NOTE

Relative Lipidemic Responses in Rats Fed Oat Bran or Oat Bran Concentrate[1]

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ABSTRACT

Oat bran that contained 15.35% total dietary fiber and 5.57% soluble fiber and oat bran concentrate (37.14% total and 13.57% soluble fiber) were tested for their effect on blood lipid levels, using young rats as the test model. Compared with a diet free of soluble fiber, oat bran concentrate exerted a more pronounced serum cholesterol-lowering effect than oat bran fed at the same dietary level (50%). This effect was of a similar magnitude in both hypercholesterolemic and normocholesterolemic rats. Oat bran concentrate (but not oat bran) also increased the level of high-density lipoprotein cholesterol, but this effect was significant only in hypercholesterolemic rats. At the 50% diet level, oat bran concentrate also lowered serum triglyceride levels, but again only in hypercholesterolemic rats.

Studies with humans and animals, as recently reviewed (Anderson and Gustafson 1988), have shown that oat bran (OB) lowers elevated blood cholesterol (CH) levels, a risk factor in heart disease (Anonymous 1985). A lowering effect of OB on blood triglyceride (TG) levels, recognized as an independent risk factor in heart disease, has also been reported (Anderson and Tietyen-Clark 1986). This hypolipidemic effect has been attributed to the presence of water-soluble fiber (SF) in OB.

Although commercially produced OB products show a great deal of variation in the content of total dietary fiber (TDF) and SF, most products contain about 15% TDF (as-is basis) of which one-third or more is SF. OB has now been processed into OB concentrate (OBC), which contains significantly higher levels of TDF and SF than OB. As a prelude to a study of human diets, this study was undertaken to examine the relative lipidemic responses in rats fed OB or OBC.

MATERIALS AND METHODS

Test Samples

OB and OBC samples were supplied by the ConAgra Grain Processing Co., Omaha, NE; OBC was prepared by an alcoholic extraction process followed by heat drying. Cellulose (CL), marketed as a nonnutritive bulking agent, was obtained from ICN Biochemicals, Cleveland, OH. Each fiber source was thoroughly mixed and then sampled for chemical analysis (Table I).

Test Diets

Eight diets were formulated containing CL, OB, or OBC (Table II). They were complete in all nutrients required by the rats (NRC 1987). Diets A-D differed from diets AA-DD in that they contained added CH and cholic acid to induce hypercholesterolemia in the rats. In diets A-C and AA-CC, at the level used, CL, OB, or OBC provided the same level of TDF and, in the case of OB or OBC, the same level of SF. When used at a much higher level in the diet (in an amount equal to OB), OBC provided a higher level of TDF and SF.

Animals

Eight groups of male, weanling rats (10 rats/diet) of Sprague-Dawley strain (Harlan Sprague-Dawley, Indianapolis, IN) were housed individually in mesh-bottom stainless steel cages in a controlled environment. Each rat was allowed to consume an adequate, but the same (pair fed), amount of total diet over the four-week test period; deionized water was offered ad libitum. Body weight records were maintained.

Blood Sampling

At weeks 2 and 4, rats were fasted overnight (14 hr), then lightly anesthetized, and about 1.0 ml (2.0 ml at week 4) of blood was withdrawn by heart puncture. The blood was allowed to clot and then centrifuged prior to obtaining the serum. Lipid analyses were run on the refrigerated serum the next day.

Analytical Methods

The standard AACC methods (AACC 1983) were used to analyze test samples for protein (Kjeldahl), fat (acid hydrolysis), and ash. Moisture was determined by weight loss of samples dried under vacuum (16 hr, 70°C, ≤25 mm Hg). TDF and SF contents were determined by the method of Prosky et al (1988). Total CH and high-density lipoprotein (HDL) CH in serum were determined enzymatically using kit no. 352 from Sigma Chemical Co., St. Louis, MO; HDL-CH was determined following magnesium dextran sulfate precipitation of nonHDL-CH fractions. Serum TG was also determined enzymatically using kit no. 336 from Sigma.

Statistical Analyses

Mean comparisons were made with Duncan's multiple-range test using the Statistical Analysis System (SAS 1982).

RESULTS AND DISCUSSION

Fiber in Test Samples

OBC contained 142% more TDF and 145% more SF than OB (Table I). This indicates that processing OB to obtain OBC resulted in a parallel increase in both TDF and SF. SF represented about 36% of the TDF in both bran products.

Soluble Fiber in Test Diets

The set of diets A-C and its matching CH-free set (diets AA-CC) contained the same level of TDF, 7.68% (Table II). A little over one-third of this fiber in diets B and BB (OB-based) and diets C and CC (OBC-based) was SF. Diets A and AA contained no SF and, thus, served as the control. Diets D and DD (OBC-based) contained 18.57% TDF and 6.84% SF and, thus, allowed assessment of the hypolipidemic effect of a much higher level of SF.

Diet Intake and Weight Gains

To eliminate or minimize variables (other than SF) that might affect blood lipid levels, diets were equalized to contain the same level of fat (type of fat also differed minimally) and protein. They were also offered to the animals in amounts to ensure adequate but identical consumptions. In this way the dietary CH intake was also identical in rats fed CH-containing diets (Table III).

Because the caloric density of diets A-C and AA-CC differed little, body weight gain of rats fed these diets also differed little

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(Table III). In contrast, because of lower calorie density (more TDF) of diets D and DD, rats fed these diets showed a significantly ($P < 0.05$) lower weight gain than rats fed other diets.

Serum Total Cholesterol

Feeding CH elevated the serum CH levels in rats (diets A–D vs. AA–DD). This elevation was significant ($P < 0.05$) at week 2, but at both sampling times the serum CH elevation was less than that observed in similar earlier studies (Ranhotra and Gelroth 1989, Ranhotra et al 1990).

Serum CH levels were most elevated in rats fed the control (cellulose-based) diet (Table III). Several studies have reported cellulose (Ranhotra 1973) and other insoluble fiber sources (CSA 1989, Vahouny 1982) to be ineffective in lowering (or preventing elevation of) serum CH. In comparison to the control diet, serum CH levels were significantly ($P < 0.05$) lower in rats fed diets containing OB (week 2) or OBC (weeks 2 and 4). This effect was most pronounced in rats fed OBC at a dietary level identical to OB (diet D); compared with diet A, this diet lowered serum CH levels by 43% at week 2 and by 34% at week 4. When OBC was fed to provide the same level of SF as OB (diet B vs. C), the CH-lowering effect of the two diets did not differ significantly.

Diets B–D contained the same TDF/SF ratios. However, the absolute amount of SF in diet D was much higher. This may

TABLE I
Percent Composition of Test Samples[a]

Sample	Moisture	Protein (N × 5.7)	Ash	Fat	Total Dietary Fiber	Soluble Fiber	Carbohydrates
Cellulose	3.60	0	0.18	0	96.20	0	0
Oat bran	9.25	18.14	3.14	9.57	15.35	5.57	44.55
Oat bran concentrate	11.14	20.97	5.71	9.54	37.14	13.67	15.50

[a]On as-is basis.

TABLE II
Test Diets

Components and Composition	Diet A	B	C	D	AA	BB	CC	DD
Components, g/100 g								
Cellulose	7.98	...	...	...	7.98	...	...	...
Oat bran	...	50	...	...	...	50	...	...
Oat bran concentrate	...	...	20.67	50	...	...	20.67	50
Vitamin mix[a]	1	1	1	1	1	1	1	1
Mineral mix[b]	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Soybean oil	5	0.21	3.03	0.23	5	0.21	3.03	0.23
Casein[c]	14.38	3.51	9.19	1.81	14.38	3.51	9.19	1.81
Cholesterol	1	1	1	1	...	...	...	...
Cholic acid	0.2	0.2	0.2	0.2	...	...	...	...
Cornstarch	66.94	40.58	61.41	42.26	68.14	41.78	62.61	43.46
Composition, %								
Fiber								
total	7.68	7.68	7.68	18.57	7.68	7.68	7.68	18.57
soluble	0	2.79	2.83	6.84	0	2.79	2.83	6.84
Fat (total)	5	5	5	5	5	5	5	5
Protein (total)	12	12	12	12	12	12	12	12
Carbohydrates (total)	66.94	62.86	64.61	50.01	68.14	64.06	65.81	51.21
Energy (kcal/100 g)	361	344	351	293	366	349	356	298

[a]American Institute of Nutrition vitamin mixture 76 obtained from ICN Biochemicals, Cleveland, OH.
[b]Contained (in sucrose base) Ca, P, Fe, Mg, K, Na, Cr, Cu, I, Mn, Se, and Zn, to meet rat's requirements (NRC 1987).
[c]Contained 83.4% protein (N × 6.25).

TABLE III
Lipidemic Responses in Rats[a]

Parameter	Diet A	B	C	D	AA	BB	CC	DD
Fiber source[b]	CL	OB	OBC	OBC	CL	OB	OBC	OBC
Soluble fiber, %	0	2.79	2.83	6.84	0	2.79	2.83	6.84
Body weight gain, g[c]	76 ± 2 c	77 ± 8 c	82 ± 3 b	68 ± 5 d	78 ± 5 bc	87 ± 2 a	81 ± 7 bc	69 ± 4 d
Diet intake, g	248 ± 0	245 ± 7	248 ± 0	248 ± 0	248 ± 0	248 ± 0	247 ± 3	248 ± 1
Diet/gain, ratio	3.3 ± 0.1	3.2 ± 0.3	3.0 ± 0.2	3.7 ± 0.3	3.2 ± 0.2	2.9 ± 0.1	3.1 ± 0.2	3.6 ± 0.2
Serum cholesterol, mg/dl								
Week 2	142 ± 9 a	116 ± 17 b	121 ± 15 b	81 ± 14 c	91 ± 9 c	90 ± 8 c	50 ± 15 d	61 ± 10 d
Week 4	102 ± 11 a	93 ± 18 ab	88 ± 13 b	67 ± 6 c	98 ± 10 a	86 ± 6 b	60 ± 8 c	58 ± 9 c
Serum HDL cholesterol, %[d]								
Week 4	67 ± 14 d	66 ± 14 d	85 ± 7 bc	85 ± 3 bc	88 ± 3 abc	81 ± 4 c	94 ± 4 a	91 ± 4 ab
Serum triglycerides, mg/dl								
Week 2	37 ± 3 a	34 ± 5 ab	33 ± 5 ab	26 ± 4 cd	25 ± 4 d	27 ± 3 cd	30 ± 5 bc	33 ± 3 ab
Week 4	39 ± 5 c	40 ± 3 bc	38 ± 3 c	25 ± 3 d	45 ± 9 ab	40 ± 5 bc	43 ± 7 bc	50 ± 4 a

[a]Values are averages ± SD for 8–10 rats per diet. Within a row, means not sharing a common letter are significantly different ($P < 0.05$).
[b]Cellulose (CL), oat bran (OB), and oat bran concentrate (OBC).
[c]Initial (0 day) body weight (g): 35 ± 3.
[d]High-density lipoprotein as a percentage of total serum cholesterol.

indicate that, regardless of the TDF/SF ratio, a certain amount of SF in the diet is needed to be an effective CH-lowering agent. This study did not reveal whether a still higher amount of SF would lower serum CH even more.

In normocholesterolemic rats, OB showed a modest CH-lowering effect and that only at week 4 (diet AA vs. BB). However, OBC again showed a profound CH-lowering effect; compared to diet AA, serum CH levels were 33% lower at week 2 and 41% lower at week 4 (diet AA vs. DD). Thus, OBC exerted a CH-lowering effect of a similar magnitude in both normocholesterolemic and hypercholesterolemic rats. However, in normocholesterolemic (but not in hyperchloresterolemic) rats, OBC showed an equally profound CH-lowering effect whether fed at the lower level (diet CC) or at the higher level (diet DD) (Table III). This may suggest a uniqueness of SF in OBC to be more effective than SF in OB. This conclusion may be tempered, however, because the caloric density of OBC-based diets was low compared with other diets and this may have contributed to the hypocholesterolemic effect observed in rats fed OBC diets.

Serum HDL Cholesterol

Due to the small serum sample, HDL-CH was not measured at week 2. At week 4, HDL-CH levels (as a percentage of total CH) were significantly ($P < 0.05$) elevated in hypercholesterolemic rats fed OBC (diet A vs. diets C and D). HDL-CH is reported to provide protection (Anderson and Tietyen-Clark 1986) against heart disease in contrast to nonHDL-CH fractions. The HDL-CH fraction was also slightly elevated in normocholesterolemic rats fed OBC (Table III).

Serum Triglycerides

The effect of OB on serum TG levels remains unclear. In the present study, OB and OBC (at similar dietary levels of TDF and SF) did not show a TG-lowering effect in hypercholesterolemic or normocholesterolemic rats. When hypercholesterolemic rats were fed OBC at a higher level (50%) in the diet, OBC did lower TG levels significantly ($P < 0.05$). Although a high-carbohydrate diet does not lower TG levels (Anderson 1986), when accompanied by a high fiber level it may do so, as seems to be the case for diet D. Diet DD did not confirm this, however.

LITERATURE CITED

AMERICAN ASSOCIATION OF CEREAL CHEMISTS. 1983. Approved Methods of the AACC. Methods 08-01 and 30-10, approved April 1961, revised October 1981; Method 46-12, approved October 1976, revised October 1986. The Association: St. Paul, MN.

ANDERSON, J. W. 1986. Fiber and health: An overview. Am. J. Gastroenterol. 81:892.

ANDERSON, J. W., and GUSTAFSON, N. 1988. Hypocholesterolemic effects of oat and bean products. Am. J. Clin. Nutr. 48:749.

ANDERSON, J. W., and TIETYEN-CLARK, J. 1986. Dietary fiber: Hyperlipidemia, hypertension, and coronary heart disease. Am. J. Gastroenterol. 81:907.

ANONYMOUS. 1985. Lowering blood cholesterol to prevent heart disease, Consensus Conference. JAMA J. Am. Med. Assoc. 253:1080.

COUNCIL ON SCIENTIFIC AFFAIRS. 1989. Dietary fiber and health. JAMA J. Am. Med. Assoc. 262:542.

NATIONAL RESEARCH COUNCIL. 1987. Nutrient requirements of laboratory animals. Page 23 in: Nutrient Requirements of Domestic Animals. National Academy of Sciences: Washington, DC.

PROSKY, L., ASP, N.-G., SCHWEIZER, T. F., DEVRIES, J. W., and FURDA, I. 1988. Determination of insoluble, soluble, and total dietary fiber in food products: Interlaboratory study. J. Assoc. Off. Anal. Chem. 71:1017.

RANHOTRA, G. 1973. Effect of cellulose and wheat mill-fractions on plasma and liver cholesterol levels in cholesterol-fed rats. Cereal Chem. 50:358.

RANHOTRA, G. S., and GELROTH, J. A. 1989. Lipidemic responses in rats fed biscuits made with fish oil. Cereal Chem. 66:19.

RANHOTRA, G. S., GELROTH, J. A., and ASTROTH, K. 1990. Fish oil added to biscuits is a potent hypolipidemic agent in hypercholesterolemic rats. Cereal Chem. 67:213.

VAHOUNY, G. V. 1982. Dietary fiber, lipid metabolism and atherosclerosis. Fed. Proc. Fed. Am. Soc. Exp. Biol. 41:2801.

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