Guar Gum and Plasma Cholesterol
Effect of Guar Gum and an Oat Fiber Source on Plasma Lipoproteins and Cholesterol in Hypercholesterolemic Adults

Gene A. Spiller, John W. Farquhar, Joan E. Gates, and Stephen F. Nichols

The hypolipidemic effect of guar gum (GG, 15 g/day) was compared with that of an oat fiber source (OFS, 77 g/day). Both treatments supplied the same amount of total dietary fiber (11 g/day) and were taken with water three times a day for 3 weeks at mealtime. Thirteen free-living adult men and women participated in the study. Their total plasma cholesterol (TC) was 244±21 mg/dl (mean±SD), and plasma triglycerides (TGLYs) were 149±93 mg/dl before the intervention. Diets were monitored to ensure that no changes occurred other than the replacement of carbohydrate calories for the 200 kcal/day supplied by the OFS. Combined averages for both of the crossover phases showed that GG induced a reduction in TC of 26±10 mg/dl and in low density lipoprotein cholesterol of 25±9 mg/dl. The OFS induced a reduction in TC of 9±13 mg/dl and in low density lipoprotein cholesterol of 11±4 mg/dl. Although both treatments were effective in reducing elevated TC, GG at the levels fed was significantly more effective (<0.001) in reducing TC. Neither treatment induced significant changes in high density lipoprotein cholesterol or very low density lipoprotein cholesterol. (Arteriosclerosis and Thrombosis 1991;11:1204-1208)

Some water-soluble dietary fiber (WSDF) fractions have been shown to be hypocholesterolemic in humans.1-3 These WSDFs can be used in human diets to lower total plasma cholesterol (TC) in two ways that relate to the concentration of the WSDF in the product used.

The first way is to use highly concentrated substances, usually gums that typically have a WSDF content greater than 70%. Guar gum (GG; Cyamopsis tetragonolobus) is the best known of this group. These gums can be incorporated into the diet by addition to prepared foods such as puddings or by dispersal in a glass of fluid. Research on these types of substances dates back to the work of Jenkins et al1 in the late 1970s. Many more studies have followed, and all have confirmed the cholesterol-lowering efficacy of certain gums, such as guar, which are usually provided in amounts of approximately 15 g/day.2,4-8

The second way that WSDFs can be used to lower TC is by using a whole unrefined food that contains reasonable amounts of hypocholesterolemic WSDFs, such as β-glucan or pectin, as well as digestible macro-

nutrients. β-Glucan is found in oats and is probably the hypocholesterolemic portion of the WSDF in oats. Because most β-glucan is found in a layer between the bran and the endosperm of this grain, commercial oat brans vary somewhat in both total WSDF and β-glucan content. Total WSDF in commercial oat bran samples has been found to vary, from as low as 8% to as high as 28%, with different percentages of β-glucan. This variability has led to conflicting results in published research on the effect of oat bran on TC.9-14 Pectins are also found in a wide range of concentrations in fruits and vegetables.15

Because most plant gums are practically all WSDF, their addition to the diet can be virtually calorie free. However, the addition of a whole unrefined food high in WSDF to the diet is accompanied by various amounts of macronutrients that supply calories and that may affect the macronutrient balance of that diet. Thus, the cholesterol-lowering efficacy of whole foods high in WSDF may be due to the combined effect of the fiber and of the altered macronutrient balance of the diet.

As gums have not been compared with foods high in WSDF in a single study in a homogeneous population, we compared, using a crossover design, the effect of GG as a well-known hypocholesterolemic gum to that of oats as a common food containing β-gluçans (oat fiber source [OFS]). The choice of the term OFS rather than oat bran has been made to avoid generalization to other oat brans that may have...
a different β-glucan content. In general, the fiber contents of the oat brans used in published studies vary and are often poorly defined in the publication. This situation points out the importance of defining the term oat bran carefully in future studies. Because of these problems and in view of the welcome, recent official definition of oat bran by the Association of Cereal Chemists,16 we have chosen to call our oat product OFS rather than oat bran.

Methods

Subjects

Sixteen male and female adults, all residents of the Palo Alto area in northern California, were entered into the study after a preliminary medical history review and laboratory screening for TC greater than 200 mg/dl and triglyceride (TGLY) less than 400 mg/dl. Three subjects did not complete the study. One subject developed acute diverticulitis after his first OFS treatment—the problem was found to be unrelated to the small amount of treatment taken. A second subject dropped out before any treatment was started due to a family emergency, and a third subject experienced soft, frequent stools on the GG treatment and withdrew after 3 weeks. Thirteen subjects completed both phases of the study. The age of these thirteen subjects was 62±3.0 years (mean±SD; range, 59–70 years); their body weight was 70±10.8 kg, (range, 51–86 kg), all within ±25% of the standards of the 1983 Metropolitan Height and Weight Tables. Their TC was 247±21 mg/dl (range, 204–276 mg/dl), their TGLYs were 144±95 mg/dl (range, 43–365 mg/dl), and their high density lipoprotein cholesterol (HDL-C) was 62±15 mg/dl (range, 43–365 mg/dl), and their high density lipoprotein cholesterol (HDL-C) was 62±15 mg/dl (range, 43–365 mg/dl), and their high density lipoprotein cholesterol (HDL-C) was 62±15 mg/dl (range, 43–365 mg/dl), and their high density lipoprotein cholesterol (HDL-C) was 62±15 mg/dl (range, 43–365 mg/dl), and their high density lipoprotein cholesterol (HDL-C) was 62±15 mg/dl (range, 43–365 mg/dl). Baseline values used for statistical analysis were the means of the above values and a repeat measurement after 1 week. The second measurement was taken in the morning, before the subjects began taking their treatment.

The protocol of the study, which had been approved by an independent investigational review board, was explained to each subject, who then signed an informed consent. Subjects were told not to take any medication that had not been approved by the investigators and to inform a study investigator immediately should medication become necessary. No subject was taking any cholesterol-lowering medication.

Diets

Subjects were instructed to remain on their normal diet, whether it was fat modified or not, for the duration of the study. Compliance was monitored during the entire study. Subjects were instructed on how to keep 3-day food records during the baseline week and again during the third week of each treatment phase. During each visit for blood sampling, every subject met individually with the study nutritionist, and details of diet compliance were discussed.

Treatments

Each treatment dose was preweighed in a small sealed pouch, and a 3-week supply was distributed at the beginning of each phase. Both treatments were mixed with 8 oz of water or other fluid and ingested three times a day just before meals. The OFS was mixed in warm water or fluid, the GG in cold water or fluid.

To supply the same level (11 g/day) of total dietary fiber (DF), each subject consumed 15 g/day of a specially processed, easily dispersible GG formula with CaCO₃ (Bioguar, Bios, Santa Barbara, Calif.) supplying 72%, or 11 g/day, DF and 10 g/day WSDF in one phase, and 77 g/day of a commercial OFS supplying 11 g/day total DF and 5 g/day WSDF, of which 3.3 g was β-glucan, in the other phase. The OFS was purchased as “oat bran” (Honeyville Grains, Rancho Cucamonga, Calif.), but as previously stated we have chosen to call it OFS, as the amount of endosperm and β-glucan present varies widely in commercial oat brans. This amount of OFS was chosen for two reasons: 1) when mixed with two parts water, the OFS corresponded approximately to the weight of a typical serving of this high-fiber hot cereal (about 240 g) and 2) it supplied approximately the same level of DF per day as the GG. The OFS treatment supplied approximately 200 kcal/day compared with virtually no calories for the GG treatment.

Study Design

Baseline blood lipid levels were measured on days 1 and 7 of the study. Subjects were ranked by their TC values on day 1, so that on day 7 they could be randomized to either GG or OFS during the first phase of the study. They consumed either GG or OFS for a period of 21 days. Blood lipid measurements were obtained on the 14th and 21st day of treatment. On day 21 of the first treatment phase, the GG group was crossed over to OFS, and the OFS group was crossed over to GG for another 21 days. Blood lipid measurements were again taken on the 14th and 21st days of the second treatment phase. Blood lipid levels were measured two final times, 14 and 16 days after cessation of the treatment.

Subjects were weighed at the beginning of the study, at the crossover point, and at the end of the study. They were asked not to attempt to gain or lose weight while on the study.

Plasma Cholesterol and Lipoprotein Measurements

After a 12-hour fast, two 10-ml blood samples were drawn from the antecubital vein of the subjects into Vacutainer tubes containing 15 mg NaEDTA. Each Vacutainer tube was then centrifuged for 10–15 minutes at 800g. The specimens were shipped by overnight air carrier under refrigeration to Northwest Lipid Laboratory in Seattle, Wash., and all samples were analyzed on the day that followed the blood sampling.
HDL-C was separated from plasma by a precipitation procedure with dextran sulfate (50,000 d) and MgCl₂. TC in the remaining plasma and in the separated HDL-C fraction was measured by an enzymatic procedure on a Spectrum bichromatic analyzer (Abbott Laboratories, North Chicago, Ill.). TGLYs corrected for the glycerol blank were analyzed by an enzymatic ultraviolet-type procedure on the Spectrum analyzer. These analytical procedures were standardized and met the performance requirements of the Lipoprotein Standardization Program of the Centers for Disease Control, Atlanta, Ga., and are traceable to the National Reference System for Cholesterol. Very low density lipoprotein cholesterol (VLDL-C) was estimated by dividing the TGLY value by five. Low density lipoprotein cholesterol (LDL-C) was estimated according to the Friedewald algorithm. The long-term interassay coefficient of variation during the study was 1-2% for TC and less than 2.5% for HDL-C at all concentrations measured. Intra-assay coefficient of variation was less than 1.5% for both TC and HDL-C.

Statistical Methodology

The two crossover sequence groups, GG to OFS and OFS to GG, were compared for any baseline differences by a one-way analysis of variance (ANOVA) statistic. The baseline levels of the two crossover sequence groups were compared with the posttreatment levels (averages of days 63 and 65) by use of a two-way ANOVA model.

The average baseline plasma lipid levels were subtracted from the average lipid levels obtained for each of the two treatment phases for each subject. A crossover ANOVA on these differences was used to test for significant differences between the two treatment phases, the two sequence groups, and the two diet treatments. All tests of significance were performed as the α=0.05 levels of significance.

Results

Results of a one-way ANOVA procedure indicated that there were no statistically significant differences between the two sequence groups of subjects for any of the plasma lipid measurements at baseline. The reduction in TC and LDL-C took place in 14 days for both treatments, with no significant changes taking place between days 14 and 21 (Table 1).

The average of all the measured plasma lipids returned to baseline values 2 weeks after treatments were discontinued. The average of two posttreatment measurements (days 63 and 65 of the study) was 244±29 mg/dl for TC, 140±80 mg/dl for TGLY, and 62 ±14 mg/dl for HDL-C.

When the changes indicated in Table 2 were tested against zero (i.e., hypothesis of no change from baseline), both the GG and the OFS caused statistically significant reductions in TC and LDL-C, but the reductions in TC and LDL-C were significantly greater when the subjects were taking GG than when they were taking OFS. There was no significant change in body weight during the study. Body weights

TABLE 1. Effect of Guar Gum and Oat Fiber Source on Plasma Cholesterol and Lipoproteins

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Baseline*</th>
<th>After 14 days†</th>
<th>After 21 days‡</th>
<th>Avg of days 14 and 21§</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TC</td>
<td>TGLY</td>
<td>LDL-C</td>
<td>HDL-C</td>
</tr>
<tr>
<td>Guar gum</td>
<td>244±31</td>
<td>145±93</td>
<td>152±23</td>
<td>62±14</td>
</tr>
<tr>
<td>Oat fiber source</td>
<td>235±26</td>
<td>153±43</td>
<td>142±25</td>
<td>62±14</td>
</tr>
</tbody>
</table>

Values are mean±SD and are in milligrams per deciliter. TC, total cholesterol; TGLY, triglyceride; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; VLDL-C, very low density lipoprotein cholesterol; Avg, average.

*Baseline values are means of days 1 and 7 (before treatments).
†Means of phases 1 and 2 for day 14 for each treatment.
‡Means of phases 1 and 2 for day 28 for each treatment.
§Means of phases 1 and 2 for days 14 and 21 combined.

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TABLE 2. Reduction in Plasma Cholesterol and Lipoprotein by Guar Gum and Oat Fiber Source

<table>
<thead>
<tr>
<th>Treatment</th>
<th>TC*</th>
<th>TGLY</th>
<th>LDL-C</th>
<th>HDL-C*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guar gum</td>
<td>-26±10</td>
<td>-0.5±35</td>
<td>-0.2±6.9</td>
<td>-27±9</td>
</tr>
<tr>
<td>Oat fiber source</td>
<td>-9±13</td>
<td>5.3±40</td>
<td>0.9±8.0</td>
<td>-11±4</td>
</tr>
</tbody>
</table>

Values are mean±SD and are in milligrams per deciliter; values are means of 14 and 21 days after intervention. TC, total cholesterol; TGLY, triglyceride; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol.

*Significant between treatment at p<0.001.
were 70.0±10.8 kg (mean±SD) on day 7 of the study (end of baseline), 69.8±10.9 kg on day 21 (crossover point), and 70.2±10.8 kg at the end of the second phase of the study. This finding confirms that no significant changes in caloric intake had taken place during the study.

Discussion

This study confirms the efficacy of 15 g/day GG taken in 5-g portions three times a day with meals. This amount appeared to be well tolerated by most subjects after a few days of adaptation.

Other GG studies have shown a wide range of results, probably due to the type of GG used, often not well defined in the publication; the degree of hypercholesterolemia of the subjects; or the type of diet and amount of dietary control. The 11% reduction in TC achieved in this study is similar to the 11.7% achieved by Aro et al4 with 15 g/day GG and to the 10% achieved by Superko et al.1 Reductions of 12.8% were achieved by Simons et al6 with 18 g/day, whereas Jenkins et al1 achieved a reduction of 13.6% with 13 g/day. A greater reduction (−16.6%) was achieved by Kah et al7 with 9 g/day in normcholesterolemic subjects.

Because of the complexity of the oat kernel, various fractions of oats (oat flakes, oat bran, etc.) may contain different amounts and possibly different types of WSDF. The hypocholesterolemic effect of oat brans and cereals should be carefully related to their actual active WSDF content. β-Glucan is probably the active portion of the WSDF of oats, but its actual WSDF content is often not given in the publication, a major flaw that has led to a great number of conflicting results. The reduction in TC of about 6% found in this study for the OFS is similar to the reduction of about 5% obtained by Kestin et al,9 who fed an oat bran supplying 11.8 g/day DF, of which about 50% was WSDF. Van Horn et al10 also obtained a reduction in mildly hypercholesterolemic subjects of about 5% in 6 weeks with 60 g/day of oat products, and Gold and Davidson,11 feeding their subjects oat muffins containing about 10 g/day total DF, induced the same 5% reduction in normcholesterolemic subjects. Kirby et al,12 using 100 g/day of an oat bran that contained 26.4% DF and 14.8% WSDF achieved, as may be expected, a greater reduction in serum cholesterol of about 13% in hypercholesterolemic subjects. Anderson et al13 achieved an even greater reduction (−19%) with about 100 g/day of oat bran in a metabolic ward study. Swain et al14 found that both an oat bran product and a low-fiber cream of wheat equally reduced serum cholesterol by 7–8%. These authors attributed this reduction to changes in dietary saturated and unsaturated fats rather than to any direct effect of the compounds present in either the oat or the wheat product used.

The hypocholesterolemic effect of oat brans and cereals should be carefully related to their actual active WSDF content. The amount of the digestible portion of oats left in various products and the amount of WSDF present are major factors in the hypocholesterolemic effectiveness of oat products, even though some lipids in oats may have a hypocholesterolemic effect as well.

In this study the subjects did not modify their macronutrient balance in any way except for replacing some other carbohydrate foods with OFS. In other studies, WSDFs have sometimes been studied as an adjunct treatment after the diet has been modified in fat content and at other times without modification of dietary fat intakes.9–14 The effect of adding 200 kcal/day to the OFS for one group and no calories for the GG group certainly had some effect, but from review of food records and subject interviews, these calories replaced other carbohydrate calories. That total caloric intake was kept fairly constant is supported by the lack of weight gain or loss in both study phases.

The effect of GG on plasma lipids was undoubtedly exclusively due to the WSDF content (10 g/day), as the small amount fed is very unlikely to have affected the rest of the diet.

The mechanism of action of WSDF could be such that the amount of oat WSDF fed was below a critical threshold that is presently unknown for this WSDF. No extensive dose–response studies have been done with WSDF; whether there is a linear hypocholesterolemic response to increasing levels of WSDF, or whether the response is greater on a per gram basis above this hypothetical critical threshold needs extensive study with a variety of hypocholesterolemic dietary fibers.

In recommending hypocholesterolemic diets, both concentrated gums and foods such as oats or barley with hypocholesterolemic WSDF fractions have a place. Each can complement the effects of the other, and in some cases the recommendations may be designed according to the individual living habits and needs of the patient. The GG and OFS in this study were well tolerated by the majority of subjects. Most subjects found the consumption of both products easier as the study progressed.

It should be noted that in this study, both WSDF sources were fed with each meal. If the effect of WSDF on plasma cholesterol is that of binding dietary cholesterol as well as bile cholesterol and bile acids, it appears important to feed this kind of treatment with each major meal. It is also important to notice that WSDF sources, when in high concentration as in GG, should always be consumed suspended in a glass of water or other fluid not only to ensure its efficacy but also to prevent undissolved tablets from expanding in the gastrointestinal tract, with deleterious consequences.

More studies correlating the specific structural type of water-soluble fibers to plasma cholesterol reduction are needed. For a true understanding of the effects of various fiber sources, dose–response studies and long-term studies with and without fat-modified diets should be performed.
References

KEY WORDS • water-soluble dietary fiber • plasma cholesterol • lipoproteins • oat fiber • guar gum
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