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PII: S0308-8146(97)00149-0

Food Chemistry, Vol. 62, No. 1, pp. 69–72, 1998

Printed in Great Britain
0308-8146/98 $19.00 + 0.00

Plasma total, lipoprotein cholesterol, organs cholesterol and growth performance in rats fed dietary gum arabic

Abdullah A. Al-Othman,* Reshod A. Al-Shagrawi, Fawzy M. Hewedy & Mamdoh M. Hamdi

Department of Food Science, College of Agriculture, King Saud University, Riyadh, Saudi Arabia

(Received 25 October 1996; revised version received and accepted 11 June 1997)

Thirty two male Wistar rats with initial body weight ranging from 45 to 55 g were randomly assigned to four dietary treatments. Rats were fed with *ad libitum* access diets containing 7.5% as cellulose or gum arabic with or without 1% added cholesterol for five weeks. Final body weight, body weight gain and feed efficiency ratio were comparable in all groups. Within cholesterol-fed groups, the cholesterol concentration of plasma was significantly lower in rats fed diet supplemented with gum arabic compared with those fed cellulose. Among cholesterol-fed groups, liver cholesterol was significantly higher in the group fed diet supplemented with gum arabic compared with those fed cellulose. In rats fed cholesterol-free diets, the cholesterol levels of plasma, LDL, HDL and liver were comparable. © 1998 Elsevier Science Ltd. All rights reserved.

INTRODUCTION

The effect of dietary fibre sources on lipid metabolism has been studied extensively in humans and in experimental animals (Kritchevsky, 1986; Schneeman and Levferve, 1986; Nishina *et al.*, 1993; Jonnalagadda *et al.*, 1993). The cholesterol-lowering properties of certain dietary fibres seems to be related to the soluble component of these fibre sources (Anderson *et al.*, 1984). Viscous fibres, such as pectin, psyllium and oat bran have been shown to reduce serum cholesterol in both human and animals (Chen and Anderson, 1981; Kirby *et al.*, 1981; Vigne *et al.*, 1987; Anderson *et al.*, 1988). On the other hand, insoluble nonviscous fibres (cellulose or wheat bran) have been reported to be relatively ineffective in lowering serum cholesterol levels (Chen and Anderson, 1981).

Jenkins *et al.* (1986) reported the hypocholesterolemic potential of guar gum (from Indian cluster beans). Many guar gum supplementations resulted in a reduction in serum cholesterol (Anderson, 1987).

The mechanism by which the soluble dietary fibre fractions elicit their hypocholesterolemic effect is still not clear, although many hypotheses have been proposed (Anderson, 1987). One effect of the dietary fibres that has gained some attention is the ability to increase the faecal bile acid and neutral steroid excretion. This is thought to interfere with cholesterol and bile acid homeostasis, thereby affecting the hepatic secretion of lipoprotein (Anderson, 1987). However, Tsai *et al.* (1976) showed that gum arabic and agar may elevate liver cholesterol levels, suggesting that these complex carbohydrates may have other actions.

The objective of the present study was to provide information on the lipidemic responses and growth performance in rats fed dietary gum arabic.

MATERIALS AND METHODS

Animals

Thirty two male Wistar strain rats were obtained from the animal breeding unit, College of Pharmacy, King Saud University, Riyadh. Upon arrival, animals, weighing 45–50 g, were housed individually in suspended stainless steel cages with wire mesh bottoms in a room controlled for temperature (22 ± 1°C), humidity (45–55%), and light (12 h light:dark cycle). Animals were adapted to the laboratory conditions for 4 days and fed the control diet during that time.

Diets

All diets were based on AIN-93 rodent diet (Reeves *et al.*, 1993. The composition of the experimental diets is given in Table 1. All experimental groups were fed the basal diet supplemented with 7.5% cellulose (diets 1 and

*To whom correspondence should be addressed.

Table 1. Diet composition (g per 100 g)

Ingredient	Without cholesterol		With cholesterol	
	Cellulose (diet 1)	Gum arabic (diet 2)	Cellulose (diet 3)	Gum arabic (diet 4)
Casein	20	20	20	20
Corn starch	37.25	37.25	36.25	36.25
Dextrinized corn starch	13.20	13.20	13.20	13.20
Sucrose	10	10	10	10
Corn oil	7	7	7	7
Cellulose	7.5	—	7.5	—
Gum arabic	—	7.5		7.5
AIN mineral mix	3.5	3.5	3.5	3.5
AIN vitamin mix	1	1	1	1
L-cystine	0.3	0.3	0.3	0.3
Cholesterol	—	—	1	1
Choline bitartrate	0.25	0.25	0.25	0.25

3) or gum arabic (diets 2 and 4). Diets 3 and 4 were supplemented with 1% cholesterol.

Protocol

At the end of the acclimatization period, animals were divided into four groups (eight rats each) and were fed their respective diets for five weeks. Food and water were provided *ad libitum*. Food consumption was recorded daily. Body weights were recorded weekly. At the end of the feeding period, animals were fasted overnight and anesthetized with diethyl ether. Blood was withdrawn by cardiac puncture in heparinized tubes. Plasma was isolated by centrifuging whole blood at 6000 rpm for 15 min at room temperature. Then, the plasma was stored at −70°C for lipid analysis. Liver and heart were excised, blotted, weighed and stored at −70°C.

Lipids were extracted from the organs using the method of Folch *et al.* (1957). The dried lipid extracts were resuspended in 1 ml of saline solution (9 g litre^{-1} Nacl, 1% triton X-100) (Hundemer *et al.*, 1991). Total cholesterol contents of plasma and organs were determined enzymatically by the procedure of Richmond (1973) using Randox cholesterol kit No. 290. The LDL and VLDL fractions were precipitated using Randox kit No 203. The cholesterol in the HDL fraction was measured enzymatically with Randox kit No 290 (Richmond, 1973).

Statistical analysis

Data are expressed as the means ± SE. The effect of dietary fibre treatments was determined by the one-way analysis of variance (ANOVA) procedure. Differences were considered significant at $p < 0.05$ (Winer, 1971).

RESULTS AND DISCUSSION

The effect of dietary treatments on final body weight, weight gain, food intake, feed efficiency ratio and organ weight is summarized in Table 2. Statistical analysis of the data indicated no significant differences in final body weight and weight gain among dietary groups during the whole experimental period. Mean daily food intakes (in g/day/rat) for each group were: cellulose diet 11.3 ± 0.66, gum arabic diet 10.80 ± 0.09, cellulose diet with added 1% cholesterol 10.70 ± 0.58 and gum arabic diet supplemented with 1% cholesterol 11.9 ± 0.04. Feed efficiency ratios were not significantly different among the experimental groups. Gum arabic feeding resulted in slightly higher final body weight relative to the final body weight of cellulose-fed groups.

Among the dietary treatments, total liver weight was significantly higher in the group fed the gum arabic diet supplemented with cholesterol than in the other groups. On the other hand, statistical analysis showed no significant differences in the relative heart weight among experimental groups.

The influence of various diets on the total cholesterol of plasma and lipoproteins is listed in Table 3. The cholesterol concentrations of plasma, HDL and LDL were significantly higher in groups fed diets supplemented with cholesterol compared with those fed cholesterol-free diets. Within cholesterol-fed groups, the total plasma cholesterol level was significantly lower in rats

Table 2. Body weight gain, organ weights and feed efficiency ratio of rats fed experimental diets

Ingredient	Without cholesterol		With cholesterol	
	Cellulose (diet 1)	Gum arabic (diet 2)	Cellulose (diet 3)	Gum arabic (diet 4)
Inital body weight (g)	47.5 ± 3.33^a	49.4 ± 4.4^a	50.4 ± 4.0^a	56.5 ± 4.6^a
Final body weight (g)	178 ± 18^a	182 ± 10^a	167 ± 4.0^a	187 ± 10^a
Weight gain (g)	130 ± 15^a	133 ± 6.4^a	112 ± 4.2^a	130 ± 6.0^a
Feed intake (g day^{-1})	11.3 ± 0.66^a	10.8 ± 0.09^a	10.7 + 0.58^a	11.9 ± 0.04^a
Feed efficiency ratio	0.32 ± 0.02^a	0.34 ± 0.03^a	0.30 ± 0.02^a	0.30 ± 0.02^a
Liver weight (g)	5.57 ± 0.60^a	6.13 ± 0.38^a	6.04 ± 0.32^a	7.63 ± 0.42^b
Liver weight (g per 100 g BW)	3.13 ± 0.07^a	3.36 ± 0.08^a	3.87 ± 0.07^a	4.09 ± 0.09^b
Heart weight (g)	0.66 ± O.O9^a	0.68 ± 0.04^a	0.63 ± 0.03^a	0.77 ± 0.04^b
Heart weight (g per 100 g BW)	0.37 ± 0.03^a	0.38 ± 0.02^a	0.41 ± 0.04^a	0.41 ± 0.02^a

^{a,b}Means ± SE values with different superscripts in the same row are significantly different ($p < 0.05$).

Table 3. Plasma total and lipoprotein cholesterol levels in rats fed the experimental diets[a–c]

Ingredient	Without cholesterol		With cholesterol	
	Cellulose (diet 1)	Gum arabic (diet 2)	Cellulose (diet 3)	Gum arabic (diet 4)
Cholesterol (mg dlitre^{-1})	97 ± 1.5^a	105 ± 1.7^a	119 ± 3.6^b	109 ± 3.0^c
HDL cholesterol (mg dlitre^{-1})	24 ± 1.5^a	23 ± 1.1^a	17 ± 1.5^b	22 ± 2.3^a
LDL cholesterol (mg dlitre^{-1})	61 ± 2.5^a	63 ± 2.0^a	95 ± 4.3^b	84 ± 5.0^b
HDL C[d] total C	0.25 ± 0.03^a	0.20 ± 0.03^a	0.14 ± 0.02^b	0.20 ± 0.02^a
LDL C/ HDL-C	2.65 ± 0.24^a	2.79 ± 0.26^a	6.00 ± 0.50^b	4.31 ± 0.41^c

[a–c]Means ± SE. Values with different superscripts in the same row are significantly different ($p < 0.05$).
[d]Cholesterol.

fed gum arabic than in those fed a cellulose diet. Supplementing the gum arabic diet with 1% cholesterol resulted in a significantly higher HDL cholesterol content compared with the cellulose diet enriched with 1% cholesterol. The cholesterol levels of plasma and lipoproteins were comparable among groups fed diets without added cholesterol.

The soluble fraction of various dietary fibre sources, as found in oat bran and barley, seem to have the potential for lowering plasma total and LDL cholesterol levels (Anderson, 1987; Anderson and Gustafson, 1988; Council of Scientific Affairs, 1989). Gel-forming soluble fibres, such as pectin and guar gum, have also been observed to be effective hypocholesterolemic agents (Abraham and Melita, 1988; Kinosian and Eisenberg, 1988). On the other hand, insoluble fibres, such as cellulose or wheat bran, have been reported to be relatively ineffective in lowering serum cholesterol levels (Chen and Anderson, 1981).

The soluble dietary fibre (gum arabic) used in the present study was observed to be effective in lowering the total plasma cholesterol level compared with insoluble fibre (cellulose) when rats were fed diets supplemented with 1% cholesterol. In a human study, Ross *et al.* (1983) found that the mean concentration of total serum cholesterol decreased significantly after a three week treatment of gum arabic. Similarly, pectin resulted a decrease in the total plasma cholesterol (Kay and Truswell, 1977). The present findings are in agreement with previous studies (Life Science Research Office, 1987; U.S. Department of Health and Human Services, 1988; National Research Council, 1989) showing that an increased intake of certain types of dietary fibre may reduce blood cholesterol, especially in those individuals with greatly elevated blood cholesterol levels. Furthermore, oat bran has been shown to reduce blood cholesterol concentrations in both hypercholesterolemic animals and humans (Kirby *et al.*, 1981; Anderson *et al.*, 1984; Ney *et al.*, 1988). This can be explained by the observation of Kelley and Tsai (1978) who reported that feeding gum arabic led to a reduction in dietary cholesterol absorption. Moreover, diets containing barley have been shown to reduce cholesterol levels and to inhibit cholesterol synthesis in chickens (Quershi *et al.*, 1980, 1986; Prentice *et al.*, 1982).

The effect of the experimental diets on liver and heart cholesterol is shown in Table 4. There were no significant differences in total liver lipid and cholesterol concentrations among the groups fed cholesterol-free diets. On the other hand, liver total cholesterol levels were significantly greater in animals fed diets enriched with 1% cholesterol than in those fed cholesterol-free diets. Among cholesterol-fed groups, liver cholesterol was significantly higher in rats fed gum arabic than in those fed cellulose. Feeding rats with a gum arabic diet supplemented with 1% cholesterol resulted in slightly, but not significantly, higher heart cholesterol (mg/heart) than in rats fed the other diets (Table 4). Tsai *et al.* (1976) found that gum arabic and agar may elevate the liver cholesterol level which is in agreement with present data.

This study demonstrates that insoluble fibre (cellulose) has little effect on plasma and liver cholesterol. On the other hand, soluble fibre (gum arabic) has a

Table 4. Liver and heart cholesterol levels in rats fed the experimental diets[a–c]

Ingredient	Without cholesterol		With cholesterol	
	Cellulose (diet 1)	Gum arabic (diet 2)	Cellulose (diet 3)	Gum arabic (diet 4)
Liver cholesterol (mg g^{-1})	1.34 ± 0.06^a	1.12 ± 0.02^a	2.04 ± 0.10^b	2.56 ± 0.10^c
Liver cholesterol (mg per liver)	7.33 ± 0.70^a	6.90 ± 0.50^a	12.3 ± 0.82^b	19.6 ± 2.33^c
Heart cholesterol (mg g^{-1})	1.23 ± 0.06a	1.32 ± 0.04^a	1.30 ± 0.06^a	1.22 ± 0.06^a
Heart Cholesterol (mg per heart)	0.80 ± 0.07^a	0.86 ± 0.07^a	0.81 ± 0.03^a	1.02 ± 0.06^a
Total liver lipids (mg g^{-1})	23.9 ± 0.57^a	20.4 ± 0.95^a	39.0 ± 1.54^b	40.0 ± 2.25^b

[a–c]Means ± SE. Values with different superscripts in the same row are significantly different ($p < 0.05$).

pronounced positive effect on plasma cholesterol, while it increases liver cholesterol, in particular when rats are fed a high cholesterol diet. This study confirms the plasma cholesterol-lowering effect of gum arabic.

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