Full-Fat Rice Bran and Oat Bran Similarly Reduce Hypercholesterolemia in Humans[1,2]

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ABSTRACT Scientific studies support recommendations to increase dietary soluble fiber as part of hyperlipidemia treatment. Rice bran contains minimal soluble fiber, but rice bran oil has a hypolipidemic effect. Full-fat rice bran was compared with oat bran and a rice starch placebo in hyperlipidemic humans to see if it might have a role in the treatment of hyperlipidemia. Moderately hypercholesterolemic (5.95–8.02 mmol/L), nonsmoking, nonobese adults were studied in a 6-wk, randomized, double-blind, noncross-over trial. Three groups added 84 g/d of a heat-stabilized, full-fat, medium-grain rice bran product ($n = 14$), oat bran product ($n = 13$) or rice starch placebo ($n = 17$) to their usual low-fat diet. Serum cholesterol, triglycerides, HDL-cholesterol (HDL-C), LDL-cholesterol (LDL-C), apoA1 and apoB were measured before and at the end of the supplementation period. Serum cholesterol decreased significantly ($P \leq 0.05$) by 8.3 ± 2.4% and 13.0 ± 1.8% in the rice bran and oat bran groups, respectively, but there was no change in the rice starch group. This change was attributable to LDL-C, which decreased by 13.7 ± 2.8% in the rice bran group and 17.1 ± 2.4% in the oat bran group ($P \leq 0.05$). Serum apoB decreased proportionately. There was no consistent effect on triglycerides within each group and HDL-C and apoA concentrations did not change. The LDL-C:HDL-C ratio decreased significantly in the rice bran and oat bran groups. Stabilized, full-fat rice bran or oat bran, added to the prudent diet of hyperlipidemic adults, similarly reduced cholesterol and LDL-C and improved lipid ratios in 78% of these individuals. Rice bran, as well as oat bran, should be included in the prudent diet of individuals with hyperlipidemia. J. Nutr. 128: 865–869, 1998.

KEY WORDS: • *cholesterol* • *hyperlipidemia* • *rice bran* • *fiber* • *human*

Hypercholesterolemia is an established major risk factor for coronary artery disease. Lifestyle modification is the preferable form of treatment for most types of hyperlipidemia (National Cholesterol Education Program 1993). The American Heart Association guidelines for treating hypercholesterolemia and most studies concerning dietary modification have focused on dietary cholesterol and fat reduction (American Heart Association, 1984).

Including water-soluble fiber in the diet was shown to be an additional, important component of cholesterol reduction efforts (Anderson et al. 1990). Oat gum, guar gum and pectin, all soluble fibers, have hypocholesterolemic effects in animals (Anderson et al. 1984, Matheson et al. 1995, Todd et al. 1990). The addition of beans, oat bran, locust bean gum, guar gum, psyllium or pectin to human diets reduces elevated cholesterol levels by 3–20%, depending on study design (Anderson et al. 1984, 1991, Everson et al. 1992, Judd and Truswell 1982, Kay and Truswell 1977, Zavoral et al. 1983). Water-insoluble fiber does not affect cholesterol levels (Anderson et al. 1990, 1991, 1994, Jenkins et al. 1993, Miettinen and Tarpila 1989).

The mechanism by which soluble fiber reduces serum cholesterol is not definitively established. The most likely postulate is that intestinal bile salt adsorption by fiber prevents bile salt reabsorption with or without dietary cholesterol absorption (Arjmandi et al. 1992; Ebihara and Schneeman 1989; Miettinen and Tarpila 1989). This leads to increased bile salt synthesis (Everson et al. 1992; Matheson et al. 1995) and low-density lipoprotein (LDL) receptor upregulation and enhanced LDL catabolism, and there is evidence supporting this (Fernandez et al. 1995; Miettinen and Tarpila 1989).

Rice bran contains less total dietary fiber (6–14.4 vs. 15–22 g/100 g), and less soluble fiber (1.8–2.7 vs. 5.3–8.4 g/100 g) than oat bran (Marlett, 1993; Saunders, 1985). Based on its soluble fiber content alone, rice bran should have less hypolipidemic effect than other sources of fiber. However, rice bran is 12–23% oil, a relatively high percentage compared to most other bran sources, and the oil has an unusually high unsaponifiable matter concentration (4.2%) (Saunders 1985; Sugano and Tsuji 1997). This fraction includes tocotrienols, γ-oryzanol, β-sitosterol and unsaturated fatty acids, all of which may contribute to cholesterol reduction (Saunders 1985; Sharma and Rukmini 1987; Sugano and Tsuji 1997; Yoshino et al. 1989). Rice bran oil, possibly because of this unsaponifiable fraction or its fatty acid content, lowers cholesterol levels in

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[4] Abbreviations used: apo, apolipoprotein; HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein-cholesterol.

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hamsters, rats, humans and nonhuman primates (Kahlon et al. 1992; Nicolosi et al. 1991; Purushutharma et al. 1995; Seetharamaiah and Chandrasekhara 1989; Sharma and Rukmini 1986).

Feeding hamsters, mice, chicks and pigs rice bran containing the oil significantly reduces serum cholesterol (Hundemer et al. 1991; Kahlon et al. 1992; Marsono et al. 1993; Newman et al. 1992); rat studies show conflicting results (Anderson et al. 1994; Topping et al. 1990). Studies of rice bran in humans failed to show lipid reduction using defatted rice bran or brown rice (Kestin et al. 1990; Miyoshi et al. 1986; Sanders and Reddy 1992), but rice bran oil does produce an effect (Lichtenstein et al. 1994; Raghuram et al. 1989). Thus full-fat rice bran might reduce cholesterol more in humans than defatted rice bran and other sources of insoluble fiber.

We describe here the results of a randomized, double-blind, placebo-controlled, non-cross-over trial comparing the hypolipidemic effects of stabilized, full-fat rice bran, oat bran and rice starch (placebo) in moderately hyperlipidemic humans.

METHODS

Subjects. Healthy subjects of both sexes were recruited through community advertising. The protocol was approved by the Sutter Community Hospitals Institutional Review Board and informed consent was obtained. Fifty-two subjects were enrolled and randomly assigned to groups. They were predominantly middle-class Caucasians. They were nonsmokers, average age 51.7 ± 1.5 y (range 32–64 y), and 85–125% of ideal body weight (Metropolitan Life Insurance Company 1979). The average body mass index was 23.05 and 25.82 kg/m^2 for males and females, respectively. None had experienced weight change of >4.5 kg in the preceding 6 mo.

Subjects were excluded if they were taking medication that might affect serum lipids (thyroid or steroid hormones, beta blockers, prednisone or diuretics) or had diabetes mellitus, uncontrolled hypertension (systolic blood pressure >140 mm Hg or diastolic blood pressure >90 mm Hg), symptomatic coronary or vascular disease, thyroid disease, hepatic abnormality or renal disease. The health status of prospective subjects was verified by physical examination and fasting blood chemistry.

Screening serum lipid levels were measured twice in each prospective subject, ≥1 wk apart, before the onset of the study. Those with consistent cholesterol concentrations between 5.95 and 8.02 mmol/L and a fasting triglyceride level <4.48 mmol/L were included in the study.

Materials. A heat-stabilized, full-fat rice bran product, processed from California medium grain rice and containing a small amount of pectin-free apple juice concentrate (Vitafiber, Pacific Rice Products, Woodland, CA), was used. Oat bran product was obtained from Grain Millers Inc., Bellevue, WA. The rice starch placebo consisted of rice flour, sugar, salt and malt extract (202 Crisp Rice, Pacific Rice Products). Each was presented in a crisp form that could be sprinkled on or mixed into other food. The macronutrient and selected micronutrient content of each product is detailed in **Table 1.**

Protocol. In this randomized, double blind, noncross-over study, subjects were assigned to receive rice bran product, oat bran product or rice starch placebo. There was no significant difference among groups in age, body mass index or male:female ratio. Subjects were given 84 g product per day to eat in addition to their regular diet for 6 wk. They continued to consume their usual diets and perform their customary exercise. At weekly visits the week's supply of product packets (3/d of 28 g each) was distributed, any unused packets from the previous week were collected and counted, blood pressure and weight were measured, food records were collected and symptoms and exercise were reviewed. Venous blood for measurement of serum cholesterol, triglycerides, high-density lipoprotein-cholesterol (HDL-C)[2] and apolipoproteins was drawn at weeks 0, 3 and 6.

Weekly food records were analyzed by computer using Food Processor II (R) software (ESHA Research, Salem, OR). Analysis confirmed that there was no change in the baseline diet during the study period. Product was not included in this analysis.

TABLE 1

Rice bran, oat bran and rice starch products composition

	Rice starch	Rice bran	Oat bran
		unit/84 g product	
Energy, *kJ*	1333	1237	1329
Protein, *g*	6.0	11.7	14.4
Carbohydrate, *g*	71.0	44.9	57.0
Fat, *g*	2.4	16.5	7.2
Fatty acids, *g*			
Polyunsaturated	0.9	5.4	1.9
Monounsaturated	0.7	5.6	2.4
Dietary fiber, *g*	2.4	19.7	8.3
Soluble fiber, *g*	0.5	1.4	3.3
Niacin, *mg*	4.1	30.7	1.1
d,l-α-tocopherol, *mg*	0.84	7.79	<0.4
Iron, *mg*	1.3	28.3	5.4
Magnesium, *mg*	72.2	544.3	143.6
Copper, *mg*	0.17	0.56	0.14
Potassium, *mg*	370.4	1276.8	370.4

Chemical analysis. Cholesterol in finger-stick blood samples (used for screening potential subjects) was measured by Reflotron reflectance photometer (Boehringer Mannheim Diagnostics, Indianapolis, IN). Comprehensive chemistry panels were performed on a Technicon SMAC analyzer (Maclin and Yang 1986) at Physicians Clinical Laboratory, Sacramento, CA. Serum lipid levels were assayed by the Associated Regional and University Pathologists, Inc., Salt Lake City, Utah, using the following methods: total cholesterol and triglycerides were measured by Boehringer Mannheim enzymatic assays (Allain et al. 1974; Wahlefeld 1974). HDL-C was assayed after phosphotungstate precipitation of LDL and very low density lipoprotein (VLDL) (Burstein et al. 1970). LDL cholesterol (LDL-C) was calculated by Friedwald's formula (Friedewald et al. 1972). Apolipoproteins (apoA and apoB) were measured by rate nephelometry (Maciejko et al. 1987) with an ICS Analyzer II Immunochemistry System (Beckman Instruments Inc., Indianapolis, IN). Product nutritional analysis was performed by Hazelton Laboratories America, Madison, WI, by standard methods (Williams 1984, 1985). The Prosky method was employed for fiber quantitation (Williams 1984, 1985).

Statistical analysis. Pearson correlation coefficients were used to assess the relationship between baseline dietary intake measures and cholesterol, triglyceride, HDL-C, LDL-C, apoA and apoB. Single factor analysis of variance was used to assess differences in sex, age and group on baseline dietary measures. Mixed design analyses of variance were performed separately for each of the lipid variables to assess mean differences across time (baseline and 6 wk) and group (oat bran, rice bran, rice starch) (Keppel, 1982). Statistically significant group by time interactions were followed up with simple effects tests and Tukey post hoc comparisons. Alpha level for all statistical analyses was $P < 0.05$.

RESULTS

Of the 52 subjects entered into the study, the data of 23 males and 21 females were used in the final analysis. Three subjects in the rice bran group failed to complete the study because of product intolerance due to laxation effect. One subject in the rice bran and one in the oat bran group were omitted from the final analysis because of laboratory error. Two subjects, one in the rice bran and one in the rice starch group, could not finish for personal reasons, and one subject in the oat bran group changed his baseline diet.

Baseline macronutrient intake in each group is described in **Table 2.** This intake does not include test products. The mean energy, fat and cholesterol intakes were not significantly different among groups. The energy supplied by fat was 32, 31

TABLE 2

Baseline daily intake of moderately hypercholesterolemic humans[1,2]

	Rice bran (n = 14)	Oat bran (n = 13)	Rice starch (n = 17)
Fat, *g*	53.2 ± 17.2	53.2 ± 20.7	55.1 ± 19.8
Cholesterol, *mg*	192.5 ± 63.4	173.5 ± 72.4	196.4 ± 110.6
Saturated fat, *g*	18.1 ± 6.1	15.9 ± 6.6	17.8 ± 9.3
Fiber, *g*	15.7 ± 6.7[a]	17.7 ± 7.5[a]	13.9 ± 4.8[b]
Carbohydrate, *g*	170.6 ± 53.2	193.0 ± 66.2	183.4 ± 54.7
Protein, *g*	65.6 ± 19.1	61.2 ± 20.1	68.6 ± 23.4
Energy, *kJ*	6429 ± 1514	7225 ± 2436	7094 ± 1677

1 Analyses of food records from each week of the study did not show any significant change with time.

2 Values are means ± SD; those with different superscripts are significantly different, $P < 0.05$.

and 32% of total intake in the rice bran, oat bran and rice starch groups, respectively, and saturated fat comprised approximately one third of the fat in each group. In all groups, mean cholesterol intake was under the recommended level of 300 mg/d (American Heart Association 1984). Dietary energy, protein, cholesterol and fat were significantly greater in males than females, without relation to group (data not shown). Pearson correlations showed that a statistically negative significant correlation existed between baseline HDL-C and carbohydrate intake ($r = -0.44$, $P = 0.003$). No other significant correlations were found between baseline dietary measures and lipid levels.

Subjects added an average of 74 ± 5 of the 84 g of product provided to them to their diet each day. Compliance was not different among groups. Subjective complaints of abdominal bloating, diarrhea and flatulence were noted but not quantitated and occurred only in the rice bran and oat bran groups.

Analysis of food records showed that dietary intake did not change over the study duration. Changes in cholesterol, LDL-C and apoB were not related to any baseline dietary macronutrient.

Serum lipid concentrations at weeks 1 and 6 were compared (**Table 3**). Week 3 values did not affect the results and confirmed trends within each group. There were significant decreases in serum total cholesterol, LDL-C and apoB, but not triglycerides HDL-C or apoA in the rice bran and oat bran groups during the 6-wk period. No variable significantly changed in the rice starch group. Serum total cholesterol declined by 8.3 ± 2.4% in the rice bran group and by 13.0 ± 1.8% in the oat bran group. LDL-C declined by 13.7 ± 2.8% in the rice bran group and by 16.7 ± 2.4% in the oat bran group. ApoB declined by 9.6 ± 3.0% in the rice bran group and by 12.2 ± 3.1% in the oat bran group. The LDL-C:HDL-C ratio significantly declined in subjects fed rice bran and oat bran by 16.1 ± 3.7% and 17.3 ± 5.9%, respectively. There was no effect of age or sex on lipid responses within groups (data not shown).

Eleven of 14 (78%) individuals in the rice bran group and 11 of 13 (85%) in the oat bran group experienced cholesterol reduction of >3%, with proportionate change in LDL-C. There was great variability in the rice starch group, with cholesterol changing by −1.2 to +1.6 mmol/L. Triglyceride response varied widely among individuals within each group, and no group exhibited a significant change.

Analyses of differences in lipid variables between the three groups from baseline to 6 wk indicated that there were significant group by time interactions for serum cholesterol ($P = 0.001$), LDL-C ($P = 0.007$), and apoB ($P \leq 0.001$). Simple effects tests analyzing differences between the groups showed that there were no differences in mean serum cholesterol, LDL-C or apoB among the three groups at baseline. Significant differences were present among the groups after 6 wk of treatment for serum cholesterol ($P \leq .001$), LDL-C ($P = .001$) and apoB ($P \leq .001$). Post hoc tests for these simple effects indicated that there were significant differences in mean serum cholesterol, LDL and apoB between the rice bran and oat bran groups compared with the rice starch group, but no differences were found when comparing the rice bran and oat bran groups.

DISCUSSION

Because food diary analyses verified that the subjects' baseline diets were maintained throughout the study, this study suggests that rice bran or oat bran can be added to the diet, without replacement of other food, and effect cholesterol reduction in moderately and severely hypercholesterolemic adults. It cannot be concluded, however, that this effect would necessarily occur with any usual American diet. The study included only subjects ingesting reasonably prudent diets, with average fat and cholesterol content similar to the AHA Step I dietary recommendations (American Heart Association 1984). This was not the original intent of the subject selection crite-

TABLE 3

Serum lipid concentrations before and after 6 wk of rice bran, oat bran or rice starch supplementation in moderately hypercholesterolemic humans[1]

Lipid	Rice starch	Rice bran	Oat bran
Cholesterol			
n	17	14	13
Initial[2], *mmol/L*	7.24 ± 0.32	6.92 ± 0.57	7.19 ± 0.48
Final, *mmol/L*	7.20 ± 0.78	6.34 ± 0.76[a,b]	6.25 ± 0.58[a,b]
Triglyceride			
n	17	14	13
Initial, *mmol/L*	1.78 ± 1.16	1.24 ± 0.87	1.70 ± 0.92
Final, *mmol/L*	2.04 ± 0.87	1.41 ± 0.97	1.61 ± 1.03
LDL-C[3]			
n	16	14	13
Initial, *mmol/L*	5.21 ± 0.70	4.94 ± 0.66	5.03 ± 0.32
Final, *mmol/L*	5.02 ± 0.56	4.26 ± 0.74[a,b]	4.19 ± 0.50[a,b]
HDL-C			
n	16	14	13
Initial, *mmol/L*	1.32 ± 0.32	1.41 ± 0.34	1.37 ± 0.42
Final, *mmol/L*	1.30 ± 0.33	1.43 ± 0.28	1.33 ± 0.33
ApoB			
n	17	14	13
Initial, *nmol/L*	2.50 ± 0.34	2.29 ± 0.45	2.32 ± 0.28
Final, *nmol/L*	2.61 ± 0.40	2.05 ± 0.34[a,b]	2.05 ± 0.26[a,b]
ApoA			
n	16	12	12
Initial, *nmol/L*	55.84 ± 10.54	58.45 ± 8.69	55.54 ± 9.82
Final, *nmol/L*	53.21 ± 11.44	50.96 ± 9.20[a]	51.70 ± 8.19[a]
LDL-C:HDL-C			
n	16	14	13
Initial, *mol/mol*	4.20 ± 1.19	3.74 ± 1.12	4.01 ± 1.23
Final, *mol/mol*	4.05 ± 1.13	3.14 ± 1.00[a]	3.32 ± 0.88[a]

1 Values are means ± SD. a Significantly different from initial value within group ($P \leq 0.05$). b Change in level with time significantly different from the change that occurred in the rice starch group ($P < 0.05$).

2 Initial, concentration at baseline; Final, concentration after 6-wk supplementation 84 g of bran or starch.

3 Abbreviations: HDL-C, HDL cholesterol; LDL-C, LDL cholesterol; apoA, apolipoprotein A; apoB, apolipoprotein B.

ria, which were established to minimize variables that might have affected cholesterol levels. Given the average age of the subjects (52 y), however, individuals who would satisfy the selection criteria (nonobese, nonsmoking, and without disease or medication that affect lipids), would most likely be health conscious and following reasonably prudent diets. Therefore these results cannot be extrapolated to the general population, ingesting a high-fat diet, without further study.

Both rice bran and oat bran induced a wide range of within-group cholesterol responses, including some individuals in each group that were not affected. It is unclear why there was so much interindividual variability within groups. Attempts to correlate response to other variables were unsuccessful. Variability was not explained by age, sex, weight or initial lipid levels.

The study products contain ingredients other than fiber that might have affected the results. The rice starch placebo contains 3.8/100 g sugar, providing 54.34 kJ/d in this study. The rice bran product contains apple juice concentrate, which is free of pectin, and provides 7.2 g sugar per 100 g of rice bran product (100 kJ/d). Sugar raises VLDL triglyceride levels (Council on Scientific Affairs 1983), however, the amounts of sugar in each product were very small and are unlikely to have greatly affected the results.

This study included both male and female subjects. There were initial sex-related differences in weight, HDL-C levels and dietary protein, fat and energy, as anticipated. Analysis of variance of lipid changes during the 6 wk study period showed no effect of sex. The number of individuals was not large enough to draw separate conclusions concerning the responses of males and females.

Other studies have shown consistently that oat bran lowers cholesterol more effectively than rice bran (Cara et al. 1992; Katan 1987; Kestin et al. 1990). There were no significant differences in the lipid-lowering effects of oat bran and rice bran used in this study population. This may, in part, be due to the low fiber content of our oat bran, relative to the oat bran used in previous studies. Oat gum is distributed throughout the oat kernel, and extraction efficiency determines the percent of product that is fiber. It is possible that a different oat bran product with greater soluble fiber content might have lowered cholesterol more.

The focus of previous research involving bran and its effect on cholesterol has been the bran's fiber content (Cara et al. 1992; Katan 1987). Water-soluble fiber, such as that found in oat bran, legumes and fruit, is deemed responsible for the cholesterol reduction seen with these foods (Anderson et al. 1990). Rice bran's fiber consists of a relatively low proportion of soluble fiber, 7–13% of its total dietary fiber compared with 40–47% in oat bran. The remainder is insoluble fiber. Other types of insoluble dietary fiber have failed repeatedly to reduce cholesterol levels (Anderson et al. 1990, 1991, 1994; Cara et al. 1992; Katan 1987; Kay and Truswell 1977; Kestin et al. 1990; Miettinen and Tarpila 1989; Sanders and Reddy 1992). This is in spite of the fact that insoluble fiber alters other nutrients' digestibility. A human study in which brown rice affected nutrient absorption did not show cholesterol reduction (Miyoshi et al. 1986), and a study of pigs showed that a brown rice diet caused the greatest fecal mass but did not maximally reduce cholesterol (Marsono et al. 1993). Because soluble fiber rather than insoluble fiber lowers cholesterol and the soluble fiber content of rice bran is low, the factor in the rice bran product used in this study responsible for lowering cholesterol is most likely not fiber.

Rice bran is composed of the aleurone layer of the rice kernel and some part of the endosperm and germ, rich sources of proteins, lipids, vitamins and trace minerals (Saunders 1985). Rice bran's oil and unsaponifiable lipid content is high compared with other grains (Marlett 1993; Sugano and Tsuji 1997). Unrefined rice bran oil consists of ~20% saturated, 40% monounsaturated and 40% polyunsaturated fatty acids and contains tocotrienols, γ-oryzanol, and β-sitosterol (Raghuram and Rukmini 1995).

Rice bran oil lowers cholesterol in pigs, hamsters, primates, rats and humans (Kahlon et al. 1992; Lichtenstein et al. 1994; Nicolosi et al. 1991; Purushutharma et al. 1995; Raghuram et al. 1989; Seetharamaiah and Chandrasekhara 1989; Sugano and Tsuji 1997). γ-Oryzanol reduces serum cholesterol in rats and hyperlipidemic humans (Seetharamaiah and Chandrasekhara 1989; Yoshino et al. 1989). In rats both refined rice bran oil (oryzanol is lost with refining) and oryzanol lower cholesterol levels, suggesting that both oryzanol and some other component(s) of the oil are responsible for the hypocholesterolemic effect (Seetharamaiah and Chandrasekhara 1989).

Studies in hamsters, mice, chicks and pigs have shown a hypolipidemic effect with stabilized, full-fat rice bran, but not defatted rice bran, suggesting that the oil is the active component (Hundemer et al. 1991; Kahlon et al. 1992; Marsono et al. 1993; Newman et al. 1992). The presence of lipase in rice bran causes rapid deterioration of oil to free fatty acids and glycerol unless the lipase is stabilized by heat or other treatments. The decline in serum cholesterol levels was significantly greater in mice fed full-fat rice bran than in those fed oat, barley or mixed bran diets (Hundemer et al. 1991). In Kahlon's study of hamsters (Kahlon et al. 1992), cholesterol levels declined as hamsters were fed an increasing amount of full-fat rice bran or rice bran oil, but defatted rice bran had no effect. Chicks fed full-fat rice bran, compared with those fed defatted rice bran, experienced reduced cholesterol and triglycerides and increased HDL-C levels (Newman et al. 1992). Cholesterol levels declined in pigs fed rice bran only when dietary palm oil was replaced by rice bran oil (Marsono et al. 1993).

Investigators have seen little effect in humans fed rice bran in the past, probably because they used defatted rice bran or only moderate amounts of brown rice. Miyoshi et al., (1986) fed five healthy, normocholesterolemic males 550 g brown rice per 60 kg body weight per day. They experienced increased fecal weight and decreased nutrient digestibility but no decrement in cholesterol levels. Sanders and Reddy (1992) noted lowered triglycerides, but not cholesterol levels, in 18 healthy, normocholesterolemic males after short-term feeding of 15 g/d of defatted rice bran compared with 15 g/d wheat bran. Kestin et al. (1990) performed a double-blind, cross-over trial of wheat, oat and rice bran in moderately hypercholesterolemic men (with lower mean cholesterol levels than the patients in our study). The HDL-C to cholesterol ratio rose with 12 g fiber/d from rice bran or oat bran, but LDL-C fell significantly only with oat bran. The results of the these investigators possibly differ from our study because we used a full-fat rice product, much more rice bran per day, a longer study period and subjects with more severe hyperlipidemia.

In conclusion, full-fat rice bran, when added to the prudent diets of moderately hyperlipidemic individuals, produces significant cholesterol reduction and improvement in the LDL-C:HDL-C ratio in most of these individuals. There was no significant difference between the effectiveness of the rice bran and oat bran products used in this study to reduce serum cholesterol or between responses in males and females. No conclusions can be drawn about which nutrient in the rice bran caused cholesterol reduction, but inference from other work makes the oil component of full fat rice bran the most likely candidate.

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