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The Potential Effects of Moringa (*Moringa oleifera L.*) Seeds and Celery (*Apium graveolens L.*) Seeds on Diabetic Rats

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Abstract:
This study aims to compare the effect of different concentrations of 5 and 10% of M.oleifera (*Moringa oleifera L.*) and celery (*Apium graveolens L.*) seeds on glucose levels in diabetic rats. Forty-two adult male albino rats weighing (140-150 g) were divided into seven groups (six rats in each group). The first group was kept as a control (-ve) group, while the other groups were injected with Alloxan (150 mg/kg body weight) to become diabetic rats; one group of them was kept as a control (+ve) while four diabetic groups were treated with different concentrations of M. oleifera and celery. The last group was treated with Glucophage. After 35 days, glucose levels, cholesterol, triglycerides (T.G), high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), very low-density lipoprotein cholesterol (VLDL-c), kidney functions, and liver functions were evaluated by biochemical tests. The results revealed that both plants decreased glucose levels and improved functions of the kidney and liver by lowering SGPT, SGOT, creatinine, and uric acid. Also, both plants enhanced lipids profile by reduction of serum triglycerides, low-density lipoprotein, very low-density lipoprotein, and increased high-density lipoprotein compared to the positive control group. In conclusion, all biochemical analyses reflect the power of Moringa oleifera and celery seeds as nutraceutical therapeutics for treating diabetes in rats. The best result was recorded at a 10% Moringa oleifera seeds powder concentration.

***Keywords**: Diabetes, Rats, Biochemical analysis, Moringa oleifera, Celery*

Introduction

Diabetes mellitus is one of the most common chronic diseases affecting more than 100 million people over the world [1]. It represents a series of metabolic conditions associated with hyperglycemia caused by a deficiency in insulin secretion from pancreatic β-cells or no /low effectiveness of secreted insulin [2,3]. Hyperglycemia is characterized by polyuria,

polydipsia, weight loss, and blurred vision [4]. Additionally, acute hyperglycemia is led to ketoacidosis or nonketotic hyperosmolar syndrome [5].

For a long time, herbs and plants were used as traditional medicine or healthy food in many countries. These plants are natural sources of bioactive compounds such as antioxidants that have therapeutic potential for various diseases [6]. In that case, *M. oleifera* is one of the best therapeutic plants which is described as the miracle tree or a God's Gift to man [7]**.**

M. oleifera has different names in different languages like "horseradish tree", "moringa", "ngela" "rawag" [8]. The native origin of *M. oleifera* is India and sub-Himalayan tracts, Pakistan, Asia Minor, Africa, and Arabia [9]**.** Almost all parts of *M. oleifera* can be used in different ways as edible food and medicinal resources, including leaves, roots, seeds, flowers, and bark [10,11]. *M. oleifera* is widely utilized in indigenous medical systems such as antipyretic, anti-inflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol-lowering, antidiabetic, hepatoprotective, antibacterial, and antifungal activities [12]. Additionally, the extract of *M. oleifera* seeds has antidiabetic properties because it contains phytochemical compounds (mainly glucomoringin, quercetin, kaempferol, and chlorogenic acid) [13]. Therefore, it is often used to maintain pancreatic β-cells by decreasing oxidative stress and protecting pancreatic β-cell integrity. [14]

Celery seeds are another example of therapeutic plants. Celery seeds are known scientifically as *Apium graveolens* and belong to the plant family Apiaceae, which has long been used for medicinal purposes [15]. The original native of celery is Spain, which is grown mainly in coastal regions; therefore, the highest quality celery grows in cold and mild environments [16].The most active compounds in celery were found in its seeds rather than in the other parts of the plant [17]. Celery has a high content of flavonoids such as (apiosyl-glycosides, glucosides of luteolin, apigenin, and Chryseoriol), and phenolic acids such as (chlorogenic acid, cinnamic acid, coumarins, and their glycosides) [18].Celery has some synergistic beneficial effects on diabetes and hypertension. In addition, no reports pointed to the toxicological effects of celery seeds [17].

Hypoglycemic effects of celery seeds may result from increased utilization of peripheral glucose; also, the isolated compounds from the seeds exhibited antioxidant and inhibitory effects of cyclooxygenase and topoisomerase enzymes (type I and II) [19]. Celery may support the extra-pancreatic mechanism, which might be involved in reducing blood glucose concentration via enhanced glucose transport into the cells and increased utilization of glucose by the liver for glycogen synthesis [15].

The purpose of this study was to find out the effects of different levels of *M. oleifera*, and celery seeds as powder on reducing blood glucose levels and some hematological parameters in alloxan-induced diabetic rats.

Material & Methods

Materials

M. oleifera seeds (*Moringa oleifera Lam*) and celery seeds (*Apium graveolens*) were purchased from the Agricultural Research Center, Al-Dokki, Giza governorate, Egypt. Alloxan

(5,5-Dihydroxypyrimidine-2,4,6(1*H*,3*H*,5*H*)-trione) was obtained from Sigma Chemical Co. in the United States and used to induce diabetes in rats.

Chemical kits used for determination (TG, TC, HDL-c, SGPT, SGOT, uric acid, and creatinine) were purchased from the Al-Gomhoria Company for Trading Drugs and Medical Instruments, Cairo, Egypt.

Sample extraction

Ethanol extract of *M. oleifera* seeds and celery seeds was prepared as follows: one gram of *M. oleifera* seeds or celery seeds powder was added to 100 ml ethanol. The mixture was left on a shaker for 24 h, then centrifuged under cooling at 10000 rpm for 10 min (Centrifuge, HERMLE Z 326K, Germany) and the supernatant was filtered through Whatman No. 41 filter paper. The volume of filtered supernatant was adjusted to 100 ml again, kept at -20^{0}C, and for up to one week to use

DPPH, ABTS, and FARP antioxidant activity assays

Three activity assays were carried out to measure the free radical scavenging capacity of *M. oleifera* seeds and celery seeds. Ethanolic extract using the in DPPH assay (1,1-diphenyl-2-picryl hydrazyl) according to the method described by Akillioglu and Karakaya [20], the ABTS$^{\bullet}$+ (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) assay was carried out according to the method of Gouveia and Castilho [21] and FRAP (Ferric Reducing Antioxidant Power) assay was carried out according to the method reported by Benzie and Strain [22].

Preparation of balady bread

Balady bread preparation was done on an automatic commercial baking line according to Eissa *et al*. [23] in the official baking house, North of Cairo city, Egypt. In the control sample, balady bread was prepared from wheat flour (82% extraction). The baking recipe was as follows: 100 g of flour, 0.5 g of active dry yeast, 1.5 g of sodium chloride, and 75–80 mL of water. All ingredients were mixed by hand for about 6 min to form the needed dough. The dough was left for 1 h to have a good fermentation at 30°C and 85% relative humidity (RH). After that, the dough was divided into 125 g pieces and was arranged on a wooden board which was covered by a fine layer of bran. The pieces of dough were left to ferment again for about 45 min at the same previous temperature and RH. The pieces of fermented dough were spread to be about 20 cm in diameter. After the flatting process, the loaves were proof at 30 ^{0}C and 85 % RH for 15 min., and then baked at 400 - 500 ^{0}C for 1-2 min. The loaves were left to cool for 2 h at room temperature. The experimental samples were executed in the same steps as the control sample, but with different levels of *M. oleifera* (5, 10 %) on account of wheat flour.

Physical analysis of balady bread

The measurements of loaf quality were estimated in triplicate according to Dawoud [24]. The diameter of the loaf was taken by measuring tape (cm). The height (cm) was measured in the center of the loaf. After one hour at room temperature (~25^{0}C), the loaves were cooled, and volume was measured by rapeseed displacement. The loaves were weighed after baking, and specific volume was also calculated (Volume/weight).

Sensory evaluation

All samples were presented to twenty panelists. The samples were coded with a three-digit number and were evaluated for their sensory attributes. The scoring scheme was as follows: taste (20), odor (15), texture (15), pulp (15), crust (15), and general appearance (20) as described by Atia [25]. The average total score was converted to a descriptive category as follows: 90-100: very good 80- 90: good 70-79: satisfactory less than 70: questionable.

Biological experiment

Animals

Forty-two healthy adult male albino rats of Sprague Dawley strain, 10 weeks age, weighing between 140-150 grams were purchased from the Giza Memorial Institute for Ophthalmic Research, Animal House, Ministry of Health, Giza, Egypt. The experiment was done in the Experimental Animal Laboratory, Faculty of Home Economics, Menoufia University, Shebin El-Kom. The animals were housed in wire cages under controlled normal laboratory conditions. All rats were fed on the basal diet prepared according to the American Institute of Nutrition (AIN), [26] for one week. After this adaptation period, the rats were divided into seven groups (six rats in each group). The first group was kept as a negative control (-ve) group, while the other rat groups were injected with a single intraperitoneal Alloxan dose (150 mg/kg body weight) to become diabetic rats according to the method described by Desai and Bhide [27]; one group of them was kept as a positive control (+ve), while each group from the four diabetic groups was treated with 5 or 10 % concentrations of M.oleifera or celery. The last group was treated with Glucophage at a concentration of 250 mg/kg body weight in 0.9% NaCl solution.

Normal diet ingredients including casein, choline chloride powder, cellulose, and DL-methionine powder were purchased from Morgan Company, Cairo, Egypt. The mixture of normal diet was kept in the refrigerator at 4°C until used.

Sample collection

After thirty-five days, animals were fasted overnight and sacrificed under diethyl ether anesthesia. Blood samples will be collected in a clean dry centrifuge tube from the hepatic portal vein. Serum was taken from completed blood by centrifuge (Centrifuge, HERMLE Z326K, Germany) at 5000 rpm for ten minutes, then kept in a plastic vial in a deep freezer until analysis.

Biochemical analysis

Serum blood glucose was assessed using the modified kinetic technique described by Kaplan, [29] using a kit provided by spin reacts.

The colorimetric technique reported by Thomas, [30] was used to measure serum total cholesterol, While Serum triglycerides (T.G) were determined by enzymatic method using kits according to Young [28] and Fossati and Pricipe. [29], HDL-c was determined according to the method described by Allain [30] while VLDL-c and LDI-c were determined in milligrams per deciliter (mg/dl) according to Lee and Nieman, [31] using the following formula:

VLDL-c (mg/dL) = Triglycerides / 5.

LDL-c (mg/dL) **=** Total cholesterol – (HDL-c + VLDL-c).

Determinations of serum alanine amino transferase (SGPT) and serum asparatate amino transferase (SGOT), by using the modified kinetic method of Tiez [32] and Henary [33], respectively. Serum creatinine was measured by the method of Henary [33], while the assessment of uric acid has been performed by using the colorimetric method of Barham and Tinder, [34].

This experiment was carried out in accordance with the guidelines of the Scientific Research Ethical Committee of Menoufia University, Experimental Animal Laboratory, Faculty of Home Economics, Shebin El-Kom, Menoufia Governorate, Egypt.

Statistical analysis:

Results were presented as mean (M) ± standard deviation (SD). To assess significant differences among experimental animal groups or other parameters. The one-way ANOVA analysis of samples was performed using the costate program. If the F. test is significant at P≤ 0.05, the least significant differences (LSD) test was done.

Results and Discussion

The values of total flavonoids and total phenols in *M. oleifera* and celery extracts were presented in Table 1, which have been implicated as possible bioactive agents leading to toxicological and antidiabetic effects. The content of total phenols in *M. oleifera* (94.99 mg gallic/g sample) was almost four times in the celery (26.57 mg gallic/g sample), while the total flavonoids had an opposite trend compared with total phenols.

Data from the previous table displayed the DPPH test, which was used to evaluate the radical-scavenging potential of a sample including *M. oleifera* and celery extracts. Usually, the high percentage or concentration of DPPH reflects the ability of theses extracts to scavenge the free radicals in human body. The percentage of DPPH in the *M. oleifera* and celery was 37.11 % and 28.16 %, respectively.

In comparison between extracts of M.oleifera and celery in their ABTS content, our results showed that the ABTS content was recorded higher value in the *M. oleifera* (498.12 µM Trolox/g sample) than celery (163.51 µM Trolox/g sample). The ABTS is a unique assay, which can be estimated in both organic and aqueous extracts, and can be applied at different pH conditions. The mechanism of ABTS depends on the cation radical of ABTS which result from loss of electron yields to form 2,2-azino-bis (3- ethylbenzothiazoline-6-sulphonic acid) diammonium salt. In the presence of hydrogen donated atom from any substance such as test article or standard Trolox. The charges are suppressed and the solution change from bluish green colored to uncolored or clear.

FRAP is another simple method used to estimate the power of substance as an antioxidant. The value of FRAP antioxidant capacity assay recorded 0.185 and 0.147 µM Trolox/g sample of M.oleifera and celery extracts, respectively. The principle of this method depends on the reduction of ferric (Fe3+) form of substance to ferrous (Fe2+) form, this method was carried out in acidic conditions (pH 3.6) to maintain the solubility of iron in ferric and ferrous form Hagerman et al. [35]

In general, *M. oleifera* showed higher values in all parameters except T. flavonoids than celery extract. These results are in harmony with Watanabe et al. [36] and Irfan et al.[37]

reported that M.oleifera seeds have a high concentration of antioxidants, and it had a protective role for organs such as the pancreas and liver and protecting them from oxidative stress resulting from increased blood sugar. Additionally, Abd El-Ghany et al. [38]; Kooti et al. [39] and Mans and Aburjai [19] reported that phenols, flavonoids, and antioxidants play biological vital roles including clearing the active oxygen species and preventing oxidative stress-related diseases and hyperglycemia.

Table (1): Determination of total phenols, total flavonoids, and antioxidant capacity assays (ABTS, DPPH radical scavenging activity, and free radical reducing power (FRAP)) in M. oleifera and celery extracts.

	M.oleifera seeds Mean ± SD	Celery seeds Mean ± SD
T.Phenols (mg Gallic acid /g sample)	94.992 ± 0.745	26. 571 ± 0.123
T. Flavonoids (mg Catachin /g sample)	0.087 ± 0.002	2.264 ± 0.023
DPPH (%)	37.116 ± 0.991	28.166 ± 0.198
ABTS (µM Trolox/g sample)	498.12 ± 2.485	163.514 ± 2.623
FRAB (µM Trolox/g sample)	0.185 ± 0.015	0.147 ± 0.012

Each value is represented as mean ± standard deviation (n=3).

Data in Table 2 presents the effect of *M. oleifera* and celery seeds powder on the glucose level of diabetic rats. The obtained data indicated that the positive control group had a higher glucose level compared with the negative control group which had a lower level, with a significant difference (P≤0.05). The mean values of the positive and negative groups were 342.33 and 89 mg/dl, respectively. On the other hand, a group of rats treated with Glucophage have a significant (P≤0.05) reduction in serum glucose levels compared with the positive control group.

In general, the high level of 10 % *M. oleifera* or celery has improved the glucose level more than the level at 5% but the groups of *M. oleifera* have a high effect on the reduction of the serum glucose level compared with the celery groups.

These findings were in accordance with previous findings of AL-bayuomi and Gabr [40] who found that the treatment with M.oleifera seeds revealed a safe and excellent antidiabetic activity that led to a significant decrease in fasting serum glucose (FSG) and HbA1c. This result was due to *M. oleifera's* content of antioxidant compounds such as phenols, flavonoids, and glucomoringin which helped to restore the diabetic rats to a normal healthy state [41].On the other hand, celery seeds contain flavonoids, which have anti-diabetic effects by increasing stimulated insulin secretion, improving the integrity of pancreatic beta cells, decreasing gluconeogenesis in the liver, and control of glucose absorption from the intestine [14].

Data in Table 3 showed the effect of *M. oleifera* and celery seeds powder on the mean value of the liver functions (SGPT and SGOT) of diabetic rats. No significant differences (P>0.05) were observed between the negative control group, the Glucophage group, and 10 % *M. oleifera* group in serum SGPT, which recorded 30, 33, and 32.33 U/L, respectively.; It means

the previous groups have the same effect in reducing serum SGPT in diabetic rats. The same previous trend was observed between celery groups.

Table (2): Effect of M. oleifera and celery seeds powder on glucose level of diabetic rats.

Groups	Glucose level (mg/dL) Mean ± SD
G1 (Control -)	89.000a ± 3.605
G2 (Control +)	342.34f ± 2.516
G3 (Glucophage)	100.33b ± 6.506
G4 (5 % *M. oleifera*)	124.33c ± 3.055
G5 (10 % *M. oleifera*)	99.000b ± 3.605
G6 (5 % Celery)	175.00e ± 5.000
G7 (10 % Celery)	134.67d ± 4.509
LSD	8.253

Each value is represented as mean ± standard deviation (n = 6). Mean under the same column superscript with different letters are different significantly (P≤0.05).

It is clear to notice that the groups of diabetic rats fed with 10 % *M. oleifera* or Glucophage had a lower serum SGOT than the other groups except the negative control group. In general, *M. oleifera* groups were the most effective in reducing the SGOT level more than the celery groups. These results are in harmony with [42,43] who found that M.oleifera extract has hepatoprotective power by restoring normal liver function due to its nutritional properties such as boosting the total proteins and albumin level. Additionally, the hepatoprotective activity of M.oleifera is due to the presence of phytochemicals (alkaloids, anthocyanins, and β-carotene) that have an antioxidant and anti-inflammatory effect and the ability to scavenge free radicals [44,45].On the other hand, Mahmood and Abdul Kreem, [46], and Hegazy et al. [47] found that celery seeds have hepatoprotective action against hepatocarcinogenesis by inhibitory effects on certain enzymes and enhance antioxidative activity. This effect of celery may be due to its content of flavonoids, tannins, alkaloids, sterols, and triterpenes [48, 49].

The results of *M. oleifera* and celery seeds powder on creatinine and uric acids levels in diabetic rats are displayed in Table 4. At 5 or 10 % concentration of *M. oleifera* and celery groups, no significant differences (P>0.05) were observed between these groups.

In general, the *M. oleifera* and celery groups had a reduction effect on creatinine level compared with the positive control group, but the best concentration was observed at 10% M.oleifera or celery.

Uric acid had the same creatinine trend but between the same kind not concentrations. It means no significant differences (P>0.05) were observed between 5 and 10 % of *M. oleifera* groups or celery groups, but both *M. oleifera* groups or celery groups showed significant (P≤0.05) differences between them (P≤0.05).In any case, the *M. oleifera* groups had the best significant (P≤0.05) effect of reducing uric acid concentration more than the celery groups at any concentration.

Table (3): The effect of M. oleifera and celery seeds powder on liver functions (SGPT and SGOT) of diabetic rats.

Groups	SGPT(U/L) Mean ± SD	SGOT(U/L) Mean ± SD
G1 (Control -)	30.00a ± 1.000	29.00a ± 2.645
G2 (Control +)	75.33d ± 2.516	89.33e ± 4.041
G3 (Glucophage)	33.00a ± 1.732	32.66ab± 2.516
G4 (5 % *M. oleifera*)	37.33b ± 1.154	42.66c ± 2.516
G5 (10 % *M. oleifera*)	32.33a ± 2.516	36.33b ± 2.309
G6 (5 % Celery)	41.66c ± 1.527	57.33d± 2.516
G7 (10 % Celery)	40.00bc ± 1.000	52.66d ± 2.516
LSD	3.0567	5.113

Each value is represented as mean ± standard deviation (n = 6). Mean under the same column superscript with different letters are different significantly (P≤0.05).

These findings are consistent with those of Pooja et al. [50], and El Rabey et al. [51] who found that treating diabetic rats with *M. oleifera* seeds powder impact a highly significant decrease in the level of serum creatinine and has a protect against diabetic nephropathy. In another study, the extract of *M. oleifera* enhanced the ability of the kidneys by lowering the urea in serum due to the high concentration content of glucomoringin, phenols, and flavonoids in *M. oleifera*. [52, 53]

Beltagy et al. [54] and Soliman et al. [55] said that the effect of celery against renal failure in rats fed on diets with different levels of celery is due to the presence of polyphenols. Based on the above celery had a clear influence on exhibited improvement in the activity of creatinine.

Table (4): The effect of M. oleifera and celery seeds powder on kidney functions of diabetic rats:

	Creatinine (mg/dl) Mean ± SD	Uric acid (mg/dl) Mean ± SD
G1 (Control -)	0.713ab ± 0.010	2.333a ± 0.208
G2 (Control +)	1.310d ± 0.005	6.400e ± 0.360
G3 (Glucophage)	0.720abc ± 0.095	3.300cd ± 0.200
G4 (5 % M.oleifera)	0.773bc ± 0.058	2.866bc ± 0.208
G5 (10 % M.oleifera)	0.623a ± 0.090	2.433ab± 0.305
G6 (5 % Celery)	0.816c ± 0.032	3.670d ± 0.407
G7 (10 % Celery)	0.656a ± 0.016	3.500d ± 0.264
LSD	0.1003	0.528

Each value is represented as mean ± standard deviation (n = 6). Mean under the same column superscript with different letters are different significantly (P≤0.05).

The effect of *M. oleifera* and celery seeds powder on the lipid profile of diabetic rats is displayed in Table 5. According to the previous table, three parameters showed the same trend, these parameters were triglyceride, total cholesterol, and very low-density

lipoprotein. According to the kind and concentration, the best group was observed in *M. oleifera* at 10 % concentration, while the Glucophage group recorded the best treatment compared with the negative control group. On the other hand, significant differences (P≤0.05) were observed between 5 and 10 % of *M. oleifera* groups or the celery groups.

Low-density lipoprotein cholesterol (LDL-c) is another parameter is shown in Table 5. 10 % of *M. oleifera* was very effective in reducing LDL-c level compared with the positive control group which recorded 15.43 and 150.45 mg/dl respectively. All *M. oleifera* groups and celery groups at the same/different concentrations showed significant differences (P≤0.05) between them in LDL-c level.

The High-density lipoprotein cholesterol (HDL-c) values are displayed in Table 5. The statistical analysis of the HDL-c variable has the same trend of triglyceride, total cholesterol, and very low-density lipoprotein except for one result. This result has observed no significant differences (P>0.05) between 5 % of the celery group and 10 % of the celery group or Glucophage group. In addition, the Glucophage group has a low impact on HDL-c levels between all treatments

Finally, it is clear to notice that the high level of M.oleifera at 10% concentration has improved the lipid parameters more than 5 % of *M. oleifera* and any concentration of celery groups. These findings support Reddy et al. [56] and Elbakry et al. [57] who said that the polyphenol extract of *M. oleifera* exhibited cholesterol-lowering activity in rats by influencing lipid metabolism as proven by inhibiting the key enzyme in the synthesis of cholesterol and fecal excretion of cholesterol metabolites. Addition to, the high phenolic and other bioactive compounds in *M. oleifera* seeds prevented the increase in an angiotensin-I converting enzyme (ACE) and arginase activities therefore, it has a role in the management of hypertriglyceridemia [58].On the other hand, Kamal et al. [59] and Hedayati et al. [60] found that celery had an antihyperlipidemic effect on diabetic mice and could be reducing serum total cholesterol by helping in the support of healthy blood pressure and cholesterol levels because it has a positive impact on prostaglandin levels. Also, celery can be used for reducing lipid peroxidation and cholesterol due to its antioxidant compounds, especially Apigenin which acts as a very powerful antioxidant that prevented an increase in LDL. [39].

Table (5): The effect of M. oleifera and celery seeds powder on the lipid profile (triglycerides, serum total cholesterol HDL-c, LDL-c, and VLDL-c) of diabetic rats.

	Triglycerides (mg/dl) Mean ± SD	T.cholesterol (mg/dl) Mean ± SD	HDL-c (mg/dl) Mean ± SD	LDL-c (mg/dl) Mean ± SD	VLDL-c (mg/dl) Mean ± SD
G1 (Control-)	83.49^{ab}±3.02	84.33^{ab}±3.05	56.68^{a} ±0.30	10.94^{a}±0.26	16.7^{ab}±0.60
G2 (Control+)	226.05^{f}±7.56	228.33^{f}±7.63	32.66^{f} ±2.51	150.45^{f}±7.82	45.21^{f}±1.51
G3(Glucophage)	80.19^{a}±2.61	81.00^{a}±2.64	45.16^{e} ±0.87	19.80^{bc}±1.31	16.03^{a}±0.52
G4(5%M.O)*	92.07^{c}±2.97	93.00^{c}±3.00	50.98^{c} ±0.34	23.60^{c}±2.10	18.41^{c}±0.59
G5(10% M.O)	85.14^{b}±1.71	86.00^{b}±1.73	53.54^{b} ±1.33	15.43^{ab}±0.25	17.03^{b}±0.34
G6(5% *Celery*)	107.9^{e}±0.99	109.00^{e}±1.00	46.70^{de}±1.00	40.71^{e}±0.96	21.58^{e}±0.20
G7(10%*Celery*)	101.64^{d}±2.49	102.66^{d}±2.51	47.96^{d} ±1.56	34.37^{d}±0.75	20.32^{d}±0.49

	Triglycerides (mg/dl) Mean ± SD	T.cholesterol (mg/dl) Mean ± SD	HDL-c (mg/dl) Mean ± SD	LDL-c (mg/dl) Mean ± SD	VLDL-c (mg/dl) Mean ± SD
LSD	4.828	4.877	2.379	5.358	0.966

** M.O = Moringa oleifera*

Each value is represented as mean ± standard deviation (n = 6). Mean under the same column superscript with different letters are different significantly (P≤0.05).

In general, *M. oleifera* seed powder had a better effect than celery seed powder on lowering sugar, lipid profile, and kidney functions in hyperglycemic rats under the influence of alloxan; for this reason, *M. oleifera* was used to fortify balady bread as a cheap, easy, and appropriate application. Therefore, the fortification of flour (80% extraction) was done by 5% and 10% of *M. oleifera* seed powder for the production of balady bread.

Physical analysis of balady bread

The Loaf characteristics of balady bread supplemented with 5% and 10% of *M. oleifera* seed powder are presented in Table 6. It was observed that the addition of 10% *M. oleifera* seed powder showed the best significant ($P \leq 0.05$) effect on the weight and volume of balady bread compared with balady bread fortified with 5 % *M. oleifera* seed powder. The weight and volume of balady bread fortified with 10 % of *M. oleifera* seed powder were enhanced from 86.3 gm and 102.8 cc to 91.5 gm and 105.2 cc, respectively. On the other hand, at all levels of *M. oleifera* seed powder added to balady bread no significant ($p > 0.05$) differences were noticed on other parameters (specific volume, height, and loaf diameter) compared with the control balady bread.

These results agree with those reported by Ogunsina et al. [61] who blended flour with different levels (5% and 10%) of Moringa seed powder. Also Bolarinwa et al. [62] fortified bread with *M. oleifera* seed powder at varying proportions (0–20%) and suggests the potential of using *M. oleifera* seed powder as food fortifying.

Table (6): Physical analysis of balady bread supplemented with different levels of M. oleifera seed powder.

Parameters	Concentrations of M.oleifera Control sample Mean ± SD	5% Mean ± SD	10% Mean ± SD	LSD
Weight (gm)	86.3^{b} ± 4.351	81.4^{c} ± 2.790	91.5^{a} ± 6.32	4.644
Volume (cc)	102.8^{a} ± 3.881	95.2^{b} ± 3.552	105.2^{a} ± 3.645	3.667
Specific vol. (cc/g)	1.191^{a} ± 0.074	1.169^{a} ± 0.063	1.149^{a} ±0.097	0.0804
Height (cm)	3.8^{a} ± 0.0788	3.22^{a} ± 0.0746	3.58^{a} ±0.0451	0.601
loaf diameter(cm)	19.85^{a} ± 0.406	19.81^{a} ± 0.424	19.92^{a} ± 0.122	0.332

Mean in the same row with different superscript letters are different significantly ($p < 0.05$)

Each value in the table is the average of three replicates.

The sensory evaluation of the balady bread fortified by different levels of *M. oleifera* is presented in Table 7. From this table, it could be observed that balady bread fortified with different levels of *M. oleifera* had no significant ($p > 0.05$) effects on appearance, texture,

and crust when compared with the control sample. While pulp and taste have significant ($P \leq 0.05$) differences at different levels (5% and 10%) of *M. oleifera* when compared with the control sample; at the same time, no significant ($p > 0.05$) effects were observed between both 5% and 10% of *M. oleifera* levels in balady bread.

At levels of 5 and 10 % *M. oleifera* fortification, no significant differences ($p > 0.05$) between them were displayed for odor and acceptability properties but showed significant ($P \leq 0.05$) differences at 10 % as compared with the control sample.

These results agree with those reported by Bolarinwa et al. [63] who said that the flour fortified with 5% *M. oleifera* seed powder was like the control sample in almost all the quality parameters evaluated.

Table (7): Sensory evaluation of balady bread supplemented with different levels of M. oleifera seed powder.

Parameters	Concentrations of M.oleifera			
	Control sample	5%	10%	LSD
	Mean ± SD	Mean ± SD	Mean ± SD	
Appearance (20)	16.866^{a}± 3.044	17.8^{a} ± 1.780	16.466^{a}± 2.325	1.526
Crust (15)	13.333^{a}± 1.496	12.133^{a}± 3.159	12.733^{a}± 1.437	1.711
Pulp (15)	13.867^{a}± 0.9155	12.467^{b}± 1.5523	12.200^{b}± 2.651	1.22
Texture (15)	12.400^{a} ± 2.772	12.467^{a} ± 2.065	12.333^{a} ±1.718	1.463
Odor (15)	13.80^{a} ± 2.366	11.8^{ab} ± 2.782	10.8^{b} ± 3.707	2.270
Taste (20)	17.60^{a} ± 2.848	14.733^{b} ± 5.188	12.467^{b} ± 5.083	2.326
Acceptability (100)	87.866^{a}± 10.252	81.4 ab ± 12.681	77^{b} ± 11.116	6.106
Grade	Good	Good	Satisfactory	

Mean in the same row with different superscript letters are different significantly ($p < 0.05$).
Each value in the table is the average of twenty panelists.

Conclusions

This study aims to evaluate the effects of incorporating different concentrations of M. oleifera and celery seeds with diet on glucose levels in diabetic rats, the results revealed that both plants decreased glucose levels, but the best result was recorded at 10% concentration of M. oleifera seeds powder. Moreover, it indicated a reduction effect on lipid profile (cholesterol, triglycerides, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and kidney and liver functions. Moreover, M. oleifera dried seeds powder has been used to produce balady bread as a better choice for diabetics because the differences in the sensory evaluation were minimal between fortified bread and unfortified bread. After that, M. oleifera and celery seeds still need Future research to ensure they can be a potential source to treat diabetes.

References

1. Patel, D.K.; Kumar, R.; Laloo, D. and Hemalatha, S. Diabetes mellitus: An overview on its pharmacological aspects and reported medicinal plants having antidiabetic activity. *Asian Pac. J. Trop., Biomed*, (2012); (12): 411-420.

2. Egan, A. M., and Dinneen, S. F. What is diabetes?. Medicine., (2019); 47(1): 1-4.

3. Gupta, N.; Gudipati, T. and Prasad, G. B. K. S. Plant Secondary Metabolites of Pharmacological Significance in Reference to Diabetes Mellitus: An Update. *Int. J. Curr. Microbiol. App. Sci*., (2018); 7(5): 3409-3448.

4. Kausar, H. Diabetes Mellitus: A Metabolic Disorder and its Screening Approaches. *Pakistan J. Medical Health Sci*.., (2022); 3(2).01-01.

5. Parveen, N.; Roy, A. and Prasad, P. Diabetes mellitus – pathophysiology & herbal management. *UK j. pharm. biosci*., (2017); 5(5): 34-42.

6. Bamagous, G. A.; Al Ghamdi, S. S.; Ibrahim, I. A. A.; Mahfoz, A. M.; Afify M. A.; Alsugoor, M. H.; Shammah, A.A.; Palanisamy Arulselvan, P. and Rengarajan, T. Antidiabetic and antioxidant activity of ethyl acetate extract fraction of Moringa oleifera leaves in streptozotocin-induced diabetes rats via inhibition of inflammatory mediators. *Asian Pac. J. Trop. Biomed*., (2018); 8(6): 320.

7. Mbikay, M. Therapeutic Potential of *Moringa oleifera* Leaves in Chronic Hyperglycemia and Dyslipidemia: A Review. *Front. Pharmacol*., (2012); 3: 24.

8. Mishra, G.; Singh, P.; Verma, R.; Kumar, S.; Srivastav, S.; Jha, K. and Khosa, R. Traditional uses, phytochemistry and pharmacological properties of *Moringa oleifera* plant: an overview. *Der Pharmacia Lettre*., (2011); 3(2): 141-164.

9. Anwar, F.; Latif, S.; Ashraf, M. and Gilani, A.H. *Moringa oleifera*: a food plant with multiple medicinal uses. *Journal of Wiley InterScience*., (2007); (21): 17–25.

10. Ma, Z. F., Ahmad, J., Zhang, H., Khan, I., and Muhammad, S. Evaluation of phytochemical and medicinal properties of Moringa (*Moringa oleifera*) as a potential functional food. *South African Journal of Botany*., (2020); 129: 40-46.

11. Rocchetti, G.; Pamplona P. J.; Blasi, F.; Cossignani, L.; Hilsdorf P. R.; Zengin, G.; Montesano, D.; Sandro C. P. and Lucini, L. Phenolic profiling and in vitro bioactivity of *Moringa oleifera* leaves as affected by different extraction solvents. *Food Research International*., (2020); 127, 108712.

12. Suresh, S.; Chhipa, A. S. ; Gupta, M. ; Lalotra, S. ; Sisodia, S. S. ; Baksi, R. and Nivsarkar, M. Phytochemical analysis and pharmacological evaluation of methanolic leaf extract of *Moringa oleifera Lam*. in ovalbumin induced allergic asthma. *South African Journal of Botany*., (2020); 130: 484–493.

13. Leone, A.; Spada, A.; Battezzati, A.; Schiraldi, A.; Aristil, J. and Bertoli, S. *Moringa oleifera* Seeds and Oil: Characteristics andUses for Human Health. *International Journal of Molecular Sciences*., (2016); 17(12): 2141.

14. Yusni, Y.; Zufry, H.; Meutia, F. and Sucipto, K. W. The effects of celery leaf (*Apium graveolens L*.) treatment on blood glucose and insulin levels in elderly pre-diabetics. *Saudi medical journal*., (2018); 39(2):154.

15. Abbas, H.A.; Abd, A.H.; AbdulRhman, S. and Abbas, I.S. The antihyperglycemic and antihyperlipidemic effect of ethanolic extract of *Apium Graveolens* (celery) in Streptozocin/ high fat diet induced hyperglycemic mice. *Kerbala journal of pharmaceutical sciences*., (2017); (13):10-28.

16. Stephen, M. S. ; Adelakun, E. A.; Kanus, J. H. and Meshack M. Gideon, M. M. Antioxidant Activities of Extracts from Celery Leaves (*Apium Graveolens L*) Grown in Jos, Nigeria. *International Research Journal of Pure & Applied Chemistry*., (2020); 21(4): 1-5.
17. Tashakori-Sabzevar, F.; Ramezani, M.; Hosseinzadeh, H.; Parizadeh, S.M.R.; Movassaghi, A.R.;Ghorbani, A. and Mohajeri, S.A. Protective and hypoglycemic effects of celery seed on streptozotocin-induced diabetic rats: experimental and histopathological evaluation. *Acta Diabetol* ., (2016)a ;53:609–619.
18. Lin, L. Z.; Lu, S. and Harnly, M. Detection and quantification of glycosylated flavonoid malonates in celery, chinese celery and celery seeds by LC-DAD-ESI/MS. *J. Agric. Food Chem*., (2007); 55(4): 1321–1326.
19. Mans, K. and Aburjai, T. Accessing the Hypoglycemic Effects of Seed Extract from Celery (*Apium graveolens*) in Alloxan-Induced Diabetic Rats. *Journal of Pharmaceutical Research Internationa*l., (2019); 26(6): 1-10.
20. Akillioglu, H. G. and Karakaya, S. Changes in total phenols, total flavonoids, and antioxidant activities of common beans and pinto beans after soaking, cooking, and in vitro digestion process. *Food Science and Biotechnology*., (2010); 19(3): 633-639.
21. Gouveia, S. and Castilho, P. C. Antioxidant potential of *Artemisia argentea* L'Hér alcoholic extract and its relation with the phenolic composition. *Food Research International*., (2011); 44(6): 1620-1631.
22. Benzie, I. F., and Strain, J. J. The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power": the FRAP assay. *Analytical biochemistry.*, (1996); 239(1): 70-76.
23. Eissa, H. A.; Hussein, A. S. and Mostafa, B. E. Rheological properties and quality evaluation on Egyptian balady bread and biscuits supplemented with flours of ungerminated and germinated legume seeds or mushroom. *Polish Journal of Food and Nutrition Sciences*., (2007); 57(4): 487-496.
24. Dawoud, F.M. High Fiber Bread for the Management of Diabetes – Product Development, Physiological Testing and Sensory Evaluation. *Ph.D. Food and Nutrition Science Dept. Food Sci. Division, Kings collage London – University of London.*, (1989).
25. Atia, A.A. Physical and chemical studies on the staling of some Egyptian bread. *Ph.D. in Food Science, Cairo Univ., Egypt.,* (1986).
26. AIN, American Institute of Nutrition. American institute of nutrition purified diet for laboratory Rodent, Final Report. *J. Nutrition*, 123: 1939-1951 and O. Compactum Benth. *J. Essential Oil Res*., (1993); 8 (6): 657-664.
27. Desai, A.C. and Bhide, M.B. Hypoglycemic activity of *Hamiltonia suaveolens*. Indian *J. Med Res*., (1985); 81:86-91.
28. Young, D. Effects of drugs on clinical laboratory tests. *Pestaner, L. Clin. Chem*., 21: 5, (1975); 1D-432D. (chemical K its).
29. Fossati, P. and Pricipe, I. Determination of serum triglycerides. *Clin. Chem*., (1982), 28: 2077.
30. Allain, C.C. Cholesterol enzymatic colorimetric method. *J. of Clin. Chem*., (1974); 20; 470.
31. Lee, R. and Nieman, D. Nutrition Assessment. 2nd Ed. *Mosby, Missouri*, (1996); U.S.A.
32. Tiez, N. M.: Fundamental of clinical chemistry, *Philade 1 phia, (2) W.B*., (1976);53-56.

33. Henry, R.J. Clinical Chemist: Principles and Techniques, 2nd Edition, *Hagerstoun (MD), Harcer.*, (1974); ROW, 882.
34. Barham, D. and Trinder, P. Determination of uric acid. *Analyst*., (1972); 97: 142.
35. Hagerman, A. E.; Riedl, K. M.; Jones, G. A.; Sovik, K. N.; Ritchard, N. T.; Hartzfeld, P. W. and Riechel, T. L. High molecular weight plant polyphenolics (tannins) as biological antioxidants. *Journal of agricultural and food chemistry*, (1998); 46(5): 1887-1892.
36. Watanabe, S.; Okoshi, H.; Yamabe, S. and Shimada, M. *Moringa oleifera Lam.* in Diabetes Mellitus: A Systematic Review and Meta-Analysis. *Molecules*., (2021); 26(12): 3513.
37. Irfan, H. M.; Asmawi, M. Z.; Khan, N. A. K.; Sadikun, A., and Mordi, M. N. Anti-diabetic activity-guided screening of aqueous-ethanol *Moringa oleifera* extracts and fractions: Identification of marker compounds.*Tropical Journal of Pharmaceutical Research*., (2017); 16(3): 543-552.
38. Abd El-Ghany, M. A.; Ramadan, A. M. and Ghozy, S. F. Nutraceutical effects of curcuma, ginger, celery, yeast and honey on side effects of gentamicin induced nephrotoxicity in rats. *World Applied Sciences Journal*., (2012); 16(5): 646-655.
39. Kooti, W.; Ghasemiboroon, M.; Asadi-Samani, M.; Ahangarpoor, A.; Noori Ahmad A. M.; Afrisham, R. and Dashti, N. The effects of hydro-alcoholic extract of celery on lipid profile of rats fed a high fat diet. *Advances in Environmental Biology*., (2014); 8(9): 325-330.
40. AL-bayuomi, A. F. and Gabr, N. M. Effects of *Moringa oleifera* Seeds Aqueous Extract on Type-II Diabetic Nephropathy in Adult Male Albino Rat. *The Medical Journal of Cairo University*., (2021); 89(3): 1129-1139.
41. Villarruel-López, A.; López-de la Mora, D. A.; Vázquez-Paulino, O. D.; Puebla-Mora, A. G.; Torres-Vitela, M. R.; Guerrero-Quiroz, L. A. and Nuño, K. Effect of *Moringa oleifera* consumption on diabetic rats. *BMC complementary and alternative medicine*. (2018); 18(1): 1-10.
42. Albrahim, T. and Binobead, M. A. Roles of *Moringa oleifera* leaf extract in improving the impact of high dietary intake of monosodium glutamate-induced liver toxicity, oxidative stress, genotoxicity, DNA damage, and PCNA alterations in male rats. *Oxidative medicine and cellular longevity*. (2018); 1-11.
43. Asgari-Kafrani, A.; Fazilati, M. and Nazem, H. Hepatoprotective and antioxidant activity of aerial parts of *Moringa oleifera* in prevention of non-alcoholic fatty liver disease in Wistar rats. *South African Journal of Botany*., (2020); 129: 82-90.
44. Sreelatha, S., and Padma, P. R. Antioxidant activity and total phenolic content of *Moringa oleifera* leaves in two stages of maturity. *Plant foods for human nutrition*., (2009); 64(4): 303-311.
45. Minaiyan, M.; Asghari, G.; Taheri, D.; Saeidi, M. and Nasr-Esfahani, S. Anti-inflammatory effect of *Moringa oleifera* Lam. seeds on acetic acid-induced acute colitis in rats. *Avicenna journal of phytomedicine*., (2014); 4(2): 127.
46. Mahmood, S.A. and Abdul Kreem, Q.I. effect of celery flavonoid on liver enzyme got and gpt in mice. *International Journal of Current Research*., (2014); 6 (3): 5726-5728.

47. Hegazy, B. A.; Ahmed, M. M.; Orabi, S. H.; Khalifa, H. K. and Tahoun, E. A. Protective effect of *Apium Graveolens* seeds (Celery Seeds) extract against Gentamicin-induced Hepatorenal toxicity in rats. *Bioscience Research*., (2019); 16(3):2665-2677.

48. Momin, R. A. and Nair, M. G. Antioxidant, cyclooxygenase and topoisomerase inhibitory compounds from *Apium graveolens Linn.* seeds. *Phytomedicine*., (2002); 9(4):312-318.

49. Al-Howiriny, T.; Alsheikh, A.; Alqasoumi, S.; Al-Yahya, M.; ElTahir, K., and Rafatullah, S. Gastric antiulcer, antisecretory and cytoprotective properties of celery (*Apium graveolens*) in rats. *Pharmaceutical biology*., (2010); 48(7):786-793.

50. Pooja, A. S.; Madhuri, A. A.; and Ranjit, S.A. Study of renal function and serum electrolyte in type 2 DM. *International journal of innovative research in medical science*., (2017); 2(8):2455-8737.

51. El Rabey, H. A.; Khan, J. A.; Sakran, M. I. and Al-Ghamdi, M. A. The Antioxidant Activity of Low Doses of Moringa Seeds (*Moringa oleifera Lam.*) in Hypercholesterolemic Male Rats. *Reactive Oxygen Species*., (2018); 6(17): 363-370.

52. Saleh, S. S. and Sarhat, E. R. Effects of Ethanolic Moringa Oleifera Extract on Melatonin, Liver and Kidney Function Tests in Alloxan-Induced Diabetic Rats. *Indian Journal of Forensic Medicine & Toxicology*., (2019); 13(4): 1015-1019.

53. El-Kassas, S.; Abdo, S. E.; Abosheashaa, W.; Mohamed, R.; Moustafa, E. M.; Helal, M. A. and El-Naggar, K. Growth performance, serum lipid profile, intestinal morphometry, and growth and lipid indicator gene expression analysis of mono-sex Nile tilapia fed *Moringa oleifera* leaf powder. *Aquaculture Reports*., (2020); 18: 100422.

54. Beltagy, N.;Mahmoud, A.; Ghazi, A. and Metwalli, S. M. Using of Celery (*Apium graveolens L*) for Lowering Obesity of Experimental Rats. *Journal of Food and Dairy Sciences*., (2018); 9(2): 59-67.

55. Soliman, M. M.; Nassan, M. A.; Aldhahrani, A.; Althobaiti, F. and Mohamed, W. A. Molecular and Histopathological Study on the Ameliorative Impacts of *Petroselinum Crispum* and *Apium Graveolens* against Experimental Hyperuricemia. *Scientific reports*., (2020); 10(1): 1-11.

56. Reddy, P.V.; Urooj, A.; Sairam, S.; Faiyaz Ahmed, F. and Prasad, N.N. Hypocholesterolemic Effect of *Moringa oleifera* Polyphenols in Rats Fed High Fat-Cholesterol Diet. *Mal J Nutr*., (2017); 23(2):473-478.

57. Elbakry, M. A.; Almutairi, F.M.; Khan, J.A. and Rabey, H.A.EL. The low dose of drumsticks (*Moringa oleifera L*.) seed powder ameliorates blood cholesterol in hypercholesterolemic male rat. *Indian journal of Biochemistry & Biophysics*., (2017); 54:306-313.

58. Oyeleye, S.I.; Olasehinde,T.A.; Ayokunle, O.; Ademosuna; Ayodele, J. and Oboha,G.A. Horseradish (*Moringa oleifera*) seed and leaf inclusive diets modulates activities of enzymes linked with hypertension, and lipid metabolites in high-fat fed rats. *PharmaNutrition*., (2019); 7: 100141.

59. Kamal, M.; Adel, M.A.; Ahmad, D. and Talal, A. Hypolipidemic Effects of Seed Extract of Celery (*Apium graveolens*) in Rats. *Pharmacognosy Magazine*., (2009); 5(20): 301-305.

60. Hedayati, N.; Bemani Naeini, M.; Mohammadinejad, A. and Mohajeri, S. A. Beneficial effects of celery (*Apium graveolens)* on metabolic syndrome: A review of the existing evidences. *Phytotherapy Research*., (2019); 33(12): 3040-3053.

61. Ogunsina, B. S.; Radha, C. and Indrani, D. Quality characteristics of bread and cookies enriched with debittered *Moringa oleifera* seed flour. *International Journal of Food Sciences and Nutrition*., (2011); 62(2): 185–194.

62. Bolarinwa, I. F.; Aruna, T. E. and Raji, A. O. Nutritive value and acceptability of bread fortified with moringa seed powder. *Journal of the Saudi Society of Agricultural Sciences.*, (2019); 18(2): 195-200.

63. Bolarinwa, I. F.; Aruna, T. E. and Raji, A. O. Nutritive value and acceptability of bread fortified with moringa seed powder. *Journal of the Saudi Society of Agricultural Sciences*., (2019); 18(2): 195-200.

التأثير المحتمل لبذور المورينجا وبذور الكرفس على الفئران المصابة بالسكر

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الملخص العربي:
تهدف هذه الدراسة إلى مقارنة تأثير تركيزات مختلفة (5٪ و10٪) من بذور كلا من المورينجا الكرفس على مستويات الجلوكوز في الفئران المصابة بداء السكر. تم تقسيم اثنين وأربعين من ذكور الفئران البالغة وزنها (140-150 جم) إلى سبع مجموعات (ستة فئران في كل مجموعة). تم وضع المجموعة الأولى كمجموعة ضابطة سالبة، بينما تم حقن المجموعات الأخرى بالألوكسان (150 مجم / كجم من وزن الجسم) لتصبح الفئران مصابة بداء السكر. تم الاحتفاظ بمجموعة واحدة منها كعنصر تحكم (مجموعة ضابطة موجبة)، بينما تم علاج أربع مجموعات مصابة بمرض السكر بتركيزات مختلفة من المورينجا والكرفس. المجموعة الأخيرة عولجت بالجلوكوفاج. بعد 35 يومًا، تم قياس مستويات الجلوكوز والكوليسترول والدهون الثلاثية (T.G) وكوليسترول البروتين الدهني عالي الكثافة (HDL-c) وكوليسترول البروتين الدهني منخفض الكثافة (LDL-c) وكوليسترول البروتين الدهني منخفض الكثافة جدًا (VLDL-c) ووظائف الكلى، وتم تقييم وظائف الكبد عن طريق الاختبارات البيوكيميائية. أظهرت النتائج أن كلا النباتين قلل من مستويات الجلوكوز وتحسين وظائف الكلى والكبد عن طريق خفض إنزيم SGPT، SGOT، والكرياتينين، وحمض البوليك. أيضًا، كلا النباتين لهما دور في تقليل الدهون الثلاثية في الدم، والبروتين الدهني منخفض الكثافة، والبروتين الدهني منخفض الكثافة للغاية، وزيادة البروتين الدهني عالي الكثافة مقارنة بمجموعة التحكم الإيجابية. الخلاصة، تعكس جميع التحليلات الكيميائية الحيوية وخاصة مستويات الجلوكوز في الفئران المصابة بمرض السكر قوة بذور المورينجا والكرفس لذلك يمكن الاستنتاج أن إضافة المنتجات المختبرة أدت إلى تقليل الأثار الغير مرغوبة لمرض السكر. تم تسجيل أفضل نتيجة بتركيز 10٪ من مسحوق بذور المورينجا

الكلمات المفتاحية: مرض السكر، الفئران، التحاليل الكيميائية الحيوية، المورينجا، الكرفس.