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UTILIZATION OF SOME GRAMINEA BY – PRODUCTS AS HYPOGLYCEMIC AGENT

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ABSTRACT

Hypoglycemic effect of two dietary fibers i.e., wheat bran and barley hulls, were studied on diabetic rats. Materials were chemically analyzed. Diabetes were induced using alloxan. Rats were fed either with barley hull or wheat bran at two levels of 2.5% or 5% of the diet. Body weight and organs weight, level of blood glucose during experiment, liver and kidney functions and lipid fractions were determined.

The results showed that feeding diets rich fibers reduce the loss of body weight in diabetic rats. Plasma glucose of diabetic rats was decreased due to feeding diets rich fibers, and the effect of barley hull was the better than that of wheat bran. The data revealed also that feeding hypoglycemic diets increased albumin content and reduced all of urea, blood cholesterol, triglycerides, HDL and LDL-cholesterol in diabetic rats. Generally, there was an improvement in the health of diabetic animals due to fiber containing feed, which act as hypoglycemic agent of diabetic animals under study.

Keywords: dietary fibers, wheat bran, barley hull, diabetes, glucose tolerance, HDL-cholesterol, LDL-cholesterol, liver function, kidney function.

INTRODUCTION

Dietary fibers (DF) are essential components in human and animal nutrition. A high intake of DF is positively related to different physiologic and metabolic effects. Cereal products, particularly from whole grains, are the most important source of dietary fibers (Spiller, 2001). Diet plays a major role in the management of diabetic complication. Dietary fiber, broadly defined as unabsorbable carbohydrates in foods, has many effects in the gastrointestinal tract, including altering fluid dynamics, slowing macromolecule digestion, and absorption of nutrients, etc. The beneficial role of dietary fiber against a variety of diseases including diabetes is well established (Cummings *et al.*, 1985 and Spiller, 1986). The role of DF in diabetes has been studied by several workers. Long term dietary treatment with increased amounts of rich–fiber, low-glycaemic index natural foods improves blood glucose and reduces the number of hypoglycemic events in diabetic patients (Nandini *et al.*, 2003). A part from insulin and anti-diabetic drugs; fibers have become important nutritional components in the management of diabetes. Effect of fibers in the managements of diabetes is well documented (Kritchevsky and Benfield, 1995). Dietary fibers play an important role in facilitating slow absorption of glucose. Fibers from cereals exert a pronounced effect of the colon, cellulose-containing fibers decrease transit time which is increased by soluble fibers (Anderson and Chen, 1979). Purified cellulose, wheat bran and pea hulls have been incorporated into food products as fiber ingredients. Other crops contain hulls and other fiber-rich by–products which may be suited for development as food-grade products (Spiller *et al.*, 1978). Fiber and whole-cereal intakes may protect against hyperinsulinemia and the risk of type 2 diabetes (Juntunen *et al.*, 2003). Liu *et al.* (1989) reported that wheat bran could lower blood glucose, increase the intestinal absorption and positive balance of zn. Montminy and Galibois (1994) found that fiber-source nature (wheat bran) affects the appearance in circulation of glucose in the postprandial period. In addition, they indicated that fiber –source nature interact to modulate some aspects of glucose systemic utilization. Dietary wheat bran protects against colon cancer, but the mechanism (s) of this effect is not known (Compher *et al.*, 1999). In a recent direct comparison, and ad libitum diet containing wheat bran fiber led to 40% lower incidence of colon tumors, compared with a cellulose- containing diet (Kritchevsky, 1999). High –fiber rye and wheat food consumption improved several markers of bowel and metabolic health relative to that of low-fiber food (Mcintosh *et al.*, 2003). Rodrigues *et al.* (2005) showed that serum glucose level of diabetic patients were reduced when they fed on rice bran. Commercially available barley bran and wheat bran appear to significantly reduce tumour incidence and burden in the model relative to other brans, influencing both the initiatory as well as promotional stages of chemically induced carcinogenesis (Mcintosh *et al.*, 1996). About 140 million tons of barley is produced annually world wide (FAOSTAT, 2004). The major products are whole and erushed or pearled barley kernels, flours and flakes. The hull represents at least 10-15 percent of the weight and volume of comparable hulled varieties. The by-products of the pearling process, 30-40% of the total kernel weight, are mainly used in animal feed. These by-products contain interesting amounts of bioactive compounds. Barley grains are relatively rich in dietary fibers such as B-glucan, arabinoxylans and cellulose. The consumption of B-glucan rich diets resulted in several beneficial physiologic effects due to a relatively high concentration, soluble state and high molecular weight of these polysaccharides (Robertson *et al.*, 1997). Gerhard *et al.*, (2002) suggested that dietary fiber-rich barley-containing diets have beneficial physiologic effects. Plasma glucose level in the high barley fiber diet was significantly lower –due to feeding rats on it –than in the case of rice bran and corn starch (Li *et al.*, 2003).

The aim of this study was to assess the possibility of using some by-products i.e., wheat bran or barley hull as hypoglycemic agents for type II diabetics.

MATERIALS AND METHODS

Materials:

Wheat bran: was obtained from south Cairo Mills Company, Fysal, Giza, Egypt.

Barley hulls: were obtained after milling the barley seeds using a universal type laboratory rice mill.

Animals: thirty adult albino male rats, Sprague Dawley Strain,(weighed 160±5g) were obtained from the animal house, Crops Technology Department, FTRI, Giza, Egypt.

Methods:

1- Chemical composition: wheat bran and barley hulls were chemically analyzed according to A.O.A.C (2000). Total carbohydrates were calculated by difference.

2- Biological evaluation:

Experimental design:

Animals were housed in clean cages under healthy conditions and fed on basal diet for 10 days (adaptation period). After this period, five rats were kept as control which fed basal diet during the experimental period (normal control "G1"). Diabetes was induced in other rats (25) using alloxan (150mg/kg body weight). The diabetic rats were divided randomly into five groups (n=5) according to the following scheme:

G2: rats fed basal diet till the end of experiment.
G3: rats fed diet containing 2.5% barley hull
G4: rats fed diet containing 5% barley hull
G5: rats fed diet containing 2.5% wheat bran
G6: rats fed diet containing 5% wheat bran
(2.5 and 5% calculated as net fiber).

The basal diet, minerals and vitamins mixtures were prepared as recommended by A.O.A.C.(2000). During the experimental period, the weight of the animals were individually recorded. At the end of the experiment (45 days), the final weight of body and organs, i.e., liver, kidney, heart and spleen were recorded. During the experimental period, blood sample was obtained from the orbital plexus of each rat and centrifuged at 3000 rpm to separate serum which kept at-18°c till analysis. At the end of experiment, the liver functions, kidney function, serum glucose and lipid fractions were determined in serum.

Determination of serum glucose:

Serum glucose was determined using the method of Trinder (1969).

Determination of liver function:

Albumin was determined using the method of Doumas *et al.* (1971). ALT and AST were determined by using the method of Bergmeyer and Horder (1986).

Determination of kidney function:

Urea was determined using the method of Tobacco *et al.* (1979). Creatinine was determined using the method of Bartels and Bohmer (1971).
Determination of lipid fractions in serum:

Total cholesterol, triglycerides, high density lipoprotein (HDL–cholesterol) and low density lipoprotein (LDL–cholesterol) were determined according to the methods described by Fasce (1982), Young and Pestaner (1975), Grove (1979) and Steinbery (1981), respectively.

Statistical analysis:

The data were statistically analyzed according to the methods described by Fisher (1970). The statistical package for social science S.P.S.S. (1999) program version 10 was used for all analysis.

RESULTS AND DISCUSSION

Chemical composition of wheat bran and barley hull:

Chemical composition, i.e., protein, oil, ash, crude fiber, dietary fiber and total carbohydrates of wheat bran and barley hull were given in Table (1). The findings showed that protein value in wheat bran was higher than barley hull (about twice) and this may be due to the presence of a part of wheat germ as a result of milling process, but there was no difference between them in oil content. Concerning ash and crude fiber, wheat bran contains approximately 50% as that of barley hull. The highest value of dietary fiber was shown in barley hull (61.1%), but in wheat bran, it was lower (36.4%).

It could be concluded that barley hull is considered rich source of dietary fiber. This result was in agreement with Marconi *et al.* (2000).

Table (1): Chemical composition of wheat bran and barley hull (on dry weight)

Material	Protein%	Oil%	Ash%	Crude fiber%	Dietary fiber%	*T.C.%
Wheat bran	14.8	4.0	4.5	8.5	36.4	68.2
Barley hull	7.4	3.6	9.6	17.3	61.1	62.1

*** T.C= Total carbohydrates.**

Effect of feeding diets rich fibers on the body weight of diabetic rats:

Table (2) showed change in body weight due to feeding diets rich in two sources of fibers, wheat bran and barley hull. The obtained data revealed that there were non significant differences in final body weight due to all treatments except that of positive control which showed a significant decrease compared with all treatments. Loss in body weight slightly decreased by increasing the ratio of fibers from 2.5 to 5% but not significantly. The most effective treatment was that of 5% barley hull which showed almost the constant weight during the experiment.

It could be concluded that feeding diets contained dietary fibers reduce the loss of weight body in diabetic rats. These results agreement with Al-Shagrawi *et al* (1999).

Table (2): body weight gain of diabetic rats fed diets rich fibers

Treatments	Initial weight	Final weight	Weight gain or loss	Daily body weight gain
Negative Control (G_1)	167.80 ± 16.24^{a}	176.20 ± 16.32^{a}	8.40 ± 0.87^{ab}	0.19 ± 0.02^{a}
Hyperglycemic control (G_2)	168.40 ± 13.17^{a}	100.80 ± 4.45^{b}	-67.60 ± 12.95^{d}	-0.68 ± 0.73^{a}
2.5% barley hull (G_3)	167.80 ± 6.21^{a}	146.60 ± 5.16^{a}	-21.20 ± 2.73^{c}	-0.47 ± 0.06^{a}
5% barley hull (G_4)	168.20 ± 10.37^{a}	167.80 ± 9.31^{a}	-1.20 ± 1.85^{abc}	-0.02 ± 0.04^{a}
2.5% wheat bran (G_5)	168.00 ± 9.14^{a}	156.20 ± 7.45^{a}	-11.80 ± 8.34^{bc}	-0.26 ± 0.18^{a}
5% wheat bran (G_6)	167.80 ± 9.35^{a}	178.20 ± 13.41^{a}	10.40 ± 6.36^{a}	0.23 ± 0.14^{a}
LSD (5%)	N.S	30.02	20.27	N.S

Effect of feeding diets rich fibers on organs weight of diabetic rats:

Organs weight, i.e., liver, kidney, heart, and spleen of diabetic rats fed diets rich fibers are shown in Table (3). Data showed a significant difference in liver weight due to feeding two sources of fibers (wheat bran and barley hulls at 2.5 and 5%, respectively), but no significant difference was found between diabetic rats fed diet contains 2.5% and 5% barley hull, and 2.5% wheat bran compared with control. No significant differences on kidney, heart or spleen weight due to feeding diets containing 2.5% or 5% barley hull, and 5% wheat bran were found, but feeding 2.5% wheat bran resulted a significant effect on kidney and heart weight compared with control.

The differences in the organs relative ratio may be due to the loss of the body weight due to the presence of dietary fiber as a hypoglycemic agent during the experimental period.

Table (3): organs weight of diabetic rats fed diets rich fibers

Treatments	Final weight	Liver	Kidney	Heart	Spleen
Negative Control (G_1)	176.20±16.32^{a}	4.27±0.51^{b}	0.83±0.07^{b}	0.40±0.03^{b}	0.72±0.07^{a}
Hyperglycemic control (G_2)	100.80±4.45^{b}	2.90±0.23^{c}	0.90±0.07^{ab}	0.40±0.04^{b}	0.42±0.07^{b}
2.5% barley hull (G_3)	146.60±5.16^{a}	4.06±0.42^{b}	1.13±0.20^{ab}	0.50±0.03^{ab}	0.55±0.05^{ab}
5% barley hull (G_4)	167.80±9.31^{a}	4.64±0.38^{ab}	1.15±0.10^{ab}	0.46±0.06^{ab}	0.57±0.06^{ab}
2.5% wheat bran (G_5)	156.20±7.45^{a}	5.01±0.28^{ab}	1.26±0.16^{a}	0.55±0.06^{a}	0.65±0.08^{a}
5% wheat bran (G_6)	178.20±13.41^{a}	5.67±0.19^{a}	1.20±0.08^{ab}	0.47±0.04^{ab}	0.66±0.08^{ab}
LSD (5%)	N.S	1.03	0.36	0.13	0.20

Effect of feeding diets rich fibers on the glucose level of diabetic rats:

Table (4) showed the effect of feeding diets rich fibres on serum glucose level during and at the end of experiment. Injection with alloxan caused a highly significant increase of serum glucose level. It was raised from 73.47 mg /dl (control "G_1") to 376.24, 442.27, 288.36, 350.0 and 329.20 mg /dl for G_2, G_3, G_4, G_5 and G_6, respectively, after hyperglycemic induction. Serum glucose of hyperglycemic control (G_2) reached to maximum value at the end of the experiment (389.50 mg/dl). The highly decrease of serum glucose level during and at the end of experiment was shown in G_3, due to feeding 2.5% barley hull, which amounted to about one fifth as that of zero time (from 442.27 to 90.46 mg/dl), followed by G_5 and G_6 (fed 2.5 and 5% wheat bran). On the other hand, feeding 5% barley hull was steadily decreased and reached to one third as that of zero time at the end of experiment.

Table (4): Serum glucose levels of diabetic rats fed diets rich fibers

Treatments	Glucose (mg/dl)			
	ZERO	15 days	30 days	45 days
Negative Control (G_1)	73.47 ± 0.19^{d}	82.55 ± 14.75^{d}	94.09 ± 5.18^{c}	92.50 ± 2.50^{b}
Hyperglycemic control (G_2)	376.24 ± 3.72^{ab}	367.92 ± 7.92^{a}	366.09 ± 14.52^{a}	389.50 ± 9.50^{a}
2.5% barley hull (G_3)	442.27 ± 30.25^{a}	253.63 ± 24.62^{b}	144.35 ± 12.00^{b}	90.46 ± 1.63^{b}
5% barley hull (G_4)	288.36 ± 10.12^{c}	161.74 ± 21.28^{c}	118.02 ± 8.78^{bc}	86.55 ± 1.17^{b}
2.5% wheat bran (G_5)	350.00 ± 22.52^{bc}	271.95 ± 14.13^{b}	126.37 ± 20.64^{bc}	97.27 ± 4.98^{b}
5% wheat bran (G_6)	329.20 ± 29.20^{bc}	184.50 ± 4.50^{c}	120.00 ± 5.00^{bc}	88.34 ± 0.21^{b}
LSD (5%)	69.08	55.78	42.60	15.82

From the obtained data, it could be concluded that consumption of fiber significantly reduced blood sugar. It seems also that barley hulls reduced blood glucose more than wheat bran and this may be due to some components found in hull of barley such as β – glucan, arabinoxylose and cellulose (Robertson *et al*, 1997). The results were in agreement with Ikegami *et al.* (1991) who reported that blood glucose in diabetic rats fed on barley returned to normal values after 25 days and glucose tolerance improved as early as 9 days.

Effect of feeding diets rich fibers on the liver and kidney function of diabetic rats:

The result of liver function, i.e., albumin, ALT and AST, and kidney function, i.e., urea and creatinine of rats fed diets rich fibers were given in Table (5). Concerning liver function, the obtained data illustrated that serum albumin decreased and the lowest value of albumin was shown in hyperglycemic group (2.05 g/dl), then it increased due to feeding diets rich fibers and reached maximum value in G_6 (2.71 g/dl) which fed 5% wheat bran to reach-nearst-to control value. Non significant differences in albumin value were shown between rats fed 2.5% either barley hull or wheat bran. On the other hand, there was non significant change in both of ALT and AST due to administrate hypoglycemic diets to hyperglycemic rats.

Concerning kidney function, urea content in G_3 (fed 2.5% barley hulls) showed the lowest value (54.63 mg/dl) as well as-normal control (53.30 mg/dl). Due to feeding diets rich fibers, the values of urea decreased compared with hyperglycemic control. Non significant differences were found in urea content of rats fed diets rich fibers- except G_3. The results showed also that the creatinine was decreased in rats fed diets rich fibers compared with hyperglycemic control.

It could be concluded that hypoglycemic diets (containing barley hulls or wheat bran) increased albumin content, and reduced the high levels of urea and creatinine of diabetic rat, compared with hyperglycemic rats, which reflect the improving on kidney function. This may be due to that the barley hulls contains less amounts of protein and high fibers which affect the kidney nephrosis and albumin, urea, creatinine excretion.

Table (5): Liver and Kidney function of diabetic rats fed diets rich fibers

Treatments	Albumin (g/dl)	*AST U/l	**ALT U/l	Urea mg/dl	Creatinine mg/dl
Negative Control (G_1)	2.86±0.39[a]	8.75±1.18[a]	13.25±1.25[a]	53.30±10.26[b]	0.72±0.22[a]
Hyperglycemic control (G_2)	2.05±0.11[c]	7.75±1.57[a]	14.50±2.04[a]	75.49±4.30[a]	0.91±0.25[a]
2.5% barley hull (G_3)	2.42±0.21[abc]	7.25±1.67[a]	14.00±2.89[a]	54.63±10.54[b]	0.55±0.11[a]
5% barley hull (G_4)	2.12±0.22[bc]	9.25±1.06[a]	16.25±0.68[a]	71.23±2.71[ab]	0.56±0.16[a]
2.5% wheat bran(G_5)	2.54±0.16[abc]	9.75±0.68[a]	12.25±2.03[a]	67.84±3.62[ab]	0.70±0.06[a]
5% wheat bran (G_6)	2.71±0.17[ab]	6.50±1.47[a]	16.50±0.41[a]	71.12±9.30[ab]	0.54±0.16[a]
LSD (5%)	0.58	N.S	N.S	18.14	N.S

* AST = Aspartate transaminase (GOT)

** ALT = Alanin transaminase (GPT)

Effect of feeding diets rich fibers on the lipid fractions of diabetic rats:

Table (6) showed the effect of feeding diets rich fibers (barley hulls and wheat bran) on total cholesterol, triglycerides, HDL- cholesterol and LDL-cholesterol in diabetic rats. The data revealed that injection with alloxan resulted in a high increase in total cholesterol of hyperglycemic rat (177.40 mg/dl) but it was decreased due to feeding diets rich fibers. Non significant differences in total cholesterol due to hypoglycemic diets-except G_6 (fed 5% wheat bran) which recorded the lowest value of total cholesterol (124.59 mg/dl). These results were in agreement with Schneeman *et al.* (1984), Davidson *et al.* (1991) and Maqueda *et al.* (2000) who illustrated that dietary fibers and barley foods are effective agent for lowering plasma cholesterol. Feeding hypoglycemic diets to hyperglycemic rats resulted in a decrease of plasma triglycerides-as well as- total cholesterol. The same trend was shown in HDL and LDL- cholesterol; its levels were reduced due to feeding hypoglycemic diets compared with hyperglycemic control. Feeding diet containing 5% wheat bran was the most effective of reduction lipid fractions.

Table (6): Lipid fractions of diabetic rats fed diets rich in fibers

Treatments	Total cholesterol mg/dl	Triglycerides mg/dl	HDL – cholesterol mg/dl	LDL – cholesterol mg/dl
Negative Control (G_1)	79.20±3.80[d]	118.99±3.47[c]	28.62±3.57[c]	26.79±3.86[c]
Hyperglycemic control (G_2)	177.40±3.78[a]	175.35±3.80[a]	48.87±2.26[a]	93.47±2.63[a]
2.5% barley hull (G_3)	155.18±9.39[b]	130.55±2.09[b]	46.33±1.84[ab]	82.74±9.95[a]
5% barley hull (G_4)	150.09±4.06[b]	134.31±3.17[b]	42.14±1.61[ab]	81.09±3.32[a]
2.5% wheat bran (G_5)	157.54±4.11[b]	132.73±1.97[b]	39.82±2.29[b]	91.18±4.09[a]
5% wheat bran (G_6)	124.59±4.12[c]	126.10±3.27[bc]	41.48±1.66[b]	57.89±5.16[b]
LSD (5%)	15.68	9.04	6.84	16.06

It could be concluded that high fiber intake has beneficial effect on blood lipid levels (Jue *et al.*, 2004) and barley foods reduced blood cholesterol, lipoprotein concentration and triglycerides in animals. This may be due to its combination with the secreted feaces. These results were in agreement with that reported by Kalra and Jood (2001) and Al-Shagrawi *et al.* (1999).

Conclusion

The present findings demonstrated that barley hull and wheat bran enabled glycemic control and improved glucose tolerance. On the other hand, diabetic diet containing appropriate wheat bran and barley hull was helpful for diabetic control, though food rich dietary fibers is recommended to diabetics. Also, it could be concluded that barley hull could be a useful therapeutic diet for diabetic patients. Jue *et al.* (2004) suggested that fiber intake should be increased in individuals who have diabetes mellitus to prevent complications. Barley hulls can be consumed as a tablets or capsules or substitution material of wheat bran during breadmaking.

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مدى إمكانية استخدام المنتجات الثانوية لبعض النجيليات لخفض نسبة السكر بالدم

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تم استخدام نوعين من الوجبات المحتوية على مصادر مختلفة للألياف الغذائية وهى قشر الشعير وردة القمح لمعرفة تأثير التغذية بهذه الوجبات على مرض السكر. تم تحليل هذه المواد كيماويا وتم حقن الفئران بالالوكسان لاصابتها بالسكر. تم تغذية الفئران المصابة على وجبات تحتوى اما على قشرة الشعير او ردة القمح (بنسبة ٢,٥ أو ٥٪). تم دراسة تأثير هذه الألياف على وزن الجسم، وزن الأعضاء، مستوى الجلوكوز بالدم ، ووظائف الكبد والكلى وكذلك الليبيدات خلال التجربة. وقد أثبتت النتائج أن التغذية على وجبات محتوية على الألياف أدت إلى خفض ضئيل فى الوزن فى الفئران المصابة. وقد انخفض معدل السكر بالدم انخفاضا ملحوظا نتيجة للتغذية على الألياف وقد أعطى قشر الشعير نتائج أفضل من ردة القمح في انخفاض معدل السكر. وقد اشارت النتائج الى وجود زيادة فى محتوى الألبيومين وكذلك انخفاض فى كل من اليوريا والكوليسترول والجلسريدات الثلاثية وكذلكHDL ، LDL فى الفئران المصابة .
وعموما فقد وجد تحسن ملحوظ فى الفئران المصابة بالسكر نتيجة التغذية على وجبات تحتوى على الالياف.