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Cauliflower Plant (*Brassica Oleracea*) Parts as Possible Agents to Cope Diabetes Mellitus for Male Albino Rats

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ABSTRACT:

Diabetes is a chronic metabolic disease characterized by elevated blood glucose levels. The study aims to investigate the effect of cauliflower (Brassica oleracea) on diabetic rats. Forty-two adult rats were divided into two main groups; the first was control negative (NCG; n=6) fed on a basal diet (BD). The second group (36 rats) was given alloxan (dose 150 mg/kg BW) to induce diabetes and divided into six equal groups (6 rats per each group): Control positive (PCG), Cauliflower group (CFG), Cauliflower leaves group (CLG), Cauliflower seeds group (CSG), Cauliflower mix group (CMG) and Cauliflower Fortified Pizza (CPG), All diabetic treated groups were administered with a dose of 7% replaced from the basal diet. Results found that the mixed group (CMG) had the best impact of reducing serum glucose, while CLG had the lowest impact; the change by decreasing rate were 44.59 & 27.56%, respectively. Moreover, the best BWG and FER were recorded for CMG by means value 1.084±0.085 (g/rat/day) and 0.07±0.006, respectively. All experimented groups showed a significant decrease in the mean values of lipid profiles and lipoproteins; the percent of decrease ranged from (-52.82 to -33.64%) and (-27.9 to -7.24%) for TC and TG, respectively, within 28 days of feeding. Furthermore, the group receiving the mixture observed the most significant improvements in AST, ALT, ALP, creatinine, uric acid, and creatinine levels. In summary, the various parts of cauliflower (including the flower, leaves, seeds, and their combination) and fortified pizza may serve as potent nutraceutical treatments for diabetes.

Keywords: *Cauliflower, Hyperglycemia, Lipids, Kidney, Liver Enzymes.*

1. INTRODUCTION

Diabetes mellitus, a hyperglycemia disorder, occurs on by lower insulin production and increased blood sugar ratios or use of body cells, individuals with diabetes who are type 2 exhibit frequent urination (polyuria), frequent drinking (polydipsia), and frequent eating (polyphagia) [1]. It is currently classified into two main types, type 1 and type 2 diabetes, based on status of the autoantibodies directed at the **β**-cell [2]. Untreated diabetes can lead to numerous complications. Acute issues include diabetic ketoacidosis (DKA) and non-ketotic hyperosmolar coma. Severe long-

term complications encompass heart disease, stroke, kidney failure, foot ulcers, and eye damage. The metabolic abnormalities in carbohydrates, lipids, and proteins are due to insulin's crucial role as an anabolic hormone. [3].

Cauliflower, a member of the Brassicaceae family (also known as Cruciferae), is scientifically classified as Brassica oleracea var. botrytis. [4]. The plants in this family all share a common feature: Their four-petaled flowers resemble to a Greek cross and are often referred to as crucifers or cruciferous vegetables [5]. Cauliflower is rich in antioxidants like glucosinolates, vitamins, phenolic compounds, and carotenoids, collectively known as "phytochemicals." These substances contribute significantly to its nutritional value and may help prevent chronic diseases when included in our diet. [6,7]. The impact of glucosinolates on glycemic control has garnered attention concerning hyperglycemia and diabetes. Isothiocyanates like raphasatin and sulforaphane may help prevent or reduce glycemic-related complications in both animal and human studies [5, 8, 9]. In a study involving hyperglycemic mice, those administered sulforaphane (0.5 mg/kg daily for 5 days a week) for 3 months, followed by an additional 3 months of observation, demonstrated that sulforaphane can prevent diabetes-induced hypertension. [5, 10]. Moreover, numerous observational studies have looked into relationships between the consumption of cruciferous vegetables and risk factors for type 2 diabetes and glucose metabolism. A high intake of cruciferous vegetables was associated with a 13% decreased risk of type 2 diabetes, according to a meta-analysis incorporating 11 prospective studies on cases of the disease. [11]. Therefore, this study aims to investigate the effect of cauliflower parts (flowers, seeds, and leaves) and fortified bakery products with it on the rate of high blood glucose in diabetic rats.

2. Materials and Methods

2.1 Materials

Cauliflower was obtained from the National Research Center, Doki, Cairo, Egypt. Alloxan was procured from Sigma Company for Trading Drug Chemicals and Medicals, located in Cairo, Egypt. Kits, chemicals, and reagents were obtained from Morgan Chemicals Co., also based in Cairo, Egypt.

Rats: Adult male albino rats of the Sprague Dawley strain were sourced from the Vaccine and Immunity Organization, Ministry of Health, Helwan Farm, Cairo, Egypt.

Preparation of cauliflower plant parts powder: Cauliflower plant parts (cauliflower, leaves, and seeds) were cleaned and sorted manually then dried in a hot air oven at 550C until the moisture in the final product reached about 10%. The dried samples were ground into a fine powder in high mixer speed. The

material that passed through an 80 mesh sieve was retained for use.

Preparation of pizza dough: was prepared at the same method described by Sagar and Pareek, [12].

Experimental design:

The experiment was approved by the Research Ethics Committee of the Faculty of Science, Menoufia University, Egypt (Approval No. MUFHE/S/NFS/9/24).

Forty-two adult male albino rats, Sprague Dawley Strain, 8 weeks age, weighing (150±10g) were used in this experiment. All rats were fed on basal diet (casein diet) prepared according to the American Institute of Nutrition [13] for 7 consecutive days. Following this adaptation period, six rats were designated as the negative control group, while the remaining rats were divided into the following groups, each consisting of six rats:

Positive control group: Diabetic rats, injected with alloxan, were fed on the basal diet during the study period. Experimental Groups (n=24): Rats of these groups gave different doses of cauliflower parts, which administered for 28 days. Rats were divided into four groups as follow: Group (NCG): Control negative, normal rats were fed on basal diet only. Group (PCG): Control positive, diabetic rats were fed on basal diet only. Group (CFG): Diabetic rats were fed on basal diet and administered cauliflower seeds (7%) powder. Group (CLG): Diabetic rats were fed on basal diet and administered cauliflower leaf powder (7%). Group (CSG): Diabetic rats were fed on basal diet and administered cauliflower flower powder (7%).

Group (CMG): Diabetic rats were fed a basal diet containing 7% mixed powder. Group (CPG): Diabetic rats were fed on basal diet and administered Pizza and flower of cauliflower 7%.

At the end of experimental periods, the rats from each group were fasted for 12 hours, then started dissecting them and blood samples were collected from the hepatic portal vein into a dry clean centrifuge tube. Blood samples were centrifuged at (4000rpm) for ten minutes to separate blood serum, then kept in a deep freezer till using.

Biological Evaluation:

Body weight gain (BWG), feed intake (FI), and feed efficiency ratio (FER):

Throughout the experiment, daily net feed intake and weekly body weight measurements were recorded. These data points were then utilized to calculate feed efficiency ratios (FER) using the following method:

$$\text{FER \%} = \frac{\text{Body weight gain (g)}}{\text{Feed intake (g)}} \times 100$$

Biochemical Analysis:

Determination of serum glucose was carried out colorimetrically according to studies by Yound [14] and Tietz [15]. Serum total cholesterol levels were measured using the colorimetric method outlined by Thomas [16]. Serum triglyceride levels were determined enzymatically using kits based on the method described by Van Steirteghem et al. [17] & Fossati and Prencipe, [18]

studies. Evaluating of high-density lipoprotein (HDLc) was determined according to the method described by Lopez, [19]; Grodon and Amer, [20]. Calculation of very low-density lipoprotein cholesterol (VLDLc) was calculated in mg/dl according to Sagar and Pareek, [12]. Calculation of low-density lipoprotein cholesterol (LDLc) was performed in mg/dl according to Lee and Nieman, [21]. Determination of serum alanine aminotransferase (ALT) was carried out according to the method of Yound, [14]. The quantity estimation of serum asparatate aminotransferase (AST) was carried out according to the method of Hafkenscheid and Dijt [22]. The quantity estimation of serum alkaline phosphatase (ALP) was carried out according to the method of Moss, [23]. Serum urea, creatinine and uric acid concentrations were determined using the modified kinetic methods of Fawcett and Scott, [24] & Chaney and Marbach, [25], respectively.

Histopathological investigation: From each experimental group, small specimens of the liver, kidney, and spleen were removed, fixed in neutral buffered formalin, dehydrated in increasing ethanol concentrations (70, 80, and 90%), cleaned in xylene, and embedded in paraffin. Hematoxylin and Eosin was used to create sections with a thickness of (4-6) µm.

Statistical Analysis: The data were presented as mean ± standard deviation, and one-way analysis of variance (ANOVA) was conducted to assess statistical significance. A p-value less than 0.05 was considered indicative of statistical significance. The SAS user's guide was utilized for data analysis [26].

3. Results and Discussion

Data presented in table (1) demonstrate the mean value of body weight gain (BWG) g, feed intake (FI) g/d and feed efficiency ratio (FER) of diabetes rats fed on cauliflower parts (flower, leaves, seeds, mix and pizza). All treatment groups revealed significant differences when compared with control (+) except of G5 (seeds 7%) showed nonsignificant change in mean values as compared with control (+). The best BWG was recorded for G6 (Mix 7%) which was (-1.08 ±0.09) when compared to Control (+), being (0.98 ±0.04). Regarding feed intake (F.I) (g/d), it was found from data in table (1) the F.I of control (+) was higher than control (-), being 19.8±.90 and 17.10 ± 0.10, The control (-) group showed a 13.64% decrease compared to the control (+) group, indicating a significant difference between the two groups. All treatment groups (3, 4, 5, 6, 7) showed that there was significant differences when compared with control (+) group, the means of all groups were 16.30± 0.40, 16.15 ± 0.61, 17 ± 0.50, 16 ± 0.20 and 16.21 ± 0.44 respectively. The better F.I% was recorded to G5 hyperglycemic rats fed on seeds, the percent of increase was -14.14%, then G3, G7, G4 and G6

sequentially, as compared to control (+) group. For feed efficiency ratio (F.E.R), all treated groups (except G4 and 5) reveled significant difference in mean values compared to control (+) group. The highest significant increase recorded to mixed group (G6) at mean value -0.07 ± 0.006. On the same line of the present results, Rashad and Moharib, [27] & Mansour et al. [28] observed a highly significant decrease in weight gain and feed intake in rats fed cauliflower fibers over an 8-week experimental period. Additionally, Amany et al. [29] found that rats on an animal fat diet supplemented with 5% cauliflower had lower feed intake and reduced body weight gain compared to the negative control group. In a study by Li et al. [30], they indicated that high cruciferous vegetable intake tends to be associated with healthy behaviors, which are related to lower body mass index and reduced risk of diabetes.

Table (1): Effect of cauliflower administration on BWG, FI and FER of diabetic rats

Group	BWG G/rat/day		FI (g/rat/day)		FER	
	Mean ±SD	%	Mean ±SD	%	Mean ±SD	%
NCG	1.24 ±0.12 a	26.14	17.11 ±0.10b	-13.64	0.07±0.007a	46.94
PCG	0.98 ±0.04 b	0	19.81±0.90a	0	0.05 ±0.004b	0
CFG	-0.86 ± 0.03 e	187.89	16.32± 0.40bcd	-17.67	-0.05± 0.001d	-208.16
CLG	0.77± 0.05 c	-21.34	16.15± 0.61 CD	-18.43	0.05± 0.0049 b	-2.04
CSG	0.89 ±0.06 b	-9.25	17.00±0.50bc	-14.14	0.05±0.002b	6.12
CMG	-1.08 ±0.09 f	-210.27	16.00±0.20d	-19.19	-0.07±0.006e	-238.77
CPG	-0.66 ± 0.04 d	-167.14	16.21 ± 0.44 CD	-18.18	-0.04± 0.001 c	-183.67
LSD	0.114		0.895		0.008	

*NCG: Negative control group; PCG: positive control group; CFG: cauliflower flower group; CLG: cauliflower Leaves group; CSG: Seeds group; CMG: Mix group; CPG: Pizza group. BWG: Body weight gain; FI: Feed intake; FER: feed efficiency ratio. Values denote arithmetic ± standard deviation of the mean. *BWG: Body weight gain, FI: Feed intake and FER: Feed efficiency ratio. The groups marked with distinct letters (a, b, c, d, e, f and g) within a given column exhibit significant differences of p ≤ 0.05 as determined by the one-way ANOVA test using the LSD (Least Significant Difference) method. Groups labeled with the same letter are not significantly different from each other.*

Table (2) shows the effect of cauliflower, leaves, seeds, mixtures and Pizza fortified with cauliflower on serum glucose (mg/dl). The mean value of control positive group higher than control (-) group, being 241.75 ± 1.03 and 95.51 ± 1.01 respectively, showing significant differences between them. Also, it is evident that all treatment groups had an effective impact, but such impact is different between the groups. For example, it was found that mixture (G6) had the best impact from the therapeutic point of view, while the leaves group (G4) had the lowest impact, the change by decreasing rate were 44.59 & 27.56%, respectively.

Consistent with our results, According to Mansour et al. [28], rats fed raw broccoli showed a 20.99% decrease in blood

glucose levels, while those fed steamed broccoli exhibited a 12.92% decrease. Similarly, rats fed raw cauliflower had a 20.22% decrease, and those fed steamed cauliflower showed a 13.65% decrease in blood glucose levels compared to groups on the basal diet. The previous findings of Li et al., [30] showed that cruciferous vegetables act as a good source of natural antioxidants and can produce an antidiabetic effect. Kataya and Hamza [31] noted in their study on Brassica oleracea and its role in alleviating diabetic nephropathy in mice that B. oleracea extract reduced blood glucose levels, restored renal function, and prevented body weight loss. Furthermore, B. oleracea extract reduced the negative effects of diabetes on the antioxidant capacity, catalase activity, glutathione, and superoxide dismutase activity of diabetic kidneys. Consequently, B. oleracea extract's antioxidant and antihyperglycemic qualities may present a viable medicinal option for the management of diabetes. The most distinctive bioactive derivatives of cruciferous feeds, that are responsible for their positive health effects, are a number of glucosinolates (GSL) and their related hydrolysis products, isothiocyanates (ITC) and indoles, according to epidemiological studies that have been done thus far regarding the phytochemical composition of cruciferous feeds. The effect of glucosinolates on glycemic management is gaining attention. Studies on humans and animals have shown that isothiocyanates, like sulforaphane and raphasatin, may prevent or lessen glycemic-related problems. [8, 32, 33]. In research with hyperglycemic mice treated with sulforaphane (0.5 mg/kg daily for 5 days a week) for 3 months, followed by a 3-month observation period, it was found that sulforaphane prevented hypertension and heart dysfunction induced by diabetes. [5,10]. Several observational studies have examined the relationship between consumption of cruciferous vegetables, like broccoli and cabbage, and glucose metabolism as well as the risk of developing type 2 diabetes. A meta-analysis that pooled data from 11 prospective studies on type 2 diabetes cases found that individuals with high intakes of cruciferous vegetables had a 13% lower risk of hyperglycemia (elevated blood sugar levels) compared to those with lower cruciferous vegetable consumption. Research has shown that Brassica vegetables, such as broccoli and cabbage, have the potential to prevent type 2 diabetes. This appears to be linked to the activation of the Nrf2 system, which regulates a variety of antioxidant enzymes. The Nrf2 pathway also seems to modulate the NF-**κ**B inflammatory response. Specifically, Brassica consumption has been observed to improve hyperglycemia (high blood sugar) and reduce levels of pro-inflammatory molecules like TNF-**α** and IL-6. This anti-inflammatory effect may help mitigate the secondary damage that

can occur in various organs and bones as a result of type 2 diabetes [34,35). Exciting findings have emerged regarding the impact of ITCs on **β**-cell survival and function. Sulforaphane, for instance, protects **β**-cells by inhibiting the nuclear factor **κ**B pathway or other Nrf2-mediated pathways [36,37). However, an in vitro study indicated that while sulforaphane initially enhances basal insulin secretion in **β**-cells through ROS mediation, prolonged exposure may diminish glucose-stimulated insulin secretion, potentially by reducing ROS levels [38). The bioavailability of ITCs is known to be influenced by factors such as plant myrosinase activity and the metabolic capacity of human gut microbiota [39). Additionally, variables like transportation, storage conditions of cruciferous vegetables, chewing intensity, cooking methods and duration, as well as the composition of meals containing these vegetables, can all impact plant myrosinase activity. [40, 41).

Table (3) presents the serum levels of total cholesterol and triglycerides (mg/dl) for the negative and positive control groups, as well as various groups of diabetic rats fed different parts of the cauliflower plant. The findings found that, the mean values of PCG (286.10±1.85 and 156.80±2.80) higher than NCG group (131.45 ±2.05 and 107.40 ± 1.20) for TC and TG respectively, showing significant differences between them at (P<0.05). The percentage of change for the negative control group is -54.05 and –31.5% when compared to control positive group.

Table (2): Effect of cauliflower administration of serum glucose of diabetic rats

Group	Glucose (mg/dl)	
	Mean ± SD	%Change of control +
NCG	95.51 ± 1.01 g	-60.49
PCG	241.75 ± 1.03a	0
CFG	140.51 ± 1.10 e	-41.87
CLG	175.12 ± 1.13 b	-27.56
CSG	147.77 ± 1.26 d	-38.88
CMG	133.95 ± 1.58 f	-44.59
CPG	167.18±1.82 c	-30.85
LSD	2.279	

NCG: Negative control group; PCG: positive control group; CFG: cauliflower flower group; CLG: cauliflower Leaves group; CSG: Seeds group; CMG: Mix group; CPG: Pizza group. Values denote arithmetic ± standard deviation of the mean. The groups marked with distinct letters (a, b, c, d, e, f and g) within a given column exhibit significant differences of p ≤ 0.05 as determined by the one-way ANOVA test using the LSD (Least Significant Difference) method. Groups labeled with the same lere not significantly different from each other.

It is evident that the best impact of reducing the percentage of TC and TG was found in the mixed group (G6) (135. 01 ±1.01) and (113.01±1.51) mg/dl, respectively. All experimented groups showed significant decrease in the mean values of serum cholesterol and triglycerides as compared to positive control group, the percent of decreasing were ranged from (-52.82 to -33.64%) and (-27.90 to -7.24%) for TC and TG respectively within 28 days of feeding. On the other hand, the effects of TG on CFG and CSG are not statistically significant. In line with our findings, According to Amany et al. [29], cauliflower was found to enhance the lipid profile more effectively than broccoli. Both plants showed a

significant reduction in serum total lipid and total cholesterol levels compared to the positive control.

Table (3): Effect of cauliflower administration on serum total cholesterol and triglycerides of diabetic rats.

Group	T.C (mg/dl)		T.G (mg/dl)	
	Mean ±SD	%	Mean ±SD	%
NCG	131.45 ±2.05g	-54.05	107.40 ±1.2f	-31.5
PCG	286.11±1.85a	0	156.80 ±2.8a	0
CFG	145.00 ±1e	-49.32	136.40 ±1.4d	-13.01
CLG	189.89±1.93b	-33.64	145.44 ±1.21 b	-7,24
CSG	170.00±1 d	-40.58	139.02±1d	-11.33
CMG	135.01 ±1.01 f	-52.82	113.01±1.5e	-27.92
CPG	180.35 ±1.23 c	-36.96	142.00 ±1c	-9.43
LSD	2.636		2.725	

*NCG: Negative control group; PCG: positive control group; CFG: cauliflower flower group; CLG: cauliflower Leaves group; CSG: Seeds group; CMG: Mix group; CPG: Pizza group. *T. C: total cholesterol, T.G: triglycerides. Values denote arithmetic ± standard deviation of the mean. The groups marked with distinct letters (a, b, c, d, e, f and g) within a given column exhibit significant differences of p ≤ 0.05 as determined by the one-way ANOVA test using the LSD (Least Significant Difference) method. Groups labeled with the same lere not significantly different from each other.*

Table 4 displays the serum lipoprotein fractions (HDLc, VLDLc, and LDLc in mg/dl) for the negative control, positive control, and various groups of diabetic rats fed different parts of cauliflower (flower, leaves, seeds, mixture, and fortified pizza). In comparison to other treated groups, the mean value of CMG demonstrated the greatest impact on lowering serum lipoproteins, by means of 49.08±2.01, 66.43±0.55, and 22.60±0.60 for HDLc, LDLc, and VLDL, correspondingly, at (P≤0.05). Additionally, when compared to PCG, there was a non-significant difference in the percentages of LDL and VLDL between CMG and NCG (-67.06% and -66.2%) and -27.93 and -31.46), respectively. Conversely, CLG had the smallest percentage of a decreasing effect on LDL and VLDL, at -46.14% and 3.09%, respectively. According to Mansour et al. [28], feeding rats raw or steamed broccoli or cauliflower for 40 days led to significant reductions in blood lipid fractions including total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and very low-density lipoprotein cholesterol (VLDL-C) compared to rats on a basal diet. Conversely, high-density lipoprotein cholesterol (HDL-C) levels increased, aligning with their reported outcomes. Mansour et al. [28] found that feeding rats broccoli or cauliflower (either raw or steamed) for 40 days led to significant reductions in various blood lipid components like total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), aisnd very low-density lipoprotein cholesterol (VLDL-C) compared to rats on a standard diet. Conversely, high-density lipoprotein cholesterol (HDL-C) levels increased,

consistent with their reported outcomes. Amany et al. [29] reported that rats fed an animal fat diet supplemented with cauliflower had the lowest VLDL levels and a slight increase in LDL cholesterol. In contrast, rats fed broccoli had lower LDL cholesterol levels but higher VLDL levels, possibly due to elevated triglyceride levels in the animal fat diet supplemented with 5% broccoli. Furthermore, compared to the positive control group (2.87%), rats fed cauliflower had a lower total cholesterol to HDL cholesterol ratio (2.20%) compared to those fed broccoli (2.30%). Several studies suggest that incorporating vegetables such as cauliflower into laboratory animals' diets positively affects the lipid profile. Antioxidants from these vegetables have been shown to reduce atherogenic cholesterol fractions (LDL + VLDL) while simultaneously increasing the beneficial HDL fraction, which may help prevent cardiovascular diseases, as mentioned in studies by Rasmussen et al. [42] and Elhassaneen et al. [43].

Table (4): Effect of cauliflower administration on serum vLDL, HDL and LDL of diabetic rats

Groups	HDL (mg/dl)		LDL (mg/dl)		VLDL (mg/dl)	
	Mean±SD	%	Mean±SD	%	Mean ±SD	%
NCG	53.09 ±1.08a	-21.13	68.15± 1.55def	-66.2	21.49±1.50e	-31.46
PCG	41.88 ± 1.12d	0	201.65± 2.83a	0	31.36±1.36 ab	0
CFG	47.00 ±20bc	-11.47	70.77± 2.19e	-64.9	27.25±1.05d	-13.12
CLG	46.00 ±1.5c	-7.56	108.59 ± 30b	-46.14	32.33±1.87 a	3.09
CSG	47.79±1.39 bc	-9.99	94.41±1.60d	-53.18	27.80±0.96cd	-11.35
CMG	49.08±2.01 b	-13.36	66.43± 0.55f	-67.06	22.60±0.6e	-27.93
CPG	48.89±1.01b	-7.92	101.37 ± 1.66c	-49.73	29.69 ±0.79 BC	-5.33
LSD	2.619		3.609		2.155	

*N.C.G: Negative control group; P.C.G: positive control group; CFG: cauliflower flower group; CLG: cauliflower Leaves group; CSG: Seeds group; CMG: Mix group; CPG: Pizza group. * HDL: High density lipoprotein, LDL: Low density lipoprotein and VLDL: Very low-density lipoprotein. The groups marked with distinct letters (a, b, c, d, e, f and g) within a given column exhibit significant differences of $p \leq 0.05$ as determined by the one-way ANOVA test using the LSD (Least Significant Difference) method. Groups labeled with the same lere not significantly different from each other.*

Table (5) displays the levels of liver enzymes AST, ALT, and ALP in units per liter (U/L) for the negative control, positive control, and various groups of diabetic rats fed different parts of cauliflower (flower, leaves, seeds, a mixture of them, and pizza). The data showed that all liver enzymes were significantly elevated in the positive control group compared to the negative control group. These changes were attributed to the effects of alloxan injection, which induced adverse reactions, damaged the pancreatic islets (Langerhans islands), and caused abnormalities in the laboratory parameters of the diabetic rats.

The greatest reductions in AST, ALT, and ALP detected in mix group, which were (122.70±1.25 U/L, 86.06±.99 U/L and 230 ±1U/L) respectively. The decline in AST between CFG and CPG, with percentage changes of -36.44 and -38.36,

respectively, was not statistically significant. Regarding ALT, there was no noticeable get between CSG (-16.25) and CPG (-13.54), as well as between CSG and CLG (-16.56). These results of current study apply to research findings such as the research of Elhassaneen et al., [43] found that, the activities of liver enzymes were lowered in serum of rats fed with cauliflower leaves as compared with control group. According to research by Zoidis et al., [44], glutathione peroxidase's role in the active site of the selenium-containing enzyme is the most significant antioxidant feature of selenium. In addition to supporting the detoxification of harmful radicals, glutathione peroxidase additionally promotes the fed reacylation of lipid molecules within the cellular membrane. Selenium was found to considerably diminish the hepatic damage. According to Barakat and Almundarij [45], phenolic compounds like those in the cruciferae family have been shown to mitigate the rise in serum levels of AST, ALT, and ALP.

Table (5): Effect of cauliflower administration on serum liver Enzymes (AST, ALT and ALP) (U/L) among diabetic rats

Group	AST (U-L)		ALT(U-L)		ALP (U-L)	
	Mean ±SD	%	Mean ±SD	%	Mean ±SD	%
NCG	95.47 ±2.79 f	-57.25	69.14 ±1.14 f	-55.79	170.96±1.22 g	-53.82
PCG	223.32 ±1.38a	0	156.42 ±1.07 a	0	370.20±1.05 a	0
CFG	141.92±1.92cd	-36.44	111.07± 1.06 d	-28.989	232.05±1 e	-37.32
CLG	158.08±0.92 b	-29.21	130.52±1.5 c	-16.56	294.10 ± 1.01 b	-20.55
CSG	145.45 ±0.78 c	-34.87	131.00 ±2 BC	-16.25	234.00±1 d	-36.79
CMG	122.70±1.25 e	-45.07	86.06±.99 e	-44.97	230.00 ±1f	-37.87
CPG	137.65 ±0.84d	-38.36	135.24±1.39 b	-13.54	246.00±1 c	-33.54
LSD	2.74		2.36		1.83	

*N.C.G: Negative control group; P.C.G: positive control group; C.F.G: cauliflower group; CLG: cauliflower Leaves group; CSG: Seeds group; CMG: Mix group; CPG: Pizza group. *AST: Aspartate aminotransferase, ALT: Alanine transaminase and ALP: Alkaline phosphatase. The groups marked with distinct letters (a, b, c, d, e, f and g) within a given column exhibit significant differences of p ≤ 0.05 as determined by the one-way ANOVA test using the LSD (Least Significant Difference) method. Groups labeled with the same lere not significantly different from each other.*

Table (6) illustrates how different parts of cauliflower and pizza impact the levels of creatinine, urea, and uric acid in diabetic rats. There was significant increases in creatinine, urea and uric acid for PCG at means (1.13±0.13, 50.00±1 and 5.91±0.17mg/dl), respectively, as compared with normal rats NCG group which showed (0.60 ±0.06, 28.54±0.94 and 2.80 ±0.30 mg/dl) respectively. These alterations resulted from the administration of alloxan to induce diabetes. Regarding for creatinine and uric acid, the influences of the experimented groups fed the cauliflower parts were similar and did not statistically significant, the mixture group showed the greatest enhancement by mean values

0.74 ±0.03 and 4.80±0.330, respectively. Regarding urea, all treated groups differ significantly from one another; the CLG group was the least effective and the CMG group was greatest effective, with average values 48.00±1 and 39.39±0.86, respectively. Cauliflower is a versatile vegetable suitable for individuals with chronic kidney disease (CKD]. Properly prepared, it can effectively substitute foods like rice, mashed potatoes, and even pizza crust. Additionally, cauliflower is nutrient-rich while being low in sodium, potassium, and phosphorus. Cauliflower had Sulforaphane that also improve kidney functions and controls blood pressure [46]. Also, the study of Arafa and Elmaadawy, [47] reported that the decreasing in serum uric acid and creatinine as the result of feeding with any family members of Cruciferae could be attributed to their higher content of phenolic compounds. Numerous studies have shown that polyphenols enhance kidney weight and improve serum levels of urea nitrogen, creatinine, and creatinine clearance. Additionally, they increase the activity of superoxide dismutase in the kidneys. Liebman and Le, [48] refers to the potential role for sulforaphane (SFN), that found in all members of the plant family Brassicaceae like cauliflower, in improves kidney functions

Table (6): Effect of cauliflower administration on serum Creatinine, Urea and uric acid of diabetic rats

Group	Creatinine (mg/dl)		Urea (mg/dl)		U.A (mg/dl)	
	Mean ±.SD	%	Mean ± .SD	%	Mean ±SD	%
NCG	0.60 ±0.06 d	-46.9	28.54±0.94 g	-42.92	2.80 ±0.30 e	-52.62
PCG	1.13 ±0.13 a	0	50.00 ±1 a	0	5.91±0.17 a	0
CFG	0.81±0.04 bc	-28.32	42.00 ±1 e	-16	5.01±0.33 cd	-15.22
CLG	0.90 ±0.04 b	-20.35	48.00 ±1 b	-4	5.60 ±0.30 ab	-5.24
CSG	0.83±0.03 bc	-26.54	44.00±1 d	-12	5.21 ±0.30 bcd	-12
CMG	0.74 ±0.03 c	-34.5	39.39±0.86 f	-21.22	4.80±0.33 d	-18.68
CPG	0.84 ±0.03 BC	-25.66	46.00 ±1 c	-8	5.40±0.20 bc	-8.63
LSD	0.1075		1.703		0.492	

*NCG: Negative control group; PCG: positive control group; CFG: cauliflower flower group; CLG: cauliflower Leaves group; CSG: Seeds group; CMG: Mix group; CPG: Pizza group. * U.A: uric acid. Values denote arithmetic ± standard deviation of the mean*
The groups marked with distinct letters (a, b, c, d, e, f and g) within a given column exhibit significant differences of p ≤ 0.05 as determined by the one-way ANOVA test using the LSD (Least Significant Difference) method. Groups labeled with the same lere not significantly different from each other.

Histopathological examination of the pancreas:

Light microscopic examination of rat pancreases from group 1 showed normal pancreatic acini and intact islets of Langerhans (Photos 1 & 2). In contrast, pancreases from group 2 exhibited histopathological findings including necrosis in islet cells (Photos 3, 4 & 6), infiltration of inflammatory cells (Photos 3, 4 & 5), and vacuolation of acinar epithelial cells (Photo 6). Some sections from group 3 showed slight vacuolization in islet cells and acinar epithelial cells (Photos 7), while

others displayed no histopathological changes (Photo 8). Pancreases from group 4 displayed vacuolization in islet cells (Photos 9, 10 & 11) and acinar epithelial cells (Photo 11). Additionally, some sections from group 5 showed normal pancreatic acini (Photo 12), whereas others indicated slight interacinar edema (Photos 13). Pancreases from group 6 showed no histopathological damage (Photos 14 & 15) except for slight vacuolization in some islet cells (Photo 16). Furthermore, pancreas sections from group 7 exhibited histologically normal pancreatic tissue (Photos 17, 18 & 19).

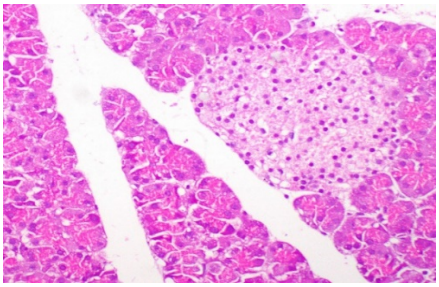


Photo. (1): A photomicrograph of a rat pancreas from group 1 depicts normal pancreatic acini and intact islets of Langerhans (H&E stain, 200x magnification).

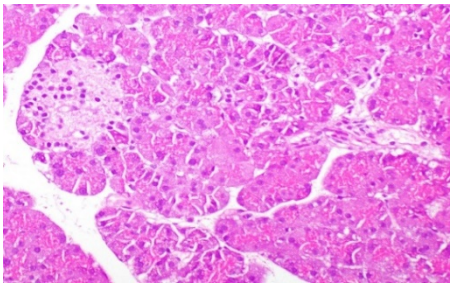
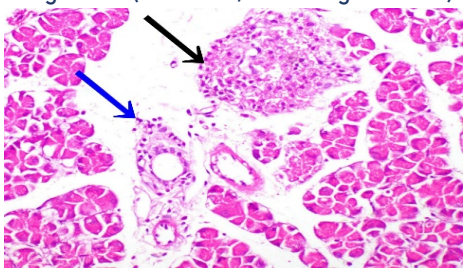
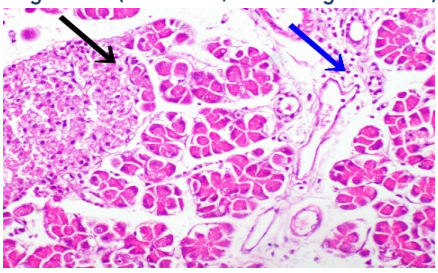


Photo. (2): A photomicrograph of a rat pancreas from group 1 reveals typical pancreatic acini and unremarkable islets of Langerhans (H&E stain, 200x magnification).



A photomicrograph of a rat pancreas from group 2 displays cell necrosis in the islets of Langerhans (marked with a black arrow) and infiltration of inflammatory cells (marked with a blue arrow) (H&E stain, 200x magnification).



A photomicrograph of a rat pancreas from group 2 indicates cell necrosis in the islets of Langerhans (indicated by a black arrow) and infiltration of inflammatory cells (indicated by a blue arrow) (H&E stain, 200x magnification).

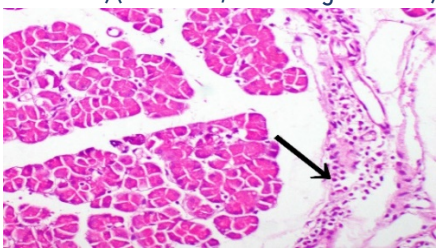


Photo. (5): A photomicrograph of a rat pancreas from group 2 displays infiltration of inflammatory cells (marked with a black arrow) (H&E stain, 200x magnification).

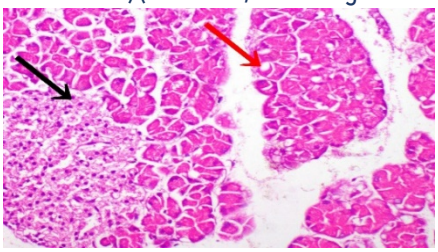


Photo. (6): A photomicrograph of a rat pancreas from group 2 reveals cell necrosis in the islets of Langerhans (indicated by a black arrow) and vacuolation in acinar epithelial cells (indicated by a red arrow) (H&E stain, 200x magnification).

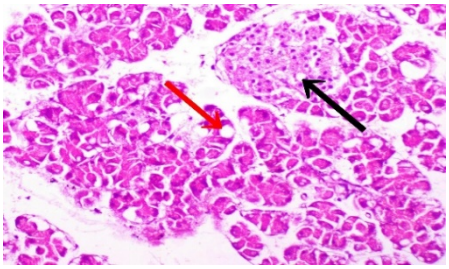


Photo. (7): A photomicrograph of a rat pancreas from group 3 exhibits minor vacuolization in certain cells of the islets of Langerhans (marked with a black arrow) and vacuolization in the epithelial lining of some acne (marked with a red arrow) (H&E stain, 200x magnification).

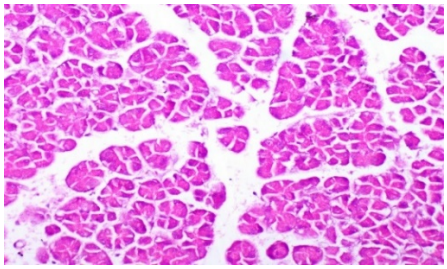


Photo. (8): A photomicrograph of a rat pancreas from group 3 indicates absence of histopathological alterations (H&E stain, 200x magnification).

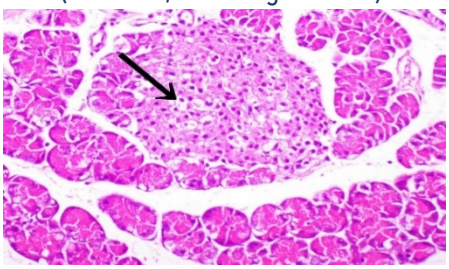


Photo. (9): A photomicrograph of a rat pancreas from group 4 displays vacuolization in certain cells of the islets of Langerhans (marked with a black arrow) (H&E stain, 200x magnification).

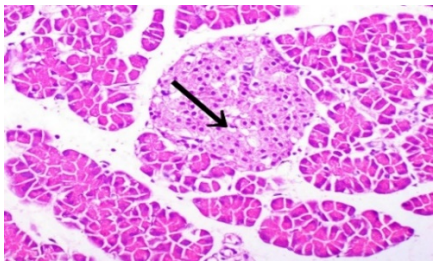


Photo. (10): A photomicrograph of a rat pancreas from group 4 reveals vacuolation in certain cells of the islets of Langerhans (indicated by a black arrow) (H&E stain, 200x magnification).

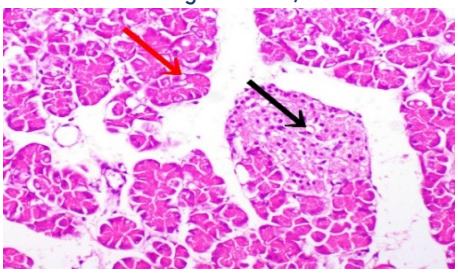


Photo. (11): A photomicrograph of a rat pancreas from group 4 reveals vacuolization in certain cells of the islets of Langerhans (marked with a black arrow) and vacuolization in cells lining some acini (marked with a red arrow) (H&E stain, 200x magnification).

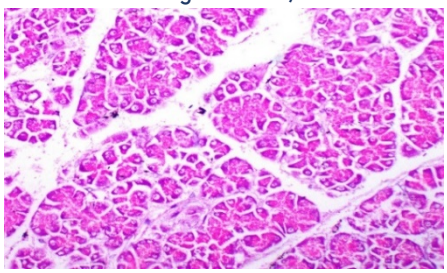
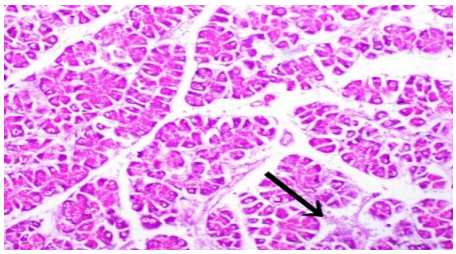


Photo. (12): A photomicrograph of a rat pancreas from group 5 displaying typical pancreatic acini (H&E stain, 200x magnification).



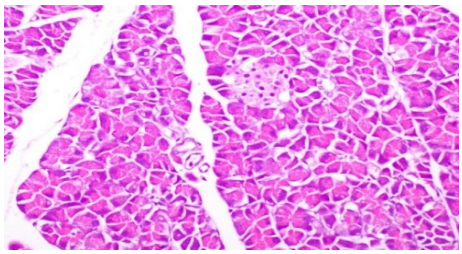


Photo. (13): A photomicrograph of a rat pancreas from group 5 reveals mild interacinar edema (marked with a black arrow) (H&E stain, 200x magnification).

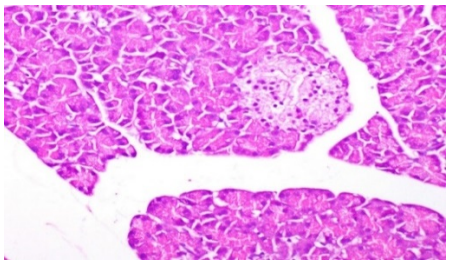


Photo. (14): A photomicrograph of a rat pancreas from group 6 indicating absence of any histopathological abnormalities (H&E stain, 200x magnification).

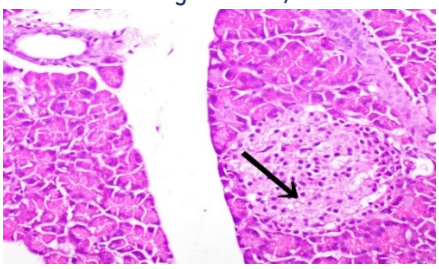


Photo. (15): A photomicrograph of a rat pancreas from group 6 reveals no evidence of histopathological damage (H&E stain, 200x magnification).

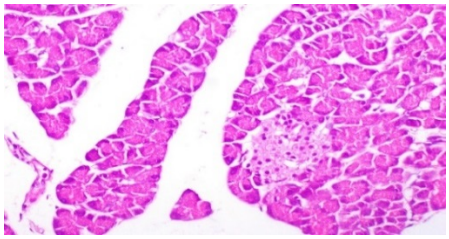


Photo. (16): A photomicrograph of a rat pancreas from group 6 displays mild vacuolization in certain cells of the islets of Langerhans (marked with a black arrow) (H&E stain, 200x magnification).

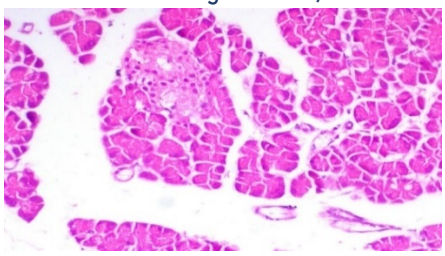


Photo. (17): A photomicrograph of a rat pancreas from group 7 depicting the normal histological appearance of pancreatic tissue (H&E stain, 200x magnification).

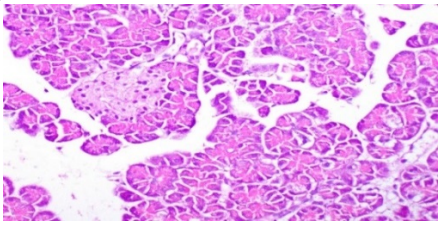


Photo. (18): A photomicrograph of a rat pancreas from group 7 displaying pancreas tissue with normal histology (H&E stain, 200x magnification).

Photo. (19): A photomicrograph of a rat pancreas from group 7 reveals pancreatic tissue with normal histological characteristics (H&E stain, 200x magnification).

5. Conclusion

The results summarized that the mixing group (CMG) had the best effect in reducing blood glucose levels, as the rate of decreasing change reached 44.59%. The greatest improvement was found in AST, ALT, ALP, creatinine, uric acid, and creatinine. All tested groups showed a significant decrease in the average values of lipids and lipoproteins. In conclusion, cauliflower parts (flower, leaf, seed, and a mixture of them) can be considered a powerful nutritional therapeutic method for treating diabetes.

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أجزاء نبات القرنبيط كعوامل محتملة للتغلب على مرض السكري لدى ذكور الفئران البيضاء

إيمان عبد الحميد، فاطمة الزهراء الشريف، مى غريب

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تاريخ النشر: ١ اكتوبر ٢٠٢٤

الملخص العربى:

داء السكري هو مرض مزمن يتعلق بعملية الأيض، ويتميز بارتفاع مستويات الجلوكوز في الدم. تهدف الدراسة إلى التحقيق في تأثير القرنبيط على الفئران المصابة بداء السكري. تم تقسيم اثنين وأربعين فأراً بالغاً إلى مجموعتين رئيسيتين؛ الأولى هى المجموعة الضابطة السلبية التي تم تغذيتها على النظام الغذائي الأساسي. تم إعطاء المجموعة الثانية (36 فأراً) مادة الألوكسان (بجرعة 150 ملغ/كغ من وزن الجسم) لتحفيز الإصابة بداء السكري، وتم تقسيمها إلى ست مجموعات متساوية (6 فئران في كل مجموعة): المجموعة الضابطة الإيجابية، مجموعة القرنبيط، مجموعة أوراق القرنبيط ، مجموعة بذور القرنبيط، مجموعة مزيج القرنبيط، ومجموعة بيتزا القرنبيط المدعمة. تم إعطاء جميع المجموعات المصابة بداء السكري جرعة تمثل 7% من النظام الغذائي الأساسي. أظهرت النتائج أن مجموعة المزيج كان لها التأثير الأفضل في خفض مستوى الجلوكوز في الدم، بينما كان لمجموعة أوراق القرنبيط أقل تأثير، حيث كانت نسبة التغيير بانخفاض 44.59% و27.56% على التوالي. بالإضافة إلى ذلك، تم تسجيل أفضل زيادة في الوزن ومعدل كفاءة التغذية لمجموعة المزيج بمتوسط قيمة 1.084±0.085 (غرام/فأر/يوم) و0.07±0.006 على التوالي. أظهرت جميع المجموعات التجريبية انخفاضاً ملحوظاً في متوسط قيم الملف الدهني والبروتينات الدهنية، حيث تراوحت نسبة الانخفاض بين (-52.82% إلى -33.64%) للكوليسترول الكلي و(-27.9% إلى -7.24%) للدهون الثلاثية خلال 28 يوماً من التغذية. علاوة على ذلك، لوحظت التحسينات الأكثر وضوحاً في مستويات إنزيمات الكبد، الكرياتينين، حمض اليوريك، ومستويات الكرياتينين في المجموعة التي تلقت المزيج باختصار، يمكن أن تكون الأجزاء المختلفة من القرنبيط (بما في ذلك الزهرة، الأوراق، البذور، ومزيجها) بالإضافة إلى البيتزا المدعمة عوامل علاجية فعالة لمرض السكري.

الكلمات الكاشفة: القرنبيط، ارتفاع السكر في الدم، الدهون، الكلى، إنزيمات الكبد