

# THE GUTS OF IT








Latest evidence on the critical role of whole grains and cereal fibre for a healthy gut microbiome




AUSTRALIAN  
BREAKFAST  
CEREAL  
MANUFACTURERS  
FORUM



# WHAT DOES THE EVIDENCE TELL US?

-  The effects of whole grains and cereal fibres on the gut microbiome may in part explain their health benefits, particularly in relation to weight, cardiovascular disease and cancer.
-  Whole grains and cereal fibres contain several types of dietary fibre and phytochemicals that promote microbiota diversity and good gut health. Many of these components are unique to grains or found in higher amounts than in other plant-based foods.
-  The evidence strongly suggests the protective effects of whole grains comes from the cereal fibre they contain.
-  Cereal fibre, found in the bran layers of the intact whole grain, includes both fermentable fibres with prebiotic actions (Microbiota-Accessible Carbohydrates or MACs), as well as insoluble fibres.
-  Insoluble fibres play a crucial role in carrying MACs through the length of the colon, slowing their fermentation and, by doing so, releasing important phytochemicals in areas of the colon that are more prone to cancerous changes.
-  Whole grain and cereal fibres rely on the gut to unlock their antioxidant potential, with many of the powerful phytochemicals they contain only released through microbial fermentation. This slow release prolongs antioxidant protection.
-  The insoluble fibres have the highest phenolic content and greatest antioxidant capacity.

 Regular consumption of whole grain or high fibre breakfast cereals has been shown to have a positive effect on the microbiota and microbiome, with significant changes evident in just three weeks.



# INTRODUCTION

The gut microbiome is one of the most intriguing areas of nutrition science. While we're only just beginning to understand the complex role it plays in human health, there are already clear biological mechanisms linking the gut microbiome to numerous aspects of metabolic, physical and mental health.

This emerging evidence includes new insights into whole grains and cereal fibre and may, in part, explain their association with a lower risk of several chronic diseases, including some cancers, type 2 diabetes, obesity and cardiovascular disease (CVD).

A lack of whole grains was recently identified as one of the top three dietary factors impacting mortality and health worldwide. We're now beginning to fully understand why.

The wide range of dietary fibres and phytochemicals found in whole grains and cereal fibre are important for a healthy microbiome. Many are unique to grains and complementary to those found in vegetables and other plant foods. Some provide direct gut health benefits, such as the prebiotic effects of fibres in the gut or absorption of phytochemicals, while many others are actually mediated by the gut microbiome.

For Australians, breakfast cereals are a leading food source of whole grains, cereal fibre and dietary fibre. Regular consumption of whole grain and high fibre breakfast cereals has been shown to have a positive effect on the microbiome, increasing microbial diversity and evenness, reducing inflammation and providing long-lasting antioxidant protection.

Clear advice on how to incorporate a variety of breakfast cereals, containing high levels of whole grains and/or cereal fibre, would greatly assist Australians to make healthy choices that could benefit their microbiome.

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“THE WIDE RANGE OF FIBRES AND PHYTOCHEMICALS  
FOUND IN WHOLE GRAINS AND CEREAL FIBRES ARE  
IMPORTANT FOR A HEALTHY MICROBIOME.”

Dr Joanna McMillan

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# OVERVIEW

Dr Joanna McMillan was commissioned by the Australian Breakfast Cereal Manufacturers Forum (ABCMF) to review the published scientific literature on the impact of whole grains, cereal fibre and products made from them, in particular breakfast cereals, on the gut microbiome, gut health and overall health.

## METHODOLOGY

The research review was undertaken using Medline to search the scientific literature for research on grains, wholegrains, wholegrain products and breakfast cereals in particular, on all aspects of health and their influence on the microbiome. This research, concentrating on papers published in the past five years, formed the basis of this report.

## DEFINITIONS

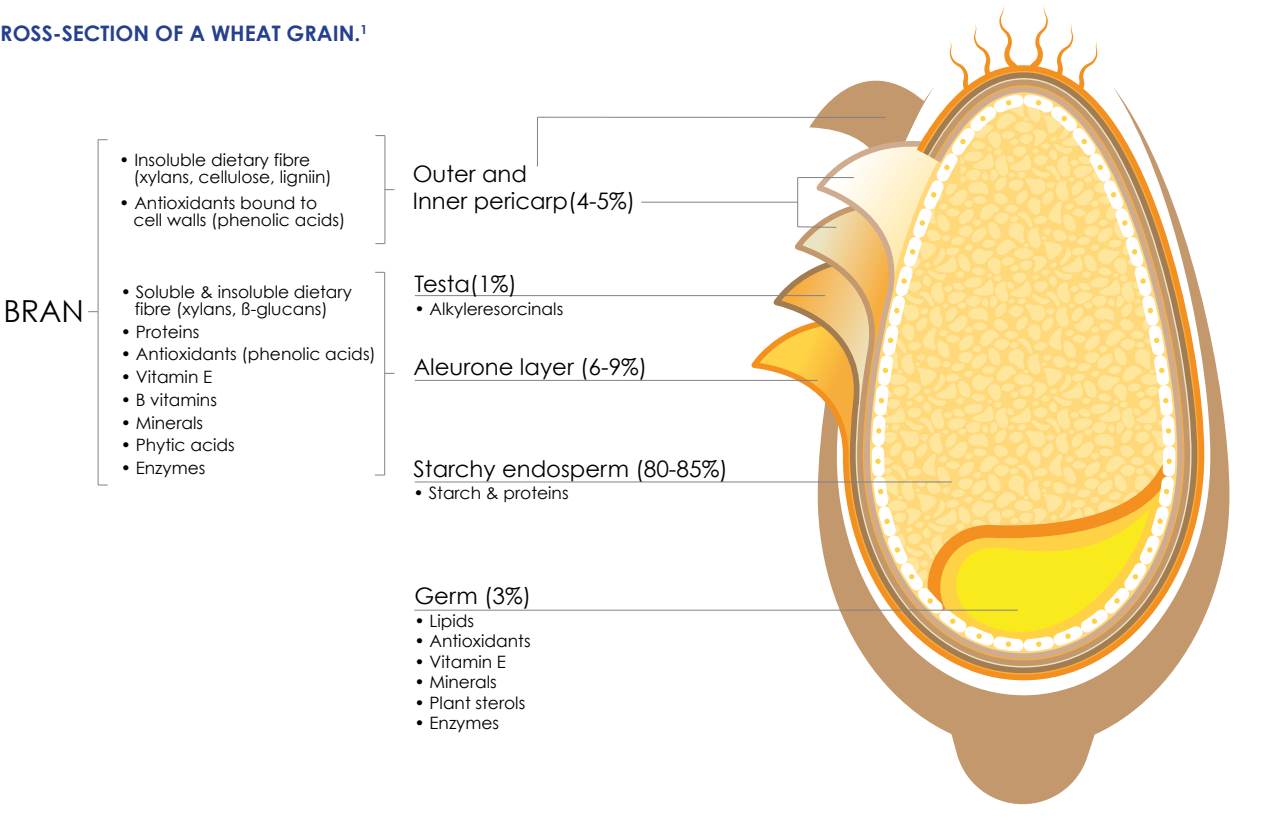
**Grains and cereals:** These terms are often used interchangeably and they both refer to the edible seeds of grasses from the Poaceae family. These include wheat, oats, rice, barley, rye, corn (maize), millet and sorghum.

**Whole grains:** The Australia New Zealand Food Standards Code defines whole grain as “the intact grain or the dehulled, ground, milled, cracked or flaked grain where the constituents – endosperm, germ and bran – are present in such proportions that represent the typical ratio of those fractions occurring in the whole cereal, and includes wholemeal”. This includes intact minimally processed grain foods such as rolled oats and brown rice, flaked whole grain breakfast biscuits as well as products made from whole grain or wholemeal flour such as whole grain breakfast cereals and breads.

**Cereal fibres:** These are specific fibres found in whole grains/cereals. They are almost all located in the outer layers of the grain that are collectively called the bran. The bran can be removed from the grain and added to food products, as part of the manufacturing process, to increase the fibre of foods such as breakfast cereals and breads. Wheat bran and oat bran are two common examples.

# ANATOMY OF A GRAIN

CROSS-SECTION OF A WHEAT GRAIN.<sup>1</sup>



Whole grains are comprised of three main layers: the endosperm, germ and bran. The endosperm is mainly starch, but food processing methods affect its digestibility and the levels of resistant starch (RS). Fructans are also mostly present in the endosperm.

The outer layer of the endosperm is called the aleurone layer and contains small amounts of proteins, arabinoxylans and β-glucan.<sup>2</sup>

The germ is the smallest part of the intact grain and is the embryo for the growth of a new plant. It contains B group vitamins along with healthy fats, protein and minerals.

The outer layers of the intact whole grain, collectively called the bran, are where the vast majority of the fibres and bioactive phytochemicals are found, along with more B group vitamins.

Cereal fibres (fibre found in cereal/grains) are almost all located in the bran and are concentrated sources of both fibres and phytochemicals.

Both whole grain products and those rich in cereal fibres, including breakfast cereals, have shown health benefits, whereas isolated fibre extracts alone elicit some but not all of the same effects. This indicates that it is the whole grain or bran matrix of compounds that collectively provides the most benefit.

Refining of grains removes the bran and the germ, leaving only the endosperm. This process removes the cereal fibres, the phytochemicals and many of the micronutrients. This affects the nutritional quality of foods made from refined grains, as well as their impact on the gut microbiome.

# WHOLE GRAINS & CEREAL FIBRE

Whole grains are important foods that influence health. Whole grain intake has been associated with a reduction in risk of several chronic diseases including cancer (especially colon cancer), type 2 diabetes, obesity and cardiovascular disease (CVD).<sup>3-5</sup>

However, most Australians (70%) fall short of the recommended 48g of whole grains a day, with a median adult intake of 21g a day and a median intake among children of 16g a day (below their 32g-40g whole grain target).<sup>6</sup> For cereal fibre, the median intake for adults was 6.4g a day and for children and adolescents was 6.2g a day, based on data from the 2011-12 National Nutrition and Physical Activity Survey.<sup>7</sup>

A recent analysis of the influence of dietary risks on health globally found a low intake of whole grains was associated with the most deaths and DALYs (disability-adjusted life years), more than a low intake of fruit and vegetables.<sup>8</sup> The question is why?

Traditionally, any benefits from whole grains have been attributed to their high fibre content.

Epidemiological studies have used varying definitions of whole grain foods, some including foods high in cereal fibre and others not, somewhat confusing the issue.

However, intake of whole grains and cereal fibre have both been associated with reduced risk of all-cause mortality and death from several chronic diseases - a relationship that is weakened after adjusting for cereal fibre intake. The evidence strongly suggests the protective effect of whole grains comes from the cereal fibre they contain.<sup>9</sup>

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The fibres present in whole grains include:

- Non-starch polysaccharides (NSP) - mainly arabinoxylans, β-glucan and cellulose
- Resistant starch (RS)
- Oligosaccharides - fructans, fructo-oligosaccharides (FOS), galacto-oligosaccharides (GOS)
- Lignin and lignans

The amount and type of fibre differs for each variety of whole grain. Rye and wheat have the most overall fibre, NSP and arabinoxylan. Oats are well known for their high levels of the soluble fibre beta-glucan, while corn has more RS and rye has relatively high levels of fructans.

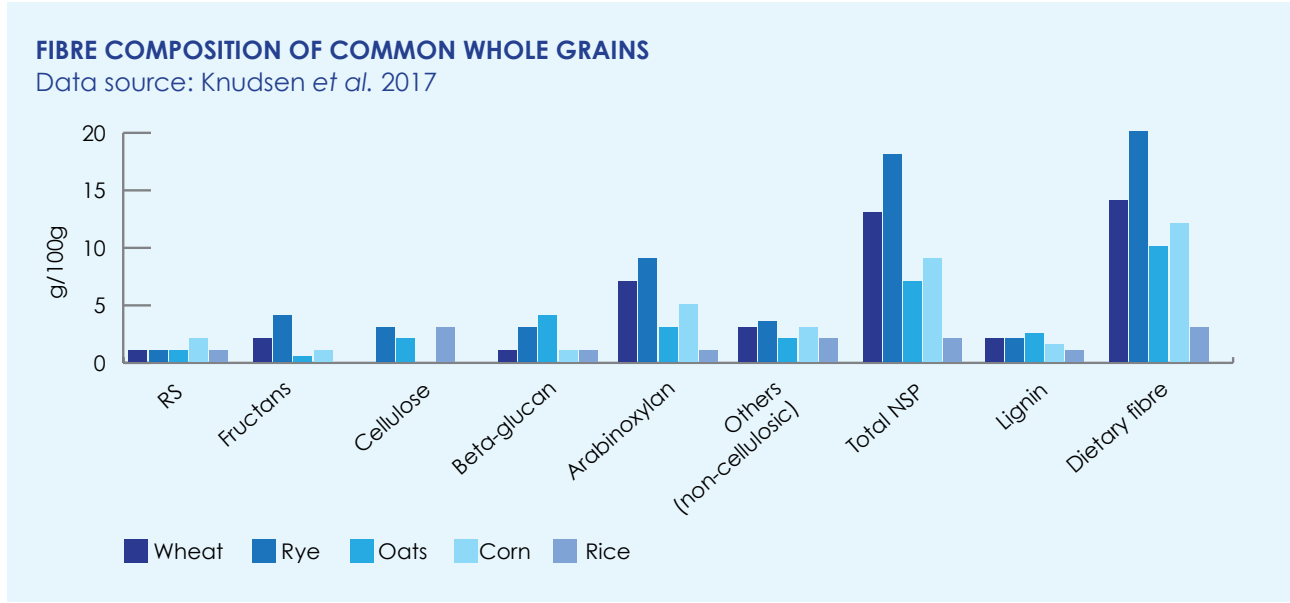
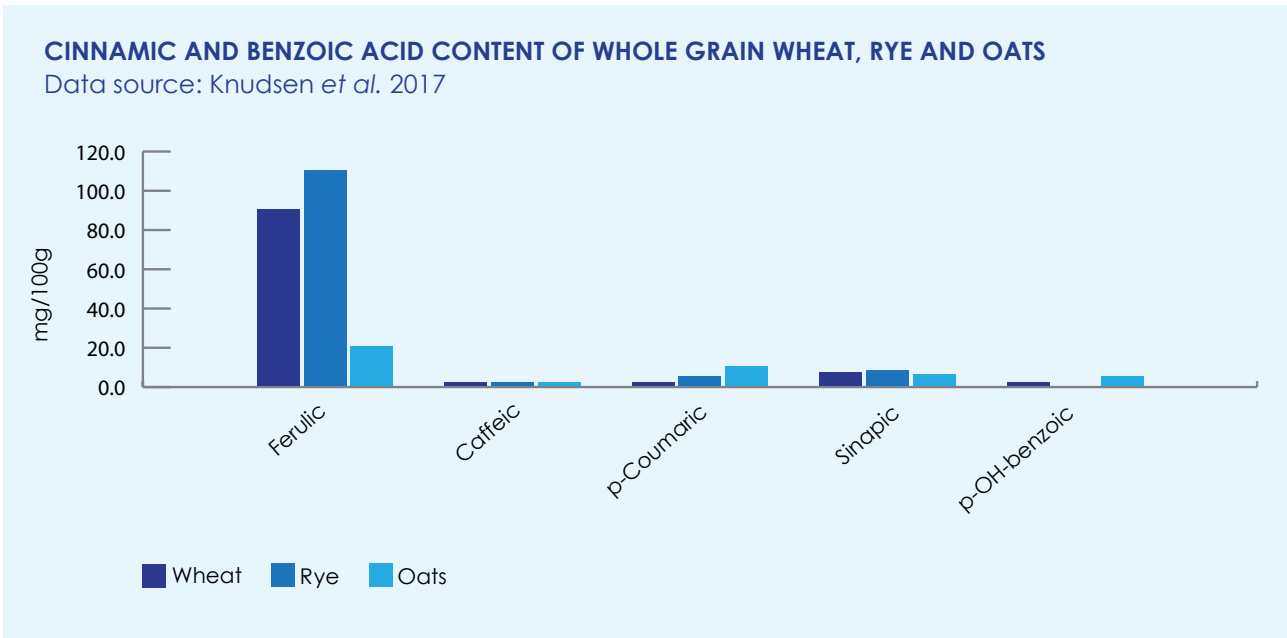
## PHYTOCHEMICALS IN WHOLE GRAINS

Although most attention has been given to the fibre content of whole grains, more recent research is uncovering the major role of the bioactive phytochemicals in grains.

Whole grains provide significant amounts of polyphenols, plant sterols, tocopherols and betaine. There are differences in the types of bioactive phytochemicals found in grain varieties. Wheat,

for example, is a good source of polyphenols (<1459 mg/100g), whereas sorghum (3-43 mg/100g) and oats (9-34 mg/100g) have lower levels. Rice, while much lower in fibre, is rich in flavonoids compared to other cereals.<sup>10</sup>

The major phenolics present in whole grains are benzoic and cinnamic acids, with ferulic acid being the most abundant.





# THE GUT MICROBIOME

Residing within the human gut are 10<sup>14</sup> resident micro-organisms, mostly bacteria. Collectively these are called the gut microbiota. The combined genetic material of the microbiota is called the microbiome.

Everyone's microbiome is unique and is shaped by many factors including genetics, environment, diet and lifestyle. The development of a child's microbiome is influenced by the type of delivery at birth and feeding practices, such as breast feeding and types of weaning foods. By roughly 2-3 years of age, a child has an adult-like microbiota and, from that point on, diet plays a starring role in its diversity and composition.

Dietary changes are thought to be responsible for around 57% of the variation in the gut microbiota, compared with only 12% for genetics.<sup>11</sup> There is therefore huge potential in using diet to modulate the microbiome towards shifts associated with better health outcomes.

There has been much interest in recent years in the role of the gut microbiome in influencing both physical and mental health. Functional and compositional changes in the microbiota have been associated with several chronic diseases including type 2 diabetes, overweight and obesity, CVD, inflammatory bowel disease (IBD), autoimmune diseases and inflammatory skin diseases such as psoriasis.<sup>12-14</sup>

The gut microbiota is also thought to modulate communications between the gut and the brain (the gut-brain axis) where it may influence anxiety, depression and mood, as well as appetite regulation.<sup>15</sup>

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The diversity of the microbiota seems to be particularly important, with greater diversity associated with better health outcomes. The commonly promoted goal of having 'a balance of good and bad bacteria' is not accurate. Aside from disease-causing pathogenic bacteria, most bacteria are neither good or bad. It is the balance between the various bacterial groups that is essential. This is referred to as 'species evenness'. This means that neither an individual species, or small group of species, dominates. In essence, a healthy microbiome is one with a diverse and even mix of different micro-organisms.

The microbiota aid the digestive process by helping to break down components of food, harvesting energy and producing some vitamins. Fermentation of the gut contents leads to the production of various metabolites - some beneficial and others thought to be detrimental (e.g. trimethylamine, which is converted in the liver to trimethylamine-n-oxide (TMAO), has been associated with atherosclerosis).<sup>16</sup> Diet influences the production of these metabolites.



## WHAT DOES THE MICROBIOME DO? <sup>14</sup>

- Helps with digestion by breaking down food components our enzymes are unable to.
- Produces some micronutrients e.g. vitamin K.
- Keeps colonic cells healthy and maintains an intact gut lining with a healthy mucosal layer.
- Produces metabolites that travel to the heart, lungs, liver, kidneys and brain influencing many aspects of physical and mental health.
- 'Trains' the immune system early in life and continually influences immune function throughout life.

From birth to around two years is a crucially important time when the microbiome is still developing. As it does, it interacts with the immune system signalling it to respond appropriately to incoming microorganisms, as well as food components. In this way the microbiome is thought to be involved in allergies and auto-immune conditions.



## MEASURING THE MICROBIOME

Our understanding of the microbiome, and its broader associations with health, has been greatly accelerated in recent years with the development of what is called 'shotgun metagenomics'. This is an advanced type of DNA sequencing that allows researchers to gain an accurate picture of what microbes are present in the gut and what they do.

Initially stool culture tests were used, but since most microbes living in the gut are anaerobic, they cannot be easily grown in the laboratory. The development of 16S ribosomal RNA sequencing, first pioneered in 1977, was a great advancement. This process sequences the DNA from a single gene common to all bacteria - the 16S ribosomal gene.

This type of testing still has limitations and is unable to provide accurate analysis of individual species, but as whole genome sequencing becomes more cost effective and available, there will be the potential for more personalised dietary advice and interventions to alter the microbiome.



# FIBRE & THE MICROBIOME

Dietary fibres can broadly be grouped into soluble fibres, insoluble fibres and resistant starch(RS). They have different physiological effects and importantly not all are fermentable by the microbiota.

There have been several misconceptions about insoluble fibres. As well as being bulking agents, many are also fermentable. As an example, whole grain wheat is rich in insoluble fibre and about a third of wheat bran fibre has been shown to be fermented.<sup>17</sup>

A crucially important function of insoluble fibres is to carry highly fermentable fibres, such as RS, through the length of the colon. This slows their fermentation and allows beneficial metabolites, such as butyrate and other short chain fatty acids (SCFA), to be produced distally.<sup>2,18</sup> Most cancers occur in this distal section of the colon and therefore, this may be one way that consuming foods containing a wide variety of fibre types, such as breakfast cereals, may provide cancer protection.

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The term Microbiota-Accessible Carbohydrates (MACs) has been coined to identify fermentable fibres. RS is highly fermentable, as are most soluble fibres, while a smaller percentage of insoluble fibres are also fermentable.

Greater consumption of MACs leads to increased production of the SCFA propionate, acetate and butyrate from bacterial fermentation. This lowers the pH in the lumen, inhibiting the growth of many pathogens and increases the absorption of some nutrients.

Fermentable fibres, or MACs, may also play a role in weight control. Epidemiological studies have shown that those with higher fibre and whole grain intakes tended to weigh less and were leaner.<sup>19,20</sup> A diet higher in MACs leads to a greater production of SCFAs, which aid with appetite regulation and food intake by binding to colonic cells involved in the production of peptide YY and GLP-1.<sup>21</sup>

Butyrate, also produced from MACs bacterial fermentation, has received much attention as it is the primary energy source for the colonic cells. Butyrate induces changes in gene expression influencing colonic function, reduces inflammation, prevents the growth of colonic cancer cells and increases the production of mucin, improving tight junction integrity. This helps to maintain gut barrier function.<sup>22</sup>

While a high-MACs diet has many gut health benefits, a diet low in MACs has been shown to lead to a decline in overall bacterial diversity and to influence the balance of different bacterial groups.

In particular, a low-MACs diet increases the growth of mucin-degrading bacteria. These are bacteria that thrive on the mucus produced in the gut wall. An overabundance of these bacterial groups can lead to thinning of the mucus layer, decreased epithelial integrity and increased gut permeability ('leaky gut syndrome'). In turn, this can lead to inflammation within the gut wall, increased susceptibility to infections and activation of specific immune responses.<sup>23</sup>

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There may also be particular benefits from specific fibres. For example, whole grains rich in  $\beta$ -glucans and arabinoxylans have been shown to stimulate the proliferation of butyrate-producing bacteria and raise butyrate levels. This may have clinical relevance, as patients with ulcerative colitis consuming 60g of oat bran rich in  $\beta$ -glucans had a significantly increased faecal butyrate level.<sup>24</sup>

There is some evidence to suggest that the complex mixture of bioactive chemicals in whole foods is much better for us than isolated extracts. Studies have not shown the same effect from an extracted arabinoxylan-rich fraction of wheat, compared to consuming whole grain wheat or wheat bran.<sup>2</sup>

There is, therefore, the suggestion that the consumption of the whole grain matrix is important, perhaps because it slows down the fermentation process and results in butyrate being produced for a greater length of the colon.<sup>2</sup>

A Danish study of 50 adults with an increased metabolic risk profile, compared a diet high in whole grains with a refined grain diet over eight weeks. The whole grain foods included rolled oats, an oat flake breakfast cereal, whole grain bread and pasta, bulgur wheat and rye crispbreads. The whole grain diet significantly reduced body weight and serum inflammatory markers (IL-6 and CRP).

The amount of whole grains was associated with these measures, especially the consumption of rye. There were also subtle microbiota changes in response to the whole grain diet (increase in some specific species including *F. prausnitzii* and *Prevotella copri*) and there was an increase in the urinary excretion of microbial metabolites indicating increased fermentation.<sup>25</sup>



# PHYTOCHEMICALS & THE MICROBIOME

Whole grains and cereal fibres contain a range of potent phytochemicals, particularly phenolics of the two groups hydroxybenzoic acids and hydroxycinnamic acids, with ferulic acid being the most abundant.<sup>26</sup>

Ninety percent of the phenolics found in grains are bound to fibres in the bran layer. This means only 5-10% are directly absorbed by the body. The remainder reach the colon, where they are released via microbial fermentation.

The phenolics have been shown to modulate the microbiota composition, boosting the growth of beneficial species. Some are directly absorbed into the bloodstream and others are metabolised by the microbiota into more active and better absorbed metabolites.<sup>26</sup>

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Ferulic acid is the most abundant phenolic in whole grains and cereal fibre, particularly whole grain wheat, wheat bran and corn. It is one of the most potent antioxidants found in plant cell walls and may have benefits in preventing and managing various disorders associated with oxidative stress.<sup>27</sup>

Very little of the ferulic acid in whole grains and cereal fibre is directly absorbed because it is bound to the cereal fibres. Once it reaches the colon, it is gradually released via microbial fermentation. This slow fermentation process keeps levels of ferulic acid elevated in the blood, providing antioxidant protection for up to 24 hours. In contrast, ferulic acid from fruits or drinks, such as coffee, increase blood levels for only 0.5-3 hours.

The consumption of whole grain or wheat bran cereals, rich in ferulic acid, may therefore provide 24-hour oxidative protection to LDL-cholesterol and other components in the blood.<sup>28</sup> This may be one mechanism by which they reduce the risk of CVD.

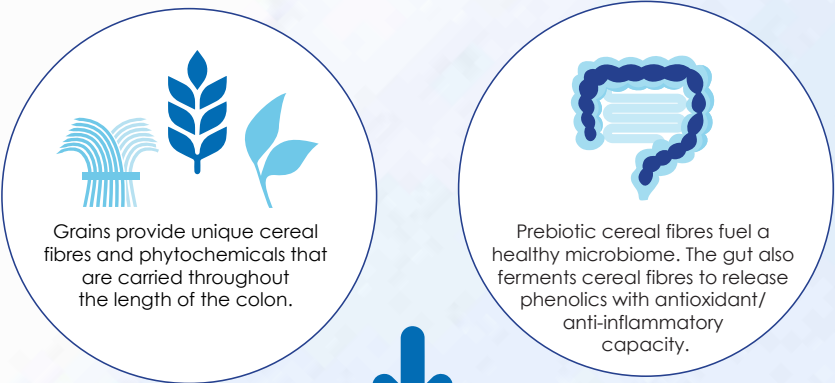
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Oats contain a unique group of phenolic compounds called avenanthramides. In topical applications avenanthramides have an anti-itch and anti-inflammatory effect, hence the abundance of oatmeal bathing products and ointments for itchy skin conditions.<sup>29</sup>

Avenanthramides in oats are linked to cell wall polysaccharides and, similar to ferulic acid, absorption is limited until they reach the large intestine. Once there, the microbiota converts the avenanthramides into various bioactive metabolites, which have effects locally within the colon and colonic walls, as well as systemically once absorbed into the bloodstream. They reduce inflammation and oxidative stress, thought to be one of the mechanism by which they reduce the risk of CVD and cancer.<sup>30</sup>

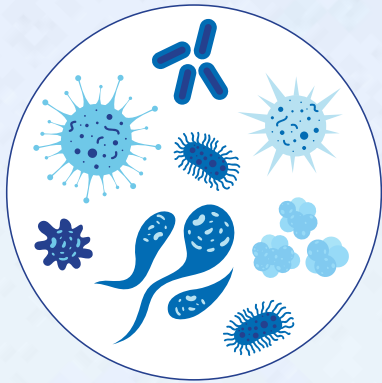


# THE GUT - GRAIN CONNECTION





## GUT BENEFITS

- Fosters and feeds a diverse microbiota
- Improves nutrient absorption
- Lowers pathogen growth
- Prolongs antioxidant protection
- Delivers protective compounds to distal colon



## PHYSIOLOGICAL CHANGES

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**REDUCES**  
Inflammation  
Oxidative stress  
Growth of colonic cancer cells
- 

**INCREASES**  
Appetite regulation  
Gut barrier function

## IMPACTS ON HEALTH

Positive changes in the microbiota have been shown to benefit CVD, T2D, body weight, autoimmune diseases, IBD, and inflammatory skin disorders and may influence anxiety, depression and mood.



# BREAKFAST CEREALS & THE MICROBIOME

Breakfast cereals are a popular breakfast choice. A recent analysis showed that among the 88% of Australian adults who consume breakfast, almost half ate breakfast cereal. Nutritionally this is important, as those that ate breakfast cereal had healthier diets overall.<sup>31</sup>

In Australia, breakfast cereals are a leading source of whole grains, cereal fibre and total dietary fibre.

Forty percent of all whole grain eaten in Australia is in the form of breakfast cereals,<sup>6</sup> while ready-to-eat breakfast cereals and porridge together provided 28.8% of cereal fibre for adults and 21.7% for children.<sup>32</sup>

Looking at the category, 70% of breakfast cereals available in Australia are classified as whole grain and 85% classified as either a source, good source or excellent source of fibre.<sup>33</sup>

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In relation to a potential impact on the microbiome, breakfast cereal eaters ate double the daily serves of whole grain foods compared to those who ate other breakfasts and triple that of breakfast skippers. Breakfast cereal eaters also had the highest fibre intakes, driven by higher fibre intakes both at breakfast and through the rest of the day.<sup>31</sup>

So, when it comes to breakfast cereal and gut health, what does the latest science tell us?

- A recent systematic literature review of cereal grain fibres on the gut microbiota found there was increased microbiota diversity and/or abundance after regular cereal fibre consumption. This was shown in 39 out of the

42 studies included in the review. The study reported whole wheat was a major source of fibre in Western diets and as little as 6-8g a day was enough to produce significant effects on the microbiota. A daily bowl of a high fibre breakfast cereal was found to have a positive effect on the microbiota within three weeks. The benefits of daily breakfast cereal consumption were observed for at least a year.<sup>34</sup>

- A study of healthy adults fed a whole grain corn breakfast cereal for three weeks showed a significant increase in the beneficial species *Bifidobacterium*, compared to a non-whole grain cereal.<sup>35</sup>
- A UK study examined the impact of breakfast cereal type on the gut microbiota. The participants, 31 healthy men and women with no known gut disorders, ate either whole grain wheat breakfast cereal or a wheat bran enriched breakfast cereal, every day for three weeks. Compared to the wheat bran cereal group, consuming the whole grain cereal resulted in a significant increase in the beneficial bacteria *Bifidobacterium* spp. and a greater increase in *Lactobacilli*.<sup>28</sup> While both the whole grain and the wheat bran breakfast cereals increased plasma levels of ferulic acid three-fold. The findings do suggest there may be differences between consuming whole grain products, versus those enriched with cereal fibres, such as wheat or oat bran.
- A randomised controlled trial in 80 healthy overweight/obese adults showed that consumption of a whole grain wheat breakfast cereal, compared to an isocaloric refined wheat breakfast (crackers and toasted bread), increased 0.8-fold excreted ferulic acid content in faeces and increased 5-fold blood levels of diferulic acid (DHFA), a microbial metabolite derived from ferulic acid. Those consuming the whole grain wheat cereal also had a significant reduction in inflammatory markers.<sup>36</sup>

- Oats are well-known for their potential to reduce cholesterol levels and this is thought to be the major mechanism by which they offer cardiovascular protection. The cholesterol reducing effect has largely been attributed to the high levels of the soluble fibres  $\beta$ -glucans, also present in barley. However, studies have shown that  $\beta$ -glucans are effective prebiotics, boosting the growth of *Lactobacilli* and *Bifidobacterium*.<sup>37</sup> For example, consuming a 45g serve of whole grain oat granola, compared to a non-whole grain breakfast cereal, for six weeks was shown to lower total cholesterol levels by 10% and LDL-C by 6% in adults at high risk of CVD and increase the relative abundance of *Bifidobacterium* by 5% and *Lactobacilli* by 2%.<sup>38</sup>
- A randomised, controlled, crossover study in mildly hypercholesterolaemic adults found high molecular weight barley  $\beta$ -glucan incorporated into breakfast in the form of porridge, crepes, tortillas or chips increased the abundance of *Bacteroidetes* and decrease the abundance of *Firmicutes*, in line with the profile found in lean compared to obese individuals. There were also changes in specific bacterial species associated with an improved CVD risk profile.<sup>39</sup>

Collectively these studies illustrate the potential for breakfast cereals to beneficially impact the microbiome and boost health. Of course, the choice of breakfast cereal is important. Some are made from refined grains and some are high in fibre (either based on bran, or with added whole grains, bran or fibre extracts), others are made from minimally processed intact whole grains (e.g. rolled oats, muesli, toasted grains, whole grain wheat biscuits and shredded wheat) and others from whole grain flour. Further research is needed to explain any differences on their gut health impact, due to processing of these products.

At present, the existing research suggests that consuming a variety of whole grain or high fibre cereals and incorporating different grains would be beneficial for gut health. A bowl of breakfast cereal a day has been shown to be effective in producing positive changes to the microbiome.

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# CONCLUSIONS

Whole grains and cereal fibres have the potential to alter the gut microbiome in beneficial ways. They include important phytochemicals, prebiotics that fuel the microbiota, as well as insoluble fibres that help carry fermentable fibres throughout the length of the colon.

Bacterial fermentation releases their bound phenolic compounds, principally ferulic acid. These have benefits within the colon, as well as resulting in blood levels of this antioxidant that remain elevated for some 24 hours providing protection from oxidative damage to blood components.

Many of the antioxidants and other phytochemicals found in whole grains and cereal fibre are either unique to the grain, such as avenanthramides in oats, or present in much higher amounts compared to other foods, as with ferulic acid. This makes them highly complementary combined with fruits, vegetables and other plant foods in the diet. The diversity of both fibre types and phytochemicals in plant-based diets is key to promoting a diverse healthy microbiome with knock-on effects on mental and physical health.

Recommendations to consume a bowl a day of whole grain or high cereal fibre breakfast cereal, porridge or muesli, is a cost-effective and convenient means of helping Australians to meet their target intakes for fibre, cereal fibre and whole grains. In fact, research suggests it is difficult to reach these targets in typical Australian diets without regular consumption of breakfast cereal.<sup>40</sup> Regular consumption has the potential to induce positive changes to the microbiome and benefit physical and mental health.

More research is needed to clarify the differences between cereal fibre types and the consumption of whole grain foods with a matrix of fibres, nutrients and phytochemicals. This will help with advice as to choosing the healthiest breakfast cereals and for manufacturers to formulate products with the best gut health and microbiome effects.

## DIETARY RECOMMENDATIONS FOR A HEALTHY GUT MICROBIOME

- Emphasise a plant-rich diet, whether or not someone chooses to also consume animal foods.
- Include a diversity of plant foods to ensure a diversity of fibres to fuel a diversity of microbes.
- Choose foods high in wholegrains and cereal fibre daily – a bowl of whole grain or high fibre breakfast cereal, muesli or porridge is a convenient, easy and budget friendly option.
- Include legumes at least two to three times a week.
- Encourage a daily handful of nuts and/or seeds.
- Eat a variety of different vegetables and fruits.



# REFERENCES

1. Knudsen K *et al.* Dietary fibers and associated phytochemicals in cereals. *Mol. Nutr. Food Res.* 2017;7:1600518.
2. Knudsen K. Microbial degradation of whole-grain complex carbohydrates and impact on short-chain fatty acids and health. *Adv Nutr* 2015;6:206-13.
3. Ye EQ *et al.* Greater whole-grain intake is associated with lower risk of type 2 diabetes, cardiovascular disease, and weight gain. *J Nutr* 2012;142:1304-13.
4. Chen G *et al.* Whole-grain intake and total, cardiovascular, and cancer mortality: a systematic review and meta-analysis of prospective studies. *Am J Clin Nutr* 2016;104(1):164-72.
5. Benisi-Kohansal S *et al.* Whole-grain intake and mortality from all causes, cardiovascular disease, and cancer: A systematic review and dose-response meta-analysis of prospective cohort studies. *Adv Nutr* 2016;15;7(6):1052-65.
6. Grains & Legumes Nutrition Council. Australian Consumption & Attitudes Study. 2017. Unpublished.
7. Barrett E *et al.* Cereal fibre intake in Australia: A cross-sectional analysis of the 2011-12 National Nutrition and Physical Activity Survey. *Int J Food Sci Nutr* 2017;69(5):619-27.
8. GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. *The Lancet* 2019; 393(10184):1958-72.
9. Huang T *et al.* Consumption of whole grains and cereal fiber and total and cause-specific mortality: Prospective analysis of 367,442 individuals. *BMC Medicine* 2015;13:59.
10. Gong L *et al.* Whole cereal grains and potential health effects: Involvement of the gut microbiota. *Food Res Int* 2018;103:84-102.
11. Brown K *et al.* Diet-induced dysbiosis of the intestinal microbiota and the effects on immunity and disease. *Nutrients* 2012;4:1095-119.
12. Singh R *et al.* Influence of diet on the gut microbiome and implications for human health. *J Transl Med* 2017;15:73.
13. Hills RD *et al.* Gut Microbiome: Profound Implications for Diet and Disease. *Nutrients* 2019; 11:1613.
14. Mills S *et al.* Precision Nutrition and the Microbiome, Part I: Current State of the Science. *Nutrients* 2019;11:923.
15. Lach G *et al.* Anxiety, depression and the microbiome: A role for gut peptides. *Neurotherapeutics* 2018;5(1):36-59.
16. Nowinski A, Ufnal M. Trimethylamine N-oxide: A harmful, protective or diagnostic marker in lifestyle diseases? *Nutrition* 2018;46:7-12.
17. Nyman M *et al.* Fermentation of dietary fibre in the intestinal tract: Comparison between man and rat. *Br J Nutr* 1986;55:487-96.
18. Govers M *et al.* Wheat bran affects the site of fermentation of resistant starch and luminal indexes related to colon cancer risk: A study in pigs. *Gut* 1999;45:840-7.
19. Maki KC *et al.* The Relationship between Whole Grain Intake and Body Weight: Results of Meta-Analyses of Observational Studies and Randomized Controlled Trials. *Nutrients* 2019;11:1245.
20. Slavin JL. Dietary fibre and body weight. *Nutrition* 2005;21(3):411-8.
21. Sleeth ML *et al.* Free fatty acid receptor 2 and nutrient sensing: a proposed role for fibre, fermentable carbohydrates and short chain fatty acids in appetite regulation. *Nutr Res Rev* 2010;23:135-45.
22. Ríos-Covián D *et al.* Intestinal short chain fatty acids and their link with diet and human health. *Front Microbiol* 2016;7:185.
23. Daïen CI *et al.* Detrimental impact of microbiota-accessible carbohydrate-deprived diet on gut and immune homeostasis: An overview. *Frontiers in Immunol* 2017;8:548.
24. Hallert C *et al.* Increasing fecal butyrate in ulcerative colitis patients by diet: Controlled pilot study. *Inflamm Bowel Dis* 2003;9:116-21.
25. Roager HM *et al.* Whole grain-rich diet reduces body weight and systemic low-grade inflammation without inducing major changes of the gut microbiome: A randomised cross-over trial. *Gut* 2019;68:83-93.
26. Guo W *et al.* Phenolic acid composition and antioxidant potential of insoluble and soluble dietary fibre extracts derived from select whole-grain cereals. *Food Res Int* 2013;51:518-25.
27. Boz H. Ferulic Acid in Cereals – a Review. *Czech J Food Sci* 2015;33(10):1-7.
28. Costabile A *et al.* Whole-grain wheat breakfast cereal has a prebiotic effect on the human gut microbiota: a double-blind, placebo-controlled, crossover study. *Br J Nutr* 2008;99(1):110-20.
29. Kristek A *et al.* The gut microbiota and cardiovascular health benefits: A focus on wholegrain oats. *Nutr Bull* 2018;43:358-73.
30. Sang S, Chu Y. Whole grain oats, more than just a fiber: Role of unique phytochemicals. *Mol Nutr Food Res* 2017;61:7.
31. Fayet-Moore F *et al.* Breakfast choice is associated with nutrient, food group and discretionary intakes in Australian adults at both breakfast and the rest of the day. *Nutrients* 2019;11:175.
32. Galea LM *et al.* Whole grain intake of Australians estimated from a cross-sectional analysis of dietary intake data from the 2011-13 Australian Health Survey. *Public Health Nutr* 2017;20(12):2166-72.
33. Grains & Legumes Nutrition Council. 2018 Breakfast Cereal Audit. Unpublished: 2018.
34. Jefferson A *et al.* The effects of intact cereal grain fibers, including wheat bran on the gut microbiota composition of healthy adults: A systematic review. *Frontiers in Nutr* 2019;6:33.
35. Carvalho-Wells AL *et al.* Determination of the in vivo prebiotic potential of a maize-based whole grain breakfast cereal: A human feeding study. *Br J Nutr* 2010;104(9):1353-6.
36. Vitaglione P *et al.* Whole-grain wheat consumption reduces inflammation in a randomized controlled trial on overweight and obese subjects with unhealthy dietary and lifestyle behaviors: role of polyphenols bound to cereal dietary fiber. *Am J Clin Nutr* 2015;101:251-61.
37. Jayachandran M *et al.* A critical review on the impacts of β-glucans on gut microbiota and human health. *J Nutr Biochem* 2018;61:101-10.
38. Connolly ML *et al.* Hypocholesterolemic and prebiotic effects of a whole-grain oat-based granola breakfast cereal in a cardio-metabolic “at risk” population. *Front Microbiol* 2016;7(7):1675.
39. Wang Y *et al.* High molecular weight barley β-glucan alters gut microbiota toward reduced cardiovascular disease risk. *Front Microbiol* 2016;7:129.
40. Fayet-Moore F *et al.* Dietary Fibre Intake in Australia. Paper II: Comparative Examination of Food Sources of Fibre among High and Low Fibre Consumers. *Nutrients* 2018;10:1223.



#### ABOUT ABCMF

The Australian Breakfast Cereal Manufacturers Forum (ABCMF), is a forum of local manufacturers established to support the Australian breakfast cereal category. ABCMF is committed to providing the most up-to-date information for both the Australian public and professionals, as well as correcting misinformation about Australian breakfast cereals.

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The report was prepared for the Australian Breakfast Cereal Manufacturers Forum in consultation with Dr Joanna McMillan.

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