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Study the Effect of Kale (*Brassica oleracea*) Plant Powder and Extract on Hyperglycemic Rats

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ABSTRACT:

This study aims to determine the effect of kale (Brassica oleracea var. acephala) plant powder and extract used for hyperglycemic rats. Thirty adult male albino rats weighing 150 ± 10 g were used during the experiment. Rats were divided into two main groups. The first main group (5 rats) was fed the basal diet (B.D.) as the control negative group. The second main group (25 rats) was injected with alloxan (150 mg/kg body weight) to cause hyperglycemia and then divided into 5 groups (n=5). The first of these groups was left as a positive control group, while the third and fourth groups were fed on B.D. and administered with ethanolic kale leaf extract (200 and 400 mg/kg body weight) orally, respectively. The fifth and sixth diabetic rats groups fed on kale leaves powder (2.5 and 5% of basal diet), respectively. At the end of the experiment (28 days), blood samples were collected for chemical analysis, and liver and kidneys were extracted for histopathological analysis. Results showed that treating kale leaves in powder or extract reduced serum glucose, TC., TG., LDLc, VLDLc, Liver, Kidney, and MDA. At the same time, the results showed an increase in the levels of HDLc and antioxidant enzymes such as catalase and superoxide dismutase. Biological estimates, such as F.I., FER, and BWG, have also improved. In conclusion, the group treated with 2.5% kale powder achieved the best results, and it is recommended for use in our diets to treat diabetes and its associated complications.

Keywords: *Kale, Glucose, Alloxan, Oxidative Stress, Functional Foods*

1. INTRODUCTION

Diabetes mellitus is a long-term metabolic disease characterized by high blood sugar levels brought on by a reduction in the body's ability to produce or use insulin. Polyphagia (frequent eating), polydipsia (frequent drinking), and polyuria (frequent urination) are signs of diabetes mellitus [1]. Diabetics numbered 171 million in 2000 and are expected to climb to 360 million by 2030. As the number of persons with diabetes expands globally, national and international health-care budgets increase [2]. Lately, there has been an increasing curiosity about substitute

therapy for diabetic patients, including the use of plant diets [3]. In the last decade, individuals have become more interested in consuming antioxidant-rich veggies. When it comes to veggies, kale (Brassica oleracea var. acephala) has a higher antioxidant content than other types. Different varieties of kale are leafy vegetables. Nonetheless, different types of kale can be identified by their shiny blue-green leaves, their flat or thick shapes, and the amount of small flower curds that resemble broccoli [4]. Brassica oleracea var. acephala, sometimes known as kale, is a healthy semiannual or perennial vegetable. The roots, leaves, and stem are the three components that make up a kale plant. There are nutritional and therapeutic uses for the stem and leaves. Smooth, curled, and aesthetically pleasing leaves can be produced from kale. Because of its nutritious qualities, this green vegetable is steadily becoming more and more popular worldwide. Both raw and processed forms of these are consumed [5]. Fresh leaves are especially challenging to eat because of their curling beauty. The Latin term for "kale" is "borecole," and it belongs to the cabbage family. Depending on the variety and growth conditions, this crop is produced once a year and harvested in two months [6]. Based on initial research, kale has moderate amounts of oxalates, and are minerals such as Cu, Na, Mg, Fe, Ca and K. A 250 mL portion of green curly kale juice can satisfy the mineral requirements for Na2+, Mn2+, Mg2+ and Ca2+ (89%, 38%, 18% and 63%, respectively) [7]. Furthermore, one cup of raw kale has 33 calories and 7 grams of carbohydrates, both of which are helpful to the gut bacteria. It is a highly nutritious vegetable for diabetics and anyone looking to reduce weight [8]. The most frequent soluble sugars found in kale are fructose and glucose. Kale has plenty of prebiotics, vitamins, and calories. It contains dietary fibers and sugar alcohols that occur naturally and are both beneficial prebiotics. Monosaccharides, disaccharides, polysaccharides, and fructooligosaccharides are seen as a sensible approach to alleviating several chronic illnesses, such as metabolic disorders, cardiovascular disease, inflammation, and cancer [9] and [10]. Kale had 0.4 to 6.7 grams of recognized prebiotic carbs per 100 grams, however there were additional 5.0-8.0 grams of unknown soluble carbohydrates [11]. Kale is abundant in carotenoids, glucosinolates, polyphenols, as well as vitamins C and E. Kale has higher total polyphenols than any other cruciferous plant material, tannins, flavonols, phenolics, anthocyanidins, coumarins and flavones, which are phenolic chemicals found in green vegetables [12] and [13]. Consequently, kale has the ability to decrease the risk of chronic diseases which include cancer, arthritis, bone disorders, diabetes, vision troubles, liver diseases, obesity, and cardiovascular disorders [14]. Kale's excessive

sulforaphane content increases the Nrf2 gene (nuclear factor erythroid 2-related factor 2), which improves insulin sensitivity and protects against oxidative damage induced by hyperglycemia, such as nephropathy, retinopathy, and cardiomyopathy [12] and [13]. Therefore, this study was conducted to know the effect of kale plant and its extracts on the sugar level in diabetic rats.

2. Materials and methods

2.1. Materials

2.1.1 Kale plant

Kale plant was obtained at Gourmet supermarket, Maadi Degla, Egypt.

2.1.2 Alloxan:

Alloxan was attained from El-Gomhoriya Company, Cairo, Egypt. The analysis kits were purchased from the Bio Diagnostics Company in Cairo, Egypt.

2.1.3 Rats:

Thirty adult male albino rats were bought from The Egyptian Company for the Production of Serums, Vaccines, and Medicines (VACSERA) at Helwan Farm in Cairo, Egypt.

2.1.4 Diet

Diet ingredients (Casein, cellulose, DL-Methionine and choline chloride powder): The diet ingredients was purshased from Morgan Co. Cairo, Egypt.

2.2 Methods:

2.2.1 Preparation powders from the leaves of the plant:

All the leaves of the plant were dried after removing impurities from them in an oven at 40 oC. Each 100 grams takes 24 hours according to the area of the oven, then the entire quantity is ground using an electric grinder, after which the quantity is stored in atightly closed glass cup in the refrigerator in a dark place until used, who stated that, in order to prevent oxidation of their contents, all plants and herbs should be stored in a dark environment, dry, and cool according to [15].

2.2.2 Preparation the alcoholic extract from the leaves of the plant:

Using distilled ethanol 96%, the maceration procedure was used to extract the leaves from the kale. After pounding of dehydrated kale leaf samples with a blender, they were immersed in 1,500 milliliters of 96% ethanol in a dark bottle, sealed, and left to stand for four consecutive days while being stirred periodically. Then it is filtered through filter paper, It was prepared by soaking and sifting several times. Thus, we obtain the filtrate (I) and filtrate (II). which were mixed and evaporated to produce a thick extract. This Kale leaf extraction is based on an extract from Sangitan leaves published in the journal Dasopang (2017). Subsequently, a dilution of the Kale leaf extract is performed in order to get concentrations of 60, 80, 100, 120, and 140 mg/mL [16].

2.2.3 Basal diet:

The basal diet created with the following guidelines: Protein 10%, choline chloride 0.2%, cellulose 5%, corn oil 10%, corn starch 69.5% provided by AIN [17]. Also salt mixture composition and vitamin

mixture composition according to, respectively [18] and [19].

2.2.4 Induction of diabetes:

A single intraperitoneal injection of freshly produced alloxan at a dose of 150 mg/kg body weight in normal saline was used to develop diabetes in the rats after fasting for 12 hours according to [20].

2.2.5 Experimental design:

Thirty adult male albino rats weighing 150 ± 10 grams were used during the experiment. Rats were divided into two main groups. The first main group (5rats) fed on the basal diet as control negative group. The second main group (25 rats) injected with alloxan (150 mg/kg body weight) to raise the level of glucose in the blood and cause diabetes, then divided into 5 groups (5 rats in each group). One of these groups was left as a positive control group while the third and fourth groups were fed on basal diet and treated with ethanolic kale leaves extract (200 and 400 mg/kg body weight), orally, respectively. The fifth and sixth diabetic rats groups fed on kale leaves powder (2.5 and 5.0% of basal diet), respectively.

Collection of blood samples and organs:

Rats were anesthetized with diethyl ether and slaughtered after fasting for 12 hours. Blood samples were collected through the hepatic portal vein and then left for 15 minutes for blood to clot and the samples were centrifuged at 3000 rpm for 10 minutes to separate the blood serum. After the serum was thoroughly separated, it was placed into dry, clean eppendorf tubes and frozen at -20°C until analysis. After that, the rats were carefully dissected, and all organs were extracted, especially the liver and kidneys, separated from the blood, The specimens were rinsed with cold saline solution, dried between two filter sheets, weighed, and immersed in formalin solution (10%) for histological analysis [21].

2.2.6 Biological evaluation:

Body weight (BWG), Feed intake (FI) and feed efficiency ratio (FER) have been calculated in according to [22].

2.2.7 Biochemical Analysis:

Serum glucose was determined according to [23]. Serum triglycerides (T.G) Serum total cholesterol were measured according to [24) and [25]. The levels of high-density lipoprotein were determined using the methods of [26]. Very Low-Density Lipoprotein (VLDL-c) was calculated using the given formula :

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

serum low density lipoprotein (LDI-c) was calculated as follow [27]:

LDL (mg/dl) = (Total cholesterol – HDL) – VLDL b

Serum Alkaline Phosphatases (ALP), aspartate aminotransferase transferase (AST) levels and serum Alanine Aminotransferase (ALT) were estimated by using the method of [28].

Superoxide dismutase (SOD), catalase enzyme (CAT), and malondialdehyde (MDA) values were determined using the methodology of [29], [30] and [31], respectively. Also the method of measuring serum creatinine, urea, and

uric acid were employed by [28], [32] and [33], respectively.

2.2.8 Statistical Analysis:

The data were analyzed using ANOVA, using a computerized Costate Program. The findings are shown as mean +/- SD. Differences in treatments at (P≤0.05) were considered significant [34].

3. Results and Discussion

Data in table (1) show the effect of kale leaves powder form as well as extract on feed intake, feed efficiency ratio and body weight gain of diabetic rats. It is clear from the data shown in the table that the value of feed intake, feed efficiency ratio and body weight gain decreased in the diabetic group compared to the healthy group. Treatment with different concentrations of kale leaves powder and its aqueous extract showed an improvement in the level of the previous values. The fifth group which treated with 2.5% kale powder showed the best results. the improvement rates reached to +116.66, +18.96 and +83.82% for BWG, FI, and FER when compared to the positive control group. These results are consistent with [35] who stated that Kale is high in fiber, which is vital for intestinal health. Fiber aids in the cleaning of the gastrointestinal tract, allowing for more regular bowel movements. This vital function keeps poisons out of the body. Furthermore, the fiber in kale nourishes our good gut bacteria, or gut microbiome, which is responsible for not only our digestive health but also our mood, immunity, and lifespan. Also, [36] investigated that Kale is high in antioxidants (e.g., beta-carotene, ascorbic acid, and tocopherol), water-soluble vitamins (WSV), fat-soluble vitamins (FSV), bioactive compounds, phytochemicals (such as lutein, zeaxanthin, and polyphenols), fiber and macro minerals because of its diverse composition, it improved human health and played an important part in body growth.

These results are in parallel with that of [37] working on other plants considering the control (+) of diabetic rats.

Table (1): Effect of kale leaves extract and powder on body weight gain (BWG), feed intake (FI) and feed efficiency ratio (FER) of control negative and diabetic rats groups

Groups	BWG (g/day/rat)	%Change of (+Ve)	FI (g/day)	%Change of (+Ve)	FER	%Change of (+Ve)
control -ve	3.35±0.12a	+153.79	23.94±1.4a	+24.69	0.13±0.001a	+104.41
control +ve	1.32±0.197e	00.00	19.2±1.18c	00.00	0.068±0.001f	00.00
KLEx (200mg/kg/orally)	2.14±0.11c	+62.12	21.68±1.14abc	+12.92	0.099±0.001c	+4.56
KLEx (400mg/kg/orally)	1.82±0.265d	+37.88	20.42±1.19bc	+6.35	0.089±0.001d	+30.88
KLP (2.5%, w/w)	2.86±0.16b	+116.66	22.84±1.04ab	+18.96	0.125±0.001b	+83.82
KLP (5%, w/w)	1.44±0.14e	+9.09	19.99±1.56bc	+4.11	0.072±0.001e	+5.88
LSD:P≤0.05	0.308	------	2.25	------	0.002	------

Means in the same column with different letters are significantly different at P≤0.05. KLP: Kale leaves powder. KLEx: Kale leaves extract.

Table (2) demonstrated that the mean value of serum glucose level in the positive control group was higher than the negative control group with a significant difference with a Percentage of reduction -61.54% for the control negative group as compared to the control positive group. All groups treated with kale leaves and its extracts showed significant decrease in blood glucose levels compared to the positive control group, as significant differences were found between all groups and the positive control group. The percentage of improvement in blood glucose levels in the group treated with 2.5% kale powder reached to -47.69% and this group recorded the best results.

These results are fully consistent with [38] who showed that phytochemical analysis revealed that kale extract (Brassica oleracea var. acephala) includes flavonoids, tannins, terpenoids, and phenols. Flavonoids are chemicals that have the ability to lower glucose via inhibiting metabolic enzymes, increasing insulin production, decreasing apoptosis, and decreasing insulin resistance [39]. Also, [40] said that Kaempferol and quercetin contained in kale have a functioning mechanism that protects beta cells from injury, supports glycogen production, and prevents alpha glucosidase. According to [36], Numerous bioactive compounds found in kale allow it to help repair cells, including abnormal cell growth and pancreatic beta-cells. It also helps prevent major diseases of the human body, including cancer, heart muscle, type 2 diabetes, eyes, brain, bone, and gastrointestinal (GIT) disorders as well as hypertension. These results are agreement with of [41] when using other hyperglycemic plants for diabetic rats.

Table (2): Effect of kale leaves extract and powder on serum glucose level of control negative and diabetic rats groups

Groups	Glucose (mg/dl)	%Change of (+Ve)
control -ve	103.2±0.96f	-61.54
control +ve	268.3±0.76a	00.00
KLEx (200 mg/kg/orally)	159.4±1.00d	-40.60
KLEx (400mg/kg/orally)	206.6±1.20c	-22.98
KLP (2.5%, w/w)	140.3±0.95e	-47.69
KLP (5%, w/w)	237.4±1.22b	-11.53
LSD:P≤0.05	1.83	------

Means in the same column with different letters are significantly different at P≤0.05. KLP: Kale leaves powder. KLEx: Kale leaves extract.

Table (3) shows the effect of kale leaves and its extracts on the level of triglycerides and total cholesterol in diabetic rats. It is clear from the data shown in the table that the value of total cholesterol and triglycerides increased in the affected groups compared to the healthy group. All groups treated with kale leaves and its extracts showed significant decreases in the percentage of triglycerides and total cholesterol compared to the positive control group. The percentage of improvement in the level of triglycerides and total cholesterol in the group treated 2.5 % kale powder reached to -44.08 % and -52.96, respectively. This group recorded the best results.

Table (3): Effect of kale leaves extract and powder on serum total cholesterol (T.C) and serum triglycerides (T.G) of control negative and diabetic rats groups

Groups	TC (mg/dl)	% Change of (+Ve)	TG (mg/dl)	% Change of (+Ve)
control -ve	111.46f±1.14f	-54.38	95.90±1.03e	-44.40
control +ve	244.33±1.2a	00.00	172.49±1.05a	00.00
KLEx(200mg/kg/orally)	170.24±1.23c	-30.32	144.47±1.25c	-16.24
KLEx(400mg/kg/orally)	154.63±1.19d	-36.71	136.86±1.09d	-20.66
KLP (2.5%, w/w)	114.93±1.03e	-52.96	96.44±1.12e	-44.08
KLP (5%, w/w)	194.61±1.07b	-20.35	151.35±1.24b	-12.26
LSD:P≤0.05	2.04	------	2.02	------

Means in the same column with different letters are significantly different at P≤0.05. KLP: Kale leaves powder. KLEx: Kale leaves extract.

The following table (Table 4) shows the effect of treatment with kale leaves and its aqueous extract on serum HDL-c, LDL-c and VLDL-c of control negative and diabetic rats group. As can be seen from the table, treatment with alloxan led to an increase in serum LDL and VLDL level in the diabetic group, while LDL and VLDL level decreased in the groups treated with kale leaf powder and its aqueous extracts. The group treated with 2.5 kale leaves powder showed the best results. In contrast, the concentration of high-density lipoprotein decreased in the affected group compared to the healthy group. Treatment with kale in the form of powder and extract led to an increase in this percentage compared to the inflicted group. The fifth group also showed the best results.

These results are consistent with the results in the study conducted by [42] who reported that, (Brassica oleracea var. acephala) therapy effectively reduced total cholesterol, triglycerides, LDL, and VLDL in KBrO3-induced toxicity rats. One possible explanation for this effect is the management of hepatic and renal toxicity. Also, [43] discovered that foods such as apples, pears, and brussels sprouts, particularly kale, are high in soluble fiber, which helps to lower cholesterol levels in the blood vessels. A daily fiber intake of five to ten grams or more is essential to reduce LDL (bad) cholesterol. Water-soluble fiber lowers cholesterol when cholesterol-rich foods enter the small intestine, where fiber binds to cholesterol. The fiber particle forms a link with cholesterol, which prevents LDL from entering the bloodstream; however, it does not move throughout the body. So, bound cholesterol is eliminated from the body through feces. Also, [44] demonstrated that the HFD supplemented with kale lowers LDL cholesterol levels. Food components are suggested to decrease cholesterol through bile acid binding. Kale includes bile acid sequestrants, which limit bile acid recirculation, reducing fat absorption, excreting cancer-causing toxic metabolites, and utilizing cholesterol to manufacture additional bile acids. The greater levels of triglycerides seen in colon fecal samples of mice

treated with kale indicate that it decreases fat absorption in the intestines.

Table (4) : Effect of kale leaves extract and powder on serum HDL-c , LDL-c and vLDL-c of control negative and diabetic rats groups

Groups	HDL (mg/dl) (Mean ± SD)	% Change of (+Ve)	LDL (mg/dl) (Mean ± SD)	% Change of (+Ve)	VLDL (mg/dl) (Mean ± SD)	% Change of (+Ve)
control -ve	48.5±0.012a	+10.49	43.78±1.33f	-73.62	19.18±1.08d	-44.39
control +ve	43.9±0.03d	00.00	165.94±1.72a	00.00	34.49±1.28a	00.00
KLEx (200mg/kg/orally)	47.18±0.1c	+7.49	94.17±1.08c	-43.25	28.89±1.34bc	-16.24
KLEx (400mg/kg/orally)	47.8±0.11b	+8.93	79.45±1.34d	-52.12	27.37±1.26c	-20.64
KLP (2.5%, w/w)	48.61±0.11a	+10.74	47.04±1.03e	-71.65	19.28±1.2d	-44.09
KLP (5%, w/w)	47.98±0.27b	+9.31	116.36±1.13b	-29.88	30.27±1.14b	-12.24
LSD:P≤0.05	0.237	------	2.30	------	2.17	------

Means in the same column with different letters are significantly different at P≤0.05. KLP: Kale leaves powder. KLEx: Kale leaves extract.

Table (5) shows the effect of kale on liver enzymes in diabetic rats. It is clear from the data shown in the table that the value of liver enzymes (AST, ALT and ALP) increased in the affected group compared to the healthy group. All groups treated with kale leaves and their extracts showed significant decrease in the value of liver enzymes compared to the positive control group. The percentage of improvement in the level of liver enzymes (AST, ALT and ALP) in the group treated with kale powder 2.5% reached to -53.27, -64.44 and -42.85%, respectively. This group recorded the best results.

This is consistent with [45], who said that one of the most prevalent aglycone flavonoids in glycoside form is kaempferol. This yellow molecule, which has four hydroxy groups at positions 3, 5, 7, and 4, is a tetra hydroxyl flavone. It can be found in many different plant foods and plant-based supplements, such as broccoli, spinach, beans, tea, and kale [46] and [47]. Studies have shown that kaempferol and its glycosylated derivatives have hepatoprotective effects [48]. it can decrease level of ALT and AST, induce hepatocellular damage and increases expression of antioxidant enzymes and apoptosis [49].

Also, [50] revealed that kaempferol can increase the expression of Carnitine palmitoyl transferase 1A (CPT1A), block the NF-6B signal transduction pathway, and enhance 7oxidation in mitochondria.

The information in table (6) illustrates how kale leave powder and extract affect renal function in diabetic rats, specifically creatinine, uric acid and urea. It was found that the mean values of creatinine, uric acid and urea in control positive group were greater than that of the control negative group with a percent decrease of -36.21, -29.96 and -62.29 % for the control (-ve) group compared to the control (+ve) group. Renal functions

significantly decreased in all groups treated with kale leaf powder and extract as compared to the positive control group. The results showed that the kale leave powder (2.5%) improved kidney function more than the kale leave extract (200 and 400 mg/kg).

Table (5): Effect of kale leaves extract and powder on liver enzymes (AST, ALT and ALP) of control negative and diabetic rats groups

Groups	AST (U/L)	% Change of (+Ve)	ALT (U/L)	% Change of (+Ve)	ALP (U/L)	% Change of (+Ve)
control -ve	50.57±0.95f	-71.39	53.58±1.19f	-71.85	175.39±1.28e	-43.51
control +ve	176.79±1.29a	00.00	190.34±70a	00.00	310.52±1.26a	00.00
KLEx(200mg/kg/orally)	92.59±1.09d	-47.63	84.41±0.55d	-55.65	233.38±1.00d	-24.84
KLEx(400mg/kg/orally)	134.87±1.01c	-23.71	145.34±1.36b	-23.64	269.67±0.74b	-13.16
KLP (2.5%, w/w)	82.62±1.13e	-53.27	67.67±0.99e	-64.44	177.47±1.41e	-42.85
KLP (5%, w/w)	137.69±1.25b	-22.12	132.56±1.12c	-30.36	248.65±1.30c	-19.92
LSD:P≤0.05	2.001	------	1.83	------	2.11	------

Means in the same column with different letters are significantly different at P≤0.05. KLP: Kale leaves powder. KLEx: Kale leaves extract.

These findings are in line with those of [42], who claimed that kale has both ameliorative and protective effects against renal injury, which are at least partially mediated by its phenolic and antioxidant qualities as shown by an increase in antioxidant status and a decrease in lipid peroxidation indicators. Furthermore, [51] and [52] mentioned that rich in vitamins and minerals, dark leafy vegetables like kale and spinach support optimal kidney function. Antioxidants included in these veggies may also facilitate the kidneys' ability to filter blood. Quercetin is one of the most significant antioxidants present in kale.Quercetin is an activator of Sirtuin-1 and Sirtuin-3 that is readily available from a variety of fruits and vegetables. It has a wide range of biological effects, including the resistance of microbial, diabetic, and inflammatory processes. Additionally, [53] and [54] said that quercetin exhibits renoprotective properties against nephrotoxicity, acute kidney injury (AKI), and chronic kidney disease (CKD), and also [55] reported that through Sirtuin-1 activation, quercetin has been shown to upregulate the expression of Parkin and PTEN-induced kinase 1 (PINK1). Additionally, quercetin therapy reduces the senescence of renal tubular epithelial cells (TEC) via encouraging mitophagy. The results of this table are in parallel with that obtained by [56] when using Lemongrass for alloxan injected rats.

The following table (7) show the effect of kale leaves in powder form as well as extract on the level of oxidant and antioxidant enzymes. It is clear from the table that the level of malondialdehyde enzyme was higher in the diabetic group compared to the healthy group. While the level of catalase and superoxide dismutase enzymes decreased in the inflicted group compared to the healthy

group, treatment with kale leaves helped to raise the percentage of antioxidant enzymes such as catalase and superoxide dismutase and reduce the percentage of malondialdehyde. The fifth group showed the best results as its malondialdehyde level reached the malondialdehyde level in the healthy group.

Table (6): Effect of kale leaves extract and powder on Serum Creatinine Uric acid and Urea of control negative and diabetic rats groups

Groups	Creatinine (mg/dl)	% Change of (+Ve)	UricAcid (mg/dl)	% Change of (+Ve)	Urea (mg/d)	% Change of (+Ve)
control -ve	0.74±0.085b	-36.21	3.18±0.178c	-29.96	22.31±0.82e	-62.29
control +ve	1.16±0.11a	00.00	4.54±0.108a	00.00	59.16±1.14a	00.00
KLEx(200mg/kg/orally)	0.86±0.16b	-25.86	3.76±0.138b	-17.18	38.98±1.86c	-34.11
KLEx(400mg/kg/orally)	1.03±0.023ab	-11.21	4.42±0.145a	-2.64	47.36±1.24b	-19.95
KLP (2.5%, w/w)	0.75±0.152b	-35.34	3.26±0.224c	-28.19	27.72±1.32d	-53.14
KLP (5%, w/w)	0.98±0.092ab	-15.52	4.49±0.24a	-1.10	48.13±1.11b	-18.64
LSD:P≤0.05	0.201	------	0.317±	------	2.29	------

Means in the same column with different letters are significantly different at P≤0.05. KLP: Kale leaves powder. KLEx: Kale leaves extract.

[42] confirmed this study when said that Even when added as dried leaves, juice, or seeds, (Brassica oleracea var. acephala) supplementation dramatically increased the antioxidant status and decreased the incidence of dyslipidemia and oxidative stress in rats exposed to KBrO3-induced toxicity. Also, [57] reported that Dark green leafy vegetables, such as kale, contain carotenoids that have the ability to function as antioxidants and fortify the body's defenses against free radicals. These defenses help stop free radicals from causing damage to DNA, which can lead to cancer. Vitamin C, found in kale, is a powerful antioxidant that inhibits the production of carcinogens. Like other leafy greens, kale is rich in antioxidants. In addition, it has beta-carotene, vitamin C, and flavonoids and polyphenols. Chemicals known as antioxidants help shield the body from oxidative damage brought on by free radicals.

[58] discovered that one of the main causes of aging and many diseases, including cancer, is believed to be oxidative damage. Still, a lot of substances that are antioxidants have other important functions. The flavonoids quercetin and kaempferol, which are abundant in kale, are particularly significant among these compounds. Strong anti-inflammatory, antiviral, antidepressant, blood pressure-lowering, heart-protective, and anti-cancer effects are among their qualities.

Also, [59] revealed that the results show that feeding model rats up to 60 g/kg of dried kale leaves for 90 days has no negative effects. The alterations observed in plasma TEAC (Trolox equivalents antioxidant capacity) and hepatic

antioxidant enzymes indicate that kale leaves have a positive impact on the antioxidant status of rats. It's interesting that in males compared to females, these alterations were more noticeable. In addition, [60] showed that Vitamin C, a water-soluble vitamin that strengthens immunity, is abundant in kale. Kale contains more vitamin C than most other green leafy vegetables (approximately three times more than spinach and collard greens), and vitamin C plays an unparalleled role in maintaining healthy and robust immune cells.

Table (7): Effect of kale leaves extract and powder on blood malondialdehyde concentration (MDA) and superoxide dismutase (SOD) and catalase (CAT) of control negative and diabetic rats groups

Groups	MDA (nmol/ml)	%Change of (+Ve)	SOD (U/gHb)	%Change of (+Ve)	CAT (U/gHb)	%Change of (+Ve)
control -ve	0.57±0.01d	-92.06	200.28±1.3a	+411.57	9.68±1.63a	+1190.66
control +ve	7.18±0.94a	00.00	39.15±1.08f	00.00	0.75±0.01d	00.00
KLEx(200mg/kg/orally)	2.01±0.99cd	-72.00	114.4±1.35c	+192.23	7.52±1.31b	+902.67
KLEx(400mg/kg/orally)	3.82±1.48bc	-47.80	99.75±1.1d	+154.79	3.81±1.01c	+408
KLP (2.5%, w/w)	1.17±1.03d	-83.70	154.2±1.19b	+293.82	6.83±1.28b	+810.67
KLP (5%, w/w)	4.74±1.68b	-33.98	64.51±1.42e	+64.78	2.39±1.17cd	+218.67
LSD:P≤0.05	2.05	------	2.22	------	2.10	------

Means in the same column with different letters are significantly different at P≤0.05. KLP: Kale leaves powder. KLEx: Kale leaves extract.

Histopathological Results:

Histopathological examination of liver:

Light microscopic examination of liver sections of rats from group 1 revealed the normal histological architecture of hepatic lobules (Photo 1 & 2). In contrast, liver of rats from group 2 showed histopathological damage characterized by vacuolar degeneration of hepatocytes (Photo 3), Kupffer cells activation (Photo 3 & 4), fibroplasia in the portal triad (Photo 3), focal hepatocellular necrosis associated with inflammatory cells infiltration as well as inflammatory cells infiltration in the portal triad (Photo 4). On the other hand, liver of rats from group 3 manifested Kupffer cells activation (Photo 5 & 6), few leucocytes in the hepatic sinusoids (Photo 5) and small focal hepatocellular necrosis associated with inflammatory cells infiltration (Photo 6). Furthermore, hepatic tissue of rats from group 4 showed Kupffer cells activation (Photo 7, 8 & 9) and few inflammatory cells infiltration in the portal triad (photo 9). Meanwhile, liver of rats from group 5 revealed slight dilatation of hepatic sinusoids (photo 10), few leucocytic exocytosis (Photo 11), vacuolar degeneration of hepatocytes and inflammatory cells infiltration in the portal triad (Photo 12). Otherwise, liver of rats from group 6 exhibited vacuolar degeneration of hepatocytes (Photo 13 & 14) and Kupffer cells activation (Photo 14 & 15).

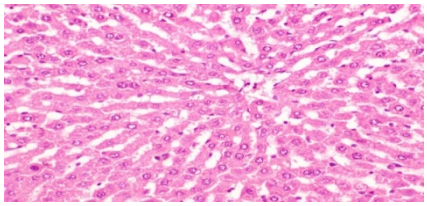

Photo (1): Photomicrograph of liver of rat from group 1 (control -ve) showing the normal histological architecture of hepatic lobule (H & E X 400).

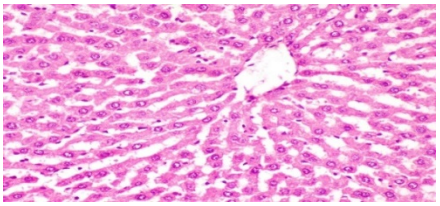

Photo (2): Photomicrograph of liver of rat from group 1 (control -ve) showing the normal histological architecture of hepatic lobule (H & E X 400).

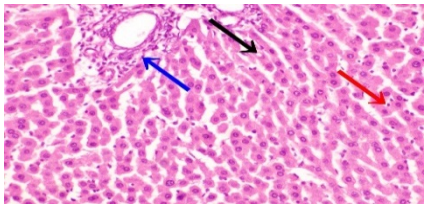

Photo (3): Photomicrograph of liver of rat from group 2 (control +ve) showing vacuolar degeneration of hepatocytes (black arrow), Kupffer cells activation (red arrow) and fibroplasia in the portal triad (blue arrow) (H & E X 400).

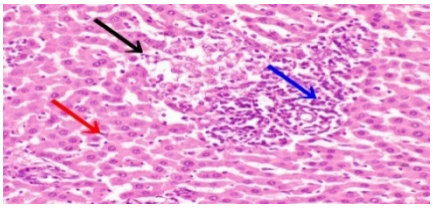

Photo (4): Photomicrograph of liver of rat from group 2 (control +ve) showing focal hepatocellular necrosis associated with inflammatory cells infiltration (black arrow), Kupffer cells activation (red arrow) and inflammatory cells infiltration in the portal triad (blue arrow) (H & E X 400).

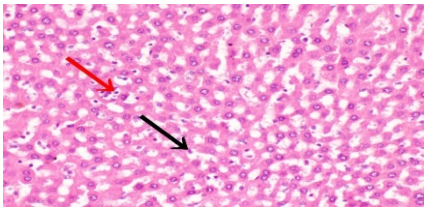

Photo (5): Photomicrograph of liver of rat from group 3 (kale leave extract 200mg/kg) showing Kupffer cells activation (black arrow) and few leucocytes in the hepatic sinusoids (red arrow) (H & E X 400).

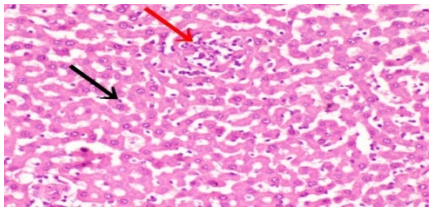

Photo (6): Photomicrograph of liver of rat from group 3 (kale leave extract 200mg/kg) showing Kupffer cells activation (black arrow) and small focal hepatocellular necrosis associated with inflammatory cells infiltration (red arrow) (H & E X 400).

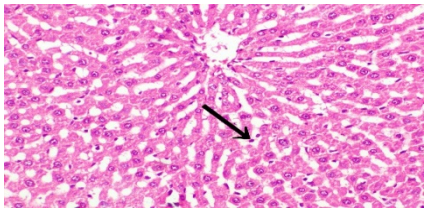

Photo (7): Photomicrograph of liver of rat from group 4 (kale leave extract 400mg/kg) showing Kupffer cells activation (black arrow) (H & E X 400).

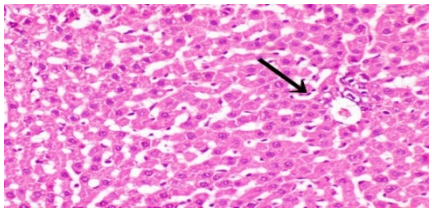

Photo (8): Photomicrograph of liver of rat from group 4 (kale leave extract 400mg/kg) showing Kupffer cells activation (black arrow) (H & E X 400).

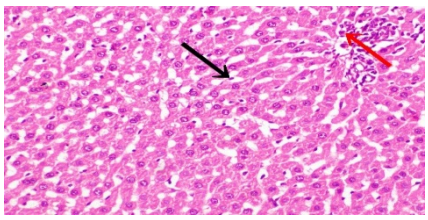

Photo (9): Photomicrograph of liver of rat from group 4 (kale leave extract 400mg/kg) showing Kupffer cells activation (black arrow) and few inflammatory cells infiltration in the portal triad (red arrow) (H & E X 400).

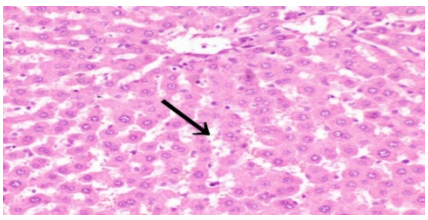

Photo (10): Photomicrograph of liver of rat from group 5 (kale leave powder 2.5%, w/w) showing slight dilatation of hepatic sinusoids (black arrow) (H & E X 400).

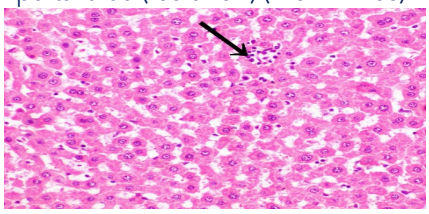

Photo (11): Photomicrograph of liver of rat from group 5 (kale leave powder 2.5%, w/w) showing few leucocytic exocytosis (black arrow) (H & E X 400).

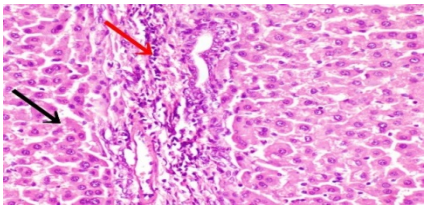

Photo (12): Photomicrograph of liver of rat from group 5 (kale leave powder 2.5%, w/w) showing vacuolar degeneration of hepatocytes (black arrow) and inflammatory cells infiltration in the portal triad (red arrow) (H & E X 400).

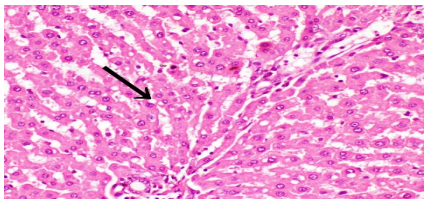

Photo (13): Photomicrograph of liver of rat from group 6 (kale leave powder 5%, w/w) showing vacuolar degeneration of hepatocytes (black arrow) (H & E X 400).

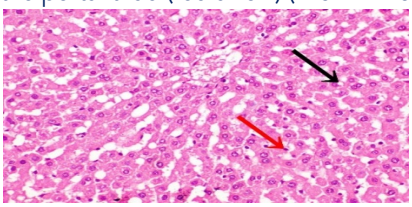

Photo (14): Photomicrograph of liver of rat from group 6 (kale leave powder 5%, w/w) showing vacuolar degeneration of hepatocytes (black arrow) and Kupffer cells activation (red arrow) (H & E X 400).

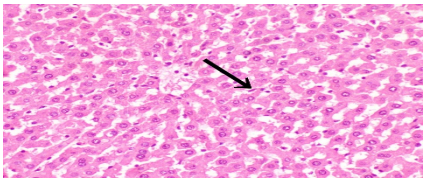

Photo (15): Photomicrograph of liver of rat from group 6 (kale leave powder 5%, w/w) showing Kupffer cells activation (black arrow) (H & E X 400).

Histopathological examination of kidneys:

Microscopically, kidneys sections of rats from group 1 exhibited apparently normal histological structure of renal parenchyma (Photo 16 & 17). In contrariwise, kidneys of rats from group 2 showed obvious histopathological damage characterized by severe cytoplasmic vacuolization of epithelial lining renal tubules (Photo 18 & 19), proteinaceous material in the lumen

of renal tubules, congestion of glomerular tuft (Photo 18), congestion of renal blood vessel (Photo 19) and interstitial inflammatory cells infiltration (Photo 20). Meanwhile, renal sections of rats from group 3 revealed cytoplasmic vacuolization of epithelial lining renal tubules (Photo 21) and proteinaceous material in the lumen of some renal tubules (Photo 21 & 22). Furthermore, kidneys of rats from group 4 described slight cytoplasmic vacuolization of epithelial lining some renal tubules (Photo 23 & 24), proteinaceous material in the lumen of renal tubules (Photo 23, 24 and 25) and congestion of renal blood vessel (Photo 23). Likewise, kidneys of rats from group 5 showed cytoplasmic vacuolization of epithelial lining some renal tubules (Photo 26 & 27), congestion of renal blood vessel (Photo 27) and proteinaceous material in the lumen of some renal tubules (Photo 28). Moreover, kidneys of rats from group 6 exhibited slight cytoplasmic vacuolization of epithelial lining some renal tubules (Photo 29, 30 and 31), proteinaceous material in the lumen of some renal tubules (Photo 29 & 30) and congestion of renal blood vessel (Photo 31).

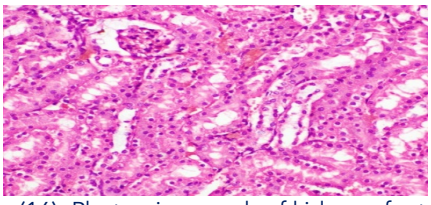

Photo (16): Photomicrograph of kidney of rat from group 1 (control -ve) showing apparently normal histological structure of renal parenchyma (H & E X 400).

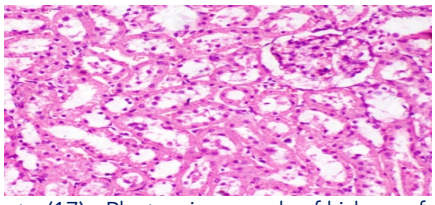

Photo (17): Photomicrograph of kidney of rat from group 1 (control -ve) showing apparently normal histological structure of renal parenchyma (H & E X 400).

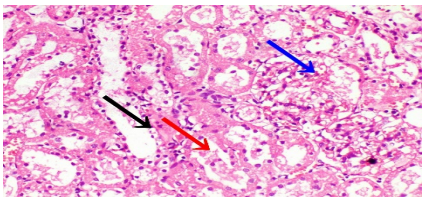

Photo (18): Photomicrograph of kidney of rat from group 2 (control +ve) showing severe cytoplasmic vacuolization of epithelial lining renal tubules (black arrow), proteinaceous material in the lumen of renal tubules (red arrow) and congestion of glomerular tuft (blue arrow) (H & E X 400).

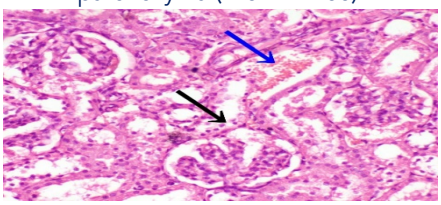

Photo (19): Photomicrograph of kidney of rat from group 2 (control +ve) showing cytoplasmic vacuolization of epithelial lining renal tubules (black arrow) and congestion of renal blood vessel (blue arrow) (H & E X 400).

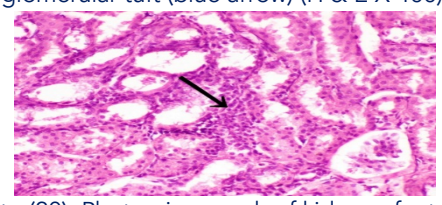

Photo (20): Photomicrograph of kidney of rat from group 2 (control +ve) showing interstitial

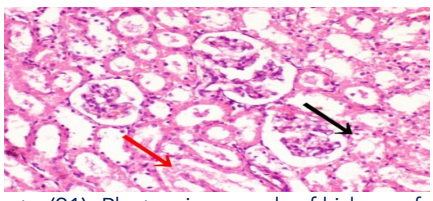

Photo (21): Photomicrograph of kidney of rat from group 3 (kale leave extract 200mg/kg) showing cytoplasmic vacuolization of epithelial

inflammatory cells infiltration (black arrow) (H & E X 400).

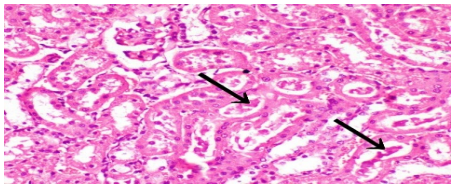

Photo (22): Photomicrograph of kidney of rat from group 3 (kale leave extract 200mg/kg) showing proteinaceous material in the lumen of some renal tubules (black arrow) (H & E X 400).

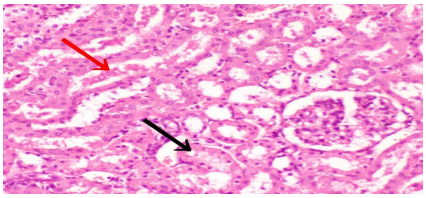

Photo (24): Photomicrograph of kidney of rat from group 4 (kale leave extract 400mg/kg) showing slight cytoplasmic vacuolization of epithelial lining some renal tubules (black arrow) and proteinaceous material in the lumen of renal tubules (red arrow) (H & E X 400).

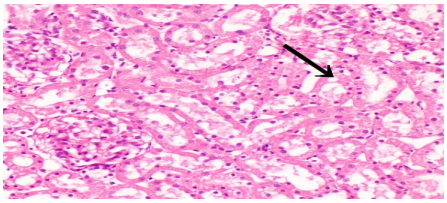

Photo (26): Photomicrograph of kidney of rat from group 5 (kale leave powder 2.5%, w/w) showing cytoplasmic vacuolization of epithelial lining renal tubules (black arrow) (H & E X 400).

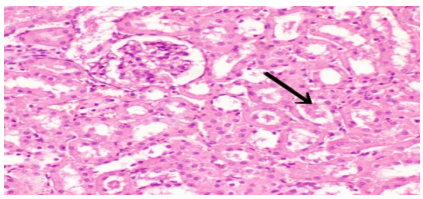

Photo (28): Photomicrograph of kidney of rat from group 5 (kale leave powder 2.5%, w/w) showing proteinaceous material in the lumen of some renal tubules (black arrow) (H & E X 400).

lining renal tubules (black arrow) and congestion of renal blood vessel (blue arrow) (H & E X 400).

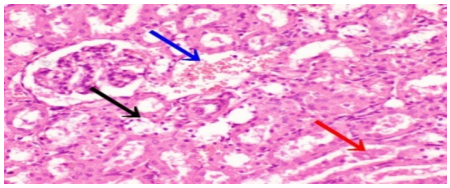

Photo (23): Photomicrograph of kidney of rat from group 4 (kale leave extract 400mg/kg) showing slight cytoplasmic vacuolization of epithelial lining some renal tubules (black arrow), proteinaceous material in the lumen of renal tubules (red arrow) and congestion of renal blood vessel (blue arrow) (H & E X 400).

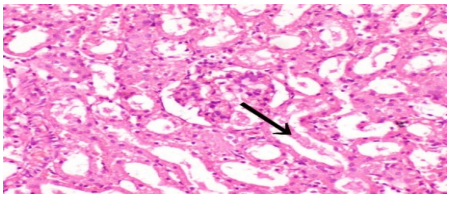

Photo (25): Photomicrograph of kidney of rat from group 4 (kale leave extract 400mg/kg) showing proteinaceous material in the lumen of renal tubules (black arrow) (H & E X 400).

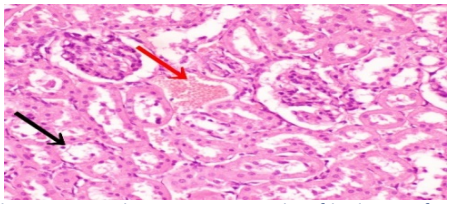

Photo (27): Photomicrograph of kidney of rat from group 5 (kale leave powder 2.5%, w/w) showing cytoplasmic vacuolization of epithelial lining some renal tubules (black arrow) and congestion of renal blood vessel (red arrow) (H & E X 400).

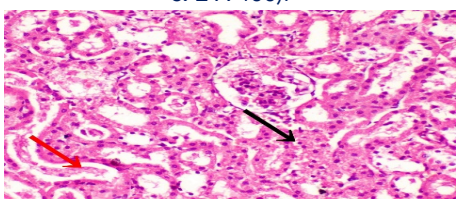

Photo (29): Photomicrograph of kidney of rat from group 6 (kale leave powder 5%, w/w) showing slight cytoplasmic vacuolization of epithelial lining some renal tubules (black arrow) and proteinaceous material in the lumen of some renal tubules (red arrow) (H & E X 400).

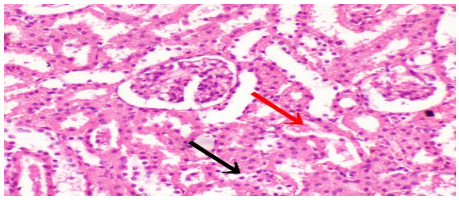

Photo (30): Photomicrograph of kidney of rat from group 6 (kale leave powder 5%, w/w) showing slight cytoplasmic vacuolization of epithelial lining some renal tubules (black arrow) and proteinaceous material in the lumen of some renal tubules (red arrow) (H & E X 400).

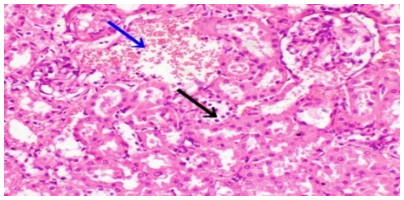

Photo (31): Photomicrograph of kidney of rat from group 6 (kale leave powder 5%, w/w) showing slight cytoplasmic vacuolization of epithelial lining some renal tubules (black arrow) and congestion of renal blood vessel (blue arrow) (H & E X 400).

4. Conclusion

The best result from the obtained data was produced by kale leaf powder (2.5%). The kale leaf extract and powder enhanced the diabetic rats' serum glucose levels, Tc, T.G, LDL, and VLDL, as well as their liver and renal functions. Thus, since kale leaf extract and powder include active components that are good for people with diabetes, they should be a part of our meals.

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التغذية وعلوم الاطعمة

دراسة تأثير مسحوق ومستخلص نبات الكيل على الفئران المصابة بارتفاع السكر في الدم

اية عادل السيد، فاطمة الزهراء أمين الشريف، بسمة رمضان خطيب،

قسم التغذية وعلوم الأطعمة .كلية الاقتصاد المنزلي .جامعة المنوفية، شبين الكوم، مصر

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الملخص العربي:

تهدف هذه الدراسة إلى معرفة تأثير مسحوق ومستخلص نبات الكيل في علاج الفئران المصابة بارتفاع السكر في الدم ، تم استخدام ثلاثين من الفئران البيضاء البالغة بوزن 150 ± 10 جرام خلال التجربة ، تم تقسيم الفئران إلى مجموعتين رئيسيتين. المجموعة الرئيسية الأولى (5 فئران) غذيت على العليقة الأساسية كمجموعة ضابطة سالبة. المجموعة الرئيسية الثانية (25 فأراً) تم حقنها بمادة الألوكسان (150 ملغم/كغم من وزن الجسم) لإصابتها بالسكري، ثم تم تقسيمها إلى 5 مجموعات (5 فئران في كل مجموعة). تركت إحدى هذه المجموعات كمجموعة ضابطة موجبة بينما تم تغذية المجموعتين الثالثة والرابعة على نظام غذائي أساسي وعولجت بمستخلص أوراق الكيل الإيثانولي (200 و 400 ملغم / كغم من وزن الجسم) ، عن طريق الفم ، على التوالي. تم تغذية المجموعتين الخامسة والسادسة على مسحوق أوراق الكيل (2.5 و5 % من العليقة الأساسية) على التوالي. في نهاية التجربة (28 يوم) تم جمع عينات الدم لتحليلها كيميائيا وتم استخلاص الكبد والكلى للفحص الهستوباثولوجى . أظهرت النتائج أن المعاملة بأوراق الكيل في شكل مسحوق أو مستخلص أدى إلى انخفاض مستويات السكر في الدم، الكوليسترول الكلي، الدهون الثلاثية، و الليبوبروتين منخفض الكثافة، والليبوبروتين منخفض الكثافة جداً، ووظائف الكبد، ووظائف الكلى و الأكسدة والمالوندیالدهید . بينما أظهرت النتائج زيادة في مستويات كل من الليبوبروتين عالي الكثافة والإنزيمات المضادة للأكسدة مثل الكتاليز والسوبر اوكسيد ديسميوتيز. كما تحسنت التقديرات البيولوجية مثل المأخوذ الغذائي ونسبة كفاءة الغذاء ووزن الجسم المكتسب. وقد حققت المجموعة المعالجة بمسحوق الكيل بنسبة 2.5% أفضل النتائج، وينصح باستخدامه في نظامنا الغذائي لعلاج مرض السكري والمضاعفات المرتبطة به.

الكلمات الكاشفة: الكيل، الجلوكوز،الألوكسان، الإجهاد التأكسدي، الأغذية الوظيفية