

Evidence is now building for the importance of regularly consuming wholegrain foods as part of a cancer-prevention diet.

Key messages and recommendations

- Consumption of fibre and wholegrain cereal foods is associated with a lower risk of obesity and related lifestyle illnesses such as type 2 diabetes and cardiovascular disease. Evidence is now building for the importance of regularly consuming wholegrain foods as part of a cancer-prevention diet.
- Dietary fibre *probably* decreases the risk of colorectal cancer, while there is *limited suggestive* evidence it may also be associated with a lower risk of oesophageal cancer. There is insufficient evidence on dietary fibre to make a conclusion regarding other cancers such as breast, prostate and ovarian.
- Dietary fibre occurs naturally in foods such as wholegrain cereals, fruit, vegetables, seeds, nuts and legumes. It is the edible part of plants resistant to digestion and absorption in the small bowel of humans. Dietary fibre can also be added to foods such as white bread to increase their fibre content.
- Wholegrain and wholemeal cereal foods include the outer layers of the grain, such as the bran and germ. Products made from whole grains, like wheat, brown rice, corn, oats, rye, barley, millet and sorghum, are an important part of a healthy diet. They provide an excellent sources of vitamins, minerals, protein, dietary fibre and protective phytochemicals.
- Dietary fibre is encouraged as part of a varied and nutritious diet. Women are advised to eat 25g of dietary fibre per day and men to eat 30g per day.
- The Cancer Council recommends people eat **at least two serves** of wholegrain or wholemeal foods every day (or ensure about **half** their daily serves of breads and cereals are wholegrain or wholemeal varieties) and to eat **at least two serves** of fruit per day and **five serves** of vegetables per day including legumes. This advice is consistent with national recommendations, including the *Dietary Guidelines for Australian Adults*ⁱ and the *Australian Guide to Healthy Eating*.ⁱⁱ
- As the benefits of fibre may derive from multiple nutrients working together, it is better to consumer fibre through whole foods rather than a dietary supplement.

Background

Dietary fibre is found in foods such as wholegrain cereals, fruit, vegetables, seeds, nuts and legumes such as peas, beans and lentils (Table 1).¹

ⁱ National Health and Medical Research Council.

ⁱⁱ Commonwealth Department of Health and Ageing.

Table 1. Average fibre content of different foods.¹

Food	Fibre (g) per 100g
Wheat bran	45.4
Oat bran	15.9
Sunflower seeds, raw	10.8
Date, dried	9.7
Rolled oats	9.5
Almond, raw	8.8
Apricot, dried	7.7
Dark rye bread	7.1
Red kidney bean, canned	6.5
Cashew, raw	5.9
Wholemeal pasta, boiled	5.3
Wholemeal bread	5.0
Wholegrain bread	4.8
Sultanas	4.4
Lentil, boiled	3.7
Broccoli	3.6
White bread	2.8
White pasta, boiled	2.7
Pear, unpeeled	2.4
Apple	2.3
Pumpkin, peeled	1.8
Brown rice, boiled	1.5
White rice, boiled	0.4

The Australia New Zealand Food Standards Code defines fibre as the fraction of the edible parts of plants or their extracts, or synthetic analogues, that are resistant to digestion and absorption in the small bowel, usually with complete or partial fermentation in the large bowel.²

Dietary fibre includes polysaccharides, oligosaccharides and lignins, and promotes one or more of the following beneficial physiological effects: laxation; reduction in blood cholesterol; and modulation of blood glucose.² Dietary fibre can be added to foods such as white bread to increase their fibre content.

Fibre can be categorised into soluble and insoluble fibre. Insoluble fibre, mostly from wheat and wheat products, acts to increase faecal bulk thereby aiding laxation.³ Soluble fibre, which is found in oats, fruit and vegetables, slows down the release of nutrients thereby helping to modulate glucose absorption.⁴ Soluble fibre also stimulates bile acid excretion which can lower cholesterol levels.⁵

Dietary fibre, especially soluble non-starch polysaccharides and resistant starch, also promotes anaerobic fermentation in the large bowel resulting in the production of short chain fatty acids and gases such as carbon dioxide, hydrogen and methane.⁶ Short chain fatty acids are believed to enhance colonic function and protect against chronic disease. In addition, fibre decreases intracolonic pH, which influences the growth of bacterial populations and this may reduce absorption of carcinogens.⁷

Resistant starch, a type of dietary fibre, is that fraction of ingested starch which survives



digestion in the human small bowel and passes to the large bowel where it is fermented by the resident microorganisms.⁷ Resistant starch is found in certain foods such as beans, cold cooked potatoes, brown rice, green bananas and food ingredients such as whole grains and high amylose starches.⁷

Wholegrain cereals

Wholegrain and wholemeal cereal foods are generally high in dietary fibre. These are foods that include all fractions (including the bran, germ and endosperm) of grains such as wheat, rice, corn, oats, rye, barley and millet.⁸

Examples of wholegrains, consistent with the definition in the Australia New Zealand Food Standards Code are:²

- Whole and intact grains as found in some bread and crisp breads
- Puffed or flaked grains in some breakfast cereals
- Coarsely milled or kibbled wheat found in breads such as pumpernickel or
- Ground grains such whole wheat flour used to make whole meal bread.

Wholemeal foods are made from whole grains which have been milled to a finer texture rather than leaving them whole in the final product. Nutritionally, wholegrain and wholemeal foods are similar but wholegrain foods are generally higher in resistant starch.

Wholegrain products contain more fibre, vitamins and minerals, and protective phytochemicals than refined cereal grain foods because many of the potentially beneficial nutrients and phytochemicals occur in the outer layers of grains.

Rationale

There is good evidence that the consumption of fibre and wholegrain cereal foods is associated with a lower risk of obesity and related lifestyle illnesses such as type 2 diabetes and cardiovascular disease.⁹

Cancer risk can be influenced by lifestyle factors such as body weight, physical activity and diet. Evidence is building for the importance of eating a diet high in dietary fibre including resistant starch and wholegrain foods in order to help lower the risk of certain cancers.

There has been some confusion regarding the role of fibre in cancer prevention, particularly fibre's role in the prevention of colorectal cancer. Descriptive studies about the role of wholegrain foods in cancer protection date back to the 1930s when a protective association was found between a range of foods, including wholemeal bread, and cancer risk in a UK population.¹⁰

In the 1970s it was hypothesised that dietary fibre protected against colorectal cancer, when low rates of the disease were observed in Africa, where fibre intakes were believed to be very high and refined carbohydrate intakes very low.¹¹ However subsequent analyses of the diets of African populations at low risk suggest that their intakes of total dietary fibre are not high by international standards but consumption of resistant starch was high.¹²



Since then some large observational studies and randomised controlled trials (RCTs) have supported the dietary fibre hypothesis, but others have not. Ecological and animal studies have also shown support for a role of dietary fibre in cancer, specifically colorectal cancer prevention.

Methods for measuring cereal food intake have improved over the last decade, and this has provided more reliable epidemiological evidence.

Therefore it is important for the Cancer Council to evaluate the current evidence regarding dietary fibre and whole grains, and make clear recommendations based on the available scientific evidence. The evidence for the role of fibre in cancer mostly relates to colorectal cancer, and also to breast, prostate, ovarian and oesophageal cancers.

Fruit and vegetables, another good source of dietary fibre, have been assessed in a separate position statement by the Cancer Council, available at:

www.cancercouncil.com.au/html/healthprofessionals/nutrition_physical/downloads/positionstatement_fruit_n_veg.pdf.

Epidemiological evidence

Literature reviews

In 1998 the United Kingdom Department of Health's Committee on the Medical Aspects of Food & Nutrition Policy (COMA) concluded that:¹³

- Moderately consistent evidence exists to suggest that higher intakes of dietary fibre are associated with lower risk of colorectal cancer
- Epidemiological studies examining the relationship between dietary fibre and the risk of breast cancer have reported conflicting findings.

In 2003, an expert report by the World Health Organization (WHO) and Food and Agriculture Organization concluded that fibre *possibly* decreased the risk of colorectal cancer.⁹

The World Cancer Research Fund (WCRF) recently released a comprehensive report on food and the prevention of cancer.¹⁴ This report found that fibre *probably* decreased the risk of colorectal cancer (Figure 1 and 2), and there was *limited suggestive* evidence that fibre decreased the risk of oesophageal cancer.¹⁴ Meta-analysis was possible on eight cohort studies investigating colorectal cancer (Figure 2), and a dose-response relationship was apparent from cohort data.¹⁴

Population studies

Colorectal cancer

Results from RCTs and observational studies have been mixed for dietary fibre and colorectal cancer.

Most cohort studies show that dietary fibre decreases the risk of colorectal cancer,¹⁵⁻²⁰ while an RCT found a weak protective association between dietary fibre intake and adenomas, the



precursors of colon cancer.²¹

The European Prospective Investigation into Cancer (EPIC) study found a significant dose-dependent inverse association between colorectal cancer risk and population specific measures of dietary fibre intake.²² A pooled analysis of 13 other cohort studies found a weak inverse association between dietary fibre and colorectal cancer risk.²³ Female based cohort studies have found a weak inverse association between colorectal cancer and dietary fibre²⁴ and an inverse association for colon cancer and wholegrain consumption.²⁵

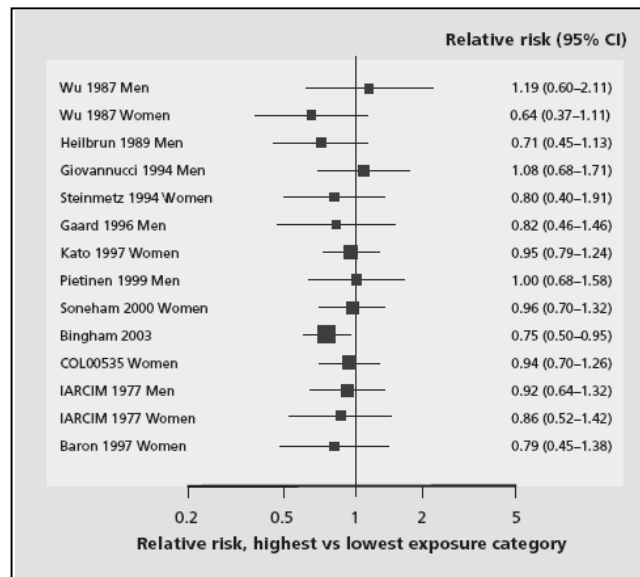


Figure 1. Results from cohort studies on dietary fibre, for highest versus lowest exposure category, and colorectal cancer as reported by the World Cancer Research Fund.¹⁴

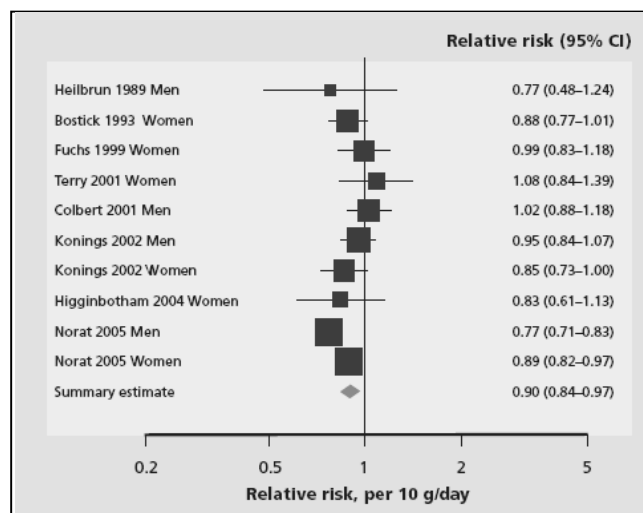


Figure 2. Results from cohort studies on dietary fibre, per 10g/day, and colorectal cancer as reported by the World Cancer Research Fund.¹⁴

A meta-analysis of 40 case-control studies on 20 cancers found an inverse association in nine out of 10 studies for wholegrain intake and risk of colorectal cancer or polyps.²⁶



However a Cochrane review of RCTs²⁷ and a cohort study in male smokers²⁸ found no association between dietary fibre intake and the risk of colorectal cancer. A pooled analysis of two RCTs shows there is no association between dietary fibre and the risk of adenomas.²⁹

One RCT found a weak positive association between colorectal cancer recurrence and a high fibre diet.³⁰

There have been a few other studies that have not supported the dietary fibre hypothesis.¹⁰ However, in these studies there have been a number of difficulties with the results including subject compliance with a high fibre diet, failure to separate cereal fibre from legume fibre, and difficulties in drawing relevant conclusions relating to cereal fibre due to differences in fibre content of supplements versus wholefoods.

Some studies have shown that fibre supplements do not protect against recurrent colorectal adenomas, and the reason for this is unclear. The Australian Polyp Prevention Trial suggested wheat-bran supplementation was associated with an increased risk of recurrence for adenomas of any size.³¹ In addition, a multicentre study that tested the effect of diet supplementation with ispaghula husk found that it significantly increased the risk of adenoma recurrence.³² Another trial found that wheat-bran supplementation had no significant protective effect against recurrent colorectal adenomas.³³

However a protective effect of fibre supplementation on the later stages of carcinogenesis cannot be ruled out. In addition, these studies may be showing a differential role for different components of dietary fibre in anti-carcinogenesis that may be worthy of further investigation. Hence further studies are required to address these issues.

Therefore in summary, it is reasonable to conclude from the current epidemiological evidence that dietary fibre from food sources *probably* decreases the risk of colorectal cancer.

Oesophageal cancer

Results from a single cohort study³⁴ and several case-control studies³⁵⁻³⁸ indicate that dietary fibre decreases the risk of oesophageal cancer. Another two case-control studies show wholegrain cereal consumption is linked to a lower risk of oesophageal cancer.^{39, 40}

Overall, the limited number of studies on oesophageal cancer show that there is a *suggestive* link between fibre intake and decreased oesophageal cancer risk.

Breast cancer

The epidemiological evidence for fibre offering protection against breast cancer is not strong. The results from four cohort studies indicate that there is no relationship between the consumption of dietary fibre and the risk of breast cancer.⁴¹⁻⁴⁴ One cohort study found no association between wholegrain intake and ER negative post-menopausal breast cancer.⁴⁵

One cohort study found a significant inverse association between the consumption of dietary fibre and risk of breast cancer,⁴⁶ while a case control study found a significant negative association between wholegrain cereal consumption and breast cancer risk.⁴⁷

Therefore more research is required to establish if a relationship exists between dietary fibre



and breast cancer before a conclusion can be made.

Prostate cancer

Not many studies have investigated dietary fibre intake and prostate cancer risk. A multi-centre case-control study in Italy found no association between total fibre and prostate cancer risk.⁴⁸ Another case control study showed that wholemeal bread was marginally protective against prostate cancer in men less than 70 years.⁴⁹ Rye bran has been shown to be protective in the rat prostate cancer model,⁵⁰ but no human intervention studies have been undertaken.¹⁰

Hence epidemiological evidence is currently insufficient to make a conclusion regarding prostate cancer risk and consumption of dietary fibre.

Ovarian cancer

The relationship between types of fibre and ovarian cancer risk was investigated in an Italian case-control study.⁵¹ A significant protective effect on ovarian cancer incidence was observed in the highest quintile of total fibre intake.⁵¹ An inverse relationship to ovarian cancer risk was found for vegetable fibre, while no effect of fruit fibre was observed and a positive relationship was found for grain fibre.⁵¹ However the presence of other components in these foods means these results are not a good indication of fibre and cancer risk alone.

Therefore as not many epidemiological studies have examined the association, there is insufficient evidence to make a conclusion about ovarian cancer and dietary fibre.

Potential biological mechanisms

It is likely that the various components of dietary fibre and their associated phytochemicals work in combination to protect against cancer. Possible mechanisms related to fibre and how it may be providing cancer protection include:¹⁰

- Increasing stool bulk, which decreases transit time thereby reducing possible exposure of the colonic epithelium to potential carcinogens
- Binding toxic or mutagenic metabolites, which may promote cell proliferation
- Lowering faecal pH, which prevents the conversion of primary bile acids into secondary acids which are potential carcinogens
- Altering bacterial fermentation and increasing short chain fatty acid production (such as butyrate) which promote a normal phenotype in colonocytes
- Lowering insulin levels, thereby preventing insulin resistance, as elevated circulating plasma insulin has been associated with colon and breast cancers.

Other suggested mechanisms include:

- Antioxidant properties of phytochemicals such as phytates and phenolics, which can prevent the production of active oxygen species and reduce the effects of free radical damage on DNA¹⁰
- Cancer inhibitory action of phytosterols, which can help boost immune recognition of cancer, influence hormonal dependent growth of endocrine tumours and alter sterol



biosynthesis.⁵² In addition, phytosterols can directly inhibit tumour growth by slowing down cell cycle progression, inducing apoptosis and inhibiting tumour metastasis.⁵²

- Effect of high fibre wholegrain foods on controlling energy intake and body weight, as they are low in fat and can help increase satiety.⁵³ Overweight and obesity have been linked to an increased risk of cancer of the endometrium, kidney, breast (only in post-menopausal women), colon, oesophagus and pancreas.¹⁴ Other cancers also thought to be associated with body weight include cancer of the gallbladder and liver.¹⁴

Potential adverse effects

Potential adverse effects of consuming wholegrain foods must be seen in context with the rest of the diet. In theory, whole grains may reduce the availability of minerals due to the binding of fibre and phytic acid to minerals. However the consumption of whole grains within recommended fibre intakes has not shown adverse effects on nutrient mineral status.⁵⁴

Recommendations

Although the evidence is not strong for the protective role of dietary fibre and colorectal cancer risk, dietary fibre should be encouraged as part of a varied and nutritious diet. Current recommendations in the Nutrient Reference Values from the National Health and Medical Research Council are for women to eat 25g of dietary fibre per day and men to eat 30g per day.⁵⁵

Substituting wholegrain and wholemeal cereal foods for refined cereal foods in at least half the daily bread and cereal serves could achieve the dietary fibre intake goal,[#] increase intakes of protective phytochemicals found in the outer grain layers, and therefore contribute to colorectal cancer risk reduction. Increasing intake of fruit, vegetables and legumes could also help achieve the dietary fibre intake goal and provide additional important phytochemicals.

Therefore the Cancer Council recommends people aim to:

- Eat **at least two serves** of wholegrain or wholemeal foods every day. This means ensuring about **half** their daily serves of breads and cereals are wholegrain or wholemeal varieties.
- Eat **at least two serves** of fruit and **five serves** of vegetables, including legumes, daily.

This advice is consistent with national recommendations from the National Health and Medical Research Council's Dietary Guidelines for Australian Adults, which recommends people "eat plenty of cereals (including breads, rice, pasta and noodles), preferably wholegrain" and "eat plenty of vegetables, legumes and fruits",⁵³ and the Australian Guide to Healthy Eating from the Department of Health and Family Services, which recommends people "eat plenty of plant foods (bread, cereal, rice, pasta, noodles, vegetables, legumes and fruit)".⁸ Table 2 shows the number of recommended serves per day of cereal foods for Australian adults.

As the benefits of fibre may be from the combination of nutrients working together it is recommended that whole foods be consumed rather than a dietary fibre supplement.

[#] People intolerant of gluten may need to consider alternative sources of fibre and discuss this with their dietitian.



Table 2. Number of serves per day of cereal foods (including breads, rice, pasta and noodles) recommended for Australian men and women.⁵³

Age/status	Men	Women
19-60 years	6-12	4-9
60+ years	4-9	4-7
Pregnant	-	4-6
Breastfeeding	-	5-7

What is a serve?

A sample serve of cereal or bread equals:^{8, 53}

- 2 slices of bread
- 1 medium bread roll
- 1 cup of cooked rice, pasta or noodles
- 1 cup of cooked porridge
- 1 1/3 cups of breakfast cereal
- 1/2 cup of untoasted muesli

A serve of fruit equals:^{8, 53}

- 1 medium piece (150g) of fruit (apple, banana, orange, pear)
- 2 small pieces (150g) of fruit (apricots, kiwifruit, plums)
- 1 cup (150g) diced pieces or canned fruit
- 1 1/2 tablespoons sultanas, 4 dried apricot halves
- 1/2 cup (125mL) fruit juice

A serve of vegetables equals:⁸

- 1/2 cup (75g) cooked vegetables
- 1/2 cup (75g) cooked dried beans, peas or lentils
- 1 cup salad vegetable
- 1 small potato

A serve of nuts or seeds[^] equals:⁸

- 1/3 cup of nuts (peanuts, almonds)
- 1/4 cup of sunflower seeds, sesame seeds

Current consumption levels in Australian adults

Dietary survey data shows that Australians are consuming less than the current recommended level of dietary fibre. The National Nutrition Survey showed that in 1995,^{*} women were eating approximately 20g of fibre per day and men about 26g per day, with around 40-45% of this dietary fibre coming from cereal foods.^{56, 57}

Recent survey data from children in Western Sydney shows that around 20% of their dietary fibre comes from products low in whole grains such as cakes, biscuits and pastries.⁵⁸

[^] Nuts and seeds contain more energy than other high fibre foods

^{*} At the time of developing this position statement, Australia's last National Nutrition Survey was conducted in 1995.



Studies have shown that people consuming higher quantities of wholegrain cereals tend to be older, have a higher socio-economic background, are less likely to smoke and more likely to exercise.^{19, 24, 59}

Therefore many Australians need to increase their intake of dietary fibre, and health promotion programs should continue to encourage the consumption of wholegrain foods.

Future research

Additional studies on fibre, wholegrain cereals and cancer risk are needed. In the future, there is a need for more:

- Well designed observational studies on diet and cancer
- Studies that explore the mechanisms of action of food bio-actives (i.e. investigate different components in wholegrain cereal foods such as lignans, oligosaccharides, amylase and protease inhibitors) to help establish mechanisms of action and thereby supportive evidence of observational effects
- Research that helps link knowledge of causal pathways with pathology of cancer at various sites, in particular paying greater attention to the influence of wholegrain cereal intake on cancers at sites other than the colorectum
- Investigations into the effect of specific foods in the context of the whole diet (such as the effect of co-consumption of fat and fibre and the impact on cancer risk, whether high wholegrain intake can counteract other negative dietary factors, or if there are specific grains in particular that are more beneficial) and lifestyle factors such as physical activity and the environment.

In addition, food databases need to be updated regularly with regard to the dietary fibre content of foods, and to accurately reflect the wide variety of cereal foods now available. Consumers also need greater assistance to identify wholegrain foods in the market place. Improvements in how these foods which meet overall criteria for healthiness are identified on labels would be one possibility.



Acknowledgements

Narelle McPhee, Nutrition Project Officer at the Cancer Council NSW, assisted in the development of this position statement.

This position statement has been reviewed by:

- Ian Olver
- Andrew Penman
- Craig Sinclair
- Manny Noakes
- Trevor Lockett
- David Topping
- Peter Clifton
- Linda Tapsell
- Trish Griffiths
- Lucy Smith
- Loren Muhlmann
- Jenny Atkins
- Steve Pratt
- Hayley Erickson
- Susan Edwards

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References

1. Food Standards Australia and New Zealand. NUTTAB 2006 (Australian Food Composition Tables). Barton, Food Standards Australia and New Zealand. 2006.
2. Food Standards Australia and New Zealand. Australia New Zealand Food Standards Code. Canberra, Anstat. 2008.
3. Jenkins DJ, Kendall CW, Vuksan V, Augustin LS, Li YM, Lee B *et al*. The effect of wheat bran particle size on laxation and colonic fermentation. *Journal of the American College of Nutrition*. 1999; **18**(4): 339-345.
4. Chandalia M, Garg A, Lutjohann D, von BK, Grundy SM, Brinkley LJ. Beneficial effects of high dietary fiber intake in patients with type 2 diabetes mellitus. *N Engl J Med*. 2000; **342**(19): 1392-1398.
5. Brown L, Rosner B, Willett WW, Sacks FM. Cholesterol-lowering effects of dietary fiber: a meta-analysis. *Am J Clin Nutr*. 1999; **69**(1): 30-42.
6. Brand-Miller J. Carbohydrates. In: *Essentials of Human Nutrition*. Mann J, Truswell AS (editors).



New York: Oxford University Press. 2002. pp. 11-29.

7. Topping DL, Clifton PM. Short-chain fatty acids and human colonic function: roles of resistant starch and nonstarch polysaccharides. *Physiol Rev.* 2001; **81**(3): 1031-1064.
8. Department of Health and Family Services. The Australian Guide to Healthy Eating. Canberra, AGPS. 1998.
9. World Health Organization. Diet, nutrition and the prevention of chronic diseases. Geneva, WHO. 2003.
10. McIntosh G. Cereal foods, fibres and the prevention of cancers. *Australian Journal of Nutrition & Dietetics.* 2001; **58**(S2): 35-48.
11. Burkitt DP. Epidemiology of cancer of the colon and rectum. *Cancer.* 1971; **28**(1): 3-13.
12. Segal I. Physiological small bowel malabsorption of carbohydrates protects against large bowel diseases in Africans. *J Gastroenterol Hepatol.* 2002; **17**(3): 249-252.
13. United Kingdom Department of Health. Nutritional aspects of the development of cancer. Report of the working group on diet and cancer of the Committee on Medical Aspects of the Food and Nutrition Policy. Committee on Medical Aspects of the Food and Nutrition Policy. Norwich, UK, The Stationery Office. 1998.
14. The World Cancer Research Fund and American Institute for Cancer Research. *Food, nutrition, physical activity and the prevention of cancer: a global perspective.* Washington DC: AICR. 2007.
15. Higginbotham S, Zhang ZF, Lee IM, Cook NR, Giovannucci E, Buring JE *et al.* Dietary glycemic load and risk of colorectal cancer in the Women's Health Study. *J Natl Cancer Inst.* 2004; **96**(3): 229-233.
16. Koh WP, Yuan JM, van den BD, Lee HP, Yu MC. Interaction between cyclooxygenase-2 gene polymorphism and dietary n-6 polyunsaturated fatty acids on colon cancer risk: the Singapore Chinese Health Study. *Br J Cancer.* 2004; **90**(9): 1760-1764.
17. Konings EJ, Goldbohm RA, Brants HA, Saris WH, van den Brandt PA. Intake of dietary folate vitamers and risk of colorectal carcinoma: results from The Netherlands Cohort Study. *Cancer.* 2002; **95**(7): 1421-1433.
18. Mai V, Flood A, Peters U, Lacey JV, Jr., Schairer C, Schatzkin A. Dietary fibre and risk of colorectal cancer in the Breast Cancer Detection Demonstration Project (BCDDP) follow-up cohort. *Int J Epidemiol.* 2003; **32**(2): 234-239.
19. McCullough ML, Robertson AS, Chao A, Jacobs EJ, Stampfer MJ, Jacobs DR *et al.* A prospective study of whole grains, fruits, vegetables and colon cancer risk. *Cancer Causes Control.* 2003; **14**(10): 959-970.
20. Terry P, Giovannucci E, Michels KB, Bergkvist L, Hansen H, Holmberg L *et al.* Fruit, vegetables, dietary fiber, and risk of colorectal cancer. *J Natl Cancer Inst.* 2001; **93**(7): 525-533.
21. Robertson DJ, Sandler RS, Haile R, Tosteson TD, Greenberg ER, Grau M *et al.* Fat, fiber, meat and the risk of colorectal adenomas. *Am J Gastroenterol.* 2005; **100**(12): 2789-2795.
22. Bingham SA, Day NE, Luben R, Ferrari P, Slimani N, Norat T *et al.* Dietary fibre in food and protection against colorectal cancer in the European Prospective Investigation into Cancer and



Nutrition (EPIC): an observational study. *Lancet*. 2003; **361**(9368): 1496-1501.

23. Park Y, Hunter DJ, Spiegelman D, Bergkvist L, Berrino F, van den Brandt PA *et al*. Dietary fiber intake and risk of colorectal cancer: a pooled analysis of prospective cohort studies. *JAMA*. 2005; **294**(22): 2849-2857.
24. Lin J, Zhang SM, Cook NR, Rexrode KM, Liu S, Manson JE *et al*. Dietary intakes of fruit, vegetables, and fiber, and risk of colorectal cancer in a prospective cohort of women (United States). *Cancer Causes Control*. 2005; **16**(3): 225-233.
25. Larsson SC, Giovannucci E, Bergkvist L, Wolk A. Whole grain consumption and risk of colorectal cancer: a population-based cohort of 60,000 women. *Br J Cancer*. 2005; **92**(9): 1803-1807.
26. Jacobs DR, Jr., Marquart L, Slavin J, Kushi LH. Whole-grain intake and cancer: an expanded review and meta-analysis. *Nutr Cancer*. 1998; **30**(2): 85-96.
27. Asano T, McLeod RS. Dietary fibre for the prevention of colorectal adenomas and carcinomas. *Cochrane Database Syst Rev*. 2002;(2): CD003430.
28. Pietinen P, Malila N, Virtanen M, Hartman TJ, Tangrea JA, Albanes D *et al*. Diet and risk of colorectal cancer in a cohort of Finnish men. *Cancer Causes Control*. 1999; **10**(5): 387-396.
29. Jacobs ET, Lanza E, Alberts DS, Hsu CH, Jiang R, Schatzkin A *et al*. Fiber, sex, and colorectal adenoma: results of a pooled analysis. *Am J Clin Nutr*. 2006; **83**(2): 343-349.
30. Ishikawa H, Akedo I, Otani T, Suzuki T, Nakamura T, Takeyama I *et al*. Randomized trial of dietary fiber and Lactobacillus casei administration for prevention of colorectal tumors. *Int J Cancer*. 2005; **116**(5): 762-767.
31. MacLennan R, Macrae F, Bain C, Battistutta D, Chapuis P, Gratten H *et al*. Randomized trial of intake of fat, fiber, and beta carotene to prevent colorectal adenomas. *J Natl Cancer Inst*. 1995; **87**(23): 1760-1766.
32. Bonithon-Kopp C, Kronborg O, Giacosa A, Rath U, Faivre J. Calcium and fibre supplementation in prevention of colorectal adenoma recurrence: a randomised intervention trial. European Cancer Prevention Organisation Study Group. *Lancet*. 2000; **356**(9238): 1300-1306.
33. Alberts DS, Martinez ME, Roe DJ, Guillen-Rodriguez JM, Marshall JR, van Leeuwen JB *et al*. Lack of effect of a high-fiber cereal supplement on the recurrence of colorectal adenomas. Phoenix Colon Cancer Prevention Physicians' Network. *N Engl J Med*. 2000; **342**(16): 1156-1162.
34. Kasum CM, Jacobs DR, Jr., Nicodemus K, Folsom AR. Dietary risk factors for upper aerodigestive tract cancers. *Int J Cancer*. 2002; **99**(2): 267-272.
35. Chen H, Tucker KL, Graubard BI, Heineman EF, Markin RS, Potischman NA *et al*. Nutrient intakes and adenocarcinoma of the esophagus and distal stomach. *Nutr Cancer*. 2002; **42**(1): 33-40.
36. Mayne ST, Risch HA, Dubrow R, Chow WH, Gammon MD, Vaughan TL *et al*. Nutrient intake and risk of subtypes of esophageal and gastric cancer. *Cancer Epidemiol Biomarkers Prev*. 2001; **10**(10): 1055-1062.
37. Soler M, Bosetti C, Franceschi S, Negri E, Zambon P, Talamini R *et al*. Fiber intake and the risk of oral, pharyngeal and esophageal cancer. *Int J Cancer*. 2001; **91**(3): 283-287.
38. Terry P, Lagergren J, Ye W, Wolk A, Nyren O. Inverse association between intake of cereal fiber



and risk of gastric cardia cancer. *Gastroenterology*. 2001; **120**(2): 387-391.

39. La Vecchia C, Chatenoud L, Negri E, Franceschi S. Session: whole cereal grains, fibre and human cancer wholegrain cereals and cancer in Italy. *Proc Nutr Soc*. 2003; **62**(1): 45-49.
40. Levi F, Pasche C, Lucchini F, Chatenoud L, Jacobs DR, Jr., La Vecchia C. Refined and whole grain cereals and the risk of oral, oesophageal and laryngeal cancer. *Eur J Clin Nutr*. 2000; **54**(6): 487-489.
41. Giles GG, Simpson JA, English DR, Hodge AM, Gertig DM, MacInnis RJ *et al*. Dietary carbohydrate, fibre, glycaemic index, glycaemic load and the risk of postmenopausal breast cancer. *Int J Cancer*. 2006; **118**(7): 1843-1847.
42. Holmes MD, Liu S, Hankinson SE, Colditz GA, Hunter DJ, Willett WC. Dietary carbohydrates, fiber, and breast cancer risk. *Am J Epidemiol*. 2004; **159**(8): 732-739.
43. Sieri S, Krogh V, Muti P, Micheli A, Pala V, Crosignani P *et al*. Fat and protein intake and subsequent breast cancer risk in postmenopausal women. *Nutr Cancer*. 2002; **42**(1): 10-17.
44. Terry P, Jain M, Miller AB, Howe GR, Rohan TE. No association among total dietary fiber, fiber fractions, and risk of breast cancer. *Cancer Epidemiol Biomarkers Prev*. 2002; **11**(11): 1507-1508.
45. Fung TT, Hu FB, Holmes MD, Rosner BA, Hunter DJ, Colditz GA *et al*. Dietary patterns and the risk of postmenopausal breast cancer. *Int J Cancer*. 2005; **116**(1): 116-121.
46. Mattisson I, Wirfalt E, Johansson U, Gullberg B, Olsson H, Berglund G. Intakes of plant foods, fibre and fat and risk of breast cancer--a prospective study in the Malmo Diet and Cancer cohort. *Br J Cancer*. 2004; **90**(1): 122-127.
47. Adzersen KH, Jess P, Freivogel KW, Gerhard I, Bastert G. Raw and cooked vegetables, fruits, selected micronutrients, and breast cancer risk: a case-control study in Germany. *Nutr Cancer*. 2003; **46**(2): 131-137.
48. Pelucchi C, Talamini R, Galeone C, Negri E, Franceschi S, Dal Maso L *et al*. Fibre intake and prostate cancer risk. *Int J Cancer*. 2004; **109**(2): 278-280.
49. Talamini R, Franceschi S, La VC, Serraino D, Barra S, Negri E. Diet and prostatic cancer: a case-control study in northern Italy. *Nutr Cancer*. 1992; **18**(3): 277-286.
50. Zhang JX, Hallmans G, Landstrom M, Bergh A, Damber JE, Aman P *et al*. Soy and rye diets inhibit the development of Dunning R3327 prostatic adenocarcinoma in rats. *Cancer Lett*. 1997; **114**(1-2): 313-314.
51. Pelucchi C, La Vecchia C, Chatenoud L, Negri E, Conti E, Montella M *et al*. Dietary fibres and ovarian cancer risk. *Eur J Cancer*. 2001; **37**(17): 2235-2239.
52. Bradford PG, Awad AB. Phytosterols as anticancer compounds. *Molecular Nutrition & Food Research*. 2007; **51**(2): 161-170.
53. National Health and Medical Research Council. Dietary Guidelines for Australian Adults. Canberra, NHMRC. 2003.
54. Slavin JL, Martini MC, Jacobs DR, Jr., Marquart L. Plausible mechanisms for the protectiveness of whole grains. *Am J Clin Nutr*. 1999; **70**(3 Suppl): 459S-463S.



55. National Health and Medical Research Council. Nutrient Reference Values for Australia and New Zealand including Recommended Dietary Intakes. Canberra, Australia, Commonwealth Department of Health and Ageing. 2006.
56. Australian Bureau of Statistics and Commonwealth Dept of Health and Family Services. National Nutrition Survey: foods eaten. Australian Bureau of Statistics. Canberra, Australian Bureau of Statistics. 1998.
57. Australian Bureau of Statistics and Commonwealth Dept of Health and Family Services. National Nutrition Survey: nutrient intakes and physical measurements. Canberra, Australian Bureau of Statistics. 1998.
58. Webb KL, Lahti-Koski M, Rutishauser I, Hector DJ, Knezevic N, Gill T *et al.* Consumption of 'extra' foods (energy-dense, nutrient-poor) among children aged 16-24 months from western Sydney, Australia. *Public Health Nutrition*. 2006; **9**(8): 1035-1044.
59. Lang R, Jebb SA. Who consumes whole grains, and how much? *Proc Nutr Soc*. 2003; **62**(1): 123-127.

