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Effect of Low Calories Pan Bread Containing Wheat Bran and Some Vegetable flours on Biological Properties of Diabetic Rats

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ABSTRACT

The aim of this study was to evaluate the biological properties of diabetic rats fed on low calories pan bread containing wheat bran flour (WBF) as source of dietary fiber; Jerusalem artichoke (JAF) and Globe artichoke (GAF) powders as sources of inulin at levels of 6 and 9 % as compared to rat groups fed on standard basal diet non-diabetic and diabetic (C+ and C-) and pan bread (100% wheat flour). The all rat groups were fed on standard basal diet for 7 days duration (for acclimatization) followed by 21 days feeding on tested pan bread diets. Feed intake and body weight gain were recorded daily during the experimental period. At the end of experimental period the organ weights (Heart, liver, kidney and spleen) were recorded as well as blood samples were obtained to determination of blood glucose level, liver functions (ALT, AST and total proteins), kidney functions (urea, uric acid and createnine), serum lipid fractions (total cholesterol, triglyceride, HDL and LDL), serum electrolytes (Ca, Mg, P, Fe and Zn) and parathyroid hormone (PTH). The results indicated that the rat groups fed on low calories pan bread diets showed optimal organ weights and a good hematological response in all above parameters as compared to diabetic rats fed on basal diet (C-) or pan bread containing 100% wheat flour. The diabetic rats fed on pan bread diet containing JAF recorded the best values of studied blood criteria among all tested diets.

Therefore, these results permit and encourage the use of wheat bran, Jerusalem artichoke and globe artichoke in preparing of some functional foods for human being suffering from diabetic and hypercholestermia. Also, pan bread fortified with WBF, JAP and GAP, may be placed on the market as a functional food.

Key words: Pan bread, Low calories, Jerusalem artichoke, Globe artichoke, Diabetic rats

Introduction

Diabetes mellitus is one of the most common problems challenging the physicians in 21st century (Nesto, 2003 and Bennet, 2004). It is estimated that diabetes mellitus affects more than 366 million people worldwide, which number would be expected to reach a staggering 552 million by 2030 (Tabatabaei-Malazy *et al.,* 2012). Diabetes mellitus is a group of diseases characterized by high levels of blood glucose resulting from defects in insulin production, insulin action, or both. Diabetes can be associated with serious complications and premature death, but people with diabetes can take steps to control the disease and lower the risk of complications (United States, 2003).

Many metabolic problems are associated with diabetes such as cardiovascular and renal disease as well as ocular and nervous system complications (Wan *et al.,* 2007). Also, it is defined as a chronic disease of carbohydrate metabolism, but lipid and protein metabolism are also affected (Heffner, 2001 and Antonio, 2005).

There is an increasing demand for healthy products, natural and of high quality, for Egyptian consumers. Therefore, one recent trend is to enrich the food products with some components to overcome health problems especially effective against diabetes. In fact bread wheat plays an important role in the human diet. Wheat is one of the most important crops in the world especially in Egypt (Halaby *et al.,* 2006 and Litwinek *et al.,* 2013).

Wheat bran, as a low cost product and rich source of dietary fiber (about 45-50%), is produced as a by-product in wheat milling factories. It is compatible with bread other bakery products in terms of taste and aroma. Bran contains good quality proteins (albumin and globulins), minerals (such as Ca, Fe, Zn) and antioxidants (Hoseney, 1994). All these have made bran an attractive component to be used in many foods particularly in bakery products. Bran also contains phytic acid i.e anti-nutrient which may be responsible for reduction of bioavailability of minerals, proteins and vitamins in human body (Palacios *et al.,* 2008 and Tavajjoh *et al.,* 2011).

Also, consumption of the products containing inulin has major health benefits for diabetic patients, mineral absorption from colon and promoting healthy intestinal microflora (Kaur and Gupta 2002, Kays *et al.,* 2007 and Meyer and Stasse-Wolthuis, 2007). Inulin as a functional food was investigated in bakery products, confectionery products, ice cream and low-fat yogurt (Kip *et al.,* 2006). It is known that incorporation of dietary fibers into bakery products can modify the obtained product including reducing loaf volume, increasing firmness

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and prolong freshness (Elleucha *et al.,* 2011). According to beneficial health and nutritive effects, Jerusalem artichoke containing inulin as a natural dietary fiber could be a valuable component of food products (Murphy, 2001).

Inulin and oligofructose belong to a class of carbohydrates known as fructans, which are considered as functional food ingredients since they affect physiological and biochemical processes in rats and human beings, resulting in better health and reduction in the risk of many diseases, e.g., lower blood cholesterol level, reduces blood sugar level, low density lipoproteins and triglycerides; promotes bifidobacteria in the large intestine; and are beneficial to certain heart diseases, because of the large number of health promoting functions of inulin and oligofructose, these have wide applications in various types of food like confectionery, fruit preparations (juices and jams), milk desserts, yogurt , fresh cheese, baked goods, chocolate, ice cream and sauces (Kaur and Gupta, 2002).

The high concentration of inulin in jerusalem artichoke and globe artichoke tubers have made it an attractive prospect for the production of natural sweeteners for a healthy diet because the human body lacks the enzyme inulinase needed to digest them, so these polymers remain inert in the digestive system. Inulin is a natural low calorie (1.25 K cal/g); it can be used as a food additive, animal feed and for the production of fructose and ethanol. More recently, there has been interest in the "neo sugars" which appear to encourage the growth of bifidobacteria spp. (Mullin *et al.,* 1994).

Jerusalem artichoke and globe artichoke powders are non-toxic, well digested by animals, do not have any negative influence on animal growth and development, neither do they have any negative influence on blood count, and can have a mild hypocholesterol effect. The use of the jerusalem artichoke tubers for manufacturing food-additive powders with the medical and preventive aims has good prospects in treating and preventing diabetes mellitus and as a radio protective substance (Partskhaladze *et al.,* 1999). Jerusalem artichoke tubers help in maintain blood sugar level in the human at normal level. Their effect is due to optimum quantity of the polysaccharide inulin, potentially useful for diabetics (Alegria and Vivanco, 2004).

Addition of different sources of inulin to bread was studied earlier. In wheat and wheat/rice bread inulin lowered caloric value and increased dietary fiber content (Meyer and Peters, 2009). Bread enriched with jerusalem artichoke powder had improved sensory quality in comparison to bread with addition of commercially available inulin (Praznik *et al.,* 2002).

Generally, development and consumption of such therapeutic bakery products would help to raise the nutritional status of population (Shalini and Sudesh, 2005). Information on incorporation of jerusalem artichoke and globe artichoke powders in bread is scanty. Therefore, this study was designed to evaluate the effect of replacement wheat flour by 6 and 9 % of wheat bran, jerusalem artichoke and globe artichoke flours on the biological characteristics of hyperglycemic albino rats including feed intake, body weight gain, organs weight (heart, liver, kidney and spleen) and blood analyses (including blood glucose level, serum lipid fractions, liver and kidney functions, serum electrolytes and parathyroid hormone).

Material and Methods

Materials

Plant materials

Jerusalem artichoke tuber (*Helianthus tuberosus L.*) and globe artichoke (*Cynara scolymus L.*) were obtained from Agricultural Research Centre, Giza, Egypt. The tubers were harvested in autumn and packed in plastic bags then transported to the laboratory for use.

Baking ingredients

Wheat flour (72% extraction), fine wheat bran, instant active dry yeast powder, shortening, sugar and salt (sodium chloride) were purchased from the local market , Nasr city region, Cairo, Egypt.

Rats and kits

The adult male albino rats (weighting 120 - 140 g) were obtained from Animal House Colony, Egyptian Organization for Biological and Vaccines, Giza, Egypt. Kits for glucose, total cholesterol, triglycerides, lipids profile, liver function (ALT, AST, and total protein) and kidney function (urea, uric acid and createnine) were obtained from El- Gamhouria Trading Chemicals and Drugs Co., Egypt. Alloxan used to produce diabetes in experimental rats by detroying the insulin-secreting islet cells of the pancreas Malekinejad *et al.* (2012). It was purchased from Sigma Chemical Co. (St. Louis, MO, USA).

Chemicals and standard basal diet

All chemicals used in this study were purchased from El-Gamhouria Trading Chemicals and Drugs Company, Egypt. Standard basal diet (composed of 17.5% protein, 2.4% fat, 15% fiber, 60.9% carbohydrates and 4.2% salts and vitamins mixture) was purchased from National Research Centre, Dokki, Giza, Egypt.

Methods

(A) Technological Treatments

Preparation of jerusalem artichoke and globe artichoke powders

Fresh jerusalem artichoke tubers (JA) and globe artichoke edible heads (GA) were washed with tap water to remove the dust followed by distilled water and cutted into slices 2 mm using Braun slicer machine (Combi Max 700), then soaked in diluted lemon juice (acidic solution) to inhibit the activity of polyphenol oxidase as recommended by Tchone *et al.* (2005). The obtained acidified slices were transferred directly to an electric oven and dried at 50ºC ± 2ºC for 12 hr. for JA and at 55 - 60ºC for 10 - 12 hr. for GA. The dried plant samples were ground into a fine powder in a mill and sieved (20 mesh sieve) to fine particles. The materials that passed through a sieve were retained for use. Finally, the obtained powders of JA and GA packed in polyethylene bags and stored at room temperature in a dry place to avoid moisture absorption as recommended by Modler *et al.* (1993).

Preparation of tested flour mixtures

Wheat flour was replaced by 0, 6, and 9 % individually of both wheat bran flour (WBF), jerusalem artichoke flour (JAF) and globe artichoke flour (GAF). The flour mixtures were individually blended and homogenized, packed in polyethylene bags, tightly closed and stored at room temperature until utilized.

Preparation of pan breads

The straight dough process was performed in pan bread preparation according to the method as described by Curie *et al.* (2002). The ingredients were: 100 g wheat flour or tested flour mixtures, 1.5 g instant active dry yeast, 2.0 g salt, 2.0 g sugar, 3.0 g shortening and water (according to farinograph test). All ingredients were mixed for 6 min, thereafter, the formulated dough was rounded manually by folding for 20 times and then the bulk dough was leaved to rest for 10 min. The prepared dough was placed in lightly greased a baking pan and proved for 80 min in a cabinet at 30 ± 0.5ºC and 85% relative humidity then baked for 20 min at 250ºC in an electrical oven. Before measurements, the baked breads were cooled for 60 min at room temperature, then packed in polyethylene bags and stored at room temperature.

(B) Biological investigation

Preparation of diets used for biological evaluation

Diets used for biological evaluation of dried low calories pan bread containing WBF, JAF and GAF at level of 6 and 9%, which prepared depending upon the chemical composition of the raw materials (wheat flour, WBF, JAF and GAF), the pan bread processed control and low calories pan bread containing WBF, JAP and GAP (table 1 and 2).

Experimental animals and design

Fifty-four adult male albino rats (weighting 120 - 140 g) were housed individually in mesh-bottom stainless steel cages in a controlled environment (at 30 ± 5°C and 65 ± 5 relative humidity). All rats were fed on standard basal diet, prepared as described by Reeves *et al.* (1993), for 7 days (for acclimatization). Diet and deionized water were supplied *ad libitum* throughout the study. Afterward, all rats were housed in filter-top polycarbonate cages and randomly divided into nine groups (six rats for each group) as follows:
Group (1): Non diabetic rats fed on standard basal diet for 21 days (C+).
Group (2): Diabetic rats fed on standard basal diet for 21 days (C-).
Group (3): Diabetic rats fed on pan bread diet (100 % wheat flour) for 21 days.
Group (4): Diabetic rats fed on pan bread diet containing 6 % WBF for 21 days.
Group (5): Diabetic rats fed on pan bread diet containing 9 % WBF for 21 days.

Group (6): Diabetic rats fed on pan bread diet containing 6 % JAF for 21 days.
Group (7): Diabetic rats fed on pan bread diet containing 9 % JAF for 21 days.
Group (8): Diabetic rats fed on pan bread diet containing 6 % GAF for 21 days.
Group (9): Diabetic rats fed on pan bread diet containing 9 % GAF for 21 days.

Diabetes mellitus were induced by interperitoneal injection of alloxan solution at rate 0.1 ml /100 g body weight according to the method described by Desia and Bhide (1985). Alloxan solution consists of 0.12 gm alloxan hydrasin per 1 ml buffer solution. Alloxan buffer is prepared by addition of 7.5 ml of 5.7% glacial acetic acid to 92.5 ml of 8.2 % sodium acetate solution. Injected rats were fasted 18 hr before injection and 2 hr. after injection according to Malaisse (1982). Feed intake and body weight gain were recorded daily during the experimental period.

Biological investigation was carried out in the animal house Lab, Food science and Technology Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

Table 1: Proximate Chemical Composition of the raw materials (wheat flour, wheat bran flour, Jerusalem artichoke flour and Globe artichoke flour on dry weight (M± SE).

Chemical Composition (%)	Raw Materials (M± SE)			
	WF	WBF	JAF	GAF
	D/W	D/W	D/W	D/W
Moisture	1.98±0.32 [b]	1.83±0.28 [a]	6.11±0.21[c]	5.89±0.22 [c]
Crude protein	9.61±0.19 [a]	15.12±0.22 [d]	10.88±0.18 [b]	14.31±0.21 [c]
Fat	1.87±0.09[b]	3.24±0.11[d]	1.61±0.12 [a]	2.54±0.11 [c]
Ash	0.27±0.09 [a]	7.21±0.11[d]	6.19±0.10 [b]	6.89±0.11[c]
Crude Fiber	0.30±0.03 [a]	62.23±0.35 [d]	5.72±0.19 [b]	14.94±0.25 [c]
Inulin	-	-	72.68±0.57 [b]	35.16±0.41[a]
Other Carbohydrates	87.95±0.41[d]	12.20±0.20 [b]	2.92±0.22 [a]	26.16±0.19 [c]
Calories (kcal/100g)	407.07±0.33 [d]	138.44±0.41[a]	160.54±0.37 [b]	228.69±0.29 [c]

M± SE: Means± standard error for chemical composition; the means within the same row having different superscript are significantly varied (P ≤ 0.05).
*D.W**: dry weight*
Other total carbohydrates (%) D.W =100 - (% crude protein + % fat + % ash+% inulin+ %fiber).
Calories= 4× (carbohydrates+ protein) + 1.25× (inulin) + 9× (fat).

Table 2: Proximate Chemical Composition of the pan bread produced as affected by different replacement levels of JAF, GAF and WBF on dry weight (M± SE)

Chemical Composition (%)	Control	WBF		JAF		GAF	
		6%	9%	6%	9%	6%	9%
	D.W	D.W	D.W	D.W	D.W	D.W	D.W
Moisture	4.84±0.18 [a]	5.43±0.13 [b]	5.51±0.15 [b]	5.89±0.14 [c]	5.94±0.10 [c]	5.62±0.11[bc]	5.81±0.13 [c]
Crude protein	11.71±0.15 [a]	12.04±0.18 [a]	12.23±0.12 [a]	11.79±0.15 [a]	11.83±0.11[a]	11.99±0.15[a]	12.13±0.13 [a]
Fat	2.21±0.05 [ab]	2.29±0.11 [b]	2.33±0.10 [b]	2.18±0.12 [ab]	2.15±0.13 [a]	2.25±0.10 [ab]	2.27±0.11 [b]
Ash	1.20±0.11 [a]	1.62±0.10 [b]	1.83±0.11[c]	1.56±0.12 [b]	1.74±0.10 [c]	1.60±0.11 [b]	1.81±0.09 [c]
Crude Fiber	1.81±0.17[a]	5.52±0.15 [f]	7.38±0.13 [g]	2.14±0.12 [b]	2.30±0.11 [c]	2.69±0.10 [d]	3.13±0.12 [e]
Inulin	-	-	-	4.36±0.21 [c]	6.54±0.20 [d]	2.11±0.18 [a]	3.16±0.16 [b]
Other Carbohydrates	83.07±0.40 [b]	78.53±0.37 [ab]	76.23±0.33 [ab]	77.97±0.35 [ab]	75.44±0.30 [a]	79.36±0.41[b]	77.50±0.42 [ab]
Calories (kcal/100g)	399.01±0.29[b]	382.89±0.23 [ab]	374.81±0.33 [a]	384.11±0.31 [ab]	376.60±0.33 [a]	388.28±0.37[ab]	382.90±0.30 [ab]

M± SE: Means± standard error for chemical composition; the means within the same row having different superscript are significantly varied (P ≤ 0.05).

Body weight gains and feed intake

Body weight gains (BWG) and feed intake were calculated as reported by Chapman et al. (1959) as follows:

$$BWG\ (\%) = \frac{\text{final body weight - Initial body weight}}{\text{Initial body weight}} \times 100$$

Feed intake was calculated by the amount of food consumed daily by each rat determined by weighing the amounts of diet given, refused and spilled.

Blood sampling

At the end of experimental period and under ether anesthesia, blood samples were collected from the retro-orbital sinus plexus from all rats after being fasted for 12 hours. The samples were placed in dry and clean centrifuge tubes and allowed to clot for 1-2 h at 37°C. The samples were separated by centrifugation at 5000 rpm for 10 min. to separate the serum and determination of blood parameters.

Determination of blood glucose

Blood glucose level was measured immediately after centrifugation and separation of serum according to the method described by Trinder (1969).

Liver function tests

Serum alanine amino transferase (ALT), aspartate amino transferase (AST) and total protein were measured calorimetrically according to the methods described by Oser (1965).

Kidney function tests

Uric acid and urea in blood serum were determined by enzymatic colorimetric methods according to Haisman and Muller (1977). Creatinine was determined according to the method of Bartles *et al.* (1972).

Determination of serum lipid fractions:

Total cholesterol and triglycerides in blood serum were determined according to the methods described by Allain *et al.* (1974), Fossati and Prencipe (1982) and Zollner and Kirsch (1962); respectively. HDL and LDL cholesterol were determined by colorimetric method as described by Schmit (1964).

Minerals determination

Calcium and magnesium were determined in the blood serum according to the methods described by Baginski (1973). Iron and zinc were determined by colorimetric method as described by Trinder (1956). Phosphorus was determined according to the method described by Yee (1968).

Parathyroid hormone (PTH)

Serum parathyroid hormone was determined using enzyme-linked immunosorbent assay (ELISA) in all blood serum samples according to Chopra (1979).

Chemical analysis

Moisture, protein (N×5.7), ether extracts, ash, fiber and Total carbohydrates were determined in tested samples according to A.O.A.C., (2005). Total carbohydrates were calculated by difference. The energy values were calculated theoretically according to the method described by Paul and Southgate (1979) as follows:
Energy value = 4(gm Protein + gm carbohydrates) + 9 (gm Fat).
Caloric value of Inulin = 1.25 Kcal /g (Mullin *et al.,* 1994).

Statistical analysis

The data were statistically analyzed by using SPSS (version 16.0 software Inc., Chicago, USA) of completely randomized design as described by Gomez and Gomez (1984). Treatment means were compared using the least significant differences (LSD) at 0.05 levels of probability and standard error.

Results and Discussion

The Effect of low calories pan bread containing WBF, JAF and GAF on body weight of diabetic rats:

The effect of low calories pan bread containing WBF, JAF and GAF on body weight of diabetic rats is present in Table (3). The data shows wide variation in the average values of gain in body weight between tested rat groups. The rat groups fed on pan bread diets containing WBF, JAF and GAF exhibited extremely higher ($P < 0.05$) values in gain of weights as compared to rats fed on basal diet (C-) and pan bread (100% wheat flour). The maximum gain of weight was achieved in the rats fed on pan bread diet containing WBF at level 9 % (27.33 % at the end of experiment). This improvement in body weight gain of diabetic rats fed on low calories pan bread containing WBF, JAF and GAF diets were connected with lowering blood sugar level due to addition of WBF (as source of dietary fiber), JAF and GAF (as source of inulin) at levels 6 and 9 % in the diabetic rat diets. Generally, these results agree with those obtained by Zaky (2009) who studied the physiological response to diets fortified with jerusalem artichoke powder by diabetic rats, and found that the diets fortified with JAF at

different levels (5, 10 and 15 %) improved the body weight gain and feed efficiency ratio of alloxan-injected diabetic rats compared to positive control group.

Table 3: The Effect of low calories pan bread containing WBF, JAF and GAF on body weight (g) of the tested diabetic rats

Day / Group	Initial body weight (g)	Gain in body weight (g)			BWG (g/rat/21day)	BWG (%)
		after 7 day	after 14 day	after 21 day		
Control (+)	145.00±2.37^{a}	159.00±3.12^{a}	170.40±3.43^{a}	178.00±3.38^{a}	33.00±1.12^{a}	22.76
Control (-)	117.70±2.09^{e}	118.00±2.36^{e}	117.50±2.31^{e}	120.70±2.24^{e}	3.00±1.09^{e}	2.54
WF 100%	119.80±2.43^{d}	123.66±2.62^{d}	125.20±2.45^{b}	135.80±2.66^{d}	16.00±1.11^{d}	13.35
WBF 6%	130.20±2.77^{b}	135.00±2.39^{c}	142.60±2.26^{c}	151.50±2.45^{c}	21.30±1.13^{c}	16.35
WBF 9%	132.33±2.18^{b}	142.16±2.51^{b}	154.16±2.32^{b}	168.50±2.30^{b}	36.17±1.12^{a}	27.33
JAF 6%	123.20±2.81^{c}	127.40±2.30^{d}	138.20±2.16^{d}	151.40±2.48^{c}	28.20±1.07^{b}	22.88
JAF 9%	123.30±2.22^{c}	125.60±2.42^{d}	133.50±2.38^{d}	141.00±2.44^{d}	17.70±1.10^{c}	14.45
GAF 6%	131.60±2.67^{b}	140.20±2.37^{b}	150.80±2.49^{b}	156.60±2.27^{c}	25.00±1.15^{b}	18.99
GAF 9%	125.00±2.31^{c}	126.20±2.56^{d}	140.30±2.51^{c}	152.00±2.31^{c}	27.00±1.14^{b}	21.60

^{a,b,c} Means in the same column with different superscripts are different significantly (P < 0.05)
(C+): Non diabetic rats
(C -): diabetic rats

Effect of low calories pan bread containing WBF, JAF and GAF on feed intake of diabetic rats:

The effect of low calories pan breads containing WBF, JAF and GAF on feed intake of diabetic rats is present in Table (4). The data shows variation (P < 0.05) in the average values of food intake between tested rat groups. It was clear that the feed intake value at the end of experimental period for diabetic rats fed on basal diet (C-) was higher (P < 0.05) than those for diabetic rat groups fed on pan bread (100 % wheat flour) and low calories pan breads containing WBF , JAF and GAF at different levels.

It is worth mentioning that the increase of WBF, JAF and GAF level in pan bread resulted in an increase in the feed intake by diabetic's rats, except in diabetic rats fed on diet containing GAF, this may be due to the physiological status of experimental rats which affect the amount of needed feed intake. This result may be agreed with results obtained by Amro *et al.* (2010).

Table 4: Effect of low calories pan bread containing WBF, JAF and GAF on feed intake of the tested diabetic rats

Group	Feed intake (g / 6 rats)				
	after 7 day	after 14 day	after 21 day	Feed intake after experimental period (g / 6 rats / 21 day)	Daily feed intake (g/rat/day)
Control (+)	116.3 ±0.58^{a}	126.7±0.58^{a}	114±0.58^{a}	357.0±0.58^{a}	19.8±0.58^{a}
Control (-)	102.2 ±0.85^{b}	132.5±0.58^{a}	116.4±0.58^{a}	351.1±0.58^{a}	19.5±0.58^{a}
WF 100%	108.4±0.79 ^{b}	108.6±0.58^{b}	96.0±0.58^{b}	313.0±0.58^{b}	17.3±0.58^{b}
WBF 6%	90.1±0.51^{d}	99.6±0.58^{c}	94.8±0.58^{b}	284.5±0.58^{d}	15.8±0.58^{c}
WBF 9%	94.1±0.48^{c}	105.3±0.58^{b}	91.8±0.58^{d}	291.2±0.58^{c}	16.2±0.58^{c}
JAF 6%	95.5±0.62^{c}	114.4±0.58^{b}	78.0±0.58^{e}	287.9±0.58^{d}	15.9±0.58^{c}
JAF 9%	95.6±0.50^{c}	94.8±0.58^{d}	94.8±0.58^{b}	295.2±0.58^{c}	15.8±0.58^{c}
GAF 6%	90.3±0.47^{d}	91.8±0.58^{d}	93.0±0.58^{c}	275.1±0.58^{d}	15.2±0.58^{d}
GAF 9%	85.4±0.54^{e}	90.2±0.58^{e}	94.8±0.58^{b}	270.4±0.58^{e}	15.0±0.58^{e}

^{a,b,c} Means in the same column with different superscripts are different significantly (P < 0.05)
*Control **(+)**: Non diabetic rats*
Control (-): diabetic rats

Effect of low calories pan breads containing WBF, JAF and GAF on blood glucose level of diabetic rats:

The results present in Table (5) shows rat blood glucose levels initially and after feeding on different pan bread diets for 21 day. As shown in this Table, initial glucose levels of normal and diabetic rats fed on basal diet (C+ and C-) and pan bread containing 100 % wheat flour were 80.7, 335.6 and 318.7 mg/dl, respectively. After 21 day of feeding rats, these levels were obviously increased (P < 0.05) to 97.8, 369.5 and 362.7 mg/dl, respectively with glucose risinglevel of % of 21, 8 and 16 %, respectively.

Also, from the same table, it could be noticed that significant decreases (P < 0.05) were recorded in glucose levels between diabetic rats fed on pan breads containing WBF, JAF and GAF throughout of feeding periods up to 21 day. Since, these levels gradually decreased in tested diabetic rats with increasing of feeding periods up to 21 day with reduction rates reached 33.78 - 43.14 %. The highest reduction % in glucose levels was observed with diabetic rats fed on pan breads containing JAF at levels 6 and 9% (40.51 and 43.14%, respectively) as shown in Table (5).

On the other hand, glucose levels were obviously decreased (P < 0.05) in diabetic rats fed on pan breads containing JAF and GAF for 21 day (from 181.9 to 177.5 mg/dl and from 190.8 to 178.1 mg/dl, respectively)

with increasing levels of JAF and GAF in diets. The decrease of serum glucose level in diabetic rats may be due to the improvement of impaired glucose tolerance, decrease glycemia and partially restores insulin secretion (Majno and Joris, 1999). Alegria and Vivanco (2004) reported that the jerusalem artichoke help in maintain blood sugar level in the human at normal level. Their effect is due to optimum quantity of the polysaccharide inulin, potentially useful for diabetics. Generally, these results are in accordance with those found by Busserolles *et al.* (2003) and Cani *et al.* (2005), they found that during feeding rats on diets containing oligofructose (inulin) for 4 - 6 week's improved the impaired glucose metabolism and glucose/insulin ratio. Also, Zaky (2009) studied the physiological response to diets fortified with Jerusalem artichoke powder by diabetic rats, found that the diets fortified with JAF at different levels (5, 10 and 15 %) significant decreased serum glucose level for all groups when compared with alloxan-induced diabetic rats.

Table 5: Effect of low calories pan bread containing WBF, JAF and GAF on glucose level (mg/dl) in the tested diabetic rats:

Group	Glucose level (mg/dl)				
	Initial	After 7 day	After 14 day	After 21 day	Glucose rise (%)
Control (+)	80.7±2.32^{e}	87.6±1.12^{e}	88.8±1.41^{e}	97.8±1.52^{e}	+21.18
Control (-)	335.6±3.43^{a}	343.3±2.31^{a}	358.6±2.37^{a}	369.5±2.44^{a}	+8
WF 100%	318.7±3.11^{a}	326.4±2.44^{a}	350.9±2.45^{a}	362.7±2.30^{a}	+16
WBF 6%	272.9±2.51^{d}	229.6±2.03^{cd}	188.5±2.12^{c}	180.7±1.99^{c}	- 33.78
WBF 9%	316.1±3.08^{a}	293.6±1.99^{b}	212.3±1.90^{b}	200.1±1.87^{b}	-36.70
JAF 6%	305.8±2.89^{b}	225.7±1.81^{c}	194.5±1.79^{c}	181.9±1.97^{c}	-40.51
JAF 9%	312.2±2.37^{a}	200.5±1.67^{d}	187.4±1.84^{c}	177.5±1.92^{d}	-43.14
GAF 6%	298.7±3.24^{c}	240.5±2.05^{c}	203.6±2.39^{b}	190.8±2.09^{b}	-36.12
GAF 9%	276.5±2.73^{d}	252.3±2.11^{b}	181.7±2.52^{d}	178.1±1.88^{d}	-35.58

^{a,b,c} Means in the same column with different superscripts are different significantly (P < 0.05)
Normal glucose level: 70 -120 (mg/dl) according to Maiti et al. (2004)
Control (+): Non diabetic rats
Control (-): diabetic rats

On contrast, glucose levels of diabetic rats fed on pan breads containing 6% WBF for 21 day was 80.7 mg/dl and increased (P < 0.05) to 200.1 mg/dl with increasing level of WBF in diet. This result is supported by Brinch-Pedersen *et al.* (2002), they indicated that bran of cereal grains showed effect on postprandial glucose levels, serum cholesterol, colon cancer and body mass.

The above results revealed that hyperglycemia can be considered as direct reflex to the marked hypoinsulinemia caused by selective cationic effects of alloxan on the β-cells of pancreas because it has direct effect on membrane permeability by causing failure of ionic pumps and increase cell size. It also inhibits intracellular energy generation and insulin secretion hence the nuclear size of β cells showed significant increase (Majno and Joris, 1999).

Effect of low calories pan breads containing WBF, JAF and GAF on liver functions and total protein of diabetic rats

The activities of ALT and AST are sensitive indicators of acute hepatic necrosis and indicative of hepatobiliary disease (Rigalleau *et al.,* 2008). The activity of serum alanine amino transaminase (ALT), aspartate amino transaminase (AST) and serum total protein (TP) in diabetic rats fed on low calories pan breads containing WBF, JAF and GAF is shown in Table (6). It could be noticed that significant differences (P < 0.05) were observed in serum AST and ALT activities between rats fed on basal diet (C+) and both diabetic rats fed on basal diet (C-) and diabetic rat groups fed on pan bread diets. Whereas diabetic rats fed on basal diet (C-) recorded the highest (P < 0.05) activities of AST and ALT (61 and 59 mg/dl, respectively) followed by diabetic rats fed on pan bread containing 100 % wheat flour (60 and 57 mg/dl, respectively) among the other rat groups.

On the other hand, the diabetic rats fed on pan breads containing 6 and 9 % JAF recorded the lowest (P < 0.05) activities of AST and ALT (45 and 41 mg/dl) and (42 and 40 mg/dl), respectively as compared with diabetic rat groups fed on other diets. Concerning serum total protein, Table (5) indicated that the normal rats fed on basal diet (C+) recorded the highest (P < 0.05) value of serum total protein (6.7 mg/dl) as compared with the other diabetic rat groups (4.1 - 5.9 mg/dl). On the other hand, diabetic rats fed on low calories pan breads showed higher (P < 0.05) values for total protein (5.1 to 5.9 mg/dl) than those value of diabetic rats fed on pan bread containing 100 % wheat flour (4.2 mg/dl). Adzet *et al.* (1987) reported that the artichoke has been used in the folk medicine against several diseases, such as hepatic diseases, dyspepsia, postoperative anemia and as diuretic and liver tonic. It has ability to lower cholesterol, protect and support liver functions (Ceccarelli *et al.,* 2010).

Notably, the activity of ALT and AST are sensitive indicators of acute hepatic necrosis and indicative of hepatobiliary disease (Abdel-Wahhab *et al.,* 2007). Moreover, the increased in level of TP may be indicating protein catabolism (Abdel-Wahhab and Aly, 2003). Generally these results may indicate degenerative changes

and hypofunction of liver and supported the hypothesis that diabetes impairs liver (Saely *et al.,* 2008; Rigalleau *et al.,* 2008).

Table 6: Effect of low calories pan bread containing WBF, JAF and GAF on ALT, AST and total protein (mg/dl) in the tested diabetic rats

Group	Liver function parameters (mg/dl)		Total protein (mg/dl)
	AST	ALT	
Control (+)	30±1.32^{e}	32±1.32^{e}	6.7±0.14^{a}
Control (-)	61±1.32^{a}	59±1.32^{a}	4.1±0.14^{e}
WF 100%	60±1.32^{a}	57±1.32^{a}	4.2±0.14^{e}
WBF 6%	51±1.32^{b}	45±1.32^{b}	5.1±0.14^{d}
WBF 9%	49±1.32^{c}	43±1.32^{b}	5.3±0.14^{c}
JAF 6%	45±1.32^{c}	42±1.32^{c}	5.2±0.14^{c}
JAF 9%	41±1.32^{d}	40±1.32^{d}	5.6±0.14^{b}
GAF 6%	50±1.32^{b}	44±1.32^{b}	5.5±0.14^{c}
GAF 9%	48±1.32^{c}	41±1.32^{d}	5.9±0.14^{b}
Normal level	Up to 37	Up to 41	6 – 8

^{a,b,c} *Means in the same column with different superscripts are different significantly (P < 0.05)*
Control ***(+):*** *Non diabetic rats*
Control (-): diabetic rats

Effect of low calories pan breads containing WBF, JAF and GAF on kidney functions of diabetic rats

Urea, uric acid and createnine levels of diabetic rat groups fed on tested low calories pan breads were determined and compared with rat groups fed on basal diet (C+ and C-) and pan bread containing 100 % wheat flour as shown in Table (7). Data show that there were significant differences (P < 0.05) in urea, uric acid and createnine levels between rats fed on basal diet (C+) and both diabetic rats fed on basal diet (C-) and diabetic rat groups fed on tested pan bread diets. Also, the same Table shows that there were no significant differences among diabetic rats fed on basal diet (C-) and diabetic rats fed on pan breads containing 100 % wheat flour. The rise of urea, createnine and uric acid levels may indicate to protein catabolism and/or kidney dysfunction (Rigalleau *et al.,* 2008). These results may indicate to degenerative changes and hypofunction of kidneys; and supported the hypothesis that diabetes impairs kidney function (Saely *et al.,* 2008).

Table 7: Effect of low calories pan bread containing WBF, JAF and GAF on urea, uric acid and createnine levels (mg/dl) in the tested diabetic rats

Group	Kidney function parameters (mg/dl)		
	Urea	Uric acid	Createnine
Control (+)	31±1.32^{e}	2.7±0.14^{e}	0.34±0.02^{e}
Control (-)	67±1.13^{a}	5.6±0.12^{a}	0.70±0.08^{a}
WF 100%	65±1.24^{a}	5.4±0.17^{a}	0.68±0.07^{a}
WBF 6%	48±1.20^{c}	4.3±0.18^{c}	0.48±0.09^{b}
WBF 9%	45±1.02^{d}	4.1±0.12^{c}	0.44±0.08^{c}
JAF 6%	46±1.11^{c}	4.0±0.13^{c}	0.45±0.07^{c}
JAF 9%	43±1.09^{d}	3.9±0.17^{d}	0.43±0.09^{d}
GAF 6%	50±1.12^{b}	4.5±0.19^{b}	0.49±0.06^{b}
GAF 9%	48±1.20^{c}	4.4±0.12^{b}	0.47±0.08^{c}
Normal value	15 – 45	2.5 - 4.5	0.3 - 1.2

^{a,b,c} *Means in the same column with different superscripts are different significantly (P < 0.05)*
** Normal values range according to Nicoll et al. (2004)*
Control ***(+):*** *Non diabetic rats*
Control (-): diabetic rats

On the other hand, the diabetic rats fed on pan bread containing 9 % JAF recorded the lowest (P < 0.05) values of urea, uric acid and createnine (43, 3.9 and 0.43 mg/dl, respectively) as compared with diabetic rat groups fed on other diets. It is worth mentioning that the urea, uric acid and createnine levels were obviously decreased (P < 0.05) in diabetic rat groups fed on low calories pan breads with increasing levels of WBF, JAF and GAF in diets. The decreased level of urea, createnine and uric acid may indicate protein catabolism and/or kidney dysfunction (Abdel-Wahhab and Aly, 2003); these results may indicate degenerative changes and hypofunction of kidneys (Abdel-Wahhab *et al.,* 2007) and supported the hypothesis that diabetes impairs kidney function (Saely *et al.,* 2008; Rigalleau *et al.,* 2008). These results are in agreement with Moriyama *et al*. (2005) and Saito *et al*. (2005). Generally, these results are in agreement with the results of Zaky (2009), who studied the physiological response to diets fortified with jerusalem artichoke powder by diabetic rats and found that significant decreased in urea, uric acid and createnine of all tested groups fed on the diets fortified with JAF at different levels (5, 10 and 15 %) as compared with control diabetic rats.

Effect of low calories pan breads containing WBF, JAF and GAF on lipid profile parameters of diabetic rats

Plasma total lipid is an important parameter to determine the cardiac and liver state. The increases in the plasma total lipids reflect the disorders in the functional state (Abdullah, 2004). The effect of feeding the diabetic rats on basal diet and low calories pan breads containing WBF, JAF and GAF on contents of total cholesterol, triglyceride, high density lipoprotein cholesterol (HDL), low density lipoprotein cholesterol (LDL) and very low density lipoprotein cholesterol (V-LDL) are shown in Table (8).

It could be noticed that significant differences ($P < 0.05$) were observed in the total cholesterol and triglyceride contents between rats fed on basal diet (C+) and diabetic rat groups fed on pan bread diets. Also, the results show that there were no significant differences between the coresponding parameters of diabetic rats fed on basal diet (C-) and diabetic rats fed on pan bread containing 100 % wheat flour.

On the other hand, the diabetic rats fed on pan bread containing 9 % JAF recorded the lowest ($P < 0.05$) contents of total cholesterol and triglyceride (126 and 55 mg/dl, respectively) as compared with diabetic rat groups fed on other diets, this may be due to the improvement of the physiological status for experimental rats as a result of feeding on diet containing jerusalem artichoke powder.

Interestingly that, the total cholesterol and triglyceride contents were remarked decreased ($P < 0.05$) in diabetic rat groups fed on low calories pan breads with increasing the levels of WBF, JAF and GAF in diets as shown in Table (8).

Table 8: Effect of low calories pan bread containing WBF, JAF and GAF on lipid profile parameters (mg/dl) in the tested diabetic rats

Group	Lipid profile parameters (mg/dl)				
	Total cholesterol	Triglyceride	HDL	LDL	*V-LDL
Control (+)	116±2.09^{e}	50±±1.82^{d}	24±0.96^{c}	42±1.71^{e}	10.0±0.43^{e}
Control (-)	199±3.11^{a}	108±2.14^{a}	17±0.79^{e}	70±1.88^{a}	21.6±0.39^{a}
WF 100%	192±3.42^{a}	103±2.09^{a}	19±0.72^{e}	67±2.02^{a}	20.6±0.32^{a}
WBF 6%	140±1.89^{b}	63±1.77^{b}	24±0.67^{c}	53±1.18^{b}	12.6±0.41^{b}
WBF 9%	131±2.07^{c}	59±2.13^{c}	25±0.63^{b}	47±1.22^{c}	11.8±0.31^{c}
JAF 6%	132±1.92^{c}	60±1.87^{b}	26±0.82^{b}	48±1.65^{c}	12.0±0.22^{b}
JAF 9%	126±1.77^{d}	55±1.62^{c}	30±0.77^{a}	45±1.62^{d}	11.0±0.27^{d}
GAF 6%	140±1.69^{b}	64±2.01^{b}	22±0.90^{d}	54±1.48^{b}	12.8±0.33^{b}
GAF 9%	132±1.82^{c}	59±2.11^{c}	25±0.82^{b}	49±1.32^{c}	11.8±0.43^{c}
Normal value	Up to 140	Up to 100	Up to 40	Up to 60	Up to 20

^{a,b,c} Means in the same column with different superscripts are different significantly ($P < 0.05$)
**V-LDL = TG ÷ 5 according to Friedewald et al. (1972).*
*Control **(+)**: Non diabetic rats*
Control (-): diabetic rats

Also, Table (8) indicate that the HDL content in normal rats fed on basal diet (C+) was higher (24 mg/dl) ($P < 0.05$) than that HDL content in diabetic rats fed on basal diet (C-) and diabetic rats fed on pan bread containing 100 % wheat flour (17 and 19 mg/dl, respectively). On contrast, LDL and V-LDL contents in normal rats fed on basal diet (C+) were lower ($P < 0.05$) than those found in diabetic rats fed on basal diet (C-) and diabetic rats fed on pan bread containing 100 % wheat flour.

On the other hand, diabetic rats fed on low calories pan breads showed higher ($P < 0.05$) contents for HDL (22 to 30 mg/dl) than that found of diabetic rats fed on pan bread containing 100 % wheat flour (19 mg/dl). On contrast, diabetic rats fed on low calories pan breads showed lower ($P < 0.05$) contents of LDL (45 - 54 mg/dl) and V-LDL (11.0 – 12.8 mg/dl) than content of diabetic rats fed on pan bread containing 100 % wheat flour (67 and 20.6 mg/dl, respectively). These alterations may stimulate the oxidation of lipids, which in turn stimulate auto oxidation reactions of sugars, enhancing damage to both lipids in the circulation and the vascular wall, continuing and reinforcing the cycle of oxidative stress and damage (Baynes, 1991).

It is worth mentioning that HDL content was remarked increased ($P < 0.05$) in diabetic rat groups fed on low calories pan breads with increasing the levels of WBF, JAF and GAF in diets. While, LDL and V-LDL contents were remarked decreased ($P < 0.05$) in diabetic rat groups fed on low calories pan breads with increasing the levels of WBF, JAF and GAF in diets as shown in Table (8). These findings are in agreement with those of Levrat *et al.* (1991), who found that the dietary inulin played active role in reducing serum cholesterol level in rats fed on diet contained inulin for 3 week. A significant decrease in plasma total lipids level this may be ascribed to insulin action on lipoprotein lipase inhibition in diabetic rats (Khalil, 2005). In this concern , Pushparraj *et al*. (2007) reported that administration of inulin caused a significant reduction in serum glucose, triglyceride and total cholesterol in diabetic rats.

Also, Zaky (2009) studied the physiological response to diets fortified with jerusalem artichoke powder by diabetic rats, and found that the diets fortified with JAF at different levels (5, 10 and 15 %) reduced the triglycerides, total cholesterol and LDL cholesterol in the hyperglycemic rats.

Finally, the values of total cholesterol, triglyceride, HDL, LDL and V-LDL for all diabetic rat groups fed on low calories pan breads were within permissible levels as reported by Donahoo *et al.* (2000) and Uckun *et al.* (2003). While, these values in diabetic rats fed on basal diet (C-) and diabetic rats fed on pan bread containing 100 % wheat flour were exceeded the permissible levels (except HDL values) as shown in Table (8).

Effect of low calories pan breads containing WBF, JAF and GAF on serum electrolytes and parathyroid hormone of diabetic rats:

The levels of Ca, Mg, P, Fe, Zn and parathyroid hormone (PTH) in serum rats fed on basal diet and low calories pan breads containing WBF, JAF and GAF are shown in Table (9). It could be noticed that significant differences ($P < 0.05$) were observed in those contents between rats fed on basal diet (C+) and diabetic rat groups fed on pan bread diets. Also, the results show that there were no significant differences between these contents of diabetic rats fed on basal diet (C-), and diabetic rats fed on pan bread containing 100 % wheat flour and diabetic rats fed on pan bread containing WBF 6 %.

Table 9: Effect of low calories pan bread containing WBF, JAF and GAF on serum electrolytes and parathyroid hormone (PTH) in the tested diabetic rats

Group	serum electrolytes					PTH (µg/ dl)
	Ca (mg/dl)	Mg (mg/dl)	P (mg/dl)	Fe (µg/ dl)	Zn (µg/ dl)	
Control (+)	8.9±0.19^{c}	4.1±0.17^{c}	5.2±0.11^{c}	4.2±0.10^{c}	5.1±0.19^{b}	11.1±0.10^{c}
Control (-)	6.3±0.17^{d}	3.8±0.15^{d}	4.0±0.12^{d}	3.4±0.11^{d}	4.1±0.22^{c}	9.8±0.09^{c}
WF 100%	6.5±0.15^{d}	4.0±0.17^{d}	4.1±0.14^{d}	3.7±0.12^{d}	4.2±0.21^{c}	10.0±0.11^{c}
WBF 6%	6.4±0.11^{d}	3.7±0.12^{d}	3.6±0.12^{d}	3.4±0.16^{d}	3.9±0.17^{c}	9.4±0.12^{c}
WBF 9%	6.0±0.12^{e}	3.1±0.15^{e}	3.1±0.11^{e}	3.0±0.10^{e}	3.3±0.19^{d}	8.9±0.17^{d}
JAF 6%	9.7±0.13^{a}	5.4±0.13^{a}	6.9±0.10^{a}	5.7±0.12^{a}	5.5±0.22^{a}	19.7±0.19^{a}
JAF 9%	10.3±0.14^{a}	5.9±0.18^{a}	7.1±0.12^{a}	6.0±0.19^{a}	6.0±0.17^{a}	21.8±0.22^{a}
GAF 6%	9.1±0.15^{b}	5.0±0.16^{b}	6.2±0.13^{b}	5.0±0.15^{c}	5.0±0.15^{b}	17.3±0.18^{b}
GAF 9%	9.4±0.12^{b}	5.2±0.13^{b}	6.7±0.12^{b}	5.6±0.12^{b}	5.3±0.19^{b}	18.9±0.17^{b}
Normal value	8.4 - 10.5	3.5 - 7.5	3.5 - 7.5	3.2 - 6.1	3.2 - 6.1	11 – 59

^{a,b,c} Means in the same column with different superscripts are different significantly ($P < 0.05$)
*Control **(+)**: Non diabetic rats*
Control (-): diabetic rats

On the other hand, the diabetic rats fed on pan bread containing 9 % JAF recorded the highest ($P < 0.05$) contents of Ca (10.3 mg/dl), Mg (5.9 mg/dl), P (7.1 mg/dl), Fe (6.0 µg/ dl), Zn (6.0 µg/ dl) and PTH (21.8 µg/ dl) followed by the diabetic rats fed on pan bread containing 6 % JAF (9.7 mg/dl, 5.4 mg/dl, 6.9 mg/dl, 5.7 µg/ dl, 5.5 µg/ dl and 19.7 µg/ dl; respectively) as compared with diabetic rat groups fed on other diets, this may be due to the improvement of the physiological status for experimental rats as a result of feeding on diet containing jerusalem artichoke powder. Some studies have suggested that chicory inulin as a soluble fiber may increase the body absorption of calcium, improve bone mineral density, and reduce the risk of osteoporosis development (Kaur and Gupta, 2002 and Balcazar-Munoz *et al.,* 2003).

Generally,These results are similar to results of Delzenne *et al.* (1999), they demonstrated that the rats fed with inulin absorbed more calcium and magnesium compared to the control rats. Also, Sun *et al.* (2012), they found that Ca, Mg, P, Fe and Zn elements plays an important role in synthesis, storage and release of insulin, these elements affects the functioning of the beta cells in the islets of Langerhans in pancreas.

Interestingly that these elements content and parathyroid hormone were remarked increased ($P < 0.05$) in diabetic rat groups fed on low calories pan breads with increasing levels of JAF and GAF in diets. On contrast, the same contents were remarked decreased ($P < 0.05$) in diabetic rat groups fed on pan bread containing WBF with increasing the addition level in diet as shown in Table (9). This due to the increase of wheat bran level in diet, Where, the presence of phytate has been considered as anti-nutrient in humans because of its effect on the bioavailability of iron, magnesium, zinc and calcium (Brinch-Pedersen *et al.,* 2002).

Kidney weights of diabetic rats fed on tested low calories pan breads are recorded and compared with normal and diabetic rats fed on basal diet (C+ and C-) and pan bread containing 100 % wheat flour as shown in Table (10). Data show that there were no significant differences between kidney weights of diabetic rats fed on basal diet (C-) and diabetic rats fed on low calories pan breads containing 9 % WBF and 6 % JAF, but kidney weight of rats fed on basal diet (C+) was clearly increased ($P < 0.05$) as compared with diabetic rat groups fed on other diets.

It is worth mentioning that, the diabetic rats fed on pan breads containing 6 and 9 % GAF recorded the highest values ($P < 0.05$) in their kidney weights (1.55 and 1.48 g/rat; respectively) as compared with diabetic rat groups fed on other pan bread diets (1.19 - 1.38 g/rat), this may be due to the improvement of the physiological status for experimental rats as a result of feeding on diet containing globe artichoke powder.

The effect of low calories pan breads containing WBF, JAF and GAF on hearts weight of diabetic rats is present in Table (10). Data show that there were no significant difference between heart weight values of normal rats fed on basal diet (C+) and diabetic rats fed on pan bread (100 % wheat flour), while heart weight value of diabetic rats fed on basal diet (C-) was significant different ($P < 0.05$) with diabetic rat groups fed on other diets, except diabetic rats fed on pan bread containing 6 % JAF.

Effect of low calories pan bread containing WBF, JAF and GAF on organ weights of diabetic rats:

The effect of low calories pan bread containing WBF, JAF and GAF on organs weight in diabetic rats is present in Table (10). The results show clear differences ($P < 0.05$) in the organ weight values between all tested rat groups.

The presented results cleared that the diabetic rats fed on low calories pan bread containing 6 % WBF and JAF at levels 6 and 9 % showed a significant decrease ($P < 0.05$) in their livers weight (5.14, 5.12 and 4.42 g/rat, respectively) as compared with normal and diabetic rats fed on standard basal diet (C+ and C-), which recorded values 5.56 and 5.36 g/rat; respectively.

On the other hand, the diabetic rats fed on low calories pan bread containing 9 % WBF and 9 % GAF showed the highest increase ($P < 0.05$) in their livers weight (5.61 and 5.92 g/rat, respectively) as compared with diabetic rats fed on other diets. Also, the same Table shows that there were no significant differences among diabetic rats fed on pan breads containing 100 % wheat flour and 6% GAF in their livers weight.

Table 10: Effect of low calories pan bread containing WBF, JAF and GAF on organ weights (g/rat) in the tested diabetic rats

Group	Organ weights (g/rat)			
	Liver	Kidney	Heart	Spleen
Control (+)	5.56±0.05^{a}	2.18±0.12^{a}	0.70 ±0.03^{b}	0.45±0.05^{a}
Control (-)	5.36±0.05^{c}	1.27±0.10^{d}	0.66 ±0.04^{c}	0.31±0.03^{c}
WF 100%	5.49±0.05^{b}	1.38±0.09^{c}	0.71 ±0.03^{b}	0.33±0.06^{c}
WBF 6%	5.14±0.05^{d}	1.34±0.11^{c}	0.78 ±0.04^{a}	0.34±0.05^{c}
WBF 9%	5.61±0.05^{a}	1.28±0.09^{d}	0.58 ±0.02^{d}	0.41±0.04^{b}
JAF 6%	5.12±0.05^{d}	1.23±0.11^{d}	0.65 ±0.05^{c}	0.26±0.03^{d}
JAF 9%	4.42±0.05^{e}	1.19±0.09^{e}	0.57 ±0.04^{e}	0.23±0.05^{e}
GAF 6%	5.47±0.05^{b}	1.55±0.13^{b}	0.77 ±0.03^{a}	0.43±0.04^{b}
GAF 9%	5.92±0.05^{a}	1.48±0.12^{b}	0.76 ±0.05^{a}	0.37±0.06^{c}

^{a,b,c} Means in the same column with different superscripts are different significantly ($P < 0.05$)
*Control **(+)**: Non diabetic rats*
Control (-): diabetic rats

Also, it is worth mentioning that the increasing of WBF, JAF and GAF levels (from 6 to 9 %) in produced pan breads resulted in decrease in the heart weights by diabetic's rats (from 0.78 to 0.57 g/rat).

Spleen weights of diabetic rats fed on the tested low calories pan breads are recorded and compared with normal and diabetic rats fed on basal diet (C+ and C-) and pan bread containing 100 % wheat flour as shown in Table (10). Data show that there were no significant differences between spleen weight values of both diabetic rats fed on basal diet (C-) and diabetic rats fed on pan bread (100 % wheat flour), and also between pan breads containing 6 % WBF and 9 % GAF from the other side, but spleen weight of rats fed on basal diet (C+) and diet with 9 % WBF and 6 % GAF was markedly increased ($P < 0.05$) as compared with diabetic rat groups fed on other diets.

It is worth mentioning that the increasing of WBF level (from 6 to 9 %) in produced pan breads resulted an increase in the spleen weights of diabetic's rats from 0.34 to 0.41 g/rat. On contrast, spleen weights of diabetic rats fed on low calories pan bread containing JAF and GAF were reduced from 0.26 to 0.23 and from 0.43 to 0.37 g/rat; respectively, with rise of the addition level. However, Yokozawa *et al.* (2002) reported that inulin at a high level restores the decrease in body and organ weights in diabetic rats. Also, Zaky (2009) studied the physiological response to diets fortified with Jerusalem artichoke powder by diabetic rats, found that the diets fortified with JAF at different levels (5, 10 and 15 %) improved the weights of liver, kidney, heart and spleen and which were found as similar to those of the control (+) rats group.

Conclusion

It could be concluded that the diabetic rats fed on low calories pan bread containing JAF, GAF and WBF at levels 6 and 9 % led to an improvement of the body weight, liver and kidney functions, total protein and HDL of rats. The level of improvement was higher and more visible in diabetic rats fed on diets containing 6 and 9 % JAF, especially, the level of sugar in blood serum, total cholesterol, triglyceride, LDL and V-LDL. Also, the diabetic rats fed on low calories pan bread containing JAF and GAF levels 6 and 9 % showed significant increase in serum electrolytes and PTH hormone, while, the diabetic rats fed on pan bread containing 6 and 9 % WBF showed significant decrease in serum electrolytes and PTH hormone. A result of feeding diabetic rats on diet rich in dietary fiber and inulin content, which permit and encourage the use of WBF as source of dietary fiber, JAP and GAP as inulin source in preparing the functional foods for human suffering from diabetic and hypercholestermia.

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