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Effect of full-fat or defatted rice bran on serum cholesterol*

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Abstract. Rice bran has been shown to lower serum cholesterol in hamsters. Leghorn cockerel chicks were fed 60% full-fat rice bran (FFRB) and corn/soy (CS) diets with 0.5% added cholesterol. Both diets contained 18% protein. All reported parameters are on blood serum. Significant differences ($p < 0.05$) were found in total cholesterol (TC), triglycerides (TG), high-density and low-density lipoprotein cholesterol (HDL and LDL). In a second study, chicks were fed FFRB, defatted rice bran (DFRB), and CS diets balanced for 18% protein, 14.47% total dietary fiber and 10.78% lipid with 0.5% added cholesterol. Both TC and TG were significantly lower ($p < 0.05$) in chicks fed FFRB and CS diets. Significant differences were found in HDL values for all diets with FFRB exhibiting the highest mean value (155 mg/dl) and CS exhibiting the lowest mean value (114 mg/dl). All diets were significantly different ($p < 0.05$) in LDL, with mean values of 249, 318 and 275 mg/dl for FFRB, DFRB and CS, respectively. FFRB appears to increase HDL and to lower LDL in chicks, but does not always affect TC, whereas DFRB may increase all three serum lipid components.

Introduction

Rice bran, a by-product of the rice milling industry, has many possible applications in the food industry (Saunders, 1990). Stabilization of the bran by an extrusion process which deactivates lipase and peroxidase has extended its potential uses (Randall et al., 1985). The ability of rice bran to lower serum cholesterol is of particular interest for today's consumer who is aware of healthful diets. Kahlon et al. (1990) demonstrated that stabilized or parboiled full-fat rice bran (FFRB) significantly lowered plasma and liver cholesterol in hamsters, whereas defatted rice bran had no effect on plasma cholesterol. The cholesterol-lowering properties of FFRB have been recently reported in humans. In a crossover design, diets containing 37% kcal as

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fat, 300 mg cholesterol per day and 100 g rice bran per day significantly lowered total and LDL-cholesterol in moderately hypercholesterolemic adults (Hegsted et al., 1990).

The hypocholesterolemic property of rice bran appears to be concentrated in the oil fraction. Rice bran oil (RBO) has been reported to lower total serum cholesterol and low density lipoprotein cholesterol relative to groundnut oil in hypercholesterolemic rats (Sharma and Rukmini, 1986). RBO has also been reported to lower total and LDL-cholesterol and apoprotein-B in hypercholesterolemic monkeys (Nicolosi et al., 1989). When humans consumed RBO in place of other cooking oils, serum cholesterol and triglycerides were significantly reduced (Raghuram et al., 1989).

The effectiveness of various plant oils in modifying serum cholesterol may be due to various chemical characteristics or components. In rice bran oil, factors may be degree of fatty acid unsaturation, unsaponifiable fraction components, or sterols such as oryzanol. Fat-soluble hypercholesterolemic components in barley flour were identified to be d-α-tocotrienol (Qureshi et al., 1986), and linolenic acid (Qureshi et al., 1984).

The objective of this study was to evaluate the effects of FFRB and defatted rice bran (DFRB) diets on serum lipids in cholesterol-fed chicks. The Leghorn chick was reported to be a more suitable model than the rat for studies of plant sterols as antihypercholesterolemic agents (Chandler et al., 1979). In addition, numerous previous chick-feeding studies in these laboratories on the hypocholesterolemic property of barley have been consistent, reproducible and in conformity with human studies (Newman et al., 1989). Two experiments are reported herein. The first was a pilot trial wherein FFRB was fed in a relatively high-fat diet, and the second compared FFRB with DFRB in lower fat diets.

Materials and methods

Experimental chicks and pre-experimental diets

Day-old Leghorn cockerel chicks were obtained from H&N International, Redmond, WA, and housed in groups in battery type cages with wire mesh floors. Housing conditions were maintained according to the recommendations of the Montana State University Animal Care and Use Committee. Chicks were fed an 18% protein corn-soybean meal diet (CS) for six days prior to initiation of each experiment. For an additional six days, all chicks were fed CS with the addition of 0.5% cholesterol (Table 1). Diets and water were provided ad libitum. Chicks were wing-banded to assign individual

Table 1. Diet composition for chicks fed rice bran

	Experiment 1		Experiment 2		
	Rice Bran, Full-Fat	Corn/Soy Control	Rice Bran, Full-Fat	Rice Bran, Defatted	Corn/Soy Control
	% dmb				
Rice bran, full-fat	60.00	–	60.00	–	–
Rice bran, defatted	–	–	–	60.00	–
Soybean meal	19.08	27.27	–	–	55.03
Corn meal	10.92	62.73	–	–	23.18
Casein	–	–	10.67	8.97	1.68
Corn starch	–	–	20.89	14.60	2.62
Cellulose[1]	–	–	2.52	–	3.44
Oil[2]	4.19	4.19	–	10.51	8.13
Vitamin-mineral supplement[3]	5.31	5.31	5.42	5.42	5.42
Cholesterol	0.50	0.50	0.50	0.50	0.50
Analyzed protein, %	18.30	17.60	16.90	16.70	16.90
Calculated					
crude fat, %	24.40	6.95	10.80	10.80	10.80
dietary fiber, %	14.50	11.70	14.50	14.46	14.50

[1] Alphacel, US Biochemical Corp., Cleveland, OH

[2] Oil was a mixture of Mazola Corn Oil and Crisco Shortening

[3] Supplement composition per 100 g diet: 2.8 g dicalcium phosphate, .6 g limestone, .25 g vitamin premix, .5 g salt, .3 g DL-methionine, and .1 g antibiotic (110 g oxytetracycline/kg). Vitamin-mineral premix supplied the following per kilogram of diet: 6,790 USP units vitamin A, 2,546 ICU vitamin D_3, 4.24 IU vitamin E, 7.7 μg vitamin B_{12}, 5.08 mg riboflavin, 25.5 mg niacin, 7.6 mg d-pantothenic acid, 424 mg choline chloride, 3.39 mg menadione sodium bisulfite complex, 254 μg folic acid, 48 mg ethoxyquin, 847 μg thiamine, 845 μg pyridoxine, 963 mg DL-methionine, 41.8 mg Mn, 41.8 mg Fe, 119 mg Co, 1.25 mg I, 41.8 mg Zn, and 77 μg Se.

numbers and individual body weights were recorded initially and at the conclusion of each experiment.

Experiments and diets

The rice brans were obtained from Rice Growers Association of California, Sacramento, CA, and the cornmeal and soybean meal from a local feedmill. Chemical composition of these materials is shown in Table 2. Chick diets (Table 1) were prepared to meet nutritional requirements of chicks up to three weeks of age (NRC 1980).

Experiment 1 (a pilot study) compared FFRB with the CS diet, with 0.5% cholesterol included in each diet, fed to 10 chicks for 10 days. No attempt

Table 2. Composition of stabilized rice bran, corn meal and soybean meal used in chick diets

	Protein[1]	Fat	Ash	TDF[2]	SDF[2]	Moisture
	% dmb					%
Experiment I						
Rice bran, full-fat	14.9	22.4	8.4	20.9	1.9	5.8
Experiment II						
Rice bran, full-fat	13.6	18.0	7.3	19.9	1.8	6.9
Rice bran, defatted[3]	16.2	0.4	8.6	24.1	2.1	7.5
Corn Meal	8.9	3.8	1.3	10.5	–	9.0
Soybean Meal	44.1	1.4	5.8	18.7	–	7.6

[1] Kjeldahl, N × 6.25

[2] Total dietary fiber and soluble dietary fiber; determined by method of Prosky et al., (1988)

[3] Defatted with hexane at 54 °C

was made to equalize fat content between diets. At the end of the experiment, following a 12 h fast, blood was drawn from the brachial vein for analysis.

In Experiment 2, three replicate groups of ten chicks each for each of three treatments, FFRB, DFRB and CS, were used. The rice bran diets were formulated with casein and cornstarch and balanced for protein, total fat and fiber content. Conditions and duration of this experiment were the same as in Experiment 1.

Chemical analyses

Diet components were analyzed for crude protein (Kjeldahl N × 6.25), ash, and crude fat (ether extract) using standard methods (AOAC, 1980) and dietary fiber (Prosky, et al., 1988).

Total serum cholesterol concentration, using Bakers Centrifichem 500, was determined by an enzymatic, colorimetric procedure (Allain et al., 1974). Plasma high-density lipoprotein (HDL) cholesterol was separated in the supernatant by treating plasma with a solution containing manganese chloride and heparin. The HDL in the supernatant was determined as described above for total cholesterol. The low-density lipoprotein (LDL) cholesterol was determined from Friedwald's equation (Friedwald et al., 1972). Serum triglycerides were also determined using Bakers Centrifichem 500 by an enzymatic and colorimetric procedure (Megraw et al., 1979).

Statistical analysis

Analysis of variance of diet effects was performed using the General Linear Models procedure (SAS, 1985) and differences between means were

Table 3. Serum Lipids of Chicks[1] Fed Rice Bran, Experiments 1 and 2

	Total Cholesterol	HDL-Cholesterol	LDL-Cholesterol	Triglycerides
	mg/dl			
Experiment 1[1]				
Rice bran, full-fat	336[a]	109[a]	221[a]	34[a]
Corn-soy control	461[b]	94[b]	356[b]	58[b]
$p <$	.0001	.05	.0001	.0004
Experiment 2[1]				
Rice bran, full-fat	411[a]	155[c]	249[a]	38[a]
Rice bran, defatted	460[b]	133[b]	318[c]	50[b]
Corn-soy control	397[a]	114[a]	275[b]	35[a]
$p <$	.0001	.0001	.05	.0001

[1] There were 10 chicks in each treatment in Experiment 1 and 30 chicks in each treatment in Experiment 2.

[a,b,c] Means with different superscripts in the same column within experiments are significantly different at the level of probability indicated.

analyzed by the Student Neuman Kuels test if the F-test was significant at the 0.5 level.

Results and discussion

Table 3 presents the serum lipids of chicks fed the experimental diets. The chicks fed FFRB in Experiment 1 had lower total cholesterol ($p < 0.0001$), LDL-cholesterol ($p < 0.0001$) and triglycerides ($p < 0.0004$), while HDL-cholesterol was increased ($p < 0.05$). It is noteworthy that with the high level of fat in the FFRB diet, 24%, compared with 7% in the control diet, an inverse relationship existed between fat intake and total and LDL-cholesterol.

When isocaloric diets were fed in Experiment 2, FFRB decreased LDL-cholesterol ($p < 0.05$) and increased HDL-cholesterol ($p < 0.0001$), but total cholesterol was not changed in comparison to the control diet.

DFRB appeared to be devoid of any cholesterol-lowering effects. In fact, significant increases ($p < 0.05$ to $p < 0.001$) occurred in all cholesterol forms as well as triglycerides. This increase was inconsistent with observations by Kahlon et al. (1990) where DFRB lowered total plasma cholesterol in hamsters. In that study, liver cholesterol of hamsters fed DFRB was significantly lower than control animals, 45 mg/g versus 57 mg/g, while liver cholesterol of animals fed FFRB was 31 mg/g. These data suggest there may be a species difference in response to DFRB, as well as changes in the fiber structure due to the defatting and stabilizing processes.

The cholesterol-lowering properties of FFRB appear to be mainly a function of the RBO content. Since Nicolosi et al. (1989) conclude that the fatty acid composition of RBO is not responsible for its effects, several other RBO constituents may be involved such as oryzanols, tocotrienols or other sterols.

The healthful benefits of cereal grain foods are related to multiple factors. Both soluble and insoluble dietary fiber have unique physiological functions when consumed in the diet. Soluble dietary fiber, such as is found in barley, oats and beans, plays a role in control of hypercholesterolemia and diabetes (Anderson et al. 1990). Insoluble fiber, for example that in wheat, corn or rice bran, contributes to healthy gastrointestinal function and prevention of colon cancer (Eastwood, 1990).

It is becoming increasingly evident that the fat-soluble constituents of plants play an important role in a healthful diet. Isoprenoid pathway products such as tocotrienol, geraniol and limonene appear to have a dual role on cholesterol level and tumor development (Elson, 1989). The role of ferulic acid has not been fully clarified (Sharma, 1980), but warrants investigation. The revised Dietary Guidelines for Americans (USDA 1990) advocate "choose a diet with plenty of vegetables, fruits, and grain products". Cereal grain by-products such as rice bran and barley brewers' grains can become beneficial ingredients of food products included in a healthy diet.

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