CHOLESTEROL METABOLISM IN RABBITS FED DIETS CONTAINING EITHER CORN OIL OR OLIVE OIL

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ABSTRACT

The effects on cholesterol metabolism of replacement of coconut fat by either corn oil or olive oil in cholesterol-free, semipurified diets were studied in rabbits. After 19 days serum total cholesterol had dropped by 37 and 21% respectively, after feeding corn oil and olive oil. HDL cholesterol levels in serum decreased by about 20%, irrespective of whether the diet contained corn oil or olive oil. Olive oil caused a significantly greater decrease in serum triglyceride concentrations than corn oil. When compared to corn oil, olive oil induced a 65% increase in the cholesterol concentration of the liver. The lithogenic index of saturation in bile was not differentially influenced by the feeding of either corn oil or olive oil. It would appear that in the rabbit model corn oil has a more favorable effect on cholesterol metabolism than olive oil.

INTRODUCTION

There is considerable evidence that high concentrations of low density lipoprotein (LDL) cholesterol in serum cause atherosclerotic diseases. In order to lower LDL cholesterol it is widely recommended to increase the intake of polyunsaturated fats at the expense of saturated fats. There is some concern as to the other effects of such a change in dietary composition. Polyunsaturated fatty acids may reduce the concentration of high density lipoproteins (HDL) in serum (1, 2). Since HDL is generally considered antiatherogenic, it could be suggested that a reduction in HDL may decrease the impact of LDL lowering. Mattson and Grundy (2) have put forward that in humans monounsaturated fatty acids are as effective in reducing LDL cholesterol as polyunsaturated fatty acids, but do not cause a decrease in HDL cholesterol. The objective of the present study was to study the effects of mono- versus polyunsaturated fatty acids on HDL cholesterol in the rabbit model.

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Another point of concern about polyunsaturated fatty acids relates to gallstone formation (3). This prompted us to address also the question whether monounsaturated fatty acids given in the form of olive oil and polyunsaturated fatty acids given as corn oil would have a differential effect on the lithogenicity of bile in rabbits.

MATERIALS AND METHODS

Animals and housing. Random-bred, male rabbits of the New Zealand White strain were purchased from the Broekman Institute, Helmond, The Netherlands. They were housed individually as described (4).

Experimental design and diets. Three semipurified diets differing only in their fat component were used. The composition was as follows (g/kg feed): casein, 210; corn starch, 170; dextrose, 210; molasses, 50; fat source, 100; sawdust, 180; dicalciumphosphate, 29; sodium chloride, 6; magnesium carbonate, 3; magnesium oxide, 2; potassium bicarbonate, 18; vitamin premix, 12, and mineral premix, 10. The composition of the vitamin and mineral premixes has been described (4). The fat sources (g/kg feed) of the diet were as follows. Coconut-fat diet: coconut fat, 90 and corn oil, 10. Corn-oil diet: corn oil, 100. Olive oil diet: olive oil, 90 and corn oil, 10. Coconut fat was purchased from Croklaan NV, Wormerveer, The Netherlands, corn oil (Reddy®) from NV Vandemoortele, Oudenbosch, The Netherlands and virgin olive oil (Louis de Regis®, vierge) from C[le]. Française d'huiles d'olive, Marseille, France. The fatty acid composition of the complete diets is given in Table 1.

TABLE 1. Fatty acid composition of the semipurified diets

	Pre-experimental diet	Experimental diets	
Fatty acid	Coconut fat	Corn oil	Olive oil
	(g/100 g fatty acids)		
12:0	39.0	0.9	0.3
14:0	15.5	0.6	0.3
16:0	9.4	11.7	10.5
18:0	3.4	3.1	3.6
18:1	9.6	28.8	70.1
18:2	7.9	46.6	12.2
Sat, total	80.5	18.3	15.4
Mono, total	10.2	30.0	71.5
Poly, total	8.9	49.2	12.8

The analysed total fat contents of the diet (g/kg) were: coconut-fat, 113; corn-oil diet, 107; olive-oil diet, 110.

During the pre-experimental period all animals, which were aged about 5 months at the beginning of this period, were maintained on the coconut-fat diet. The pre-experimental period lasted 16 days. The rabbits were then divided into two groups of 10 animals which were stratified for body weight and serum cholesterol concentrations. One group was transferred to the corn-oil diet and the other to the diet containing olive oil. The experimental period lasted 19 days.

Food was provided each day at 0900 hours on a restricted basis, the animals receiving 70 g/day. Water was provided ad libitum.

Analytical methods. Serum total cholesterol and biliary lipids were determined as described (5). HDL cholesterol was determined as dextran sulfate-Mg^{2+} soluble cholesterol (6) using the kit (Monotest®) purchased from Boehringer-Mannheim GmbH, FRG. Serum triglycerides were measured enzymatically as described (7). Liver cholesterol was extracted and analysed according to Abell et al. (8).

RESULTS

Body-weight changes of the rabbits during the experimental period were similar on the corn-oil and olive-oil diets (Table 2). The transfer of

TABLE 2. Body weight and serum lipids

	Experimental diets	
	Corn oil	Olive oil
Body weight (g)		
Initial (Day -2)	2747 ± 120	2743 ± 79
Change	+ 197 ± 55	+ 225 ± 64
Serum total cholesterol (mmol/l)		
Initial (Day -2)	1.94 ± 0.50	1.96 ± 0.49
Change	-0.71 ± 0.33	-0.41 ± 0.29*
HDL cholesterol (mmol/l)		
Initial (Day -2)	0.67 ± 0.18	0.66 ± 0.16
Change	-0.15 ± 0.16	-0.12 ± 0.17[1]
Serum triglycerides (mmol/l)		
Initial (Day -2)	0.51 ± 0.17	0.56 ± 0.17[1]
Change	-0.20 ± 0.10	-0.35 ± 0.16[2],*

*Results, expressed as means ± SD for 10 animals per dietary group. [1]n=9, [2]n=8. All rabbits were fed the semipurified diet containing coconut fat for 16 days until Day 0 of the experiment, when half of the animals were either allocated to the corn-oil or to the olive-oil diet for another 19 days. *, P<0.05 (Student's two-tailed t test).*

the animals from the coconut-fat diet to the experimental diets caused a decrease in serum total cholesterol. In rabbits fed on the corn-oil diet the decrease was significantly greater than in their counterparts fed

the diet containing olive oil. The mean decreases were 37 and 21%, respectively.

In both dietary groups the concentration of HDL cholesterol dropped by about 20%. The effect on serum triglycerides was very pronounced in the animals fed olive oil, the lowering being about 60%. In the rabbits fed corn oil there was a 40% fall in serum triglycerides (Table 2).

The cholesterol content of the liver, in absolute and relative terms, was significantly increased after feeding the olive-oil diet (Table 3).

TABLE 3. Liver weight, liver cholesterol and biliary lipids at the end of the experiment

	Experimental diets	
	Corn oil	Olive oil
Liver wet weight		
(g)	77.5 ± 9.4	80.8 ± 7.5
(g/100 g body weight)	2.64 ± 0.33	2.73 ± 0.27
Liver cholesterol		
amount/liver (mmol)	0.54 ± 0.09	0.92 ± 0.25*
concentration (µmol/g)	6.93 ± 0.84	11.45 ± 2.98*
Biliary lipids		
cholesterol (mmol/l)	3.63 ± 0.42	3.90 ± 0.71
phospholipids (mmol/l)	4.9 ± 2.0	7.4 ± 2.5 *
bile acids (mmol/l)	164 ± 42	178 ± 15
Lithogenic index of bile	0.70 ± 0.15	0.64 ± 0.10

*See legend to Table 1. Results, expressed as means ± SD for 10 animals per dietary group, except for biliary lipids which are given for 9 animals per group. * $P<0.05$ (Student's two-tailed t test).*

When compared to dietary corn oil, olive oil did not significantly affect the concentrations in bile of cholesterol and bile acids. However, olive oil caused a significant increase in the concentration of biliary phospholipids. The lithogenic index of saturation was not differentially affected by corn oil and olive oil (Table 3).

DISCUSSION

This study shows that dietary corn oil is more effective than olive oil in lowering the concentration of cholesterol in rabbit serum. This corroborates results reported by Carroll (9). In contrast, Masi et al. (10) presented data suggesting that dietary corn oil produces serum cholesterol levels that are not much different from those seen after feeding a diet containing olive oil. Possibly, the use of different types of olive oil may have caused this discrepancy. We have used oil obtained from the first pressing of olives. Carroll (9) and Masi et al. (10) did not specify the type of olive oil used.

Mattson and Grundy (2) have shown in human patients that high-oleic safflower oil was as effective in lowering serum total cholesterol as high-linoleic safflower oil. Since we found that corn oil, which is rich in linoleic acid, is more effective than olive oil, which is rich in oleic acid (Table 1), it could be suggested that the rabbit is not a suitable model to study the effects of these oils. However, this suggestion remains to be proven in experiments using the same oils as used in the experiments of Mattson and Grundy (2). In addition, unlike Mattson and Grundy (2), other workers (11) have presented evidence that polyunsaturated fatty acids are more effective in lowering human serum total cholesterol levels than monounsaturated fatty acids.

In our rabbits corn oil did not lower HDL cholesterol to a greater extent than did olive oil. Serum triglyceride concentrations however, were reduced more effectively by olive oil than corn oil. Both observations may be in disagreement with those found in humans by Mattson and Grundy (2). These authors have presented evidence that linoleic acid more drastically lowers both serum HDL cholesterol and triglycerides than oleic acid.

Table 3 shows that olive oil at a concentration of 9% in the diet caused a marked increase in the content of liver cholesterol when compared to corn oil. A similar effect was seen earlier by Carroll (9) who fed rabbits semisynthetic diets containing 15% by weight of the oils. At present, it is difficult to assess the importance of this observation. It is possible that the increased amount of cholesterol in the livers of rabbits fed olive oil as shown in Table 3, did actually not consist of cholesterol but of plant sterols derived from the oil. Liver cholesterol was measured using the acetic acid/sulfuric acid reagent of Abell et al. (8), which may not discriminate between cholesterol and plant sterols. It should be stressed however, that Kritchevsky et al. (12) found that rabbits fed olive oil had significantly higher levels of liver cholesterol than rabbits fed peanut oil. In this study liver cholesterol was determined enzymatically.

It has been suggested that replacement of saturated fats by polyunsaturated fats increases the risk for gallstones in humans (3). Animal data may not be in agreement with this suggestion. Borgman (13) fed rabbits on semipurified diets either rich in oleic acid or linoleic acid for 12 or 8 weeks, respectively. Oleic acid was found to induce the formation of gallstones, but a time effect cannot be excluded. Our data would suggest that with respect to the lithogenic index of bile in rabbits it is immaterial whether coconut fat is replaced by either corn oil or olive oil. Whether these oils, when compared to coconut fat, increase the lithogenic index cannot be assessed from the present study.

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