsic to the food sources. This includes cereal carbohydrates with a degree of polymerisation greater than two.

In addition, the cereal fibre content was only considered if contributing >0.1g per 100g of the food product. Fibre below this level would be beyond the accuracy of analytical measures used in fibre quantification (McCleary et al. 2010 and Prosky et al. 1985).

Review of foods within the database also required a number of overarching decisions on inclusions, which are listed below and were applied as needed during the process.

1. Where maltodextrin was included on a product label as simply 'maltodextrin', it was assumed that this was not resistant maltodextrin and thereby would not be contributing any cereal fibre. However, items listed as resistant or commercial fibres such as a commercially available resistant corn maltodextrin ingredient, were considered to contribute to the cereal fibre content. This is in accordance with the FSANZ 2004 assessment report conclusion that resistant maltodextrin is capable of meeting all components of the FSANZ definition of dietary fibre (FSANZ, 2004).

2. The added starch known as "thickener (1442)" used in many commercial Asian-style sauces can be made from various starches. Some of these starches are not cereals, which presented a challenge in the estimation of cereal fibres. The AUSNUT Food Recipe File (FSANZ, 2013c) contains recipes for similar, Asian-style commercial sauces, which listed *flour, cornflour, from maize starch* as the main thickener. For this database expansion, it was therefore assumed that the thickener used within other products would be of similar composition, and the cereal fibre value for *flour, cornflour, from maize starch* was applied for thickener (1442) when used in commercial products.

3. The AUSNUT 2011-13 database contains a food *Fibre,* which is used in the Food Recipe File for food products that contain added fibre. This 'food' encompasses many sources of added fibres, not necessarily of cereal origin. These food products were individually addressed to determine the source of added fibre.

4. Fibre contributions from inulin were not considered a source of cereal fibre. Although inulin can originate from cereal sources, the majority of inulin within Australia comes from chicory root (FSANZ, 2008).

2.2 Cereal fibre content calculation

The approach used for calculating cereal fibre content is outlined in Figure 1. All 100% cereal foods without nutritive additives (e.g. *flour, wheat, white* and *oats, rolled, uncooked*) within the AUSNUT 2011-13 database were assigned a cereal fibre value equal to total dietary fibre. To calculate the cereal fibre content of mixed ingredient foods required a recipe-based approach using the AUSNUT Food Recipe File for individual ingredient composition (Equation 1; Table 1).

Cereal fibre content (g/100g) = $\frac{\text{Ingoing cereal fibre content (g)}}{\text{Final weight of product (g)}}$ x 100,

Ingoing cereal fibre content (g) = sum of ingredient cereal fibre content (g)

Final weight of the product = sum of ingredient weight (g) x ($\frac{100+\text{weight factor}}{100}$).

Equation 1: Calculation of cereal fibre in mixed foods using the recipe-based approach

Where the AUSNUT Food Recipe File did not provide a recipe, the AUSNUT Food Details File (FSANZ, 2013d) was used to determine the specific commercial products referenced for that food product. Where available, ingredient information from these specific commercial products was accessed through product label data and manufacturer websites. Products deemed similar were used where the specifically referenced products were not available.

For commercial products that included the exact proportion of cereal ingredient on the label, the cereal fibre was calculated using a food label-based approach (Equation 2; Table 2). Ingoing cereal fibre was calculated in the same way as the recipe-based approach, described previously. This value was calculated as a proportion of total fibre provided on the product label (Label total fibre), and this proportion was applied to total dietary fibre of the relevant food product in the database (AUSNUT dietary fibre value).

$$\text{Cereal fibre content (g/100g)} = \frac{\text{Ingoing cereal fibre (g/100g)}}{\text{Label total fibre (g/100g)}} \text{x AUSNUT dietary fibre value (g/100g)}$$

Equation 2: Calculation of cereal fibre in mixed foods using the food label-based approach

Where the exact amount of cereal ingredient was not provided on the product label, but the amount of all other fibre-containing ingredients was provided, for example, "sultanas (8%), almonds (6%)", the food label-based approach was also used, whereby non-cereal fibre was calculated as a proportion of total fibre and cereal fibre was estimated as the remaining proportion.

If available label data could not be used to make an accurate estimation, manufacturers were contacted for a detailed breakdown of ingredients.

Where none of the above methods (step 1-6 of Figure 1) were feasible, standard recipes of products were applied. If similar products existed within the AUSNUT database and contained a Food Recipe file, the cereal fibre proportion (as a percentage of total fibre) was applied in the same way as in the food label-based approach, outlined above. For example, cereal fibre proportion within *Sausage, kangaroo, plain or flavoured, fried, grilled, BBQ'd or baked* recipe (14%) was applied for all sausage products within the database. If no similar

188 products existed, standard recipes available online from Australian websites were used.
189 Cereal fibre and total fibre were calculated manually and the proportion was applied to the
190 AUSNUT database as in the food label-based approach.
191
192 **3. Results**
193 A total of 1918 foods (33% of all foods) within the AUSNUT database were identified as
194 containing >0.1% of cereal fibre (0.1-41.8g/100g cereal fibre; see Supplementary material).
195 The foods spanned 19 of the 24 two-digit major food groups, including groups such as *Non-*
196 *alcohol beverages* through to *Milk products and dishes*. Over 95% of values for cereal fibre
197 could be calculated using a recipe-based approach or food label-based approach. Only four
198 products were tracked using manufacturer data and the remainder required applied
199 proportions based on similar products in the database or Australian recipes.
200
201 The major food group *Cereal based products and dishes* comprised 47.2% (n=906) of all
202 cereal fibre containing foods and *Cereal and cereal products* comprised 25.7% (n=492) of
203 these foods (Table 3). Cereal fibre was found in 17 other major food groups, with a combined
204 contribution of 27.1% (n=520) to all cereal fibre containing foods.
205
206 Within each major food group, the maximum cereal fibre content differed considerably. The
207 largest amount of cereal fibre/100g was within the *Cereal and cereal products* group, with
208 41.8g of cereal fibre in 100g of *Wheat bran, unprocessed, uncooked* food product. *Popcorn,*
209 *regular, unflavoured, unsalted, vegetable oil,* providing 16.5g/100g of cereal fibre from the
210 *Snack foods* group, had the second largest amount of cereal fibre.
211

4. Discussion

Food composition databases are used globally to provide comprehensive data on the nutrient profile of foods. Methods of obtaining data contained within these databases can vary considerably, with chemical analyses of foods considered preferable (Greenfield and Southgate, 2003). While chemical analyses are the most accurate measure of obtaining nutrient information, this is a costly process and often impractical, particularly for national food composition survey databases which endeavour to include all foods reported within a population survey. In development of food databases it is also possible that manufacturers have used recipe calculations rather than proximate analysis. In addition, there are some food components where analytical methods may be absent (e.g. whole grains, added sugars) or impractical such as separating cereal fibres from other fibre sources as discussed here. Therefore a combination of methods is often used, ideally with the food composition of basic or staple ingredients obtained from chemical analyses.

The AUSNUT 2011-13 database was compiled by FSANZ using a combination of methods. Chemical analyses were used to obtain nutritional data for 1342 food items within the initial database, with additional food item data borrowed from international databases, imputed from past databases or similar products, developed through recipes or taken from label data or industry information (FSANZ, 2013d). The present study sought to expand the AUSNUT 2011-13 database to include cereal fibre content of foods. Chemical analyses were beyond the scope of this work and the source of some fibre types cannot be identified analytically. As such the majority of data (>75%) within this expansion was calculated using a recipe-based approach from readily available nutrient information within the database. Approximately 20% of food items within the database were calculated using product label data. The reliance on label data from some items within the database may limit the certainty of values

ascertained within this process, as previous research has found product label data to vary in accuracy (Urban 2010). While this was a limitation of the study, the systematic process described allows replication if required, within the limitation of the original database.

Within major observational studies, cereal fibre intake is often calculated through a simple summation of the total fibre consumed from foods categorised as 'breads and cereals' within food frequency questionnaires. This method does not capture the small amounts of cereal fibre contained within foods outside of the breads and cereals food group, such as from crumbed dishes or foods that use cereal ingredients as thickeners, which may contribute significantly to total intake and consequently impact findings. For example, in the present study over a quarter (27.1%) of foods that contained cereal fibre were not from either of the two major two-digit groups typically thought to comprise "cereal foods", highlighting the wide variety of foods that contain cereal fibre and the likely prevalence of cereal fibre within many varied Australian diets. Conversely, many products within the breads and cereals group were found to contain dietary fibre that was not from a cereal source, such as breads and cereals that contain added seeds, nuts and dried fruits, which would each contribute to the overall fibre content. The use of a food composition database, whereby we are able to break down each food item to its individual ingredients, allows a greater precision in calculation of cereal fibre than previous methods used.

A limitation in this study is that the AUSNUT 2011-13 database has in part been calculated using estimated recipes and nutrient profiles of various foods and mixed dishes. The foods listed in this database represent an average composition of some foods and will not have the exact ingredients and nutritional profile of those foods reported by each participant in 2011-

12 NNPAS. This, however, is a limitation of food composition databases globally. Indeed, there is slight variability in even the nutritional composition of natural food products.

In addition, some of the commercial products analysed for the initial database may have since undergone product reformulation, which cannot be accounted for and could present some inaccuracies when applying the database to current food products available. This is particularly relevant when dealing with nutrients such as dietary fibre, which is a common component added within the increasing variety of functional foods available. The use of data that is several years old may therefore fail to capture some of these newer, functional products, and may potentially miscalculate the cereal fibre content of the current Australian food supply. Similarly, many commercial products have since been discontinued and product information was no longer available. Products deemed most similar and widely consumed were used in their place for cereal fibre calculations.

All decisions regarding inclusions and exclusions were made by the researcher in consultation with members of the research team. However, the systematic process of expanding the database could only be applied by the primary researcher, adding a degree of human error to the expanded database.

Due to the enormity and ever-changing nature of the food supply, the development of a complete food composition database, which covers all food eaten within the intended population, is not possible (Greenfield and Southgate, 2003). However, the usefulness of data can be maximised if the database reflects the main foods of the population. The AUSNUT 2011-13 was developed to include foods reported with the nationally representative 2011-12 NNPAS and therefore provides a representation of Australian foods at the time. As the survey

was conducted recently and contained a large sample, it is likely that the database captured the majority of foods eaten within the Australian population. The database can therefore be used as a valuable tool to provide insight into cereal fibre consumption within the Australian diet.

5. Conclusion

The expansion of the AUSNUT 2011-13 database provides a tool for estimating cereal fibre intakes in an Australian context. This database is of particular use in the analysis of the 2011-12 NNPAS to estimate cereal fibre intakes of the Australian population. However, the tool is applicable for all Australian data collected in any context. Similar development of databases internationally would allow comparisons internationally and could be used to investigate health outcomes associated with cereal fibre intake.

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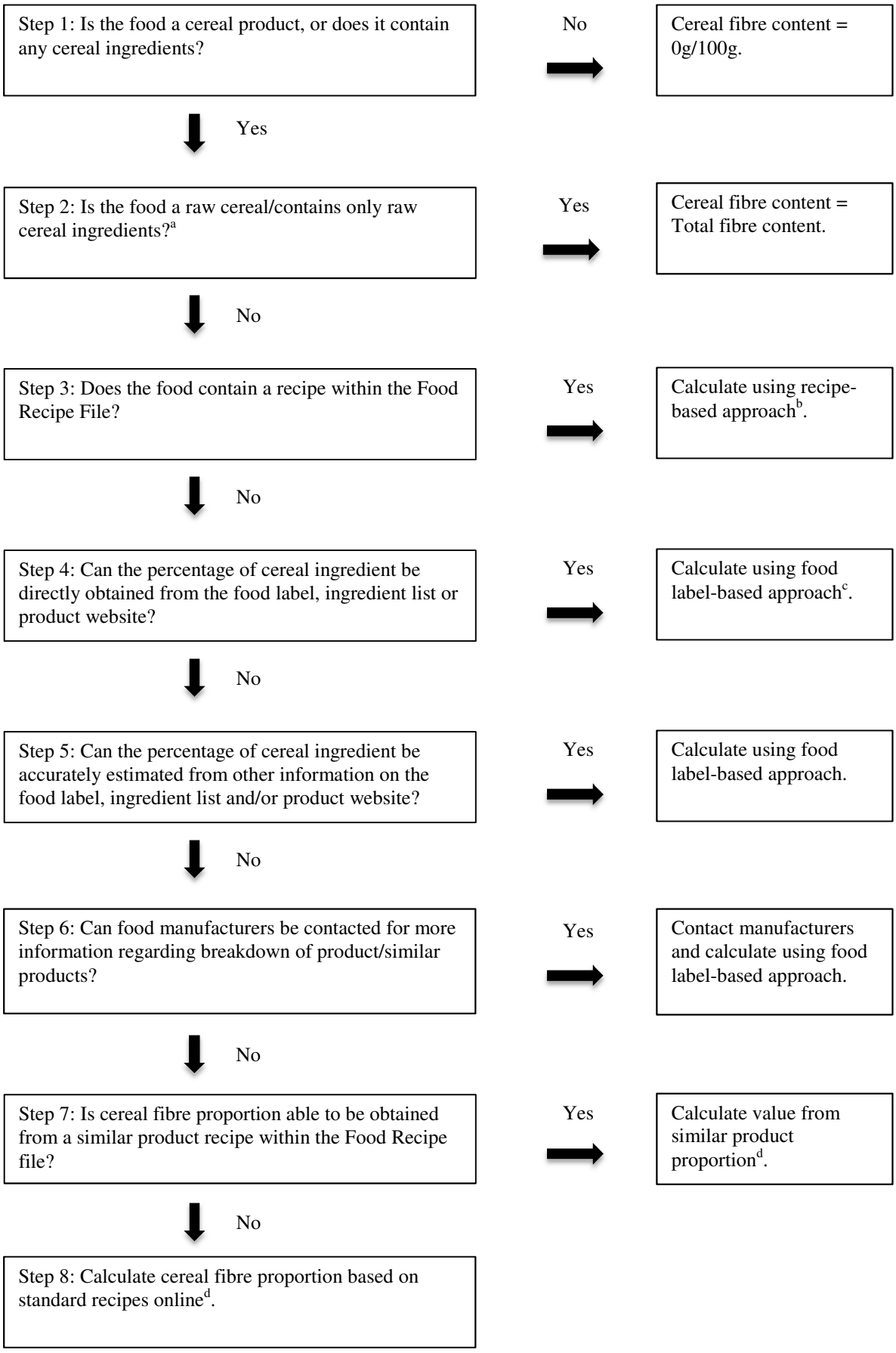
Step 1: Is the food a cereal product, or does it contain any cereal ingredients?
No
Cereal fibre content = 0g/100g.
Yes
Step 2: Is the food a raw cereal/contains only raw cereal ingredients?[a]
Yes
Cereal fibre content = Total fibre content.
No
Step 3: Does the food contain a recipe within the Food Recipe File?
Yes
Calculate using recipe-based approach[b].
No
Step 4: Can the percentage of cereal ingredient be directly obtained from the food label, ingredient list or product website?
Yes
Calculate using food label-based approach[c].
No
Step 5: Can the percentage of cereal ingredient be accurately estimated from other information on the food label, ingredient list and/or product website?
Yes
Calculate using food label-based approach.
No
Step 6: Can food manufacturers be contacted for more information regarding breakdown of product/similar products?
Yes
Contact manufacturers and calculate using food label-based approach.
No
Step 7: Is cereal fibre proportion able to be obtained from a similar product recipe within the Food Recipe file?
Yes
Calculate value from similar product proportion[d].
No
Step 8: Calculate cereal fibre proportion based on standard recipes online[d].

Figure 1: The systematic process for calculation of cereal fibre content of foods to expand the AUSNUT 2011-13 Database.

a. Cereals include barley, maize, millet, oats, rice, rye, sorghum, teff, triticale, wheat (all varieties: burghul, durum, einkorn, farro, freekeh, Khorasan and spelt), amaranth, buckwheat and quinoa. Cereals can be in their raw forms or processed form (flour or meal) that contains no other non-cereal ingredients.

b. Recipe-based approach: Cereal fibre content (g/100g) = $\frac{\text{Ingoing cereal fibre (g)}}{\text{Final weight of product (g)}}$ x 100.

Ingoing cereal fibre content (g) is sum of ingredient cereal fibre content (g) and final weight of the product is sum of ingredient weight (g) x ($\frac{100+\text{weight factor}}{100}$).

c. Food-label-based approach: Cereal fibre content (g/100g)= $\frac{\text{Ingoing cereal fibre (g/100g)}}{\text{Label total fibre (g/100g)}}$ x AUSNUT dietary fibre value (g/100g).

Ingoing cereal fibre is calculated as in Step 3, Label total fibre is sourced directly from product label, AUSNUT dietary fibre value refers to food product dietary fibre value already contained in AUSNUT database.

d. Cereal fibre calculated from similar product within Food Recipe file or online recipe as per Ingoing cereal fibre (g) in Step 3 & 4. Cereal fibre calculated as a percentage of total fibre and applied to the AUSNUT dietary fibre value as in step 4.

Table 1: Calculating cereal fibre content using the recipe-based approach

Food Name	Weight change factor[a]	Ingredients	Ingredients weight (g)	Ingoing total fibre content (g)	Ingoing cereal fibre content (g)	Final weight (g)[b]	Total fibre (g/100g)	Total cereal fibre[c] (g/100g)
Plain grain products								
Flour, wheat, white, plain		Flour, wheat, white plain	100	3.8	3.8	100	3.8	3.8
Oats, rolled, uncooked		Oats, rolled, uncooked	100	9.7	9.7	100	9.7	9.7
Mixed product								
Crumble, apple, baked, homemade	-7	Flour, wheat, white plain	90	3.4	3.4	1118.3	2.2	0.6
		Sugar, brown	85	0	0			
		Nut, almond, without skin, blanched, unsalted	50	4.5	0			
		Oats, rolled, uncooked	30	2.9	2.9			
		Cinnamon, dried, ground	2.5	1.4	0			
		Juice, lemon, home squeezed	60	1.5	0			
		Fat, butter, dairy blend or margarine spread, not further defined	85	0	0			
		Apple, peeled, stewed, sugar sweetened, no added fat	800	11.2	0			

a. From Food Standards Australia New Zealand AUSNUT 2011-13 Food Recipe File

b. Final weight = sum of ingredient weight (g) x $(\frac{100+\text{weight factor}}{100})$

c. Total cereal fibre = $\frac{\text{Ingoing cereal fibre content (g)}}{\text{Final weight (g)}}$ x 100

Table 2: Calculating cereal fibre content using the food label-based approach

AUSNUT food name	Matching commercial product[a]	Ingredients as per label	Ingredient amount as per label (%)	Ingoing cereal fibre content (g/100g)[b]	Label total dietary fibre (g/100g)	AUSNUT dietary fibre value (g/100g)	Cereal fibre content[c] (g/100g)
Breakfast cereal, whole wheat, small biscuit, with apricot, added vitamins B1, B2, B3 & folate, Ca & Fe	Sanitarium Apricot Bites[d]	Whole grain wheat	63%	7.6	9.0	9.2	9.1
		Oats	6%	0.6			
		Raw sugar	4.5-6%				
		Concentrated apricot puree	4.5%				
		Invert sugar	1-4.5%				
		Humectant (glycerol)	1-4.5%				
		Honey	1%				
		Sugar	0.7-1%				
		Minerals (calcium, iron)	0.7-1%				
		Wheat fibre	0.7-1%	~0.7			
		Salt	0.7%[e]				
		Pectin	<0.7%				
		Flavours	<0.7%				
		Barley malt extract	<0.7%				
		Citric acid	<0.7%				
		Colours	<0.7%				
		Vitamins	<0.7%				
				Total: 8.9g			

a. Located using Food Standards Australia New Zealand AUSNUT 2011-13 Food details file

b. Using recipe approach for matching ingredients within AUSNUT 11-13 database

c. Cereal fibre content (g/100g) = $\frac{\text{Ingoing cereal fibre content (g/100g)}}{\text{Label total dietary fibre (g/100g)}}$ x AUSNUT dietary fibre value (g/100g)

d. Sanitarium Health Food Co., Berkeley Vale, NSW

e. Based on 285mg sodium/100g product (food label data)

Table 3: Breakdown of cereal fibre content within the AUSNUT 2011-13 two-digit major food groups

Major food group	Foods containing cereal fibre, n (%)	Maximum cereal fibre content (g)/100g
Non alcohol beverages	11 (0.6)	5.9
Cereal and cereal products	492 (25.7)	41.8
Cereal based products and dishes	906 (47.2)	14.3
Fish and seafood products and dishes	85 (4.4)	1.7
Fruit products and dishes	4 (0.2)	0.7
Egg products and dishes	5 (0.3)	0.7
Meat, poultry and game products and dishes	211 (11.0)	1.2
Milk products and dishes	23 (1.2)	0.9
Dairy & Meat substitutes	7 (0.4)	1.2
Soup	24 (1.3)	1.2
Savoury sauces and condiments	17 (0.9)	4.9
Vegetable products and dishes	30 (1.7)	1.5
Legume and pulse products and dishes	7 (0.4)	0.6
Snack foods	31 (1.6)	16.5
Confectionary and cereal/nut/seed bars	51 (2.7)	10.7
Alcohol beverages	1 (0.0)	0.1
Special dietary foods	7 (0.4)	1.5
Miscellaneous	2 (0.1)	1.3
Infant formulae and food	4 (0.2)	4.8