Raisin Consumption by Humans: Effects on Glycemia and Insulinemia and Cardiovascular Risk Factors

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Abstract: Raisins are widely recommended as good foods and preferred snacks because of their nutrient content. They are rich in dietary fiber, potassium, and many health-promoting phytonutrients and antioxidants. Raisins have a high dietary fiber score. Laboratory studies document that raisins rank in the upper quartile of foods for antioxidant content. Clinical research related to the potential health benefits of raisins has intensified over the past 10 y. Much of this research has focused on blood glucose and insulin responses to raisins compared to other foods or snacks. Meal studies indicate that raisins have a low to moderate glycemic index and a low insulimetic index. Longer term studies suggest that customary intake of raisins is associated with lower postprandial blood glucose values than with equicaloric control foods. Cross-sectional studies suggest that higher levels of dried fruit consumption are associated with lower systolic and diastolic blood pressure than seen with minimal dried fruit use. One clinical study documents that raisin intake over 12 wk is accompanied by a significant reduction in blood pressure. Preliminary results indicate that raisins are associated with increased satiety and decreased food consumption over an 8-h period, but the potential benefits of raisins for weight loss have not been assessed. Raisin intake is accompanied by reductions in serum low-density lipoprotein cholesterol, triglycerides, and oxidized low-density cholesterol values. Thus, raisins have the potential to significantly reduce the risk for developing diabetes or cardiovascular disease.

Keywords: diabetes, dietary fiber, health, raisins

Introduction

Most raisins are naturally sun-dried grapes and approximately 95% are dried “Thompson Seedless” grapes, *Vitis vinifera L.* (Carughi 2009). Raisins are commonly recommended as good food choices because of their nutrient content and their health-promoting benefits. They are rich sources of potassium and dietary fiber and provide an array of phytonutrients (Karadeniz and others 2000). Raisins rank in the highest quintile of foods for their potential to deliver physiologic antioxidants to tissue cells (Halvorsen and others 2006; Wolfe and others 2008). Furthermore, raisins do not provide fat, saturated fat, or cholesterol (USDA Nutrient Database for Standard Reference 2012).

Research over 25 y documents that raisins decrease the glycemic and insulimetic response to meals, compared to meals without raisins (Oettle and others 1987). Longer term consumption of raisins compared to control foods leads to significant reductions in postprandial blood glucose values (Bays and others 2012b). Raisin intake is also associated with lower blood pressures (Keast and others 2011; Bays and others 2012a). Compared to other foods, raisin snacks significantly increased the feeling of satiety and decreased food intake over the 8 h of observation (Patel and others 2011). The cardiovascular protective effects of raisins are suggested by their effects in reducing postprandial glucose values, low-density lipoprotein (LDL) cholesterol, triglycerides, oxidized LDL, and oxidative stress (Puglisi and others 2008; Rankin and others 2008; Barnes and others 2011; Bays and others 2012b).

The specific effects of raisin intake, compared to comparable foods, on glycemia and insulimemia, as well as cardiovascular risk factors, will be reviewed in this report. Unless specifically indicated the term “raisins” refers to traditional sun-dried raisins.

Nutrition Qualities of Raisins

Sun-dried raisins retain the minerals and most of the phytocemicals and antioxidants of the grape, including its resveratrol (Zhao and Hall 2008). Sun-drying enhances the antioxidant content of raisins. Because of the dehydration process, phytonutrients are more concentrated in raisins than in grapes. However, concentrations of some compounds are decreased by the sun-drying process (Halvorsen and others 2006; Carughi 2009; USDA Nutrient Database for Standard Reference 2012).

Minerals

Raisins are rich in potassium, magnesium, and boron (Carughi 2009; USDA Nutrient Database for Standard Reference 2012).

Dietary fiber

Raisins are excellent sources of insoluble and soluble fibers and also provide significant amounts of fructooligosaccharides.
(FOS) including inulin. The dietary fiber content of raisins using conventional measurements ranges from 3.7 g/100 g (USDA Nutrient Database for Standard Reference 2012) to 5.1 g/100 g (Camire and Dougherty 2003; Carugh 2009). Soluble fiber accounts for about 36% of this measured dietary fiber. In addition, raisins provide 5.7 g/100 g of FOS (Camire and Dougherty 2003). Thus, the dietary fiber value of raisins may be as high as 5.8 g/100 g giving them a high fiber score. Using these values, a 1-oz serving of raisins would provide 3.0 g of dietary fiber per 90 calories giving them an excellent “source of dietary fiber” rating. Whereas raisins are rich in FOS, grapes have a very low FOS content (Camire and Dougherty 2003). These FOS, such as inulin, have a very important prebiotic effect in addition to other health benefits for humans (Anderson 2009; Anderson and others 2009; Bell 2011).

**Phytochemicals**

Raisins are rich sources of a wide variety of polyphenols, catechins, resveratrol, and isoflavones (daidzein and genistein) (Karadeniz and others 2000; Liggins and others 2000; Wu and others 2004; Parker and others 2007; Zhao and Hall 2008; Carugh 2009; Iriti and Faoro 2009). Wine, grapes, and raisins provide resveratrol that may have significant cardiovascular and other health-protective effects (Lekakis and others 2005; Zern and others 2005; Banini and others 2006; Lagouge and others 2006; Ou and others 2006; Stef and others 2006; Dohadwala and Vita 2009; Rampasath and Jones 2010; Williamson and Carugh 2010; Ghani and others 2011). Among fruits and nuts, raisins have the highest concentrations of daidzein and genistein (Liggins and others 2000); the potential cardiovascular-protective effects of these components have been reviewed elsewhere (Stephenson and others 2005).

The pathophysiology of diabetes, for example, is very complex and any protective effect of a food such as raisins may reflect synergistic activities of multiple phytonutrients. As reviewed in Pasupuleti and Anderson (2008), nutrients and phytochemicals may contribute to reducing risk for diabetes by affecting these physiologic processes: antioxidant properties; modifications of gut physiology; affecting hormone secretion and action (for example, insulin, glucagon, and gut hormones); insulin sensitivity; satiety; and immune function. In a similar fashion, the effects of raisins, for example, on risks for cardiovascular disease likely represent the synergism of multiple nutraceuticals on physiological processes. The important effects of antioxidants related to diabetes and cardiovascular have generated the greatest research investigations and will be briefly reviewed below.

**Antioxidants**

Many of the phytochemicals in raisins have potent antioxidant potential; examples include various phenolic acids, flavonols, and phytoestrogens. Assessment of the physiologic importance of food antioxidants is difficult. Until recently, the total antioxidant values of foods—calculated by such measures as oxygen radical absorbance capacity (ORAC)—were used to estimate the antioxidant potential of foods. Wolfe and others (2008) developed a more sensitive measure, the cellular antioxidant activity (CAA) of food components, for this assessment. However, the bioavailability of phytonutrients in humans is very difficult to assess since many compounds are chemically altered in the gastrointestinal tract or the liver before entering the general circulation (Manach and others 2005b). Recently, the bioavailability of quercetin from red grape juice was documented (Castilla and others 2006). Thus, the assessment of the absorption and metabolism of a candidate molecule and its metabolites is difficult. Furthermore, the physiologic effects of the compound on some outcome measure must be measured before the clinically important effects of the compound in humans can be assessed. Knowledge about vitamin E illustrates the importance of assessing the effects of a phytochemicals in vitro and extending these studied to physiologic effects in humans. Vitamin E has a well-recognized in vitro antioxidant activity as well as bioavailability information; it also has clinically important antioxidant activity in humans. Vitamin E supplements are associated with significant reduction in oxidized LDL in humans (Anderson and others 1999). However, the final assessment of the antioxidant efficacy of a compound from grapes or other foods is to document in clinical trials that administration of this compound reduces the development of a disease such as coronary artery disease (CAD) (Sirtori and others 2009).

Some of the specific antioxidants that have been identified in raisins include these: flavonoids (catechins, kaempferol, quercetin, and rutin), hydrocinnamic acids (caferic and coutaric acids), epicatechins, phytoestrogens (daidzein and genistein), and resveratrol (Karadeniz and others 2000; Liggins and others 2000; Parker and others 2007; Zhao and Hall 2008; Rampasath and Jones 2010). The chemical estimations of antioxidant capacity of raisins have been compared to other foods using measures of total phenolic acids, ORAC, ferric reducing-oxidant power (FRAP), Trolox equivalent antioxidant capacity (TEAC), total antioxidant capacity (TAC), and total radical-trapping antioxidant parameter (TRAP) (Wu and others 2004; Vinson and others 2005; Pellegrini and others 2006; Parker and others 2007; Wolfe and others 2008; USDA Nutrient Database for Standard Reference 2012). When comparisons are made to an array of fruits and vegetables, raisins appear in the upper quartile of antioxidant activity (Wu and others 2004; Halvorsen and others 2006; USDA Nutrient Database for Standard Reference 2012).

Serum antioxidant capacity has been significantly correlated with the intake of fruits and vegetables over the past year (Cao and others 1998a). Consumption of red wine, spinach, or strawberries increased serum and urine total antioxidant capacity over a 4-h period after intake (Cao and others 1998b). Recent studies with pomegranate illustrate that intake of an antioxidant-rich fruit has important health benefits for humans (Mink and others 2007; Balbir-Gurman and others 2011; Chen and others 2012; Shema-Dida and others 2012). Grapes are rich in health-promoting antioxidants (Halvorsen and others 2006) and administration of grape extracts has well documented benefits on antioxidant status in humans (Lekakis and others 2005; Zern and others 2005). Evidence relating specifically to the antioxidant benefits of raisins is emerging (Rankin and others 2008; Barnes and others 2011) and will be presented in a subsequent section.

**Health Benefits of Dietary Fiber**

The rich dietary fiber content of raisins suggests that this dietary component may make a significant contributions to health (Anderson 2009; Anderson and others 2009, 2012; Anderson and Jhaveri 2012). Many prospective cohort studies have documented the significant health benefits of dietary fiber (Anderson and Jhaveri 2012). Higher consumption of dietary fiber is associated with significantly lower risks for CAD, stroke, hypertension, diabetes, and obesity (Anderson and Jhaveri 2012). While there are no long-term studies of the effects of raisin intake on coronary heart disease, 5 prospective cohort studies suggest that individuals who have the highest intake of fruit or fruit fiber have a distinctly
lower risk for CHD than those who consume the smallest amount of fruit (Anderson and Jhaveri 2012).

The risk for stroke appears to be significantly lower for individuals who have high consumption of dietary fiber (Anderson and Jhaveri 2012). Individuals who have the highest intake of fruit and vegetables have a significantly decreased risk for stroke compared to those with minimal intakes of these foods. This may relate to the beneficial effects of dietary fiber on blood pressure (Anderson 1983; Anderson and Jhaveri 2012).

Blood pressure values are lower in individuals who have high intakes of dietary fiber compared to those who have fiber-deficient diets (Anderson and Jhaveri 2012). Studies of dried fruit intake, including raisins, indicate that those individuals with the highest intakes of dried fruit have significantly lower blood pressures than those with the lowest intakes (Keast and others 2011). Emerging data, as will be reviewed, indicate that raisin consumption has a significant effect on decreasing blood pressure (Bays and others 2012a).

Diabetes (Anderson 2008; Anderson and others 2009) and obesity (Anderson and Jhaveri 2012) also are significantly less prevalent among persons with high-fiber compared to low-fiber intakes. The effects of raisin, dried fruit, or fruit intake on the prevalence of diabetes have not been critically assessed but emerging evidence related to the effects of raisin intake on glycemia and insulinemia, as will be reviewed, are encouraging (Bays and others 2012b). Dried fruit intake is associated with lower body weight and measures of adiposity (Keast and others 2011).

Dietary fiber, glycemia, and diabetes

Diabetes is a major health problem worldwide. In the United States, over 24 million persons have diabetes and another 70 million have prediabetes; it is likely that half of all U.S. adults will develop diabetes (Anderson and Pasupuleti 2008). Approximately 90% of persons with diabetes have the type 2 form and 80% of these are obese; weight management is the first challenge in preventing the condition (Anderson and others 2003). Other dietary measures for diabetes prevention include these: replacing high-glycemic-load foods with high-fiber foods with a low glycemic index (GI); decreasing dietary fat intake; and increasing intake of protective antioxidants and phytochemicals (Pasupuleti and Anderson 2008).

Observational studies suggest that those individuals with the highest levels of dietary fiber intake have a 29% lower risk for developing diabetes than those with the lowest levels of fiber consumption (Anderson 2008). Prediabetic individuals with the highest fiber consumption had a 62% reduction for progression of prediabetes to florid diabetes over a 4-y period compared to low-fiber users (Lindstrom and others 2006).

Over the past 20 y prospective controlled clinical trials have documented that healthy individuals, as well as those with prediabetes, have improvement in fasting and postprandial glucose and insulin values when consuming larger amounts of dietary fiber compared to control subjects with low-fiber intakes (Anderson and others 2009). Glycemic control is improved when diabetic subjects increase their dietary fiber consumption (Anderson and others 2009). Soluble fiber has a specific benefit in improving postprandial glycemia and insulinemia (Anderson 2009; Anderson and others 2012). Recently, we examined the effects of barley beta-glucan, a soluble fiber, on glycemia and insulinemia. In overweight subjects with mean fasting glucose values in the prediabetic range, regular consumption of a soluble barley beta-glucan with diets that were equivalent in energy and carbohydrate content was accompanied by a significant reduction in postprandial glucose values, decreases in fasting insulin values, and improvement in insulin sensitivity (Bays and others 2011).

Dietary fiber and serum lipoproteins

A generous intake of dietary fiber is central to the dietary management of dyslipidemia (Anderson 1980, 2000; Sirtori and others 2007). Soluble fiber—from oat bran or psyllium, for example—has specific effects in decreasing fasting serum cholesterol, LDL-cholesterol, and apolipoprotein B (Anderson and others 2000; Anderson 2009). Insoluble fibers—such as those from whole grains, for example—have hypoglycemic effects (Anderson 2000). Responses of serum high-density lipoprotein (HDL) cholesterol values to dietary changes are dynamic, often decreasing with short-term dietary changes and then increasing over the period after 3 mo (Anderson 2007). The short-term response of HDL-cholesterol values to increased consumption of fiber is variable, but long-term use of oat bran increases HDL-cholesterol values (Anderson and others 1984).

Dietary fiber and obesity

Epidemiological studies—both cross-sectional and prospective cohort studies—indicate that individuals with the highest intake of dietary fiber have a 30% lower risk for having or developing overweight or obesity (Anderson and others 2009). Clinical trials comparing subjects randomly assigned to weight-reduction diets rich in dietary fiber compared to similar diets not enriched with fiber support the beneficial role of fiber for weight loss. Analysis of 15 clinical trials enrolling more than 800 subjects indicates that individuals consuming fiber-rich hypocaloric diets lose significantly more weight over 12 wk than those using conventional hypocaloric diets (Anderson and others 2009).

Raisin Intake: Glycemia and Insulinemia

The GI compares the blood glucose response to ingestion of a food compared to intake of an equivalent amount of carbohydrate from glucose. Jenkins and others (1981) reported that raisin intake by 6 healthy subjects was associated with a GI of 64. Subsequent studies have defined this as a moderate GI (values of 55 to 69), compared to a low GI (< 55) or a high GI (> 70). A later study reported low GI values for 10 healthy subjects (49.4) and 10 prediabetic subjects (49.6); 11 athletic subjects had moderate GI values (62.3) (Kim and others 2008). The GI value for 28 pregnant women with gestational diabetes was 65.7. The insulogenic index of 10 healthy subjects was low (47.1) and very similar to the GI (49.4). However, the comparative study of Oettle and others (1987) suggested that including raisins in snacks might be associated with a lower insulin response than other snacks with similar glycemic responses. Rankin and others (2008) reported favorable but nonsignificant trends after 2 wk of raisin intake compared to control for fasting plasma glucose and insulin values.

In a randomized comparator trial subjects consumed 1 cup of raisins daily or increased their walking over a 6-wk period (Puglisi and others 2008); there were 12 adult subjects in each group. Changes in fasting serum glucose and insulin values did not differ significantly between groups and none of the changes from baseline were statistically significant. Changes from baseline for serum glucose values were: raisins, −0.14 mmol/L (−2.1%); and walking, +0.18 mmol/L (+3.3%). Changes from baseline for serum insulin values were: raisins, −11 units/L (−2.7%); and walking, −2 units/L (−0.6%).
The effects of 3 pre-exercise snacks on glycemia and insulinenia before, during, and after exercise for 9 healthy men and 11 men with impaired glucose tolerance test were compared (Byrne and others 2011). Energy bars intake decreased postprandial glycemia without affecting insulinenia, whereas raisins decreased both glycemia and insulinenia.

A recently completed randomized clinical trial compared the effects of consumption of raisins before each meal (1 oz, about 30 g, 3 times daily) with intake of equicaloric, nonfruit snacks such as crackers or cookies (Bays and others 2012a); the total carbohydrate content of the 2 diets did not differ significantly. Forty-six overweight subjects with prediabetes or high risk for diabetes were followed for 12 wk. Baseline fasting plasma glucose values ranged from 90 to 150 mg/dL. After 12 wk mean percentage changes in postprandial glucose values were +6.3% for snacks and −9.8% for raisins (difference, −16.2%, P = 0.03). Compared to baseline values, raisins significantly reduced mean postprandial glucose values by 13 mg/dL (P = 0.003), while no significant differences were seen with snacks. Compared to baseline, raisins significantly decreased hemoglobin A1c by 0.12% (P = 0.004), while no significant differences were seen with snacks. There were no significant changes in fasting glucose or insulin values or body weights in either group.

**Raisin Intake: Blood Pressure**

Because of their rich content of dietary fiber, potassium, and phytonutrients, the regular consumption of raisins has the potential to lower blood pressure (He and others 2005; Anderson and others 2009; Anderson and Jhaveri 2012). In a cross-sectional analysis, the association of dried fruit consumption with blood pressure and indices of body fat was assessed (Keast and others 2011). Seven percent of the adults consumed at least 1/8 cup equivalent of dried fruit daily. Dried fruit consumers had significantly higher intakes of dietary fiber, 6.6 g/d higher, and of potassium, 432 mg/d higher, than nonconsumers. The prevalence of hypertension was 3.5% lower (P < 0.05) and mean blood pressures were significantly lower (P < 0.05) for systolic (−1.5 mm Hg) and diastolic (−1.0 mm Hg) blood pressures.

In a randomized comparator trial subjects consumed 1 cup of raisins daily or increased their walking over a 6-wk period, there were 12 adult subjects in each group. Systolic blood pressure decreased significantly in both groups but the differences between groups were not significant. Changes in blood pressure for the raisin group were: systolic, −2.5 mm Hg; and diastolic, −0.5 mm Hg (Puglisi and others 2008).

In our recent study (Bays and others 2012a), we assessed blood pressure changes over 12 wk for the raisin and the control snack group. Forty-six subjects with baseline systolic (133 mm Hg) and diastolic (82 mm Hg) blood pressures completed this trial. Compared to snacks, raisin consumption was associated with significantly reduced systolic blood pressures with mean changes ranging from −4.8% to −7.2% or −6.0 to −10.2 mm Hg (P < 0.05). Compared to baseline values mean systolic blood pressures were −4.8 to −8.2 mm Hg lower (P < 0.05) at the 4, 8, and 12 wk for raisin consumers. Compared to snacks, raisin consumption was associated with nonsignificant lower diastolic blood pressures with mean changes ranging from −2.5% to −6.4% or −2.6 to −5.0 mm Hg. However, compared to baseline values, mean diastolic blood pressures were −2.4 to −5.2 mm Hg lower (P < 0.05) at the 4, 8, and 12 wk for raisin consumers. Snacks were not associated with significant changes on systolic or diastolic blood pressures at any study visit.

**Raisin Intake: Body Weight and Obesity**

In their cross-sectional study, the association of dried fruit consumption with indices of body fat was examined. Only 7% of the adults consumed at least 1/8 cup equivalent of dried fruit daily; raisin intake was not specifically assessed. Dried fruit consumers had intakes of dietary fiber that were 6.6 g/d higher than nonconsumers. Body weight, body mass index (BMI), and waist circumference were all significantly lower in dried fruit consumers than in nonconsumers (Keast and others 2011).

In their comparator trial (Puglisi and others 2008), subjects consumed 1 cup of raisins daily or increased their walking over a 6-wk period. Body weight increased 0.1 kg in the raisin group and decreased 0.1 kg in the walking group. Waist circumference decreased 0.7 cm in the raisin group after 6 wk and did not change in the walking group but the differences were not significant.

Anderson and Woodend (2003) have a long-standing interest in assessment of appetite or satiety and the effects of different foods on short-term energy intake. Recently, this research team has compared the effects of raisin snacks to other snacks such as chips and cookies for children. They have reported that raisins decreased appetite and were associated with less food intake during the observation period of approximately 8 h (Patel and others 2011). These results are described by Patel and others in another report in this issue.

Mechanisms related to the potential benefits of raisin intake for weight management have not been critically explored. The recent study of Patel and others (2011) suggests that raisins enhance satiety and decrease appetite. The fairly extensive studies of dietary fiber suggest that the fiber content of raisins may contribute to the satiation and decreased appetite by affecting secretion of various orexigenic and anorexigenic gut hormones. The effects of soluble fibers to slow gastric emptying may also contribute to satiation (Anderson 2009; Anderson and others 2009). The effects of other nutrients and phytochemicals present in raisins on weight management have not been carefully explored.

**Raisin Intake: Cardiovascular Risks**

Cardiovascular diseases—such as CAD, stroke, and hypertension—affect more than 80 million people and are the leading causes of morbidity and mortality in the U.S. Risks for developing these conditions can be modified by lifestyle measures. An estimated 82% of CAD could be prevented through lifestyle measures and 60% through health-promoting nutrition practices (Anderson and others 2009). Serum lipoprotein abnormalities, hypertension, diabetes, and obesity are major contributors to risk for CAD (Anderson and Konz 2001). Oxidative damage to LDL and to other blood components and to the endothelium accelerate the atherosclerotic process (Lekakis and others 2005). Inflammatory factors also contribute to the initiation and progression of atherosclerotic cardiovascular disease (Ross 1999).

**Serum lipoproteins**

In a randomized comparator trial subjects consumed 1 cup of raisins daily or increased their walking over a 6-wk period (Puglisi and others 2008), there were 12 adult subjects in each group. Serum cholesterol and LDL cholesterol values were reduced significantly, HDL-cholesterol values did not change significantly, and triglyceride values were decreased significantly in the walking group. Absolute changes for the raisin group were: total cholesterol, −7.5%; LDL cholesterol, −9.7%; HDL cholesterol, −1.9%; and triglycerides, −4.0%. Since there was no control group, it is
Raisin, glycemia, and cardiovascular risk…

difficult to assess whether these lipoprotein changes were related to the intervention or to dietary changes during the trial.

Raisin intake compared to placebo for 2 wk decreased fasting and postprandial serum-free fatty acid values (Rankin and others 2008). The potential serum-free fatty acid and triglyceride-lowering effects of raisins may relate to their rich polyphenols and inulin content (Zern and Fernandez 2005; Brighenti 2007).

Oxidized LDLs

Observations of the effects of grape juice, while having very different polyphenol content than raisins, serve as a background to examine the effect of raisins. In an observational study, the recommended intake among 15 adults with CAD was of 4 oz of purple grape juice (about 120 mL). LDL particles were significantly \( (P = 0.015) \) less susceptible to oxidation after 2 wk of grape juice intake. Flow-mediated vasodilation, an important measure of vascular health, was also significantly \( (P = 0.003) \) improved (Stein and others 1999).

In a comparator trial, 32 volunteers were randomly assigned to consume 2, 3.5, or 5.5 ounces \((56.5, 98.9, \text{or} 155.4 \text{g})\) of raisins daily for 4 wk. Serum oxidized LDL was decreased significantly below baseline values in the 2-oz group at 2 wk, 3.5-oz group at 4 wk, and 5.5-oz group at 2 and 4 wk (Barnes and others 2011).

Antioxidant defenses

In the Barnes study, serum FRAP values were significantly increased at 2 and 4 wk (Barnes and others 2011). Using a randomized crossover design with a washout period, Rankin and others (2008) compared the response to raisin intake or control on a number of indicators of glycemia, lipidemia, antioxidant status, and inflammatory factors. Raisin intake was associated with significant increases in total ORAC and protein-free ORAC scores.

Inflammatory factors

Red wine consumption significantly reduces inflammatory risk markers in the blood stream and also decreases monocyte and endothelial adhesion molecules that contribute to atherosclerotic plaque development (Estruch and others 2004). Zern and Fernandez (2005) have reviewed the effects of grape polyphenols on serum markers of inflammation.

Zern and others (2005) also examined the effects of administering a lyophilized grape powder \((\text{LGP})\) or placebo to 44 women for 4 wk on markers of inflammation. LGP administration was associated with a significant decrease in tumor necrosis factor, TNF-\(\alpha\) \( (P < 0.05) \), but not other markers of inflammation such as interleukin-6 \((\text{IL}-6)\) or C-reactive protein \((\text{CRP})\).

Endothelial function

Endothelial dysfunction is an important contributor to the development of atherosclerotic vascular disease. Flow-mediated dilation of the brachial artery was studied in subjects with CAD. These measurements were performed after administration of 600 mg of a red grape polyphenols extract \((n = 15)\) or placebo \((n = 15)\). The grape extract provided epicatechin, gallic acid, resveratrol, rutin, \(\epsilon\)-viniferin, and p-coumaric acid. Grape polyphenols administration was accompanied by a significant increase in flow-mediated vasodilation \((P < 0.001)\) (Lekakis and others 2005). Very large doses of grape polyphenols were administered in this study and it is uncertain whether significant improvement in flow-mediated vasodilation would be seen with usual dietary intakes of polyphenol-rich foods such as raisins.

Discussion

There is persuasive evidence that individuals who have higher fiber intakes are at lower risk for CAD, stroke, hypertension, diabetes, and obesity than are those who ingest minimal amounts of dietary fiber (Anderson and Jhaveri 2012). Since high-fiber diets are rich in fruits, vegetables, and whole grains, it is uncertain whether it is the dietary fiber, the minerals, or the phytochemicals present in these diets that are the “active” ingredients (Anderson 2004). Since wheat germ is the most phytonutrient-dense portion of the wheat kernel, one would anticipate that wheat germ would be more protective than wheat bran, which does not have the high phytonutrients concentration that germ does; however, wheat bran is associated with significant protection from CAD, while wheat germ is not protective (Anderson and Jhaveri 2012). Clinical studies have not provided clues to whether it is the soluble and insoluble dietary fiber, the phytonutrient, or the minerals, or other components of high-fiber foods that provide the greatest protection from CAD or whether it is a unique synergy of multiple ingredients that has the most important health-protective role.

Raisins also are rich in phytonutrients (including potent antioxidants) and minerals. Similar to the dietary fiber story, we do not know which ingredients play the most important role in health protection. Resveratrol, 1 potent phytochemical with antioxidant effects, has attracted considerable attention and has health-promoting effects in humans and animals (Baur and Sinclair 2006; Stef and others 2006; Ramprasath and Jones 2010). Similarly, other grape polyphenol extracts have well-documented beneficial effects for humans (Manach and others 2005a; Zern and others 2005; Banini and others 2006; Castilla and others 2006; Iriti and Faoro 2009; Ghanim and others 2011). Their rich content of potassium of raisins could make an important contribution to the reductions in blood pressure that have been documented (He and others 2005; Puglisi and others 2008; Bays and others 2012a). Based on the persuasive data on the health-promoting effects of dietary fiber (Anderson and others 2009; Anderson and Jhaveri 2012), it seems likely that the fiber content of raisins has an important, and probably synergistic, role related to the health benefits delivered by raisin consumption.

In designing clinical studies, my colleagues and I have developed hypotheses that raisin consumption would reduce risk for developing diabetes; contribute to improved blood glucose control for diabetic individuals; and be a useful adjunct for weight loss and weight management. Some of the evidence to support these hypotheses is reviewed below.

Several clinical studies suggest that raisin consumption improves glycemia and insulinemia (Puglisi and others 2008; Byrne and others 2011; Bays and others 2012b). Banini and others (2006) compared blood glucose, insulin, and hemoglobin A1c values for nondiabetic and diabetic subjects given grape juice or wine daily for a 28-d period; while the polyphenols contents of grape juice and wine are very different from grapes, these studies may contribute to our evolving understanding of the effects of grape products. They noted that all 3 parameters of glycemic and insulinemic control were improved with use of these grape products. We noted that raisin consumption was associated with a significant reduction in hemoglobin A1c compared to baseline values (Bays and others 2012b).

Studies with experimental animals also support the potential benefit of grape products for animal models for diabetes or obesity. Zunino and others (2009) reviewed the research, indicating that grape products may have a beneficial effect on glucose values in experimental models for diabetes or obesity in rats. Some of
Raisin, glycemia, and cardiovascular risk . . .

the phytochemicals from grapes that appear to have favorable effects on glycemia and insulinemia: polyphenols, procyanidins, quercetin, and resveratrol. Resveratrol (Baur and Sinclair 2006; Chen and others 2007) specifically appears to have a number of benefits for rats with diabetes and/or obesity that include these: increased insulin sensitivity and prevented development of fatty liver (Baur and others 2006); prevented diet-induced obesity and reduced insulin resistance (Lagouge and others 2006); decreased plasma glucose, triglycerides, and diastolic and systolic blood pressures (Chi and others 2007); and decreased blood glucose, insulin, and triglyceride values (Su and others 2006).

Two studies by Keast and others (2011) and Bays and others (2012a) suggest that regular consumption of dried fruit, or specifically raisins, has the potential to significantly lower blood pressure. Blood pressure reductions of the magnitude observed with raisin intake have the potential to significantly reduce the risk of cardiovascular disease. A 5% to 6% reduction in systolic blood pressure, for example, decreases estimated risk for coronary heart disease by 10% to 12% (Anderson and Konz 2001). Clinical studies of hypertensive subjects are essential to confidently recommend that raisin consumption significantly decreases blood pressure.

Further human clinical trials are required to support the hypotheses regarding the benefits of raisins for individuals with prediabetes, diabetes, or obesity. Longer term studies including larger subject numbers are vital to document that regular consumption of raisins slows the progression of prediabetes to diabetes, as documented for fiber intake in the Finnish Diabetes Prevention Study (Lindstrom and others 2006). Studies at multiple centers including 40 or more subjects per study are required to document that raisin intake has a significant effect on intermediate-term glycemic control for individuals with diabetes. Finally, studies at multiple centers with adequate numbers of obese volunteers are vital to establish a role for regular raisin consumption for weight loss and long-term weight management.

Conclusion

Raisins are excellent food choices for persons of all ages. They are very nutritious and deliver dietary fiber, potassium, and health-promoting phytochemicals. Among a wide range of foods, raisins rank in the top quartile for antioxidant content. They are an excellent source of dietary fibers, providing about 35% soluble and 65% insoluble fiber, as well as generous amounts of FOS such as inulin. Many clinical studies have documented the health-promoting effects of raisin consumption. Raisins have a low to moderate GI and a low insulimic index. Raisins have been compared to equicaloric, nonfruit foods in many studies. Raisin consumption consistently decreases postprandial glycemia and insulinemia. They are associated with lower blood pressures. Raisin intake decreases fasting serum LDL cholesterol, triglycerides, and oxidized LDL cholesterol. Regular raisin consumption increases serum antioxidant capacity. These studies suggest that habitual consumption of raisins may reduce the risk for diabetes, improve diabetes glycemic control, and reduce the risk for atherosclerotic cardiovascular disease.

References


