Arch. Pharm. Res. 12(2), 125-127 (1989)

Effects of Dietary Fibres on Blood Glucose and Liver Glycogen in Rats

Sahar Y. Al-Okbi, O.M. Metwalli and Afaf E. Abbas
Food Science and Nutrition Department,
National Research Centre, Dokki, Cairo, Egypt.
(Received April 12, 1989)

Abstract□Effects of three types of dietary fibres on blood glucose and liver glycogen were studied in male rats. The fibres were used as 10% of the diet supplemented from dietary sources, white beans, peas and carrots. The experiment continued for 5 weeks. At the end of the experiment, fasting blood glucose and liver glycogen were determined. The results showed that replacing carrot fibres and pea fibres by white bean fibres produced significant reduction of blood glucose by 28% and 43%, respectively, while exchanging pea fibres by carrot fibres produced no significant reduction of blood glucose gy 20%. Liver glycogen level (mg/100 g liver) was not affected by altering the fibre type in the diet.

Keywords□ fibers, pea, white bean, carrot, blood glucose, liver glycogen, rats

Recently there has been much discussion concerning dietary fibre and its relation to stool weights[1], body weight[2] and lipid metabolism[3]. To understand more adequately roles of dietary fibre, further investigations are needed. One of these is effect of fibre on carbohydrate metabolism, since Simpson *et al.*[4] reported that a reduction in the amount of dietary fibre was implicated in the etiology of diabetes mellitus.

The aim of our work is to study to what extent blood glucose and liver glycogen may be modified by altering the type of dietary fibres.

MATERIALS AND METHODS

Animals

Male adult rats of Sprague Dawley strain of 160-200 g body weight were used in the experiment.

Diets

Three types of diets were used, as shown in Table I.

Table I. Composition of experimental diets, diet I (10% white bean fibres), diet II (10% pea fibres) and diet III (10% carrot fibres) in g per 100 g

	Diet I	Diet II	Diet III
Contents of fibre sources*:			
Protein	6.20	10.00	3.90
Carbohydrate	15.50	15.50	27.46
Fibre (10 g):			
Hemicellulose	8.17	4.88	1.91
Cellulose	1.55	4.21	5.70
Lignin	0.27	0.39	2.25
Casein	13.80	10.00	16.10
Fat	15.00	15.00	15.00
Sucrose	35.00	35.00	23.04
Salt mixture[9]	3.50	3.50	3.50
Vitamin mixture[10]	1.00	1.00	1.00
Total	100.00	100.00	100.00

*Fibre sources:
- 31.65 g dry white bean powder (Diet I).
- 35.70 g dry peas powder (Diet II).
- 41.00 g dry peas powder (Diet III).

Each diet contains: 20% protein, 15% fat, 50.5% carbohydrate, 3.5% salt mixture, 1% vitamin mixture and 10% fibre.

Method

Rats were divided into three groups, each containing 10 rats. The first group of the rats was fed with the diet containing 10% fibre supplemented from 31.65 g white beans, oven-dried after soaked in water for 3 hours. This quantity of white beans contained 6.2 protein, 15.5 carbohydrate and 10 g fibre (as hemicellulose, cellulose and lignin as 8.17, 1.55 and 0.27 g/10 g, respectively). The second group of the rats was fed with the diet containing 10% fibre supplemented from 35.7 g oven-dried peas which contained 10 g protein, 15.5 g carbohydrate and 10 g fibre (hemicellulose, cellulose and lignin as 4.88, 4.21 and 0.39 g/10 g respectively). While the third group of the rats was fed with the diet containing 10% fibre supplemented from 41 g oven dried carrots which contained 3.9 g protein, 27.46 g carbohydrate and 10 g fibre (as hemicellulose, cellulose and lignin as 1.91 g, 5.7 g and 2.25 g/10 g). The fibre contents and the other constituents of white beans, peas and carrots were provided from two sources[5,6]. The oven dried white beans, peas and carrots were ground and mixed to the different diets in a manner as shown in Table I. It is obvious that white beans fibres contained the highest amount of hemicellulose. Carrots had the highest amount of cellulose and lignin, whereas peas contained the intermediate amount of cellulose, hemicellulose and lignin.

The diets fed to the rats for 5 weeks. At the end of the experiment, the rats were fasted for 16-18 hours and the blood samples were drawn for immediate determination of blood glucose by an enzymatic method[7]. Livers were separated for determination of liver glycogen[8].

Statistical analysis by student t. test was performed.

Table II. Fasting blood glucose, liver glycogen and liver weights of rats fed diets contain 10% white bean fibres (Diet I), pea fibres (Diet II) and carrot fibres (Diet III)

	Diet I	Diet II	Diet III
Fasting blood glucose (mmol/l):			
mean	2.420	4.227	3.368
± SE	0.133	0.696	0.212
P_1		< 0.025	< 0.005
P_2			> 0.05
Liver glycogen (mg/100 g liver):			
mean	41.220	44.510	46.130
± SE	5.122	4.325	4.921
P_1		> 0.050	> 0.050
P_2			> 0.050
Liver weight (g):			
mean	4.433	7.112	7.050
± SE	1.056	2.086	1.097
P_1		> 0.050	> 0.050
P_2			> 0.050

P_1: Probability when rats fed diet II and III were compared by those fed diet I.

P_2: Probability when rats fed diet III were compared by those fed diet II.

When $p > 0.05$ the values are non significant, whereas when $p < 0.025$ or < 0.005, this means that values are significant.

RESULTS AND DISCUSSION

Fasting blood glucose of the rats fed with 10% pea fibres diet was 4.227 ± 0.696 mmol/l. Those fed with 10% carrot fibres was 3.368 ± 0.212. The least level of blood glucose was that of the rats fed with 10% white bean fibres, since the fasting blood glucose level was 2.420 ± 0.133 (Table II). This means that substitution of carrot fibres with white beans fibres produced a significant reduction of blood glucose ($p < 0.005$) by 28%, whereas replacing pea fibres with white bean fibres produced significant reduction ($p < 0.05$) by 43%. Exchanging pea fibres with carrot fibres produced no significant reduction of bloo glucose ($p > 0.05$) by 20%. This may throw some lights on the effectiveness of hemicellulose as the most effective hypoglycemic agent than lignin, especially when mixed with the other tow fibres in the same ratio as they were present in white beans and carrots, respectively.

It was reported that fibre consumption improved glucose tolerance and decreased serum glucose level[11,12]. The exact mechanism of the action has not been clarified. Others suggested that the reduction of blood sugar may be due to the effect on carbohydrate absorption. Dryden *et al.*[13] proved that coarse bran diet significantly reduced the rate of glucose uptake in both duodenum and jejunum and that the particle size of dietary fibre was important in determining the absorptive characteristics of the gut. Cherbut *et al.*[14] proved that fibre increased retention time of digest and that absorption of carbohydrate could be affected by a relatively minor change in the intestinal transit of digest produced by fibre irrespective of its nature. Increasing the volume of intestinal contents may be important in decreasing carbohydrate absorption by some dietary fibres[15]. Kunihiro *et al.*[16] proved that the more viscous the dietary fibres, the more effective in suppressing the postprandial rise of blood glucose.

Dietary fibres may change hormonal profiles (especially for insulin and gastrointestinal polypeptides) and likely influence carbohydrate metabolism[17]. Different fibres may affect these factors at various degrees.

The liver glycogen level (mg/100 g liver) was not affected by changing the type of fibre in the diet. However, the liver weight and subsequently the whole liver glycogen were decreased but not significantly ($p > 0.05$) when either pea fibres or carrot fibres were replaced with white bean fibres. Liver weight was reported to decrease during fibre consumption[15,18].

LITERATURE CITED

1. Eastwood, M.A., Fisher, N., Greenwood, C.T. and Hutchinson, J.B.: Perspectives in the bran hypothesis. *Lancet,* **1,** 1029 (1974).
2. Nygren, C., Hallnans, G. and F. Lithner.: Long-term effects of dietary fibre in bread on weight, blood glucose, glucosuria and fecal fat excretion in alloxan diabetic rats. *Diabete Metab.* **7,** 115 (1981).
3. Kritchevsky, D. Davidson, L.M., Goodman, G.T., Tepper, S.A. and Mendelsohn, D.: Influence of dietary fibre on lipids and aortic composition of vervet monkeys. *Lipids* **21,** 338 (1986).
4. Simpson, R.W., Mcdonald, J., Wahlquist, U., Balazs, N. and Dunlop, U.: Effect of naturally occuring dietary fibre in western foods on blood glucose. *Aust NZJ Med.* **11,** 484 (1981).
5. Foy, W.L., Evans, Jr.J.L. and Wohlt, J.E.: Detergent fibre analysis on thirty food stuffs. *Nutr. Rep. Int.* **24,** 575 (1981).
6. Food Composition Tables for Use in the Middle East, 2nd edition. American University of Beirut, Beirut, Lebanon (1970).
7. Werner, W.H., Rey, G. and Wielinger, H.: Uber die Eigenschaften eines neuen Chromogens fur die Blutzuckerbestimmung nach der GOD/POD. *Methode Z. Analyt. Chem.* **252,** 224 (1970).
8. Carroll, N.V., Longley, R.W. and Roe, J.H.: The determination of glycogen in liver and muscle by use of anthrone reagent. *J. Biol. Chem.* **220,** 583 (1956).
9. Briggs, C.M. and William, M.A.: A new mineral mixture for experimental rat diets and evaluation of other mineral mixtures. *Fed. Proc.* **22,** 261 (1963).
10. Morcos, S.R.: The effect of protein value of the diet on the neurological manifestations produced in rats by iminodipropionitrile. *Brit. J. Nutr.* **21,** 269 (1967).
11. Janetr, U., Sandstead, H.H., Johnson, L.K., Inuan, L.F., Milne, D.B., Warner, R.C. and Hanz, E.A.: Effect of consuming fiber from corn bran, soy hulls or apple powder on glucose tolerance and plasma lipids in type II diabetes. *Am. J. Clin. Nutr.* **39,** 25 (1984).
12. Manojlovic, D., Todorovicova, M., Pavlovicova, M., Ristic, V. and Ristic, M.: Effect of food rich in fibre on carbohydrate regulation and blood lipids of diabetic patients. *Casopis Lekaru Ceskych* **125,** 1437 (1986).
13. Dryden, P.A., Jones, G.P., Durcher, E. and Pead, R.S.D.:Effect of chronic ingestion of dietary fiber on the rate of glucose absorption in rats. *Nutr. Rep. Int.* **31,** 609 (1985).
14. Cherbut, C., Meirien, O. and Ruckebusch, Y.: Effect of diet on intestinal xylose absorption in dogs. *Dig. Dis. Sci.* **31,** 385 (1986).
15. Suail, P.K. and Schueeuan, B.O.: Pancreatic and intestinal response to dietary guar gum in rats. *J. Nutr.* **113,** 1544 (1983).
16. Kunihiro, D., Matsura, M., Kawara, A., Bada, S. and Nishikawa, K.: Treatment of diabetics with dietary fibres. The effect of high viscosity of dietary fibres on the postprandial blood glucose. *J. JPN Diabetic Soc.* **25,** 197 (1982).
17. Wahlquist, M.L.: Dietary fibre and carbohydrate metabolism. *Am. J. Clin. Nutr.* **45,** 1232 (1987).
18. Rossner, S., Ryttig, K., Zweigbergk, D. Von and Oiilin, A.: Effects of dietary fibre on weight loss in treatment of moderate obesity. *Recent Adv. Clin. Nutrit.* **2,** 378 (1986).