Effect of a rice bran fiber diet on serum glucose levels of diabetic patients in Brazil

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SUMMARY. Eleven diabetic patients: 5, type 1 and 6, type 2 received a low-fiber diet (I) during 1 week and during the next 7 days the same diet, enriched with 40g of fiber (30,6% insoluble and 11,7% soluble components) from rice bran (II) per day. Results showed that mean fasting and postprandial serum glucose levels were reduced, but values of high fiber diet were significantly lower ($p < 0,001$) than that of the lower fiber diet. For all patients, the high-fiber diet increased fecal weight. This increase was due to the fiber excreted, rather than water retained. There was no relationship between the increase in fiber intake and its fecal excretion. Sucrose and raffinose were found in the bran, but not in the feces. Lactose was present in the stools of the patients receiving enriched diet.
Keywords: Fiber, rice bran, diabetes.

RESUMEN. Efecto del salvado de arroz como dieta en fibra en los niveles séricos de glucosa de pacientes con Diabetes Mellitus en Brasil. Once pacientes diabéticos: 5, tipo 1 y 6, tipo 2 ingirieron durante una semana una dieta baja en fibra (I) y durante otros siete dias, otra enriquecida con 40 g por dia de fibra (30,6% insoluble y 11,7% soluble) del salvado de arroz (II). Los resultados mostraron que el valor medio de las glucemias de ayuno y posprandial fue reducido ($p < 0,001$) cuando fueron sometidos la dieta II. En cada paciente, la dieta alta en fibra provocó aumento en el peso fecal. Este aumento se debió mas a la fibra excretada que al agua retenida. No hubo correspondencia entre el aumento en el consumo de fibra y la excreción fecal. Se constató la presencia en el salvado de arroz, de sacarosa y rafinosa, pero no en las heces. Se registró la presencia de lactosa en heces cuando los pacientes ingirieron dieta alta en fibra.
Palabras clave: Fibra, salvado de arroz, diabetes.

INTRODUCTION

'Dietary fiber' includes a complex association of different plant polysaccharides, such as cellulose, hemicellulose, pectin, gums, mucilage and lignin, which are resistant to hydrolysis caused by the endogenous enzymatic secretions from human digestive tract (1). Cellulose, hemicellulose and lignin constitute the insoluble fibers, while pectin, gums, and mucilage are soluble fibers.

It is important to know these components in order to understand and explain the physiological and therapeutic effects associated to fiber intake, which has great importance for diabetic patients. Diabetes incidence was rare among African people from small towns,

eating high amounts of fiber, while this disease is common on Western populations, whose diet is low in fiber (2,3).

Traditionally low carbohydrates diets of diabetic patients has been altered during the last 20 years based on the a beneficial action of increased fiber intake on the glucose levels (4-6). Supplement or natural fiber added to the diets decreases these serum levels (7,8). This action is more pronounced when food is rich in dietary fiber (35-45g per day) as in complex carbohydrates (55-65% per day) (9-11).

There is an increased interest on the effect of cereal bran on serum glucose levels (12-15). Epidemiological studies support that high intake of whole grain foods protects against the development diabetes mellitus, type 2 (14). Diets high in rapidly absorbed carbohydrates and low in cereal fiber are associated with an increased risk of type 2 diabetes (13). Some studies emphasize that rice bran should be used not only because of its high levels of protein, fat, carbohydrates and minerals, but also of its indigestible residue (12). Additionally, there are studies (16-19) demonstrating that rice bran has a hypocholesterolemic effect on patients who had high levels of serum lipids. Researchers at University of Tohoku, Japan, fragmented the rice bran components and found that polysaccharides (fiber components) isolated from watery extract played a hypoglycemic role on mice with normal serum glucose as well as on those alloxan-induced hyperglycemics (17).

The present paper studied the composition of Brazilian rice bran fiber (insoluble and soluble compounds), the serum glucose levels of selected diabetic patients attended at the University Hospital of Ribeirão Preto, Medical School of Ribeirão Preto, University of São Paulo - Brazil, fed a high rice bran fiber diet and the patients' fecal excretion of monosaccharides and oligosaccharides.

MATERIALS AND METHODS

Eleven diabetic patients, 5 insulin-dependent (type 1) and 6 type 2 (4 treated with oral hypoglycemic agents and 2 controlled by diet) participated in the study. Patients were of both gender, aged between 45-60 years old, were selected according to the following criteria: diabetes controlled by insulin, diabetes controlled by oral hypoglycemic agents and or diabetes controlled by diet. Patients were selected through the University Hospital of Ribeirão Preto, Medical School of Ribeirão Preto, University of São Paulo – Brazil. Ethical approval of the study was obtained from the Hospital Ethics Review Committee. Patients signed an informed consent form agreement to participate in the study. An information document was given to each participant.

The diets offered were referred as I and II, according to the amount of rice bran added to them, that is low-fiber and high-fiber diets. Food content of diet I were: corn starch, skimmed milk, banana, bean (broth), meat, lettuce, tomato, pineapple juice, roast chicken, French bread, orange juice, apple juice, cooked rice, mashed potatoes, margarine and soy oil. Food components of diet II were the same, except for corn starch and margarine, which were caloric replaced by rice bran. Potatoes and soy oil were reduced in the 2 diets to 50g and 5g, keeping them isocaloric. The diet II included 40g of fiber a day (2g / 100Kcal), four times more than diet I.

All patients under study were admitted to the University Hospital for 16 days. They were fed with one of the diets during 1 week in alternating sequence. Patients 1, 3, 5, 7, 9, and 11 were initially given the diet I and then on the 2 nd week diet II, while patients 2, 4, 6, 8, and 10 were initially given on the first week diet II and on the 2 nd diet I. Fasting (7:00 A. M.) and postprandial (2 hours after lunch) blood was drawn daily, from each patient. Blood was sent to the Hospital Laboratory, were the serum was separated and glucose measured.

The feces were collected daily after the appearance of fecal carmine markers until the 7th day of period I and II. After being collected they were packaged separately in plastic bags and frozen. Afterward they were sent to the laboratory of Bromatology of Faculty of Pharmaceutical Sciences of Ribeirão Preto (FCFRP – São Paulo University) where were analized.

Availability of rice bran

Rice bran was bought on a specific place at the local market. It is obtained as a subproduct of white rice processing produced by rice processing machine. Its quality was checked by an Institute specialized in microbiologycal analysis of food. Therefore, the analyzed rice bran was used on the meals prepared at the Dietetic Kitchen of the University Hospital to be eaten by the patients.

Components of rice bran

Water, fixed mineral residues, oils and proteins were determined according to the techniques of the Association of Official Analytical Chemists - AOAC (20). The total amount of carbohydrates was calculated by difference, subtracting 100 from the sum of other fractions.

Analysis of dietary fiber insoluble components in rice bran and feces

Methodologies proposed by Van Soest (21) and Van Soest & Wine (22) were employed to measure cellulose, lignin and hemicellulose.

Analysis of dietary fiber soluble in rice bran and feces

The modified procedure proposed by Mc Ready & Mc Comb (23) was employed to determine the total of pectic substances.

Identification of monosaccharides and oligosaccharides in rice bran and feces

Using the thin layer chromatography (24), monosaccharides and oligosaccharides were identified in the extracts.

Assessment of blood glucose levels

The glucose serum levels of the patients were evaluated through a commercial kit, enzymatic method of glucose oxidase (25), using the Automatic Equipament Tecnicon RA -1000.

Statistical analysis

Tukey' s test (DIXON & MASSEY JR.) (26) and T-Student were employed in order to analyze fasting or postprandial serum glucose data as well as the relationship of fiber intake and excreted.

RESULTS

Rice bran components

The product had high protein and oil content (15.96% - 14.95%), as well as 14.39% of carbohydrate, in a proportion of 1:1:1.

Dietary fiber components

Rice bran had the following amounts of insoluble components: cellulose 5.50%, hemicellulose 18.21% and lignin 6.95%. Of soluble fractions represented by pectic substances was found 11.71%, amounting to a total of 42.37% of dietary fibers.

Serum glucose during low and high dietary fiber periods

It was found lower fasting glucose levels in the serum, more evident in patients 4 and 8, both treated with oral hypoglycemic agents. The same happened to patient 1, an insulin-dependent. Patients 7 and 9, both treated with diet only, the glucose reduction was smaller compared to that of other patients (Table 1).

The postprandial serum glucose in patient 11 - the oral hypoglycemic one - showed the highest glucose reduction, followed by patients 8 and 3. The same reduction was observed in patients 9 and 10. It was also found that patients 4 and 5 receiving oral hypoglycemic drug and the insulin-dependent one, showed the lowest serum glucose reduction (Table 1).

TABLE 1
Fasting and postprandial serum glucose (mean X ± SD) values in diabetic patients: high-fiber period versus low-fiber period

Patient	[1]Fasting serum glucose (mmol/L)		Mean glycemic serum reduction*	[2]Post prandial serum glucose (mmol /L)		Mean glycemic serum reduction*
	period I	period II		period I	period II	
1 - C.C.T. 25*U insulin NPH 100	11,43	7,66	3,77	11,82	10,15	1,67
2 – N.P.F. 60U insulin NPH 100 (7:00 A. M.) and 15U insulin NPH 100 (5:00 P.M.)	6,99	4,82	2,17	7,27	6,21	1,06
3 – D.P.F. oral hypoglycemic	6,54	5,60	0,94	9,21	6,16	3,05
4 – A.P.L. oral hypoglycemic	10,54	6,10	4,44	7,71	7,04	0,67
5 – M.A.C. 50 U insulin NPH 100	13,37	11,43	1,94	16,65	15,98	0,67
6 – R.O.D. 20 U insulin NPH 100	17,87	14,93	2,94	17,87	15,60	2,27
7 - L.R.S. diet	7,27	5,88	1,39	8,66	7,43	1,23
8 - N.A.W. oral hypoglycemic	10,04	6,21	3,83	12,82	9,54	3,28
9 - A.L.N. diet	7,27	5,93	1,34	12,60	10,60	2,00
10 - M.G.M. 25 U insulin NPH 100	7,38	5,10	2,28	9,77	7,77	2,00
11 – S.A.S. oral hypoglycemic	7,16	4,71	2,45	13,76	9,10	4,66
X ± SD	9,60 ± 3,5 0,40	7,10 ± 0,90 p < 0.001		11,65 ± 3,5 0,28	9,10 ± 2,7 P < 0.001	

1 = normal values: 3,89 – 6,11 mmol/L
2 = normal values: 3,89 – 8,89 mmol /L
period I = low-fiber diet
period II = high-fiber diet
*period I value minus period II value

Dietary fiber excreted

In order to evaluate the total amount of fiber excreted and the amount of each component, the data and the average, in grams, of both ingested and excreted material by each patient per day (Table 2) shows that the proportion of increased fiber intake and fecal excretion was not maintained. The former increased a fourfold average and the later increased much less.

TABLE 2

Average dietary fiber content (g/day) ingested and excreted by diabetic patients treated with diet I or II

	cellulose	hemicellulose	lignin	total
diet I				
ingested	1.89	6.50	1.90	10.29
excreted	0.26 ± 0.30	3.51 2.21	2.30 ± 1.65	6.03 ± 3.93
T- Student	15.88**	4.47**	0.80*	3.59*
diet II				
ingested	7.39	24.0	8.85	40.24
excreted	0,68 ± 0.40	5.37 ± 2.50	5.03 ± 1.79	11.09 ± 4.30
T- Student	55.06**	24.48**	7.06**	22.47**

diet I: low-fiber diet
diet II: high-fiber diet
**p < 0.001 *p < 0.05

Monosaccharides and oligosaccharides in the rice bran

The methodology applied to alcoholic extracts allowed us to identify both sucrose and raffinose in the rice bran.

Monosaccharides and oligosaccharides in fecal material

The qualitative fecal analysis of fecal material from the 11 patients showed that the alcoholic extracts obtained from the high-fiber period of four patients had increased amounts of glucose, galactose and lactose. Furthermore, it was observed an increased elimination of oligosaccharides with greater molecular weight in four patients.

DISCUSSION

Blood glucose during low and high dietary fiber periods

In period II, the fasting and postprandial glucose mean values were lower than those of period I. It happened in all patients of this study. Considering fasting normal serum glucose values as 3.89-6.11 nmol/L, none of the patients receiving the low-fiber diet reached these levels. On the other hand 7 out of 11 patients showed normal serum glucose levels on high-fiber diet (Table 1).

The mechanism to explain the fiber role on the improving of the glucose metabolism is unknown. Insulin might play a role on diabetic patients by increasing their sensibility to this drug (27). Other studies of glucemic response (28, 29) suggest that the fiber might act on starch assimilation. One can speculate whether the basic mechanisms of the fiber inhibitory effect on starch absorption can be, in part due to mechanical action, through changes on the intestinal transit-times or by interference of digestive enzymes.

These results indicate that diet containing rice bran, which is rich in both soluble and insoluble fibers, contributed to the reduction of glucose in diabetic patients.

Dietary fiber excreted

Values reported by WALTERS et al. (30) and SOUTHGATE et al. (31) regarding the "apparent digestibility" of cellulose by human body show a large variation. This could be explained by the different intestinal florae found in each individual. WILLIAM & OLMSTED (32) have demonstrated that normal individuals who had ingested a high-fiber diet excreted less cellulose than that consumed suggesting that part of it had been digested.

Results regarding the variation factor "periods" (Table2), revealed statistically significant difference ($p< 0.001$ or $p< 0.05$) between periods I and II. According to these data, there seems to be a probable bacterial digestion greater for some cellulose residues than for others. Higher intake, higher cellulose residue degraded. Knowing the products from such degradation, which involves short-chain fatty acids, one can speculate on their possible increased absorption. This absorption may be responsible for the effects observed in glucose serum levels; such a mechanism has been accepted by some authors (33,34).

Monosaccharides and oligosaccharides

Non-reductor saccharides like sucrose and raffinose found in rice bran could be confirmed (28). In the present study it could also be observed the non-existence of glucose and stachyose.

The qualitative analysis of fecal extracts from the 11 patients showed that lactose elimination occurred in some cases following an increased fiber intake. Thus, one can admit that such an increase has hindered the biological utilization of part of the milk sugar. Also, the majority of patients treated with high-fiber diet had excreted glucose and galactose under this circumstance.

A study by SCHNEEMAN (35) shows that carbohydrates involved by dietary fibers can be protected against digestive enzymes. In this mechanic action, the fiber nutrients do not suffer complete digestion and absorption because they are not so accessible to the enzymes. Furthermore, the fiber may inactivate partially the digestive enzymes.

In conclusion, it was demonstrated that rice bran is rich in both soluble and insoluble dietary fiber. All the diabetic patients of this study receiving the bran showed, on average, a significant decrease in both fasting and postprandial glucose levels. In terms of absolute value, more components of soluble fiber were excreted in the feces (g/day) following the high-fiber diet. According to the data on ingestion, however, the values of cellulose excretion in both periods (I and II) were quite similar, while the excretion values for hemicellulose and lignin decreased following the high-fiber diet. Both sucrose and raffinose were identified in rice bran. Glucose, galactose, and lactose (mainly) were found in the fecal material excreted during the high-fiber diet period.

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