Effect of Consumption of Dried California Mission Figs on Lipid Concentrations

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Key Words

Figs • Dietary fiber • Hypercholesterolemia • Dietary intake • Lipids

Abstract

Background: Figs are a rich source of soluble fiber. We evaluated the effect of consuming dried California Mission figs on serum lipids in hyperlipidemic adults. **Methods:** In a crossover trial men and women aged 30–75 years with elevated low-density lipoprotein cholesterol (100–189 mg/dl) were randomized to add dried California Mission figs (120 g/day) to their usual diet for 5 weeks or eat their usual diet for 5 weeks, then crossed over to the other condition for another 5 weeks. Six 24-hour dietary recalls were obtained. **Results:** Low- and high-density lipoprotein cholesterol and triglyceride concentrations did not differ between usual and figs-added diets (Bonferroni-corrected $p > 0.017$), while total cholesterol tended to increase with fig consumption ($p = 0.02$). Total cholesterol increased in participants ($n = 41$) randomized to usual followed by figs-added diet ($p = 0.01$), but remained unchanged in subjects ($n = 42$) who started with figs-added followed by usual diet ($p = 0.4$). During the figs-added diet, soluble fiber intake was 12.6 ± 3.7 versus 8.2 ± 4.1 g/day in the usual diet ($p < 0.0001$). Sugar intake increased

from 23.4 ± 6.5 to $32.2 \pm 6.3\%$ of kcal in the figs-added diet ($p < 0.0001$). Body weight did not change ($p = 0.08$). **Conclusions:** Daily consumption of figs did not reduce low-density lipoprotein cholesterol. Triglyceride concentrations were not significantly changed despite an increase in sugar intake.

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Introduction

Elevated low-density lipoprotein (LDL) cholesterol concentrations are causally linked with atherogenesis and coronary heart disease [1, 2]. One of the dietary approaches to lower LDL cholesterol is the incorporation of food components with hypocholesterolemic effects into the daily diet, including fiber, plant sterols, soy protein and isoflavones. Numerous studies have established that dietary fiber plays a role in lowering serum cholesterol [3]. This effect is more pronounced for soluble or gel-forming fibers found in some cereals, such as barley and oat, some vegetables and legumes. Recent guidelines on lowering blood cholesterol recommend increased consumption of fiber-rich foods to achieve a total daily intake of 30 g/day [4, 5].

One of the foods that may be effective in lowering blood lipid concentrations is figs. Figs in both the fresh and dried forms contain soluble fiber in appreciable amounts [6, 7]. Each 100 g of dried figs provides about 1 g of soluble fiber according to a 1997 database [8] but nearly 4 times that amount (3.47 g/100 g) according to Vinson [9]. Dried fruits like California Mission figs have a greater nutrient density, greater fiber content, increased shelflife and significantly higher phenol antioxidant content compared to fresh fruit [7]. When figs are diluted in water their viscosity increases and intestinal transit time may be lengthened, gastric emptying delayed as well as glucose absorption decreased. Such actions have the potential to lower postprandial blood glucose concentrations and decrease blood cholesterol [7].

Presently, a review of Pubmed found no published studies studying the effect of fig consumption on reducing serum cholesterol concentrations. In order to evaluate the effect of the consumption of dried California Mission figs (*Ficus carica* 'Mission') on serum lipid concentrations, we conducted a randomized controlled clinical trial in men and women with LDL cholesterol concentrations in the above optimal to high ranges.

Methods

This was a randomized controlled 2-week screening and 10-week intervention crossover study conducted at Loma Linda University School of Public Health. The study was conducted from September through December 2008. The protocol was approved by the Loma Linda University Institutional Review Board. All subjects provided informed written consent. Participants were recruited from communities in and surrounding San Bernardino, Calif., USA. Information and flyers were presented at churches and business establishments as well as at the fitness center at Loma Linda University. All subjects provided background health history information in the form of a brief health questionnaire.

Participants were 70 women and 32 men aged 30–75 years with LDL cholesterol concentrations in the above optimal (100–129 mg/dl), borderline (130–159 mg/dl) or high (160–189 mg/dl) ranges, the latter after clearance by their physician. Additional inclusion criteria were a body mass index (BMI) of 18.5–35 and no cigarette smoking within the past year. Exclusion criteria were: any secondary cause of hyperlipidemia (kidney or liver disease, untreated hypothyroidism); current or previous use (within the past 2 months) of any lipid-lowering drug; type 1 diabetes or uncontrolled type 2 diabetes (HbA1c > 7%); triglyceride concentrations >300 mg/dl; current or previous treatment (within the past 3 months) with estrogen or steroid therapy; stated dislike of figs; use of certain dietary supplements, such as Metamucil, sterol/stanol margarine and others that may influence lipid concentrations; chronic disease that may affect concentrations of lipids or markers of inflammation (for example, cancer other than skin cancer

within the last 5 years, chronic rheumatological disease or chronic severe depression); any condition that would limit compliance with the protocol (for instance, drug abuse).

Following screening procedures, 32 adult men and 70 women were randomly assigned to either figs-added or their usual diet for the first 5 weeks after randomization and then switched to the other phase for the second 5 weeks. For randomization the study coordinator opened opaque prenumbered envelopes that revealed assignment. During the figs-added diet, participants were asked to consume a prepackaged, preweighed 120 g serving of dried California Mission figs (12–15 figs) as part of their 3 daily meals for 5 weeks. Consumption of figs other than those provided by the study and prune (dried plum) or date consumption was not allowed. During the usual diet participants followed their habitual diet but without the consumption of figs or prunes. All participants were given a list of desserts and sweets to replace with figs in order to maintain stable caloric intake. Dried California Mission figs were provided by the California Fig Advisory Board.

Study visits were scheduled at weeks 2, 4, 5, 7, 9 and 10 after randomization. Week 5 was the crossover visit. At each study visit vital signs and anthropometrics were measured. The study procedures were reiterated and subjects completed a short health questionnaire to check whether any changes had occurred in their health status or use of medications since the screening visit. If the fig portions were forgotten (for example, not taken to work) they were consumed at a later time in the day with meals or as a snack. Daily compliance with the assigned portions of figs was recorded on a compliance form. A USD 25 gift certificate was given to each participant who completed the 12-week study.

Dietary Analyses

Six interviews to obtain 24-hour dietary recalls were performed at week 2 and onwards; three of these recalls were obtained during the figs-added period and three were obtained during the usual diet period. The recalls were performed by registered dietitians and a trained graduate student via two phone interviews and one in-person interview in each study phase. Two randomly chosen weekdays and one weekend day were targeted in each period. To select the day the dietitian or student pulled a selection from a box containing folded papers with the day (Sunday through Friday) for each participant. If the interview was not possible on the drawn day, it was conducted as soon as possible thereafter. The Nutrition Data System for Research [10], which is maintained by the Nutrition Coordinating Center at the University of Minnesota, was the software used to acquire the 24-hour dietary recall. We also analyzed changes in fiber intake during the usual diet and fig phases using the Vinson [9] data on the fiber content of dried figs.

Laboratory Methods

All participants had blood samples drawn after a 12-hour fast at screening, and at weeks 4, 5, 9 and 10 after randomization. Water and usual medications were allowed on the morning prior to the visit. Blood samples were drawn early in the morning between 6:30 and 9:00 a.m. Samples obtained at screening were sent to the Loma Linda University Medical Center Clinical Laboratory for analysis of total cholesterol, LDL cholesterol, high-density lipoprotein (HDL) cholesterol and triglyceride levels as well as alanine aminotransferase, creatinine and glucose.

Fig. 1. Participant flowchart.

Blood samples were separated in a refrigerated centrifuge at 1,800 g and 4°C. Serum/plasma was then aliquoted into vials kept in a -70°C freezer. Frozen samples were analyzed batchwise at the Research Laboratory at the University of California at Davis using a Poly-Chem system. Total cholesterol and triglycerides were measured enzymatically by automated procedures. Two distinct reaction steps for direct measurements of LDL and HDL cholesterol were conducted: (1) Elimination of chylomicron, very low density lipoprotein (VLDL) cholesterol and LDL cholesterol (for HDL cholesterol) or HDL cholesterol (for LDL cholesterol) by cholesterol esterase, oxidase and catalase; (2) specific measurement of lipids was done after the release of other lipids by detergents.

Statistical Analyses

Previous literature indicated a decrease of 0.028 mmol/l (1.1 mg/dl) and 0.029 mmol/l (1.1 mg/dl) in total and LDL cholesterol, respectively, for each additional gram of water-soluble fiber in the diet. For a daily intake of 120 g of dried figs, the additional amount of soluble fiber was predicted to be approximately 4 g/day [9]. Given the estimated average serum LDL cholesterol at baseline of about 130 mg/dl, the reduction of LDL cholesterol would be about 3.5% or approximately 4.6 mg/dl. With a standard deviation of 8% we estimated that to achieve 80% power with α of 0.05, 84 participants were required. To allow for an attrition rate of up to 20%, 100 participants were planned.

Following data entry, a random sample of 10% was re-entered into the database to verify values. A Student's *t* test or χ^2 analysis, as appropriate, was used to compare participant characteristics. Lipids at weeks 5 and 10 after randomization were compared by a paired *t* test, which was also used to compare changes in body weight and diet within each period. Analyses using the means of weeks 4 and 5 as well as 9 and 10 did not differ substantially. Comparisons were also made across groups at the end of each period (Student's *t* test). A general linear model of repeated measures analysis was done to determine if there were period treatment interactions (none were found). Because 3 *p* values were calculated for each lipid, the Bonferroni adjustment was used to determine statistical significance. Thus, only $p < 0.017$ were considered statistically significant. Software utilized for analyses was SPSS version 15.0 (SPSS Inc., Chicago, Ill., USA).

Results

Figure 1 shows the flow chart ($n = 141$). Ineligibility for the study was due to too low LDL cholesterol ($n = 15$), too high LDL cholesterol levels ($n = 4$), too high triglycerides ($n = 6$), BMI above the cutoff ($n = 4$), BMI below

Table 1. Study participant characteristics at screening for subjects that were randomized to start with usual diet (n = 51) versus subjects that started with figs-added diet (n = 51)

	Usual diet	Figs-added	p value
Age, years	54.8 ± 11	56.2 ± 10	0.52
Gender			0.67
Female	34 (66.7)	36 (70.6)	
Male	17 (33.3)	15 (29.4)	
Ethnicity			0.49
White	17 (33.3)	19 (37.3)	
Hispanic	13 (25.5)	10 (19.6)	
Caribbean	3 (5.9)	0 (0)	
Black/Hispanic	0 (0)	1 (2)	
Black	8 (15.7)	6 (11.8)	
Asian	7 (13.7)	10 (19.6)	
Unknown	3 (5.9)	5 (9.8)	
Lipid values			
Total cholesterol, mg/dl	205 ± 32	203 ± 27	0.77
Triglycerides, mg/dl	128 ± 60	113 ± 59	0.20
HDL cholesterol, mg/dl	55 ± 15	56 ± 13	0.78
LDL cholesterol, mg/dl	136 ± 23	135 ± 22	0.77
BMI, kg/m ²	25 ± 4	26 ± 3	0.21
TSH, mIU/ml	2.4 ± 1.3	2.5 ± 1.4	0.77
Glucose, mg/dl	93 ± 11	93 ± 13	0.99
Creatinine, mg/dl	0.9 ± 0.2	0.9 ± 0.3	0.70
ALT, U/l	21 ± 11	28 ± 15	0.08
Systolic blood pressure, mm Hg	125 ± 19	125 ± 22	0.98
Diastolic blood pressure, mm Hg	79 ± 9	80 ± 10	0.70

Figures in parentheses are percentages. For continuous variables, means ± SD are shown. TSH = Thyroid stimulating hormone; ALT = alanine aminotransferase.

the cutoff (n = 1) and lack of interest in the study (n = 9). Thus, the total number randomized was 102, of which 51 subjects began with the figs-added diet and 51 subjects began with the usual diet. There were 8 participants who dropped out among those initially randomized to the figs-added diet (3 were lost to follow-up, 1 developed persistent diarrhea, 1 disliked figs, 1 had a family emergency, 1 was diagnosed with cancer and 1 started cholesterol-lowering medication). Among those that started with the usual diet, 6 dropped out (3 were lost to follow-up, 1 had a family emergency, 1 developed diarrhea and 1 disliked figs). Of 88 completing subjects, 83 had final blood tests drawn but 1–3 were missing a specific lipid value.

Table 1 lists the characteristics of participants randomized to usual or to figs-added diet at screening. They were evenly distributed in relation to demographic, an-

thropometric, and laboratory values. Table 2 shows that body weight increased slightly at the end of the figs-added diet compared to the usual diet with a mean difference of 0.4 kg, however, this difference did not achieve statistical significance. Table 3 shows the dietary data. There was an increase in energy intake (187 ± 44 kcal) during the figs-added compared to the usual diet. The percentage of energy from fat and protein was reduced while the percentage of energy from carbohydrates and sugar was increased. When examined according to the Vinson [9] data, there was an increase in soluble fiber intake in the figs-added diet.

Total cholesterol was 224 ± 45 mg/dl with the usual diet versus 230 ± 41 mg/dl with the figs-added diet (p = 0.021), LDL cholesterol was 127 ± 31 mg/dl with the usual diet versus 130 ± 27 mg/dl with the figs-added diet (p = 0.111), HDL cholesterol was 53 ± 15 mg/dl in both dietary phases (p = 1.0) and triglycerides were 132 ± 91 mg/dl with the usual diet versus 135 ± 109 mg/dl with the figs-added diet (p = 0.06). However, inspection of data indicated that the two groups' lipid concentrations differed. Thus, analyses of subjects starting with figs-added and switching to usual diet are shown separately from analyses of subjects starting with usual diet and crossing over to the figs-added diet. Table 4 shows that for subjects who started with figs-added diet, there was no change in lipid concentrations. However, for subjects that started with the usual and crossed over to the figs-added diet, there was an increase in total cholesterol and a similar trend in LDL cholesterol, though not with the Bonferroni correction. Triglyceride and HDL cholesterol concentrations were unchanged within both groups.

Discussion

We found no changes in LDL cholesterol concentrations in hyperlipidemic subjects who added figs to their usual diet, compared to their usual diet alone. HDL cholesterol levels were also unchanged. The study population was a hyperlipidemic one, in which any effects of fiber in lowering LDL cholesterol would be expected to be manifest. Foods from sources like oats and barley that are high in soluble fiber significantly lower LDL cholesterol and thereby total cholesterol [4]. However, oats and barley do not contain such large amounts of sugar per gram as figs (table 5). Despite the increase in sugar intake triglyceride concentrations did not change significantly.

Table 2. Anthropometric data of participants that completed the study at screening and at the end of the figs-added and usual diet phases

	Screening (n = 88)	Usual diet (n = 85)	Figs-added diet (n = 88)	Mean difference	p value
BMI, kg/m ²	26.4 ± 4.0	26.4 ± 4.0	26.6 ± 4.0	-0.2	0.06
Body weight, kg	71.0 ± 13.4	71.0 ± 13.5	71.4 ± 14.0	-0.4	0.08

Means ± SD are shown. Body weight was missing for 3 subjects at the end of the usual diet. p values indicate significance level for paired t tests comparing the end of the figs-added versus usual diet.

Table 3. Nutrient intake of study participants during the usual versus figs-added diets (n = 84; data missing for 4 subjects)

Variable	Usual diet	Figs-added diet	p value
Energy, kcal	1,646 ± 621	1,854 ± 695	0.002
% Energy			
Fat	29.1 ± 7.6	25.0 ± 7.0	<0.0001
Saturated fat	8.1 ± 3.0	6.6 ± 2.8	<0.0001
Polyunsaturated fat	7.8 ± 3.1	6.5 ± 2.3	<0.0001
Monounsaturated fat	10.9 ± 3.6	9.6 ± 3.2	<0.0001
Carbohydrates	58.5 ± 8.7	64.9 ± 9.0	<0.0001
Sugar	23.4 ± 6.5	32.2 ± 6.3	<0.0001
Protein	15.6 ± 4.7	14.4 ± 3.9	0.008
Fiber total, g	29.0 ± 13.5	37.7 ± 12.4	<0.0001
Cholesterol, mg	137 ± 114	138 ± 139	0.76
Soluble fiber, g			
Database	8.2 ± 4.1	8.5 ± 3.2	0.28
Measured (Vinson 1999)	8.2 ± 4.1	12.6 ± 3.7	<0.0001

We are not aware of previous studies examining the effects of dried fruit, specifically dried California Mission figs, as a source of soluble fiber to lower LDL cholesterol in hyperlipidemic adults. Our study was planned to expect an approximately 3–4% reduction in LDL cholesterol based on the amount of soluble fiber in dried California mission figs reported by Vinson [9] in 1999. Though the study power was adequate, no effect was seen. A number of explanations may be relevant. While consuming their usual diet, subjects reported that approximately 59% of energy was from carbohydrates including almost one fourth from sugar, while <30% of energy was from fat. Compared to the general population [5], fat intake was lower and carbohydrate intake was higher, probably reflecting the subjects' awareness of hypercholesterolemia and attempts to limit dietary fat. Fur-

Table 4. Serum lipid concentrations in participants randomized to figs-added versus usual diet for 5 weeks (results of final blood tests shown)

	Period 1 (5 weeks) figs-added diet	Period 2 (5 weeks) usual diet	p value
<i>n</i> = 42			
Total cholesterol, mg/dl	231 ± 46	227 ± 34	0.4
HDL cholesterol, mg/dl	53 ± 17	54 ± 14	0.06
Triglycerides, mg/dl	141 ± 132	139 ± 78	0.9
LDL cholesterol, mg/dl	134 ± 32	127 ± 22	1.0
	usual diet	figs-added diet	p value
<i>n</i> = 41			
Total cholesterol, mg/dl	215 ± 41	235 ± 48	0.01
HDL cholesterol, mg/dl	52 ± 14	55 ± 17	0.1
Triglycerides, mg/dl	131 ± 82	141 ± 131	0.1
LDL cholesterol, mg/dl	119 ± 27	135 ± 32	0.02

Means ± SD are shown. Five participants did not have final blood tests. At the end of period 1, lipid values did not differ between the two groups (p = 0.1 for total cholesterol; p = 0.9 for HDL cholesterol; p = 0.7 for triglycerides, and p = 0.02 for LDL cholesterol). At the end of period 2, lipid values did not differ between the two groups (p = 0.4 for total cholesterol; p = 0.7 for HDL cholesterol; p = 0.9 for triglycerides, and p = 0.2 for LDL cholesterol).

thermore, subjects' intake of dietary fiber was exceptionally high (mean of 29 g/day), about double of what is reported by the general population. Thus, the baseline fiber intake may have been too high for the effects of moderate amounts of added fiber to be revealed.

Serum total cholesterol levels increased in the group that began with their usual diet and crossed over to the figs-added diet, a finding that is not explained by the di-

Table 5. Comparison of food sources rich in soluble fiber (per 100 g)

	Energy kcal	Carbo- hydrate g	Sugar g	Fiber g	Pectin g
Figs, dried, uncooked	249	63.9	47.9	9.8	2.8
Corn flakes	361	87.1	10.5	0.7	2.5
Carrots, raw	52	12	6	4	0.8
Apple, fresh	49	16	3.3	3	0.5
Apricots, dried	55	62	41.7	7	0.7
Lentils	116	20.1	1.8	7.9	0.4
Peaches, fresh	50	9	9	1.5	0.7
Prunes, dried	339	62.7	25	7	1.8
Orange, fresh	64	16	13	3	2.6

Nutrition Data System for Research [10].

etary changes observed. It is possible that the approximately 38% increase in sugar intake in the figs-added diet stimulated VLDL synthesis [11]. It is well established that dietary carbohydrates stimulate hepatic VLDL, and simple carbohydrates have a greater stimulatory effect than complex ones [12]. Increased VLDL may lead to increased LDL formation and thus increased total cholesterol levels, and may have counteracted the effect of fiber on lipids. In this context, it may be notable that participants had a high sugar intake already before the study.

There was no change in HDL cholesterol with fig consumption. Some data have indicated an effect of dietary fiber on increasing HDL cholesterol, but most studies indicate that HDL cholesterol concentrations are unchanged [11]. Increased dietary carbohydrates are associated with decreased HDL cholesterol [11]. Furthermore, the decrease in fat intake, particularly saturated fat intake, with the figs-added diet would be expected to lower HDL cholesterol. In general, study subjects reported high levels of physical activity (data not shown) and a number were recruited from the local fitness center. High levels of physical activity may counteract dietary effects on HDL cholesterol [13].

The supplemented figs provided about 330 kcal/day, while the reported diet showed an increase of 187 kcal/day, indicating compensatory restriction of other foods. Over the course of 5 weeks, an increase of 6,500 kcal would be expected to be associated with a weight increase of about 0.9 kg. The observed weight change was somewhat smaller and unlikely to cause significant lipid changes.

The strengths of the study include the randomized controlled design, adequately powered number of participants and length of follow-up which was sufficient to show the tolerability of fig consumption and lipid changes. As LDL cholesterol was measured directly, we avoided the typical artefactual reduction in LDL cholesterol that is seen when the Friedewald formula is used to calculate LDL cholesterol in the presence of an increase in triglycerides. A limitation is that we were unable to obtain adequate blood samples from all subjects that completed the study. Furthermore, the subjects were free living, and assessing dietary intake in free living subjects is fraught with threats to validity, which include underreporting and biased reporting of dietary intakes [14]. The use of repeated 24-hour recalls is increasingly recommended to avoid limitations on other methods requiring more effort on the part of the subject [15]. Though the study was conducted within a short time period to avoid seasonal changes, such effects may have been present. The generalizability of the results to other populations is limited, as this population had a high fiber intake at baseline, were health conscious and physically active. Also, the higher soluble content of figs reported by Vinson [9] in 1999 rather than earlier lower values [6] was used to calculate sample size.

In conclusion, consumption of dried figs, despite the high content of soluble fiber, did not lower serum LDL or total cholesterol concentrations. Paradoxically, an increase in total cholesterol was observed in the group randomized to usual followed by figs-added diet. No increase in triglyceride concentrations or lowering of HDL cholesterol was seen despite the increase in dietary sugar.

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