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Potential Effect of some Bakery Products Supplemented with Spirulina Algae in Alloxan-Induced Diabetic Rats

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Abstract:
Spirulina has been used to treat some diabetic symptoms because it contains natural antioxidants that can prevent diabetes-related damage to cell function. The research investigates how some bakery products, such as pizza and chocolate cake, include different concentrations of spirulina (2.5 and 5%) and affect diabetic rats. Thirty-six adult albino male rats Sprague –Dawley weighing 140±10 g. Six rats served as the control negative (-ve) group, and thirty rats were injected with alloxan (150 mg/kg/BWt i.p) to induce diabetes. Then, rats were reclassified into the control positive group and four treated rat groups which were administered pizza containing 2.5 & 5% Spirulina and chocolate cake containing 2.5& 5% Spirulina. The treatment period was designed for twenty-eight days. The levels of serum glucose, the liver enzymes [alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP)], the lipid profiles of triglycerides (TG), total cholesterol (TC), low-density lipoprotein (LDL-c), very low-density lipoprotein (VLDL-c), and high-density lipoprotein (HDL-c), as well as a renal function such as uric acid, creatinine, and urea all were measured. The results revealed that consuming pizza and chocolate cake incorporated with spirulina significantly decreased (P≤0.05) the level of serum glucose of rats, elevated HDL-c significantly, and enhanced liver and kidney functions in treated rat groups compared to the positive control group. In conclusion, adding spirulina-incorporated cake and pizza to our snack diet will significantly lower serum glucose levels.

Keywords*: Bakery products, Algae, Rats, Glucose, Diabetes mullites*

Introduction

Diabetes is a metabolic disorder characterized by continuously high blood sugar levels and is brought on by insufficient insulin production by the pancreas or inadequate insulin utilization

by the body (1). Types of diabetes can be distinguished. Juvenile-onset diabetes, also known as type 1 diabetes mellitus, is a disorder in which the pancreatic beta-cells do not produce any or very little insulin. It is brought on by autoimmune destruction to -cells brought on by hereditary or viral causes. It can manifest at any age but is most common in childhood or adolescence. The improper utilization of insulin by cells is a diagnostic of type 2 diabetes, known as non-insulin-dependent diabetes. It is brought on by inherited traits, obesity, and lifestyle choices. Less than 5% of pregnant women develop gestational diabetes, which is brought on by hormone levels (2). Additionally, non-hyperglycemic pathways for vascular damage, among which are also diabetic comorbidities like overweight and hypertension, complicated genetic study, diagnosis, and may be treatment of hyperglycemia-induced vascular damage (4).

Spirulina platensis is a cyanobacterium that is most frequently utilized for animal and human nutrition. Spirulina strains were given this designation by the food and drug administration (FDA) at the demand of some businesses since the metabolites it produces are not toxic to people (5). The protein, fat, crude fiber, ash, total carbohydrates, and energy value content as dry weight were 56.20%,10.50%, 5.01%, 11.27%, 17.02%, and 387.38 Kcal/100 g, respectively of Spirulina algae (6). One of the microalgae, spirulina, contains a high concentration of phycocyanin, which is an active component that can be utilized in cosmetics, pharmaceuticals, food additives, and fisheries (7). Spirulina is marketed as a non-toxic, nutritive food with remarkable qualities that provides 65% to 71% protein by dry weight. It contains high levels of amino acids like methionine, which is normally absent in other algae, carbohydrates, minerals, fat, fiber, vitamins, carotenoids, vital fatty acids, as well as phycocyanin are also present. Spirulina is being added to bread and other baked goods like bread, biscuits, and cake (8). In diabetic rats that had been given alloxan, spirulina reduced blood sugar. Because of its accessibility, affordability, and potency, spirulina may offer a new treatment route against diabetes and diseases associated with diabetes (9). The hypoglycemic properties of spirulina helped diabetic rats control their blood glucose levels. As a functional diet, spirulina holds promise in the treatment of diabetic rats. The phycocyanin's hypoglycemic action is ascribed to the chromium-binding phycocyanopeptide, which acts as an insulin receptor activator (10).

This study's objective is to investigate how different dosages of spirulina- incorporated cake and pizza affect the blood glucose levels of alloxan-induced diabetic rats.

Materials and methods

Materials

Spirulina algae were purchased from the Faculty of Agriculture, Al-Azhar University's for the boy’s section in Cairo City, Egypt. Alloxan is both a urea derivative and a cytotoxic glucose derivative, also known as 5, 5-dihydroxyl pyrimidine-2, 4, 6-trione, and a carcinogen that was acquired by the Cairo, Egypt, based Al-Gomhoria Co. for Trading Drugs, Chemicals, and Medical Instruments. The casein, cellulose, choline chloride as powder, and DL-methionine powder were delivered by the Morgan Company in Cairo, Egypt. At Helwan Farm in Cairo, Egypt, the Vaccination, and Immunity Organization gave 36 mature, healthy male albino Sprague Dawley rats weighing 140±10g. The chemical kits for the detection of glucose, lipid

profile, liver function, renal function obtained from Al-Gomhoria Co. for Chemical, Drug Trading and Medical Instruments.

The wheat flour. sugar, butter, fresh whole eggs, skim milk powder, baking soda, vanilla extract, and water are the components of the chocolate cake. These things were obtained at the North Cairo Mills Company, and local market in Cairo, Egypt.

Methods

Pizza formula and ingredients

The ingredients of wheat flour, yeast, sugar, salt, water, oil, onion sliced, tomato sauce, bell pepper, olives, and mozzarella cheese. Pizza are presented in table (1). Pizza supplemented with spirulina powders were prepared using the same formula except for adding of 2.5%, and 5% on the expense of wheat flour.

Table (1): Ingredient and formula of pizza

Ingredients (g)	Control	Pizza Spirulina powder 2.5%	5%
Wheat flour	500 g	97.50	95.0
Spirulina powder (g)	0.0	2.5 g	5 g
Yeast	10 g	10	10
Sugar	2.5 g	2.5	2.5
Sodium chloride	15 g	15	15
Water (ml)	200	200	200
Oil (ml)	10	10	10
Onion sliced	1 Onion	1	1
Tomatoes	2 Tomatoes	2	2
Bell pepper	2 Pepper	2	2
Olive	10 Olives	10	10
Mozzarella cheese	250 g	250	250

Preparation of pizza samples

Samples of pizza were produced using doughs that contained 2.5 and 5% spirulina algae powder as wheat flour supplement according to (11).

Wheat flour, yeast, sugar, and salt were combined with the other dry ingredients for the pizza, and the ingredients were progressively mixed with hot water till dough was produced. The dough was then incubated in a warm area for 30 minutes to start the fermentation process, after which it was divided into spheres and spread out to form a circle. After fermentation, 12-inch-diameter circles of dough were put in a pizza tray, which was then covered with tomato sauce, onion, tomato, pepper, olive pieces, and mozzarella cheese. The pizza tray was then baked for 15 minutes at 180°C before being utilized for sensory attributes (12).

Chocolate cakes formula and ingredients

Control chocolate cakes dough was prepared according to the formula of (13) presented in Table (2). Chocolate cakes supplemented with spirulina powders were prepared using the same formula except for adding of 2.5%, and 5% on the expense of wheat flour.

Table (2): The formula and ingredients of chocolate cakes with spirulina powder

Ingredients (g)	Control	Chocolate cake Spirulina powder 2.5%	5%
Wheat flour (72% extraction)	100	97.5	95
Spirulina powder	-	2.5	5
Sugar powder	50	50	50
Margarine	25	25	25
Fresh whole egg	15	15	15
Milk	50	50	50
Cocoa powder	10	10	10
Vanillin	0.25	0.25	0.25
Baking powder	3	3	3
Sodium chloride	1	1	1

Preparation of chocolate cake samples

Approved methods were slightly altered for cake preparation according to (14) dry cake ingredients were mixed except sugar. The butter and supplemented materials were mixed by using mixing machine at a medium speed for 3 min, then sugar was added to the mixture and beaten for 3 min, and the beaten eggs and vanilla were added then beaten for 2 minutes and affixed to the creamed fat- sugar mix and easily beaten at low speed for 5 transactions. Wheat flour (WF) and other ingredients were added to the previous blend gradually and beaten for 5 minutes. The batter was placed into tin mold pans size 30 were scaled into the greased mug and cooked at 180°C for 25 minutes in a preheated oven, air cooled at room temperature and packed in polyethylene packages.

The induction of diabetes

The (15) method described injecting 150 mg/kg of alloxan intraperitoneally into healthy, normal male albino rats to induce diabetes. The glucose concentration of diabetic rats was measured using blood samples one week after alloxan injections, and they were 200 mg/dl according to (16).

Planning an experiment

The research was conducted and approved in the Faculty of Home Economics, Animal House, Department of Nutrition and Food Science, University of Menoufia, Egypt, according to Ethical approval of the Science Research Ethics Committee of Faculty of Home Economics cleared the study protocol #19-SREC-11-2021.

The experiment used 36 mature male white albino "Sprague Dawley" rats weighed 140±10 g at 10 weeks of age, all rats were given a casein diet prepared in accordance with (17) as their basal diet. Following the adaptation phase" seven days" rats were divided into six groups of six rats each as follows: Group 1: As a negative control rats group which consume basal diet only. The other five groups were fed on basal diet and injected with alloxan (150 mg/kg/bwt i.p) to induce diabetes. Then, rats reclassified into control positive group and four treated rat groups which administered pizza containing 2.5 & 5% Spirulina and chocolate cake containing 2.5& 5% Spirulina as follows: Group (3): Diabetic rats fed on basal diet and

pizza supplemented with 2.5% spirulina algae of diet. Group 4: Diabetic rats fed on basal diet and pizza supplemented with 5% spirulina algae of diet. Group 5: Diabetic rats fed on basal diet and chocolate cake supplemented with 2.5% spirulina algae of diet. Group (6): Diabetic rats fed on basal diet and chocolate cake supplemented with 5% spirulina algae of diet.
After a 28-day experimentation period, blood samples were taken, each rat was individually weighed, and the experiment was then completed.

Blood sampling

Rats were fasted for 12 hours; they were scarified at the conclusion of the study which lasted 4 weeks. Blood samples were taken from the portal vein and placed in dry, cleaned centrifuge tubes to remove the serum. After that, the serum was centrifuged at 4000 rpm for 10 minutes (18). Serum samples were kept frozen at -18 °C for chemical analysis.

Biochemical analysis

The method of calorimetry was used for the enzymatic determination of serum glucose (19). T.C., T.G., HDL-c, LDL-c, and VLDL-c were measured using (20, 21 and 22). The procedures of (23), (24), and (25), respectively, were used to measure liver functions such as serum ALT, AST, and ALP. According to (26 and 27), an enzymatic test was used to estimate renal functions such serum urea and serum creatinine. Comparatively, serum uric acid was measured calorimetrically using the method of (28).

Statistical analysis

The data were investigated using a completely randomized factorial design (29), and the means were separated using the Student-Newman-Keuls test when a significant main effect was found. Differences between treatments with a ($P \leq 0.05$) were deemed significant by the Costat software. To evaluate the biological effects, a one-way ANOVA was performed.

Results and Discussion

Data presented in Table (3) show the effect of pizza and chocolate cake supplemented with different levels of spirulina algae on glucose levels on diabetic rats. It is clear to notice that there are significant differences ($P \leq 0.05$) between the negative control and positive control groups, with mean values of 254.80 and 125.90 mg/dl, respectively.
The diabetic group rats fed on a pizza + 2.5% spirulina algae had the maximum glucose level of any of the treated groups (diabetic). While the lowest value observed for diabetes group rats fed chocolate cake +5 % spirulina algae. The mean values were 169.00 and 134.30 mg/dl, respectively, with a significant difference ($P \leq 0.05$). These results concur with those of (30) who found that phycocyanopeptide in spirulina, which has the antioxidant properties of phycocyanin and acts as an insulin receptor activator by binding to chromium, which gives phycocyanin its hypoglycemic effects. Moreover, (31) discovered that spirulina algae at 400 mg/kg diet containing antioxidant compounds may reactivate pancreatic beta cells in rats with alloxan-induced diabetes.
Algae successfully prevented the development of diabetes in diabetic rats by lowering serum glucose levels (32).

Table (3): Effect of pizza and chocolate cake supplemented with different levels of spirulina algae on negative control and diabetic rats group

Groups	Glucose (mg/dl
G1 C (-)	125.90e±2.12
G2 C (+)	254.80a±3.16
G3 (Pizza +2.5% spirulina)	169.0b±2.50
G4 (Pizza +5% spirulina)	127.20e±1.13
G5 (Chocolate cake +2.5% spirulina)	142.57c±2.14
G6 (Chocolate cake +5% spirulina)	134.30d±1.12
LSD (P≤ 0.05)	2.741

Each value represents the mean ± SD of three replicates. Means in the same column with different letters (a, b, c & d) are significantly different at P≤0.05.

The data in Table (4) demonstrates how pizza and chocolate cake supplemented with different levels of spirulina algae affected the liver enzymes (ALT, AST, and ALP) of normal and diabetic rats. The ALT enzyme in the positive control group observed higher values than the negative control group, with values of 173.20 and 89.42 U/L, respectively that were significantly different (P≤0.05).

Regarding serum ALT liver enzyme, group 3 pizza with 2.5% spirulina had significantly greatest value, while group 6 (cake + 5% spirulina) had the lowest value. The corresponding values were 153.38 and 117.90 U/L, respectively.

Positive control group serum AST enzyme levels were considerably (P≤0.05) higher than negative control group levels. The corresponding mean values were 154.60 and 95.00 U/L.

The serum AST enzyme levels in groups 3 (pizza + 2.5% spirulina) and group 6 (cake + 5% spirulina) differed considerably between the groups (P≤0.05) that were132.30 and 103.97 U/L. These results support the findings of (33), who observed that spirulina treatment at levels of 20 and 30 mg/kg body weight improved and reduced plasma levels of liver enzymes. Additionally, spirulina supplementation significantly reduced blood AST, ALT, and ALP levels, demonstrating that this alga protects against liver dysfunctions. A preventive role for this alga against liver dysfunctions was also demonstrated by a substantial decrease in liver functions after spirulina supplementation, including serum AST, ALT, and ALP (34).

Table (4): Effect of pizza and chocolate cake supplemented with different levels of spirulina algae on liver enzymes of negative control and diabetic rats group

	ALT (U/L)	AST (U/L)	ALP (U/L)
G1 C (-)	89.42f±0.11	95.00f±0.12	73.89d±0.14
G2 C (+)	173.20a±0.16	154.60a±0.17	101.59a±0.15
G3 (Pizza +2.5% spirulina)	153.38b±0.15	132.30b±0.15	75.18d±0.13
G4 (Pizza +5% spirulina)	128.30d±0.13	113.15d±0.13	66.32f±0.12
G5 (Chocolate cake +2.5% spirulina)	147.33c±0.14	126.73c±0.14	90.50b±0.11
G6 (Chocolate cake +5% spirulina)	117.90e±0.12	103.97e±0.11	79.81c±0.10
LSD (P≤ 0.05)	3.842	2.650	2.401

ALT = Alanine aminotransferase, AST = Aspartate aminotransferase, ALP= Alkaline phosphatase. Each value represents the mean ± SD of three replicates. Means in the same column with different letters (a, b, c & d) are significantly different at P≤0.05.

Table 5 displays the effects of pizza and chocolate cake supplemented with different levels of spirulina algae on total cholesterol and triglycerides in hyperglycemic rats. The findings revealed that the positive and negative control groups' total cholesterol levels, that were 131.50 and 78.00 mg/dl, respectively, differed considerably (P≤ 0.05). Group 4 (pizza + 5% spirulina) had significantly recorded lowest cholesterol levels, whereas group 5 (chocolate cake + 2.5% spirulina) had the highest, that were 71.60 and 107.90 mg/dl.

Triglyceride values of the positive and the negative control group, on the other hand, were observed to differ significantly (P≤0.05). The values were 89.10 and 43.50 mg/dl, respectively. With a significant difference (P≤0.05), the group 4 that received chocolate cake + 2.5% spirulina had the highest levels of triglycerides whereas the group that consumed pizza + 5% spirulina had the lowest levels (P≤0.05). The respective readings were 54.48 and 68.55 mg/dl, respectively. These results support (35) who claimed that the algae's ability to lower triglyceride and total cholesterol levels-which it does since it has a high protein content and a low-fat content.

According to (36), the findings of our meta-analysis demonstrated the significant effect of supplementing with algae and its extracts in lowering TC and TG levels and enhancing HDL-C levels.

Table (5): Effect of pizza and chocolate cake supplemented with different levels of spirulina algae on total cholesterol and triglycerides of negative control and diabetic rats group

	TG (mg/dl)	TC (mg/dl)
G1 C (-)	43.50f±0.13	78.00e±0.10
G2 C (+)	89.10a±0.16	131.50a±0.17
G3 (Pizza +2.5% spirulina)	63.50c±0.14	100.27c±0.16
G4 (Pizza +5% spirulina)	54.48e±0.12	71.60f±0.11
G5 (Chocolate cake +2.5% spirulina)	68.55b±0.15	107.90b±0.13
G6 (Chocolate cake +5% spirulina)	59.42d±0.12	96.25d±0.15
LSD (P≤ 0.05)	1.263	2.960

(TG)=triglycerides, (TC) =total cholesterol. Each value represents the mean ± SD of three replicates. Means in the same column with different letters (a, b, c & d) are significantly different at P≤0.05.

The data listed in Table 6 shows how pizza and chocolate cake supplemented with different levels of spirulina algae affected the lipid profiles of hyperglycemic rats. The results revealed that the rats' HDL-c values in the negative and positive control groups differed significantly. They were 50.00 and 27.90 mg/dl on average. The treatment group's greatest HDL-c was found in group 6 (cake + 5% spirulina), while the lowest value was found in group 3 (pizza + 2.5% spirulina), with significant differences. The corresponding mean values were 44.59 and 32.60 mg/dl.

Rats in the positive control group, however, displayed higher LDL-c values with significant differences, which were 77.30 and 12.40 mg/dl, as compared to the negative control group. With a statistically significant difference, groups 3 (pizza + 2.5% spirulina) and 4 (pizza + 5% spirulina) had the highest and lowest LDL-c values of the treatment groups, respectively, measuring 47.62 and 16.80 mg/dl.

The data obtained by the positive and the negative control groups significantly differed in terms of VLDL-c. The respective mean values were 17.82 and 8.70 mg/dl. With significant differences (P≤0.05), group 5 (chocolate cake + 2.5% spirulina) in the treatment group had the greatest VLDL-c value compared to group 4 (pizza + 5% spirulina), which had the lowest value. These values were 13.71 and 10.90 mg/dl, respectively. These findings are in line with those of (37) who found that diabetic rats given various dosages of spirulina had considerably lower lipid fractions such as TC, TG, and LDL-c levels as well as greater HDL-c concentrations than the diabetic control group.

Algae powder can be added up to 4% to regular diets and contains physiologically active components that reduce oxidative stress and obesity-related bone health markers (38).

Table (6): Effect of pizza and chocolate cake supplemented with different levels of spirulina algae on lipid fraction of negative control and diabetic rats group.

	HDL-C (mg/dl)	LDL-c (mg/dl)	VLDL-c (mg/dl)
G1 C (-)	50.00a±0.17	12.40f±0.11	8.70d±0.10
G2 C (+)	27.90f±0.10	77.30a±0.17	17.82a±0.16
G3 (Pizza +2.5% spirulina)	32.60e±0.13	47.62b±0.15	12.70b±0.12
G4 (Pizza +5% spirulina)	40.48c±0.15	16.80e±0.10	10.90c±0.11
G5 (Chocolate cake +2.5% spirulina)	37.20d±0.14	45.12c±0.14	13.71b±0.15
G6 (Chocolate cake +5% spirulina)	44.59b±0.16	28.10d±0.12	11.84c±0.14
LSD (P≤ 0.05)	2.150	1.837	1.204

HDL-c = High-density lipoprotein cholesterol, LDL-c = Low-density lipoprotein cholesterol, VLDL-c = Very low-density lipoprotein cholesterol. Each value represents the mean ± SD of three replicates. Means in the same column with different letters (a, b, c & d) are significantly different at P≤0.05.

The data provided in Table 7 shows how pizza and chocolate cake supplemented with different levels of spirulina algae affected renal function in diabetic rats. The findings revealed a significant difference in the urea levels observed in the groups of positive and negative control rats, which were 63.91 and 35.29 mg/dl, respectively. Whereas group 3 (pizza plus 2.5% spirulina) had the highest urea level among the treatment group. However, group 6 (cake + 5% spirulina) recorded the lowest value with statistical difference, that were 57.33 and 39.16 mg/dl.

The uric acid levels in the group of rats used as a positive control and negative control group, however, differed significantly, that values were 7.60 and 2.96 mg/dl. The lowest value was found in group 6 (cake + 5% spirulina), and there was no statistical difference between the groups, whereas group 5 (cake + 2.5% spirulina) had the highest uric acid level of the treatment group. Both 6.88 and 5.92 mg/dl were the average values.

Although there was no statistically significant difference, creatinine levels were greater in the positive control group rats than the negative control group rats. They were, respectively, 1.01 and 0.52 mg/dl. With no statistical difference, G 6 (cake + 5% spirulina) had the lowest mean value while G3 (pizza + 2.5% spirulina) had the maximum creatinine level of the treatment group, with values of 0.99 and 0.81 mg/dl, respectively. These data suggest the theory put up by (39) that the mitigating effect due to the antioxidant properties of the spirulina extract, which improved renal function by attenuating the decline in kidney

function brought on by oxidative stress. Furthermore, according to (40) several bioactive components with possible antioxidant effects and the ability to enhance renal function are present in spirulina extracts.

Table (7): Effect of pizza and chocolate cake supplemented with different levels of spirulina algae on renal functions of negative control and diabetic rats group.

	Urea (mg/dl)	Uric acid (mg/dl)	Creatinine (mg/dl)
G1 C (-)	35.29f±0.12	2.96c±0.10	0.52b±0.12
G2 C (+)	63.91a±0.16	7.60a±0.15	1.01a±0.14
G3 (Pizza +2.5% spirulina)	57.33b±0.14	6.81a±0.14	0.99a±0.15
G4 (Pizza +5% spirulina)	44.12d±0.12	6.33b±0.14	0.84a±0.13
G5 (Chocolate cake +2.5% spirulina)	48.31c±0.15	6.88a±0.15	0.92a±0.12
G6 (Chocolate cake +5% spirulina)	39.16e±0.13	5.92b±0.13	0.81a±0.11
LSD (P≤ 0.05)	2.275	0.912	0.480

Each value represents the mean ± SD of three replicates. Means in the same column with different letters (a, b, c & d) are significantly different at P≤0.05.

Conclusion

The results obtained from the study revealed that the addition of spirulina with pizza and chocolate cake had a therapeutic value for lowering blood glucose levels and improving blood lipid profile and liver and kidney functions. Therefore, we recommend adding spirulina to baked goods to increase the therapeutic benefit for diabetics.

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التأثير المحتمل لبعض منتجات المخابز المدعمة بطحلب الأسبيرولينا في الفئران المصابة بالسكر المستحث بالألوكسان

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الملخص العربي:

تناول الأسبيرولينا تساعد على خفض أعراض مرض السكر لاحتوائها على مضادات الأكسدة الطبيعية التي يمكن أن تحمي وظيفة الخلايا التي يسببها مرض السكر. وتهدف هذه الدراسة إلى تقييم تأثير بعض منتجات المخابز مثل البيتزا وكيك الشوكولاتة مع الأسبيرولينا بمستويات مختلفة 2,5٪ ، ٥٪ في الفئران المصابة بمرض السكر. تم استخدام ستة وثلاثين من ذكور الفئران البيضاء البالغة التي تم تغذيتهم على الوجبات القياسية في هذه الدراسة. وتم تقسيم الفئران إلى ست مجموعات كل منها تحتوي علي ست فئران وكان متوسط وزن الفئران (١٤٠±١٠ جم). تم حقن الألوكسان بجرعة (١٥٠ مجم / كجم من وزن الجسم) في الغشاء البروتوني في الفئران للإصابة بالسكر. واستمرت التجربة لمدة ٢٨ يوم وفي نهاية التجربة ، تم قياس مستويات الجلوكوز في الدم، وأنشطة إنزيمات الكبد ألانين أمينوترانسفيراز (ALT)، والأسبارتات أمينوترانسفيراز (AST)، والفوسفاتيز القلوي (ALP)، وكذلك صورة دهون الدم مثل الدهون الثلاثية (TG)، والكوليسترول الكلي (TC) و البروتين الدهني منخفض الكثافة (LDL-c) والبروتين الدهني منخفض الكثافة جدا (VLDL-c) والبروتين الدهني عالي الكثافة (HDL-c) ووظائف الكلى لمستويات الكرياتينين وحمض البوليك واليوريا. وأظهرت النتائج أن تناول البيتزا وكيك الشوكولاتة المدعمة بالاسبيرولينا أدى إلى انخفاض معنوي ($P\leq0.05$) في مستوى الجلوكوز في الدم لدى الفئران، وارتفاع HDL-c بشكل ملحوظ، وتحسين وظائف الكبد والكلى في الفئران مقارنة بالمجموعة الضابطة الإيجابية. الخلاصة، إضافة الكيك المدعم بالأسبيرولينا والبيتزا إلى نظامنا الغذائي للوجبات الخفيفة ساهم بشكل أكبر في خفض مستويات الجلوكوز في الدم.

لكلمات الأفتتاحية: منتجات المخابز، الطحالب، الفئران، الجلوكوز، مرض السكر