Dietary Carbohydrate and Tissue Cholesterol Concentration in Young Rats

It has been demonstrated specifically that increased dietary sucrose, when employed as an isocaloric substitute for a starch dietary supplement, is associated with a rise in serum triglyceride levels[1]. Because of the possible relationship between elevations of certain components of the serum lipids and atherosclerotic vascular disease, a possible etiological role for sucrose in the pathogenesis of coronary artery disease in man has been suggested[2].

In earlier work we found that tissue cholesterol concentration was most amenable to change by varying the source of dietary carbohydrate[3]. Sucrose and lactose feeding to 150-day-old male rats led to much higher carcass cholesterol concentrations than did the feeding of starch. The feeding of a mixture of carbohydrates similar to that found in U.S. 'market basket' diets[4] led to a situation where carcass cholesterol concentration was most dependant on body weight. The lightest animals fed such a mixture had a carcass cholesterol concentration similar to that found in rats fed starch, but the heaviest animals fed such a mixture had a greater concentration of carcass cholesterol than was found in rats fed sucrose or lactose as the only source of carbohydrate.

To our knowledge, no study has been conducted on this relationship between dietary carbohydrate and tissue cholesterol in young, rapidly growing animals.

Materials and animals. The 25 rats used in this study were weanling, male Sprague-Dawley strain and they were held on a commercial stock diet for 5 days prior to the start of the study. 5 rats were then randomly selected and sacrificed in order for initial carcass and serum composition to be determined. The blood was removed by heart puncture and the gastrointestinal tract was removed, flushed of its contents and returned to the carcass. All carcasses were homogenized prior to analysis for moisture, protein, fat, ash, and cholesterol by mixing in a Waring blender with 2 parts water and ice[3].

The 20 experimental animals were assigned in groups of 10 to one of 2 diets as described in Table I. These diets contain around 50% of their calories as fat, which is average for U.S. human diets, and only 12% of the calories from carbohydrate. Such a carbohydrate low diet has been recommended by YUDKIN et al.[6] for weight reduction. In one diet the only source of carbohydrate is starch while in the other it is a mixture of carbohydrates simulating that found in U.S. 'market basket' diets. One half of the animals on each diet were forced to run for 15 min on a treadmill daily, while the other half remained sedentary. After 30 days the 20 animals were sacrificed and changes in serum and carcass composition determined.

Results. Body weight gain and body composition gain in terms of moisture, protein, fat, and ash were not altered by either diet or the mild exercise forced on the animals (Table II). There were also no significant differences in the caloric intake and serum cholesterol levels presented in Table III. However, the Figure shows that carcass cholesterol gain was related in a different way to ingesta-free weight gain when different carbohydrate sources were fed. As in our previous results with young adult male rats[3], there was little relationship between tissue cholesterol gain and ingesta-free weight gain when starch was the only dietary carbohydrate. However, when the dietary carbohydrate was a mixture similar to that found in U.S. 'market basket' diets, the cholesterol gain was much more weight gain dependent and the differences between these two linear regressions are highly significant ($p < 0.01$). Exercise per se under these conditions did not influence these regressions.

Table I. Composition of high fat diets containing either starch as the only carbohydrate or a mixture of carbohydrates simulating that found in U.S. 'market basket' diets

	Starch only %	Carbohydrate mixture %
Lactalbumin	48.07	48.07
Corn starch	15.50	6.20
Lactose	–	3.10
Dextrin	–	1.55
Sucrose	–	1.55
Glucose	–	1.55
Fructose	–	1.55
Safflower oil	6.70	6.70
Beef tallow	21.40	21.40
Vitamin A and D concentration	0.06	0.06
Salt mix, BERNHART-TOMARELLI[5]	5.40	5.40
Cellulose	2.81	2.81
Vitamin mix[3]	0.06	0.06
TOTAL	100.00	100.00
Gross Calories, kcal/g	5.07	5.07

[1] P. T. KUO and D. R. BASSETT, Ann. intern. Med. *62*, 1199 (1965).
[2] J. YUDKIN, Lancet *2*, 4 (1964).
[3] R. A. AHRENS, S. S. WELSH, Y. L. ADAMS, R. P. TAYLOR and D. L. KELLEY, J. Nutr. *95*, 303 (1968).
[4] J. F. EHEART and B. S. MASON, J. Ass. off. agric. Chem. *47*, 823 (1964).
[5] F. W. BERNHART and R. M. TOMARELLI, J. Nutr. *89*, 495 (1966).
[6] A. L. NICHOLSON and J. YUDKIN, Proc. Nutr. Soc. *28*, 13 (1969).

Table II. Effects on body weight gain and gains in body components by force-exercising rats fed 2 carbohydrate sources

Carbohydrate source–activity combination	Ingesta-free gain Weight (g)	Water (g)	Protein (g)	Fat (g)	Ash (g)
Starch–Exercised	107.0 ± 12.2[a]	63.6 ± 7.0	25.2 ± 4.5	18.5 ± 2.0	3.1 ± 0.4
Starch–Sedentary	91.0 ± 14.8	52.0 ± 8.8	21.7 ± 3.0	19.9 ± 2.8	2.6 ± 0.7
Mixture–Exercised	129.0 ± 7.2	75.2 ± 4.8	29.9 ± 1.5	24.0 ± 0.9	3.6 ± 0.2
Mixture–Sedentary	116.2 ± 15.4	65.8 ± 9.4	29.5 ± 3.0	20.7 ± 3.2	4.7 ± 0.6

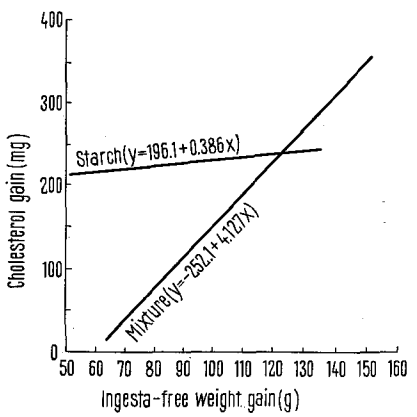
[a] Standard error of the mean.

Table III. Comparison of mean caloric intakes and serum cholesterol levels as influenced by dietary carbohydrate source and forced exercise

Carbohydrate source	Caloric intake		Serum cholesterol	
	Exercised (kcal/day)	Sedentary (kcal/day)	Exercised (mg/100 ml)	Sedentary (mg/100ml)
Starch	41.0 ± 2.5[a]	38.7 ± 2.2	48.0 ± 6.0	89.0 ± 32.4
Mixture	45.3 ± 2.7	43.1 ± 3.4	78.0 ± 27.0	78.6 ± 13.8

[a] Standard error of the mean.

Conclusion. Weanling, male rats were fed diets where the carbohydrate source was provided either by starch or a mixture of carbohydrates similar to that found in U.S. 'market basket' diets. Half the animals were forced to exercise by 15 min of treadmill running daily. Tissue cholesterol accumulation in the rats fed only starch was unrelated to weight gain, but in those fed the mixture of carbohydrates the tissue cholesterol gain was highly weight gain dependent.



Regression lines of body cholesterol gain vs. ingesta-free body weight gain as influenced by dietary carbohydrate sources. Moderate forced exercising by treadmill running (15 min/day) had no effect on this regression, and hence each line represents 10 observations. The linear regression equation is indicated for each line.

Zusammenfassung. Drei Wochen alte männliche Ratten wurden auf eine Diät gesetzt, aus der die Kohlehydratquelle entweder aus Stärke oder einer Mischung von Kohlehydraten, die dem U.S.-Ernährungsstandard gleicht, bestand. Die Cholestrolansammlung im Gewebe der Ratten, denen nur Stärke gefüttert wurde, stand nicht in Verbindung mit der Gewichtszunahme; dagegen stand die Cholestrolzunahme im Gewebe jener Ratten, die mit einer Mischung von Kohlehydraten ernährt wurden, in direktem Zusammenhang mit der Zunahme in Gewicht.

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Optic Evoked Potential Changes Induced by Deaminated Metabolites of Serotonin: 5-Hydroxytryptophol and 5-Hydroxyindole Acetic Acid

Although monoamine oxidase (MAO) has been considered the 'cholinesterase' of serotonin (5HT), many of the effects of this amine or of its precursor, 5-hydroxytryptophan (5HTP), are prevented or 'reversed' rather than enhanced by MAO inhibition: enhancement of carbohydrate metabolism[1], protection against radiation[2], sleep induction in newly hatched chicks[3,4], enhancement of slow photic evoked potentials[5], etc. Among other alternatives, it is possible that part of the effect of 5HT be indirect, i.e., mediated by the formation of one or more of its deaminated products: 5-hydroxyindoleacetaldehyde (5-hydroxytryptaldehyde, 5HTA), 5-hydroxytryptophol (5HTOL) or 5-hydroxyindole acetic acid (5HIAA). We have shown that 5HTA and tryptaldehyde (3-indoleacetaldehyde) mimic the effects of 5HT and tryptamine on rabbit photic evoked potentials[5,6] and on sleep induction in newly hatched chicks[4]. 5HTOL may intervene in the control of the secretion of luteinizing hormone in rats[7].

There is also biochemical evidence for a physiological significance of 5HT deaminated products: (a) The incorporation of radioactivity into the acid-insoluble fraction of brain homogenates from labeled 5HT or 5HTP is blocked by MAOI's[8,9]. (b) The reduction of 5HTA to

[1] S. H. BARONDES, J. biol. Chem. *237*, 204 (1962).
[2] V. Z. GORKIN, Pharmac. Rev. *18*, 115 (1966).
[3] A. J. MANDELL, C. E. SPOONER, W. D. WINTERS and D. BURNET, Biol. Psychiat., in press.
[4] W. J. GIARDINA, H. C. SABELLI, S. G. A. ALIVISATOS and J. E. P. TOMAN, Fedn. Proc. *28*, 588 (1969).
[5] H. C. SABELLI, S. G. A. ALIVISATOS, W. J. GIARDINA, F. UNGAR, P. K. SETH and S. MYLES, Pharmacologist *10*, 211 (1968).
[6] H. C. SABELLI, W. J. GIARDINA, S. G. A. ALIVISATOS, P. K. SETH and F. UNGAR, Nature, in press.
[7] F. FRASCHINI, B. MESS, F. PIVA and L. MARTINI, Science *159*, 1104 (1968).
[8] S. G. A. ALIVISATOS and F. UNGAR, Biochem. *7*, 285 (1968).
[9] D. KEGLEVIC, S. KVEDER and S. ISKRIC, in *Advances in Pharmacology* (Eds. S. GARATTINI and P. A. SHORE; Academic Press, New York 1968), vol. 6A, p. 79.