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Antidiabetic effects of dietary formulas prepared from some grains and vegetables on type 2 diabetic rats

Hesham Z. Tawfeuk[1*], Nagwa. M. Hassan[2], Hany I. Khalil[2], Shawky Y. Kerolles[1]

[1]*Medicinal Food, National Organization for Drug Control and Research (NODCAR), Giza, Egypt.*
[2]*Food Sci. Dept.; Fac. Agriculture; Ain-Shams University; Shoubra El-Kheima, Cairo, Egypt.*

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Abstract

This study was carried out to prepared dietary formulas prepared from grains and vegetables for type 2 diabetic patients to optimize health and to prevent and treat the chronic complications of diabetes by attaining and maintaining optimal metabolic outcomes. For this purpose three formulas were prepared as a part of diet for diabetes mellitus by mixing equal weight of different ground dried raw materials as follows: (F_1: rice, corn and barley), (F_2: potato, carrot and green bean) and (F_3: barely, corn, rice, potato, lentil, carrot and green bean). The influence of these formulas on the levels of serum glucose, triglycerides and cholesterol was investigated using alloxan-induced diabetic rats. Forty eight male albino rats were divided into six groups and were fed on experimental diets for 4 weeks, G_1 (control -) normal rats fed on standard diet (SD), G_2 (control +) diabetic rats fed on SD and G_3 diabetic rats fed on diabetic specific diet (DSD), G_4 (DDF_1), G_5 (DDF_2) and G_6 (DDF_3) groups are diabetic rats fed on diabetic dietary formulas 1, 2 and 3 respectively.

Feeding the diabetic rats on diabetic specific diet (G_3) and diabetic dietary formula$_3$ (G_6) significantly reduced serum glucose level (122.37 and 131.25 mg/dl) than those of the G_2, G_4 and G_5 groups (301.88, 200.25 and 188.13 mg/dl) respectively.

In addition, diabetic dietary formulas significantly lowered serum total cholesterol and triglycerides levels when compared with control (+) group. Thus, it can be concluded that formula 3 was more effective for lowering blood glucose in diabetic rats than other tested formulas and can be used to improve glycaemic control in type 2 diabetic patients.

Keywords: Diabetes mellitus; Diabetic specific diet; Diabetic formula; alloxan; Glycaemic control.

1. Introduction

Diabetes mellitus is a chronic metabolic disorder characterized by too much glucose in the blood and urine due to defective insulin action or deficiency in its secretion. Insulin, a hormone produced by the beta cells of the Islets of langerhans of the pancreas helps to utilize glucose for the production of energy by the body. Insulin helps in glucose uptake by the cells, prevents rise in blood sugar and maintains its level within normal limits.[34,17].

Diabetes can be caused by several things, such as genetic factors, and also due to lifestyle of the people who have changed. The change are an sleep deprivation, less exercise habits, stress, and diet shift in society from a traditional diet that contains lots of carbohydrates and fiber from vegetables to the diet of western culture such as fast food meals that contain too much protein, fat, sugar salt and a little fiber [5]. Diabetes can be classified into 2 types, namely diabetes type 1 and diabetes type 2. When the body does not produce insulin, it called diabetes type 1.

Corresponding author: *e-mail:*heshamzakaria2013@gmail.com

When the body produces insulin but can not use insulin well, it called diabetes type 2 [11]. The prevalence of diabetes for all age-groups worldwide was estimated to be 2.8% in 2000 and 4.4% in 2030 as reported by Wild *et al*. (2004) [35]. This type of insulin-independent diabetes is much more widespread and accounts for almost 90–95% of the DM cases [23,25].

Complications of diabetes mellitus develop as a result of uncontrolled blood glucose levels. Complications of diabetes mellitus can be classified into acute and chronic. Acute complications arise as an immediate response to blood glucose levels (low or high). On the other hand chronic complications are a result of prolonged hyperglycemia (increased blood glucose level) for prolonged period of time. Acute complications of diabetes mellitus develop either immediately (hypoglycemia) or over a period of few days, and are treated as medical emergencies. Below given is the lest of acute and chronic complication of diabetes mellitus.[17]

The nutritional recommendations for individuals with DM of the American Diabetes Association for instance indicate that in the 1990's, the recommended contribution to total energy (TE) of carbohydrate was 50–60%, fat had to be < 30% and no recommendations were made for glycaemic index (GI) [6].

Al-Tibi *et al*. (2010) [3]conducted to investigate the effect of lentils on serum glucose and serum lipid levels in diabetic rats. Forty adult male rats were randomly divided into five groups: a casein diet (control), raw whole lentil (RWL), cooked whole lentil (CWL), raw dehulled lentil (RDL) and cooked dehulled lentil (CDL). Animals were fed with experimental diets for six weeks, sacrificed and blood samples were taken. Serum glucose level of the CDL group (387.9 ± 53.3 mg/dl) was significantly lower ($P<0.05$) than that of the control, RDL and RWL groups (529.0 ± 11.7, 538.6 ± 45.0, 542.1 ± 32.2 mg/dl respectively).

It is concluded that cooked lentils rather than raw lentils was more effective in lowering blood glucose and improving HDL cholesterol in diabetic rats. There was no difference between whole and dehulled lentils with regard to their effects on blood glucose and HDL cholesterol levels.

Cekic *et al*. (2011) [9] investigated influence of the preparation based on barley and brewer's yeast extracts with chromium (BBCr) and stevioside (S) on fasting glycaemia and glycaemia in mice after glucose, adrenalin and alloxan application. The animals were divided into three groups: glucose 500 mg/kg-1 (I); adrenalin 0.2 mg/kg-1 (II) and alloxan 100 mg/kg-1 (III). And they concluded that, BBCr caused a significant decrease of fasting glycaemia, significant reduction of glycaemia after glucose load and prevented onset of alloxan-induced diabetes. Stevioside caused the decrease of adrenalin-induced hyperglycaemia.

Therefore, the aim of this work was to prepared dietary formulas from grains and fresh vegetables for type 2 diabetes mellitus patients to improve glycaemic control in diabetic patients.

2. Method and methods

2.1.Materials

*Raw materials:*Seven different sources of grains and fresh vegetables including; corn (*Zea maize*), hull-less barley (*Hordeum vulgare*), rice (*Oryza sayival*),lentil (*Lens esculenta*), potato (*Solanum tubereasum*), carrot (*Daucus carota*) and green bean (*Phaseolus vulgaris*) were obtained from local marked in Cairo, Egypt, season 2010-2011.

Raw materials used in this study were selected to develop dietary formulas for type 2 diabetic patients as they characterized by high level of slowly digestible carbohydrates and dietary fiber.

Chemicals: Alloxan monohydrate (used for diabetes induction in rats) and kits for biochemical analysis (used for biological evaluation) were obtained from Sigma Chemicals Co. (USA). The other chemicals used in this work were of analytical grade.

Animals: Healthy male albino rats weighting 180-220 g were obtained from the farm of the National Organization for Drug Control and Research, Giza, Egypt.

2.2.Methods

Preparation of the raw materials. Different selected grains were sorted to be impurities free, washed & soaked in tap water and blanched by steam until cooking. The fresh vegetables were washed with tap water, pealed with stainless steal peeler, sliced into

fine parts and blanched by steam until cooking. Different cooked raw materials were dried at 60 ºC in hot air oven (LTE SCIENTIFIC LTD. Greenfield Oldham OL37EN), grounded into 60-mesh to obtain fine powder (British Standard Screen) using a house hold flour mill (Braun, Germany) and kept in glass jars at 5 ºC until use.

Proximate chemical composition. Moisture, total protein, crude fat, ash and crude fiber contents were determined for all tested materials according to the standard procedures described in the AOAC (2005) [7]. Total carbohydrates were calculated by difference.

*Preparation of diabetes formulas.*Three formulas were prepared as a part of diet for diabetes mellitus by mixing equal weight of different dried raw materials as follows:

Formula$_1$ (F_1): Rice, corn and barley.
Formula$_2$ (F_2): Potato, carrot and green bean.
Formula$_3$ (F_3): Barely, corn, rice, potato, lentil, carrot and green bean.

Biological experiment.Forty eight male albino rats were randomly divided into six groups each of eight rats and they were fed on the following experimental diets for 30 days:

Group $_1$ (G_1): (control negative) normal rats fed on standard diet (SD).
Group $_2$ (G_2): (control positive) diabetic rats fed on standard diet (SD).
Group $_3$ (G_3): diabetic rats fed on diabetic specific diet (DSD).
Group $_4$ (G_4): diabetic rats fed on diabetic dietary formula No.1 (DDF_1).
Group $_5$ (G_5): diabetic rats fed on diabetic dietary formula No. 2 (DDF_2).
Group $_6$ (G_6): diabetic rats fed on diabetic dietary formula No. 3 (DDF_3).

Rats in group 1 and 2 were fed on standard diet (g/100g) consisting of 15 g casein, 65 g starch, 10 g corn oil, 4 g salt mixture, 1 g vitamin mixture, and 5 g cellulose [7]. Rats in group No. 3 fed on diabetes specific diet consisting of 20 g casein, 50 g starch, 15 g corn oil, 4 g salt mixture, 1 g vitamins mixture and 10 g cellulose [24].

The other groups (4, 5, and 6) were fed on diabetic dietary formulas which prepared by replacing the starch as a source of carbohydrates in DSD with an equal carbohydrates content from the selected formulas (F_1, F_2 and F_3). The chemical composition of the tested formulas (Table 2) was considered during preparing the diabetic dietary formulas [7].

Induction of diabetes in experimental rats. Rats were fasted over night and diabetes was induced by a single intraperitoneally injection of freshly prepared solution of alloxan at a dose of (150 mg / kg body weight) in sterile saline [13]. Rats were fed on basal diet for three days during which hyperglycemia were developed. Development of diabetes was confirmed three days after injection of alloxan by measuring fasted blood glucose levels. Only rats with fasting blood glucose levels greater than 250 mg/ dl were considered diabetic and then included in the experiment.

Body weight. Body weight changes of rats were recorded during the experimental period (30 days). Blood samples were collected sequentially from the eye plexuses of animals before and during the experimental period.

Biochemical parameters. At the beginning, 10 days, 20 days and at the end of experimental period, blood samples were collected from the eye plexuses of animals by a fine capillary glass tubes. Blood serum samples were separated by centrifugation for 10 min at 1500 xg and kept at –20 ºC until analysis [29].

Glucose (mg/dL) was determined using enzymatic colorimetric method according to the method of Trinder (1969) [31]. Urea, Serum total protein, Total triglyceride and Cholesterol were determined according to Patton and Crouch (1977) [26], Doumas, (1975) [12], Fossati and Prencipe (1982) [14] and Roeschlau *et al*., (1974) [27], respectively

Statistical analysis. The results were statistically analyzed according to statistical analysis system SAS (1999) [28]. Duncan's at 5% level of significance was used to compare between means according to Snedecor and Cochran, (1980) [30].

3. Results and discussions

Proximate chemical of raw materials and dietary formulas. The proximate chemical composition of different cooked materials dried at 60 °C was presented in Table 1. Lentil had the highest crude protein content (26.00%) followed by green bean

(23.00%). Corn showed significant ($p \leq 0.05$) high crude fat (5.00%) comparing with other tested materials. Green bean contained significant high ash (7.50%) and crude fiber content (10.40%) than other tested materials. Rice and potato showed the highest total carbohydrates values (83.20 and 81.67%) and the lowest crude fat content (1.50% and 0.40%).

These results are approached with that obtained by Aman *et al*. (1985) [4] and Grausgruber *et al*. (2004) [15] for hull-less barley, Zhongkai *et al*. (2002) [38] for corn, Al-kanhal *et al*. (1999) [2] for rice, USDA (2010) [33] for potato, Indira and Bhattacharya (2006) [16] and Zia-Ul-Haq *et al*. (2011) [39] for lentil, Kahlon *et al*. (2007) [18] for carrot and Adams *et al*. (2006) [1], Kahlon *et al*. (2007) [18] for green bean.

Three dietary formulas were prepared by mixing equal weight of grains (F_1), vegetables (F_2) and grains with vegetables (F_3) and were evaluated as a part of diet for lowering serum glucose level of diabetic rats.

Significant differences ($p \leq 0.05$) were observed between different dietary formulas in their chemical composition (Table 2). The highest value of protein was recorded for F_3 (13.71%) followed by F_2 (13.33%). The fat content of F1 was found to be higher (2.8%) than those of F_3 and F_2 (2.2 and 1.6%). It was found that F_2 contained the highest ash and crude fiber levels (6.30 and 5.70%) respectively. The energy value (Kcal/100 g) was ranged from 351.96 for F_2 to 375.2 for F_1.

Biological evaluation of dietary formulas in diabetic rats. The effect of feeding with different prepared dietary formulas (as a part of diet made for diabetic people) compared with diabetic specific diet on body weight, serum glucose, total protein, urea, triglycerides and total cholesterol in alloxan-induced diabetic rats was followed during 30 days.

Body weight. Mean initial body weights (BW) of rats in different groups were ranged from 198.50 to 235.25 g (Table 3). Gradual increase was observed in BW of rats fed on SD in G_1 (control -). Drastic reduction was obtained in the BW of diabetic rats fed on SD in G_2 (control +) followed by those fed on DDF_1 (G_4) and DDF_2 (G_5) during the experimental period. Rats in these group lost 31.98, 11.8, 9.9 % of their BW respectively. On the other hand, a considerable enhancement was observed in the BW of diabetic rats fed on DSD (G_3) and DDF_3 (G_6).

Body weight gain of rats fed on DDF_3 (11.13 g) was slightly lower than those fed on DSD (18.50 g), this indicates that diabetic dietary $formula_3$ was slightly less efficient than DSD in promoting growth.

These results are similar to those obtained by Das *et al*. (2012), Kumar *et al*. (2011) [10,21].

Serum glucose. Serum glucose level of different groups of rats fed on different experimental diet for 30 days is given in Table 4. Results showed that induction of diabetic in rats with alloxan (150 mg /kg body weight) significantly increased serum glucose from 82.88- 83.08 mg/dl to 233.68 – 262.25 mg/ dl after week of alloxan injection. Kumar *et al*. (2011) [21] reported that alloxan acts as diabetogenic by destruction of β-cell of the islets of langerhans and causes massive reduction in insulin release, thereby inducing hyperglycemia. Serum glucose of diabetic rats fed on standard diet (control +) was significantly ($p \leq 0.05$) increased to 301.88 mg/ dl at the end of experiment. Fed of diabetic rats on different experimental diet (from G_3 to G_6) for 30 days significantly reduced serum glucose gradually with different diets. The lowest serum glucose level was significantly obtained in the group of rats fed on diabetic standard (G_3, 122.37 mg/ dl), followed by that fed on diabetic dietary formula No_3 (G_6, 131.25 mg/ dl) as compared with the control positive.

Serum glucose level of rats fed on diabetic dietary formula $No._1$ (G_4) and $No._2$ (G_5) was significantly ($p \leq 0.05$) higher (200.25 and 188.13 mg/ dl . respectively.) than that of rats fed on diabetic standard diet (G_3). Reduction in serum glucose level reached 52.43, 48.95, 25.71 and 17.91% in rats in G_3, G_6, G_5 and G_4 respectively.

It could be concluded that diet prepared from different tested grains and vegetables formula (DDF_3) was found to reduce the elevated glucose level significantly in alloxan-induced rats during 30 days. These observations may be due to the high level of slowly digestible carbohydrates and dietary fiber in the different tested formulas.

Similar results were obtained by Kumar *et al*. (2010), Kumar *et al*. (2011), Makni *et al*. (2010). [20, 21,22]

Serum total protein. It was observed from Table 5 that feeding of diabetic rats in the group 2 and 4 on standard diet and diabetic dietary formula No.$_1$ resulted in a significant decrease in total serum protein (6.19 and 6.49 g/dl respectively) as compared to the normal group fed on standard diet, control negative (7.85 g/dl).

The highest serum total protein (8.13 g/dl) was found in the group of rats fed on diabetic dietary formula No.$_3$ (G_6) followed by that fed on diabetic standard diet (G_3, 8.08 g/dl).

It could be seen from the results that total protein level was found to be in the normal range (6- 8.2 g/dl).

These results are in agreement with those reported by Kaur and Gupta (2002) and Zaky (2009) [19,36].

Serum urea. Results in Table 6 revealed that induction of diabetic rats with alloxan significantly increased serum urea from 26.00 mg/ dl (control -) to 62.00 mg/ dl (control +). Feeding of diabetic rats with standard diet (G_2, control +) for 30 days significantly increased serum urea to 74.13 mg/ dl. On the other hand, diabetic rats fed on diabetic standard diet, diabetic dietary formula No. 1, 2 and 3 (G_3, G_4, G_5, and G_6) showed significantly lower serum urea level (ranged from 51.35 to 57.25 mg/ dl) as compared to those fed on standard diet . The results also showed that levels of serum urea of different diabetic rats groups were higher than normal rats (control -). Similar results are obtained by Kumar *et al*. (2011), Makni *et al*. (2010) [20,22].

Table 1. Proximate chemical composition of cooked dried materials.

Component%* / materials	Moisture	Crude Protein	Crude Fat	Ash	Crude Fiber	Total carbohydrates**
Barley(B)	9.20 ±0.40^{a}	12.00 ±0.20^{b}	2.00 ±0.41^{b}	2.07 ±0.01^{d}	2.69 ±0.19^{c}	74.73 ±0.20^{d}
Corn(C)	8.20 ±0.40^{b}	10.00 ±1.00^{b}	5.00 ±0.36^{a}	1.20 ±0.20^{ef}	1.27 ±0.02^{d}	75.60 ±0.20^{c}
Rice(R)	6.40 ±0.40^{c}	8.00 ±1.00^{b}	1.50 ±0.40^{bc}	0.90 ±0.10^{f}	0.00 ±0.00^{f}	83.20 ±0.20^{a}
Potato(P)	6.40 ±0.35^{c}	7.00 ±1.00^{b}	0.40 ±0.05^{c}	4.60 ±0.10^{c}	1.10 ±0.03^{d}	81.60 ±0 60^{b}
Lentil(L)	3.00 ±0.20^{d}	26.00 ±3.10^{a}	2.10 ±0.96^{b}	1.30 ±0.09^{e}	0.45 ±0.03^{e}	67.60 ±0.20^{e}
Carrot(Ca)	7.70 ±0.70^{b}	10.00 ±0.80^{b}	2.00 ±0.95^{b}	6.80 ±0.10^{b}	5.63 ±0.19^{b}	73.50 ±0.50^{d}
Green bean(Gb)	9.00 ±0.20^{a}	23.00 ±2.70^{a}	2.40 ±0.18^{b}	7.50 ±0.20^{a}	10.40 ±0.40^{a}	58.10 ±0.50^{f}

* Means (n=3) ± SD in the same column with different superscripted letters are significantly different ($p \leq 0.05$).
** Calculated by difference.

Table 2. Proximate chemical composition of different tested dietary formulas.

Component %* / Formulas***	Moisture	Crude Protein	Crude Fat	Ash	Crude fiber	Total carbohydrates**	The energy value**** (Kcal/100g)
F_1	8.30 ±0.10^a	10.00 ±0.20^b	2.80 ±0.34^a	1.40 ±0.30^c	1.32 ±0.10^c	77.50 ±0.50^a	375.2
F_2	7.71 ±0.01^b	13.33 ±0.33^a	1.60 ±0.10^b	6.30 ±1.00^a	5.70 ±0.50^a	71.06 ±0.22^c	351.96
F_3	7.25 ±0.01^b	13.71 ±0.03^a	2.20 ±0.20^a	3.50 ±0.10^b	3.40 ±0.40^b	73.34 ±0.20^b	368

* Means (n=3) ± SD in the same column with different superscripted letters are significantly different ($p \leq 0.05$).
** Calculated by difference.
*** F_1(B,C,R), F_2(P,Ca,Gb), F_3(B,C,R,P,L,Ca,Gb).
**** (Protein x 4), (fat x 9) and (carbohydrate x 4).

Table 3. Body weight and body weight gain (g) of diabetic rats fed on different tested diets for 30 days.

Rats group	Body weight(g) during feeding period(days)					
	0	7	10	20	30	Body weight gain
Healthy group control (-) G_1	235.25 ±8.79^a	239.00 ±28.42^a	258.00 ±11.84^a	273.63 ±15.17^a	283.75 ±16.42^a	48.50
Diabetic groups control (+) G_2	205.38 ±8.6^{cd}	198.50 ±17.90^{bc}	173.88 ±15.40^c	154.13 ±21.45^e	135.00 ±19.85^d	-70.37
G_3	217.75 ±21.17^{cb}	205.13 ±8.72^{bc}	205.31 ±13.64^b	216.88 ±21.17^b	236.25 ±13.45^b	18.50
G_4	215.50 ±13.54^{cb}	215.25 ±13.54^b	205.13 ±8.72^b	198.50 ±17.90^c	190.00 ±17.11^c	-25.50
G_5	198.50 ±17.90^d	190.00 ±17.11^c	183.50 ±16.56^c	180.13 ±18.64^d	179.63 ±18.82^c	-18.88
G_6	222.63 ±15.40^{ab}	216.75 ±21.17^b	217.25 ±21.23^b	223.00 ±15.17^b	233.75 ±9.22^b	11.13

Mean (n=8) ± SD in the same column with different letters are significantly different ($p \leq 0.05$).
Control -, + (fed on SD), G3 (fed on DSD), G4 (fed on DDF_1), G5 (fed on DDF_2), G6 (fed on DDF_3).

Table 4. Serum glucose (mg/dL) of diabetic rats fed on different tested diets for 30 days.

Rats group	feeding period(days)				
	0	7	10	20	30
Healthy group					
control (-) G_1	83.08 $\pm 0.50^{aB}$	84.14 $\pm 0.88^{fA}$	81.20 $\pm 1.07^{eC}$	81.20 $\pm 1.07^{fC}$	84.14 $\pm 0.88^{fA}$
Diabetic groups					
control (+) G_2	83.08 $\pm 0.50^{aE}$	233.68 $\pm 3.40^{aD}$	276.34 $\pm 3.25^{aC}$	287.28 $\pm 2.26^{aB}$	301.88 $\pm 4.46^{aA}$
G_3	82.81 $\pm 0.22^{aE}$	257.25 $\pm 1.58^{bA}$	220.50 $\pm 1.69^{dB}$	187.88 $\pm 1.55^{dC}$	122.37 $\pm 1.85^{eD}$
G_4	82.88 $\pm 0.12^{aE}$	243.95 $\pm 1.90^{dA}$	224.73 $\pm 1.14^{cB}$	210.88 $\pm 5.26^{bC}$	200.25 $\pm 2.82^{bD}$
G_5	82.75 $\pm 0.25^{aE}$	253.25 $\pm 1.48^{cA}$	234.56 $\pm 1.13^{bB}$	204.25 $\pm 4.03^{cC}$	188.13 $\pm 1.46^{cD}$
G_6	82.75 $\pm 0.25^{aE}$	262.25 $\pm 2.55^{aA}$	224.01 $\pm 1.84^{cB}$	178.88 $\pm 1.96^{eC}$	131.25 $\pm 1.16^{dD}$

Mean (n=8) ± SD in the same column with different small letters are significantly different ($p \leq 0.05$) based on animal group.
Mean (n=8) ± SD in the same row with different capital letters are significantly different ($p \leq 0.05$) based on feeding period.
Control -, + (fed on SD), G3 (fed on DSD), G4 (fed on DDF_1), G5 (fed on DDF_2), G6 (fed on DDF_3).

Table 5. Total protein (g/dL) of diabetic rats fed on different tested diets for 30 days.

Rats group	feeding period(days)				
	0	7	10	20	30
Healthy group					
control (-) G_1	7.45 $\pm 0.16^{aB}$	7.51 $\pm 0.06^{bB}$	7.95 $\pm 0.24^{bA}$	7.85 $\pm 0.14^{bA}$	7.85 $\pm 0.13^{bA}$
Diabetic groups					
control (+) G_2	7.45 $\pm 0.16^{aA}$	7.29 $\pm 0.08^{cB}$	6.91 $\pm 0.22^{dC}$	6.49 $\pm 0.11^{eD}$	6.19 $\pm 0.16^{dE}$
G_3	7.39 $\pm 0.15^{aE}$	7.51 $\pm 0.06^{bD}$	7.85 $\pm 0.14^{bC}$	8.34 $\pm 0.09^{aA}$	8.08 $\pm 0.13^{aB}$
G_4	7.45 $\pm 0.16^{aA}$	7.51 $\pm 0.06^{bA}$	7.29 $\pm 0.08^{cB}$	6.91 $\pm 0.22^{dC}$	6.49 $\pm 0.11^{cD}$
G_5	7.51 $\pm 0.06^{aB}$	7.85 $\pm 0.14^{aA}$	7.39 $\pm 0.16^{cB}$	7.51 $\pm 0.06^{cB}$	7.85 $\pm 0.14^{bA}$
G_6	7.51 $\pm 0.06^{aD}$	7.85 $\pm 0.14^{aC}$	8.16 $\pm 0.16^{aB}$	8.34 $\pm 0.09^{aA}$	8.13 $\pm 0.17^{aB}$

Mean (n=8) ± SD in the same column with different small letters are significantly different ($p \leq 0.05$) based on animal group.
Mean (n=8) ± SD in the same row with different capital letters are significantly different ($p \leq 0.05$) based on feeding period.
Control -, + (fed on SD), G3 (fed on DSD), G4 (fed on DDF_1), G5 (fed on DDF_2), G6 (fed on DDF_3).

Table 6. Urea (mg/dL) of diabetic rats fed on different tested diets for 30 days

Rats group	feeding period(days)				
	0	7	10	20	30
Healthy group control (-) G_1	25.00 $\pm 0.00^{aC}$	26.00 $\pm 2.33^{aC}$	30.00 $\pm 2.38^{dB}$	32.00 $\pm 2.43^{dB}$	35.00 $\pm 2.45^{dA}$
Diabetic group control (+) G_2	25.00 $\pm 0.00^{bD}$	62.00 $\pm 2.72^{abC}$	69.00 $\pm 3.27^{aB}$	74.00 $\pm 2.43^{aA}$	74.13 $\pm 3.53^{aA}$
G_3	25.00 $\pm 0.00^{fC}$	57.25 $\pm 3.20^{cdA}$	54.50 $\pm 3.69^{cAB}$	51.25 $\pm 4.00^{cB}$	51.38 $\pm 4.11^{cB}$
G_4	25.00 $\pm 0.00^{cD}$	64.00 $\pm 2.91^{aA}$	61.00 $\pm 3.44^{bAB}$	57.50 $\pm 3.66^{BcB}$	57.00 $\pm 3.76^{bC}$
G_5	25.00 $\pm 0.00^{dB}$	54.50 $\pm 3.04^{dA}$	54.00 $\pm 3.55^{cA}$	57.00 $\pm 3.81^{bA}$	57.25 $\pm 3.92^{bA}$
G_6	25.00 $\pm 0.00^{eD}$	60.00 $\pm 3.13^{cbAB}$	62.00 $\pm 3.63^{bA}$	57.25 $\pm .3.91^{BcB}$	54.50 $\pm 4.03^{bcC}$

Mean (n=8) ± SD in the same column with different small letters are significantly different ($p \leq 0.05$) based on animal group.
Mean (n=8) ± SD in the same row with different capital letters are significantly different ($p \leq 0.05$) based on feeding period.
Control -, + (fed on SD), G3 (fed on DSD), G4 (fed on DDF_1), G5 (fed on DDF_2), G6 (fed on DDF_3).

Table 7. Triglyceride (mg/dL) of diabetic rats fed on different tested diets for 30 days.

Rats group	feeding period(days)				
	0	7	10	20	30
Healthy group control (-) G_1	88.10 $\pm 0.00^{aD}$	116.00 $\pm 2.33^{fB}$	110.00 $\pm 2.28^{fC}$	116.50 $\pm 2.33^{eB}$	129.00 $\pm 2.43^{eA}$
Diabetic groups control (+) G_2	88.10 $\pm 0.00^{bD}$	260.00 $\pm 3.40^{cB}$	264.00 $\pm 2.57^{aA}$	258.00 $\pm 1.67^{aB}$	250.00 $\pm 2.42^{aC}$
G_3	88.10 $\pm 0.00^{fE}$	250.00 $\pm 3.83^{dA}$	148.00 $\pm 2.90^{eB}$	134.00 $\pm 1.89^{dC}$	123.00 $\pm 2.74^{fD}$
G_4	88.10 $\pm 0.00^{cE}$	213.00 $\pm 3.57^{eA}$	174.00 $\pm 2.71^{dB}$	136.00 $\pm 1.76^{cD}$	148.88 $\pm 2.55^{cC}$
G_5	88.10 $\pm 0.00^{dD}$	280.00 $\pm 3.69^{bA}$	179.13 $\pm 2.79^{cB}$	136.00 $\pm 1.82^{cC}$	135.75 $\pm 2.63^{dC}$
G_6	88.10 $\pm 0.00^{eE}$	292.00 $\pm 3.77^{aA}$	237.00 $\pm 2.85^{bB}$	157.75 $\pm .1.86^{bD}$	164.00 $\pm 2.69^{bC}$

Mean (n=8) ± SD in the same column with different small letters are significantly different ($p \leq 0.05$) based on animal group.
Mean (n=8) ± SD in the same row with different capital letters are significantly different ($p \leq 0.05$) based on feeding period.
Control -, + (fed on SD), G3 (fed on DSD), G4 (fed on DDF_1), G5 (fed on DDF_2), G6 (fed on DDF_3).

Table 8. Cholesterol (mg/dL) of diabetic rats fed on different tested diets for 30 days.

Rats group	feeding period(days)				
	0	7	10	20	30
Healthy group control (-) G_1	132.00 $\pm 0.00^{aA}$	109.00 $\pm 3.21^{eC}$	114.00 $\pm 3.84^{fB}$	103.13 $\pm 3.20^{eD}$	107.00 $\pm 2.76^{fC}$
Diabetic group control (+) G_2	132.00 $\pm 0.00^{bC}$	252.75 $\pm 3.22^{aB}$	252.00 $\pm 3.85^{aB}$	260.25 $\pm 3.20^{aA}$	252.75 $\pm 2.76^{aB}$
G_3	132.00 $\pm 0.00^{fC}$	212.00 $\pm 3.63^{cA}$	206.00 $\pm 4.34^{bB}$	116.00 $\pm 3.61^{dE}$	128.00 $\pm 3.12^{dD}$
G_4	132.00 $\pm 0.00^{cC}$	240.00 $\pm 3.39^{bA}$	138.00 $\pm 4.04^{eB}$	127.00 $\pm 3.37^{cD}$	125.00 $\pm 2.91^{eD}$
G_5	132.00 $\pm 0.00^{dD}$	214.00 $\pm 3.49^{cA}$	185.00 $\pm 4.17^{cB}$	187.00 $\pm 3.47^{bB}$	154.00 $\pm 3.00^{bC}$
G_6	132.00 $\pm 0.00^{eD}$	200.00 $\pm 3.57^{dA}$	173.00 $\pm 4.27^{dB}$	127.00 $\pm .3.55^{cE}$	137.25 $\pm 3.07^{cC}$

Mean (n=8) ± SD in the same column with different small letters are significantly different ($p \leq 0.05$) based on animal group.
Mean (n=8) ± SD in the same row with different capital letters are significantly different ($p \leq 0.05$) based on feeding period.
Control -, + (fed on SD), G3 (fed on DSD), G4 (fed on DDF_1), G5 (fed on DDF_2), G6 (fed on DDF_3).

Serum Triglycerides (TG). Induction of diabetic in rats significantly ($p \leq 0.05$) raised triglycerides to 213.00- 292.00 mg/ dl compared to 88.10 mg/dl in the control negative group (Table 7). Feeding of diabetic rats with different tested diabetic formulas resulted in a significant ($p \leq 0.05$) decrease in serum triglyceride level. The more pronounced lowering effect was observed in the groups of rats fed on diabetic standard diet (G_3, 123.00 mg/dl) and diabetic dietary formula No.2 (G_5, 135.75 mg/dl). The reduction in serum triglycerides level reached 51.51, 50.8 and 43.83% in rats fed on diabetic standard diet, diabetic dietary F_2 and F_3 respectively, while it was only 30.10% for that fed on diabetic dietary F_1. These means that diet prepared from formula 2 and 3 showed better response towards reduction in serum triglyceride level.

Similar results are obtained by Makni *et al*. (2010), Kumar *et al*. (2011) [21,22].

Total serum cholesterol. Induction of rats with alloxan significantly increase total serum cholesterol to about 200 -252 mg /dl compared to only 109.00 mg/ dl for normal rats. Data in Table (8) revealed that feeding of diabetic rats for 30 days on the diabetic diets, resulted in a significance decrease in total serum cholesterol as compared to the group fed on standard diet (control +). Reduction in total serum cholesterol level was higher in the groups of rats fed on diabetic dietary F_1 (G_4, 47.91%) followed by diabetic standard diet (G_3, 39.62%) and diabetic dietary $formula_3$ (G_6, 31.37%). While the lower reduction was obtained in the group of rats fed on diabetic dietary $formula_2$ (G_5, 28.03%) as compared with the control positive group. Total serum cholesterol level was declined to the normal range (TC < 200 mg/ dl) in all diabetic groups fed on the experimental diabetic diets.

The hypocholesterolemic effect of different prepared diabetic diets may be due to their high content of

dietary fiber [8,32]. It has been found in many studies that monounsaturated and polyunsaturated fatty acids in diets are also responsible for lowering the total cholesterol [37].

4.Conclusion

It could be concluded that diet prepared from different tested grains and vegetables formula (DDF_3) was found to reduce the elevated glucose level significantly in alloxan-induced rats during 30 days. These observations may be due to the high level of slowly digestible carbohydrates and dietary fiber in the different tested formulas.

Compliance with Ethics Requirements: Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human and/or animal subjects (if exists) respect the specific regulations and standards.

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