Zeitschrift für
Ernährungswissenschaft Z Ernährungswiss 26:158–160 (1987)

Originalarbeiten

Type of dietary carbohydrate and liver cholesterol in rats

A. C. Beynen*)) and A. G. Lemmens*)**

*) Department of Laboratory Animal Science, State University, Utrecht
**) Department of Human Nutrition, Agricultural University, Wageningen (The Netherlands)

Summary: Rats were fed semipurified diets containing either sucrose or corn starch (72 % or 29 % of their total calories). Carbohydrates were exchanged for corn oil in equicaloric amounts. After 28 days, dietary sucrose had caused significantly lower concentrations of liver cholesterol than had starch. The sucrose-induced lowering of liver cholesterol, compared to starch, was amplified by increasing the amount of fat in the diet, at the expense of the carbohydrate source.

Zusammenfassung: An Ratten wurden halbgereinigte Diäten verabreicht, die 72 % bzw. 29 % Saccharose oder Maisstärke in den Gesamtkalorien enthielten. Kohlenhydrate wurden auf Kalorienbasis durch Maisöl ersetzt. Nach 28 Tagen bewirkte Saccharose im Vergleich zu Maisstärke signifikant erniedrigte Lebercholesterinkonzentrationen. Die von Saccharose induzierte Erniedrigung des Lebercholesterins wurde durch Erhöhung des Fettgehaltes in der Diät – auf Kosten der Kohlenhydratträger – verstärkt.

Key words: dietary sucrose, dietary starch, liver cholesterol, rats

Introduction

The type of dietary carbohydrate affects cholesterol metabolism in rats. When compared to starch, sucrose produced elevated concentrations of cholesterol in serum (2, 3, 5, 6). In some studies (2, 3), but not all (6), sucrose feeding resulted in lower levels of liver cholesterol than did starch feeding. The effects of dietary carbohydrate on serum and liver cholesterol in rats can be influenced by the type of fat in the diet. The use of diets with a background high in polyunsaturated fatty acids diminished the effects of sucrose versus starch (5). The present study was carried out to see whether an interaction also exists between the type of carbohydrate and the amount of fat in the diet.

Table 1. Composition of the experimental diets.

Ingredient	Low fat diets		High fat diets	
	Sucrose	Starch	Sucrose	Starch
	(g)			
Casein	21.0	21.0	21.0	21.0
Sucrose	67.0	–	26.5	–
Corn starch	–	67.0	–	26.5
Corn oil	2.0	2.0	20.0	20.0
Sawdust	2.0	2.0	2.0	2.0
Salts, minerals, vitamins[1)]	8.0	8.0	8.0	8.0
Total	100.0	100.0	77.5	77.5

[1)] This mixture consisted of (in g): dicalcium phosphate, 2.9; sodium chloride, 0.6; magnesium carbonate, 0.3; magnesium oxide, 0.2; potassium carbonate, 1.8; vitamin premix, 1.2; mineral premix, 1.0. The compositions of the vitamin and mineral premixes have been described elsewhere (4).

Materials and Methods

Male rats of a random-bred Wistar Cpb/WU colony were used, which had been fed a commercial, pelleted diet (RMH-B, Hope Farms, Woerden, The Netherlands). At day 0 of the experiment, when the rats were aged 10 weeks, they were divided into four groups consisting of six animals each. The groups had similar distributions of serum cholesterol concentration and body weight, and were fed diets shown in Table 1. The diets, which were in powdered form, were essentially cholesterol-free and contained either 2 % (w/w) or 25.8 % corn oil. The carbohydrate source was either sucrose or corn starch. Fat was exchanged with carbohydrates in equicaloric amounts (Table 1). The diets were continued for 28 days.

During the experiment, the rats were housed individually in metabolic cages which were placed in a room with air conditioning (20 °C), controlled lighting (light: 06.00–18.00 h; dark: 18.00–06.00 h) and humidity (55–65 %). Food and demineralized water were provided ad libitum.

Blood samples were taken in the non-fasting state by orbital puncture under light diethyl-ether anaesthesia, between 08.00 and 10.00 h. Serum total cholesterol was measured enzymatically using the kit (Monotest) supplied by Boehringer-Mannheim, GmbH, FRG. At the end of the experiment, immediately after blood sampling, the anaesthetized rats were killed by decapitation, and the livers were removed. Extraction and determination of liver cholesterol was performed as described by Abell et al. (1).

Results and Discussion

Table 2 shows that body weights at the end of the experiment were similar for all dietary groups. Feed intake was lower on the high fat diets, which can be explained by their higher energy density (cf. Table 1).

Dietary sucrose caused higher concentrations of serum cholesterol than corn starch, but this effect was only seen on the low fat diets (Table 2). On the other hand, sucrose feeding resulted in lower concentrations of liver cholesterol, irrespective of whether the diets had a low or high background of fat. This sucrose effect was amplified, both in relative and absolute terms, by a high content of fat in the diets.

Table 2. Performance and cholesterol metabolism in rats fed the experimental diets for 28 days.

	Low fat diets		High fat diets	
	Sucrose	Starch	Sucrose	Starch
Body weight (g)				
initial (day −1)	252 ± 15	251 ± 19	253 ± 16	257 ± 20
final	310 ± 25	296 ± 26	319 ± 23	323 ± 29
Feed intake (g/day)	16.7 ± 1.0	16.5 ± 0.9	13.7 ± 0.8	14.0 ± 1.5
Serum cholesterol (mmol/l)				
initial (day −5)	2.5 ± 0.2	2.5 ± 0.1	2.5 ± 0.2	2.5 ± 0.2
final	3.5 ± 0.2	3.0 ± 0.1*	3.5 ± 0.4	3.5 ± 0.4
Liver weight (g)	13.6 ± 1.3	11.3 ± 1.5	12.2 ± 1.0	11.9 ± 1.7
Liver cholesterol (μmol/g)	4.8 ± 0.3	5.5 ± 0.4*	6.9 ± 1.1	10.1 ± 2.0*

Results, expressed as means ± SD for the six rats per dietary group.
*Significantly different from comparable group fed the diet containing sucrose ($P<0.05$; two-tailed Student's t test).

The sucrose-induced increase in serum cholesterol of rats has been demonstrated in various studies (2, 3, 5, 6). Likewise, the present study agrees with other work showing that sucrose versus starch lowers liver cholesterol in rats (2, 3). The new observation is that this sucrose effect on liver cholesterol is more pronounced using diets high in fat. This is a surprising finding because fat was added to the diets at the expense of isocaloric amounts of carbohydrate. Thus the differential effect of sucrose and starch on liver cholesterol becomes more evident upon reduction of their contents in the diet from 72 to 29 % of total calories.

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Received May 18, 1987

Authors' address:

Prof. Dr. Anton C. Beynen, Department of Laboratory Animal Science, State University, P.O. Box 80.166, 3508 TD Utrecht, The Netherlands