

Dietary fibre, nuts and cardiovascular diseases

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Dietary fibre has a range of metabolic health benefits. Through a variety of mechanisms, dietary fibre, and the viscous variety in particular, slows down gastric emptying and intestinal transit, decreases the rate of intestinal carbohydrate absorption, and increases faecal bile acid excretion. Therefore, consumption of some types of soluble fibre can enhance satiety, which is associated with a lower BMI, and reduce blood cholesterol and the postprandial glucose response. Surprisingly, the consumption of insoluble fibre from whole grains, though metabolically inert, has been associated with a reduction in the risk of developing coronary heart disease and diabetes in epidemiological studies. The likely reason is that whole grains, like nuts, legumes and other edible seeds, contain many bioactive phytochemicals and various antioxidants. After cereals, nuts are the vegetable foods that are richest in fibre, which may partly explain their benefit on the lipid profile and cardiovascular health.

After decades of clinical and epidemiological research, there is a general consensus about the overall dietary pattern which is best associated with good cardiovascular health. This pattern consists of a high intake of plant foods (whole-grain cereals, vegetables, legumes, fruit and nuts) and fish, habitual use of unsaturated oils and fats, a low intake of animal fats (including meat and meat products, and enriched dairies) and manufactured foods rich in fat and/or simple sugars (including sweetened drinks), and moderate drinking of alcoholic beverages with meals (Hu & Willett, 2002).

Dietary fibre, an indigestible vegetable residue, is one of the most frequently studied dietary components because of its cardiovascular protective effects. We will briefly review the beneficial properties of fibre for cardiovascular health in general and in the context of its intake with nuts, a fibre-rich food.

Carbohydrates and dietary fibre

The main sources of carbohydrates in the diet are foods of plant origin: cereals, vegetables, legumes and fruit. A distinction should be made between the slowly absorbed complex carbohydrates (starch) contained in natural vegetables, often associated with indigestible polymers (dietary fibre), and the rapidly absorbed simple carbohydrates (sugars) contained in milk (lactose), fruit (fructose) and table sugar (sucrose). Simple carbohydrates would also include numerous dietary products, such as pastries, cakes and chocolates, sweets and various sweetened drinks, foods that are so often consumed in contemporary diets. The distinction between the two types of carbohydrates is an important one because, when they substitute total fat, complex carbohydrates often have beneficial effects on the lipid profile and glucose metabolism. Simple carbohydrates induce hypertriglyceridemia and hyperinsulinism, and favour the development of obesity and diabetes in

predisposed people (Reaven, 1997; Parks & Hellerstein, 2000). When the proportion of fat in the diet is reduced, the consumption of carbohydrate increases since the consumption of proteins remains relatively constant. Carbohydrate-rich diets ($\geq 60\%$ En) that contain simple sugars are associated with increased triglyceride levels, reduced HDL cholesterol and a poor metabolic control of diabetes. However, when substituting complex carbohydrates for fat in the diet, both the lipid profile and glucose control are improved, and these effects may be ascribed in part to dietary fibre (Parks & Hellerstein, 2000).

Dietary fibre, made up of indigestible carbohydrates and lignin which can be found whole in plants, is an important component of a vegetable-rich diet. Its effects on digestive physiology, lipid metabolism, glucose homeostasis and general health have raised considerable interest since 1974, when Burkitt *et al.* (1974) formulated the hypothesis that a low consumption of fibre in Western societies was one cause underlying the increased incidence of a variety of diseases linked to progress. Among these are obesity, diabetes, cholelithiasis, coronary heart disease (CHD), diverticular disease of the colon and colorectal cancer.

Types of dietary fibre

There are two types of dietary fibre, defined by their physical behaviour in water: insoluble fibre, such as cellulose, lignin and some hemicelluloses, which are abundant in wholegrain cereals (wheat bran is particularly rich in this type of fibre), and soluble fibre, such as gums, mucilages and pectins, contained specially in fresh vegetables, legumes and fruit, and the beta-glucans, present in oats, barley and some yeasts. One particular variety of soluble fibre is psyllium, a hydrophilic colloid that is found in the bark of the ispaghula husk and is used as a non-cathartic laxative, because it increases faecal

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mass, and as a cholesterol-lowering agent in patients with moderate hypercholesterolemia (Anderson *et al.* 2000). Also classifiable as soluble fibres are the non-digestible short-chain polysaccharides known as fructo-oligosaccharides or fructans, the main examples of which are inulin and oligofructose (Roberfroid & Delzenne, 1998).

Most vegetable products contain a mixture of soluble and insoluble fibre in a proportion of approximately 1:3. Table 1 shows a list of plant foods and their total fibre content (Marlett, 1992). The foods that are richest in fibre are whole cereals, followed by nuts and legumes. The fibre content of these three food products is greater than that of refined cereals, fruits and fresh vegetables. Although all food contains both soluble and insoluble fibre, oats (and particularly oat bran), barley, legumes, apples and citrus fruits contain the highest quantities of soluble fibre, while wheat bran, bread and whole-grain cereals contain greater quantities of insoluble fibre. As shown in Fig. 1, the content of total fibre in nuts is high (USDA, 1984; Holland *et al.* 1991). The nut content of soluble fibre is appreciable, although most is insoluble (Marlett, 1992). Fresh vegetables, cereals and fruits are the main sources of fibre in our diet. Bearing in mind that nuts contribute little to total caloric intake in industrialized countries, the amount of fibre they contribute to the diet is considerable (Arija *et al.* 1996).

Different plant foods have different amounts and types of fibre. Whole wheat flour, bran and vegetables are, in general, good sources of cellulose, while bran and wholegrain cereals contain sizeable amounts of hemicellulose. Lignin is mainly found in ripe vegetables, wheat and some edible seeded fruits, such as strawberries. The total lignin content of the diet is very low, approximately 1 g/d, and mainly comes from wheat and fruit, vegetables with skin, and/or edible seeds. Oats, barley and legumes (from which 'guar' is derived) are rich in gum, while apples, citrus fruits, strawberries and carrots contain appreciable amounts of pectin. There is little difference in the content of fibre of raw and cooked fruits or vegetables, although its quality and structure may vary. Nuts are particularly rich in cellulose, followed by hemicellulose, pectin and lignin (Marlett, 1992).

Metabolic effects of fibre

Because it is indigestible in the human intestine and is made up of long-chain polymers that retain water, fibre in general, and insoluble fibre in particular, reduces intestinal transit

time and increases the hydration of the faecal bolus, thus acting as a physiological laxative. The metabolic effects of fibre (reduction of blood cholesterol and postprandial glucose peaks) can be attributed solely to soluble fibre and, more specifically, to viscous fibre (Jenkins *et al.* 2000), these effects are summarized in Fig. 2. Viscosity is the ability to form gels. Because it is well-hydrated, this type of fibre can make the intestinal contents more viscous, thereby reducing the rate of absorption and spreading the nutrient load over time. Factors involved include resistance to bulk diffusion due to the increased viscosity of the luminal contents and increased resistance of the unstirred water layer that lines the absorptive surface of enterocytes. Because the distal ileum is the absorptive site for bile acids, increasing viscosity as water is progressively removed from the luminal contents will hamper bile acid absorption. This effect, together with physical binding of bile acids to the fibre, causes increased faecal bile acid loss and is the principle mechanism by which fibre may reduce serum cholesterol.

Nevertheless, the hypocholesterolemic effect of soluble fibre is modest, as the decrease in total and LDL cholesterol has been estimated to be around 0.05 mmol/l for every gram of soluble fibre added to the diet (Brown *et al.* 1999). For example, eating two apples a day contributes 2 g of pectin to the diet, which can reduce blood cholesterol by 0.10 mmol/l during the period of consumption. Likewise, the intake of 10 g psyllium a day as a supplement in people with moderate hypercholesterolemia reduces LDL cholesterol by an average of 7%, which is already an appreciable figure (Anderson *et al.* 2000).

It has been known for some time that the intake of soluble fibre, such as guar gum (obtained from legumes, such as beans) and pectin, modifies the absorption kinetics of glucose, reducing the postprandial peaks of glucose and insulin (Jenkins *et al.* 1976; Potter *et al.* 1981). Its intake at meal times, therefore, can be a useful adjunct in the treatment of diabetes (Chandalia *et al.* 2000). The reduction of blood glucose is also related to viscosity causing a delay in gastric emptying. This, together with the decreased bulk diffusion due to both intraluminal trapping and increased resistance of the unstirred water layer, results in lower postprandial glucose peaks and, consequently, decreased stimulation of insulin and other intestinal peptides (Potter *et al.* 1981; Bourdon *et al.* 1999).

Fructans have been studied as prebiotic compounds because they are the ideal substrate for the colonic fermentation of lactic bacteria and the subsequent production of short-chain fatty acids that can have numerous benefits for the host (Roberfroid, 1998). However, there is no clear evidence that the intake of tolerable amounts of this special variety of soluble fibre has any appreciable effect on the lipid profile or glucose metabolism (Ros, 2003a).

Importance of fibre in nuts for cardiovascular health

As reviewed by Sabaté & Kelly (2006) in this supplement and elsewhere (Kris-Etherton *et al.* 2001; Mukuddem-Petersen *et al.* 2005), the results of observational studies in large cohorts have consistently shown a negative and dose-dependent association between frequent nut intake and the risk for CHD or the risk for cardiovascular or total mortality.

Table 1. Fibre content of selected foods and food groups

	g/100 g
Wholegrain cereals	15–30
Nuts	5–10
Legumes	3–6
Wholemeal bread	5
Raisins	4
White bread	2–3.5
Leaf vegetables and fruit	1.5–4
Potatoes and other tubers	1–3
Vegetables	0.5–3
White rice and pasta	0.5–2

Taken from Marlett, 1992.

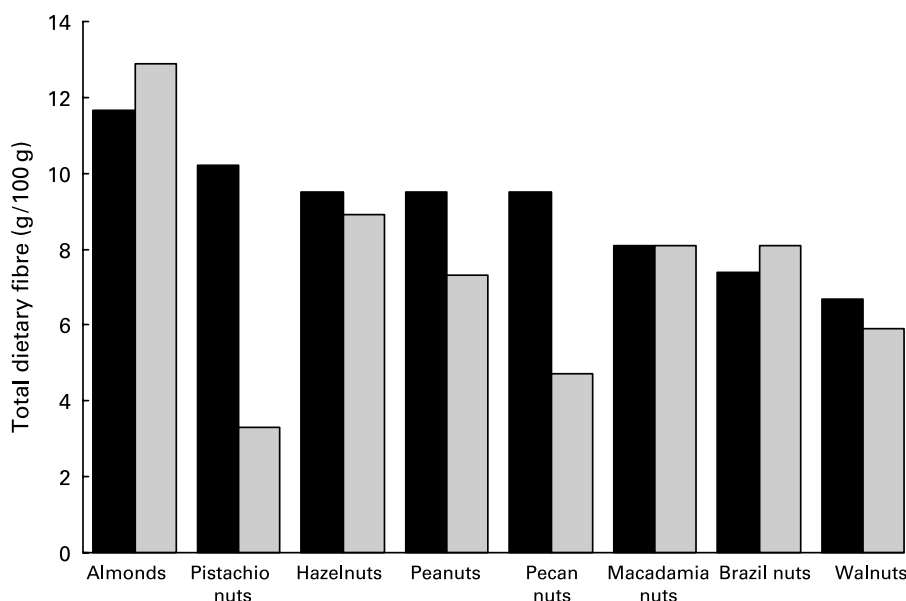


Fig. 1. Fibre content of selected nuts. ■, USDA; ■, McCANCE & WIDDOWSON'S.

The results of these studies suggests that regular nut consumption reduces the risk of cardiovascular disease by between 30 and 60 %, an effect that has been observed in several population groups and is independent of other lifestyle factors. On the other hand, as reviewed by Griel & Kris-Etherton (2006) in this supplement, clinical studies have consistently shown that regular nut intake improves the lipid profile by reducing total and LDL cholesterol in both normocholesterolaemic and hypercholesterolaemic subjects (Kris-Etherton *et al.* 2001). The cholesterol-lowering effect of nut intake is greater than that estimated from fatty acid exchange, suggesting that bioactive components other than fatty acids, such as fibre, may be involved (Kris-Etherton *et al.* 1999).

Epidemiological observations of large cohorts have provided strong evidence of an inverse relationship between the consumption of total dietary fibre and the incidence of cardiovascular diseases, particularly CHD (Lupton & Turner, 2003; Pereira *et al.* 2004). The aggregate results of eleven epidemiological studies suggest a mean decrease in

CHD risk of 17% for every 10 g fibre added to the diet (Liu *et al.* 2002). Curiously, most studies have observed a stronger association with cardiovascular protection of insoluble cereal fibre than soluble vegetable or fruit fibre. The results of these and other prospective studies on the incidence of diabetes also consistently reveal that the intake of cereal fibre (or wholegrain cereals) has a protective effect (Montonen *et al.* 2003). However, the only randomized clinical study that investigated the cardioprotective potential of dietary fibre in patients with a history of CHD failed to find any benefit (Burr *et al.* 1989). It should be pointed out, however, that in this study wheat bran, and not wholegrain cereal was administered.

Here there is a dilemma: the intake of wholegrain cereals, a source of bran (metabolically inert insoluble fibre), is associated with protection against CHD and diabetes, but there is no evidence that a similar association exists with soluble fibre despite its positive metabolic effects. The reason for this paradox probably lies in the unique composition of wholegrain foods, because plant cell walls are complex matrices containing many bioactive phytochemicals (Milner & Craig, 2000). Besides bran in the coarse outer layer and as opposed to refined cereal products, whole grains keep the inner embryo layer or germ. Both the bran and the germ are rich in minerals, vitamins, antioxidants and other compounds likely to have significant health benefits. These bioactive food components abound in both the skin and the germ of all seeds (cereals, legumes, nuts), where, among other functions, they serve to protect the plant's DNA from oxidation stress and thus preserve the potential of perpetuating the species. This probably explains why the frequent intake of all types of edible seeds (whole grains, nuts and legumes) and consumption of plant-based diets in general is consistently associated with prevention of cardiovascular diseases in observational studies (Hu, 2003).

Because all kinds of fibre are found in vegetable products, which also contain other physiologically active molecules

	Soluble (pectin, guar)	Insoluble (bran)
<i>Increased fecal bulk</i>	+/-	+
<i>Cholesterol lowering</i>		
↑ bile acid excretion	+	-
↑ unstirred water layer	+	-
↓ enterocyte diffusion	+	-
<i>Glycemic control</i>		
↓ gastric emptying	+	-
↓ glucose absorption rate	+	-
↓ postprandial insulin	+	-

Fig. 2. Mechanisms of the metabolic effects of dietary fibre.

that have beneficial effects on health, a specific advice about fibre is not as important as a recommendation to follow plant-based diets, eating a variety of vegetable products in as natural a state as possible. In the case of cereals, the habitual process of refining leads to important losses of both fibre and phytochemicals, thus consumption of wholegrain cereals should be encouraged.

The available epidemiological evidence shows that fibre in wholegrain cereals and other vegetable products commonly consumed is protective against cardiovascular diseases (Liu *et al.* 2002; Lupton & Turner, 2003; Montonen *et al.* 2003; Pereira *et al.* 2004). It is unknown, however, whether fibre in nuts also contributes a cardio protective effect. This is because most studies do not correctly identify the intake of this food group. Alternatively, nut consumption is so infrequent that it is difficult to observe differences within the population studied.

Besides the putative health benefits of phytochemicals associated with fibre intake, the protective cardiovascular effect of fibre proper can be explained in several ways. The intake of total fibre can affect satiety and reduce body weight increases over time. Soluble fibre has an additional beneficial effect on lipids and insulin sensitivity. The effects of fibre on body weight, the lipid profile and diabetes are discussed below.

Nuts, fibre and body weight

The common perception that fatty foods provide excess energy and thus promote obesity has had a negative effect on the image of nuts. However, as reviewed by Rajaram & Sabaté (2006) in this supplement and elsewhere (Garcia-Lorda *et al.* 2003; St-Onge, 2005), there is considerable scientific evidence strongly suggesting that frequent nut intake is not associated with weight gain. First, there are epidemiological studies showing a neutral or even negative association between nut intake and BMI. Second, interventional trials in free-living individuals have shown no weight gain or a tendency to lose weight in those assigned to nut diets compared with control diets. Finally, the addition of nuts to low-calorie diets for weight loss results in superior long-term participation and adherence, with consequent improvements in weight loss. Explanations for the lack of a weight-promoting effect of nut intake range from an increased thermogenic effect to increased satiation or incomplete intestinal absorption (Burr *et al.* 1989; Garcia-Lorda *et al.* 2003). The latter two effects may be due largely to their high fibre content.

In fact, there is considerable epidemiological evidence that associates the intake of fibre with the regulation of body weight. Obesity is rare in developing countries where large quantities of fibre are consumed. In developed countries, however, where the prevalence of obesity is increasing alarmingly, the trend is to consume less and less complex carbohydrates and fibre. Moreover, vegetarian populations have a lower prevalence of obesity, which suggests that their high fibre intake could play an important role in the prevention of obesity (Newby *et al.* 2005). Cross-sectional studies show that the intake of both total fibre and soluble fibre is negatively related to total fat intake, body fat content, and BMI, after adjustment for confounding variables. Thus, obese subjects typically

consume less fibre than normal weight subjects (Alfieri *et al.* 1995). Data from a recent cross-sectional study in adolescents also suggest that the intake of wholegrain cereals is associated with a lower BMI (Steffen *et al.* 2003). In a 10-year prospective study in young adults, fibre intake was associated with lower weight increases and a lower risk of developing obesity after adjusting for the possible confounding effect of fat intake (Ludwig *et al.* 1999).

Fibre can affect energy balance and, as a result, body weight through a variety of mechanisms that lead to both decreased energy intake and increased energy losses. It has been shown that the intake of sufficient amounts of fibre reduces the sensation of hunger. In fact, the presence of fibre in the diet effectively decreases its energy density, and short-term studies show that a lower energy density increases satiety and decreases intake (Bell & Rolls, 2001). Additionally, high-fibre foods require greater mastication, which can contribute to the feeling of satiety because the speed of intake is reduced. Likewise, the intake of viscous fibre or foods that are rich in this sort of fibre forms a gel that increases gastric distension and reduces the rate at which the stomach is emptied. This mechanism has been proposed as an explanation for the sensation of fullness and increase in satiety after viscous fibre intake (Jenkins *et al.* 2000). In turn, soluble fibre decreases the postprandial secretion of insulin (Potter *et al.* 1981), which may contribute to satiety.

Soluble fibre can also delay or reduce the intestinal digestion and absorption of macronutrients, thus increasing faecal energy losses. In fact, there is a negative relationship between fibre intake and the digestibility of fats and proteins (Howarth *et al.* 2001). Finally, fibre may also affect the energy balance through its effects on release of intestinal hormones, such as Glucagon-Like Peptide 1, which favours satiety and weight loss, although the mechanisms are only theoretical (Bourdon *et al.* 1999).

Several intervention studies have been carried out in an attempt to evaluate how enriching the diet with fibre affects body weight. According to a recent review (Howarth *et al.* 2001), most studies show a decrease in energy intake in response to the consumption of soluble and insoluble fibre supplements (between 6 and 40 g/d, depending on the studies). The lower energy intake associated with the consumption of fibre leads to a modest reduction in body weight. In this respect, most studies show that high fibre diets (between 5–30 g/d) lead to weight loss, either within the context of *ad libitum* (Walsh *et al.* 1984) or energy controlled diets (Ryttig *et al.* 1989). This extensive review (Howarth *et al.* 2001) concludes that the intake of approximately 12 g fibre per day for 4 months in an *ad libitum* diet is associated with a decrease of 10% in energy consumption and a weight loss of approximately 2 kg. These changes are even more favourable in obese patients. A daily portion of 50 g nuts adds 3–8 g of fibre to the diet (Fig. 1) and may thus have a beneficial effect on adiposity.

It should be pointed out that some of the studies analyzed were neither randomized nor controlled, were short- or medium-term, or had few participants. Thus it is difficult to draw firm conclusions and the results should be interpreted with caution. What is more, on very few occasions has the degree of adherence to long-term fibre supplement intake been evaluated correctly, although it does not seem to be

very high because of the unpalatable physical characteristics of the various types of fibre.

Nuts, fibre and insulin sensitivity

It has been suggested that nuts may improve insulin sensitivity, partly because of their content in fibre and other micro-nutrients. As Rajaram & Sabaté (2006) review in this supplement, preliminary evidence from epidemiological studies suggests that frequent nut intake might protect from the development of diabetes. Likewise, feeding trials in diabetic subjects suggest that almonds have a beneficial effect on insulin sensitivity. This may be due in part to the fact that nuts contain mainly unsaturated fatty acids, which have been related to a lower risk of developing diabetes (Meyer *et al.* 2001) and better glycemic control in diabetic patients (Ros, 2003*b*). However, an important role is probably played by the high content of fibre and magnesium in nuts, as both nutrients have been associated with a lower risk of developing diabetes (Liu *et al.* 2002; Lopez-Ridaura *et al.* 2004). The recent report of an inverse association between nut intake and clinical gallstone disease (Tsai *et al.* 2004) could also be explained in part by improved insulin sensitivity.

One of the principal goals of medical nutrition therapy for diabetic subjects is to attain and maintain optimal metabolic control of blood glucose, both in the fasting and postprandial state. Among the medical nutrition strategies that lessen postprandial glucose peaks in diabetic subjects are diets that are high in fibre and foods that have a low glycemic index (Wolever *et al.* 1992), which possibly act by slowing down the absorption of carbohydrates (Jenkins *et al.* 2000). Population studies have shown that these kind of high-fibre diets may play a protective role in the prevention of type-2 diabetes (Salmeron *et al.* 1997; Montonen *et al.* 2003) and cardiovascular diseases (Rimm *et al.* 1996). Diets that are high in complex carbohydrates and fibre are associated with greater insulin sensitivity and a reduction in plasma insulin levels. It has also been observed that high-fibre diets contribute to a better metabolic control in diabetic subjects (Chandalia *et al.* 2000).

However, in clinical studies it appears that only the viscous variety of soluble fibre plays a significant role in reducing postprandial glycemia (Würsch & Pi-Sunyer, 1997) and improving other cardiovascular risk factors (Brown *et al.* 1999). At any rate, there is no direct evidence showing that the intake of fibre from nuts improves insulin sensitivity or the metabolic control of diabetes.

Nuts, fibre and lipid metabolism

At present, it is clear that dietary factors influence cardiovascular risk largely because of the effect they have on blood cholesterol. Diets that are low in saturated fatty acids and cholesterol and weight loss in obese subjects are the most important dietary-nutritional factors showing a beneficial effect on the lipid profile.

As far as dietary fibre is concerned, numerous observational studies have shown an inverse relation between total fibre intake and cardiovascular and total mortality (Lupton & Turner, 2003; Pereira *et al.* 2004). Also, comparative studies between vegetarians and non-vegetarians have shown lower cholesterol levels and mortality rates due to cardiovascular

diseases in the former, although it has not been possible to determine whether this is due to the fact that vegetarians consume greater amounts of dietary fibre or is simply a reflection of a greater intake of complex carbohydrates and a lower intake of saturated fatty acids (Sacks *et al.* 1975).

As discussed, soluble fibre has a salutary effect on lipid metabolism because it increases intestinal viscosity, therefore reducing bile acid absorption and promoting cholesterol catabolism. In particular, a high fibre intake is associated with a decrease in the serum concentrations of total and LDL cholesterol (Jenkins *et al.* 1993; Brown *et al.* 1999) and, at the same time, with a lower incidence of coronary disease (Bingham *et al.* 2003). On the basis of this level of evidence, physicians tend to use high-fibre diets and fibre supplements to decrease blood cholesterol and prevent cardiovascular diseases. Because of their high content in fibre and other healthy compounds, nuts are ideal for this purpose. A recent study in hypercholesterolemic subjects shows how a diet that contains a variety of healthy vegetable foods, including nuts and viscous fibre supplements, can have a notable hypocholesterolemic effect, similar to that of medium doses of statins, the powerful hypolipidemic drugs used for treating hypercholesterolemia (Jenkins *et al.* 2003). Indeed, part of the decrease in blood cholesterol and cardiovascular risk associated with nut intake may be ascribed to their high fibre content (Kris-Etherton *et al.* 2001).

Current fibre intake and recommendations

The consumption of fibre in developed countries has progressively decreased in recent decades. In general, a Western-type diet provides a low fibre intake, largely because of the customary refining of cereals used in bread-making and the production of so many starch-rich foods. Decreased fibre intake in developed countries is also due to the reduction in recent decades of the consumption of bread, potatoes and legumes, which has not been compensated for by an increase in the consumption of fruit and vegetables.

Nutritional data from the European Prospective Investigation into Cancer and Nutrition (EPIC), obtained between 1992 and 1998 in eight large European cohorts, show a mean fibre intake of 23 g/d in men and 21.5 g/d in women, with the highest intakes in Spanish men and women and the lowest intakes in British men and Swedish women (Bingham *et al.* 2003). Slightly lower fibre intakes were observed by our group in a longitudinal study of food and nutrient intake carried out in a Spanish Mediterranean population between 1983 and 1993 (Arija *et al.* 1996). In this 10-year period, fibre intake increased by 6.2% in men (from 21.8 to 22.3 g) and by 13.7% in women (from 17.5 to 19.9 g). It should be pointed out that increased fibre intake was observed in adults, but not in adolescents (Arija *et al.* 1996).

Current recommendations on fibre intake necessary to maintain good health, proposed by the US Dietary Reference Intake (Food and Nutrition Board, 2002), are 38 g/d for men and 25 g/d for women (adults below age 50 years). These figures are compatible with recent recommendations from various scientific societies, which propose amounts of 25 and 35 g/d (between 10 and 13 g per 1000 kcal). Therefore, a 2000 kcal-diet should contain approximately 25 g of fibre per day, and a diet of 2500 kcal, approximately 30 g. The recommended

insoluble/soluble fibre ratio when the diet is varied and contains wholegrain cereals, nuts, legumes, fruit and other vegetables is the ratio of 3:1 contained in most edible plants.

Conclusion

Dietary fibre consists of indigestible carbohydrates and lignin, which are intrinsic to plants and can be found whole in them. Fibre is an important component of a plant-based diet, because there is considerable epidemiological evidence to suggest an inverse relationship between the intake of fibre in the habitual diet and cardiovascular risk. This evidence is consistent, powerful and plausible, be it because fibre protects *per se* or because it is a marker of a healthy dietary pattern. Edible plants mainly contain insoluble fibre, which has no metabolic effects; the minority component, soluble fibre and, particularly, viscous fibre, gelifies intestinal contents, thereby delaying the absorption of glucose and bile acids, and has beneficial effects on the lipid profile and glucose metabolism. However, fibre intake seems to protect against cardiovascular diseases and diabetes independently of the type of fibre and its metabolic effects. This is probably due to the fact that fibre of any sort is associated with the consumption of a wide variety of vegetable products which, as well as fibre, contain numerous bioactive compounds (i.e. antioxidants) with various beneficial effects on health. The vegetables that contain most fibre are wholegrain cereals, followed by nuts. Therefore, to comply with the present recommendations for daily fibre intake and maintain a good cardiovascular and general health, frequent nut consumption is advisable.

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