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Failure of Bran to Alter Diet-Induced Hyperlipidemia in the Rat (39716)

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Epidemiological studies have shown that serum cholesterol is low in Africans who live south of the Sahara and consume large amounts of fiber in the form of natural carbohydrates and maize flour (1, 2). Dietary fiber is defined as the skeletal remains of plant cells which are resistant to digestion by luminal and brush-border digestive enzymes. Bran is the fiber-rich fraction of wheat which is eliminated during the milling of white flour. Bran has been increasingly used in the diet in recent years as a source of dietary fiber. Although bran exerts its effect in the colon, it has been recognized that it may inhibit the utilization of energy derived from the diet through a negative effect on fat and nitrogen metabolism (3). It has been proposed that plasma lipids and ischemic heart disease are related to a deficiency in vegetable dietary fiber (4, 5). In order to determine the influence of fiber on lipids, we have investigated the effect of dietary fiber in the form of bran on diet-induced hyperlipidemia in the rat, under controlled experimental conditions, in a long-term prospective study.

Methods. Sprague–Dawley male rats weighing 300–360 g were housed in individual cages. Feed and water were supplied *ad libitum*. Four groups of animals were studied for a period of 16 weeks. The composition of isocaloric diet (Teklad Test Diets, Madison, Wis.) in the different groups is shown in Table I. Group I was fed with a control diet with cornstarch; group II was fed with cornstarch and wheat bran (10%); group III was given an atherogenic diet with sucrose; and group IV was given an atherogenic diet with sucrose and wheat bran (10%). In order to determine the physical characteristics of the bran, test sieves were used. The bran was shaken for 15 min and the weight of the flour passed through the mesh was recorded; 38% filtered through a 1.0-mm aperture size, 28% filtered through 0.5 mm, and 34% filtered through 0.35 mm.

Animal weight was recorded at weekly intervals and feed intake was recorded daily. At the end of a 16-week period, rats were sacrificed by decapitation and blood was collected from the inferior vena cava. Liver, heart, and aorta were removed and wet weight was recorded. Tissue from the liver, heart, small intestine, aorta, and coronary arteries was fixed in 10% formaldehyde and stained with hematoxylin–eosin for light microscopy.

Serum cholesterol was determined by the method of Wybenga *et al.* (6). Serum triglycerides were determined in aliquots of isopropyl ether extract by the method of Azarnoff (7). Cholesterol and triglyceride concentrations were determined in the liver extract homogenate with isopropyl alcohol, according to the methods described above.

Statistical significance of the data was determined by the Student's t test, unpaired data.

Results. All groups of rats gained weight by 34–38%, as compared to the initial weight, by the end of a 16-week study period (Table II). There was no statistically significant difference in the weight between any of the groups. Animals which were given bran had an increase in stool weight and the consistency of the stool was softer, as compared to the dry pellet-like stool of the animals which did not receive bran.

The results of serum and liver lipid levels are summarized in Table II. Bran had no effect on serum cholesterol and triglyceride in the control (cornstarch diet) and the ex-

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TABLE I. COMPOSITION OF DIET IN THE FOUR GROUPS OF RATS

Dietary components	Group I (%)	Group II (%)	Group III (%)	Group IV (%)
Casein, high protein	22.0	19.9	20.6	18.7
Cornstarch	62.3	56.0	–	–
Sucrose	–	–	58.2	52.8
Corn oil	9.0	8.1	–	–
Coconut oil	–	–	8.4	7.4
Mineral mix (Rogers–Harper)	5.5	5.0	5.2	4.6
Vitamin mix (Teklad)	1.1	1.0	1.1	0.9
Cholesterol	–	–	5.0	4.2
Cholic acid	–	–	1.5	1.4
Bran	–	10.0	–	10.0

TABLE II. EFFECT OF VARIOUS DIETS ON ANIMAL WEIGHT, SERUM, AND LIVER LIPIDS.[a]

Diet[b]	Initial weight (g)	Final weight (g)	Feed intake (g)	Serum cholesterol (mg/100 ml)	Serum triglyceride (mg/100 ml)	Liver cholesterol (mg/g body wt)	Liver triglyceride (mg/g body wt)
I. Control diet with cornstarch (19)	343 ± 6	458 ± 10	19 ± 2	186 ± 14	35 ± 5	6 ± 0.2	14 ± 1.0
II. Cornstarch with 10% bran (16)	349 ± 5	443 ± 15	20 ± 3	188 ± 14	33 ± 4	5 ± 0.1	13 ± 2.0
III. Atherogenic diet with sucrose (17)	352 ± 5	439 ± 6	22 ± 2	491 ± 62	65 ± 5	58 ± 9.0	20 ± 0.3
IV. Atherogenic diet with sucrose and bran (20)	348 ± 6	449 ± 9	21 ± 3	577 ± 50	94 ± 8	59 ± 7.0	18 ± 1.4

[a] Mean ± SE.
[b] Number of animals is given in parentheses.

perimental groups (atherogenic diet with sucrose). The difference in serum cholesterol between the control (group I) and the experimental (group III), as well as with group IV (atherogenic diet with bran), was highly significant ($p < 0.001$). No significant difference was found between group III and group IV.

Similarly, serum triglyceride levels were comparable in groups I and II, as well as in the experimental groups III and IV. There was a significant difference between group I and group III ($p < 0.005$), as well as between groups I and IV ($p < 0.05$). Bran added to the atherogenic diet not only failed to prevent hypertriglyceridemia, but resulted in a modest elevation of serum triglyceride.

Liver cholesterol and triglyceride levels were significantly higher in the experimental groups III and IV than in the control group I ($p < 0.001$). Bran did not influence the deposition of lipids to the liver in the cholesterol-fed animals.

Morphological changes. There was a marked degree of fatty metamorphosis of the liver in the group of rats given the atherogenic diet. The addition of 10% wheat bran in the diet did not prevent fatty liver. Liver weight in group III was 29 ± 1 g (mean ± SE) vs 11 ± 0.5 g in group I ($p < 0.005$). Liver weight in group III was comparable to that in group IV (29 ± 1 vs 27 ± 0.7). Heart and aorta weights were comparable in the four groups. There was no evidence of atherosclerotic plaque formation in the aorta in the groups given a high cholesterol diet. The heart, aorta, small intestine, and liver were normal by light microscopy in groups I and II. There was marked fatty metamorphosis of the liver in groups III and IV, but no changes were noted in the heart and aorta.

Discussion. The results of this study indicate that the addition of 10% bran in the diet in the rat did not exert any effect on hyperlipidemia induced by a high cholesterol diet. Similarly there was no effect on liver lipids or the fatty changes which occurred in the rats treated with a high cholesterol diet. It was also of interest that bran did not lower serum lipids in the control group of rats on a cornstarch diet. We elected to add bran in the diet in order to provide the animals with a more physiological dietary pattern, rather than administer the bran in one dose. The addition of bran markedly influenced the colonic function of the rats in our study by increasing stool bulk and altering the consistency of stool. However, alteration in colonic function had no effect on serum or liver lipids.

Our data confirm previous studies in the rat reported by Kay and Truswell (8) and Randhotra (9), as well as studies in the hamster (10). Failure of bran to reduce blood lipid levels has also been reported in man in a number of studies (11–14).

The negative results of these studies utilizing bran do not necessarily imply that other components of dietary fiber lack a lowering effect on serum lipids. The subject continues to stimulate considerable interest and variable results have been reported with different types of vegetable fiber depending on the amount used, physicochemical properties, and the biological implication on bile salts and intestinal flora.

Summary. The effect of bran on diet-induced hyperlipidemia was examined in a long-term 16-week study in the rat. Animals were divided into four groups: group I (control diet with cornstarch); group II (cornstarch with 10% wheat bran); group III (atherogenic diet with sucrose); and group IV (atherogenic diet with sucrose and 10% wheat bran). The addition of bran did not affect serum and liver lipids (cholesterol and triglycerides) in the control or the experimental groups on atherogenic diet.

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1. Trowell, H., "Non-Infective Disease in Africa," p. 119, Arnold, London (1960).
2. Shaper, A. G., *in* "Atherosclerosis," Proceedings of the Second International Symposium (R. J. Jones, ed.), p. 314, Springer Verlag, Berlin (1970).
3. Southgate, D. A. T., and Durwin, J. V. G. A. Brit. J. Nutr. **24,** 517 (1970).
4. Trowell, H., Amer. J. Clin. Nutr. **25,** 926 (1972).
5. Burkitt, D. P., Walker, A. R. P., and Painter, N. S. JAMA **229,** 1068 (1974).
6. Wybenga, D. R., Pileggi, V. J., Dirstine, P. H., and DiGiorgia, J. Clin. Chem. **16,** 980 (1970).
7. Azarnoff, D. L., J. Lab. Clin. Med. **69,** 331 (1962).
8. Kay, R. M., and Truswell, A. S., Proc. Nutr. Soc. **34,** 17A (1975).
9. Randhotra, G. S., Cereal Chem. **50,** 358 (1973).
10. Truswell, A. S., and Kay, R. M., Lancet **1,** 922 (1975).
11. Eastwood, M. A., Kirkpatrick, J. R., Mitchell, W. D., Bone, A., and Hamilton, T., Brit. Med. J. **4,** 392 (1973).
12. Jenkins, D. J. A., Leeds, A. R., Newton, C., and Cummings, J. H., Lancet **1,** 116 (1974).
13. Connell, A. M., Smith, C. L., and Sorusel, M., Lancet **1,** 496 (1975).
14. Durrington, P., Wichs, A. C. B., and Heaton, K. W., Lancet **2,** 133 (1975).

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