JOURNAL OF MEDICINAL FOOD
*J Med Food* 14 (9) 2011, 877–883

DOI: 10.1089/jmf.2010.0215



# A Review of Dietary Fiber and Health: Focus on Raisins

Stacey J. Bell

*Boston, Massachusetts, USA.*

ABSTRACT Fibers vary in their physiologic effects. For example, viscous fibers may delay gastric emptying of ingested foods into the small intestine, creating a sensation of fullness; reduce blood glucose concentrations; and potentially benefit insulin sensitivity. They also improve blood cholesterol levels. Insoluble fibers are poorly absorbed and are known to improve fecal bulk and laxation and ameliorate constipation. Despite these numerous benefits, most Americans do not get enough of either kind of fiber in the diet. Some have argued that fiber-rich foods are not appetizing and therefore avoided. Raisins contain both forms of fiber and have a sweet flavor. This review provides support for consuming adequate fiber in the diet and suggests a role for raisins to help increase total dietary fiber.

**KEY WORDS:** • ***dietary fiber*** • ***fiber and gastrointestinal disease*** • ***fiber and type 2 diabetes*** • ***fiber and weight loss*** • ***raisins***

## INTRODUCTION

DIETARY FIBERS CONTRIBUTE ALMOST no energy and have numerous healthy benefits, yet Americans consume about half of the recommended amounts.[1] Males need 38 g of dietary fiber a day and consume around 17 g; women need 25 g of fiber and get only about 13 g. Why this paradox exists in unknown, but certainly the most commonly consumed foods must be low in dietary fiber. This review defines different types of fiber and presents an overview of some of the key studies showing the relationship between fiber intake and disease risk reduction. An argument is made for consuming raisins, which are rich in fiber and may help reduce selected disease risk.

## DEFINITIONS

Dietary fibers are highly complex substances that can be described as any nondigestible carbohydrates and lignans not degraded in the upper gut.[2,3] Fibers are usually classified according to their solubility in water. However, physiologically more relevant are viscosity, gel-forming capabilities, or fermentation by gut microbes. Soluble fibers (*e.g.*, pectin, inulin) tend to have higher fermentation rates than cereal fibers (*e.g.*, cellulose and hemicelluloses), which have less fermentation. Whole grains contain about 12% insoluble fiber, while bran has 25% dietary fiber, mostly insoluble. Main sources of soluble fiber are fruits and vegetables, and to a smaller extent oat and barley, which are rich in both forms. Most naturally available high-fiber foods contain both soluble and insoluble fibers but in varying ratios.

Old thinking was that all soluble fibers reduced serum cholesterol concentrations and all insoluble fibers increased laxation.[2] The numerous studies in this field are inconsistent with this belief. However, health benefits of consuming a high-fiber diet are plentiful. The fibers that are typically highlighted as being of important for overall health were those from whole grains, legumes, and fruits and vegetables. Foods that contain these fibers are typically nutrient-dense and have a low energy density.

## DISEASE RISK REDUCTION

Most of the nutritional literature on fiber intake and disease risk reduction is related to weight loss, cardiovascular disease (CVD), gastrointestinal diseases, diabetes, and cancer.

### *Obesity/weight loss*

Fiber-rich foods can facilitate body weight loss through different physiologic mechanisms.[4] First, fiber-rich foods tend to be more satiating because of their relatively low energy density and palatability compared with low-fiber foods. Second, dietary fiber, especially soluble fiber, may increase the viscosity of meals and slow down digestion, which stimulates the release of gut hormones such as cholecystokinin and glucagon-like peptide 1, thereby promoting satiety. Third, dietary fiber may provide a barrier to the enzymatic digestion of other macronutrients, such as fat and starch, in the small bowel. Slower digestion and absorption rate of carbohydrate could lead to a reduction in postprandial blood glucose response, which over the long term will

Manuscript received 18 August 2010. Revision accepted 13 October 2010.

*Address correspondence to: Stacey J. Bell, 1 Huntington Avenue, Boston, MA 02116, USA, E-mail:* staceyjbell@yahoo.com

favor an improvement in insulin sensitivity and increased fat oxidation. These actions should help maintain a healthy body weight, promote weight loss, and prevent weight gain.

Epidemiologic data have shown an inverse relationship between dietary fiber and body weight.[2] Thus, it seems plausible that for successful weight loss to occur, the energy-restricted diet must at least contain the recommended amount of dietary fiber. Many Americans use popular diets to lose weight, but until recently, the dietary fiber contribution of those diets has been unknown. Perhaps somewhat surprising, of the popular diets reviewed, only the Atkins diet has failed to meet the dietary fiber recommendations, by supplying only 20 g of dietary fiber per day.[5] In contrast, both the Mediterranean and South Beach diets supply 28 g of fiber per day. Even higher daily fiber amounts are provided with the Zone diet (52 g) and Ornish diet (67 g). In terms of dietary fiber, these popular weight-loss diets appear to be adequate. However, these diets have other pitfalls unrelated to fiber (*e.g.*, they provided excesses or were short on other macronutrient recommendations), so the study authors have not endorsed any of them.

To determine the full effect of fiber from whole grains and fruits and vegetables on body weight, a large (90,000 individuals) study has been conducted in healthy 20- to 78-year-olds.[4] The participants are from 5 different European countries and were followed for more than 6 years, during which time dietary intake information was assessed. Total dietary and cereal fiber intake is significantly and inversely related to subsequent weight ($P < .01$) and waist circumference ($P < .001$) change. Fruit and vegetable fiber is related only to changes in waist circumference. By increasing total dietary fiber intake from grains, fruits, and vegetables by 10 g per day, about 10% of the weight gained during that 6-year period would have been prevented. Because these participants are consuming only about 23 g of total fiber per day, an increase in 10 g per day would get them closer to the recommended goal.

Following a high-fiber diet may prove too burdensome for some individuals, but simply eating one bowl of a grain-based breakfast cereal (whole-grain and refined) each day has been shown to reduce the risk for CVD in men age 40–84 years.[6] During this 13-year study, consuming 1 or more breakfast cereal servings is inversely associated with a 22% (after 8 years) and 12% (after 13 years) less chance of becoming overweight. In this study,[6] no extra benefit in weight loss has been achieved from whole grains over refined ones. On the other hand, others have been able to show that whole-grain consumption from a variety of foods beyond breakfast cereals is associated with lower total percentage body fat and percentage trunk fat mass in older adults age 60–80 years.[7] Fruit and vegetable fiber intake do not affect body composition changes in this study.

Children and teens (age 11–17 years) seem to benefit from increasing dietary fiber from all food sources.[8] The diet consumed in this cohort is already poor in dietary fiber, containing about 9 g per day. This dietary fiber is supplied by fruit and whole-grain (1 serving per day for each) and 2 servings a day for vegetables. Over 2 years, participants who reduced dietary fiber intake by 3 g/1,000 kcal (they were eating about 1,800 kcal/d) have a 21% increase in visceral adiposity. The converse is true; increasing dietary fiber intake by about 5 g per day from any source reduces visceral adipose tissue. This change occurs rapidly—over 16 weeks. Thus, children and teens who modestly increase the intake of any type of fiber appear to experience reductions in abdominal fat.

Fruit and vegetable intake has been shown to predict weight loss in overweight adults.[9] Middle-aged Brazilian participants (average age, 46 years) were instructed to follow a healthy diet, increase walking to 30 minutes a day, and visit with a nutritionist 3 times over 6 months. Participants have lost 1.4 kg of body weight ($P < .05$) and increased consumption of fruits and vegetables ($P < .05$). These are significant predictors of weight loss. For each 100 g per day (about a half-cup) increase in fruit, 300 g of weight is lost ($P < .009$). For each increase in vegetable serving of the same size per day, another 500 g of weight can be lost ($P < .003$). The extra fiber contained in these foods may have accounted for the targeted increase in weight loss.

In sum, fiber intake from whole grains, fruits, and vegetables has been shown to promote weight loss and, in some cases, loss of abdominal fat. Many individuals who are overweight or obese consume about half the amount of fiber recommended. To achieve weight loss and meet the daily fiber intake goal requires consuming an additional 5–10 g of fiber from any food source each day. This amount of fiber is found in 1 cup of raisins, a half-cup of bran cereal, 1 cup of baked beans, or 1 cup of winter squash.[10] Losing weight is difficult, but adding 1 of these foods each day may help promote weight loss without necessitating other dietary changes.

### *CVD*

Soluble fiber probably decreases the risk for CVD through cholesterol reduction from increases in bile acid excretion and decreases in hepatic synthesis of cholesterol.[11] In addition, fiber slows digestion of macronutrients, leading to increases in insulin sensitivity, lowering of plasminogen activator inhibitor type 1 and factor VII coagulation activity, and increases in satiety, leading to weight loss. Serum cholesterol reduction attributable to soluble fiber intake may range from 0.5% to 2% per gram of intake. Because a 1% decrease in cholesterol level decreases the risk for CVD by 2%, then a 10-g increase in cereal fiber should decrease the risk by 2.5%–10%. It is possible that obtaining fiber mainly from fruits and vegetables should be the optimal way to obtain soluble fiber because they are also rich in cardioprotective antioxidants. However, one review has revealed only a weak benefit of fruits and vegetables on CVD protection but strong protection against stroke risk.[12]

A major study in 1996 has found that fiber, independent of fat intake, is an important dietary component for the prevention of coronary disease.[11] More than 43,000 men without CVD were followed for 6 years. The risk of developing CVD was 41% higher for men who ate about 12 g

of fiber per day than for those who regularly consumed 29 g a day. Specifically, consuming an additional 10 g of total dietary fiber per day reduces the risk for a myocardial infarction by 29%. Total fiber intake is important, but cereal fiber (75% insoluble) is a stronger predictor of risk compared with fruit and vegetables. As such, insoluble fiber is significantly predictive of risk (25% risk reduction), but soluble fiber intake is not (7% increase in risk). However, increasing intake of fruits and vegetables is still important. Compared with eating fewer than 3 servings of fruits and vegetable a day, those who eat 5–7 servings have a 22% reduced risk for having a myocardial infarction.

Later, a study that included men (>91,000) and women (>245,000) has shown that consumption of fiber from cereals and fruits is inversely associated with the risk for coronary heart disease.[13] Participants were living in the United States and Europe and were followed for 6–10 years. Coronary mortality decreased 27% for every 10-g per day incremental increase of total dietary fiber consumed. Coronary events with the same increase in dietary fiber decreased by 14%. Fiber from cereals and fruit has the strongest effects; vegetable fibers are not significant predictors of death or coronary events.

The benefits of fiber intake among French adults has been shown to mirror those seen in the United States and other European countries.[14] This study carefully assessed the type of fiber consumed. Dietary records from over 6,000 adults have revealed that high intakes of insoluble fiber and total dietary fiber are significantly predictive of many CVD risk factors ($P < .05$). These include blood pressure, selected blood lipids (*e.g.*, apolipoprotein [apo] B, total cholesterol), homocysteine concentrations, body mass index, and waist-to-hip ratio. Soluble fibers have less effect. Specifically, fiber from cereals is inversely associated with body mass index, blood pressure, and homocysteine levels. Vegetable fiber is inversely related to blood pressure and homocysteine concentrations. Dried fruits (including raisins) and nuts or seeds are inversely associated with body mass index, waist-to-hip ratio, fasting apo B, and glucose concentrations. Just by increasing total dietary fiber intake to at least 25 g per day will afford many of these benefits. Thus, it appears that fibers from different sources have different effects on improving CVD health.

Others[15,16] found that fiber intake has also been predictive of all-cause mortality and CVD mortality. As part of the Zutphen Study, 1373 men were followed repeatedly between 1960 and 2000.[15] For every additional 10-g of dietary fiber consumed per day, coronary heart disease mortality was reduced by 17% and all-cause mortality by 9%. The effect decreased with increasing age, starting around age 50 years. The fibers that contributed to the 10-g am increase included fruits, vegetables, legumes, potatoes, and bread and other cereals. These are commonly consumed foods in Europe and the United States, so increasing total dietary fiber should be relatively easy. Others have shown that whole-grain predicts risk for CVD death ($P < .04$).[16] Going from eating less than one-third serving per day of whole grains to eating 3 servings a day reduces risk for death by 52%. Whole-grain intake does not affect all-cause mortality, as others have shown.[15] Nevertheless, it seems prudent to at least include 3 servings of whole grain for cardiovascular health and reduce the risk for CVD death. However, that would require too big a change in typical dietary patterns; instead, adding an additional 10 g a day from a variety of foods seems preferable.

A newer marker identified as predictive of CVD is C-reactive protein (CRP), which is released upon acute inflammation. Dietary fiber has been shown to be protective of high CRP levels in 500 participants (20–70 years of age).[17] The CRP level was 63% lower in the group with the highest daily total dietary fiber intake (22 g) than the group with the lowest (10 g). Both soluble and insoluble fibers are effective at reducing CRP concentration, which supports current dietary recommendations. Moreover, fruits and vegetables, besides being rich in fiber, also have high antioxidant capacities.[18] Diets that have a high total dietary antioxidant capacity have been shown to be associated with lower CRPs compared with diets with a low antioxidant capacity. Thus, fruits and vegetables may provide a dual role in reducing CRP because they are rich in fiber and antioxidants.

In sum, CVD risk is inversely related to total dietary fiber intake, and it appears that both forms of fiber—soluble and insoluble—offer benefit. Small changes (10 g) in dietary fiber intake per day from commonly consumed foods make significant differences in risk for CVD mortality and all-cause mortality.

### *Type 2 diabetes*

A high dietary fiber intake is recommended for patients with type 2 diabetes. It is accepted that viscous and gel-forming properties of soluble fiber inhibit macronutrient absorption, reduce postprandial glucose response, and benefit important blood lipid concentrations.[3] However, prospective cohort studies have shown that insoluble cereal fiber and whole grains are consistently associated with a reduced risk for diabetes.[19,20] In a study of over 20,000 adults age 35–65 years (prospective study) and 9 cohort studies on fiber, higher cereal fiber intake has been shown to reduce the risk for type 2 diabetes by 28%.[19] Fruit and vegetable intake are not related to disease risk in this study.

Of note, patients who already developed type 2 diabetes also benefitted from consuming a diet rich in fibers, particularly those from whole grains, bran, and cereal fibers.[20] Patients in the highest quintile for whole grain and bran intake had the lowest CRP and tumor necrosis factor-α receptor 2 concentrations. These are inflammatory markers related to diabetes and CVD risk. A later report in over 10,000 patients with diabetes has shown that increasing legume, fruit, and vegetable intake by just 80 g a day (less than a half-cup) could reduce the risk for death from any cause by 6%.[21] The association between CVD death and these foods is also significant. The lowest risk for death in these patients has been found in those who regularly consume 6 servings per day (about a half-cup each); the group at the highest risk regularly consumes half that amount.

In addition, insoluble fiber appears to have an important role in reducing diabetes risk. Other unknown mechanisms probably exist, such as increasing insulin sensitivity. Soluble fiber from fruits and vegetables seems to be of more benefit once diabetes has already developed.[3,21] However, a high-fiber diet containing both forms seems important because of these shared benefits of having low energy densities, promoting weight loss, increasing satiety, and reducing CVD risk.

### *Cancer*

Diet quality, in particular fiber consumption, may influence cancer risk or survival from it. For breast cancer in postmenopausal women, it is postulated that dietary fiber intake may reduce estrogen levels through interference from fiber on enterohepatic metabolism.[22] High levels of endogenous/exogenous steroid hormones may play a critical role in the development of postmenopausal breast cancer. Proposed mechanisms of fiber on reducing breast cancer risk include increasing fecal excretion of estrogens, inhibition of intestinal reabsorption of estrogens by suppressing bacterial $\beta$-glucuronidase activity, or binding unconjugated estrogens to fiber in the colon. Thus, fiber intake may be associated with a decreased risk for breast cancer through the reduction of circulating estrogen levels. However, in a Swedish study of over 51,000 postmenopausal women, after 8 years no significant relationship has been observed between total fiber intake and breast tumor risk.[22] A subset of women who had previously used estrogen replacement therapy have a reduced cancer risk of 50% between the highest quintile of fiber intake and the lowest. Fibers from cereals are especially important. Just taking into account fruit fiber, the authors found that it has been associated with a 34% overall risk reduction.[22]

Small changes in fiber intake afforded these benefits.[22] Women in this study who consume less than 18.5 g of total dietary fiber per day are at highest risk for breast cancer compared with those who consume more than 26.6 g. From these data in postmenopausal women, it seems prudent to increase the daily fiber intake, of which about 8 g should come from fruit fiber. However, another European study has shown no effect of fruit intake on breast cancer risk.[23] This was a large, prospective study of nearly 300,000 women between the ages of 25 and 70 years. It may be that fruit and fruit fiber are more important for reducing breast cancer risk in older women (*i.e.*, postmenopausal) and that a younger cohort does not experience the same benefit.

The relationship between dietary fiber intake and colon cancer risk is inconclusive. As part of a larger study (Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial), a subset of nearly 30,000 participants age 55–74 years have been assessed for risk on the basis of fiber intake.[24] A higher intake of fruit (about 5.7 servings vs. about 1.2 servings per day) was significantly ($P < .001$) associated with a 25% lower risk of developing a colorectal adenoma, which is a precursor of colorectal cancer. This finding was independent of total fiber or folate intake, and when the location of the tumor was identified, only tumors in the colon, and not the rectum, were related to fruit intake. Total vegetable intake was not significant, but certain vegetables appear to be protective (*e.g.*, deep-yellow and dark-green vegetables and onions). Because colorectal carcinoma probably takes a decade before it evolves from a colorectal adenoma, getting dietary fiber from fruits may be protective if they are consumed over a lifetime.

However, others[25] have found that men may experience more benefit from dietary fiber than women to reduce colon cancer risk. This conclusion has been based on 2 intervention studies: the Wheat Bran Fiber trial, in which participants were randomly assigned to consume extra fiber cereal for 3 years, and the Polyp Prevention Trial, in which participants were randomly assigned to an intervention diet that had decreased fat and increased fiber, fruit, and vegetables. From a sample of over 3,000 individuals, men had a 19% reduced risk for adenoma recurrence in the higher fiber groups of both studies, whereas women did not experience a risk reduction. The discrepancy has not been totally elucidated; however, it may be due to poor dietary adherence.[26] When the data in the Polyp Prevention Trial are examined more closely, it appears that some participants assigned to the intervention group did not adhere to the dietary regimen. When the risk for adenoma recurrence was assessed in a subset of participants with excellent adherence ($n = 210$), a 35% reduction in risk was seen compared with controls. This group met or exceeded their dietary goals and attended all annual visits. This finding suggests that fiber intake coupled with a low-fat diet reduces the risk for colon cancer by reducing adenoma recurrence.

Unlike relationships seen between dietary fiber intake and breast and colon cancer, no such relationship has been observed in reducing prostate cancer risk.[27] In an 8-year study in over 140,000 men from 10 European countries, total fiber intake from cereals, fruits, or vegetables has not been significantly shown to predict who would develop prostate cancer.

### *Noncancer bowel disease*

Dietary fiber intake is related to noncancer diseases of the gastrointestinal tract.[28,29] Total dietary fiber intake is inversely associated with the risk for symptomatic diverticular disease in men eating the most fiber compared with those who ate the least over 4 years.[28] The risk reduction was 42% between those eating 32 g of total dietary fiber and those eating 18 g a day. Fruit and vegetable fibers were significant predictors of disease risk, while cereal fiber was not. Small changes in dietary intakes from these foods have been shown to be important. The difference in fiber between the highest and lowest quintile for fruit fiber was 5–6 g, and for vegetable fibers, the difference was about 7 g. These amounts can readily be achieved with 2–3 servings of these foods daily.[10] Fiber from fruits and vegetables, unlike cereal grains (mainly bran), may be helpful in diverticular disease because the fibers increase fecal output by stimulating microbial growth. As a result, dietary fiber from fruits and

vegetables is degraded to short-chain fatty acids and other products, such as methane, hydrogen, and carbon dioxide. Luminal short-chain fatty acids are recognized now as an important fuel source for the colon, particularly the distal colon, which is the most common site for diverticular disease.

Fermentable fibers, such as those found in fruits and vegetables, are also in psyllium.[29] This supplement (10 g of psyllium per day) has been shown to be of great benefit to patients ($n = 275$ participants age 18–65 years) with irritable bowel syndrome; another group was randomly assigned to bran (insoluble fiber). After 3 months, the severity of symptoms was significantly reduced in the psyllium group. The bran group did not have a clinical benefit, and many patients seemed not to tolerate the bran and dropped out of the study early. These study results suggest that including generous amounts of fruits and vegetables—also rich in soluble fiber—would be of benefit to patients with irritable bowel syndrome.

## RAISINS

Raisins contain fiber and therefore may be a welcome addition to a diet that is lacking in fiber. One serving (a small box weighing around 40 g) contains 2 g of fiber, of which 30% is soluble fiber. The rest is insoluble fiber. Unlike vegetables and some fruits, raisins have a sweet flavor and are well-liked. In addition, they are portable and do not require refrigeration.

Raisins can serve as additional dietary fiber and mitigate health risks associated with the lack of fiber in the diet, such as CVD and diseases of the bowel.[11–15,22–25,28,29] Twelve hyperlipidemic women consumed a diet rich in whole foods, such as raisins (126 g found in 3 small boxes) and other phytonutrient-rich, unrefined foods (*e.g.*, other fruits, wheat germ, nuts, green tea), for 4 weeks.[30] During a second 4-week period, they consumed a highly refined diet, low in nutrient density. The nutrient-rich diet beneficially affected lipoproteins, decreased the need for oxidative defense mechanisms (*i.e.*, reduced erythrocyte superoxide dismutase by 69% and glutathione peroxidase by 35%; $P < .01$), and improved colonic function. These findings show that raisins coupled with other healthy foods can improve blood lipids even in patients with hyperlipidemia, along with improving bowel function.

### *CVD*

Raisins may protect against CVD because of their fiber content. The fiber in raisins is part of a family of fibers called fructans, also known as fructooligosaccharides (FOS). Compounds in this group include inulin, which can be of benefit to reduce CVD risk. However, in measuring the fiber content of raisins by the official American Association of Cereal Chemists (AOAC), fibers like inulin are not recovered or counted as total dietary fiber. Thus, the true beneficial effects of raisins based on inulin plus other fibers may not be fully appreciated.[31] By adding fructans (inulin) to total fiber values for raisins, the fiber content nearly doubles, going from 5.5 g per 100 raisins, to 9 g per 100 g.

The fiber composition, including the soluble portion containing inulin, of 3 types of raisins was assessed.[31] These included sun-dried (natural), artificially dried (dipped), and sulfur dioxide–treated (golden). No differences have been seen among the 3 types of raisins for soluble or total dietary fiber content. Each type of raisin contains fructans, in contrast to grapes, which have almost none. All the raisins have been shown to bind to different bile acids in an *in vitro* model because of its potential benefit for lowering serum total cholesterol levels. Wheat bran bound significantly fewer ($P < .05$) bile acids tested compared with any of the raisin types.

When the raisins are coarsely chopped, more bile can be bound than for raisins that are finely chopped or for whole raisins.[31] The skin of the whole raisin may be a barrier to bile acid binding, but because raisins are presented to the gastrointestinal track coarsely chewed, optimal binding should occur. The findings suggest that raisins may be more cardioprotective than originally thought because (1) the true fiber content of raisins may be twice what is actually on a nutrition label since inulin is not included and (2) chewing renders raisins more available to be bound to bile acids, leading to lowering of blood cholesterol levels.

### *Bowel health*

Dietary fiber can improve intestinal function by modulating transit time, fecal weight, and fecal bile acid composition.[32] Decreased transit time and increased fecal water contribute to easier elimination and dilution of fecal carcinogens. Fecal acid composition decreases with an increase in dietary fiber intake, which may reduce colon cancer risk. Sixteen healthy volunteers age 43–80 years had different raisin intakes, which changed every 2 weeks. During the first phase, no raisins or dried fruits were allowed; in phase 2, the participants consumed 84 g of raisins (about 2 small boxes); in phase 3, they consumed 126 g of raisins; and in phase 4, they consumed 168 g of raisins. Measurements were made on fecal samples by using radiopaque pellets on the first day of a 4-day collection period.

Increasing the weight of the raisins that are consumed results in an increase in fecal weight and a decrease in transit time, but these changes are not significant.[32] Fecal bile acid concentration and excretion were significantly reduced when 84 g of raisins per day was consumed ($P < .005$) but not with any other amount of raisins. The decrease in fecal bile acids was mainly due to major decreases in lithocholic ($P < .02$) and deoxycholic ($P < .002$) acid. At the 84-g consumption level, transit was decreased to less than 2 days (change, −19%), compared with 54 hours during the no-raisin phase. Phase 3 (126 g of raisins) increased fecal weight by 18%; phase 4 (168 g of raisins) increased fecal weight by 20% and caused a decrease in transit time of 22% (42 hours).

This study showed that a small intake of raisins (2 small boxes, or 84 g) can reduce intestinal transit time to a meaningful

amount ( < 2 days).[32] Small changes in the diet such as this can lead to clinically significant reductions in risk for bowel disease. Because fecal bile acids are also reduced with this amount of raisins, consuming 84 g of raisins a day could play a role in reducing colon cancer risk as well.

In addition to fiber, raisins contain a large amount of tartaric acid. This compound bypasses the small intestine and is fermented by colonic bacteria, which use it for production of short-chain fatty acids (SCFA).[33] The SCFAs increase fecal acid, which is seen in higher amounts in populations with low rates of colon cancer. After a 3-week period in which no grapes or raisins were consumed, 13 healthy volunteers were randomly assigned to consume 120 g of raisins or 5 g of tartaric acid as cream of tartar (the equivalent amount in the raisin portion). At the end of each session, the participants were crossed over to the other intervention. Participants reported that for both treatments, stools were softer and easier to eliminate. For the raisin group, but not the tartaric acid group, intestinal transit time decreased, fecal weight increased, and the concentration of total bile acids in the feces decreased ($P < .05$). Similarly, SCFA production significantly increased with the raisins but not the tartaric acid ($P < .05$). Although the tartaric acid group did not experience significant changes in stool weight (increase, 10 g/d) or in transit time (9-hour reduction) compared with baseline, these changes suggest an additive effect of tartaric acid on top of the fiber benefit. Moreover, for both groups, the lithocholic acid–to–deoxycholic acid ratio was reduced, but the difference was significant only for the raisins ($P < .02$). This ratio has been proposed as a predictor of colon cancer. The ratio for participants consuming raisins is commensurate with values shown to predict a low risk for colon cancer. Thus, the beneficial effects on bowel function of raisins appear to be mediated by fiber and tartaric acid, and these benefits may translate into a reduced the risk for colon cancer.

## CONCLUSION

In sum, raisins have been underappreciated as a source of fiber because half of the dietary fiber (inulin) is not counted as the fiber content listed on nutritional labels. Raisins, when consumed as part of a nutrient-dense, healthy diet, help reduce CVD risk and improve bowel function. Studies specifically in raisins reveal their protective effect against colon cancer and improvement in bowel function. Raisins uniquely contain tartaric acid, which enters the large bowel to serve as substrate for colonic bacteria to make SCFAs. This is thought to reduce the risk for colon cancer. Given the totality of the evidence, raisins can easily be incorporated into the existing low-fiber diet of Americans to increase total dietary fiber intake, while potentially reducing CVD and colon cancer risk and improving bowel function.

## ACKNOWLEDGMENT

Support for the writing of this article came from the California Raisin Marketing Board, Fresno, California.

## REFERENCES

1. National Academy of Sciences, Institute of Medicine, Food and Nutrition Board: Dietary, functional, and total fiber. In: *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty acids, Cholesterol, Protein, and Amino Acids (Macronutrients)*. Washington, D.C., National Academy of Sciences, 2005, chapter 7, pp. 339–421.
2. Slavin JL: Dietary fiber and body weight. *Nutritio*n 2005;21:411–418.
3. Weickert MO, Pfeiffer AFH: Metabolic effects of dietary fiber consumption and prevention of diabetes. *J Nutr* 2008;138:439–442.
4. Du H, van der A DL, Boshuizen HC, *et al*.: Dietary fiber and subsequent changes in body weight and waist circumference in European men and women. *Am J Clin Nutr* 2010;91:329–336.
5. de Souza RJ, Swain JF, Appel LJ, Sacks FM: Alternatives for macronutrient intake and chronic disease: a comparison of the OmniHeart diets with popular diets and with dietary recommendations. *Am J Clin Nutr* 2008;88:1–11.
6. Bazzano LA, Song Y, Bubes V, *et al*.: Dietary intake of whole and refined grain breakfast ceral and weight gain in men. *Obes Res* 2005;13:1952–1960.
7. McKeown NM, Yoshida M, Shea MK, *et al*.: Whole-grain intake and cereal fiber are associated with lower abdominal adiposity in older adults. *J Nutr* 2009;139:1950–1955.
8. Davis JN, Alexander KE, Ventura EE, Toledo-Corral CM, Goran MI: Inverse relation between dietary fiber intake and visceral adiposity in overweight Latino youth. *Am J Clin Nutr* 2009;90: 1160–1166.
9. Sartorelli DS, Franco LJ, Cardoso MA: High intake of fruits and vegetables predicts weight loss in Brazilian overweight adults. *Nutr Res* 2008;28:233–238.
10. Anderson J, Perryman S, Young L, Prior S: Dietary fiber. Food and Nutrition Series. May 2007. www.ext.colostate.edu/pubs/foodnut/09333.pdf (accessed February 2010)
11. Rimm EB, Ascherio A, Giovannucci E, *et al*.: Vegetable, fruit, and cereal fiber intake and risk of coronary heart disease among men. *JAMA* 1996;275:447–451.
12. Ness AR, Powles JW. Fruit and vegetables, and cardiovascular disease: a review. *Int J Epidemiol* 1997;26:1–13.
13. Pereira MA, O'Reilly E, Augustsson K, *et al*.: Dietary fiber and risk of coronary heart disease. *Arch Intern Med* 2004;164; 370–376.
14. Lairon D, Arault N, Bertrais S, *et al*.: Dietary fiber intake and risk factors for cardiovascular disease in French adults. *Am J Clin Nutr* 2005;82:1185–1194.
15. Streppel MT, Ocke MC, Boshuizen HC, Kok FJ, Kromhout D: Dietary fiber intake in relation to coronary heart disease and all-cause mortality over 40 years: the Zutphen Study. *Am J Clin Nutr* 2008;88:1119–1125.
16. Sahyoun NR, Jacques PF, Zhang XL, Juan W, McKeown NM. Whole-grain intake is inversely associated with the metabolic syndrome and mortality in older adults. *Am J Clin Nutr* 2006; 83:124–131.
17. Ma Y, Griffith JA, Chasan-Taber L, *et al*.: Association between dietary fiber and serum C-reactive protein. *Am J Clin Nutr* 2006; 83:760–766.
18. Valtuena S, Pellegrini N, Franzini L, *et al.*: Food selection based on total antioxidant capacity can modify antioxidant intake, systemic inflammation, and liver function without altering markers of oxidative stress. *Am J Clin Nutr* 2008;87:1290–1297.

19. Schulze MB, Schulz M, Heidemann C, *et al*.: Fiber and magnesium intake and incidence of type 2 diabetes. *Arch Intern Med* 2007;167:956–965.
20. Qi L, van Dam RM, Liu S, Franz M, Mantzoros C, Hu FB. Whole-grain, bran, and cereal fiber intakes and markers of systemic inflammation in diabetes women. *Diab Care* 2006;29: 207–211.
21. Nothlings U, Schulze MB, Weikert C, *et al*.: Intake of vegetables, legumes, and fruit, and risk of all-cause, cardiovascular, and cancer mortality in a European diabetic population. *J Nutr* 2008;138:775–781.
22. Suzuki R, Rylander-Rudqvist T, Ye W, *et al*.: Dietary fiber intake and risk of postmenopausal breast cancer defined by estrogen and progesterone receptor status. A prospective study among Swedish women. *Int J Cancer* 2008;122:403–412.
23. van Gils CH, Peeters PHM, Bueno-de-Mesquita HB, *et al*.: Consumption of vegetables and fruits and risk of breast cancer. *JAMA* 2005;293:183–193.
24. Millen AE, Subar AF, Graubard BI, *et al*. for the Prostate, Lung, Colorectal, and Ovarian (PLCO) Cancer Screening Trial Project Team. Fruit and vegetable intake and prevalence of colorectal adenoma in a cancer screening trial. *Am J Clin Nutr* 2007;86: 1754–1764.
25. Jacobs ET, Lanza E, Alberts DS, *et al*.: Fiber, sex, and colorectal adenoma: results of a pooled analysis. *Am J Clin Nutr* 2006;83: 343–349.
26. Sansbury LB, Wanke K, Albert PS, *et al*., and the Polyp Prevention Trial Study Group. The effect of strict adherence to a high-fiber, high-fruit and vegetable, and low-fat eating pattern on adenoma recurrence. *Am J Epidemiol* 2009;170:576–584.
27. Suzuki R, Allen NE, Key TJ, *et al*.: A prospective analysis of the association between dietary fiber intake and prostate cancer risk in EPIC. *Int J Cancer* 2009;124:245–249.
28. Aldoori WH, Giovannucci EL, Rimm EB, *et al*.: A prospective study of diet and the risk of symptomatic diverticular disease in men. *Am J Clin Nutr* 1994;60:757–764.
29. Bijkerk CJ, de Wit NJ, Muris JWM, *et al*.: Soluble or insoluble fibre in irritable bowel syndrome in primary care? Randomised placebo controlled trial. *BMJ* 2009;339:b3154.
30. Bruce B, Spiller GA, Klevay KM, Gallagher SK: A diet high in whole and unrefined foods favorably alters lipids, antioxidant defenses, and colon function. *J Am Coll Nutr* 2000;19:61–67.
31. Camire ME, Dougherty MP: Raisin dietary fiber composition and in vitro bile acid binding. *J Agric Food Chem* 2003;51:834–837.
32. Spiller GA, Story JA, Lodics TA, *et al*.: Effect of sun-dried raisins on bile acid excretion, intestinal transit time, and fecal weight: a dose-response study. *J Med Foods* 2003;6:87–91.
33. Spiller GA, Storey JA, Furumoto EJ, Chezem JC, Spiller M: Effect of tartaric acid and dietary fiber from sun-dried raisins on colonic function and on bile acid and volatile fatty acid excretion in healthy adults. *Br J Nutr* 2003;90:803–807.