International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.09 pp 156-168, 2016

Phytochemical detection and Therapeutical properties of *Moringa oleifera* leaves

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Abstract : This study was undertaken to determine the hypoglycemic effect of *Moringa oleifera* leaves water extract in normal (normoglycemic) and induced diabetic rats. Hyperglycemia was induced in rats using alloxan (120 mg/kg body weight). Healthy and Diabetic rats were treated with 100, 200, 300 or 400 mg/kg b.wt.) *Moringa oleifera* water extract, 3 times a week over a period of 4 weeks, and the antidiabetic effects of the extracts were evaluated by measuring changes in the biochemical parameters within the blood serum. Results illustrated that all doses of the extract provided a significant reduction in serum glucose where, the aqueous extracts (100, 200, 300 and 400 mg) exhibited a substantial reduction in glucose levels in diabetic rats, starting from value of 388-728 mg/kg b.wt. For the diabetic rats and decreased ranging from 43.19, 70.04, 70.65, and 72.07 %, respectively for the aforementioned extracts of Moringa leaves. The *Moringa oleifera* leaves extract caused a gradual improvement in kidney function, which neared the functional normality when compared to the untreated control-group. Therefore, the present study suggests that pre-treatment of *Moringa oleifera* leaves extract has a positive effect in lowering the lipid profile for diabetic rats.

Introduction

Moringa oleifera belongs to *Moringacea* family, which accounts for 14 different species. The plant is said to have an anti-inflammatory effect[1]. *Moringa oleifera* commonly is commonly known as the drumstick tree, it possesses a multitude of nutritional and medicinal benefits due to the abundance of useful minerals, vitamins, amino acids, etc[2]. Varying portions of this plant including its leaves, roots, seed, bark, fruit, flowers, and immature pods can be employed as cardiac and circulatory stimulants, they also have antihypertensive, cholesterol lowering, antioxidant, anti-diabetic and hepatoprotective properties; demonstrating the impeccable significance of this species[3].

Moringa oleifera leaves can be used as purgatives; they can also be used to treat headaches, sores, catarrh, fevers, ear infections, piles, bronchitis, scurvy and sore throats. Apart from the leaves' capability in reducing glandular swelling, it was also stated that the leaf juices possess the ability to govern the glucose levels within the sera[4,5]**.** *Moringa oleifera* has been previously used in combating malnutrition, especially amongst infants and nursing mothers [6]. *Moringa* leaves (ML) can be orally ingested both fresh, and cooked; they could also be stored as dried powder for several months without refrigeration, and with an alleged maintenance of its nutritional and medicinal values, where its efficacy remains unaltered [7]. Both the aqueous and acetone extracts of *M. oleifera* leaves have potent antioxidant activities; however, higher values of phenols, flavonoids, flavonol and proanthocyanidins in the acetone extracts of *M. oleifera* leaves when compared to the aqueous extracts [8]. The leaves of *Moringa oleifera* were proved to have a multitudinous of biological functions

and activities such as anticancer properties, and preventative actions against cardiovascular and liver diseases [9]. Additionally, they have antitumor and anti-inflammatory functions in nervous, digestive and skin disorders, as well as the regulation of the thyroid status [10,11]. Analyzing the proximate contents concluded that crude protein at 39.13mg/100g, ash content at 6.00mg/100g, carbohydrate content at 38.21 mg/100g, crude fat at 2.43mg/100g, moisture content at 9.00mg/100g and crude fibers at 5.43mg/100g [12]. The leaves' mineral content showed plentiful amounts of Calcium (Ca), Magnesium (Mg), Sodium Na, Manganese (Mn) and Zinc (Zn). The fat absorption capacity, emulsion capacity, water absorption capacity, and foaming stability demonstrated fine functional characteristics. In the absence of early diagnosis and adequate treatment, sufferers of diabetes may experience symptoms such as ketoacidosis, hyperosmolar syndrome, dyslipidemia as well as a hyperglycemic state[13]. Suggestion of the efficiency of *Moringa oleifera* in the reduction of the amount of glucose found in alloxan induced diabetic rats, managed in *Moringa oleifera* water extract [14]. Therefore, the purpose of the present study was to assess the effect of *M. oleifera* leaves aqueous extract therapy, on glycemic control, blood sugar, kidney function, and lipid profile.

Materials and Methods

Materials:

The experiment was performed in Central laboratory of Horticulture Research Institute, Agriculture Research Center, and Eyes Research Institute, Giza, Egypt during the season of 2015. Moringa (*Moringa oliefera*) was obtained at mature stage [15] from the Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. Folin-Ciocalteu reagent was purchased from Sigma Chemical Co. Radical 2,2diphenylpicryl-hydrazyl (DPPH) was purchased from Aldrich Chemical Co. All other solvents and chemicals were purchased from El-Nasr Chemical Co., Cairo, Egypt. Diagnostic kits were obtained from Bio Merieuex Laboratory Reagents and Products, France, and were used for the determination of serum.

Methods:

Preparation and extraction of *Moringa oleifera* leaves water extract:

Moringa leaves were picked at mature stage; where it is maximum active ingredients, cleaned, and shade dried on a desk in the laboratory at room temperature. The dried samples were powdered using an electric mixer for the extraction of active compounds. 200 g of powder was infused in 1 L of hot water for 1 hour, followed by filtration and elimination of the water in oven at 70^{o} C. The given powder yield of a brown residue, was used for antidiabetic effects in rats.

Chemical Composition screening

Moringa oleifera leaves were subjected to various qualitative tests based on reactions of dyes of the major groups of chemical compounds in the extract, moisture, ash, crude protein, crude fiber and total lipids were determined in leaves [16]. Total carbohydrate was determined as glucose, using the phenol-sulfuric acid method [17]. Total saponins content in the extract was performed [18]. Amino acids were fractionated in HPLC using the method described by[19]. The Total polyphenolic content in the extract was estimated; using the Folin-Ciocalteu reagent [20], Hydrolysable tannins content in the extract was determined [21]. Total carotenoids content was determined [22]. The amount of total flavonoids in the extracts was measured [23]. The antioxidant activity of the extracts was assessed [24].

Determination of macro and microelements:

Nitrogen content was determined in the digested solution by the modified micro-kjeldahl method [25]. Phosphorus content was determined by colorimetric analysis [26]. Potassium, calcium and sodium contents were determined against a standard using flame-photometer [27]. The ashed samples were dissolved in 0.1N HCl and volumes were completed to the mark (100 ml). This solution was used for the quantitative determination of Zn, Mn, Mg, Fe and Cu by atomic absorption spectrophotometer (Thermo Jarrell Ash Model AA SCAN1). All the determinations were carried out with an air-acetylene gas mixture at a rate of 5 L/min [28].

Experimental animals:

A total of forty-nine (49) of adult's male albino rats (Wister Strain) weighing approximately 200 g were obtained from Organization of Biological Products and Vaccines from the Helwan breeding farm, Cairo, Egypt. The experiment was performed in Eyes Diseases Research Institute, Giza. The rats were housed in stainless steel cages with wire mesh bottoms at 25±2^{o}C. Rats were kept under normal healthy conditions for two weeks and fed a normal diet (basal diet) [29]. The present study was to investigate the protective effect of moringa leaves extract on alloxan induced diabetic rats.

Dosage and administration of decoction:

The decoction was administered at a dosage of 100, 200, 300 and 400 mg/kg body weight 3 times a week of moringa leaves water extract for 4 weeks [30], using a Sondi-needle by the gastric gavage method [31]**.** Rats were divided randomly into seven main groups (7 rats each):

Group 1, (control) containing 7 rats were fed with a basal diet (Table, 1); **group 2**, was fed on a basal diet and administered moringa leaves water extract at 100 mg/kg body weight; **group 3**, was the diabetic group as the rats were injected with a single dose of alloxan solution 150 mg/kg body weight [32]. After 24-hours of alloxan injection, the presence of diabetes was confirmed (glucose blood was higher than 180 mg/dl). Rats were left for one week without any treatment to stabilize diabetes; **group 4**, was diabetic rats administered of moringa leaves water extract by concentration of 100 mg/kg body weight; **group 5**, was the diabetic rats with moringa leaves water extract administration at 200 mg/kg body weight; **group 6**, was the diabetic rats which were administered moringa leaves water extract at a concentration of 300 mg/kg body weight and finally **group 7**, were diabetic rats administered moringa leaves water extract at a concentration 400 mg/kg body weight.

Table 1. Composition of the basal diet*:

Compound	Percentage %
Casein	10
Corn oil	10
Salt mixture	4
Vitamin mixture	1
Cellulose	5
Starch	70

* [29]

Serum analysis:

At the end of experiment, blood was collected in tube from the retro-orbital vein of each group, The tube was centrifuged at 3000 rpm for 20 min, for serum preparation. Serum parameters were determined by enzymatic colorimetric methods. Glucose presented in the sample was determined [33]**.**

Determination of kidney function:

Serum urea was determined [34]**.** Uric acid in serum was determined [35]**.** Creatinine in serum was determined [36]**.**

Determination of lipid profile:

Serum triglyceride was determined [37]**.** Total cholesterol was calorimetrically determined at 546 nm according to the enzymatic method [38]**.** Serum LDL-cholesterol was calculated [39]**.** Serum high-density lipoprotein cholesterol was determined [39]**.**

Statistical analysis:

Statistical analysis was carried out [40] using analysis of variance and the significance was determined using L.S.D. values at P = 0.05 [41].

Results and Discussion

A- Analysis of *Moringa oleifera* leaves:

A1- Chemical composition and mineral contents of *Moringa oleifera* leaves

Results shown in **Table (2)** demonstrate the analysis of moringa leaves, water extract and mineral contents, where the leaves demonstrated contents of 81.06% moisture, 33.41 crude fiber, 4.95% ash, 18.87% crude protein, 1.57% total lipids, 26.98% carbohydrate, 4.85% total phenols, 0.76% total flavonoids, 7.46 (mg/100g.) total carotenoids, 0.909% total tannins and 0.241% total saponins. **Table (2)** also illustrates the mineral composition of *Moringa oleifera* leaves extract, which indicated that the leaves extract contained Ca, Na, K, P, Zn, Mn, Mg, Fe and Cu recording 0.662%, 0.192%, 0.950%, 0.960%, 0.001%, 0.140%, 0.120%, 0.045% and 0.001%, respectively. While, water extract contained 6.50% crude protein, 3.33% total phenols, 0.41% total flavonoids, 5.52 (mg/100g.) total carotenoids, 0.890% total tannins, 0.203% total saponins, and mineral contents of water extract were 0.1761 Ca, 0.161 Na, 0.721 K, 0.340 P, 0.061 Mn, 0.102 Mg and 0.045 Fe as %, respectively. Similar findings for *Moringa oleifera* leaves with moisture content at 76.53%, and total carbohydrate at 45.43% and 63.11%[42]**.** Also, these results were *Moringa oleifera* leaves are a great source of *β*-carotene and protein. *Moringa oleifera* includes a variety of phytochemicals to be precise, carotenoids, alkaloids, phenolics and flavonoids [43]. Furthermore, antioxidant activity from leaves of *Moringa oleifera* was deemed high due to an increase in the concentration of polyphenolics [44]. Thus, *Moringa oleifera* tissues can be a key dietary source of polyphenolics. Elevated values of flavonoids, from the acetone extract of *Moringa oleifera* leaves when compared to that of the aqueous extract [8]. Similar finding stating that most of the *Moringa oleifera* plant contained significant minerals including Ca, K, Fe and P [43 and 44]. The calcium (Ca) content of dry *Moringa oleifera* leaves was, 2.47ppm, 1.91 and 3.4%, correspondingly [45,46, 11] all reported analogous discoveries. Which highlights the value of dry *Moringa oleifera* leaves as an excellent source of calcium (Ca) to farm humans and animals.

Table (2) : Chemical composition and mineral contents of *Moringa oleifera* leaves and its water extract

Constituent	Leaves content	Water extract content	Minerals	Leaves Content	Water extract content
Moisture (%)	81.06	Not detected	**Ca (g/100g.)**	0.662	0.1761
Crude fiber (%)	33.41	Not detected	**Na (g/100g.)**	0.192	0.161
Ash (%)	4.95	Not detected	**K (g/100g.)**	0.950	0.721
Crude protein (%)	18.87	6.50	**P (g/100g.)**	0.960	0.340
Total lipids (%)	1.57	Not detected	**Zn (g/100g.)**	0.001	Not detected
Total carbohydrate (%)	26.98	Not detected	**Mn (g/100g.)**	0.140	0.061
Total Phenols (%)	4.85	**3.33**	**Mg (g/100g.)**	0.120	0.102
Total flavonoids (%)	0.76	**0.41**	**Fe (g/100g.)**	0.045	0.011
Total carotenoids (mg/100g.)	7.46	**5.52**	**Cu (g/100g.)**	0.001	Not detected
Total tannins (%)	0.909	0.890			
Total saponins (%)	0.241	0.203			

A2- Fractionation of amino acids of *Moringa oleifera* leaves :

As for the amino acids content of moringa leaves, results tabulated in **Table (3)** demonstrated the amino acids fractionation in moringa leaves recording 11.4, 10.6, 4.8, 4.2, 3.5, 6.5, 7.6, 0.4, 10.8, 6.3, 0.5, 3.5, 6.9, 4.2 and 12.1 g/100g. for asparatic, glutamic, serine, histidine, glycine, threonine, alanine, proline, tyrosine, arginine, valine, methionine, isoleucine, leucine, phenylalanine and lysine, respectively. These results obviously indicate that lysine was the most predominant amino acid, followed by asparatic and glutamic. While the rest of amino acids recorded much lower values.

Table (3) : Amino Acids Composition of *Moringa Oleifera* leaves

Amino acid	g./100g.
Aspartic	11.4
Glutamic	10.6
Serine	4.8
Histidine	4.2
Glycine	3.5
Threonine	6.5
Alanine	6.7
Proline	7.6
Tyrosine	0.4
Arginine	10.8
Valine	6.3
Methionine	0.5
Isoleucine	3.5
Leucine	6.9
Phenylalanine	4.2
Lysine	12.1

These results are in agreement with those concluded by [47,48] where it was stated that, the composition of amino acids in *M. oleifera* leaves included aspartic acid, glutamic acid, histidine, threonine, alanine, tyrosine, arginine, methionine, phenylalanine, and lysine. All the parts of this plant contain high percentages of essential amino acids except for methionine, commonly deficient in green leaves. It could be possible that the variations in the amino acid composition of the leaves are influenced by the quality of the protein and the origin of the plant whether it is cultivated or wild. Conversely, it was concluded that Moringa leaves contained 19 amino acids [49], which slightly differ from the findings of [50] who reported 18 and 16 amino acids, respectively. Out of the 19 amino acids observed, 10 were classified as essential amino acids namely threonine, tyrosine, methionine, valine, phenylalanine, isoleucine, leucine, histidine, lysine and tryptophan. Alanine had the highest value of 3.03%, which differed with [50] who reported the value of 1.25%.

B- Biological assay :

B1- The effect of oral intake of *Moringa oleifera* leaves water extracts on blood serum glucose (mg/dl) of experimental rats

Results were tabulated in **Table (4)** and (**Figure 1**) illustrate the effect of oral intake of moringa leaves water extracts on serum glucose of the experimental rats. It is noteworthy to mention that blood serum glucose for normal rats fed on the basal diet recorded 86.904 mg/dl, then when fed the extract in addition to basal diet it reached 58.832mg/dl due to the reducing effect of moringa leaves water extract on blood serum glucose. Inducing diabetes in the rats, via alloxan, resulted in an increase in serum blood glucose that reached 388.728mg/dl. This severe result was significantly tranquilized gradually by the steady administration of the moringa leaves water extract in concentrations starting from 100mg/kg and reaching 400mg/kg. These results are demonstrated in **Table (4)** and (**Figure 1**).

Table (4) : The effect of oral intake of *Moringa oleifera* leaves water extracts on blood serum glucose (mg/dl) of experimental rats

Groups	Blood serum glucose mg/dl
Control basal diet control (-)	86.904
Control (-) + extract	58.832
Diabetic control group Control (+)	388.728
Control (+) + water extract (100mg/kg b.wt)	220.824
Control (+) + water extract (200mg/kg b.wt)	116.468
Control (+) + water extract (300mg/kg b.wt)	114.100
Control (+) + water extract (400mg/kg b.wt)	108.556

LSD 0.05 = 33.745

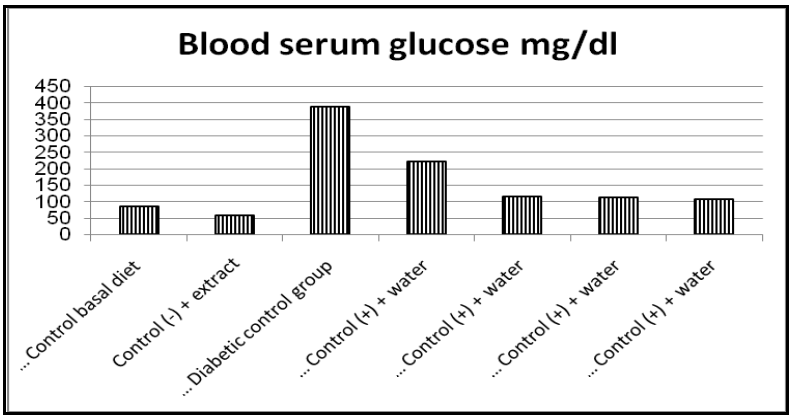

Figure (1) : Graphic Representation demonstrates the effects of Moringa leaves extract on blood glucose levels

The above stated results are in agreement with those reported by several studies, which arrived to the conclusion of the managing effect of *Moringa oleifera* leaf extract on elevated glucose levels, and when applied to glandular swelling cause a plodding decrease [51]**.** Moreover**,** *Moringa oleifera* leaves possess qualities such as cholesterol lowering and can act as an antihypertensive, anti-diabetic and antioxidant [3]. It was indicated that, a considerable reduction *(p<0.05)* was documented in glucose levels in alloxan-induced rats with diabetes, when treated with *Moringa oleifera* water extract [14]. In addition, It was concluded that, in alloxan induced diabetic rats, the water extract (100, 200, 300 mg/kg) resulted in 40.69%, 33.29%, and 44.06% diminution corresponding to the blood glucose concentration of 6 hours of management, while tolbutamide (200 mg/kg) resulted in 46%, a dramatic decrease of 75% [52]. The studies illustrated that the water extract from Moringa *oleifera* leaves function significantly in a hypoglycemic dose-dependent activity, both with normal glycemic and alloxan induced diabetic rats. Furthermore, the results are comparatively efficient to that of the normally used drug (tolbutamide). This also supports its usage in folkloric administration of diabetes.

More recently, it was cited that *Moringa oleifera* leaves are also broadly used in conventional medicine, and the leaves as well are used as dietary products in human nutrition [53]. Five studies that used powdered leaf provisions of *Moringa oleifera* were published, they have established an antidiabetic (anti-hyperglycemic) and anti-dyslipidemic action. These activities established the usage of extracts over the 'miracle' leaves powder when conducting animal studies.

B2- The effect of oral intake of *Moringa oleifera* leaves water extracts on the organ weight (g.) of experimental rats

Taking the organs' weight into consideration, Table (5) and Figure (2) demonstrates the results of the effect of the oral intake of moringa leaves water extract on the organ weight (g) of experimental rats. The first drawn observation is that alloxan resulted in a severe reduction in the organ weights overall (liver 6.5736 g,

kidney 1.4288g, spleen 0.17528g, and heart 0.38004g), which was positively enhanced via the oral administration of moringa leaves water extract, and a significant incremental normalization of weights was demonstrated as the increase of the concentration of the extract was applied from 100mg/kg to 400 mg/kg of the moringa leaves.

Table (5) : The effect of oral intake of *Moringa oleifera* leaves water extracts on the organ weight (g.) of experimental rats

Groups	Liver(g.)	Kidney(g.)	Spleen(g.)	Heart(g.)
Control basal diet control (-)	11.206	1.8058	0.75598	0.71624
Control (-) + extract	11.0608	1.7678	0.80246	0.72680
Diabetic control group Control (+)	6.5736	1.4288	0.17528	0.38004
Control (+) + water extract (100mg/kg b.wt)	6.8078	1.5286	0.25822	0.39720
Control (+) + water extract (200mg/kg b.wt)	7.4740	1.8136	0.38030	0.55614
Control (+) + water extract (300mg/kg b.wt)	10.0000	2.0714	0.54558	0.66806
Control (+) + water extract (400mg/kg b.wt)	11.0488	2.1352	0.54616	0.75932

Liver: LSD 0.05 = 1.899 Spleen: LSD 0.05 = 0.116
Kidney: LSD 0.05 = 0.270 Heart: LSD 0.05 = 0.099

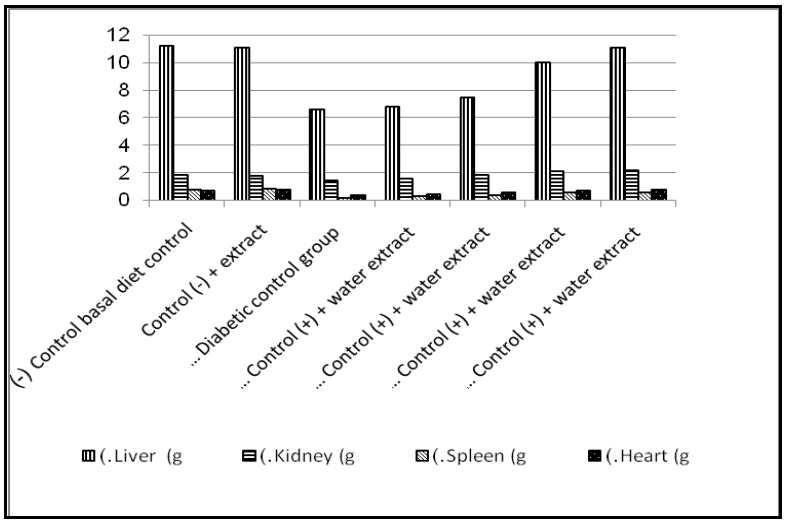

Figure (2) : Graphic Representation demonstrates the effects of Moringa leaves extract on organ weight (g.)

B3- The Effect of the oral intake of *Moringa oleifera* leaves water extracts on the kidney function (mg/dl) of the experimental rats

As for the effect of the oral intake of moringa leaves water extracts on the kidney function (mg/dl) of the experimental rats, Results presented in **Table (6) and Figure (3)** revealed that as a result of diabetes, kidney function increased, from control basal diet group logging for urea, uric acid and creatinine at 52.3212, 2.554 and 0.251766 mg/dl, respectively, to diabetic group logging for urea, uric acid and creatinine at 83.2472, 4.6376 and 0.3578mg/dl, respectively. The intake of *Moringa oleifera* leaves water extract by concentrations starting from 100mg/kg up to 400mg/kg caused a significant gradual decrease in kidney functions, almost reaching the normal values.

Table (6) : The Effect of the oral intake of *Moringa oleifera* leaves water extracts on the kidney function (mg/dl) of the experimental rats

Groups	Urea mg/dl	Uric acid mg/dl	Creatinine mg/dl
Control basal diet control (-)	52.3212	2.554	0.251766
Control (-) + extract	45.7976	2.5088	0.20234
Diabetic control group Control (+)	83.2472	4.6376	0.3578
Control (+) + water extract (100mg/kg b.wt)	81.9026	4.4904	0.32304
Control (+) + water extract (200mg/kg b.wt)	75.1628	4.05418	0.2836
Control (+) + water extract (300mg/kg b.wt)	65.1362	3.3620	0.2664
Control (+) + water extract (400mg/kg b.wt)	64.2626	3.19644	0.2584

Urea: LSD 0.05 = 3.726 Uric acid: LSD 0.05 = 0.453
Creatinine: LSD 0.05 = 0.036

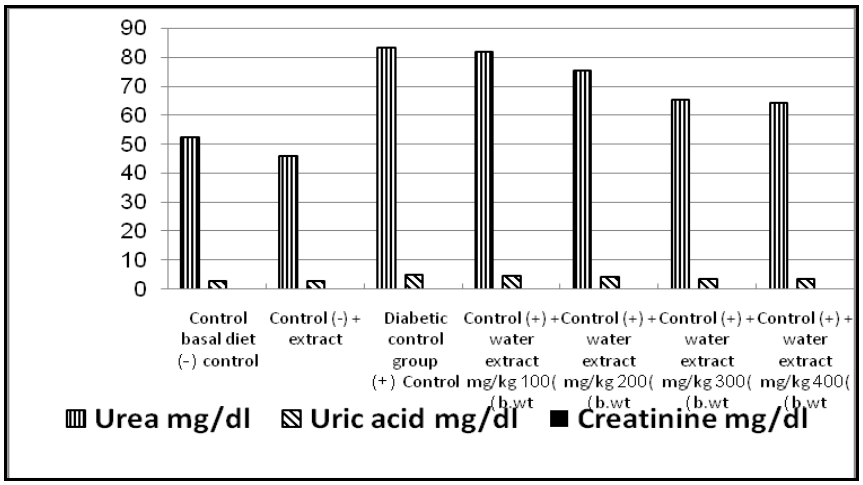

Figure (3) : Graphic Representation demonstrates the effects of Moringa leaves extract on kidney function (mg/dl)

These results correlate with those obtained by [54], who stated that the dependent factor for weight loss in diabetes includes lipolysis, acute fluid loss and proteolysis. The water extracts of *Moringa oleifera* leaves reverts the weight loss outcomes experienced by the experimental diabetic rats. Recently, it was stated that there was a momentous differentiation amongst positive control groups as well as the group fed on *Moringa oleifera* prepared leaves juice at 15%, which decreased the level of uric acid extensively [55]. The absorptions of uric acid were reduced by 18.41% and 2.84% that correspond to the previously determined values.

B4- The effect of the oral intake of *Moringa oleifera* leaves water extract on the lipid profile (mg/dl) of experimental rats

Table (7) and **Figure (4)** illustrates the effect of the oral intake of *Moringa oleifera* leaves water extract on the lipid profile (mg/dl) of experimental rats. It revealed that, as a result of diabetes, lipid profile increased, from control basal diet group logging for triglycerides, total cholesterol, LDL and HDL at 61.51, 102.69, 43.48 and 44.77mg/dl, respectively, to diabetic group logging for triglycerides, total cholesterol, LDL and HDL at 80.01, 118.11, 60.99 and 24.66mg/dl, respectively. The intake of *Moringa oleifera* leaves water extract by concentrations starting from 100mg/kg up to 400mg/kg caused a significant gradual decrease in lipid profile, almost reaching the normal values.

Table (7) : The effect of the oral intake of *Moringa oleifera* leaves water extract on the lipid profile (mg/dl) of experimental rats

Groups	Triglycerides (mg/dl)	T. Cholesterol (mg/dl)	LDL (mg/dl)	HDL (mg/dl)
Control basal diet control (-)	61.51	102.69	43.48	44.77
Control (-) + extract	51.12	77.89	32.89	43.10
Diabetic control group Control (+)	80.01	118.11	60.99	24.66
Control (+) + water extract (100mg/kg b.wt)	76.43	112.73	52.92	35.01
Control (+) + water extract (200mg/kg b.wt)	75.01	109.54	44.97	37.04
Control (+) + water extract (300mg/kg b.wt)	70.16	109.64	42.50	28.53
Control (+) + water extract (400mg/kg b.wt)	69.42	105.13	46.67	31.54

Triglycerides: LSD 0.05 = 1.66954074598 **T. Cholesterol:** LSD 0.05 = 2.48263876728
LDL: LSD 0.05 = 4.0837645862 **HDL:** LSD 0.05 = 3.26710688494

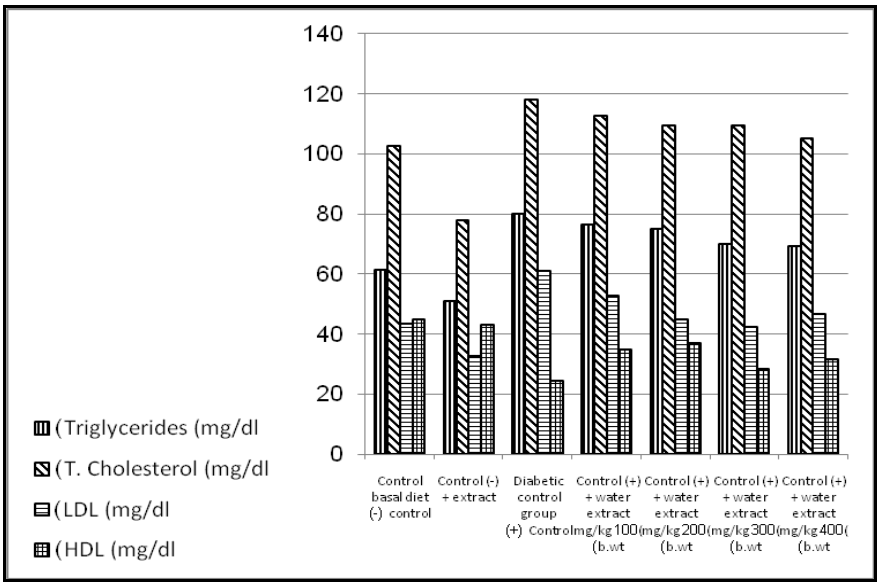

Figure (4) : Graphic Representation demonstrates the effects of Moringa leaves extract on lipid profile (mg/dl)

The ethnomedicinal value of the different parts of *Moringa oleifera* has long been recognized in Asian and African folkloric medicine to treat various ailments related to pain and inflammation. Aqueous extracts of *M. oleifera* leaves was found to reduce the blood glucose level in normal rats and normalize the high blood glucose levels in sub, mild and severely diabetic rats. It also improves glucose tolerance in normal, sub and mild diabetic animals [56].

Diabetes mellitus (DM) is a common disorder associated with increased morbidity and mortality and can be defined as a group of metabolic diseases characterized by chronic hyperglycemia due to defective insulin secretion, insulin action, or both, resulting in impaired carbohydrate, lipid, and protein metabolism Differences in the lipid profile of diabetic and non-diabetic individuals are now apparent and lipid abnormalities are common in patients with diabetes mellitus [57]. Aqueous extracts of leaves of *M. oleifera* significantly decreased the levels of serum TC, TG, and LDL. Atherogenic index is an indication of the degree of deposition of foam cells or plaque or fatty infiltration or lipids in heart, coronaries, aorta, liver and kidneys. The higher the atherogenic index, the higher the risk of Coronary Heart Disease (CHD) [58]. *Moringa oleifera* leaves appear to possess "a package of natural antioxidant" compounds such as vitamin E, C, carotenoids and polyphenols, deserves further evaluation as potential antioxidant agent. Consumption of foods containing a variety of compounds with antioxidant activities has greater nutritional significance in the management of hyperlipidemia.

The moringa hypoglycemic activity is reported to be due to the presence of α-glucosidase and pancreatic amylase enzyme inhibitors [59]. These enzyme inhibitors prevent the digestion of glucose into an absorbable product, hence the inability of blood glucose to increase after glucose intake. The presence of these inhibitors has been reported in plants like *Morus Alba*, which was able to exhibit hypoglycemic activity [60]. Also, the hypoglycemic activity of moringa leaf extract may be due to the presence of antioxidants like flavonoids, phenol, and vitamins C and E in it.

The ability of some constituents of moringa leaf extract such as oleic acid enhanced the release of insulin [51] and early attainment of hypoglycemia in this group was able to prevent lipid peroxidation.

Conclusions, Limitations, and Further Work:

Treated alloxan induced diabetes rats with the low doses of *Moringa* revealed a safe and an excellent antidiabetic activity due to its content of antioxidant compounds such as glucomoringin, phenols, and flavonoids and almost restored the diabetic rats to the normal healthy state. In addition, lower doses of Moringa under study may have greater medical benefits when used as food supplement for diabetic people's diet especially for the diabetes symptoms regarding kidney function and lipid profile. This study could have been attempted on a larger sample size, for a longer period of time to most effectively determine whether the effects were indeed reverted. Larger concentration intervals could have been used to estimate the most adequate dosage needed.

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