A Low-Viscosity Soluble-Fiber Fruit Juice Supplement Fails to Lower Cholesterol in Hypercholesterolemic Men and Women

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ABSTRACT This study was designed to determine whether a soluble dietary fiber supplement containing gum arabic and pectin in apple juice would lower serum lipids in 110 hypercholesterolemic men and women. Subjects were stabilized on an American Heart Association Phase I diet for 8 wk. Those with elevated low density lipoprotein cholesterol levels, despite dietary modification, continued to follow the diet and were randomly assigned to receive 720 mL/d of apple juice containing 0 (control), 5, 9 or 15 g of gum arabic and pectin (4:1 ratio) for 12 wk, followed by a 6-wk apple juice-only washout phase. Serum lipid profiles, body weight and 3-day diet records were collected at 3-wk intervals. No significant differences among groups were observed in serum lipid responses during treatment or washout. During the treatment phase, mean serum total cholesterol and triglyceride concentrations increased by 3.5 and 28.5%, respectively (all groups combined, \( P < 0.0001 \)). The high density lipoprotein cholesterol level did not change significantly from baseline in any group. During washout, mean total cholesterol concentration rose by an additional 2.4% (\( P < 0.05 \)) compared with the value at the end of the treatment period, suggesting that the apple juice used to deliver the fiber supplement may have contributed to the adverse changes observed in the serum lipid profile. These findings do not support the hypothesized hypocholesterolemic effect of the gum arabic/pectin (4:1) mixture studied, but do underline the importance of selecting appropriate vehicles for delivery of dietary fiber mixtures.

KEY WORDS: • hypercholesterolemia • water-soluble dietary fiber • viscosity • fructose • humans
which creates difficulties in the manufacturing process and reduces palatability. Gum arabic has a low viscosity and bland flavor, which enabled it to be more easily incorporated into foods. However, its usefulness for lowering elevated cholesterol levels has not been well documented. Pectin consumption lowers cholesterol levels (Lairon 1996), but its high viscosity limits its potential for incorporation into food products. The present randomized, double-blind, controlled study was designed to assess serum lipid responses to three doses of fruit juice containing gum arabic and pectin (4:1 ratio) in hypercholesterolemic subjects consuming a low-fat, low-cholesterol diet.

SUBJECTS AND METHODS

Study subjects. Study participants were recruited from the Chicago, Illinois, area. Men and women, 21–75 y of age, who expressed an interest in a cholesterol-lowering dietary study were asked to attend an orientation at the Rush-Presbyterian-St. Luke’s Medical Center’s Institutional Review Board. The conditions and procedures of the study were explained and a written consent form was obtained from each subject prior to entering the study. The protocol was approved by the Rush-Presbyterian-St. Luke’s Medical Center’s Institutional Review Board.

Medical history was reviewed and subjects underwent a physical examination. All were free of any clinical or laboratory evidence suggesting clinically significant cardiac dysfunction, endocrine, hepatic, renal, and thyroid disease, or drug abuse. Pregnant or lactating females were excluded from the study, as were persons with familial hypercholesterolemia or familial combined hyperlipidemia, and those greater than 150% of ideal body weight. All lipid-lowering agents and therapies, including dietary fiber supplements, were discontinued at least 6 wk prior to the initial qualifying blood draw.

Diet and screening. At screening, subjects were instructed by a dietitian on following an AHA Phase I Diet (American Heart Association 1988), which consisted of no more than 30% of energy from total fat; ≤10% of energy from saturated fat; and total cholesterol intake of less than 300 mg/dL. Participants also were instructed on how to record dietary intake in food records for three consecutive days, including one weekend day.

During the final 2 wk of the 8-wk diet stabilization period, fasting plasma lipid profiles were determined by the mean of two consecutive weekly measurements. Persons with >15% variation in LDL cholesterol levels during the baseline period were excluded [100 × (maximal value − minimal value)/mean value]]. To qualify for participation, subjects were required to have mean triglyceride levels <3.36 mmol/L and (i) LDL cholesterol > 4.13 mmol/L, or (ii) LDL cholesterol between 3.36 and 4.13 mmol/L and definite CHD, or (iii) LDL cholesterol between 3.36 and 4.13 mmol/L plus two or more CHD risk factors. Positive risk factors for CHD include: male ≥45 y of age, female ≥55 y of age or with premature menopause without estrogen replacement therapy, family history of premature CHD, current cigarette smoking, hypertension, high-density lipoprotein (HDL) cholesterol <35 mg/dL (0.9 mmol/L), and diabetes mellitus. In addition, participants were required to have adequate adherence to the AHA Phase I Diet, defined as dietary fat consumption of ≥30% of energy determined by computerized analysis of food records collected ca. 2 wk prior to randomization. Individuals who, at screening, were already adhering to an AHA Diet and had met the lipid inclusion criteria, bypasses the diet stabilization period and entered directly into the treatment phase. Therefore, notably, diet stabilization lipid analyses were conducted only on the subset of subjects who entered the diet stabilization phase.

Randomization. Of the 214 subjects screened, 104 were not eligible for randomization. The remaining 110 subjects were assigned, using a stratified randomization scheme, to one of four treatment groups to receive a supplement of 0 (control), 5, 9 or 15 g/d of soluble fiber in apple juice for 12 wk. Group assignment was stratified according to LDL cholesterol concentration (average of wk −2 and −1) as designated by low (3.36–4.37 mmol/L), medium (4.39–4.91 mmol/L), or high (≥4.91 mmol/L).

The SF mixture consisted of four parts gum arabic (an exudate from trees of the genus Acacia, family Leguminosae) to one part pectin (a high methoxyl form such as is found in apples and citrus fruits) dissolved in apple juice (Committee on CODEX Specifications 1981) (Table 1). Subjects were instructed by a dietitian to substitute their current juice, fruit or carbohydrate intake with three 240-ml servings of apple juice (either control or fiber-enriched juice) per day for the 12-wk treatment period of the study. These doses were chosen because they make a significant contribution to the recommended intake of total dietary fiber and meet or exceed levels of soluble fiber found in standard servings of many fresh fruits, vegetables and a number of bran cereals. The treatment period was followed by a 6-wk double-blind washout during which time all subjects consumed the apple juice placebo. All treatment and placebo juices were packaged and distributed by Gerber Products Company (Fremont, MI).

Study procedures. Subjects returned to the clinic at 3-wk intervals during the study for measurement of weight and vital signs, fasting blood sample collection, dietary counseling and a product compliance check. Dietary compliance was assessed by registered dietitians during patient interviews (wk −7, −4, −2, 0, 6, 12, 18) by reviewing and scoring the most recent 3-d diet record using the Food Record Rating System. Computerized food record analyses for wk −7, −4, −2, 0, 6, 12 and 18 were completed by the Nutrient Analysis Center at the Chicago Center for Clinical Research by utilizing the University of Minnesota’s Nutrient Data System (NDS), version 2.1. Adverse experiences and concomitant medications were documented throughout the study. Hematology and blood chemistry were monitored at baseline and at the end of the treatment period.

Lipid analyses. Lipid profiles (total, LDL and HDL cholesterol and triglycerides), were determined at baseline (the average of wk 0, 6, 12 and 18) by Parke-Davis Laboratories (Chicago, IL). Total cholesterol and triglycerides were measured enzymatically using a multiphasic chemistry analyzer that had been calibrated against the Center for Disease Control lipid standards (Atlanta, GA). HDL cholesterol was enzymatically assayed by using dextran sulfate as the precipitant (Warnick et al. 1982) and a discrete random access analyzer. LDL cholesterol (in mg/dL) levels were calculated using the formula: LDL cholesterol = total cholesterol − HDL cholesterol − (triglycerides/5) (Friedewald et al. 1972).

Statistical analysis. A multivariate analysis of variance with repeated measures was performed for the lipid data collection at wk 3, 6 and 9, and wk 12, 15 and 18. A second multivariate analysis with repeated measures was performed to determine if there was significant time by treatment group interaction. Treatment groups were further tested at each time point using an endpoint analysis compared to baseline. To verify dietary compliance, a multivariate analysis of variance with repeated measures was performed for several nutritional variables. The probability level for significance was set at P < 0.05. All statistical analyses were performed using SAS statistical analysis package (SAS Institute Inc., Cary, NC).

### Table 1

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Average content/240 mL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy, kJ</td>
<td>483.0</td>
</tr>
<tr>
<td>Protein, g</td>
<td>0.2</td>
</tr>
<tr>
<td>Fat, g</td>
<td>0.3</td>
</tr>
<tr>
<td>Carbohydrate, g</td>
<td>29.0</td>
</tr>
<tr>
<td>Sugars, g</td>
<td>28.9</td>
</tr>
<tr>
<td>Sucrose, % sugar</td>
<td>4.1</td>
</tr>
<tr>
<td>Glucose, % sugar</td>
<td>5.6</td>
</tr>
<tr>
<td>Fructose, % sugar</td>
<td>16.3</td>
</tr>
<tr>
<td>Total dietary fiber, g</td>
<td>0.3</td>
</tr>
<tr>
<td>Calcium, mg</td>
<td>7.5</td>
</tr>
<tr>
<td>Phosphorus, mg</td>
<td>15.0</td>
</tr>
<tr>
<td>Iron, mg</td>
<td>0.3</td>
</tr>
<tr>
<td>Sodium, mg</td>
<td>2.5</td>
</tr>
<tr>
<td>Potassium, mg</td>
<td>222.3</td>
</tr>
<tr>
<td>Ascorbic acid, mg</td>
<td>2.3</td>
</tr>
</tbody>
</table>

![Table 1](https://example.com/table1.jpg)
RESULTS

Evaluate sample. Of the 110 subjects who were randomly assigned to treatment groups, 85 completed the study through the end of the 12-wk treatment period, and 80 completed the study through the washout period (wk 18). Twenty-five participants discontinued the study (overall attrition rate = 23%) for the following reasons: newly diagnosed diabetes mellitus based on baseline measurements (n = 5); intolerance of the apple juice product (n = 5); dropped by investigator due to noncompliance (n = 3); personal reasons (n = 3); adverse events unrelated to apple juice product (n = 2); loss of follow-up or incomplete data (n = 4); elevated triglycerides (n = 1); lipid instability (n = 1); and need for medical therapy for hyperlipidemia (n = 1). Overall, the apple juice product was well-tolerated. Mean percentage compliance [100 × (scheduled servings − servings consumed)/scheduled servings] was ~94% for all four groups during the treatment period.

Baseline characteristics. The baseline demographic characteristics of subjects who completed the treatment period are shown in Table 2. No significant differences existed among groups in age or body mass index; 26 females and 59 males completed the study. Group assignment was not stratified on gender, resulting in a slight imbalance; the placebo group had a lower proportion of female subjects than the other groups (56 vs. ~75% in the other treatment arms, P = 0.07).

Lipid response

Dietary instruction/stabilization period. Following the 8-wk diet stabilization period, subjects meeting the lipid inclusion criteria had significant decreases from screening levels in total cholesterol (0.28 mmol/L) and LDL cholesterol (0.26 mmol/L) (P ≤ 0.01 for both).

Treatment period. Serum lipid concentrations during the treatment period are summarized in Table 3. No significant treatment effect or treatment by time interactions was noted. No between-treatment group differences existed in any of the lipid responses. Mean total cholesterol levels of all groups combined increased by 3.5% during 12 wk of treatment (P < 0.0001, time main effect). Mean triglyceride concentrations also showed a highly significant 28.5% increase during the 12-wk treatment period (P < 0.0001). LDL cholesterol responded biphasically during the treatment period: during the first 3 wk of treatment, levels increased from baseline and then decreased from wk 6 to 12 to a final value that was not significantly different from baseline. HDL cholesterol levels did not differ from baseline values during the 12 wk of treatment.

Washout period.

Lipid profiles for the end of the washout period (wk 18) are

TABLE 2
Baseline demographic characteristics of human subjects who consumed fruit juice containing 0, 5, 9 or 15 g/d SDF for a 12-wk treatment period1

<table>
<thead>
<tr>
<th>SDF/d</th>
<th>Placebo</th>
<th>5 g</th>
<th>9 g</th>
<th>15 g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 16</td>
<td>n = 22</td>
<td>n = 22</td>
<td>n = 25</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male, n</td>
<td>7</td>
<td>16</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>Female, n</td>
<td>9</td>
<td>6</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Age, y</td>
<td>59.0 ± 8.8</td>
<td>55.5 ± 10.9</td>
<td>59.3 ± 9.5</td>
<td>59.6 ± 10.5</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>25.4 ± 3.6</td>
<td>26.0 ± 2.9</td>
<td>26.8 ± 4.3</td>
<td>26.1 ± 3.5</td>
</tr>
</tbody>
</table>

1 BMI, body mass index; SDF, soluble dietary fibers.

TABLE 3
Serum lipid concentrations in human subjects at baseline, after 12-wk treatment with 0, 5, 9 or 15 g/d soluble dietary fiber in a fruit juice carrier, and after a washout period of fruit juice consumption (18 wk)1

<table>
<thead>
<tr>
<th>Plasma lipid</th>
<th>All groups</th>
<th>Placebo</th>
<th>5 g</th>
<th>9 g</th>
<th>15 g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 85</td>
<td>n = 16</td>
<td>n = 22</td>
<td>n = 22</td>
<td>n = 25</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>6.49 ± 0.17</td>
<td>6.80 ± 0.22</td>
<td>6.45 ± 0.15</td>
<td>6.37 ± 0.15</td>
<td>6.35 ± 0.16</td>
</tr>
<tr>
<td>Week 12</td>
<td>6.72 ± 0.19†</td>
<td>6.88 ± 0.26</td>
<td>6.46 ± 0.15</td>
<td>6.38 ± 0.17</td>
<td>6.66 ± 0.20</td>
</tr>
<tr>
<td>Week 18</td>
<td>6.88 ± 0.22†</td>
<td>7.47 ± 0.31</td>
<td>6.67 ± 0.19</td>
<td>6.88 ± 0.17</td>
<td>6.51 ± 0.21</td>
</tr>
<tr>
<td>LDL-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>4.34 ± 0.14</td>
<td>4.57 ± 0.19</td>
<td>4.30 ± 0.12</td>
<td>4.18 ± 0.12</td>
<td>4.32 ± 0.11</td>
</tr>
<tr>
<td>Week 12</td>
<td>4.35 ± 0.17</td>
<td>4.58 ± 0.25</td>
<td>4.31 ± 0.14</td>
<td>4.19 ± 0.16</td>
<td>4.42 ± 0.14</td>
</tr>
<tr>
<td>Week 18</td>
<td>4.47 ± 0.18†</td>
<td>4.87 ± 0.28</td>
<td>4.34 ± 0.17</td>
<td>4.34 ± 0.13</td>
<td>4.32 ± 0.15</td>
</tr>
<tr>
<td>HDL-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>1.43 ± 0.07</td>
<td>1.54 ± 0.09</td>
<td>1.45 ± 0.06</td>
<td>1.46 ± 0.07</td>
<td>1.25 ± 0.07</td>
</tr>
<tr>
<td>Week 12</td>
<td>1.44 ± 0.07</td>
<td>1.55 ± 0.08</td>
<td>1.46 ± 0.10</td>
<td>1.47 ± 0.07</td>
<td>1.21 ± 0.07</td>
</tr>
<tr>
<td>Week 18</td>
<td>1.48 ± 0.10</td>
<td>1.68 ± 0.12</td>
<td>1.42 ± 0.10</td>
<td>1.52 ± 0.08</td>
<td>1.30 ± 0.09</td>
</tr>
<tr>
<td>TG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>1.57 ± 0.12</td>
<td>1.49 ± 0.12</td>
<td>1.53 ± 0.15</td>
<td>1.58 ± 0.12</td>
<td>1.68 ± 0.11</td>
</tr>
<tr>
<td>Week 12</td>
<td>2.01 ± 0.18*</td>
<td>1.81 ± 0.17</td>
<td>1.78 ± 0.15</td>
<td>2.22 ± 0.20</td>
<td>2.23 ± 0.20</td>
</tr>
<tr>
<td>Week 18</td>
<td>2.03 ± 0.18</td>
<td>1.99 ± 0.19</td>
<td>1.99 ± 0.21</td>
<td>2.20 ± 0.18</td>
<td>1.93 ± 0.16</td>
</tr>
</tbody>
</table>

1 Values are means ± SEM. Washout periods includes values for only 80 subjects. SDF, soluble dietary fiber; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; TG, triglycerides. * Significantly different from baseline P < 0.05; † significantly different from the end of the treatment period P < 0.05.
shown in Table 3. Total cholesterol concentrations of all
groups combined continued to rise throughout the washout
period from 6.72 mmol/L at wk 12, to 6.76 mmol/L at wk 15,
and 6.88 mmol/L at wk 18 (P < 0.05). These changes repre-
sent an increase of ~2.4% compared with the end of the
treatment period. LDL cholesterol levels showed a parallel
increase from the end of the treatment period to the end of
washout (2.7%, P < 0.05). Triglyceride and HDL cholesterol
levels were not altered significantly from the end of treat-
ment to the end of washout. Results from analyses of lipid profiles
performed on specific study subgroups at each time point
resembled the results of the entire cohort.

**Diet and body weight data.** Baseline dietary intakes ex-
pressed as means for a 3-d period did not differ among treat-
ment groups and are shown in Table 4. Three-d diet records
collected at baseline and during the treatment period indicate
that all treatment groups were successful in achieving the
recommended intakes of total fat, saturated fat and choles-
terol. During treatment, no differences between groups were
observed for any of the dietary components evaluated except
soluble fiber.

Compared to baseline, total energy intake was higher by
~1260 kJ during the treatment and washout periods (P
< 0.05). This increase was accounted for primarily by an
increased intake of total carbohydrate, particularly fructose.
Soluble fiber intake was also higher during the treatment
period compared with baseline (P < 0.05). The percentages of
total energy from fat, saturated fat, monounsaturated fat and
protein in all groups were decreased by 12.9, 16.9, 14.9 and
15.8%, respectively, during the treatment period compared
with baseline.

Body weight rose slightly in all groups, including the pla-
cebo group, over the 12-wk treatment period. Mean changes
ranged from 0.17 to 1.6 kg (P < 0.0001, for time main effect).
Changes in body weight were not significantly different among
treatment groups.

**DISCUSSION**

The present study was designed to investigate the effects of
5, 9 or 15 g/d of an SDF mixture, dissolved in apple juice, on
serum lipids among hypercholesterolemic subjects consuming
an AHA Phase I Diet. The SDF mixture contained both
high-viscosity (pectin) and low-viscosity (gum arabic) fibers to
create a palatable supplement with a broad range of potential
product applications. The results of this study do not support
the existence of a hypercholesterolemic effect of this fiber
mixture. This contrasts with findings from other studies that
have reported lipid-lowering effects of SDF (Anderson et al.
1961, Ross et al. 1983, Sharma 1986). Factors that may have
contributed to the lack of a hypercholesterolemic effect in the
present study include insufficient dose, the comparatively low
viscosity of the fiber mixture employed, and the effects of the
apple juice vehicle used to deliver the fiber mixture.

Studies reporting a hyperlipidemic response to consump-
tion of gum arabic have most frequently utilized doses of 25 to
30 g/d. This level of consumption has generally produced
reductions in serum cholesterol of 6 to 10% (Ross et al. 1983,
Sharma 1986). In the present study, the amounts of gum arabic
consumed by the three treatment groups were ~4.0, 7.2 and
12.0 g/d.

Pectin, at intakes ranging from 10 to 50 g/d, consistently
lowered total cholesterol by 5 to 19%, mostly due to a decrease
in LDL cholesterol, in both normal individuals and those with
hypercholesterolemia (Judd and Truswell 1985). No clear
dose-response relationship emerged from these studies; how-
ever, apparently, consumption of 10 g of pectin daily lowers
serum cholesterol, while 6 g/d may not be sufficient to alter the
lipid profile. The levels of pectin consumed by subjects in the
present study were ~1.0, 1.8 and 3.0 g/d. Therefore, at even
the highest level of intake, the doses of the individual fibers
utilized in the present trial were lower than those shown to be
effective for lowering serum cholesterol levels (Judd and Trus-

A second factor that may have contributed to the lack of
effect in our trial may have been the relatively low viscosity of
the fiber mixture. A substantial body of evidence now exists
indicating that viscosity plays an important role in determin-
ing the hypercholesterolemic capacity of SDF (Blackburn and
Johnson 1983, Gee et al. 1983, Lund et al. 1989). High-
viscosity fibers form a gel-like mass in the intestinal tract that
hinders access of enzymes to glycosidic bonds, impedes micelle
formation and may also change the physicochemical properties
of the unstirred water layer, making transit across this layer

![Table 4](https://academic.oup.com/jn/article-abstract/128/11/22/22460/22460)
more difficult (Jenkins et al. 1978). The result is a slowing of digestion and/or absorption of dietary carbohydrate and lipid. Haskell et al. (1992) showed that a low-viscosity acacia gum at a dose of 15 g/d had no effect on the lipid profile compared to placebo. In contrast, a higher viscosity fiber mixture decreased total and LDL cholesterol by 8.3 and 12.4%, respectively (Haskell et al. 1992). The same group used low-viscosity acacia gum as an inactive control in a subsequent trial (Jensen et al. 1997).

Nonviscous, fermentable carbohydrates such as inulin, a fructooligosaccharide, have lipid-lowering minimal effects (Davidson et al. 1998c, Luo et al. 1996). Our group and others showed clinically important hypercholesterolemic effects of higher viscosity SDF such as psyllium, β-glucan from oats and hydroxypropylmethylcellulose at daily doses similar to, or lower than, those employed in the present study (Davidson et al. 1991, 1996, 1998a, 1998b, Glore et al. 1994).

In addition to viscosity, other properties may contribute to an SDF’s hypercholesterolemic effect, including, fermentability and ability to bind bile acids (Everson et al. 1992, Laurin 1996, Marlett et al. 1994). SDF is fermented by colonic bacteria to form short-chain fatty acids and gases that may be absorbed into the portal vein. Short-chain fatty acids impair hepatocellular cholesterol synthesis in rats, but in humans their role remains underdetermined (Anderson 1987, Schneeman 1990, Vahouny et al. 1980).

In the present study, all groups (including controls) showed elevations in triglycerides and, to a lesser extent, total cholesterol, which may be partially attributable to the high-fructose apple juice that was used to deliver the fiber supplement and as a control beverage. Several studies showed that increasing dietary fructose intake, particularly when consumed in a solution, may elevate triglycerides and very low density lipoprotein cholesterol by increasing activities of hepatic lipogenic enzymes (Hallfrisch 1990, Hollenbeck 1993). The results of the current study support this possibility since the increase in fructose intake paralleled the increases in levels.

Subjects were instructed to make isocaloric substitutions to their diet while consuming the study product (apple juice). Diet records suggest that energy intake was ~1260 kJ per day during the treatment and washout periods than at baseline. However, baseline diet records suggest that energy consumption was underreported, since values were 20–35% below the energy consumption expected for weight maintenance. Changes in body weight were small during the trial, averaging ~1 kg across the four treatment groups. Therefore, it is unlikely that energy imbalance contributed substantially to the alterations in lipid profiles observed.

In summary, the results of this study did not demonstrate a serum lipid-lowering effect of a gum arabic-pectin supplement in hypercholesterolemic subjects consuming an AHA Phase I Diet. The absence of a lipid response to this SDF supplement may be due to insufficient dose or the low viscosity of the fiber mixture. In addition, the apple juice used as a vehicle for the fiber supplement may have contributed to the elevation in triglyceride and cholesterol levels observed in all groups, including control. The results of this study both support the concept that not all SDF are equally effective for reducing elevated cholesterol levels and underline the importance of selecting an appropriate vehicle for delivery of SDF supplements to achieve a favorable lipid response.

ACKNOWLEDGMENTS

We thank Sarah Torri and Phil Lofgren for their technical assistance with the preparation and review of this manuscript.

LITERATURE CITED


