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Influence of Dietary Carbohydrates on Serum Cholesterol Levels in Albino Rats

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The influence of different carbohydrates like corn starch, tapioca starch, potato starch, sucrose and rice starch in combination with different dietary proteins (casein, ground nut protein and muscle protein from rohu (*Labeo rohita*) on the serum cholesterol levels in albino rats fed on a low fat diet was studied, over a period of one month. Under these conditions sucrose was the least atherogenic of all the carbohydrates tried whereas potato starch led to higher levels of serum cholesterol in combination with all proteins used. Rice starch had good cholesterol lowering properties in combination with all proteins. But this could be partially due to the protein content of the rice flour used. The effect of different carbohydrates varied depending upon the level of fat in diet, the protein component and also the length of feeding time and any conclusions drawn should take all these factors into consideration.

Kritchevski (1978) in his extensive review on atherosclerosis and nutrition observed that dietary components other than lipids can also affect serum cholesterol levels significantly. Influence of dietary lipids and proteins on the serum cholesterol levels is fairly well established though the exact mechanism of their action is still not fully understood. Ahrens *et al.* (1961) and Anderson *et al.* (1963) reported that dietary carbohydrates affect the serum triglycerides level, but do not always influence cholesterol levels. Yudkin (1966) suggested that sucrose consumption can be correlated to atherosclerosis but Walker (1971) and Keys (1971) differed with this view. Kritchevski *et al.*, (1968) in a study using rabbits found that starch is the most atherogenic carbohydrate and glucose the least. Sucrose and partially hydrolysed starch gave intermediate values. These conflicting and confusing reports suggest that the influence of carbohydrates on serum cholesterol levels vary depending upon the test animals and the nature and levels of dietary protein and lipids.

This laboratory has been studying the influence of different nutrients on serum cholesterol levels, using albino rats, to study the hypocholesterolemic effect of dietary fish. As a part of these studies, influence of different carbohydrates in combination with vegetable and animal proteins (ground nut protein, casein and fish protein), with refined ground nut oil at 5% level as the fat source was studied. Results of this study are reported in this paper.

Materials and Methods

Six weeks old albino rats (Wistar strain) bred in the institute's animal house, weighing around 100 g each were used for the study. They were divided into 12 groups of 5 rats each and were housed individually, in polypropylene cages of standard design. Diets for the 12 groups were divided into three sub groups based on the protein source namely, casein, defatted ground nut cake and defatted fish (Rohu-*Labeo rohita*) powder. With each protein four different carbohydrate sources were tried namely, corn starch, potato starch, tapioca (Cassava) starch and sucrose. All diets had protein at 15% level, fat at 5%, vitamin mixture (Chapman *et al.*, 1959) and essential minerals (U.S.P. salt mixture) at 1% and 4% levels respectively, cholesterol at 0.5% and glucose at 20% level. The diets were made upto 100%

with the concerned carbohydrate. In the case of defatted ground nut cake the carbohydrate content of the cake was also taken into account. Potato starch for the study was prepared fresh from raw potatoes in the laboratory. Corn starch and tapioca starch were purchased from the local market. Ground nut cake purchased from the market was further defatted by extraction with petroleum ether (Ammu *et al.*, 1989). Feed and water were given *ad libitum*. Feeding schedule and practice were as reported earlier (Ammu *et al.*, 1989). The feeding was continued for one month after which the rats were starved overnight and sacrificed on the following day. Blood samples were collected and serum cholesterol levels estimated by the method of Rudel & Morris (1973).

Along with these 12 groups of rats, another 3 groups with rice flour as the source of carbohydrate, in combination with the three sources of protein, were also studied for the change in the serum cholesterol. As the rice flour had 6 to 8% protein, the effect in this case cannot be taken as due to the rice starch alone. Hence its effect on serum cholesterol is discussed separately.

Data were statistically analysed using Analysis of Variance (ANOVA) technique. Two way analysis was carried out to find the differences, if any, between varieties (proteins), groups (carbohydates), and their interactions. Individual comparisons were made by calculating the critical difference (CD) by standard procedures.

Results and Discussion

As the diets were identical in all respects, except the protein/carbohydrate source, variations in cholesterol levels can be attributed to these two variables. The rice flour group expectedly recorded a higher weight gain in combinaion with all three proteins (Fig. 1). The sucrose based diet showed the least weight gain with ground nut and most with casein. The weight gains were lowest in ground nut - corn starch and groundnut-sucrose groups. With corn starch, fish protein gave the highest weight gain.

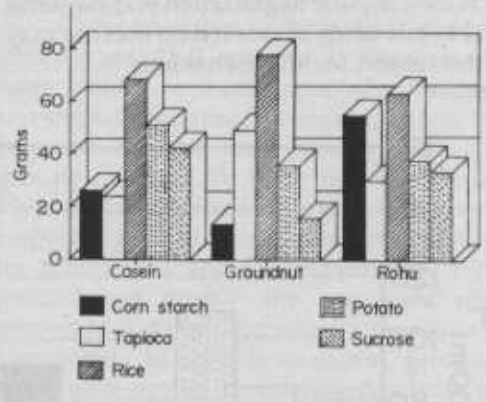

Fig. 1. Weight gain in rats fed 5 different carbohydrates in combination with either casein, groundnut or fish proteins after one month.

Even though weight gain differed with different combinations of starch and protein, in none of the cases it could be correlated in any specially significant way to its effect on the serum cholesterol levels.

In this study using albino rats on low fat, low cholesterol diet and with a feeding period of one month, we have found that sucrose is the least atherogenic of the four carbohydrates tried (Fig. 2). This is contrary to the results reported by some authors (Beurer, 1987), who have found that when a casein-sucrose diet was fed, there was an increase in intermediate density lipoprotien cholesterol content compared to a casein - glucose diet. They further observed that very low density lipoprotein (VLDL) production also shows an increase when sucrose is fed. Grande (1974) found that isocalorie substitution of dietary starch by sucrose lowered cholesterol levels. Mann and Truswell (1972) however, did not observe any such hypocholesterolemic effect. Malmros (1969) also reported that sucrose was more atherogenic than starch, but this was evident only after one year of feeding. Chang *et al.* (1976) have reported that effectiveness of pectin in lowering serum or liver lipids in rats fed low fat diet was higher when sucrose was the carbohydrate source compared to

starch. But, in high fat diets the order was reversed. Increased lipogenesis and decreased hepatic degradation of cholesterol level to bile acids in rats fed on sucrose may be the reason for this behaviour.

the additional protein component or due to rice starch, although analysis of variance showed that the effect of rice flour in combination with the three different protein sources in lowering the cholesterol content was significant at 5% level (Table 4). Amino

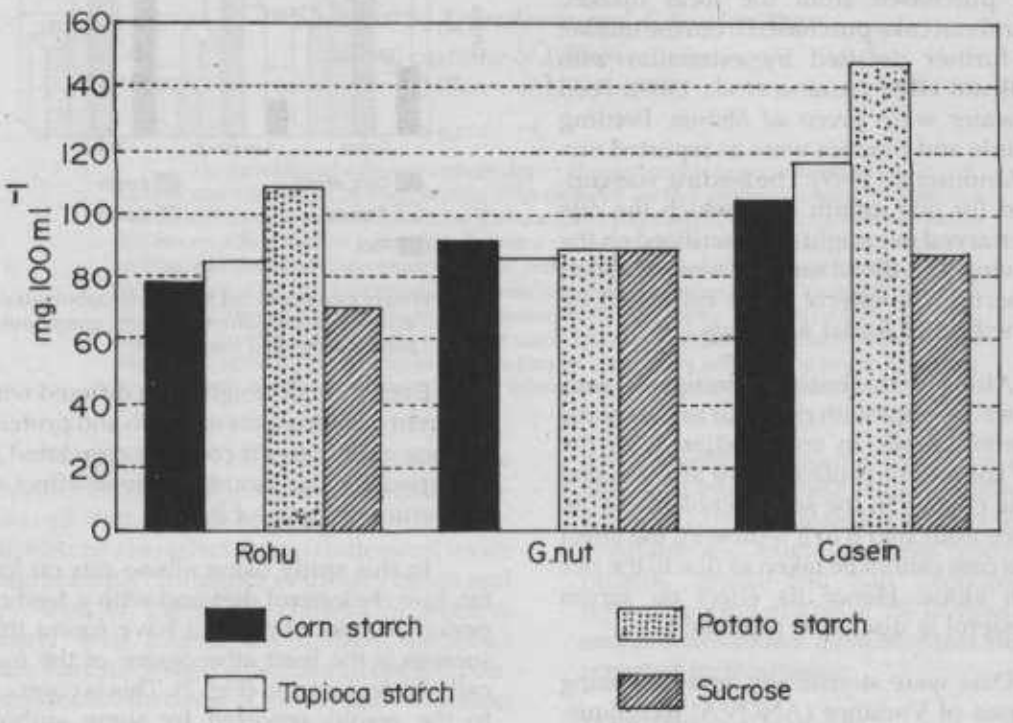

Fig. 2. Serum cholesterol levels in rats fed 5 different carbohydrates in combination with either casein, groundnut or fish proteins after one month.

Potato starch was comparatively more hypercholesterolemic than other starches in combination with all the three proteins. Carrol *et al.* (1975) reported that in rabbits, dietary wheat starch tended to increase serum cholesterol, but corn starch, rice starch and potato starch were less atherogenic when they were fed on a low fat casein based diet. When casein was replaced by soy protein all carbohydrates gave low plasma cholesterol levels.

The rice flour groups showed good serum cholesterol lowering effect with all the three protein sources tried (Table 1). It was not clear whether this behaviour was due to

acid composition of the dietary protein component is known to play a significant role in determining its hypocholesterolemic properties (Ammu *et al.*, 1989).

The data for groups other than rice flour were analysed statistically and the results are presented in Tables 2 and 3. The F values indicated that difference in serum cholesterol levels in the case of diets with different proteins (varieties) as well as with different carbohydrates (groups) were highly significant (Table 2). The interaction between varieties and groups were also found to be significant at 1% level. Thus the experiment revealed definite evidence of differen-

tial response of proteins to different carbohydrates in lowering serum cholesterol.

Table 1. *Influence of different dietary proteins in combination with rice flour on the serum cholesterol in albino rats*

Protein sources	Serum cholesterol mg%
Fat free casein	71.0
Defatted ground nut cake	70.0
Defatted Rohu powder	90.2

Table 2. *Analysis of variance of serum cholesterol in rats fed on starches other than rice flour*

Source of variation	S.S.	d.f.	m.s.	F
Proteins (V)	7691.92	2	3845.96	24.55**
Carbohydrates(G)	6773.86	3	2257.95	14.41**
Interaction(VxG)	3942.32	6	657.05	4.20**
Error	5640.53	36	156.68	

**p < 0.01; V = Variety; G = Groups

Table 3. *Critical difference analysis of serum cholesterol levels in rats fed on starches other than rice flour*

	Serum cholesterol, mg/100 ml				
	Group-I Corn starch	Group-II Tapioca starch	Group-III Potato starch	Group-IV Sucrose	Mean
Rohu protein	78.17	84.63	107.85	69.84	85.12
Ground nut protein	90.40	86.00	88.50	87.95	88.21
Casein protein	104.00	115.80	146.50	87.30	113.39
Mean	90.86	95.47	114.28	81.70	

Critical difference for group combination = 18.06
Critical difference for groups = 10.43
Critical difference for proteins = 9.03

Further, for comparing the individual proteins, carbohydrates and their respective combinations, critical differences were worked out at 5% level. It may be observed from Table 3 that the highly significant difference between proteins was due to casein. But no significant difference was observed between Rohu and ground nut protein.

Comparing the carbohydrate groups, group I and II (Corn and Tapioca starch) were similar in their hypocholesterolemic response. Comparing the combinations, the response of rohu protein with respect to groups I, II and IV were non significant. Hypocholesterolemic effect of rohu with respect to group III was the lowest followed by group II, I and IV respectively. With ground nut protein the responses with respect to different carbohydrates were not significant. As regards to casein, groups I and II were similar. Hypocholesterolemic effect was lowest with group III followed by group II, I and IV respectively. The groups and varieties could be arranged in the increasing order of their hypocholesterolemic effect as follows : V3 G3, V3 G2, V1 G3, V3 G1, V2 G1, V2 G3, V2 G4, V3 G4, V2 G2, V1 G2, V1 G1 and V1 G4 (see Table 3)

Table 4. *Analysis of variance of serum cholesterol levels in rats fed on rice flour as carbohydrate source*

Source	s.s.	d.f.	m.s.	F
Total	28.70	14	205	
Bet. varieties	1388	2	694	5.6*
Error	1482	12	123.5	

* p<0.05

The influence of the carbohydrate source was not significant in the case of ground nut protein. This may be due to the fibre content of ground nut cake. Thus the effect of carbohydrate on the serum cholesterol level was dependent on the carbohydrate source, protein source and fibre content.

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