Uttar Pradesh Journal of Zoology

Volume 45, Issue 19, Page 509-522, 2024; Article no.UPJOZ.4204
ISSN: 0256-971X (P)

Evaluating the Antihyperglycemic Effects of Elnabk Fruit Powder in Hyperglycemic Rats

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Authors' contributions

This work was carried out in collaboration among all authorsAll authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.56557/upjoz/2024/v45i194555

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.mbimph.com/review-history/4204

Original Research Article

Received: 05/08/2024
Accepted: 08/10/2024
Published: 17/10/2024

ABSTRACT

Diabetes is a major public health concern that leads to significant illness, death, and long-term effects. The research involved twenty-four (24) Sprague-Dawley male albino rats, with an average weight of 150 ± 10 g. The researchers fed the rats a basic diet for one week prior to the research. The researchers then separated the rats into four groups, each containing six rats. The control

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Cite as: *Alzahrani, Magbolah Salem Helal, Lobna Saad Mohammed Abd Elmeged, and Marwa A. Ahmed. 2024. "Evaluating the Antihyperglycemic Effects of Elnabk Fruit Powder in Hyperglycemic Rats". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (19):509-22. https://doi.org/10.56557/upjoz/2024/v45i194555.*

group consisted of normal rats without any experimental manipulation (C–ve). The initial group, referred to as the -ve control group, comprised healthy rats who received only the basal diet for a period of twenty-eight days. The remaining rats (n = 18) with diabetes received Alloxan at a dosage of 150 mg/kg. The second group, known as the positive control group, involved diabetic rats who did not receive any food from the experimental plant. We injected alloxan into the other two experimental groups, and fed each group a basic meal of elnabk fruit at concentrations ranging from 5% to 10%. Elnabk fruit powder for 28 days. We took a blood sample at the end of the experiment, removed the organs, & subjected them to biochemical analysis. The consequences demonstrated that group 4 (rats with diabetes fed on ten percent elnabk fruit powder) had the best serum (HDL c) when in contrast to the control positive group.

Keywords: Elnabk fruit; diabetic patients; biochemical changes.

1. INTRODUCTION

Diabetes is a medical condition defined as elevated amounts of glucose in the bloodstream. The nutrients in the food you consume generate glucose. Insulin, a hormone, facilitates the transportation of glucose, a sugar source for energy, to your cells. In T1DM, the pancreas stop to produce insulin. In T2DM, which is the prevailing form, your body exhibits impaired production and utilization of insulin. Inadequate insulin levels lead to glucose retention in the bloodstream. It is also possible for you to have prediabetes. This means that although your blood sugar levels are high, they do not meet the criteria for diabetes. Prediabetes elevates the likelihood of developing [1]. Elnabk fruit are small oval grains the size of cherries, their colors range from orange to dark red, and when fully ripe, they are black. Buckthorn is famous for containing a high percentage of elements that have great physical health benefits. Doctors advise eating sea elnabk fruit whenever possible to provide the body with vitamins and minerals that are important for its health [2]. Elnabk fruit, a type of food, is rich in essential nutrients including potassium, phoshorus, calcium, iron, magnesium, and other vitamins such as vit B6, vit B1, vit E, vit B2, and vitamin C, which contribute to human well-being. The extracted oil from Elnabk fruit also contains a variety of vitamins, minerals, and antioxidants that aid in the prevention of skin aging and provide assistance in the prevention of cancer as well as cardiovascular disease . Both the seeds in addition to the leaves of the buckthorn plant contain chemicals that have the ability to minimize blood pressure as well as offer shields against cardiovascular & cardiovascular diseases. These are the primary advantages of buckthorn. Elnabk oil helps prevent diabetes, which is one of the important benefits of Elnabk. Some studies were conducted on animals; Then, in humans, it was proven that Elnabk oil may contribute to increasing insulin secretion, thus reducing blood sugar and protecting against type 2, [3]. Al-Ghamdi and Shahat, [4] They found that treating streptozotocin-induced rats with elnabk extract was effective in reducing TC and TG levels, so ZSC had the ability to decrease hyperlipidemia. Parsaeyan and Rezvani, [5] reported that a significant decrease in different blood lipid profile measurements, especially serum T.C. as well as serum triglycerides, was observed in diabetic and non-diabetic rats after four weeks of being given elnabk leaf extract, in contrast to both the non-diabetic and diabetic control groups. The hypolipidemic effect of elnabk leaf extract may be attributed to its phenol ingredient, which acts as an inhibitor of oxidative stress. Makni et al*.,* [6], demonstrated that the use of elnabk leaves in male rats with high cholesterol levels resulted in a significant improvement in their lipid profile, as seen by a reduction in both blood T.C. and serum triglycerides. Al-Reza et al. [7], they reported that elnabk seeds have +ve effect on blood glucose levels.

Aim of study: This trial aimed to examine the influence of elnabk fruit powder on enhancing the health status of hyperglycemic rats.

2. MATERIALS AND METHODS

2.1 Materials

Elnabk fruit: The Elnabk fruit originates from the natural environment of Tihama, located in the Al Baha province of the Kingdom of Saudi Arabia.

Rats: We obtained twenty-four (24) adult male albino rats from the Medicinal Insects Research Institute in Doki, Cairo. Their average weight was 150 ± 10 g. The humidity, temperature (25 ± 2°C), & light cycle (12 hours of light, then the

same hours of dark) were all maintained in a controlled environment where the rats were housed. The rats were kept in typical laboratory settings in cages with adequate ventilation. The Menoufia University School of Home Economics' animal house was the source of these products. Both food and water were readily available to the rats. Strict protocols for the care of animals used in research were followed throughout the procedure.

Alloxan: The instruments are utilized in Cairo, Egypt, & administered at a dosage of 150 milligrammes per kilogram of body weight.

2.2 Methods

Analytical methods:

Preparation of material: After collecting the Elnabk, we meticulously rinsed the plant with flowing tap water. Next, we extracted the fruits from the seeds. We dehydrated all fruit components in a vacuum oven at a temperature of forty degrees Celsius. We pulverized the desiccated fruits using a Braun Biotech International GMBH grinder (located in Melsungen, Germany) to achieve a particle size that could pass through a 1.6-millimeter sieve. We then stored the resulting powder at a temperature of -12°C until it was ready for use.

Composition of rats' diets at their baseline:

Rats' normal diet: The basil diet consisted of 0.25 percent choline chloride, 10 percent casein, 1 percent vitamin mixture, 5 percent cellulose, 4 percent salt mixture, 10 percent maize oil, 0.35 percent methionine, as well as 69.5 percent corn starch [8].

The basal diet comprised the following components: five percent cellulose, ten percent maize oil, 0.25 percent choline chloride, 1 percent vitamin mixture, 0.35 percent methionine, and four percent salt mixture [8].

CaCO3 (600 milligram), MgSO4.2H2O (204 milligram), K2HPO4 (645 milligram), Fe(C6H5O7) 26H2O (55 mg), CaHPO4.2H2O (150 milligram), ZnC12 (0.5 mg), CuSO3.5H2O (0.06 mg), NaCl (334 mg), MnSO4.4H2O (10 mg), as well as K1 (1.6 mg), comprised the basal diet utilized in the experiment.

The standard test diet included all of the following: Vitamin E (10 Iu), Calcium pantothenic acid (0.40 mg), Vitamin A (200 Iu), Thiamin (0.50 mg), Vitamin K (0.50 Iu), Pyridoxine (1.00mg), Para-aminobenzoic acid (0.02 milligram), Vitamin D (100 Iu), Folic acid (0.02 mg), Vitamin B12 (2.00 g), Niacin (4.00 mg), Inositol (24 mg), and Choline chloride (200 milligram) [9].

The induction of experimental diabetes: One freshly prepared intraperitoneal (i.p.) injection of alloxan monohydrate induced diabetes in rats. One milliliter of distilled water per kg of body weight was needed to dissolve 150 milligrams of the drug. After 7 days after the injection, blood glucose levels were checked. Diabetic animals were included in the tests to avoid hypoglycemia if their blood glucose concentration was more than 200 g/dl. This condition often occurs within the first 24 hours after alloxan administration. rats with diabetes were orally administered a 5-percent glucose solution.

Experimental design: A controlled environment was maintained for the rats, which included a temperature of 25 ± 2 degrees Celsius, a humidity level that was adjusted, and lighting that involved 12 hours of light followed by 12s hours of darkness. The rats were categorized into two basic groups, of which the following is an explanation:

-The 1st main group:(n=6) The control group was provided with the baseline diet as a -ve control.
-The 2nd main group:(n=18) Those rats with diabetes were divided into three subgroups and given 150 mg/kg Alloxan injections:

- Diabetes rats + basal diet (+ve control).
- Diabetes rats + basal diet involves 5 percent Elnabk fruit
- Diabetes rats + basal diet involves 10 percent Elnabk fruit

Biochemical analysis:

Serum glucose determination: Chemical kits were used to assess serum glucose in accordance with [10].

Assessment of blood lipid levels:

Triglycerides: The measurements of triglycerides were performed utilizing an enzymatic calorimetric method in accordance with Fassati & Prencipe [11].

Total cholesterol: The main application of T.C. assessment is based on Allain, [12].

HDL-cholesterol: To determine whether phosphotungstic acid or magnesium ions are selective in precipitating all lipoproteins in the supernatant except HDL fraction-cholesterol, one can follow the same procedure as T.C., consistent with Lopez, [13].

V-LDL & LDL- cholesterol: were measured utilizing the procedure of Lee and Nieman [14].

Total Lipids: A colorimetric approach was applied to estimate the total lipids (in accordance with schmit 1964)

Determination of liver functions

Assessment of Alanine transferase (ALT):

The measurement of ALT was conducted using the Tietz [15]. Additionally, pyruvate and L-glutamate are produced as an outcome of the transfer of the amino group from L-alanine to a-ketoglutarate by ALT.

Assessment of Aspartate Transferase (AST): Evaluations of Aspartate Transferase were performed utilizing the procedure of Henry [16].

Total Protein Estimation: The analysis of total protein was conducted by the colorimetric technique of Henry [16].

Evaluation of Kidney functions:

Assessment of Creatinine: was measured using the kinetic technique of Henry [16].

Measurement of urea: The urea concentration was assessed using the enzymatic technique of Patton & Crouch [17].

Determination of Uric acid: was carried out using the procedure described by Barham & Trinde [18], Patton &Crouch [17], Faulkner & King [19], individually.

Serum antioxidation enzyme activity: Catalase (CAT), glutathione peroxidase (GSI-Px) & superoxidase dismutase (SOD), were calculated in the serum samples that had undergone separation by centrifugation at four degrees Celsius for ten minutes at 7000 * g. The antioxidant enzyme's activity was measured by the methodology outlined in Oyanagui [20]. The approach of (Paglia and Valentine, [21]) was employed to measure the GPX enzyme activity. The method of Aebi, [22] was used to measure the activity of the antioxidant enzyme CAT.

Statistical Analysis: The one-way classification method was utilized in the statistical analysis that was done. Analysis of variance (ANOVA) & least significant difference (LSD) are two examples of procedures that can be utilized, based on Snedcor and Cochran [23].

3. RESULTS AND DISCUSSION

3.1 Biological Outcomes

The impact of elnabk fruit powder on the feed efficiency ratio (FER), body weight gain (BWG), and feed intake (FI) in diabetic rats was investigated: The amount of body weight that rats with diabetes gained on average while being fed a variety of diets is presented in Table (1). With values of 0.13 +0.02 & 0.75 +0.01 individually, it is clear that the average BWG per day per rat in the control +ve group was under that in the control -ve group. This is evident from the fact that the values were lower. Due to the fact that the control -ve group showed a rise of 476.92% in contrast to the control-positive group, this disparity is important. Variations in average values were significantly larger among the control group and the diabetic rats fed different diets. All of the rats with diabetes given different diets demonstrated a significant rise in their average values in contrast to the control group. Additionally, the percentage gains were 384.6%, which corresponds to 323.07% of the distinctions. Group 3, which consisted of diabetic rats that were administered 5% Elnabk fruit powder, had the highest BWG in contrast to the group that served as the control. With mean F.I. values of 12.5+0.2 and 15.7+0.25, correspondingly, the control +ve group and the control -ve group revealed a substantial differentiation. The control -ve group revealed an increase of 25.6% in contrast to the control positive group, which demonstrated a decrease of 18.9 percent. The mean values of all rats with diabetes that were given different diets did not differ substantially from one another when in contrast to the standard +ve group that served as the control. When in contrast to the +ve group that served as the control, groups 3, 4, and 5 demonstrated increases of 10.8 percent, 20 percent, and 13.6 percent, individually. Group 4, which consisted of diabetic rats that were given 10% elnabk fruit powder, performed the best in

terms of F.I. contrasted with the control group, which was +ve. There was a significant variance among the control +ve group and the control -ve group. The control +ve group had a lower mean FER value (0.010 ±0.04) in contrast to the control -ve group (0.047 ±0.04). This indicated that the control +ve group was significantly more favorable. In the control group, the -ve group experienced an increase rate of +350%. While the group that served as the control +ve had much lower mean values, all of the rats with diabetes who were given a range of meals demonstrated significantly higher mean values. Group 3 experienced a rise of 35%, while Group 4 experienced a gain of 26%. Group 3, which consisted of diabetic rats that were administered 5% elnabk fruit powder, produced results that were superior to those of the control group -ve in terms of FER. these findings are in concordance with Soldavini et al. [24], They found that the average body weight decreased non-significantly with elnabk fruit powder contrasted with the control group.

The impact of elnabk fruit powder on the levels of TC, TG, L.D.L c, H.D.L c, & V.L.D.L c in rats with diabetes: Table (2) presents data on the average serum TC (mg/dl) values of diabetic rats that were fed diverse diets. According to the results, it is obvious that the mean value of TC in the control +ve group was higher than that in the control -ve group. The values for the two groups were 240.7±3.15 and 90±2.69, correspondingly. A significant variation can be seen among the control positive group & the control negative group, with the former exhibiting a drop of 62.5%. All of the rats with diabetes showed significant decreases in their mean values when compared to the control group, regardless of the diet that they were provided. Numerically, Group 3's serum TC was substantially greater than the control group's, consisting of diabetic rats given 5% elnabk fruit powder. The results show that the control +ve group had a higher average TG value than the control -ve group, at 100 ±1.14 and 66 ±0.25 mg/dl, respectively. There was a significant variance, with the control -ve group decreasing 34% more than the control (+) group. When contrasted with the control group, all rats with diabetes fed different diets indicated significant declines in mean values. All groups saw a decline between -32% and -29.25%. Even when in contrast to the control group +ve, the serum (T.G.) demonstrated the highest level of efficacy in group 3, which consisted of diabetic rats that were fed 5% elnabk fruit powder. The average value of HDL c in the control +ve group was initiate to be lower than the control -ve group, with values of 45 ±0.2 on the one hand and 51.8 ±0.9 on the other. This is something that can be observed. With a 13.3% increase in the control -ve group in contrast to the control +ve group, the variance is significant at this point. When in contrast to the control group, rats with diabetes who were fed a variety of diets demonstrated the most significant improvements in average values. The percentage increases ranged from more than 2.22 percent to more than 4.44 percent across all categories. In contrast to the control group +ve, the blood serum levels of HDL c were found to be highest in Group 4, which consisted of diabetic rats that were fed 10% elnabk fruit powder. These findings agree with Al-Ghamdi and Shahat, [4], who found that administering elnabk extract to rats induced with streptozotocin effectively decreased TG and TC levels, indicating that ZSC had the capacity to alleviate hyperlipidemia. Parsaeyan and Rezvani, [5], reported that the blood lipid profile markers, particularly serum T.C. and serum triglycerides, were significantly diminished in rats with diabetes in addition to non-diabetic rats treated with elnabk leaf extract for four weeks contrasted with both the non-diabetic and diabetic control groups. Elnabk leaf extract may have a hypolipidemic effect due to a phenol component that suppresses oxidative stress. Makni et al., [6], described that the lipid profile of male rats with hypercholeterolemic symptoms was improved by reducing blood T.C & serum triglycerides when treated with elnabk leaves.

Effect of elnabk fruit powder on on serum levels of LDLc and VLDLc. of rats with diabetes: Table (3) presents data illustrating the average serum (LDL c) (mg/dl) levels of diabetic rats that were fed various diets. According to the results, it is obvious that the mean value of TC in the control +ve group was higher than that in the control -ve group. The values for the two groups were 240.7±3.15 and 90±2.69, individually. A significant variation can be seen amongst the control +ve group and the control -ve group, with the former exhibiting a drop of 62.5%. If we compare the rats with diabetes who were fed different diets to the control group, we find that all of the diabetic rats indicated significant declines in their mean values. In numerical terms, the serum TC of Group 3, which consisted of rats with diabetes that were fed 5% elnabk fruit powder, was significantly higher than that of the control group. With values of 100 ±1.14 and 66 ±0.25 mg/dl, correspondingly, it is obvious that

the average value of TG has been shown to be higher in the control positive group in contrast to the control -ve group. A decrease of 34% was seen in the control -ve group in contrast to the control +ve group, which implies that there is significant variation among the two groups. If we compare the diabetic rats who were fed different diets to the control group, we find that all of the rats with diabetes indicated significant declines in their mean values. Among -32% to -29.25% was the range of the percentage drop that was observed across all groups. Even when in contrast to the control group (+), the serum (T.G.) demonstrated the highest level of efficacy in group 3, which consisted of diabetic rats that were fed 5% elnabk fruit powder. The average value of HDL c in the control (+) group was found to be lower than the control -ve group, with values of 45 ±0.2 on the one hand and 51.8 ±0.9 on the other. This is something that can be observed. With a 13.3% increase in the control -ve group in contrast to the control +ve group, the variance is significant at this point. When contrasted with the control group, rats with diabetes who were fed a variety of diets demonstrated the most significant improvements in average values. The percentage increases varied from more than 2.22 percent to more than 4.44 percent across all categories. In contrast to the control group (+), the blood serum levels of HDL c were found to be highest in Group 4, which consisted of diabetic rats that were fed 10% elnabk fruit powder. Results indicated that, in accordance with Wang et al. [25], plasma (LDL+VLDL)-cholesterol, but not HDL-cholesterol, decreased significantly in rats fed diets containing elnabk fruit powder. Additionally, triacylglycerol and cholesterol decreased.

Effect of elnabk fruit powder on kidney function for diabetic rats: Table (4) shows the average serum urea (mg/dl) in rats with diabetes fed varied diets. Results indicate a substantial disparity in uric acid levels amongst the control (+) and control -ve groups, with the former having a higher average (37.2±0.3 mg/dl) and the latter having a drop of 39.3%. The mean values of all diabetic rats fed varied diets were considerably lower than the control +ve group. The 5% and 10% elnabk fruit powder groups decreased by -32.7 and -21%, individually. Group 3 (5 percent elnabk fruit powder) outperformed the control group**.**

In the control group, the control +ve group had a bigger mean creatinine value (1.3 ±0.02) contrasted with the control -ve group (0.60 ±0.1). This distinction demonstrates that there are significant changes, with the control -ve group experiencing a decrease of 53.84% when in contrast to the control +ve group. All rats suffering from diabetes that were given altered diets demonstrated significant reductions in mean values, in contrast to the group that served as the control and was evaluated positively. A range of -45.4 to -53.84% was seen in the percentage of decreases across all of the groups. The variations in groups 3 and 4 did not show any significant distinctions either.

Furthermore, it is worth mentioning that the mean urea level in the control (+) group was more than that in the control -ve group, with values of 7±0.3 & 3.1±0.1 mg/dl, correspondingly. This demonstrates a notable disparity, as the control -ve group experienced a reduction of 55.7% in contrast to the control +ve group. rats with diabetes that were given changed diets experienced significant reductions in average values contrasted with the control group (positive). The rats that were fed in groups 3 displayed resemblances to those in groups 1, and no significant distinctions were seen among them. Our results in Table 4 are in line with those of Ominguez et al. [26], who designated that Elnabk fruit powder treatment decreases the likelihood of subcapsular fibrosis as well as microcalcifications in the kidneys, as well as the generation of calcium oxalate crystals. The levels of serum urea and creatinine were significantly reduced by sambucus, and this effect was dose-dependent.

Effect of elnabk fruit powder on liver function of rats with diabetes: Table (5) shows the results of the research measuring the average serum value of glucose out of total (GOT) (AST) (U/L) in rats with diabetes fed different diets. After a closer look, it's clear that the control +ve group had a higher average GOT value than the control -ve group, with 120 ±1 and 48 ±0.5, respectively. A significant distinction among the two control groups is that the -ve control group had a 60% decrease whereas the positive control group saw no change at all. In contrast to the group that served as the control, all of the diabetic rats who were given a variety of diets exhibited significant decreases in their mean values. For each and every category, the percentage of decline ranged from 52.5% to -56.7%. After receiving a therapy consisting of 5% elnabk fruit powder, Group 3 demonstrated the most effective effects in terms of GOT activity. This was in contrast to the good results that were observed in the control group**.**

Table 1. Influence of elnabk fruit powder on BWG, FI & FER of diabetic rats

Parameters Groups	BWG (g/ day/rat)		FI (g/day/rat)		FER	
	Mean±SD	% Change of control (+)	Mean±SD	% Change of control (+)	Mean±SD	% Change of control (+)
(1) Control - ve	0.75 [a]±0.01	476.9	15.75 [b]±0.2	25.0	0.047 [a] ±0.04	370
(2) Control + ve	0.13 [e] ±0.02	+00.00	12.5 [g] ±0.2	00.00	0.010 [d] ±0.04	00.00
(3) Elnabk fruit 5%	0.63 [b]±0.01	384.6	13.8 [d]±0.19	10.4	0.045 [b] ±0.04	350
(4) Elnabk fruit 10%	0.55 [c] ±0.02	+323.1	15 [c] ±0.3	20	0.036 [c] ±0.04	260
least significant difference	0.026		0.305		0.001	

Means in the same column with different letters are significantly different. Significance ($p < 0.05$)

Table 2. The impact of elnabk fruit powder on the levels of T.C., T.G., L.D.L.c., H.D.L.c., & V.L.D.L.c. in rats with diabetes

Groups	HDLc. (mg/dL)	TG (mg/dL)	TC (mg/dL)
(1)= Control – ve	51 [e]±0.9	66 [c] ±0.25	90 [c] ±2.69
% of Change of control(+)group	1 .11	-34	-27.6
(2) Control + ve	45 [c] ±0.2	100 [a] ±1.14	240 [a] ±3.15
% of Change of control(+)group	00.00	00.00	00.00
(3) Elnabk fruit 5%	46 [d] ±0.4	68 [c] ±0.79	100 [c] ±2.34
% of Change of control(+)group	2.22	-32	-5.3
(4) Elnabk fruit 10%	47 [d] ±0.8	89 [b]±1.34	121 [b] ±2.58
% of Change of control(+)group	4.44	-11	-6.25
least significant difference	1.1	1.51	4.78

Means in the same column with different letters are significantly different. Significance ($p < 0.05$).

Table 3. Effect of elnabk fruit powder on serum levels of LDLc and VLDLc. of rats with diabetes

Groups	VLDLc. (mg/dL)	LDLc. (mg/d L)
(l)Control – ve	13.2 ^{k} ±0.05	25.8 ^{k} ±1.12
% of Change of control (+)group	-47.2	-85.6
(2)Control + ve	25 ^{a} ±0.09	180 ^{a} ±1.59
% of Change of control (+)group	00.00	00.00
(3)5% Elderberry	13.6 ^{f} ±0.03	40.4 ^{h} ±1.24
% of Change of control (+)group	-45.6	-77.55
(4) 5% Echinacea	17.8 ^{b} ±0. 06	56.2 ^{e} ±1.64
% of Change of control (+)group	-28.8	-68.7
LSD	0.086	2.81

Means in the same column with different letters are significantly different. Significance ($p < 0.05$)

Table 4. Effect of elnabk fruit powder on kidney function for diabetic rats

Parameters	Urea (mg /dl)		Creatinine(mg/dl)		Uric acid (mg/dl)	
Groups	**Mean±SD**	**% Change of control (+)**	**Mean±SD**	**% Change of control (+)**	**Mean±SD**	**% Change of control (+)**
(1) Control - ve	22.6 ^{a} ±0.4	-39.3	0.60 ^{e}±0.01	-53.84	3.1 ^{cd} ±0.1	-55.7
(2) Control + ve	37.2 ^{d} ±0.3	+00.00	1.3l ^{b} ±0.02	00.00	7 ^{a}±0.3	00.00
(3) Elnabk fruit 5%	25 ^{b} ±0.2	-32.8	0.65 ^{d}±0. 02	-50	3.2 ^{cd} ±0.2	-54.3
(4) Elnabk fruit 10%	29.4 ^{c} ±0. 1	-21.0	0.68 ^{c} ±0.01	-47.7	3.5 ^{bc} ±0.1	-50
LSD	0.173		0.034		0.338	

Means in the same column with different letters are significantly different. Significance ($p < 0.05$).

Table 5. Effect of elnabk fruit powder on liver function of diabetic rats

Parameters	AST (U/ L)		ALT (U/ L)		ALP (U / L)	
Groups	**Mean±SD**	**% Change of control (+)**	**Mean±SD**	**% Change of control (+)**	**Mean±SD**	**% Change of control (+)**
(1) Control - ve	48 ^{g} ±0.5	-60	35 ^{f} ±0.1	-48.5	8 l ^{g}±0.55	27.69
(2) Control + ve	120 ^{a}±1	+00.00	68 ^{a} ±0.4	00.00	112 ^{a}±0.85	00.00
(3) Elnabk fruit 5%	52 ^{f} ±0.2	-56.7	41 ^{e}±0. 3	-39.7	106 ^{c} ±0.09	-5.3
(4) Elnabk fruit 10%	57 ^{e} ±0. 3	-52.5	43 ^{d} ±0.2	-36.8	105 ^{d}±0.13	-6.25
LSD	0.465		0.239		0.60	

Means in the same column with different letters are significantly different. Significance ($p < 0.05$).

Table 6. Effect of elnabk fruit powder on serum antioxidation enzyme activity of diabetic rats

Parameters	SOD (U/ L)		GPX (ng/ mL)		CAT (m mol/1)	
Groups	**Mean±SD**	**% Change of control (+)**	**Mean±SD**	**% Change of control (+)**	**Mean±SD**	**% Change of control (+)**
(1) Control - ve	40.6 ^{a}±0.4	143.1	44.6 ^{a} ±0.4	117.5	82.1 ^{a} ±0.04	125.5
(2) Control + ve	16.7 ^{f}±0.0.	+00.0	20.5 ^{r}±0.2	00.00	36.4 ^{s} ±0.16	00.00
(3) Elnabk fruit 5%	36 ^{c} ±0.2	115.6	37.4 ^{c} ±0. 1	82.4	80 ^{c} ±0.06	119.7
(4) Elnabk fruit 10%	35.4 ^{d} ±0. 2	112.0	35.6 ^{d} ±0.2	73.6	74.5 ^{f} ±0.02	114.6
LSD	0.407		0.336		0.15	

Means in the same column with different letters are significantly different. Significance ($p < 0.05$).

Table 7. Effect of elnabk fruit powder on serum glucose (mg/dl) of rats with diabetes

Variables	(1) Control - ve	(2) Control +ve	(3) Elnabk fruit 5%	(4) Elnabk fruit 10%	L.S.D
	Mean ±SD	**Mean ±SD**	**Mean ±SD**	**Mean ±SD**	
Glucose (Mg\dl)	88.5 ^{s}±0.3	280 ^{a} ± 0.1	158 ^{d} ± 0.5	169 ^{c} ± 0.2	0.596
% Change of control (+)	-68.4		-43.6	-39.6	

Means in the same column with different letters are significantly different. Significance ($p < 0.05$).

The contrast among the two groups is clear in the mean values of GPT (ALT), which are 68 ±0.4 and 35 ±0.1, correspondingly. The control -ve group revealed a significant decline of 48.5% during the course of the study, whereas the control positive group indicated no change at all. All of the rats with diabetes that were given varied diets had mean values that were significantly less than the values of the group that served as the control (+). Reductions of 39.7 and 36.6 percent, individually, were observed in Groups 3 and 4, individually. In terms of GPT activity, the third group, which was given 5% elnabk fruit powder, exhibited the most favorable effects**.**

The control positive group had a greater average ALP value (112 ±0.85 vs. 81 ±0.55), while the control -ve group had a reduction of 27.6% compared to the control (+) group. What this means is that the two groups are very different from one another. All of the rats with diabetes that were given varied diets had mean values that were significantly lower than the corresponding values of the control group that was positive. The percentage decrease ranged from -5.3 to -6.25% for each and every category separately. The outcome of the serum ALP treatment was most favorable in group 3, which consisted of 5% elnabk fruit powder.

The outcomes displayed in Table 5 correlate with the findings of USDA-ARS [27]. The levels of ALT, ALP, GGT, and albumin were not significantly affected by sambucus (anthocyanins). On the other hand, plasma bilirubin levels changed significantly, but this had little clinical significance because the levels of bilirubin were still within normal physiological ranges. Also, Yu et al. [28] reported that photochemicals isolated from elnabk, including saponins, and Zhang et al. [29] reported that saponins in herbs have hepatoprotective effects, so we can say that elnabk has hepatoprotective effects.

Effect of elnabk fruit powder on serum antioxidation enzyme activity of rats with diabetes: In Table (6), the average blood SOD concentration, measured in units per milliliter, is displayed for diabetic rats that were fed a variety of diets. It was noted that the control (+) group had a lower mean SOD value (16.7 ±0.3) contrasted with the control -ve group (40.6 ±0.4). This indicates that there were considerable changes, with the control -ve group exhibiting a 143.1% rise in contrast to the control positive group. There was a significant distinction amongst the mean values of the rats with diabetes that were given varied diets and the values of the control group that was positive. Between 111.2 and 115.6 percent was the range of the percentage increases that were observed. When in contrast to the group that served as the control (+), group 3 (which involved 5% elnabk fruit powder) had the most effective SOD treatment**.**

The control group had a greater mean value of GPX (ng/ml) compared to the control -ve group, with values of 44.6 ± 0.4 & 20.5 ± 0.2, correspondingly. This was apparent from the finding that the control group exhibited a greater average value. This gap in value indicates that the control -ve group had a significant percentage rise of 117.6% in contrast to the control positive group because of the difference in value. In contrast to all rats with diabetes that were fed a variety of diets, the control positive group had significantly lower mean values. Eighty-two and seventy-three percent, individually, were the increases in percentage terms. With regard to the contrast amongst groups + and 3, the GPX found that the third group, which consisted of 5% elnabk fruit powder, had the most beneficial treatment.

The control (+) group had a lower mean CAT value (mmol/l) than the control -ve group (36.4 ±0.16 vs. 82.1 ±0.04), indicating a significant variation with a 125.55% increase in the control -ve group in contrast to the control positive group. When contrasted with the control positive group, all diabetic rats given various diets revealed a significant increase in mean values. For every category, the percentage of growth was among 114.6 and 119.7. Group 3 (5% elnabk fruit powder) treated rats better than group "1" (healthy rats) when the CAT was taken into account**.**

These results are in line with those of Collins et al. [30], who also discovered that elnbek fruits have antioxidant properties (a decrease in thiobarbituric acid reactive substances [TBARS] and an increase in reduced glutathione (GSH), SOD, glutathione perox rats with diabetes idase (GSH-Px) as well as CAT [31]. In light of the fact that diabetic rats fed elnbek, which is rich in antioxidants, this could be beneficial in increasing the levels of SOD, GPX, as well as CAT.

Effect of elnabk fruit powder on serum glucose of diabetic rats: In Table (7), the serum glucose levels of rats with diabetes that were fed a variety of diets were measured and averaged out in milligrams per deciliter. The control +ve group exhibited a significantly greater mean glucose value (280±1) contrasted with the control -ve group (88.5±0.3). This indicates a significant variation and a 68.4% drop in contrast to the control positive group [32-34]. All of the diabetic rats that were given different diets indicated significantly lower mean values when in contrast to the positive control group. There was a decrease of -43.6 and -39.5 percent across the board in terms of percentage increases. Group 3 was the treatment that proved to be the most successful for the rats. The data shown in Table 7 have been validated by a significant number of authors. discovered that rats with diabetes given either plain or prepared elnabk leaf extract had superior glucose utilization. These findings complement the findings of This occurred as a consequence of an increase in insulin secretion, which may have been brought about by the presence of polyphenols and saponins, as well as a decrease in glucose absorption that was derived from meals, which may have been brought about by the presence of total polyphenols, and a management of hyperglycemia. Also, the findings are in line with Al-Reza et al. [7], who reported that elnabk seeds are effective in improving blood glucose [35,36].

4. CONCLUSION

This manuscript is significant for the scientific community as it explores the potential of elnabk fruit powder as a natural intervention for managing hyperglycemia. Given the increasing prevalence of diabetes and related metabolic disorders, identifying accessible and effective dietary strategies is crucial. The study contributes to the growing body of literature on functional foods and their therapeutic effects, potentially paving the way for future research and applications in both clinical and dietary. Laboratory investigations have validated the adaptogenic properties & advantages of elnabk fruit . This is because it contains many nutrients that can reduce blood sugar and have a positive effect on weight, in addition to its good effect on blood lipids, liver enzymes, and kidney function Despite having the best evidence for efficacy in diabetes among herbs, the evidence remains inconclusive for elnabk fruit .This owes both to the insufficiency in data quantity and quality, and a lack of reproducibility of its safety and efficacy. since EF has been shown to be effective in improving glycemic control in type 2 diabetes (through ncreasing post-prandial insulin levels), if further research reaffirms its safety and efficacy this new therapy could provide a useful addition to conventional treatments. Therefore, the availability of standardized extracts of elnabk fruit will assist greatly in advancing our knowledge on the role of this traditionally used herb and move industry toward a better understanding of which processing method to use in order to preserve the efficacy of EF.

5. RECOMMENDATIONS

1. The importance of increasing the use of elnabk (fruits) in our daily lives is because of its benefits in improving many diseases**.**
2. Elnabk fruit (5%, especially 10%) has the ability to improve lipid profiles**.**
3. Also, elnabk fruit (10%, especially 5%) has a highly effective effect on reducing glucose levels, kidney functions, and liver functions**.**
4. Carry out programs for nutritive education to explain the dangers of diabetic disease, nutritional recommendations for this disease, and increased consumption of elnabk.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

ETHICAL APPROVAL

The Science Research Ethics Committee of the Faculty of Home Economics accepted the research protocol #11-SREC-06-2024.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.mbimph.com/review-history/4204