Journal

J. Biol. Chem. Environ. Sci., 2008, Vol. 3(3): 193-213
www.acepsag.org

EFFECT OF HIGH FIBER BREAD DIETS ON SOME DIABETES RAT BIOLOGICAL PARAMETERS

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ABSTRACT

The present study was designed to estimate the effects of zero time, adaptation, 15, 30 and 45 days feeding efficiency of pan bread manufactured from whole meal and 72% extraction wheat flour on some biological parameters of normal and induced diabetes rat groups.

The chemical analysis of the whole meal wheat flour and the resulted pan bread made from showed that, it possessed the highest protein, fiber and minerals, iron, zinc, and calcium, contents compared to that of the wheat flour (72% ext.). A significant higher amount of soluble, insoluble and total dietary fiber contents, also, was found in the whole meal flour and its pan bread when compared with wheat flour (72%ext.) and its pan bread. The serum glucose, total cholesterol, LDL cholesterol, triglycerides, and total iron binding capacity (TIBC) in blood serum were significantly increased as a result of diabetes induces of rats. Normal rats, (nondiabetic and fed on basal diet and whole meal pan bread), for exhibited an insignificant decrement in blood glucose. However, in the diabetic rats significantly lowered blood glucose was found. Whole meal pan bread sample was more slightly effective in lowering triglycerides, total cholesterol, LDL-cholesterol and total iron binding capacity (TIBC) in the diabetic rats in a comparison to diabetic rats, either fed on a basal diet or 72% extraction flour pan bread. Diabetic rats showed a significant decrement in body weight compared with normal rats. Whole meal pan bread caused a significant improvement in the HDL-cholesterol, calcium, phosphorus and iron compared with 72% extraction flour pan bread and basal diet.

Generally, it is recommended to utilize whole meal flour to prepare healthy diets to deal with diabetic status and control of some biological parameters.

Keywords: Whole meal, wheat flour, biological parameters.

INTRODUCTION

Wheat and wheat products are long recognized as a major staple, source of calories and contribute significant quantities of other nutrients (vitamins, minerals and dietary fiber) in the_people diets (Sidhu *et al*., 1999). Whole grains provide a wide range of nutrients and biologically active constituents as dietary fiber, vitamins (B and E), minerals (selenium, zinc, copper, magnesium) and phytochemical, such as phenolic compounds, which may synergistically contribute to reduce the incidence of various chronic diseases (Adam *et al*., 2003). Whole grains are made up of the endosperm, the germ, and the bran of the grain. The endosperm makes up about 80% of the whole grain, while the germ and bran components vary among different grains. Whole grains are cholesterol-free and low in fat, high in dietary fiber and vitamins (especially B-vitamins), and are good sources of minerals (particularly trace minerals).Whole grains are concentrated sources of starch and are about 10% to 15% protein. In the refining process, the bran and germ are separated from the starchy endosperm, which is ground to flour. When the bran is removed in refining, important disease-preventing nutrients and phytochemicals (such as lignans, tocotrienols, and phenolic compounds) and antinutrients (including phytic acid, tannins and enzyme inhibitors) are removed as well. Whole grains are important sources of these nutrients and phytochemical compounds (Slavin *et al*., 2001). Some of health benefits associated with a high-fiber diet may come from other associated components, not just from fiber itself (Slavin *et al*., 1999). For example, whole-grain foods contain hundreds of identified phytochemicals, such as phytoestorgens, antioxidants, and phenols, which together with vitamins minerals such as vitamin E and selenium may play important roles in disease prevention. These and other unidentified phytochemicals in whole grains may be protective or may act synergistically to exert protective effects (Slavin *et al*., 2001).

Marques *et al*., (2007) reported that, more wheat –based products, including flour, bread, breakfast cereals, pasta and crackers, are available. It seems that such cereals products possess valuable nutritional and/or physiological properties, which could help promoting the consumption of these products. Wheat milling and utilization has emerged as one of the largest food processing industries in some countries. The consumption of toast bread is steadily increasing at about 10% per annum, whereas Arabic bread consumption has not shown any significant increases. More than 90% of the toast bread being consumed is made from white flour, which is depleted of natural dietary fiber (Sidhu *et al*., 1999). On the other hand, Ranhatra *et al*., (1990) reported that the total dietary fiber content of whole wheat flour is 10.2% compared with 2.5% for white flour (72% ext.). White bread is a commonly consumed type of bread. Therefore, to meet this requirement for dietary fiber, the development of enriched bread with a higher dietary fiber content should be the best way to increase the fiber intake (Wang *et al.,* 2002).

Diabetes mellitus is the most significant chronic disease and cause of death in the modern society. Diabetes mellitus is divided into 2 major categories: type 1 and type 2.These 2 types of diabetes have a distinct pathogenesis, but hyperglycemia and various life- threatening complications, resulting from long-term hyperglycemia, are their most common features. Diabetes is a metabolic disorder caused by an absolute or relative lack of insulin. The effective blood glucose control is the key for preventing or reversing diabetic complications and improving the quality of life in diabetic patients (Hyen-lee *et al*., 2006). It appears a nutritional relevant to check whether bread-making does not affect cholesterol-lowering properties of whole wheat flour, because whole wheat bread represents an important food to improve whole grain consumption and daily supply of fiber, minerals and other micronutrients in western countries (Adam *et al*.,2003).

A successful study showed that whole wheat flour revealed lipid-lowering properties in rats (Adam *et al.,* 2001), wherein, Adam *et al., (*2003) cleared that the plasma cholesterol was lower in rats fed whole wheat flour (WWF), whole wheat bread (WWB) than that fed on control, as well as hepatic cholesterol which was also markedly decreased in rats fed on WWF and WWB. Triglyceride concentrations in plasma and liver were also significantly altered in rats fed on WWB, compared to of control ones.

The aim of the present study is to compare the effects of the varied manufactured origin pan bread (whole meal and 72% extraction rate wheat flour) on the chemical composition and to evaluate their effects on some biological tests of the normal and diabetic rats.

MATERIALS AND METHODS

Materials:

Commercial wheat flour (72% extraction) was used in the present study. It was obtained from south Cairo and Giza Mills Company, Fysal, Giza, Egypt. Wheat grain (*Triticum aestivum*), Sakha 69 variety was obtained from the Wheat Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Alloxan (the diabetes mellitus induced drug in rats) was obtained from Sigma Company, USA. High density lipoprotein (HDL), low density lipoprotein (LDL), total cholesterol (TC), triglycerides (TG), glucose, calcium, phosphorus, iron and total iron binding capacity (TIBC) kits were obtained from Biodignostic Company, 29 El Tahreer street, Dokki, Giza, Egypt.

Methods:

Wheat grain was milled using a laboratory mill (MLW, Type: sk1, WaTT:/100, West Germany). Moisture, ash, fat, and protein were determined by implementation of the AACC (1983) standard method. The nitrogen content was measured by the semi micro- kjeldahl method .Nitrogen was converted to protein by using a factor of 5.7 .Soluble, and insoluble dietary fiber contents were estimated according to ASP *et al*.,(1983), while total dietary fiber was determined by Prosky *et al*.,(1984). Ash obtained from one gram of each sample was dissolved in 100 ml HCl (1N).Zinc, iron, calcium, sodium, potassium, manganese and magnesium determination were carried out by using aPye Unicum SP1900 Atomic Absorption spectroscopy techniques as described by AOAC(1990). The caloric values were estimated according to Atwater factors which were based on the basis that the caloric value produced by one gram of protein, carbohydrates and fat were 4, 4 and 9Kcal, respectively (FAO/WHO, 1985).

Baking procedures:

A straight dough bread making process was performed according to Wang *et al*., 2002). Basic dough formula of 500g flour basis was consisted of salt (5g), compressed yeast (10g), sugar (5g), bread improver (0.2g), oil (5g) and the required amount of water to reach 500 BU of consistency. The doughs were optimally mixed, fermented for 10min, and then dough pieces (450 g) were divided, hand – moulded and sheeted. The dough was proofed for 55 min in a fermentation cabinet under controlled temperatures (30^{o}C) and a relative humidity (78%) for 50 min and then baked for 40 min at 180^{o} C in a baking oven. The pan bread attributes were evaluated after cooling for 1hr at room temperature.

Biological assay:

The experimental study was conducted on 25 adult male albino rats, 180-200 g weighed, were used in the current experiment. Animals were fed at the animal house, Crops Technology Department, Food Technology Research Institute (FTRI). Before and during the experiment rats were fed on a basal diet containing 20% casein, 10% corn oil, 5% cellulose, 4% salt mixture and 1% vitamin and completed to 100% with corn starch (AOAC, 2000). After randomization to various groups and before initiation of experiment, the rats were acclimatized for a period of 7 days under standard environmental condition of temperature, relative humidity (55%), and dark/light cycle.

The experimental design:

All the animals were randomly divided in five groups (five rats for each one group) and namely negative control, (the normal group which fed on a basal diet), positive,(the diabetic group fed on casein diet), 72% ext. wheat, (the diabetic group fed on the traditional pan bread (72% extraction)), whole meal bread, (the diabetic group fed on whole meal pan bread diet) and non diabetic whole meal (normal group fed on whole meal pan bread).

Induced diabetic animals:

Rats were diabetic induced by a single intraperitioneal injection of alloxan monohydrate (150 mg/kg). Alloxan was first individually amount calculated for each animal according to the weight and the proper amount was solubilized with saline just prior to injection (Ahmed *et al*., 2005) and the control group was saline injection. Two days after alloxan injection, rats with plasma glucose levels of >140mg/dl were included in the study. Fasting blood glucose estimation, body weight and water intake measurements were done at zero, 15, 30 and 45 day of the study. Food intake was calculated as g/24 hours of the experimental period. At the end of the feeding period (45 days) rats were anaesthetized using diethyl ether and sacrificed. The organs .i.e. liver, heart, kidney, brain, spleen and pancreas were separated and their weighed were recorded.

Biochemical analysis:

The blood samples were collected in tubes and centrifuged at 500 xg to obtain serum. It was kept in a deep-freezer until biological analysis was performed and subjected to the following biochemical analysis: fasting blood sugar (Trinder, 1969) in the separated serum samples. Serum cholesterol (Richmond, 1973), serum triglycerides (Fossati and Prencipe, 1982), serum HDL-cholesterol (Lopez-Virella *et al*.,1977) serum LDL-cholesterol (Wieland and Seidel, 1983), serum iron (Dreux, 1977), serum calcium (Gindler and King, 1972), serum phosphorus (El-Merzabani *et al* ., 1977), serum total iron binding capacity, TIBC, (Piccardi *et al* .,1972) and serum insulin level (Temple *et al*., 1992, at National Institute of Diabetic and Endocrine Discos).

Statistical analysis:

Data analysis was performed using SAS (1987), software. All data were expressed as mean±standard deviation. Analysis of variance was used to test for differences between the groups. Least Significant Differences (LSD) test was used to determine significant differences ranking among the mean values at $P< 0.05$.

RESULTS AND DISCUSSION

Chemical composition of whole meal wheat flour and wheat flour(72%extraction):

Data presented in Table (1) shows that protein, ether extract, fiber and ash were significantly higher in whole meal wheat flour than that found in wheat flour (72%ext.), agreed with Afifi, (1999), Sidhu *et al*., (1999) and El-Nagar, (2005). It could be regarded to the presence of higher amounts of bran layer, which possessed such components with higher amounts than the other layers, in the whole meal than the 72%extraction one. On contrary, moisture content and total carbohydrates were significantly lower in the former than the latter.

Table (1): Chemical composition of whole meal and 72%extraction wheat flour (on dry weight basis).

Sample	Moisture	Protein	Ether extract	Fiber	Ash	T.C*
Whole meal wheat flour	13.15^b ±0.0707	13.25^a ±0.0707	2.580^a ±0.0424	3.55^a ±0.0707	2.125^a ±0.0353	78.500^b ±0.1410
Wheat flour (72%ext.)	14.05^a ±0.0707	11.18^b ±0.113	0.375^b ±0.021	0.66^b ±0.070	0.55^b ±0.0141	87.235^a ±0.049

T.C*= Total carbohydrates calculated by difference
-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.
-Each value (an average of three replicates) is followed by the standard deviation.

The results presented in Table (2) showed that zinc, iron, calcium, magnesium, manganese and cupper contents in whole meal wheat flour were significantly higher than that found in 72%extraction wheat flour agreed with El -Nagar (2005). Such results was due to, as previously mentioned, the presence of the higher amounts of such minerals in cover layer, which involved in the whole meal with a higher amounts than in 72%extraction wheat flour.

Table (2): Minerals content of whole meal and 72%extraction wheat flour (calculated as mg/100g dry sample).

Minerals / Samples	Zn	Fe	Ca	K	Na	Mg	Mn	Cu
Whole meal wheat flour	4.17^a ±0.042	5.37^a ±0.353	74.26^a ±0.233	32.05^b ±0.091	133.1^a ±0.141	307.25^a ±0.494	30.20^a ±0.141	6.25^a ±0.212
Wheat flour (72%ext.)	2.20^b ±0.141	1.53^b ±0.014	67.0^b ±0.141	45.30^a ±0.282	129.9^b ±0.424	62.17^b ±0.098	3.10^b ±0.289	2.35^b ±0.353

-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.
-Each value (an average of three replicates) is followed by the standard deviation.

Whole meal wheat flour (as found in Table 3) contained the highest amounts of total, soluble and insoluble dietary fiber compared to that found in wheat flour (72%ext.). These results agreed with those obtained by Frolich and Asp (1981) and Wang *et al*.,(1993).

Table (3): Dietary fiber content of whole meal and72%ext. wheat flour (on dry weight basis).

Sample	Dietary fiber %		
	Insoluble	Soluble	Total
Whole meal wheat flour	12.65[a] ±0.212	1.425[a] ±0.247	14.05[a] ±0.070
Wheat flour (72%ext.)	2.55[b] ±0.070	0.54[a] ±0.210	3.095[b] ±0.148

-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.
-Each value (an average of three replicates) is followed by the standard deviation.

Data presented in Table(4) showed the major chemical constituents and caloric values of manufactured pan bread of the suggested 72%extraction and whole meal wheat flour .The highest significantly protein, fiber, ash and ether extract contents were noticed in pan bread prepared from whole meal wheat flour. The same Table revealed that the highest significantly carbohydrates and caloric values were noticed in pan bread prepared from wheat flour (72%ext.) due to the previously mentioned reasons.

Table (4): Chemical composition and Caloric values of the manufactured pan bread (calculated on dry weight basis).

Pan bread origin	Protein	Ether extract	Fiber	Ash	T.C*	Caloric values**
Whole meal wheat flour	13.175[a] ±0.10606	3.50[a] ±0.1414	2.240[a] ±0.0141	1.95[a] ±0.0353	78.58[b] ±0.692	395.78[b] ±0.254
Wheat flour (72%ext.)	11.24[b] ±0.028	2.015[b] ±0.007	0.325[b] ±0.007	1.46[b] ±0.0141	84.66[a] ±0.3818	400.51[a] ±3.139

*T.C is Total carbohydrates, calculated by difference.
**Caloric values is expressed as Kcal/100g sample
-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.
-Each value (an average of three replicates) is followed by the standard deviation.

The results presented in Table (5) showed that the minerals contents (zinc, iron, calcium, magnesium and cupper) in pan bread prepared from whole meal wheat flour were significantly higher than that found in 72% extraction wheat flour. These findings are concurrent with that found by Adam *et al*., (2003), who reported that whole wheat bread represents an important food to improve whole grain consumption and daily supply of fiber, minerals and other micronutrients. On contrary, potassium, sodium and manganese contents were significantly lower in pan bread originated from whole meal wheat flour than that found in pan bread originated from 72% ext. wheat flour.

Table (5): Minerals content of the manufactured pan bread (mg/100g sample on dry weight basis).

Minerals / Pan bread origin	Zn	Fe	Ca	K	Na	Mg	Mn	Cu
Whole meal wheat flour	4.20[a] ±0.141	6.80[a] ±0.141	74.395[a] ±0.572	34.65[b] ±0.636	125.15[b] ±0.070	109.65[a] ±0.777	20.21[a] ±0.141	4.4[a] ±0.282
Wheat flour (72%ext.)	2.25[b] ±0.212	3.55[b] ±0.063	68.30[b] ±0.141	47.4[a] ±0.282	132.00[a] 0.141	65.1[b] 0	34.37[a] ±0.436	1.93[a] ±2.14

-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.
-Each value (an average of three replicates) is followed by the standard deviation.

Biological estimation of different groups:
Effect of whole meal wheat bread and wheat bread on blood glucose and insulin levels:

Table (6) showed that no significant differences in blood glucose content was found among the rat groups after feeding on basal diet for both of 7 day (adaptation) and zero time (initial) period. The diabetic rats showed a range of 2.24-2.91 folds increment in the blood glucose after injection with alloxan .The blood glucose concentration was significantly higher in the diabetic rats fed on the basal diet (positive control) and diabetic fed on 72%extraction wheat bread than of those diabetic rats fed on whole meal wheat bread (whole meal diabetic), non diabetic fed on whole meal wheat bread (nondiabetic whole meal) and nondiabetic fed on basal diet (negative control). There were significant differences in serum blood glucose in negative control and whole meal nondiabetic compared with the other diabetic rats (non or both corresponding) groups .These results are agreed with Adam *et al*., (2003) who reported that the dietary fiber intake, especially from whole grain sources reduced the serum glucose level and lead to reduce the risk of coronary heart disease and diabetic. On the other hand, within the diabetic rat groups, the whole meal possessed lower serum glucose content than that of 72% ext. wheat and positive control, respectively, groups.

Table (6): Blood glucose level (mg/dl) and insulin level (mu/l) in rat group, fed on the tested diets.

Groups	Zero time	Adaptation	After injection	Feeding period			Insulin level*
				15 day	30 day	45 day	
Negative control	84[a] 0	95[a] 0	95[d] 0	97 [d] ±0.500	95 [d] ±0.957	93 [c] ±2.21	0.525[b] ±0.0070
Positive control	84[a] 0	95 [a] 0	263[b] ±2.50	258 [b] ±2.363	252 [b] ±2.218	246 [a] ±2.872	0.220[d] ±0.014
Whole meal nondiabetic	84[a] 0	95 [a] 0	95 [d] 0	98 [d] ±0.957	95.5 [d] ±0.577	91 [c] ±0.816	0.565[a] ±0.021
Whole meal diabetic	84[a] 0	95 [a] 0	213[c] ±6.22	200 [c] ±0.577	195 [c] ±0.957	183[b] ±2.22	0.315[c] ±0.021
72% ext. Wheat diabetic	84 [a] 0	95 [a] 0	277 [a] ±2.217	269[a] ±2.217	269 [a] ±0.957	244 [a] ±2.83	0.015[e] ±0.007

-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.
-Each value (an average of three replicates) is followed by the standard deviation.
*At the end of experiment.

B-cell mass reflects the balance between the renewal and loss of these cell. It was also suggested that regeneration of islet B-cell may be following to the destruction occurrence by alloxan (Ahmed *et al*., 2005). Therefore, Table (6) concerned the plasma insulin of the different groups at the end of the present study. It was significantly higher for rats fed on the nondiabetic whole meal followed by the negative control, while it was significantly lower for diabetic rats, whole meal, 72% extraction wheat bread and positive control. These results are agreed with Yadav *et al*., (2004), who reported that the insulin deficiency (type 1-diabetic) or decrease in glucose utilization by insulin requiring tissues like liver and an increase in glucose production through an increased rate of gluconeogenesis, both resulting in hyperglycemia, as a consequence of increased glucose and decreased insulin level in blood plasma. It could finally concluded that the whole meal diet could be used as a serum glucose controller via the lower sugar content as reported by Adam *et al*.,(2003).

Effect of whole meal wheat bread and wheat bread on triglycerides and cholesterol fractions:

Triglycerides and total cholesterol levels in the tested rats blood serum showed a significant increase in rats fed on diabetic basal diet (positive control), diabetic whole meal wheat bread and diabetic wheat bread as a result of injection with alloxan in relative to their original rats groups. Serum total cholesterol was lower in diabetic rats fed on whole meal wheat bread, than in diabetic rats fed on basal diet (positive control group), as well as hepatic cholesterol which was also markedly decreased in rats fed on basal diet and whole meal wheat bread, respectively, after 45 days feeding. Triglyceride concentrations were also significantly altered in rats blood serum of diabetic rats fed on whole meal wheat bread and wheat bread compared to positive control group after 45 days feeding. These results were in agreement with Yadav *et al.*, (2004) who_reported that there was an increase in the plasma total lipids, triglycerides and total cholesterol in alloxan diabetic rats. This increment may be a result of lipids breakdown increment and mobilization of FAA from the peripheral depots. Since insulin inhibits the hormone–sensitive lipases, the latter becomes active in the absence of insulin.

Table (7): Triglycerides and total cholesterol (mg/dl) in rat groups fed on the tested diets.

Groups	Triglycerides (mg/dl)						Total cholesterol(mg/dl)					
	Zero time	Ada*	Inje**	Feeding period			Zero time	Ada*	Inje**	Feeding period		
				15 day	30 day	45 day				15 day	30 day	45 day
Negative control	112[a] 0	105[a] 0	100.7[c] ±0.957	79.87[c] ±0.748	73[d] ±0.668	59.2[d] ±0.450	220[a] 0	210[a] 0	200[c] ±1.290	190[c] ±0.957	175.25[d] ±0.957	153[c] ±2.217
Positive control	112[a] 0	105[a] 0	211.4[b] ±1.231	205.4[b] ±1.231	197[c] ±0.707	188[b] ±1.205	220[a] 0	210[a] 0	272[a] ±2.943	263[a] ±2.629	250[a] ±2.629	235[a] ±2.625
Nondiabetic whole meal	112[a] 0	105[a] 0	98.7[c] ±0.957	77.96[d] ±0.877	67[e] ±0.506	56.4[e] ±0.293	220[a] 0	210[a] 0	200.8[c] ±0.957	182[d] ±1.290	163[e] ±2.160	14 5[d] ±2.160
Diabetic whole meal	112[a] 0	105[a] 0	247.9[a] ±0.650	238.22 ±0.449	218[a] ±0.783	178[c] ±0.379	220[a] 0	210[a] 0	271[a] ±0.957	261[a] ±0.957	244[c] ±0.816	226[b] ±0.577
Diabetic wheat 72% ext.	112[a] 0	105[a] 0	214[b] ±4.674	206.6[b] ±2.069	201[b] ±2.096	192[a] ±2.062	220[a] 0	210[a] 0	261[b] ±0.816	256[b] ±1.892	247[b] ±1.892	235[a] ±1.892

-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.

-Each value (an average of three replicates) is followed by the standard deviation.

*Ada=after adaptation **Inj=after injection.

Data presented in Table (8) shows that there were significant changes in impact of all the tested diets under investigation on both of serum HDL and LDL-cholesterol amounts either in diabetic control or healthy (normal rats). Serum HDL-cholesterol was significantly increased in diabetic rats fed on whole meal wheat bread for 45 days compared with that of non diabetic(whole meal wheat, negative control) and diabetic (72% ext. wheat bread) rat groups. Serum LDL-cholesterol was significantly increased by alloxan injection .Feeding on pan bread samples prepared from whole meal wheat and 72%extraction flour led to a serum LDL-cholesterol significantly decrement in the nondiabetic rats group fed in the basal diet or whole meal wheat bread after 15,30,and 45 days compared with that of the positive control . These results agreed with that found by Ahmed *et al., (*2005) who, reported that HDL-cholesterol was significantly decreased by injection with alloxan, whereas serum LDL-cholesterol was significantly increased after injection with alloxan.

Table (8): HDL-cholesterol and LDL-cholesterol (mg/dl)in rat groups fed on the tested diets.

Groups	HDL-cholesterol (mg/dl)						LDL-cholesterol (mg/dl)					
	Zero time	Ada*	Inje**	Feeding period			Zero time	Ada*	Inje**	Feeding period		
				15 day	30 day	45 day				15 day	30 day	45 day
Negative control	31^{a} 0	34^{a} 0	35^{a} ±0.082	39.4^{a} ±3.121	55.2^{c} ±0.167	62.1^{b} ±0.670	101^{a} 0	99.4^{a} 0	95^{b} ±0.525	89^{c} ±0.492	85.3^{d} ±0.550	70.6^{d} ±0.465
Positive control	31^{a} 0	34^{a} 0	29.57^{c} ±0.556	31.4^{d} ±0.483	43.9^{cd} ±0.387	51.7^{c} ±1.053	101^{a} 0	99.4^{a} 0	182^{a} ±0.816	177^{a} ±0.957	167^{a} ±0.957	156^{b} ±1.414
Nondiabetic whole meal	31^{a} 0	34^{a} 0	35^{a} ±0.125	33.3^{bc} ±0.489	58.5^{b} ±0.620	63.5^{b} ±1.564	101^{a} 0	99.4^{a} 0	90.3^{c} ±0.476	82.62^{d} ±0.622	74.8^{e} ±0.556	51.3^{e} ±0.610
Diabetic whole meal	31^{a} 0	34^{a} 0	30.27^{b} ±0.485	35.47^{b} ±0.694	61.8^{a} ±0.340	76.1^{a} ±0.684	101^{a} 0	99.4^{a} 0	181^{a} ±1.414	176.8^{ab} ±0.500	165^{c} ±0.500	145^{c} ±0.577
Diabetic wheat 72% ext.	31^{a} 0	34^{a} 0	29.1^{c} ±0.129	30.1^{d} ±0.170	35.22^{e} ±0.262	40.2^{d} ±0.129	101^{a} 0	99.4^{a} 0	181^{a} ±0.816	176^{b} ±0.816	166^{b} ±0.816	157^{a} ±0.577

-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at < 0.05.
-Each value (an average of three replicates) is followed by the standard deviation.
*Ada=after adaptation **Inj=after injection.

Effect of whole meal wheat bread and wheat bread on serum calcium and phosphorus concentration

Data presented in Table (9): showed that no significant differences in serum calcium and phosphorus contents were found among all the tested groups after adaptation. On contrary, after alloxan injection, it was found that there was a significant increment in serum calcium and phosphorus contents in diabetic rats at the end of feeding period (45 days). It was also found that there were significant differences in serum calcium and phosphorus in normal rats and diabetic rats at each stage and within all the tested period.

Table (9): calcium and phosphorus (mg/dl)in rat groups fed on the tested diets.

Groups	Calcium (mg/dl)						Phosphorus (mg/dl)					
	Zero time	Ada*	Inje**	Feeding period			Zero time	Ada*	Inje**	Feeding period		
				15 day	30 day	45 day				15 day	30 day	45 day
Negative control	3.65^{a} 0	3.90^{a} 0	4.70^{b} ±0.013	6.51^{b} ±0.167	7.25^{b} ±0.129	8.26^{c} ±0.149	0.9^{a} 0	1.30^{a} 0	1.64^{b} ±0.031	1.92^{b} ±0.009	2.14^{b} ±0.034	2.47^{a} ±0.022
Positive control	3.65^{a} 0	3.90^{a} 0	2.64^{c} ±0.025	3.27^{e} ±0.150	4.60^{d} ±0.074	5.35^{e} ±0.238	0.9^{a} 0	1.30^{a} 0	0.74^{d} ±0.012	0.86^{d} ±0.037	1.54^{e} ±0.023	1.76^{d} ±0.032
Nondiabetic whole meal	3.65^{a} 0	3.90^{a} 0	6.83^{a} ±0.185	8.58^{a} ±0.322	9.9^{a} ±0.073	12.02^{a} ±0.204	0.9^{a} 0	1.30^{a} 0	1.74^{a} ±0.008	1.99^{a} ±0.012	2.34^{a} ±0.031	2.44^{a} ±0.152
Diabetic whole meal	3.65^{a} 0	3.90^{a} 0	2.33^{d} ±0.162	5.18^{c} ±0.036	7.26^{b} ±0.110	10.4^{b} ±0.241	0.9^{a} 0	1.30^{a} 0	0.84^{c} ±0.009	1.65^{c} ±0.045	1.78^{c} ±0.017	2.10^{b} ±0.068
Diabetic wheat 72% ext.	3.65^{a} 0	3.90^{a} 0	2.70^{c} ±0.041	3.97^{d} ±0.221	5.95^{c} ±0.264	7.25^{d} ±0.129	0.9^{a} 0	1.30^{a} 0	0.62^{e} ±0.012	1.28^{e} ±0.069	1.65^{d} ±0.046	1.93^{c} ±0.017

-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.
-Each value (an average of three replicates) is followed by the standard deviation.
*Ada=after adaptation **Inj=after injection.

Effect of whole meal wheat bread and wheat bread on serum iron and total iron binding capacity (TIBC) concentration

Many laboratories continue to offer TIBC measurement as a choice in iron deficiency (Hawkins 2007), while, in diabetes iron metabolism is disturbed but little information is available on the effect of diabetes on the antioxidant capacity of plasma to protect against iron-driven lipid peroxidation (Van Campenhout, *et al*., 2003). On the other hand, increased levels of TIBC suggest that total iron body stores are low, increased concentrations may be a sign of iron deficiency anemia and may occur during the third trimester of pregnancy (Hamedani, *et al*., 1987 and Puolakka, *et al*., 1980). Decreased levels of TIBC may indicate anemia of chronic disease such as hemolytic anemia, hemochromatosis, chronic liver disease, hypoproteinemia, malnutrition, pernicious anemia, and sickle cell anemia(Heilmann, 1975). Therefore, data presented in Table (10) interest to throw the light on such test. It shows that there was no significant difference in serum iron and TIBC of all groups after zero time and adaptation period. On contrary, it was lower in diabetic rats compared with those found in normal rats fed on whole meal wheat bread, concurrent with Van Campenhout *et al*., (2006). It was due to the extensive presence of iron, which was previously reported, in the whole meal and consequently in the resulting pan bread. The same Table showed also, that there were significant increments in serum iron content in normal rats fed on whole meal wheat bread and basal diet for 15, 30 and 45 days compared with the corresponding diabetic rats. It could be concluded that whole meal wheat bread increased the serum iron content in both of normal and diabetic rats. These results were concurrent with Afifi, (1999). The same Table showed, also, that there was a significant increment in serum total iron binding capacity (TIBC) after injection with alloxan. The values were 302.3±2.6-437.0±1.4 µg/dl, respectively in groups feeding on whole meal wheat bread (nondiabetic whole meal) and basal diet (positive control), respectively.

Table (10): Iron and total iron binding capacity (µg/dl) in rat groups fed on the tested diets.

Groups	Iron (µg/dl)						Total iron binding capacity (µg/dl)					
	Zero time	Ada*	Inje**	Feeding period			Zero time	Ada*	Inje**	Feeding period		
				15 day	30 day	45 day				15 day	30 day	45 day
Negative control	30^{a} 0	35^{a} 0	43^{b} ±0.238	53^{b} ±0.450	64^{b} ±0.336	76.9^{b} ±0.770	416^{a} 0	391^{a} 0	303.75^{d} ±3.095	282.25^{e} ±4.573	273^{d} ±4.082	263^{d} ±3.403
Positive control	30^{a} 0	35^{a} 0	30.3^{d} ±0.218	33.1^{dc} ±0.460	36.5^{c} ±1.603	38.1^{d} ±0.075	416^{a} 0	391^{a} 0	437^{a} ±1.414	427^{a} ±1.414	408.5^{a} ±2.081	385^{a} ±1.892
Nondiabetic whole meal	30^{a} 0	35^{a} 0	45.3^{a} ±0.170	75.6^{a} ±1.406	81.3^{a} ±0.208	101^{a} ±0.718	416^{a} 0	391^{a} 0	302.3^{d} ±2.629	292.3^{d} ±2.629	274.7^{d} ±1.892	265^{d} ±2.160
Diabetic whole meal	30^{a} 0	35^{a} 0	31.5^{c} ±0.410	41.5^{c} ±0.380	68.4^{b} ±1.494	76.4^{b} ±0.776	416^{a} 0	391^{a} 0	402.5^{c} ±2.645	390.5^{c} ±2.645	372.7^{c} ±2.986	353^{c} ±2.943
Diabetic wheat 72% ext.	30^{a} 0	35^{a} 0	21.9^{e} ±0.586	27.9^{d} ±0.123	33.4^{c} ±0.388	39.3^{c} ±0.331	416^{a} 0	391^{a} 0	420^{b} ±0.816	409^{b} ±0.816	390.5^{b} ±1.290	368^{b} ±0.816

-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.

-Each value (an average of three replicates) is followed by the standard deviation.

*Ada=after adaptation **Inj=after injection.

Impact of the pan bread feeding on the body weight, water intake and food intake of the rat groups.

Data presented in Table (11) shows that the body weight of diabetic rat groups decreased as a result of feeding on pan bread diets all over the feeding period .On the other hand, there was an insignificant difference in the initial body weight of all the tested rats and after adaptation stage, whereas, alloxan injection caused a weight reduction in the diabetic rat groups .The body weight of diabetic group was significantly different than the basal diet (positive and negative) and nondiabetic whole meal, also, along with all the experiment period. These results were in agreement with Saleh *et al.,*(2008) who reported that the significant differences in the body weight may be regarded to the variation in the food intake due to the variation in their preferences . It may regarded to that the diabetic rats fed on whole meal pan bread required an water amount excess than the other diets due to the diabetes induced process and the dietary fiber amount contents previously reported. It could also regard to that the whole grains are good sources of dietary magnesium, fiber, and vitamin E, which are involved in insulin metabolism. Relatively high intakes of these nutrients from whole grains may prevent hyperinsulinemia. Whole grains may also influence insulin levels through beneficial effects on satiety and body weight. However, even after adjusting for body mass index, studies have found a strong inverse relationship between whole grain intake and fasting insulin levels (Bjorck *et al*., 1994). Dietary fiber–rich foods are known to be consumed in higher amounts, which may also be due to greater palatability (Nandini, *et al*., 2000).

Table (11): Effect of the tested diets feeding on the body weight (g) and water intake (ml/24hr) in rat groups

Groups	Body weight (g)						Water intake(ml/24hr)					
	Zero time	Ada*	Inje**	Feeding period			Zero time	Ada*	Inje**	Feeding period		
				15 day	30 day	45 day				15 day	30 day	45 day
Negative control	190^{a} ±5.99	198^{a} ±9.39	203^{a} ±9.83	209^{a} ±9.57	221^{a} ±8.47	234^{a} ±7.12	150^{a} 0	160^{a} 0	160^{d} 0	200^{e} 0	205^{e} 0	240^{e} 0
Positive control	190^{a} ±6.05	200^{a} ±5.65	174^{b} ±4.14	165^{c} ±5.41	157^{c} ±6.34	144^{c} ±4.34	150^{a} 0	160^{a} 0	200^{c} 0	250^{b} 0	350 0	360^{c} 0
Nondiabetic whole meal	190^{a} ±6.05	202^{a} ±3.42	207^{a} ±3.11	216^{a} ±2.64	226^{a} ±3.8	237^{a} ±4.43	150^{a} 0	160^{a} 0	150^{e} 0	200^{d} 0	210^{d} 0	250^{d} 0
Diabetic whole meal	190^{a} ±2.30	199^{a} ±5.14	177^{b} ±7.58	178^{b} ±6.9	179^{b} ±6.26	178^{b} ±4.85	150^{a} 0	160^{a} 0	250^{a} 0	260^{a} 0	300^{b} 0	370^{a} 0
Diabetic wheat 72% ext.	190^{a} ±5.50	201^{a} ±5.24	176^{b} ±2.70	165^{c} ±3.70	153^{c} ±3.63	138^{c} ±1.76	150^{a} 0	160^{a} 0	200^{b} 0	240^{c} 0	300^{c} 0	360^{b} 0

-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.

-Each value (an average of three replicates) is followed by the standard deviation.

*Ada=after adaptation **Inj=after injection.

The same Table shows that there was no significant differences in water intake at zero time and adaptation period among all groups of rats. The water intake of the diabetic rats was significantly higher than that of the positive control and diabetic whole meal, respectively, as compared with the negative control. It confirmed that high water intake is a characteristic symptom of diabetes as reported by Kumar *et al*., (2005).

Impact of the pan bread feeding on the organs weight of the rat groups:

The obtained data in Table (12) illustrate that, there is a decrease in liver weight in diabetic rats compared with normal .These results are agreed with Yadav *et al*., (2004), who reported that, during diabetes liver decrease in weight due to enhanced catabolic processes such as glycogenolysis, lipolysis and proteolysis, which is the outcome of insulin lake and /or cellular glucose in liver cells. There is, however, an increase, but with insignificant level in kidney weight due to glucose over-utilization and subsequent enhancement in glycogen synyhesis, lipogenesis and protein synthesis. The same Table shows slightly changes in heart, spleen and pancreatic weight among all the rats fed on pan bread and basal diet .On the other hand, there were an insignificant difference in the kidney and brain weight of all the tested rats. It could confirm that nondiabetic groups possessed the highest food intake and significantly differed than the diabetic groups. In general whole meal bread seed to be the preferable diet due to the highest degree rats preferences.

Table (12): Organs weight (g) and food intake (g/24 hr) in rat groups fed on the tested diets at the feeding period end

Groups	Liver	kidney	Brain	Heart	Spleen	Pancreatic	Food intake
Negative control	6.90^{a} ±0.737	1.50^{a} ±0.232	1.50^{a} ±0.057	0.707^{a} ±0.068	0.722^{b} ±0.073	0.48^{b} ±0.049	82.500^{a} ±2.08166
Positive control	5.88^{b} ±0.390	1.477^{a} ±0.189	1.34^{a} ±0.009	0.55^{c} ±0.008	0.512^{c} ±0.0095	0.237^{c} ±0.0095	66.7500^{c} ±5.37742
Nondiabtic whole meal	6.87^{a} ±0.641	1.39^{a} ±0.205	1.35^{a} ±0.182	0.68^{ab} ±0.101	0.89^{a} ±0.041	0.55^{b} ±0.118	86.750^{a} ±1.25830
Diabetic whole meal	5.85^{b} ±0.780	1.38^{a} ±0.250	1.44^{a} ±0.14	0.68^{ab} ±0.054	0.740^{b} ±0.033	0.49^{b} ±0.058	77.500^{b} ±1.29099
Diabetic wheat 72%ext.	5.48^{b} ±0.288	1.56^{a} ±0.008	1.31^{a} ±0.078	0.600^{bc} ±0.048	0.760^{b} ±0.033	0.85^{a} ±0.020	73.7500^{b} ±2.98607

-Each value (an average of three replicates) within the same column, followed by the same letter are not significantly different at <0.05.

-Each value (an average of three replicates) is followed by the standard deviation.

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تأثير التغذية بوجبات خبز عالى الالياف على الصفات البيولوجية للفئران المصابة بمرض السكر.

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تم اعداد الدراسة الحالية من أجل تقييم تأثير كل من خبز القالب المصنع من دقيق الحبة الكاملة للقمح وكذلك دقيق استخلاص 72% علي كفاءة بعض الإختبارات الحيوية لفئران التجارب العادية وتلك التي تم اصابتها بمرض السكر من خلال تغذيتها لمدة 15،30، 45 يوما.

وقد لوحظ أن التركيب الكيماوي لدقيق الحبة الكاملة وكذلك خبز القالب الناتج منها يحتوي علي كمية أكبر من البروتين والألياف والعناصر المعدنية، الحديد، والزنك والكالسيوم مقارنة لمكونات الخبز الناتج من دقيق استخلاص 72% كذلك لوحظ وجود كمية مرتفعة معنوياً من الالياف الغذائية الذائبة وغير الذائبة و الكلية في دقيق الحبة الكاملة والخبز الناتج منها. كما ان قيم جلوكوز الدم، الكولسترول الكلي ، الكولسترول ذو الليبوبرتين منخفضة الكثافة ، الجلسريدات الثلاثية كفاءة الحديد المرتبطة في سيرم الدم قد ارتفعت بدرجة معنوية نتيجة عملية اصابة الفئران بالسكر. وكانت الفئران الطبيعية (التي تم تغذيتها علي الوجبة الاساسية وكذلك خبز دقيق الحبة الكاملة دون احداث اصابة بمرض السكر لها)قد أعطت انخفاض غير معنوي في مستوي السكر الدم بينما فقد حدث انخفاض معنوي في حالة الفئران المصابة بمرض السكر . كذلك فقد وجد أن الخبز الناتج من دقيق الحبة الكاملة كان اكثر تاثيرا بدرجة بسيطة في خفض الجلسريدات الثلاثية ، الكولسترول الكلي ، الكولسترول ذو الليبوبروتين منخفضة الكثافة ، كفاءة الحديد المرتبط في الفئران المصابة بالسكر مقارنة بتلك التي غذيت علي الوجبة الاساسية اوخبزالدقيق استخلاص 72% وقد وجد ان هناك انخفاض معنوي في وزن الفئران التي اصيبت بمرض السكر مقارنة بالفئران الطبيعية. وقد ادت التغذية علي خبز دقيق الحبة الكاملة في عمل زيادة معنوية في مستوي الكولسترول ذو الليبوبروتين عالي الكثافة ، الكالسيوم ، الفوسفور ، الحديد مقارنة بالتغذية علي خبز الدقيق استخلاص 72% او الوجبة اساسية.

وعامة فانه ينصح باستخدام دقيق الحبة الكاملة في تجهيز وجبات صحية تعمل علي تنظيم بعض الاختبارات الحيوية فى الحالات المصابة بمرض السكر او العادية.