Dietary Fibre

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EXECUTIVE SUMMARY

This paper reviewed the current evidence of health benefits associated with dietary fibre. Starch, simple sugars and non-polysaccharides are all components of dietary fibre and are responsible for bulking faecal matter, increasing viscosity, transit time and Short Chain Fatty Acids (SCFA) production.

It is reasonable to conclude that the beneficial effects of dietary fibre include a reduction in the risk of obesity, type-2 diabetes and coronary heart disease (CHD). It is also probable that adequate dietary fibre, particularly from grains, reduces the risk of colorectal cancer. These associations for chronic diseases have been found to have an inverse relationship with dietary fibre intake, with higher amounts being more protective.

Excessive amounts of fibre may pose a risk of mineral deficiencies through the action of the phytic acid component found in most sources of fibre. Zinc and iron absorption are negatively affected by phytic acid, reducing their absorption in a dose-dependent manner. Calcium absorption increases with phytic acid content. However this association has been found only in groups with low calcium intake, such as premenopausal women and adolescents. The effect on the general population remains unknown.

This paper also concluded that the average dietary fibre intake of New Zealand adults and children falls within a safe range, and is more likely to be below reference values rather than above. The top food sources that provided dietary fibre in New Zealand include bread followed by potato, kumara and taro.

DEFINITION OF DIETARY FIBRE

There is currently not one universally accepted definition of dietary fibre. The Australian New Zealand Food Standards code (2008) have defined dietary 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".*

BACKGROUND

Dietary fibre includes many different components, many of which are found in or associated with the cell wall of plants. Starch and simple sugars are components of dietary fibre that are broken down and absorbed in the small intestine (Lattimer & Haub, 2010). Fructans are also included in the definition of dietary fibre. These are carbohydrates with a chain length longer than ten, which are poorly absorbed in the small intestine. (Murray et al, 2013). One of the most commonly found fructans in food is inulin. Other components of dietary fibre are referred to as non-starch polysaccharides (NSPs) (cellulose, hemicellulose, lignin, pectin and B-glucans). These NSP's resist hydrolysis and absorption and pass through to the large intestine where they are fermented (Lattimer & Haub, 2010).

NSPs can be further categorised into two sub-groups, soluble and insoluble fibre. Category selection is dependent on their physical, chemical and functional properties in the bowel (Lattimer & Haub, 2010). Soluble fibre forms a gel as it passes through the small intestine and is readily fermented by microflora once it reaches the large intestine (Lattimer & Haub, 2010). Soluble fibre is found in oats, fruits and vegetables (Chandalia et al., 2000). In contrast, insoluble NSPs are not soluble in water and therefore are responsible for faecal bulking which subsequently aids laxation. Insoluble fibre is found primarily in wheat and wheat products (Lattimer & Haub, 2010).

Dietary fibre and wholegrains contain many beneficial nutrients such as vitamins, minerals, phytochemicals and antioxidants (Lattimar & Haub, 2010; Kendall et al, 2010). Research regarding dietary fibre and its benefits for health has gained considerable attention over the last decade. Dietary fibre is primarily responsible for bulking faecal matter, increasing viscosity, increasing transit time and producing short chain fatty acids (Eswaran, Muir & Chey 2013). The functions of dietary fibre along with the nutrients it provides are thought to benefit health and reduce the risk of obesity, type-2 diabetes, cancer and cardiovascular disease (Cho, Qi, Fahey Jr & Klurfeld, 2013).

OBESITY

In many studies, higher fibre intake and wholegrain consumption have been associated with lower body weight and prevention of weight gain (Davis, Hodges, Killham, 2006; Du et al., 2010; Tucker &Thomas 2009). There are several proposed mechanisms that are likely to be responsible for weight loss and weight management. These include; increased satiety, decreased food intake, fermentation and changes in gut hormones (Howarth, Saltzman & Roberts, 2001).

The viscosity of fibre is thought to play an important role in increasing satiety and therefore subsequent decreased energy intake, thus assisting weight control. There are several mechanisms by which this occurs (Lafiandra, Riccardi, & Shewry, 2014):

Dietary fibre slows the digestion of foods and inhibits the gut content's mixing and diffusion in the digestive tract, leading to delayed gastric emptying.

The rate of absorption of nutrients such as fat and glucose is reduced and this also increases satiety.

Foods high in dietary fibre such as wholegrains, fruit and vegetables have a low energy density yet act as bulking agents within the gut. The bulking action from these fibre sources may also promote satiety.

The short chain fatty acids produced during fermentation of the dietary fibre within the gut may also act to delay a hunger response before the next meal and additionally promote satiety signals (Riccardi et al., 2004)

Another mechanism is the probiotic effect of the intestinal flora. Microbiota composition has been shown to differ in lean compared to obese humans and may have an effect on energy regulation, however the evidence behind this is controversial (Lafiandra et al., 2014).

Resistant starch and both soluble and insoluble fibre have been found to have similar effects on satiety, gastric emptying and the production of SCFAs as a product of fermentation (Lafiandra et al., 2014; Salvin & Green, 2007). Conversely, a recent systematic review found that only certain types of fibre may enhance satiety; these include B-glucans, including barley and oats, whereas pectins and psyllium had little effect on satiety (Clark & Slavin, 2013).

A one year RCT found subjects who followed a low fat, high carbohydrate, high fibre diet had the highest reduction in BMI in comparison to those following the Atkins, Zone or Weight Watchers diet (Dansinger et al., 2005). Although most weight loss or weight management studies also focus on low GI as well as high fibre, many have shown that fibre (guar, oats and legumes) leads to increased satiety and a decrease in food intake. In contrast to the Clark and Slavin 2013 work, this study also found psyllium provided beneficial effect on satiety (Ludwig, 2000).

There is convincing evidence that an increased fibre intake increases satiety and therefore results in possible weight loss and weight control.

DIABETES

Dietary fibre has also been recognised to play an important role in glycemic control. Foods high in dietary fibre have a lower glycemic index as they release glucose slowly into the blood, therefore helping prevent and control diabetes (Nugent, 2005). Riccardi, Capaldo & Vaccaro (2005) and De Natale et al (2012) found that soluble fibres (such as B-glucan, psyllium and guar gum) reduce the rise in post-prandial blood glucose and improve insulin sensitivity in people with and without diabetes.

Bacteria within the gut ferment a large portion of dietary fibre, this process of fermentation produces short chain fatty acids (e.g. butyrate, acetate and propionate). These short chain fatty acids affect glucose production from the liver thus influencing blood glucose levels (Slavin, 2013).

The British Diabetes Association, Canadian Diabetes Association and the European Association for the study of Diabetes have all made nutrition recommendations to increase fibre intake in those with type 2 diabetes (Anderson, Randles, Kendall & Jenkins, 2004). These associations also encourage a low GI diet; many sources of low GI food are high in fibre too, especially all-bran, oats ad legumes (Kendall, Esfahani & Jenkins, 2010).

A low GI, high fibre diet has been shown to improve glycemic control, demonstrated by improved fasting blood glucose, HbA1c markers, and postprandial blood glucose levels (Kendall et al, 2010). Two meta-analyses also support these findings (Sievenpiper et al., 2009; Anderson et al., 2004), suggesting that high GI, high fibre diets are beneficial in glycemic control for people with diabetes. Improved glycemic control, such as a reduction in HbA1c, has also been associated with a lower risk of mortality related to type-2 diabetes (Stratton et al., 2000)

Fibre has also been investigated to determine the role it plays in the prevention of diabetes. Several studies found that fibre consumption was not associated with the incidence of diabetes (Hodge, English, O'Dea, & Giles, 2004; Meyer et al., 2000; Stevens et al., 2002). However a meta-analysis showed that low GI diets (that were also high in fibre) were protective against type-2 diabetes, indicating that low GI diets in conjunction with high fibre may reduce the risk of developing type-2 diabetes (Barclay et al., 2008). Another randomised control trial (RCT) supports these findings, showing that low GI and high fibre diets were best for managing and preventing type-2 diabetes, rather than high fibre diets with only moderate GI indices (Jenkins et al., 2008). It is worth noting that the fibre used in this RCT was sourced from vegetables.

In addition, consumption of fibre from cereals and grains have also found to be inversely associated with the risk of type-2 diabetes (Parillo & Riccardi, 2004). Overall, a high intake of whole grain cereals and their products, such as whole wheat bread, has been associated with a 20 - 30% reduction in the risk of type-2 diabetes (Gil, Ortega & Maldonado, 2011).

CORONARY HEART DISEASE AND CARDIOVASCULAR DISEASE

A large case-control study, the INTERHEART study, found that obesity and diabetes are two of the most important risk factors for coronary heart disease (Yusuf et al., 2004). In addition, type-2 diabetes alone can increase the risk of CHD by 2-5 fold (Kendall et al., 2010). Due to

the association of fibre in controlling obesity and preventing type-2-diabetes, there is an indirect association of fibre reducing the risk of CHD. However it is also thought fibre may directly reduce the risk of CHD by acting on other risk factors specific to heart disease such as inflammation and cholesterol (Kendall et al., 2010)

Several studies have shown an association between the consumption of fibre and non-communicable disease; Cardiovascular disease (CVD) risk in particular is lowered by 20-30% in subjects who have 3 or more portions of whole grain cereals a day in comparison to subjects who consume mainly refined cereals (Lafiandra et al, 2014). As well as lowering the risk for CHD alone, fibre intake has also been seen to reduce the risk of risk factors for CHD, such as insulin resistance, dyslipidemia, inflammation and oxidative stress (Wirstrom et al., 2013).

Conversely, a recent 16 week RCT that examined increased fibre intake and CVD risk factors found no significant difference between those that increased their fibre intake by 60g/day in comparison to the control group (Brownlee et al., 2010). However, this trial was only over a 4 month period which may be insufficient to detect significant changes. Giacco et al (2010) also examined wholemeal versus refined fibre diets for 3 weeks in a randomised crossover trial. Total cholesterol and LDL cholesterol reduced in the wholemeal group; however there was no change reported in inflammatory markers and insulin metabolism. As with the study published by Brownlee et al (2010), the duration of this trial may have been insufficient to detect changes.

The US FDA (Food and Drug Administration) have allowed a health claim regarding viscous fibre and the benefits regarding CVD; this claim is supported by a large pooled analysis that found that viscous fibre significantly reduced the risk of CHD deaths compared to insoluble fibre (Pereira et al, 2004). Another recent study found that a high-viscosity fibre blend in comparison with moderate (Psyllium) and low-viscosity (wheat-bran) fibre showed a positive reduction in LDL-cholesterol. This was evident even when the quantity of high-viscous fibre consumed was lower than the low and moderate viscosity fibre groups (Vuksan et al., 2011).

Jenkins et al (2006) trialed a dietary intervention to lower cholesterol on 55 hyperlipidemic subjects. The participants consumed a diet that was low in saturated fat, dietary cholesterol and also included 8.2g/1000kcal viscous fibre (from oats, barley and psyllium), 22.7g/1000kcal soy protein 1g/100kcal of plant sterols and 14g/1000kcal of nuts (almonds). Despite the small numbers within this study, this trial was one of the few that took place outside a controlled setting. The study found that LDL-cholesterol and total:HDL cholesterol were reduced 14.6% and 12.7% respectively, suggesting that dietary interventions using viscous fibre in conjunction with other cholesterol lowering foods may reduce the risk of CHD indirectly though cholesterol.

There is strong evidence to suggest that viscous fibre, along with low GI foods can lower CHD risk by reducing risk factors including LDL-cholesterol, type-2 diabetes and obesity. However from the above evidence, it is less clear whether whole grains reduce CHD risk or not.

COLORECTAL CANCER

There is significant interest in fibre intake for the prevention of colorectal cancer. The putative protective mechanisms behind fibre consumption include increasing stool weight which subsequently reduces transit time and therefore decreases contact time with toxins (Bingham et al., 2003). The other mechanism is through increased butyrate production by gut bacteria increasing energy for colonic epithelial cells. Butyrate has also been associated with DNA

repair and induced death of transformed cells (Lafiandra et al., 2014). These mechanisms are thought to be protective against colorectal cancer by keeping the intestine healthy.

The large European Prospective Investigation into Cancer and Nutrition (EPIC) cohort with participants from 10 European countries found strong evidence that fibre reduces the risk of colorectal cancer by 25-40% (Bingham et al., 2003). This significantly reduced risk was also confirmed again in the follow up EPIC study, even after adjusting for confounding factors such as physical activity, alcohol, smoking, and red and processed meat intake (Bingham et al., 2005).

However, two analyses both including large cohort studies have both shown no statistical significance in the association of fibre intake and risk of colorectal cancer (Park et al., 2005; Michels et al., 2005)

A recent meta-analysis found that consumption of dietary fibre, particularly whole grains and cereals, was associated with a reduced risk of colorectal cancer, relative risk 0.83 and 0.9 respectively (Aune et al., 2011). However the association between colorectal cancer and fruit, vegetables and legumes was not significant. Two other studies have found that fibre from fruit was been associated with a significantly reduced risk (Peters et al, 2003; Papas et al, 2004). However a study by Bingham et al (2005) supports the findings of Aune et al (2011) who found no significant association between fruit and colorectal cancer. It was suggested that the non-significant result published by Aune et al (2011) may be attributed to the lack of adjustment for confounders such as diet and lifestyle in some studies included in the analysis.

Fibre intake from vegetables has shown inconsistent results. Levi et al (2001) found a higher vegetable intake was strongly associated with a decreased risk of colorectal cancer. A case-control study (Peters et al, 2003) found that subjects in the highest quintile of fibre had a significantly less risk (27%) of developing colorectal adenomas compared with those in the lowest quintile. However this study found it was fibre from grains, cereals and fruits rather than vegetables that was associated with the decreased risk.

Overall, the results of studies investigating fibre consumption and the risk of colorectal cancer are inconsistent. However, the results of the larger, higher quality studies suggest that fibre intake from wholegrains probably decreases the risk of colorectal cancer.

HEALTH IMPLICATIONS

Excessive amounts of dietary fibre may inhibit adequate absorption of certain vitamins, minerals, energy and protein. For healthy adults consuming fibre within the New Zealand reference range, it is unlikely that fibre consumption will pose any such harm. However, excessive fibre in children may be inappropriate, though there is a lack of evidence in this area. Fermentation of dietary fibre will produce gas and therefore some individuals may experience abdominal distention and flatulence (ADA, 2008).

When an individual is increasing their dietary fibre intake, fluid intake should also be increased to accommodate the change and allow the gut to adapt (ADA, 2008).

Inadequate fibre, below that of reference values may limit intake of vitamins and minerals, decrease gut transit time and cause constipation (Eswaran et al., 2013). Inadequate fibre is also thought to be associated with diverticular disease (Stollman & Raskin, 2004; ADA, 2008).

RECOMMENDED INTAKES

The Ministry of Health (2005) advises adequate intakes for Adult (19yrs- >70yrs) Men 30g/d and Women, 25g/d.

Table 1: Recommended Average Intake for fibre for New Zealanders

Children	grams/day
1-3 years	14
4-8 years	18
Boys	
9-13 years	28
14-18 years	24
Girls	
9-13 years	20
14-18 years	22
Adult Men	30
Adult Women	25
Pregnancy	
14-18 years	25
19–50 years	28
Lactation	
14-18 years	30
19–50 years	30

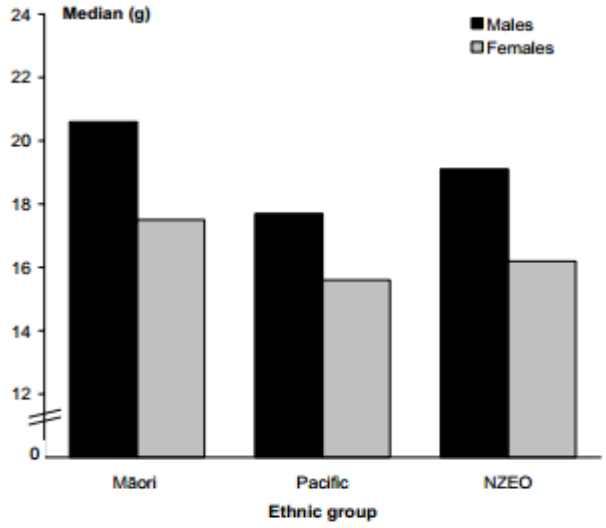
Note: There is currently no recommended intake set for infants 0-12months

ACTUAL INTAKES IN NZ

Findings from the 2008/2009 Adult Nutritional Survey showed that New Zealand Adults are consuming less than the daily adequate intake, mean intakes for male and female adults were 22.1g and 17.5g, respectively (MOH, 2011).

The 2002 Children's Nutritional survey found that the mean dietary fibre intake was 17.9g (MOH, 2003). In comparison to NZEO and Maori children, Pacific children had a lower intake

Graph 1: Median dietary fibre intake



Source: Ministry of Health 2003

SOURCES

The 2008/09 New Zealand Adult Nutrition Survey showed that the main food groups contributing to New Zealand adult fibre intake were bread and vegetables. The two main sources of fibre among adults in New Zealand were bread (17%) and vegetables (16%). Potatoes, kumara and taro, and fruit together contributed 12% to the total daily fibre intake (MOH, 2011). Light and heavy grain bread was consumed by most of the population, however, when the results were stratified for deprivation, those in NZdep5 (more deprived) consumed more white bread than white high-fibre or grain bread, while those in NZdep1 (less deprived) consumed more grainy bread than white (MOH, 2011).

Children in New Zealand primarily obtain most of their fibre from bread (20%) followed by potato, kumara and taro (14%) and fruit (14%) (MOH, 2003). Breakfast cereals and vegetables also contributed to fibre intake, however these were the lowest groups (both 11%). Pacific and Maori children obtained more fibre from pies and pastries than NZEO children (MOH, 2003).

Table 2: Examples of food sources

Food source	Total Fibre (g)
1 cup frozen mixed vegetables	8.6
½ cup baked beans	8.2
½ cup stewed apricots	7.0
½ cup muesli	6.5
100g kidney beans	6.5
1 bran muffin	6.0
2 Weetbix	4.8

small handful of almonds	3.9
1 cup brown rice	3.7
1 slice wholemeal bread	3.2
1 kumara	2.8
10 dried apricots halves	2.7
1 slice wholegrain bread	2.6
2 slices white high-fibre	2.6
3-4 prunes	2.6
1 cup porridge	2.1
1 apple or banana	2.0
2 slices white bread	1.6

The Concise New Zealand Food Composition Tables 2013

FIBRE AND OTHER MINERALS

Sources of fibre, predominantly wholegrains, cereals, legumes and bran contain a compound called phytic acid. This compound is found on the outer layers of cereal grains and in the endosperm of legumes and seeds (Connelly, 2011). Phytic acid binds to certain minerals in the intestinal tract and forms complexes that cannot be digested, resulting in reduced absorption (Rosalind et al., 2010). Therefore, a diet high in fibre may also restrict the absorption of these minerals.

It has been found that for magnesium, zinc and iron, phytate reduces absorption in a dose-dependent manner (Bohn et al, 2004; Fredlund et al., 2006). Even at small amounts, phytate consumed at the same time or from the same food source as iron or zinc, will reduce absorption. It has been suggested that non-heme iron is affected more by phytic acid than other forms of iron such as heme iron (Craig, 2010). Non-heme iron absorption enhancers, such as vitamin C, consumed alongside fibre may reduce the effect of phytates on iron absorption (Sharp, 2010). It is thought that iron in the form of ferritin, from sources such as soybeans, is less sensitive to phytate and more bioavailable (Connelly, 2011)

However, the inhibitory effect of phytates may not be a concern for adults in developed countries (such as New Zealand) consuming a well-balanced diet and who continue to get these minerals from other food sources. Individuals with inadequate iron and zinc intakes may be at greater risk of deficiency if consuming large quantities of fibre. Individuals who follow a vegan or vegetarian diet are most at risk as their diets rely on plant-based foods that often contain fibre and therefore phytates (Craig, 2010).

The evidence concerning fibre consumption and calcium bioavailability is controversial; some studies have shown that inulin, oligosaccharides, resistant starch, and other fibers increase calcium absorption (ADA, 2008; Wolf et al., 2000; Peneau et al., 2008). However, most of these studies have been performed in groups with poor calcium intakes, such as adolescents and premenopausal women. Therefore the effect of phytic acid on calcium absorption in the general population remains unknown.

Regardless of the controversial results surrounding calcium, it is still necessary to consume adequate amounts of iron, zinc as well as calcium while on a high-fibre diet. Cereals high in fibre and phytates may also need to be fortified to ensure adequate nutrient intake.

RECOMMENDATIONS

- Consume fresh fruit or raw vegetables as an in-between meal snack rather than high fat or sugary snacks. This will keep you feeling more satiated.

- Avoid peeling the skin off fruits and vegetables, especially when juicing, as the peel is a good source of fibre.

- Consume high fibre cereals, particularly ones including oats, bran and wheat.

- Incorporate barley, chickpeas and lentils into soups and stews.

- Add kidney beans, baked beans or grated carrot to mince dishes for more fibre and to make the dish go further. Baked beans on toast are also a simple breakfast idea for children.

- Consume a small handful of nuts or seeds as a snack. These can also be used as an extra salad or meal topping.

- When buying food products, aim for those with more than 3g of fibre per serve (on the food label).

- Adhere to the Food and Nutrition guidelines for Healthy adults, with particular focus on consuming at least 2 serves of fruit and 3 serves of vegetables a day.

- Make simple food swaps:
    - White Bread → Wholegrain bread
    - White pasta → Wholemeal pasta
    - White rice → Brown rice
    - White flour → Wholemeal flour

FREQUENTLY ASKED QUESTIONS

1. ***How much fibre do I need each day?***
   Adult Men should aim to consume 30g/d, while adult women 25g/d

2. ***What should I look for on a food label?***
   More than 4g/serve = good source of fibre
   More than 7g/serve = excellent source of fibre

3. ***Are there different types of fibre?***
   Yes, the two most commonly known types of fibre are insoluble and soluble. Soluble fibre forms a gel-like substance in our intestinal tract and is fermented by bacteria, subsequently softening our bowel motions. This type of fibre is found in oats, fruit and vegetables. Insoluble fibre passes through our intestine and bulks up our faecal matter so we have regular bowel motions. Insoluble fibre is found in wholegrains like corn, rice and cereals.

4. ***I've heard too much fibre is bad, is this true?***
   Too much fibre may cause gas, abdominal distention and diarrhea in some individuals. Reducing the fibre consumption may alleviate these symptoms. Adhering to the recommended intakes of fibre is advised. If you are increasing your fibre intake, be sure to also increase your water intake and increase your fibre by small amounts over time, giving your gut time to adjust. Excessive amounts of fibre in children should be avoided.

5. ***What will happen if I do not consume enough fibre?***
   You may experience side effects like constipation. Fibre helps keep the gut moving as well as acting as a 'bulking agent' to help bulk up stools. In the long-term inadequate fibre is also harmful to our overall health. Lower intakes of fibre have been associated with type-2 diabetes, CVD, obesity and diverticulitis.

6. ***What are some good fibre supplements?***
   Psyllium, Benefibre, Metamucil all contain fibre to help relieve constipation and increase your fibre intake. These are available in pharmacies and supermarkets.

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