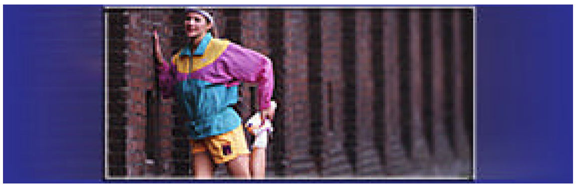
Grains, pulses and heart disease



There are many factors in grains and pulses which suggest that they may prevent the development of heart disease:

- Soluble fibre in oats and barley has been shown to lower blood cholesterol.
- Phytochemicals in grains, such as plant sterols and saponins, have been shown to have a cholesterol-lowering effect.
- Grains contain more polyunsaturated fat than saturated fat - a fatty acid profile shown to lower cholesterol levels.
- Vitamin E, selenium and phytochemicals in grains may prevent the development of atherosclerosis through its antioxidant activities.
- Folate in grains and fortified grain products may help to lower plasma homocysteine levels, a risk factor for coronary heart disease.

Cereal fibre and heart disease - the evidence

Epidemiological studies

The first indication that cereal fibre might lower the risk of heart disease was reported in 19772. In this study of 337 English men, those who developed heart disease after 10-20 years, consumed on average 6.7 g of cereal fibre per 1000kcal (less than 7 g cereal fibre/day) whereas those who didn't develop heart disease consumed on average 8.9 g of dietary fibre from cereals. Interestingly, differences in the amount of dietary fibre from fruit, vegetables, pulses and nuts consumed did not seem to indicate who would get heart disease.

Since then, several large studies from around the world have found that consuming 25-30 g of cereal fibre a day reduces the risk of developing heart disease in both men and women.

In 1996 a large study of 43 757 men also found that men consuming the highest amounts of dietary fibre (28.9 g/day) were less likely to get heart disease after six years than those consuming lower levels of dietary fibre (12.4 g/day)3. Called the Health Professionals Follow-Up Study, the authors concluded that high intakes of dietary fibre, particularly from cereal and grain sources, can substantially reduce the risk of heart disease. Cereal fibre lowered the risk of heart disease to a greater extent than fruit and vegetable fibre. Soluble fibre was shown to be more beneficial in reducing risk of heart disease than insoluble fibre.

Another study in 21 930 Finnish men who were all smokers and aged 50-60 years also found that the men with the highest intake of cereal fibre (26.3 g/day) were least likely to develop or die from heart disease compared to those consuming the lowest level of fibre (8.8 g/day) 4. In this group of men, dietary fibre was mainly derived from cereal fibre, particularly rye products which are usually consumed as the whole grain. Again, cereal fibre was more strongly associated with reduced risk of heart disease than vegetable and fruit fibre.

Cereal fibre seems to also protect women against heart disease. In the Nurses' Health study, the health of 68 782 female nurses has been monitored since 19745. As in previous studies, the

women who consumed the highest amount of cereal fibre
(7.8 g/day) were less likely to get heart disease after 10 years than women consuming the least amount of cereal fibre (1.9 g/day). As in other studies, cereal fibre was more protective than fibre from vegetables and fruits, suggesting other components, besides dietary fibre, may be involved in protecting against heart disease.

These studies consistently show that cereal fibre is more protective than dietary fibre from other sources and that more than 8 g/day in women and more than 10 g/day in men of cereal fibre is required to reduce the risk of heart disease.

Randomised controlled trials

There is only one intervention trial investigating the effect of increasing dietary fibre intake on the risk of developing heart disease6. In this study of subjects who had recovered from a heart attack, the effect of different types of dietary advice relating to dietary fibre, fish and fat intake was compared to no advice. Those advised to increase dietary fibre intake consumed 17 g/day at the end of two years compared to 9 g/day in the no advice group. However, increasing dietary fibre intake did not reduce the risk of having another cardiac event. It is possible that subjects did not consume adequate dietary fibre, particularly cereal fibre, to detect a protective effect from cereal fibre. Another possibility is that the protective effect of cereal fibre is greater in primary prevention (i.e. before the development of the disease) rather than in secondary prevention (i.e. preventing progression of the disease once it is established).

Wholegrain-based foods and heart disease - the evidence

Epidemiological studies

Several large epidemiological studies have investigated the extent to which consumption of wholegrain foods protect against heart disease.

A study of 34 000 women aged 55-69 years, showed that the risk of dying from heart disease after 9 years was reduced by about one-third in women eating as little as one serve a day of wholegrain foods compared to women who rarely ate wholegrain foods7. The major sources of wholegrain foods for these women were dark bread and breakfast cereals. In contrast, the amount of refined cereal consumed did not seem to influence the risk of dying from heart disease. The authors concluded that there are as yet unidentified dietary factors present in wholegrain foods which together with known factors such as dietary fibre seem to provide protection against the development of heart disease. Overall death rates were lower in women consuming at least one serve of wholegrain foods a day over the 9 years of the study.

The Nurses' Health Study also looked at consumption of whole grains and found lower rates of heart disease after 10 years in the women consuming more than two serves of wholegrain foods a day8. In particular, there were less cases of heart disease in women who consumed 5-6 serves a week of each of wholegrain breakfast cereal (defined as those that contained over 25% wholegrain or bran by weight), brown rice, wheat germ and bran. The most cases of heart disease were reported in those women who almost never ate wholegrain foods. Consumption of refined grain foods such as sweet rolls, cakes, white bread, pasta and rice and refined grain breakfast cereals did not seem to increase the risk of getting heart disease or provide protection.

These studies consistently show that consumption of at least one serving per day of whole-grain foods such as breakfast cereals, wholegrain breads and brown rice reduces the risk of developing heart disease. Because it is difficult to measure whole grain intake, these studies may have underestimated the effect of wholegrain foods on risk of heart disease. For instance, the dark bread category may have included refined-grain products such as breads with a tough crust which may have been wrongly perceived by participants to be wholegrain foods.

Pulses and heart disease

To date, there is little evidence to show that consumption of pulses reduces the risk of coronary heart disease, possibly since pulses are consumed in such small quantities in the populations in which these studies were carried out. Further research is needed to investigate this relationship in more detail.

There is some evidence that chickpeas lower blood cholesterol levels.

References

1. Truswell AS. Cereal grains and coronary heart disease. A review of the literature commissioned by "Go Grains" in 1999 (it can be downloaded from www.gograins.grdc.com.au).
2. Morris JN, Marr JW, Clayton DG. Diet and heart: A postcript Brit Med J 1977;2:1307-1314
3. Rimm EG, Ascherio A, Giovanucci E et al. Vegetable, fruit and cereal fiber intake and risk of coronary heart disease among men. JAMA 1996; 275:447-541
4. Pietinen P, Rimm EB, Korhonen P et al. Intake of dietary fiber and risk of coronary heart disease in a cohort of Finnish men: the Alpha-Tocopherol, Beta Carotene Cancer Prevention Study. Circulation 1996;94:248-257
5. Wolk A, Manson JE, Stampfer MJ et al. Long-term intake of dietary fiber and decreased risk of coronary heart disease among women. JAMA 1999;281:1998-2000
6. Burr ML, Fehily AM, Gilbert et al. Effects of changes in fat, fish and fibre intakes on death and myocardial reinfarction: diet and reinfarction trial (DART). Lancet 1989;2:757-761
7. Jacobs DR, Meyer KA, Kushi LH et al. Whole-grain intake may reduce the risk of ischaemic heart disease death in postmenopausal women: the Iowa Women's Health Study. Am J Clin Nutr 1998;68:248-257
8. Lui S, Stampfer MJ, Hu FB et al. Whole grain consumption and risk of coronary heart disease: results from the Nurses' Health Study. Am J Clin Nutr 1999;70:412-419

Grains, pulses and type 2 diabetes

Grains and pulses may help to lower the risk of developing type 2 diabetes by preventing hyperinsulinaemia:

- Wholegrain foods and pulses generally have a low glycaemic index.
- Dietary fibre, particularly soluble fibre, in grains and pulses have been shown to lower glucose levels and hence insulin demand.
- Phytochemicals in grains and pulses, such as saponins and phytates have been shown to lower glucose response after a meal.

Cereal fibre and type 2 diabetes - the evidence

Epidemiological studies
Several large cohort studies have investigated whether dietary factors, which reduce insulin levels, may reduce the risk of developing type 2 diabetes.

In the USA, of the 65 173 women participating in the Nurses' Health Study, 915 nurses were diagnosed with diabetes during the six years of the study1. In these women, risk of diabetes was linked to dietary glycaemic index, glycaemic load, cereal fibre and magnesium.

Cereal fibre intake reduced the risk of diabetes by 28%. Together, a high intake of cereal fibre and a low glycaemic load reduced the risk of type 2 diabetes two-and-a-half-fold compared to high glycaemic index and low cereal fibre intake.

The Health Professionals Follow-Up Study of 42 759 men found that the risk of developing diabetes in the 523 cases diagnosed after six years was related to a combination of high glycaemic load and low cereal fibre intake2. In this study, high glycaemic load combined with a low cereal fibre intake increased the risk of type 2 diabetes two-fold when compared to low glycaemic load and high cereal fibre intake.

Another large cohort study in 35 988 women, the Iowa Women's Health Study, found that over the six years of the study, higher consumption of total grains, wholegrains, total fibre, cereal fibre and magnesium were associated with a lower incidence of type 2 diabetes3.

These studies consistently show that cereal fibre reduces the risk of type 2 diabetes. Those with the highest intake of cereal fibre (7-10 g/day) reduced their risk of developing type 2 diabetes by around 30% compared to those with the lowest intake of cereal fibre (2-4 g/day). Dietary fibre from fruit, vegetables and pulses does not appear to reduce the risk of type 2 diabetes to the same extent.

A high intake of magnesium was also shown to reduce the risk of developing type 2 diabetes. Wholegrains are a good source of magnesium.

Grain-based foods and type 2 diabetes - the evidence

Epidemiological studies
In the Iowa study the risk of diabetes was reduced by 21% in women eating more than 17.5 servings of whole-grain foods a week compared with those eating less than three servings a week, and by 32% in those eating more than 33 servings of grains a week compared to less

than 13 servings per week3. Consumption of pulses did not significantly reduce the risk of developing type 2 diabetes, possibly due to low intakes in this population (the highest intake was more than 4.5 servings/week and the lowest, less than 1.5 servings/week).

Although studies have not consistently reported a protective effect from the type and amount of carbohydrate (expressed as glycaemic load), the findings suggest that eating 2-4 servings per day of whole-grain foods can decrease the risk of developing type 2 diabetes in men and women.

References

1. Salmeron J, Manson JE, Stampfer MJ et al. Dietary fiber, glycemic load, and risk of non-insulin-dependent Diabetes Mellitus in women. JAMA 1997;277 (6): 472-477
2. Salmeron J, Ascherio A, Rimm EB et al. Dietary fiber, glycemic load, and risk of NIDDM in men. Diabetes Care 1997;20 (4):545-550
3. Meyer KA, Kushi LH, Jacobs DR et al. Carbohydrates, dietary fiber and incident type 2 diabetes in older women. Am J Clin Nutr 2000;71:921-930

Grains and pulses and cancer

Dietary factors can affect the development of cancer in any one of the three stages of its development:

- **Initiation** - involves alteration or damage to the chemical composition or to the structure of DNA.
- **Promotion** - the malignant transformation of the damaged cells which leads to carcinogenesis.
- **Progression** - growth of the tumour occurs.

There are several components in grains and pulses which may prevent the development of cancer:

Dietary fibre

- Formation of butyrate from fermentation of dietary fibre and resistant starch keeps the bowel healthy and has anti-carcinogenic properties.
- Decreased intestinal transit time and increased bulk limits absorption and contact of carcinogens and toxicants with the wall of the gastrointestinal tract.
- Decreased pH of the gut inhibits formation of secondary bile acids which are potentially carcinogenic.

Folate

May prevent damage to DNA.

Antioxidants

- Prevent production of free radicals or scavenging free radicals (Vitamin E, phytic acid).
- Enhance the activity of enzymes (Selenium).
- Prevent production of carcinogens such as nitrosamines and secondary bile acids (vitamin E, phenolic acids, lignans).
- Bind carcinogens and prevent them from attacking the DNA (phenolic acids).
- Enhance immune function (vitamins E, C and beta-carotene).
- Studies have shown that there is an association between blood levels of antioxidants (vitamin C, E and beta carotene) and protection from cancer of the lung, breast, cervix, pancreas, colon, stomach, oral, and skin. Low intake of selenium has been associated with increased risk of respiratory and gastrointestinal cancer.

Lignans

- Due to the similarity in structure of lignans to estrogens, they may play a role in modulating hormone-related cancers. High levels of biologically active androgens or estrogens are associated with increased risk of prostate cancer in men, and ovary, breast and endometrial cancers in women. Diets that lower these androgens or estrogens are associated with low hormone-related cancer risk.
- Lignans increase synthesis of sex hormone-binding globulin (SHBG) which binds estrogen and hence reduces the levels of circulating estrogens.
  In the gut, lignans may prevent the reabsorption of estrogen into the body.
- In vitro studies have shown that lignans can decrease cell proliferation and reduce tumour

size and number.

Dietary fibre and cancer - the evidence

Epidemiological studies

The evidence to date is mostly based on case control studies where people diagnosed with cancer are identified and their past dietary intake is compared to that of similar people without cancer. This study design relies on people accurately reporting their past dietary intakes which may be biased and hence affect the quality of the evidence.

Most studies have focused on the relationship between the intake of nutrients, particularly dietary fibre, and cancer risk. The majority of case control studies conducted in countries from around the world have reported a reduced risk of colon cancer with increased consumption of dietary fibre. However, the results from cohort studies have been inconsistent. A large review of the relationship between diet and cancer concluded that the inconsistency reflects the heterogeneous nature of dietary fibre and the inadequate measuring techniques, rather than that there is no protective effect2.

Others argue that the study of nutrients or individual food constituents may mask the total health effect of wholegrains. The influence on wholegrain consumption may depend on the presence or absence of many constituents and their interactions. Few studies have assessed the effect of grain consumption and risk of cancer.

Wholegrain foods and cancer - the evidence

Epidemiological studies

Case control studies which provided information relating to wholegrain consumption were reviewed to determine whether consumption of wholegrain foods (such as wholegrain breads and pasta, wholegrains and high fibre-cereals) reduces the risk of cancer3.

- Overall, the risk of cancer in those with a high intake of wholegrain foods was 34% lower than those with a low intake of wholegrain foods.
- Nine out of ten studies showed that high intakes of wholegrain foods reduced the risk of colorectal cancer by 21% compared to those with low intakes of wholegrain foods.
- Seven studies showed that high intakes of wholegrain foods significantly reduced the risk of gastric cancer by 43% compared to low intakes of wholegrain foods.
- The risk of seven hormone-related cancers (breast, prostate, ovarian and endometrial) was reduced by 14%, 10%, 37%, 45% (the last two were statistically significant) in those with high intakes compared to those with low intakes of whole grain foods.

A review of 39 studies providing information on intake of wholegrain foods and colorectal cancer found 26 studies showed a protective effect, five showed no effect and four showed a positive effect (of which two were in developing countries) 4. When the same data was reviewed in terms of the cereal fibre intake (only 19 studies provided data on cereal fibre intake) 16 showed a protective effect, three showed no effect and none showed that cereal fibre increased the risk of colorectal cancer.

These studies suggest that the more wholegrain foods are consumed the greater the reduction in cancer risk.

The impact of refined grains on cancer risk is inconsistent. Some case-control studies have reported a positive association between cancer and intake of refined cereals. This may be as a result of diets high in refined carbohydrate being deficient in protective dietary constituents. However, a cohort study in Japan, where rice and wheat are usually consumed as refined grains, did not demonstrate increased risk of colorectal cancer.

Randomised controlled trials

The Polyp Prevention study conducted in Australia found that adding wheat fibre to the diet prevented the growth of large adenomas and hence possibly the development of colon cancer5.

Well designed cohort studies and randomised controlled trials are required to confirm the results of experimental and animal studies which suggest that grains reduce the risk of cancer. However, the evidence to date suggests that it may be worthwhile encouraging consumption of whole grain foods.

Pulses and cancer

There are few studies investigating the link between consumption of pulses and cancer risk. The "World Cancer Research Fund" examined the evidence from 58 epidemiological studies on the topic2. Half reported a decreased cancer risk with a higher intake of pulses and half reported an increased risk. It is therefore difficult to determine the role of pulse consumption in the prevention of cancer based on this data. Populations with high consumption of pulses are generally in poorly developed countries and increased cancer risk may be attributed to other dietary or environmental factors. Given the known nutritional attributes of pulses, it is worthwhile encouraging increased consumption especially in countries where consumption is poor.

References
1. McIntosh G. Cereal foods, fibres and the prevention of cancers. Aust. J. Nutr. Diet. (2001) 58 Suppl.2.
2. World Cancer Research Fund/American Institute for Cancer Research. Food, Nutrition and the Prevention of Cancer: a Global Perspective. Washington DC: American Institute for Cancer Research, 1997
3. Jacobs DR, Marquart L, Slavin J et al. Whole-grain intake and cancer: an expanded review and meta-analysis. Nutrition and Cancer 1998;30(2):85-96
4. Hill MJ. Cereals, dietary fibre and cancer. Nutrition Research 1998;18(4):653-659
5. MacLennan R, Macrae F, Bain C, et al. Randomized trial of intake of fat, fiber, and (-carotene to prevent colorectal cancer. J Natl Cancer Inst 1995;87:1760-6

Grains and pulses and weight control[1]

Components of grains and pulses may be useful in weight management, particularly in preventing an excessive intake of calories. The theory behind most weight management strategies is to achieve a balance between the calories consumed in foods and the calories expended in physical activity. Hence, weight loss is achieved by eating less calories and being more active. Studies have consistently shown that restricting the intake of calories is difficult to achieve in the long-term. Strategies which make it easier to eat less calories will therefore help to achieve long term weight control.

Several characteristics of grain-based foods and pulses may be useful in controlling the appetite and preventing over-consumption of calories.

- Dietary fibre slows the rate of carbohydrate digestion, reducing the insulin response and increasing appetite satisfaction. A cohort study has shown that subjects with a dietary fibre intake gre ater than 10.5 g/4184kJ a day were less likely to be overweight than those with an intake of less than 5.9 g/4184kJ a day[2].
- Grain-based foods and pulses with a low glycaemic index may be more filling and satisfying than foods with a high glycaemic index[3].
- Grain-based foods and pulses are generally high in carbohydrate, high in dietary fibre and low in fat, which means a large amount of these foods can be consumed without consuming too many calories. Several studies suggest that it may be easier to maintain long term weight control on a low fat, high carobohydrate diet.

No studies have assessed the impact of grain and pulse consumption on body weight. However, the nutritional attributes of grains and pulses suggest that without further addition of fat and sugar, they are unlikely to contribute to weight gain and are useful foods for weight management.

References

[1]. Franklin J, Caterson ID. Setting the record straight - the role of carbohydrates in weight control. A review commissioned by "Go Grains" in 1999. Copies of the review are available from BRI Australia.
[2]. Ludwig DS, Pereira MA, Kroenke CH, Hilner JE, Van Horn L, Slattery ML, Jacobs DR Jr. Dietary fiber, weight gain, and cardiovascular disease risk factors in young adults. JAMA 1999 Oct 27;282(16):1539-46
[3]. Holt SH, Brand-Miller J. Increased insulin responses to ingested foods are associated with lessened satiety. Appetite 1995;24:43-54

Evidence-based nutrition?

Evidence-based nutrition means that the nutrition advice and recommendations are based on evidence which has been assessed in an unbiased or impartial manner.

Studies, designed to investigate the relationship between a specific nutrient or food component and a disease or health condition, provide nutritionists with the necessary evidence to develop food-related recommendations.

Evidence from epidemiological, experimental and intervention studies is assessed in terms of:

- The strength and quality of the evidence.
- Consistency in the evidence.
- Demonstration of a plausible mechanism to explain the link between the nutritional factor and health outcome.
- Relevance of the findings for the population to whom the advice will be communicated.

In **epidemiological studies**, large groups of people are classified according to the type and amount of food that they usually eat. For example, they may be classified according to the amount of wholegrain cereal-based foods or pulses that they consume. After a number of years, the number of people in each group suffering from a particular disease or health condition is measured. Scientists can use this information to work out which factors can help to increase or decrease the risk of getting a disease or health condition.

Experimental studies are conducted in the laboratory to find out how the nutrient or food component functions and therefore how it provides the observed health benefit or damage. Being able to explain how a food contributes to the health outcome adds credibility to the hypothesis.

Intervention studies, particularly long term randomised controlled trials, are considered the best evidence for determining how well a nutrient or food component prevents the development of a disease or health condition. In these studies, groups of people are randomly chosen to receive either a treatment or no treatment and then followed over a period of time to see what effect the treatment has on the disease or health condition compared to the group receiving no treatment. Randomised means that an impartial method was used to allocate the participants in the study to either the treatment or placebo group. Controlled means that the participants in the study and the nutritionists running the study don't know which participants are receiving the treatment or the placebo.

Studying the relationship between diet and health is not easy. It requires subjects in a study to remember all the foods that they have eaten and to report this information accurately and truthfully. Nutrient composition data of foods consumed must be available and accurate, which is not always the case. It takes many years for the effect of diet to manifest itself and so studies need to be conducted over long periods of time. Finally, large numbers of people are required in the study to detect an effect from the diet.

For this reason, evidence to support nutrition recommendations is sometimes incomplete or inconsistent.

Dietary Fibre and Resistant Starch

Grains and pulses are useful sources of dietary fibre and resistant starch. It is well established that dietary fibre plays an important role in maintaining healthy bowel function and hence may play an important role in preventing colon cancer. More recent research suggests that there are different types of dietary fibre with a greater diversity of health benefits.

What is dietary fibre?
The definition for dietary fibre adopted by the ANZFA:

"dietary fibre means 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".

The following components are generally considered to constitute dietary fibre:

- **Non-starch polysaccharides (NSP)** include cellulose, hemicellulose, (-glucans, gums and pectin - NSP has been categorised into soluble and insoluble fibre.
- **Lignin** - a non-carbohydrate component of the plant cell wall.
- **Resistant starch** is defined as "the sum of starch and products of starch degradation not absorbed in the small intestine of healthy individuals".
- **Non digestible oligosaccharides** are small carbohydrates (with less than 10 monomeric units), e.g. raffinose, stachyose, oligofructose and inulin.

There is general agreement that NSP and lignin are the principal components of dietary fibre. Resistant starch is increasingly regarded as dietary fibre. More recently, it has been suggested that non digestible oligosaccharides also function as dietary fibre. Dietary fibre is therefore usually defined as food components that resist digestion by human enzymes in the small intestine and that pass into the large intestine where they may or may not be fermented by gut bacteria. Dietary fibre which is not fermented is excreted in the faeces. The degree of fermentation influences the role of dietary fibre in the body.

There are many methods for measuring dietary fibre. Some of these measure all of the above components, whilst others only measure NSP. This has implications when reviewing the evidence regarding the health benefits of different types of dietary fibre.

The different types of dietary fibre are generally classified according to their main physiological effect in the body:

- Soluble fibre (mainly (-glucans found in oats and barley and soluble pentoses found in rye)
- Insoluble fibre (cellulose, hemicellulose and lignin found in wheat and rice)
- Resistant starch (includes insoluble and fermentable fibre)
- Oligosaccharides (found in pulses, artichokes, onion and garlic).

Dietary fibre and bowel function

Insoluble fibre and stool weight

Dietary fibre, particularly insoluble fibre, increases stool weight and, decreases gut transit time and in so doing, helps to relieve constipation.

The laxative effect observed with dietary fibre seems to be achieved via two different mechanisms:

i. Insoluble fibre, found in wheat and rice bran, is resistant to fermentation in the gut and is excreted in the faeces. It increases stool weight by holding water.
ii. Soluble fibre, found in oat and barley bran, is almost completely fermented in the colon and provides energy for bacterial growth. Although virtually no soluble fibre is excreted in the faeces, stool weight is increased due to an increase in bacterial cells which also hold water. However, insoluble fibre tends to have a greater faecal bulking effect.

Factors that influence stool weight

i. The chemical composition of dietary fibre, i.e. insoluble versus soluble fibre.
ii. The larger the particle size of the grain or seed, the larger the stool weight and lower the transit time. For instance, coarse wheat bran has been shown to have a greater faecal bulking effect than finely ground wheat bran when consumed at the same dosage.

Benefits of insoluble fibre

i. By improving bowel function, dietary fibre can reduce the risk of diseases and disorders such as diverticular disease, haemorrhoids and constipation.
ii. Increased faecal bulk and decreased transit time allows less opportunity for carcinogens to interact with the walls of the intestine. Dietary fibre may also bind or dilute secondary bile acids which are potentially carcinogenic. Similarly, dietary fibre may reduce the toxic effect of heavy metals and pesticides. Wheat bran is the type of fibre most consistently shown to inhibit carcinogenesis.

Dietary fibre and fermentation

NSP, resistant starch and oligosaccharides, which resist digestion by human enzymes, are fermented by bacteria in the gut, producing short chain fatty acids and gases. Short chain fatty acids include acetate, propionate and butyrate. Acetate and propionate are metabolised by the body, mainly in the liver. Butyrate is an important source of energy for the cells of the colon which helps to keep them healthy. Wheat bran and oat bran produce higher proportions of butyrate. It is thought that resistant starch produces more butyrate than NSP.

Benefits of short chain fatty acids

i. Production of short chain fatty acids (SCFA) lowers the pH of the gut. In this acidic environment, the conversion of primary bile acids into carcinogenic secondary bile acids is inhibited and the solubility of free bile acids is reduced making them less carcinogenic.
ii. Butyrate not only keeps cells in the bowel wall healthy, it has also been shown to inhibit the growth and proliferation of tumour cells in vitro (i.e. the experiment is conducted outside the living body, traditionally in the test tube).

Factors which influence the extent of fermentation

i. The chemical composition of the dietary fibre (i.e. the proportion of soluble to insoluble NSP).
ii. The physical form of the grain or seed determines whether dietary fibre or starch is fermented. Undisrupted cell walls are more likely to pass intact through the gastrointestinal tract.
iii. Lignin and phenolic acids in the cell walls of the grain kernel restrict access to bacteria and hence limit fermentation of dietary fibre or starch. When the cell walls are disrupted, microflora have access to starch, oligosaccharides and NSP allowing fermentation to

occur.

Dietary fibre as pre-biotics

Probiotics
Probiotics are food supplements, such as some yoghurts and products like Yakult, which contain beneficial bacteria. These beneficial bacteria live in the gut of humans and contribute to good health.

Pre-biotics
Pre-biotics are non-digestible food ingredients, such as resistant starch and oligosaccharides, which are used as a source of fuel for bacteria in the gut. Without food, these bacteria cannot survive and perform their beneficial effects in the large bowel.

Role of pre-biotics

i. Resistant starch and oligosaccharides have been shown to stimulate the growth and/or activity of beneficial bacteria, such as bifidobacteria, and to reduce the concentration of pathogenic bacteria, such as Escherichia coli, Clostridia, and bacteroides. Hence pre-biotics contribute to the overall health of the bowel.
ii. Resistant starch has been shown to reduce the severity of bacterially induced diarrhoea.
iii. Resistant starch has been used to protect the probiotic bacteria during processing and consumption. For instance, by adding Hi-maize(r) to yogurt, the survival of probiotic bacteria is improved.

Soluble dietary fibre and blood cholesterol1

Several studies have reported a cholesterol-lowering effect with consumption of pulses, oat bran, barley as well as purified sources of soluble dietary fibre, including guar and pectin. Oats and barley are high in (-glucan, a soluble fibre.

When considering the effect of soluble fibre on blood cholesterol, care must be taken to account for other factors which may have caused the reduction in blood cholesterol. For instance, increased dietary fibre intake may reduce the proportion of saturated fat, known to increase blood cholesterol, in the diet. Differences in baseline blood cholesterol concentrations of subjects will affect the results with greater changes expected from those with high blood cholesterol than those with normal levels.

The effect of *b*-glucan in oats on blood cholesterol

Meta-analyses are studies which statistically evaluate the results from a number of similar, well controlled studies. Using this type of analyses, it has been reported that the effect of soluble fibre on blood cholesterol levels is small, but significant1.

- Three grams of soluble fibre from oats reduces total and LDL-cholesterol by about 0.13 mmol/L.
- The effect is independent of any other dietary changes - two servings of oats can reduce blood cholesterol by an additional 2-3% beyond that of modifying the type of dietary fat in the diet.
- Soluble fibre from oats and barley (mainly (-glucan), psyllium or pectin have similar cholesterol-lowering effects on total and LDL-cholesterol, but do not affect HDL-cholesterol or triglycerides.
- The USA Food and Drug Administration (FDA) believes there is sufficient evidence to approve the following health claim on food labels in the USA: "Beta-glucan from oats, when consumed as part of a diet low in saturated fat, reduces the risk of CHD".

The effect of other grains and pulses on blood cholesterol
Large amounts of rice bran (100 g/day), which contains a different type of soluble fibre in the

form of hemicellulose, has also been shown to lower total and LDL-cholesterol, slightly raise HDL-cholesterol and lower triglycerides. The oil contained in rice, which contains a sterol called (-oryzanol, may also contribute to its cholesterol-lowering effect.

Dietary fibre from wheat and other sources of insoluble dietary fibre (e.g. cellulose, wheat bran, maize bran) have no effect on blood cholesterol levels.

Pulses contain soluble fibre and have also been shown to reduce blood cholesterol.

How does soluble fibre reduce blood cholesterol?
It is as yet unclear how soluble fibre lowers blood cholesterol.

Several mechanisms have been hypothesised including:

- Soluble fibre may bind bile acids or cholesterol in the intestine, preventing their reabsorption into the body. The liver responds by taking up more LDL-cholesterol from the blood stream thereby lowering the concentration of LDL-cholesterol in the blood.
- Short chain fatty acids, products of fermentation from soluble fibre in the gut, may inhibit synthesis of cholesterol by the liver, reducing the concentration of blood cholesterol.
- The high viscosity of soluble fibre may slow the rate of digestion and absorption of carbohydrates, affecting insulin activity, which is implicated in the removal of LDL-cholesterol in the blood.
- Other aspects of grains and pulses, which have also been shown to contribute to a cholesterol-lowering effect may also be effective. For example, the low saturated, high polyunsaturated fatty acid profile; vitamin E content; phytochemicals such as plant sterols, saponins, phytic acid and tannins. A study in rats found that whole oats lower blood cholesterol more than defatted oats or oats without fibre, suggesting that factors other than dietary fibre may also be operative.

Dietary fibre and blood glucose
There is some evidence that dietary fibre, particularly soluble dietary fibre (mainly (-glucans) found in barley and oats, may slow digestion and absorption of carbohydrates and hence lower blood glucose and insulin responses.

Resistant starch may also reduce or delay the rise in blood glucose and insulin following a meal by slowing the rate and extent of digestion and absorption of carbohydrates.

Phytochemicals in grains and pulses, such as phytic acid, saponins and tannins have also been shown to lower glucose and insulin responses after a meal.

The type and amount of dietary fibre is a factor which seems to impact on the glycaemic index of carbohydrates and in this way contributes to determining the overall rate of absorption of carbohdyrate and hence their impact on blood glucose levels.

Other factors influencing the glycaemic index include particle size, fat content and the type of the starch (i.e. proportion of amylose to amylopectin).

Dietary fibre and weight control
A diet which is high in dietary fibre is generally bulky, requires more chewing and is less likely to cause overeating and the risk of weight gain.

Dietary fibre and satiety
The University of Sydney's Human Nutrition Unit has developed the world's first satiety index of foods. It tells you which foods fill you up most for the same number of kilojoules.

People seemed to eat less after eating high satiety foods than after eating low satiety foods. High satiety foods include low-fat, high-fibre foods, such as porridge, grain bread and wholemeal pasta, whereas low satiety foods included high-fat, low-fibre foods, such as croissant, doughnuts and chocolate. Other factors, such as the form of the food, the fat content and the amount of protein also seem to influence the satiety of a food.

Dietary fibre and energy density

High-fibre foods are generally considered low energy dense foods because they provide few calories per gram of food. In other words, they allow you to eat more food for the same amount of calories than high energy dense foods such as chocolate or cake. Energy density is also affected by the fat and water content of the food.

How much dietary fibre is recommended?

Adults should consume at least 30 g of dietary fibre from a variety of different food sources.

Children aged 3-18 years should have their age plus 5 g of dietary fibre a day, i.e. 8 g/day at 3 years, 15 g/day at 10 years and 25 g/day at 20 years.

Dietary fibre in grains and pulses

Dietary fibre - good, better, best

According to ANZFA's "Code of Practice for Nutrient Claims in Food Labels and Advertisements"2:

- An "excellent source of fibre" contains more than 6 g of dietary fibre per serving.
- A "good source of fibre" provides 3 g of dietary fibre per serve.
- A "source of fibre" has more than 1.5 g per serve.

What is a serve?

There is considerable inconsistency in the definition of a "serve size" for many cereal foods. The Australian Guide to Healthy Eating3 recommends the following serve sizes:

- Bread = 2 slices of bread or 1 piece of Lebanese bread/roll/bagel
- Breakfast cereal = 30-45 g (about 1 1/3 cups of flaked breakfast cereal)
- Boiled pasta, rice and noodles = 1 cup (180 g);
- Dried beans, peas or lentils (cooked or canned) = 1/2 cup (75 g).

Dietary fibre content of grains and pulse-based foods

Excellent source of dietary fibre	**Good source of dietary fibre**	**Source of dietary fibre**
Wholemeal Lebanese bread	White Lebanese bread	White bread
Dark rye bread	Multigrain bread	White rice
Breakfast cereals with bran	Light rye bread	Rice noodles
Bulgur	White, fibre-increased bread	
Wholemeal pasta	Wholemeal bread	
Baked beans	White pasta	
Lentils	Brown rice	
Dhahl (made with	Wholewheat breakfast	

mung beans)	cereals	
Chickpeas, canned	Porridge made from rolled oats	
Split peas		

Resistant starch
The chemical composition of starch
Starch is made up of amylose and amylopectin. Amylose has a linear molecular structure whereas amylopectin has a branched structure. Most plants contain about 20-25% amylose. But some, like pea starch have 60% amylose and certain species of maize starch have 80% amylose (e.g. Hi-Maize(r)). Waxy varieties of grains, such as rice, are low in amylose.

Factors that affect the formation of resistant starch
The physical and chemical composition of starch determines whether starch is digested in the small intestine or whether it ferments in the colon.

There are several reasons why starch may not be digested:

- The physical structure of the grain protects the starch from digestion (e.g. partly milled grains and pulses). The larger the particle size, the higher the amount of resistant starch.
- The natural chemical composition of the starch in foods influences the amount of resistant starch. The higher the amylose content of starch, the greater its resistance to digestion. Raw potato, green bananas, pulses and high amylose maize starch have a high amylose content.
- When starch is heated, starch granules swell and are disrupted. This process, known as gelatinisation, makes the starch much more accessible to digestive enzymes. Starch with a high amylose content and starch which is inaccessible due to the physical structure in which it is located, are less susceptible to gelatinisation and hence are more resistant to digestion.
- When starch that has been heated, is cooled, retrogradation occurs converting the starch to a crystalline form which is resistant to digestion. Foods, such as bread, cornflakes, cold cooked potato, rice and pasta, contain retrograded starch which is resistant to digestion.

How much resistant starch is required for good health?
Some resistant starch is measured when total dietary fibre is measured. However, there is currently no official analytical method for measuring the resistant content of foods. It has been estimated that resistant starch intake in Australia is around
5-7 grams/person/day. Approximately 20 grams a day is recommended to obtain the beneficial health benefits of resistant starch.

References
1. Truswell AS. Cereal grains and coronary heart disease. A review of the literature commissioned by "Go Grains" in 1999 (www.gograins.grdc.com.au).
2. National Food Authority. Code of Practice. Nutrient claims in food labels and in advertisements. Canberra: AGPS; 1995.
3. The Australian Guide to Healthy Eating. Background information for nutrition educators. Canberra: Commonwealth of Australia; 1998.

Glycaemic Index

What is the glycaemic index of food?
The glycaemic index (GI) of food is a method for ranking foods according to their immediate effect on blood glucose levels. The blood glucose response to an individual carbohydrate-containing food is compared to glucose. GI is therefore expressed as a percentage (ranging from 0-100).

Carbohydrate foods that are digested quickly have the highest GI factors. Those which are digested slowly have the lowest GI factors.

A low GI food is defined as being less than or equal to 55, whereas a high GI is greater or equal to 70.

The effect of carbohydrate on blood glucose and insulin levels depends on both the type and amount of carbohydrate. Glycaemic load (the GI of a food multiplied by its carbohydrate content) describes the overall effect of food consumption on glucose metabolism.

In the past, carbohydrates were classified as simple and complex carbohydrates where simple sugars caused a rapid rise in blood glucose levels whereas complex carbohydrates were digested slowly, causing a small rise in blood glucose.

However, nutrition research has shown that the chemical structure of carbohydrates (i.e. simple and complex carbohydrates) is not useful for predicting blood glucose and insulin levels. For instance, the carbohydrate in some sweetened breakfast cereals is digested and absorbed at the same rate as the carbohydrate in oat bran. There is general agreement that the GI should be used to describe the type of carbohydrate in foods. In 1998, the FAO and WHO recommended that the GI, as well as nutrient composition, be considered when choosing carbohydrate-containing foods1. Selecting one or two low GI foods in a meal will lower the overall GI of the meal. It is not necessary to only eat low GI foods.

What effect does the glycaemic load have on the body?

Blood glucose

Low GI foods
Since the carbohydrates in low GI foods are digested slowly, glucose is released gradually into the bloodstream, preventing fluctuations in blood glucose levels.
The ability to control blood glucose and consequently, insulin levels is central to the management of diabetes mellitus.

Low GI foods also help to sustain endurance exercise longer (e.g. marathon runners).

High GI foods
The carbohydrates in high GI foods are quickly digested resulting in a fast and high blood glucose response.

This is useful for athletes who need to re-fuel carbohydrate stores rapidly after exercising. High GI diets have been found to restore muscle glycogen levels faster than low GI diets.

Insulin levels

High GI foods
High GI diets increase insulin demand.

Low GI foods

Low GI diets reduce the level of insulin required to maintain normal blood glucose levels.

In this way, low GI diets can improve the body's sensitivity to insulin and reduce insulin resistance. Insulin resistance describes a condition where insulin does not function effectively, resulting in high glucose levels and increasing the risk of diabetes mellitus.

Weight control

- Animal models suggest that high GI foods promote high blood insulin levels as well as deposition of visceral fat (fat around the organs in the body) which is known to increase health risks.
- Several studies have indicated that low GI foods are associated with greater feelings of fullness and in some cases, result in lower energy intakes at subsequent meals.
- GI may therefore be a useful tool for controlling food intake in weight management.

Fat metabolism
Some studies suggest that high GI foods reduce HDL-cholesterol levels and increase triglycerides (both of which are risk factors leading to high cholesterol levels). However, results from studies investigating the effect of the amount of dietary carbohydrate on fat metabolism have been inconsistent. Further research is therefore required to confirm the effect of the glycaemic load on fat metabolism.

Preliminary research indicates that a high glucose load after a meal may have adverse effects in the arteries of the body and in so doing, may contribute to increasing the risk of heart disease.

Factors that affect the glycaemic index
Although individuals vary in their glycaemic response to foods, in general, the following factors will influence the GI of foods:

- **Particle size** - the larger the particle size, the lower the GI. For instance, breads made from coarsely ground wheat, rye and barley have lower GI than white bread. A study comparing boiled rolled oats, raw rolled oats and intact boiled oat kernels found that the latter had the lowest GI.
- **Cooking** - heat and water make starch granules swell. This destroys the crystalline structure of the starch and makes it easy to digest (e.g. thickening of flour and water when making a sauce illustrates this process which is called gelatinisation). Cooked foods, depending on the type of starch, generally have a higher GI than raw foods. However, the type of starch and the particle size influences the degree of gelatinisation and hence the digestibility of starch. Large particle size and high amylose content are less likely to gelatinise.
- **Grain variety** - the higher the proportion of amylose in the starch of the grain, the lower the GI. Grains naturally high in amylose include Doongara rice and Hi-maize(r). High amylose starch remains mostly ungelatinised with cooking and therefore tends to have a lower GI.
- **Dietary fibre** - although there is no correlation between GI and total dietary fibre, GI can be affected by soluble dietary fibre which slows the rate of digestion of carbohydrate.
- **Antinutrients in grains** - Phytic acid, lectins, tannins and amylase inhibitors have been shown to lower glycaemic response. In one study, the removal of phytic acid from navy beans caused an increase in blood glucose and its addition, a decrease. When added to wheat flour in unleavened bread preparations, phytic acid also reduced starch digestion rate and glycaemic response.
- **Dietary fat** increases insulin and decreases glucose levels (and hence GI).
- **Acidity** of the food - adding vinegar reduces the blood glucose responseby 30%.
- Adding **water** to a meal (either drinking or adding water to the recipe) increases the overall glycaemic response of the meal.

Low GI meals
The GI of a whole meal can be calculated by working out the total carbohydrate content of the

meal and the percentage contributed by each individual food. The meal's GI is the sum of the individual GIs multiplied by that food's percentage contribution to total carbohydrate.

To decrease the GI of the whole meal, it is sufficient to include a few low GI foods in the meal. All foods do not need to be low in GI.

Low GI grains and pulses
Grains are generally low GI foods. However, the manufacture of grain-based foods can alter the GI of grains.

Breads

- Grain breads have a lower GI than white, brown or wholemeal breads.
- Stone-ground wholemeal breads (due to a larger particle size) and sourdough breads (due to acidity) have a low glycaemic index.
- The addition of bran or kibbled grains to bread can lower the GI.
- The starch in breads which have a long fermentation time in the preparation of the dough seems to be more slowly digested and hence has a lower GI.
- Breads with a denser food matrix, such as pita bread, have a lower GI.
- Breads containing barley or oat bran have a higher soluble dietary fibre content and hence a lower GI.

Breakfast cereals

- Wholegrain cereals and coarsely milled grains, which have a larger particle size, such as rolled oats and muesli, have a lower GI. (Quick cooking oats which have a smaller particle size have a high GI).
- High fibre cereals which have added bran (oat or wheat) or psyllium have a lower GI.
- The manufacture of breakfast cereals may affect the extent to which starch is gelatinised and hence determine the GI. It is difficult to predict the GI of breakfast cereals.
- Although breakfast cereals with added sugar generally have a higher GI, it is not always the case.

Rice

Most rice contains about 20% amylose. Milled rice, including long grain and glutinous rice, generally has a high GI.

Rice varieties, such as Australian-grown Doongara rice, has about 28% amylose. Its compact structure and higher amylose content makes it more slowly digested, giving it a lower GI than other rice varieties.

Pasta

Pasta is made from semolina (large particles of wheat). During its manufacture, the starch becomes retrograded. These characteristics make pasta a low GI food.

Gluten-free pasta made with pulse flour also has a low GI.

Noodles

The high amylose content of mung bean noodles (also called cellophane noodles) and their shape (dense texture) gives them a low GI.

Noodles generally have a low GI due to manufacturing process which is similar to that of pasta.

Pulses

The higher amylose content, the seed coat, and the presence of antinutrients make pulses one of the lowest GI foods. Combining pulses with rice, lowers the GI of the rice meal.

References

1. The FAO/WHO (Food and Agriculture Organisation/World Health Organisation) position on carbohydrates in human nutrition can be found in its "Report of a joint FAO/WHO report. Rome 14-18 April 1997. Paper 66, 1998. FAO Food and Nutrition". Visit www.fao.org for more information.

2. Brand Miller J et al. The GI Factor. 2nd edition. Sydney: Hodder; 1998.

Antioxidants and Phytoestrogens

Antioxidants
What are antioxidants?
Free radicals are highly reactive substances formed in the body's cells as a result of metabolic processes. Although free radicals play an essential role in the body, they can react with DNA, protein or lipids in the cell membrane and cause damage. Antioxidants protect cell membranes from damage by free radicals by acting as scavengers or by slowing down the rate at which free radicals are formed.
An imbalance between the formation of free radicals and antioxidant capacity can lead to disease development.

How do antioxidants function?
Grains and pulses contain a wide range of antioxidants, mainly in the bran layers and the germ.

Antioxidants found in grains and pulses include:

- Vitamin E
- Selenium
- Trace minerals such as copper, zinc and manganese
- Phenolic acids, particularly ferulic acid
- Phytic Acid.

Vitamin E

- Vitamin E is an intracellular antioxidant that protects polyunsaturated fatty acids in the cell membranes from oxidative damage (i.e. becoming "rancid"). Once oxidised, polyunsaturated fatty acids enter a chain reaction which produces more free radicals.
- It may also help to keep selenium in a reduced state so that it can perform its antioxidant activities.
- Vitamin E prevents the formation of nitrosamines, known carcinogens, from nitrites in food.

Selenium

- Selenium functions as a cofactor to glutathione peroxidase, an enzyme which prevents the formation of free radicals.
- It also prevents the development of cancerous cells when they have been exposed to a carcinogen.

Phenolic acids

- Phenolic acids found in grains and pulses include ferrulic acid, caffeic acid, tannic acid and catechins.
- They prevent the formation of endogenous nitrosamines.
- Phenolic acids also block the reaction of carcinogens with cells and in so doing, protect the cell from damage.

Phytic acid

- Phytic acid can bind free iron, making it unavailable for the formation of free radicals.
- Phytic acid may also bind free radicals produced by intestinal bacteria and in so doing, suppress oxidant damage to the cells of the colon.
- Phytic acid has been shown to reduce cell proliferation and tumour number in the colon of mice and rats.

Lignans and phytoestrogens

What are lignans and phytoestrogens?

Lignans are compounds in plant foods that are converted to estrogen-like compounds, by bacteria in the human intestine. Lignans appear to be present in the outer layers of the grain rather than in the endosperm. Lignin in the plant cell wall is made from lignans.

Flaxseed has the highest lignan content of all foods but it is not widely consumed. Wholegrain cereals, legumes, oilseeds, vegetables and fruit may be more significant contributors of lignan because they are eaten frequently.

Isoflavones and coumestans are the main classes of phytoestrogens that occur in pulses. Phytoestrogens have been detected in other legumes but soybean appears to contain the highest concentration.

How do lignans and phytoestrogens function?
Lignans and isoflavones have a structure which is similar to estrogens.

In the human gut, plant lignans (matairesinol and secoisolariceresinol) are converted by bacteria to mammalian lignans (enterolactone and enterodiol). Similarly, isoflavones are transformed by colonic bacteria into daidzein and genistein.

Estrogens undergo enterohepatic circulation, a form of recycling where estrogen is conjugated in the liver, excreted through the bile duct, deconjugated by bacteria in the gut and then reabsorbed. Once converted in the gut, phyoestrogens also enter the same enterohepatic circulation.

Estrogens are transported though the blood to target tissues and the liver bound to sex hormone-binding globulin (SHBG). In the liver and tissues, estradiol, the most active estrogen, is converted to estrone or estriol.

In vitro studies suggest that enterolactone and oestrodiol stimulate the synthesis of SHBG, the protein that transports estrogens in the blood stream. Since only free or unbound estrogen is biologically active, the concentration of free-circulating estrogen is reduced as more SHBG is produced.

In the gut, lignans may prevent hormones from being deconjugated and therefore reabsorbed by the body. Instead, they are excreted in the faeces. Lignans may also prevent conversion of primary bile acids into secondary bile acids (which can act as carcinogens in the gut).

Due to their similarity in structure, mammalian lignans and phytoestrogen metabolites may have weak estrogenic activity and compete with oestrodiol, the most active estrogen, for estrogen receptors and hence prevent the growth of tumour cells.
By preventing the production of oestrone, they deny the tumour a source of endogenous estrogen.

Folate

Why do we need folate?

Folate is required for the normal development of red blood cells, for protein metabolism and for the formation of DNA. It works in conjunction with vitamin B12. Symptoms of folate deficiency include low red cell folate resulting in megaloblastic anaemia, forgetfulness, insomnia and irritability.

Recent epidemiological studies suggest that folate plays a role other than its conventional physiological role. Recent nutrition research suggests that folate may be useful in the prevention of diseases such as neural tube defects (NTDs) in newborn babies, heart disease and cancer.

Folate and reduced risk of NTDs

Neural tube defects (NTDs), particularly anencephaly and spina bifida, are a developmental defect resulting from failure of the neural tube to close properly during the first four to six weeks of pregnancy. These conditions are the most common congenital abnormalities occurring in 1-2 per 1000 births. Babies born with these conditions have severe mental and physical disorders.

In the 1990s, two large randomised controlled studies confirmed that folate supplementation reduced the risk of NTDs. The Medical Research Council Vitamin Study was conducted in seven countries and included 1817 women. This study found that high risk women (with a previous history of NTD) who took a folate supplement of 4 mg a day before conception and 12 weeks after conception reduced their risk of having another baby with NTDs by 72%. Another study, conducted in Hungary, found that a multivitamin supplement containing 0.8 mg folate was effective in preventing recurrent NTDs (Czeizel 1992).

In 1994 the NHMRC concluded that there was sufficient evidence to recommend folate fortification of the food supply to reduce the rate of NTDs in Australia.

Folate and Cardiovascular Disease

In 1997, the National Heart Foundation of Australia stated that a mildly raised homocysteine level was a risk factor for cardiovascular disease (includes stroke and heart disease). Further research is required to understand how it increases the risk of heart disease and whether reducing the levels of homocysteine in the blood will reduce the incidence of cardiovascular disease-related events or death.

Several studies have shown that folate reduces blood homocysteine concentrations. Doses of folate from 500 (g/day to 5.0 mg/day have been shown to reduce homocysteine concentrations by about 25% depending on pretreatment levels of blood homocysteine and folate concentrations.

Further research is required to demonstrate that having an adequate intake of folate lowers homocysteine levels and in so doing, reduces the risk of cardiovascular disease. A large study involving 30 000 participants which is currently underway in the United Kingdom is designed to answer this question.

Folate and risk of Cancer

Since folate contributes to DNA synthesis and repair, it may reduce the risk of cancer by preventing the occurrence and reducing the progression of cancer. Animal studies have shown that colon cancer can be induced more quickly and with greater severity in folate-deficient animals. Other studies have demonstrated a reduction in chromosomal damage when folate deficient people receive folate supplements. Chromosomal damage may initiate cancer. Further research is required to determine the role of folate in preventing cancer and the amount required to be effective.

How much folate do we need?
In Australia, the recommended dietary intake for folate is:

Men (19-64+ years) 200 µg
Women (19-54+ years) 200 µg
Pregnant women 400 µg
Lactating women 300-350 µg

Women of child bearing age are encouraged to increase their daily intake of folate-rich foods, particularly in the month before and the first three months of pregnancy.
It is recommended that high risk women, with a family history of NTDs, should take a 5 mg supplement of folate daily for at least one month before and for the first three months of pregnancy and low risk women, 0.5 mg daily.

Sources of folate in the diet
Folate is present in a wide range of fresh fruits and vegetables, legumes, wholegrain breads and cereals. The best sources of folate are green vegetables such as broccoli, pulses such as chickpeas, lentils and dried beans, bran breakfast cereals and wheatgerm.

The main source of folate in the Australian diet is vegetables but also breads, cereals, fruit and juice.

There is limited data on the folate content of Australian foods due to difficulties with the analytical method for measuring folate in foods. The British Food tables (McCance and Widdowson) is therefore often used as a reference for information on the folate content of foods. Although the folate content of Australian foods will differ, it is useful as a guide to sources of natural folate in the Australian diet. Care needs to be taken in differentiating the folate content of foods fortified with folate in some countries but not in others. Information on the folate content of folate fortified foods is available on the package of the relevant food products.

As a result of the folate fortification program, more data on Australian foods is becoming available in Australia.

The folate content of foods

Food	**Folate (m g)**
Pulses	
150 g chickpeas (boiled)	81
150 g baked beans (canned)	33
100 g blackye beans (boiled)	210
50 g soy flour	173
Grains	
A bowl of folate fortified breakfast cereal	50– - 100

100 g folate fortified bread	50–-200
100 g whole grain bread	90
100 g wholemeal flour	57
10 g wheatgerm	33
Vegetables	
50 g aAsparagus (boiled)	78
50 g broccoli (boiled)	32
50 g beetroot (boiled)	55
50 g spinach (boiled)	45
Fruit	
1 cup (250 ml) orange juice	50
1 cup (125 g) raspberries/blackberries	41
Nuts	
20 g pPeanuts	22
20 g hazelnuts	14
Dairy	
1 tub low- fat yoghurt	38
Other	
1 tsp yeast extract (Vegemite/Marmite)	50
100 g fried chicken liver	500

Holland B et al. McCance and Widdowson's The Composition of Foods. fifth edition. Cambridge: The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food; 1993

References

1. MRC Vitamin Study Research Group. Prevention of neural tube defects: Results of the Medical Research Council Vitamin Study. Lancet. 1991;338:131-137

2. Czeizel AE, Dudas I. Prevention of the first occurrence of neural tube defects by periconceptual vitamin supplementation. NEJM 1992;327 (26):1832-1835