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Rice bran and wheat bran: selective effect on plasma and liver cholesterol in high-cholesterol fed rats

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Plasma and liver cholesterol concentrations were measured in Sprague–Dawley rats fed high-cholesterol (1% w/w) semipurified diets containing various fibre sources (10% w/w) for 21 days. The dietary contents of fibre were constant among the diets, except for the control diet which was devoid of fibre source. Rice bran (either crude or parboiled) produced lower plasma LDL cholesterol concentrations than wheat bran. The content of liver cholesterol in rats fed rice bran diets was significantly lower than in rats fed the wheat bran diet. When comparing the compositions of the fibre sources, this study suggests that, apart from the polyunsaturated fatty acids of rice bran, the observed effects are mainly attributable to high soluble fibre content.

INTRODUCTION

It is well established that elevated plasma cholesterol, specifically LDL cholesterol, is a predisposing factor for atherosclerosis and cardiovascular disease (Grundy, 1984; Stamler *et al.*, 1986; The Expert Panel, 1988). Otherwise, several studies indicate that polyunsaturated fatty acids lower plasma total cholesterol concentration in humans (Sheperd *et al.*, 1980; Goodnight *et al.*, 1982) and in animals (Hostmark *et al.*, 1982; Chong *et al.*, 1987; Fernandez & McNamara, 1989). Other dietary factors are effective in lowering plasma cholesterol, such as fibre sources containing high amounts of soluble dietary fibre (Chen & Anderson, 1979; Kirby *et al.*, 1981; Ney *et al.*, 1988; Shinnick *et al.*, 1988; Topping *et al.*, 1990). On the other hand, sources containing little soluble dietary fibre (i.e. wheat bran) do not lower serum cholesterol in rats (Arvanitakis *et al.*, 1977); wheat bran has also been tested for its effects on human hypercholesterolaemia and has been found to have no effect (Kay & Truswell, 1980). Rice bran was much less studied, but some authors suggested that it may be as effective as oat bran, rich in soluble fibre, in lowering blood cholesterol (Haumann, 1989; Rutjer, 1990; Topping *et al.*, 1990).

Rice bran has a characteristic composition (soluble fibre and polyunsaturated fatty acids); moreover, parboiled rice bran is more and more utilized and the parboiling process modifies the content as well as the nature of the dietary fibre. Thus, we have examined the effect of rice bran feeding on plasma cholesterol, LDL cholesterol, HDL cholesterol and total liver cholesterol concentrations in rats fed high-cholesterol diets. Concomitantly we have determined the effect that a preliminary parboiling of rice, which might modify the content of dietary fibre, has on cholesterolaemia. Finally, the efficacy of rice bran in lowering blood cholesterol levels was compared to wheat bran. In this study, the protein and fibre source levels were equalized among the different diets and the dietary groups were submitted to pair feeding.

MATERIALS AND METHODS

Materials

Reagents were obtained from the following sources: cholesterol enzymatic assay kits from Boehringer-Mannheim (Meylan, France); fatty acids standards for gas liquid chromatography analysis from Merck (Nogent-sur-Marne, France); cholesterol and cholic acid from Sigma (St Quentin, France).

Animals

Twenty-eight male Sprague–Dawley rats (Iffa Credo, France) weighing 106 ± 7 g were housed in individual

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Table 1. Composition of experimental diets (g/kg diet)[a]

Ingredient	Control	Parboiled rice bran	Crude rice bran	Wheat bran
Casein	228	156	146	166
DL-Methionine	4	4	4	4
Cholesterol	10	10	10	10
Cholic acid	2	2	2	2
Lard	80	80	80	80
Corn oil	10	10	10	10
Vitamin mix[b]	10	10	10	10
Mineral mix[c]	35	35	35	35
Corn starch	621	373	351	473
Parboiled rice bran	0	320	0	0
Crude rice bran	0	0	352	0
Wheat bran	0	0	0	210

[a] Expressed on a dry matter basis.
[b] Composition expressed in international units or g per kg of vitamin mix: retinyl acetate, 1 980 000 IU; cholecalciferol, 600 000 IU; DL-tocopheryl acetate, 17·0; menadione, 4·0; thiamin-HCl, 2·0; riboflavin, 1·5; calcium pantothenate, 7·0: pyridoxin-HCl, 1·0; inositol, 15·0; cyanocobalamin, 5×10^{-3}; ascorbic acid, 80·0; nicotinic acid, 10·0; choline-HCl, 136·0; folic acid, 0·5: *p*-aminobenzoic acid, 5·0; D-biotin, 3×10^{-2}.
[c] Salt mixture consisted of (g/kg): calcium dihydrogen phosphate, 430·0; potassium chloride, 100·0; sodium chloride, 100·0; magnesium chloride, 50·0; magnesium sulphate, 50·0; ferric oxide, 30·0; manganese sulphate, 2·5; zinc sulphate, 2·0; cupric sulphate, 0·5; cobalt sulphate, 4×10^{-3}; potassium iodide, 8×10^{-3}.

stainless steel cages in a temperature-controlled (25°C) room maintained on a 12-h light : dark cycle. They were divided into four equal groups of seven animals according to the average body weight and received the diets according to a pair-feeding schedule. Water was provided *ad libitum*. The experiment was carried out over 21 days; food consumption and body weight were recorded daily.

Table 3. Fatty acid composition of experimental diets (g/100 g fatty acids)

Fatty acid	Control	Parboiled rice bran	Crude rice bran	Wheat bran
14:0	0·9	0·6	0·6	0·8
16:0	26·6	23·1	24·5	25·8
16:1ω7	1·8	1·0	1·0	1·6
18:0	18·3	10·1	11·0	16·0
18:1ω9	40·3	40·9	39·0	37·6
18:1ω7	—	0·9	0·7	0·1
18:2ω6	11·2	21·7	21·6	16·7
18:3ω3	—	0·4	0·5	0·5
20:0	—	0·4	0·3	0·1
20:1ω9	0·9	0·8	0·8	0·8
Saturated total	45·8	34·2	36·4	42·7
Mono. total	43·0	43·6	41·5	40·1
Poly. total	11·2	22·1	22·1	17·2

Diets and experimental design

The compositions of the four experimental diets are described in Table 1. The control diet contained no dietary fibre. The other diets contained 10% dietary fibre supplied by either parboiled rice bran, crude rice bran or wheat bran. The protein content was equalized for all the diets (20% dry weight) by addition of casein. Available carbohydrate, fat, fibre and protein contents of the experimental diets and fibre sources are reported in Table 2. All diets contained 8% lard, 1% cholesterol and 0·2% cholic acid. The fatty acid composition of the diets is shown in Table 3. The rice brans were graciously provided by France Riz (Arles, France); wheat bran was a gift from the Laboratoire de Technologie des Céréales (Institut National de Recherche Agronomique, Montpellier, France). Brans were assayed for their chemical composition and utilized within 1 week after milling in order to avoid any oxidative phenomenon.

Table 2. Chemical composition of diets and fibre sources (g/kg) (dry weight basis)

	Protein	Lipid	Available carbohydrate[a]	Dietary fibre			Ash
				Total	Soluble	Insoluble	
Diet							
Control	200 (18·3)[b]	100 (20·6)	665 (61·0)	0	0	0	35
Parboiled rice bran	200 (18·7)	187 (39·3)	450 (42·0)	100	11	89	63
Crude rice bran	200 (19·0)	172 (36·8)	465 (44·2)	100	9	91	63
Wheat bran	200 (20·0)	114 (25·8)	539 (54·2)	100	6	94	47
Fibre source							
Parboiled rice bran	187	271	—	312	34	288	119
Crude rice bran	153	205	—	284	27	260	81
Wheat bran	161	67	—	477	29	448	55

[a] Estimated by difference: 1000 g diet − (g protein + g lipid + g dietary fibre + g ash).
[b] Number in parentheses under amount of protein, lipid or carbohydrate is an estimate of the percentage of metabolizable energy from that component; 16·72 kJ/g (4 kcal/g) of protein or carbohydrate, 37·62 kJ/g (9 kcal/g) of fat.

Table 4. Effect of experimental diets on weight gain, food intake and plasma and liver cholesterol in rats[a]

	Diets			
	Control	Parboiled rice bran	Crude rice bran	Wheat bran
Weight gain (g/day)	4·2 ± 0·4[a]	4·1 ± 0·6[a]	4·3 ± 0·8[a]	4·5 ± 0·4[a]
Food intake (g/day)	10·4 ± 0·7[a]	10·0 ± 0·6[a]	10·3 ± 0·6[a]	11·1 ± 0·7[a]
Plasma cholesterol (mg/100 ml)				
Total	179·2 ± 15·7	131·4 ± 26·4[a]	135·0 ± 16·4[a]	133·2 ± 16·5[a]
Free	33·7 ± 5·1[a]	26·4 ± 4·8[b]	26·2 ± 4·7[b]	34·1 ± 5·5[a]
HDL	35·2 ± 5·8[a]	34·7 ± 7·8[a]	35·0 ± 6·7[a]	39·8 ± 4·8[a]
LDL	50·0 ± 2·1[a]	12·7 ± 3·0[b]	21·1 ± 5·6[b]	48·5 ± 7·3[a]
Liver				
Weight (% body weight)	5·0 ± 0·3[a]	4·5 ± 0·2[b]	4·6 ± 0·3[b]	5·1 ± 0·2[a]
Total cholesterol (mg/g)	89 ± 8[a]	40 ± 5[b]	60 ± 9[c]	82 ± 7[a]

[a] Mean ± SEM; $n = 7$. Values without common superscripts are significantly different at $P < 0·05$.

Analytical procedures

At the end of the experimental diet period, the animals were fasted for 16 h and anaesthetized with ether. Blood was withdrawn by cardiac puncture and collected into ice-cold tubes containing EDTA as anticoagulant; plasma was prepared by centrifugation and assayed enzymatically for total, free, LDL and HDL cholesterol. The LDL fraction was precipitated using polyvinyl sulphate according to the Boehringer procedure before assay. Livers were excised, blotted dry, weighed and stored frozen (−80°C) for lipid extraction; liver lipids were extracted with chloroform/methanol (2 : 1) according to the procedure of Folch *et al.* (1957); then, total liver cholesterol was determined with the modifications described by Carlson & Goldfarb (1977). Liver cholesterol was expressed on the basis of fresh liver weight. The total and soluble dietary fibre in the fibre sources were measured according to Prosky *et al.* (1988). The fatty acid composition of the diets was analysed by gas chromatography using methyl esters of fatty acids.

Statistical analysis

Data are shown as means ± SEM; they were compared by one-way analysis of variance and significance was determined by Student's *t*-test. A value of $P < 0·05$ was considered as the criterion of significance.

RESULTS

The chemical composition of the experimental diets is shown in Tables 2 and 3; the amount of soluble dietary fibre differs between rice bran and wheat bran. In rice bran, parboiling triggered off a 20% increase in soluble fibre content without modifying that of fatty acid. The fatty acid composition of the experimental diets is shown in Table 3; total saturated fatty acids were low in the rice bran diets whereas they exhibited higher total polyunsaturated values compared to control and wheat bran groups. No significant differences in food intake and weight gain were observed among diet groups (Table 4). Nevertheless, rats fed the rice bran diets ingested significantly more polyunsaturated fatty acids than control and wheat bran-fed ones (Fig. 1). The soluble fibre intake during the experimental period for the bran diet groups is reported in Fig. 2; animals fed the parboiled rice bran diet ingested a significantly higher amount of soluble fibre (1·07 ± 0·07 g/day) than did rats fed crude rice bran or wheat bran (respectively 0·98 ± 0·05 and 0·67 ± 0·04 g/day). Liver weights were significantly lower in parboiled and crude rice bran

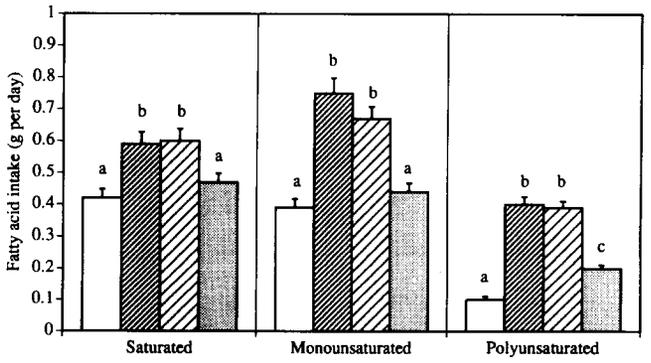

Fig. 1. Saturated, monounsaturated and polyunsaturated fatty acid intake over the experimental period ((□) control diet; (▨) parboiled rice bran diet; (▨) crude rice bran diet; (■) wheat bran diet). Within each group of fatty acid, bars bearing identical letters are not significantly different ($P < 0·05$).

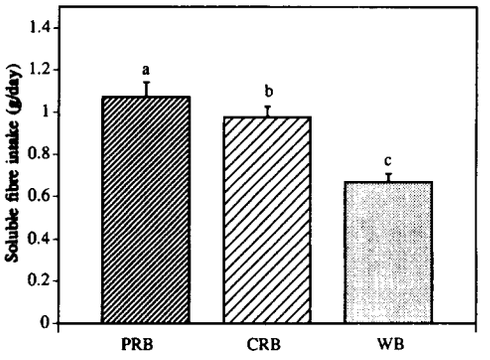

Fig. 2. Ingested amounts of soluble fibre (PRB, parboiled rice bran diet; CRB, crude rice bran diet; WB, wheat bran diet). Bars bearing identical letters are not significantly different ($P < 0·05$).

groups than in other groups. Rats fed the three bran diets showed significantly lower plasma cholesterol than those fed the control diet; rice bran intake selectively lowered free cholesterol and LDL cholesterol concentrations but did not alter HDL cholesterol concentrations (Table 4). Liver cholesterol is also shown in Table 4; it was significantly lowered after feeding the rice bran diet (either crude or parboiled) compared to the other diet groups.

DISCUSSION

Previous studies on the hypocholesterolaemic effect of brans were reported in the rat (Kritchevsky *et al.*, 1984; Topping *et al.*, 1990) as well as in the mouse (Hundemer *et al.*, 1991) and in hamsters (Kahlon *et al.*, 1990). These investigations were performed by feeding ad-libitum diets containing identical levels of total dietary fibres. In the present study, the food intake was equalized among the dietary groups according to a pair-feeding technique in such a way that the total dietary fibre consumption was identical for each group.

The results reported herein showed that the three fibre sources were effective in lowering total plasma cholesterol in cholesterol-fed rats. There was a substantial decrease in the cholesterol concentration of plasma low density lipoprotein only after feeding the rice bran diets. Topping *et al.* (1990) observed that binding of LDL by the LDL receptor was higher in rats fed rice bran than in animals fed wheat bran; this effect might be attributed to hepatic LDL receptor activity (Spady *et al.*, 1985); the HDL binding activity concomitantly tended to be inversely related to LDL receptor activity (Topping *et al.*, 1990), just as we observed in plasma HDL and LDL cholesterol concentrations among the diet groups. Two hypotheses may explain the effect of rice bran, i.e. the presence of polyunsaturated fatty acids and/or the nature of dietary fibres.

Total blood cholesterol and LDL cholesterol levels were lowered after feeding diets containing 10% rice bran oil, with or without added cholesterol to rats, compared with a control diet supplying 10% peanut oil (Sharma & Rukmini, 1986). In the same way, diets high in polyunsaturated fat significantly decreased plasma and LDL cholesterol levels, compared with diets high in monounsaturated or saturated fat in the guinea pig (Fernandez & McNamara, 1991). In the present experiments, parboiled and crude rice bran diet-fed rats ingested 0·4 g/day of polyunsaturated fatty acids whereas animals fed the control diet and the wheat bran diet ingested lower quantities (0·1 and 0·2 g/day of polyunsaturated fatty acids respectively) (Fig. 1); the hypocholesterolaemic effect of polyunsaturated fat-rich diets and the decrease of plasma LDL concentration observed herein are in agreement on the hypothesis of an increased hepatic uptake of plasma LDL through the apo B/E receptor pathway (Sheperd *et al.*, 1980; Fernandez & McNamara, 1989; Nicolosi *et al.*, 1990). The low cholesterol content in the livers of rats fed the rice bran diets could be attributed to a reduced hepatic synthesis of cholesterol or an increased loss of steroid compounds; Topping *et al.* (1990) and Illman & Topping (1985) found that feeding oat bran or rice bran diets to rats triggered off an increased faecal bile acid and sterol excretion, which explains the low plasma LDL cholesterol in dietary rice bran groups by a mechanism of compensation through the uptake of LDL cholesterol by the liver. Nevertheless, the same authors suggested that the decreased cholesterol content of liver is consistent with an insufficient compensation in the case of rice bran diets.

Otherwise, the nature of dietary fibre must be taken into account; rice bran and oat bran are closely related in soluble fibre content and the effects reported by Topping *et al.* (1990) are similar for these two fibre sources. The rice bran used in this work, either crude or parboiled, strongly differed from wheat bran in lipid content but also in total and soluble dietary fibre concentration (Table 2). As it was not defatted, known cholesterol-lowering agents are present, particularly cycloartenol (Kirbuchi *et al.*, 1982; Raghuram *et al.*, 1989) and oryzanol (Seetharamaiah & Chandrasekhara, 1988). Moreover, the observed greater impact of the parboiled rice bran compared to crude rice bran is likely attributable to its higher soluble fibre content which may be a consequence of the parboiling processing (Lopez-Guiza *et al.*, 1988). Thus, we consider it most likely that the fibre constituents were responsible for the benefit associated with consumption of a larger amount of soluble fibre (Fig. 2); similar findings have already been reported by Ney *et al.* (1988) with soluble oat fibre in cholesterol-fed rats.

This work supports the suggestion of others, using either rice bran (Topping *et al.*, 1990) or oat bran fibre (Ney *et al.*, 1988) that soluble fibre is responsible for the hypocholesterolaemic effect observed in rats. So, any technological processing which could enhance the proportion of soluble fibre or lead to a redistribution of fibre from insoluble to soluble form (Björk *et al.*, 1984; Nyman *et al.*, 1987; Lopez-Guiza *et al.*, 1988), might be beneficial while decreasing the intake of dietary fibre. Further studies will be necessary to assess the effect of processing on the properties of rice bran.

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