Research Article

Title

Antidiabetic and protective effects of *Ferula assa-foetida* L. oleo gum resin ethanolic extract on the testis of streptozotocin-induced diabetic rats: a histopathological study.

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Abstract

Diabetes is one of the most common metabolic diseases worldwide which affects all organs, including the reproductive system. Today, many researchers use medicinal plants instead of chemical drugs to reduce their side effects. *Ferula assa-foetida* L. is one of the medicinal plants that have been used to treat many diseases traditionally for years. Present study has evaluated antidiabetic and protective effects of *Ferula assa-foetida* L. on the testis of streptozotocin-induced diabetic male rats. The study of histomorphology of diabetic rats treated with *Ferula assa-foetida* L. extract shows significant improvement of testes. Histological studies show that treatment with the *Ferula assa-foetida* L. extract significantly increases the number of sperm in the seminiferous tubules and reduces fibrosis. Our study confirms the improving effects of *Ferula assa-foetida* L. on histomorphometric and biochemical parameters in diabetes and

testicular damage caused by it, which is partially attributed to the presence of bioactive compounds and antioxidants in *Ferula assa-foetida* L.

Keywords

Ferula assa-foetida; rat; diabetes; reproductive system; spermatogenesis, medicinal plants.

Abbreviations

FAE: *Ferula assa-foetida* L. oleo gum resin ethanolic extract

SOD: Super Oxide Dismutase

Met: Metformin

STZ: Streptozotocin

Introduction

One of the common metabolic and endocrine diseases that is a serious threat to public health, especially in developing countries, is diabetes [1]. Diabetes is caused by a decrease in insulin secretion or sensitivity [2]. Disturbances in carbohydrate, lipid and protein metabolism affect the secretion and function of Insulin which is very worrying for the health of society3]. Therefore, improper lifestyle nutrition that leads to obesity and overweight have an effective role in the prevalence and occurrence of diabetes4] which is very worrying for the health of society.

An increase in blood glucose level is one of the clear symptoms of diabetes, which leads to structural and functional changes in various tissues and organs, include the reproductive system. [5]. Abnormal feedback of sex steroids in the hypothalamus-pituitary axis, which is observed in diabetic rats, is the result of abnormal transfer of steroids or decreased sensitivity of the pituitary gland6,7]. Also, various studies have shown that hyperglycemia in diabetics has negative effects on male and female fertility [8,9].Testes are organs sensitive to hyperglycemia 10]. Weight loss 11], abnormal germinal epithelium [512] and disruption of the testicular blood barrier are complications of diabetes[13]. When the blood glucose level rises,

glucose autoxidation causes excessive production of free radicals and finally oxidative stress14]. One drug with fewer side effects to treat diabetes is metformin which is used to control hyperglycemia. Metformin inhibits gluconeogenesis in hepatocytes. Its mechanism of action is inhibition of mitochondrial respiration and reduction of cellular energy level, which reduces glucose production by hepatocytes [15]. Treatment of male diabetic mice with metformin preserves the structure and function of the testis16].Also, in order to reduce the negative effects of free radicals on the reproductive system and testes, a lot of researches has been done to evaluate the effect of antioxidant compounds on this system. Among these antioxidant compounds, natural antioxidants that are found in medicinal plants have attracted the attention of scientists due to they have less side effects than chemical antioxidants on living organisms. Some medicinal plants such as curcumin17], Ficus Carica [18], Telferia Occidentalis19] and Ginger 20] have been investigated. Another medicinal plant with antioxidant properties is *Ferula assa-foetida* L. [21,22,23] which has been used to treat many diseases for centuries. This plant, which is native to Iran, is also called Anghuzeh. In the classification, it is a member of the Umbelliferae (Apiaceae) family24]. Components of *Ferula assa-foetida* L. oleo- gum resin are Ferulic acid, esters, coumarins, other terpenoids [24], umbelliferone[25], bisabolol, and quercetin 23]. It has been an effective and available substance for the treatment of neurological disorders, stomachache, intestinal parasites, weak digestion, asthma, bronchitis, influenza, infertility and diabetes for many years 24,26,27]. The results of researches have shown that the use of *Ferula assa-foetida* L. is effective in the treatment of liver and kidney diseases, hyperglycemia and hyperlipidemia 28,29]. Also, the anti-obesity effects of *Ferula assa-foetida* L were investigated and the results showed that leptin and blood glucose levels decreased after consuming *Ferula assa-foetida* L. [30]. Therefore, *Ferula assa-foetida* L. can be a good candidate for the treatment of diabetes because of its availability and natural antioxidant properties. As the number of people with diabetes is increasing rapidly [1],

the age of diabetes is decreasing31] which increases the number of people with diabetes in reproductive age. Based on the above, identifying the mechanisms that destroy the testes in diabetics, discover effective substances and drugs and prevent infertility and reproductive disorders are important issues. With this background, we decided to investigate protective effects of *Ferula assa-foetida* L. oleo gum resin ethanolic extract (FAE) on the testis of streptozotocin-induced diabetic rats″.

Results

Morphometric data

According to Fig. 1 and Table. 1, the thickness of the epithelium of seminiferous tubules in group 5 (diabetic rats treated with 250 mg/kg FAE) decreased significantly compared to other groups (Fig. 1).

The data obtained from the examination of the size of the seminiferous tubules in different experimental groups showed that the size of the seminiferous tubules in groups 1, 3, and 4 increased significantly compared to groups 2 and 5, also in groups 3 and 4 compared to group 2(Fig. 1; Table. 1).

Johnson' s Score

According to Fig. 1 and Table. 1 the, Johnson' s Score has decreased in groups 2 and 5 compared to other groups.

Biochemical Evaluation

Testosterone Level Assessment

The comparison between groups 1 and 2 showed that diabetes causes a significant decrease in testosterone levels in rats. Also, a significant increase in testosterone levels in group 4 compared to group 2 indicates the positive effect of FAE on testosterone levels in diabetics (Fig. 2.d).

Fast Blood Sugar

As shown in Figure 3, the amount of glucose increased in diabetic control group rats compared to non-diabetic control group rats. Also, the lack of significant difference in groups 1 and 3 showed that the low dose of FAE in non-diabetic rats does not reduce blood sugar levels. A significant decrease in blood glucose levels was observed in group 4 compared to groups 2 and 5, which shows that lower dose of FAE reduces blood sugar levels in diabetics (Fig. 2.b).

Insulin Assessment

The results of the evaluation of blood insulin levels in different groups showed that insulin secretion in group 3 increased compared to groups 1, 2, 5, and 6. The levels of insulin in groups 3 and 4 did not differ significantly. Also, the high levels of insulin in group 3 compared to other groups indicate the positive effect of lower dose of FAE on insulin level in non-diabetics (Fig. 2.c).

Enzyme Activity

As shown in Fig. 3, SOD enzyme activity decreased in diabetics and low dose of FAE increased the activity of this enzyme in diabetic and non-diabetic rats.

Weight Evaluation

Animal Body Weight

A significant difference between group 5 and other groups was observed (Fig. 4.c).

Relative Testis Weight

As shown in Fig. 4, no significant difference was observed in the evaluation of the relative weight of the testes neither in the right testis nor in the left testis (Fig. 4.g&h).

Absolute Left Testis Weight

As shown in Figure 5. There was a significant difference between group 1, 2, 5, and 6, which shows that diabetes had a negative effect on testis weight. Also, the weight of testicles in group 2 was reduced compared to group 4, which confirmed the positive effect of FAE on increasing testis weight (Fig. 4.d).

Absolute Right Testis Weight

The decrease in testis weight in group 2 and 5 compared to group 1 indicates the negative effect of diabetes on the absolute weight of the testis. Also, the weight of the testicle in group 4 increased compared to group 2 and 5, which emphasizes the positive effect of FAE as a treatment for diabetes. Group 4 and 5 show that the low dose of FAE has an increasing effect on the weight of the testis compared to its high dose. In addition, the absence of a significant difference between the untreated diabetic group and the diabetic group treated with a high dose of FAE indicates the destructive effect of high amounts of FAE on the testis tissue (Fig. 4.e).

Evaluation of Testis Tissue Changes

H&E Staining

Histological findings of testes (**Fig. 1**) by H&E staining showed that in groups 1 and 3, the structure and shape of tubules and sperm cells were normal compared to group 2. In group 2, the structure and shape of the seminiferous tubules have changed. The number of cell layers and the number of spermatozoa is reduced and secondary spermatids are not seen. Degenerated spermatic cells and apoptotic cells with pyknotic nuclei are visible.

As seen in images (**Fig. 1**) histopathological changes in the diabetic groups treated with FAE (group 4) and Metformin (group 6) were less than the diabetic control group (group 2) and the arrangement and quality of sperm cells and the structure of the tubules were improved (Fig. 1). Also, in groups 2 and 5, the number of sperm cells decreased and secondary spermatids were not seen in the seminiferous tubules. In addition, the number of cell layers decreased (Fig. 1).

In group 3 (Fig. 1) good and normal spermatogenesis was observed in most of the tubules. Our observations showed that in group 4, spermatogenesis is good and normal, and Ferula prevented the effect of diabetes on the tubules (Fig. 1). Good and normal spermatogenesis was observed in group 6(Fig. 1).

Masson's Trichrome Staining

Masson's Trichrome staining was used in order to show the changes of the connective tissue. The results showed that the connective tissue was normal in groups 1 and 3(Fig. 5). While in group 2, the seminiferous tubules in the testes were degenerated. The extension of connective tissue into interstitial tissue, which called fibrosis, has increased significantly (Fig. 5). Fibrosis in the group receiving the lower dose of FAE is less than in other diabetic groups (Fig. 5). And in group 5 was similar to group 2, and it was less in group 6 than group 2(Fig. 5).

Discussion

Many studies have shown that diabetes has complex effects on the male reproductive system and spermatogenesis [5,6,8,9,10,12,17,38,39,40]. Some of these effects include decreasing of testosterone and insulin levels and blood increasing of blood glucose. These changes observed in this investigation (Fig. 1, Fig. 2, Fig. 5). These biochemical alterations lead to decreasing of protein synthesis and increasing of cell apoptosis 40]. As in the current study, the effects of diabetes on testicular tissue, including the reduction of the number of germinal epithelial cell layers and change in the number of germinal cells, were observed. These alterations are result of apoptosis. The increase in testosterone levels in the group 4 compared to groups 2 and 5 shows the positive effect of lower dose of FAE and the negative effect of higher dose of FAE on testosterone level in diabetic rats (Fig. 2.d). Diabetes affects pituitary gonadotropins and causes ultrastructural changes in Sertoli and Leydig cells, and these changes disrupt normal spermatogenesis [41]. Also, low and high doses of FAE increase and decrease testosterone level

in male rats, respectively [26]. Additionally, we indicated these hormonal alterations are along with tissue changes include the number of cells and thickness of germinal epithelium in diabetic testis. Low dose of FAE improves disruptive effects of diabetes on testis but high dose doesn't have such effect. In according to previous research and what was observed in our research, seminiferous tubule diameter and thickness of germinal epithelium in diabetic reduced [5]. These morphometric alterations are attributable to apoptotic and oxidative effects of diabetes [5] and more interestingly, FAE improves the morphometric features of the testis tubules in diabetic rats. It seems that these restorative effects of FAE are due to the presence of antioxidant and anti-apoptotic compounds in FAE.

Also, the effect of diabetes on Johnson' s score was evaluated and the obtained data are consistent with the results of previous study [42]. In addition, the positive effect of low dose of FAE on Johnson' s score and the negative effect of high dose of FAE on Johnson' s score in diabetic and non-diabetic animals were observed in this study (Table. 1).

The effect of FAE as a compound containing natural antioxidants on spermatogenesis in diabetic rats was investigated. These results are in consistent with previous studies. For example, one investigation showed that FAE has positive effects on spermatogenesis, although histopathological effects were observed [26]. There are many natural active compounds in FAE, which makes it a good candidate for the treatment of diabetes and infertility. Ferulic acid, quercetin and umbelliferon are the three important compounds found in FAE 23,24,25].

Ferulic acid and quercetin have antioxidant and anti-apoptotic properties [43].

Park et al showed that the effects of ferulic acid on increasing testosterone levels are done by inhibiting testosterone-reducing enzymes in the liver44]. Also, quercetin increases the level of testosterone, FSH (Follicle Stimulating Hormone), and LH (Luteinizing Hormone), while diabetes has a negative effect on these parameters. These changes in diabetic conditions are attributed to the production of reactive oxygen species (ROS) that reduce the secretion of LH

and FSH, and these events lead to a decrease in the number of Leydig cells and decrease in testosterone levels45]. As a results of our study, low dose of FAE, as a rich source of ferulic acid and quercetin, reduced blood glucose levels (Fig. 2.b) and increased insulin (Fig. 2.c) and testosterone (Fig. 2.d) levels. In current study, the treatment of diabetic and non-diabetic rats with a low dose of FAE), corrected the weight loss of the testis (Fig. 4.d, Fig. 4.e). This weight loss is due to insulin deduction that leading to decreasing structural protein synthesis [46,47]. Ferulic acid and quercetin reverse these weight changes by hyperglycemia control and insulin levels increase 43].Superoxide dismutase and glutathione peroxidase are two key enzymes that neutralize free radicals and clean the testis from reactive oxygen species, thus reducing oxidative stress48]. These enzymes decrease in diabetics, as in our study, the amount of superoxide dismutase decreased (Fig. 3). The activity of superoxide dismutase enzyme (Fig. 3) increased in group 4 compared to group 2. These results emphasize that the presence of antioxidant compounds in FAE prevents the destruction and apoptosis of the testis. Based on the above, which showed the antioxidant effects of ferulic acid and quercetin on the testis, our study shows that the effects of FAE can be attributed to the existence of its antioxidant compounds, including ferulic acid and quercetin. Umbelliferon is another antioxidant component found in FAE with many useful properties. Reduction of insulin resistance, hyperglycemia and hyperlipidemia in diabetic rats are effects of Umbelliferon. Also, the increase of FSH, LH and testosterone. and the upregulation of FSH, LH and PPAR-γ (Peroxisome Proliferator-Activated Receptor γ) receptors in the testes of rats are other effects of Umbelliferon. PPAR-γ increases insulin sensitivity 49]. Umbelliferon reduces oxidant factors including ROS, MDA and NO and increase antioxidant factors including SOD, GSH and CAT (catalase) [50]. As can be seen in our study, in Fig. 2, the increase in testosterone in group 4 compared to group 2 shows the beneficial effects of FAE and its natural antioxidant compounds, including Umbelliferon. The mammalian testis is very sensitive to lipid

peroxidation due to the presence of unsaturated fatty acids in it. So, treatment with Umbelliferon before testicular ischemia prevents the harmful effects of oxidative stress [50,51].

As shown in previous studies, antioxidants have ameliorating effects on diabetes and reproductive system disorders. Also, our study emphasizes the antioxidant and ameliorating effects of FAE as a compound rich in antioxidants in the treatment of diabetes and its side effects.

Materials and Methods

Animals

All the Wistar rats used in this study were wild-type. 42 Male Wistar rats at 3 months of age (weighting270±20 grams) were obtained from the animal house. To adapt animals to the new environment they were kept in the laboratory for two weeks before performing the experiments. The rats were housed under the standard condition at 23±1 ◦C temperature with a 12:12h light: dark cycle and had access to food and water ad libitum.

Drugs and Materials

In this study, we used Streptozotocin (STZ) (Streptozotocin, Sigma Aldrich,USA) for diabetes induction and Metformin (Met) (Metformin, Merck, Germany) as a reference for the treatment of diabetes. Rat Insulin ELIZA kit (Merccodia, Sweden) was used for insulin measurement. Also, testosterone and glucose were measured by standard kits (standard commercial supplier).

Plant Collection, Specimen Voucher, and Ethanolic Extract of *Ferula assa-Foetida* Preparation

Ferula assa-Foetida L. were collected from Bastak desert in Hormozgan province at latitude 27◦ 16′ 25″ N and longitude 54◦ 21′ 51″E and in height 1650 meters. The plant was identified by Ferdowsi University of Mashhad Herbarium with a voucher specimen (accession number: E-

1165 FUMH) in 2020. Also, the plant name has been checked with http://www.theplantlist.org .

Ferula assa-Foetida L. ethanolic extract was prepared as previously reported28]. Briefly, the dried oleo gum resin was collected and powdered by the grinder. 100 grams of the powder was dissolved in 1 liter of ethanol 70° and after 48h at room temperature, the solution was filtered four times using Whatman filter paper (grade 40). The filtered solution was dried using a rotary evaporator and the product was frozen on dry ice before storage at 4°C for further use.

Diabetes Induction and Experimental Groups

Diabetes was induced by injecting a single dose of STZ (55 mg/kg b.w, intraperitoneally) as reported 32] .All non-diabetic groups in this study (including the control) received the same volume of citrate buffer (0.01 M, PH:4.5) as the vehicle. The Fast Blood Sugar (FBS) was monitored after Streptozotocin injection for 10 consecutive days, and animals with a constant FBS level upper than 250 (mg/dl) 33]were considered as diabetic [34] and were used in our study. For studying the effect of *Ferula assa-Foetida* L. ethanolic extract on the reproductive organs of male rats, animals were divided into six groups including: 1) a non-diabetic-control group that had not received any treatment. 2) Diabetic-control group that was injected with only a single dose of Streptozotocin for diabetes induction. 3) non-diabetic treatment group treated with FAE (150 mg/kg b.w, gavage), 4 and 5) were diabetic-treatment groups treated with FAE (150 and 250 mg/kg b.w, gavage), respectively. 6) a diabetic-positive control group that received (100mg/kg b.w, intraperitoneally) metformin (Met). Both FAE and Met had been dissolved in distilled water and the final volume used for treating the animals via gastric gavage was 1ml.

Organ Collection, Tissue Processing and Microscopy

42 days after treatment, animals were anesthetized with ether and then euthanized with CO_2 gas for organ collection (28). The testes were separated, weighted, and washed in normal saline before fixation in 10% neutral buffered formalin (NBF) and Bouin-Hollande′s. Subsequently 5 µm thick tissue sections were prepared and stained routinely by Hematoxylin & Eosin (H&E) (Hematoxylin & Eosin, Merck) and also by Masson's Trichrome (Masson Tri-chrome, Merck) methods 35]. The stained tissue sections were studied by light microscope and acquired images were used for further quantifications.

Histomorphometric Analysis

To study the histomorphology of animal testis the obtained images were opened with Image J software (version 1.44 p) and parameters such as the diameter of the seminiferous tubules and germinal epithelium thickness were measured. To measure the diameter of the seminiferous tubule, two opposite points were considered in the circumference of the tubules from the location of the connective tissue in basement membrane. The basement membrane was defined based on their connective tissue and myoid cells. To measure the germinal epithelium thickness, the distance between round spermatid and the basement membrane were reported as epithelium thickness (Fig. 1.) (Table. 1). In total 20 tubules were analysed for each tissue section and the average of them reported as a single data point.

Spermatogenesis Evaluation

Johnson score is a measure to evaluate spermatogenesis in seminiferous tubules [36]. For study of the FAE effect on spermatogenesis, Johnson's score values were calculated and then data analysed. In this way, the Johnson score in each seminiferous tubule was determined based on a score of 1 to 10. At each tissue section, 50 tubules were studied and average considered as data point (Table. 1).

Biochemical Evaluation

Insulin, Testosterone and Glucose: These biochemical factors were evaluated by standard kits.

Superoxide Dismutase (SOD) activity: SOD activity determined by the Marklund method [37].

Ethics Statement

All the experimental procedures were performed in compliance with the policies of the Animal Care and Ethics Committee (ACEC) of the Ferdowsi University of Mashhad (No. 41,391). According to ACEC recommendations, we tried our best to minimize research animal pain and suffering.

Data Analysis

For each experimental group, 5-7 rats were analysed. The mean of the calculated value for each rat was reported as a single data point and were used for making the graphs. Graphs were drawn with Graph Pad Prism and Adobe Illustrator software and Microsoft Excel software. Data were subjected to statistical analysis in SPSS software (version 22). Using one-way ANOVA and Tukey post hoc test were used and data significant levels at $P \leq 0.05$ were considered. The error bars on the graph present the mean ± SEM.

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Figure legends

Fig. 1. Cross section of the testis from different groups showing Tubular Diameter (TD) and different parts of the testis. The yellow arrows showing tubular diameter (TD); the black double-sided arrow indicate lumen diameter (LD); green arrow heads showing interstitial tissue (IT); black single-side arrows show tunica albuginea (TA); the blue double-sided arrow indicate epithelium thickness (ET).

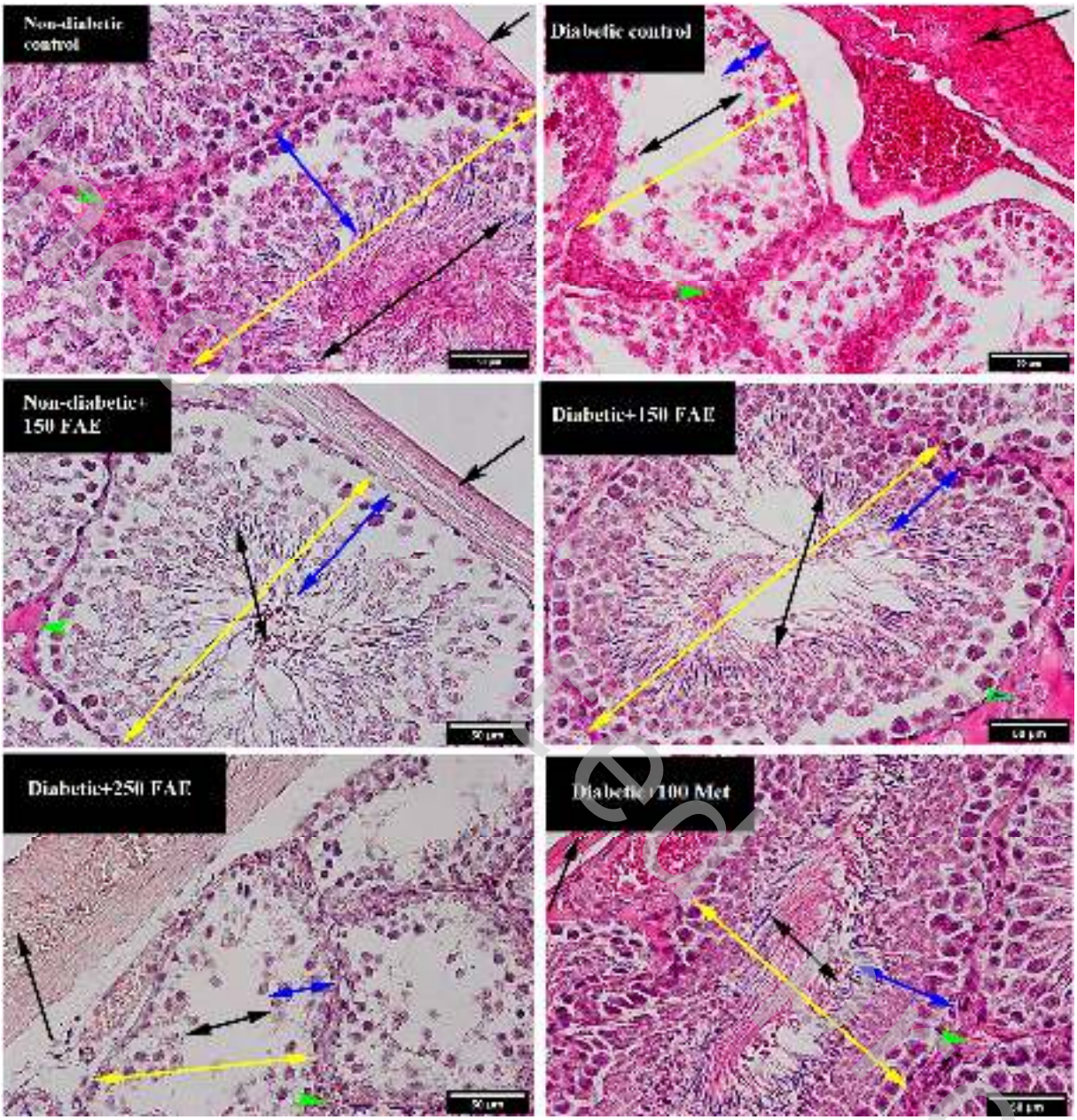


Fig. 2. FAE (150 mg/kg b.w) corrects sugar and hormonal level in the blood of treated rats and its positive effect reduces at higher doses.

a, collected blood samples from tail vein of the animals before organ collcetion.

b, bar graph showing the FBS level in different experimental groups.

c, bar graph showing the serum insulin level in different experimental groups.

d, bar graph showing the testestrone level in different experimental groups.

Statistics: bar graphs are mean values ± SEM; One-way ANOVA with Tukey test; $P < 0.05$ was considered as significant;

d& b, *, significant in comparisons with non-diabetic control; #, significant in comparison with diabetic control; †, significant in comparison with non-diabetic+150 mg/kg b.w FAE; ‡, significant in comparison with diabetic rats treated with 150 mg/kg b.w FAE; ¤, significant in comparison with diabetic rats treated with 250 mg/kg b.w FAE.**C**, *; significant in comparison with non-diabetic+150 mg/kg b.w FAE.

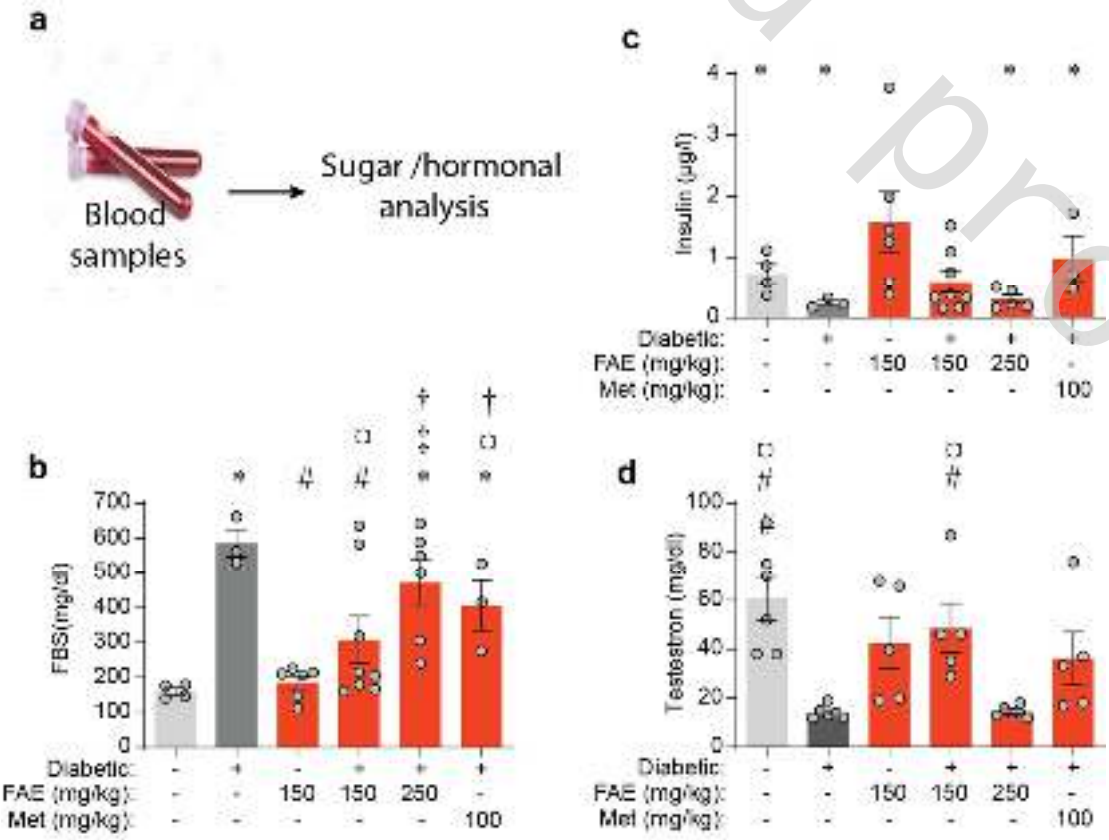


Fig. 3. FAE increases antioxidative enzyme (SOD): super oxide dismutase in diabetes-induced rats**.**

Statistics: bar graphs are mean values ± SD; One-way ANOVA with Tukey test; $P < 0.05$ was considered as significant; *, significant in comparisons with non-diabetic control (Group1); #, significant in comparison with diabetic control (group2); †, significant in comparison with non-diabetic+150 mg/kg b.w FAE (group3); ‡, significant in comparison with diabetic rats treated with 150 mg/kg b.w FAE (group4).

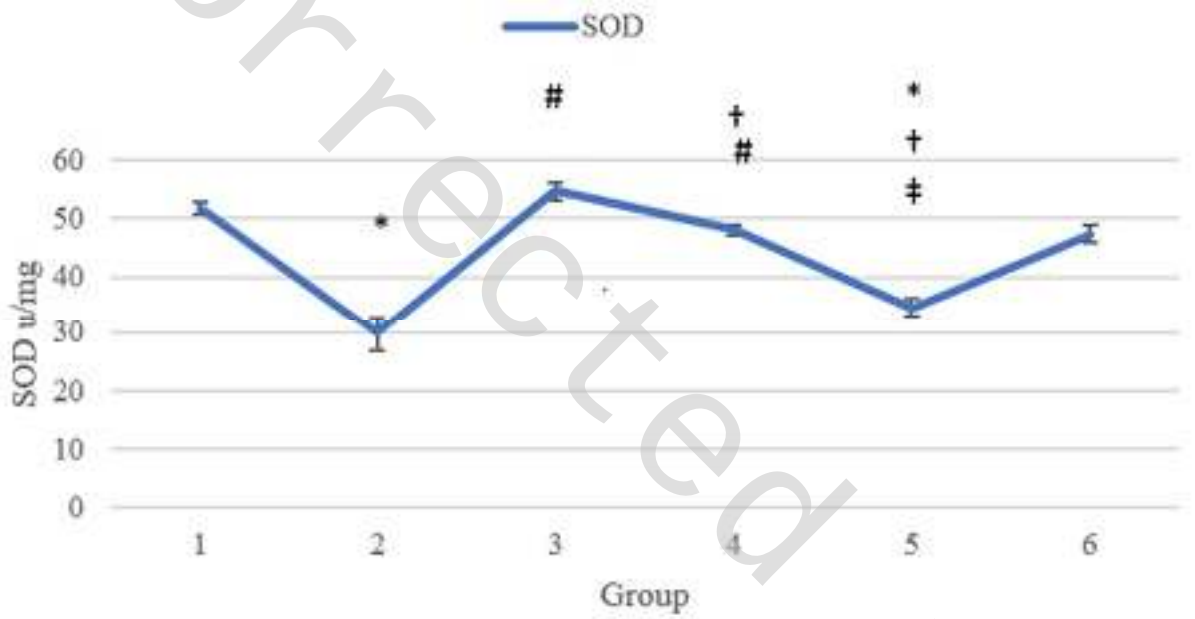


Fig. 4. FAE balances the body and testis weight in diabetic wistar rats.

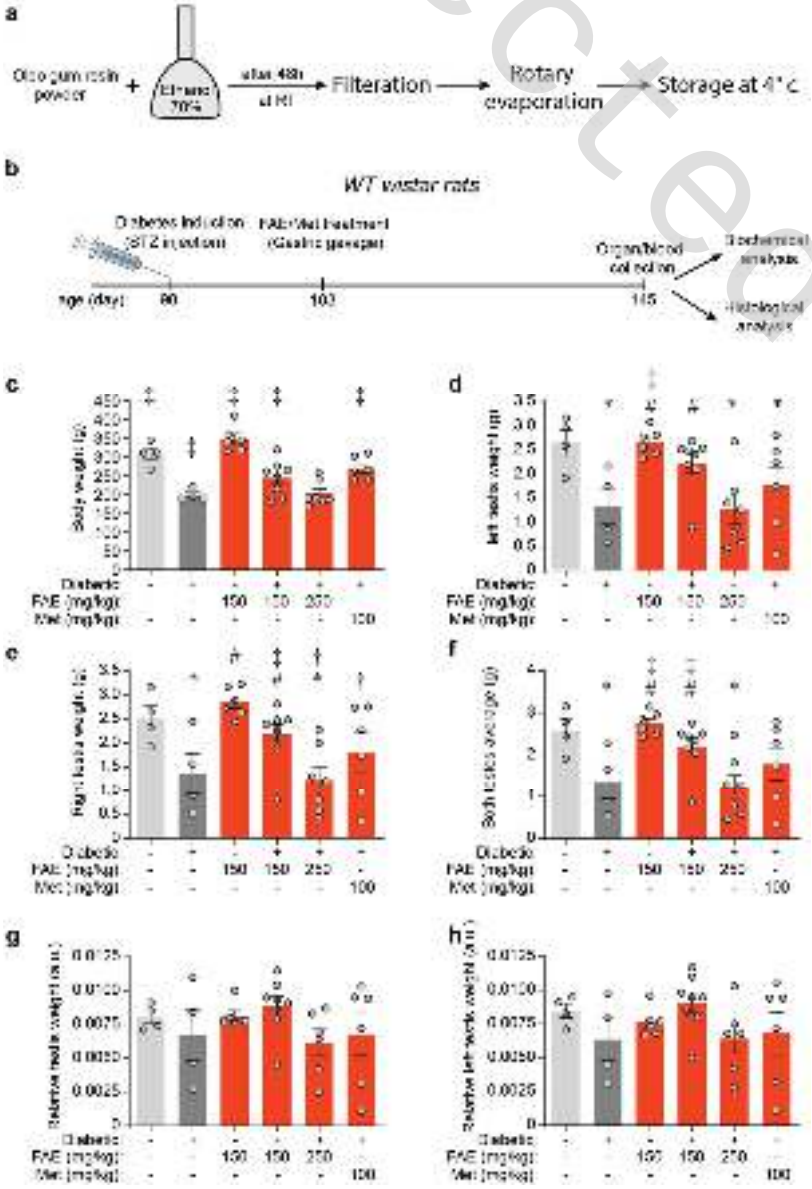
a, Schematic drawing of the used protocol for FAE extraction.

b, a drawing of the protocol used for induction of diabetes in rat and organ/blood collection from treated/untreated animals.

c, representing the weight of the animals at the time of organ collection.

d-f, showing the weight of the left, right and the average mass of both testes respectively.

g & **h**, are the bar graphs showing the relative testis weight obtained by dividing the mass of each testis to the weight of the body.



Statistics: bar graphs are mean values ± SEM; One-way ANOVA with Tukey test; $P < 0.05$ was considered as significant; *, significant in comparisons with non-diabetic control; #, significant in comparison with diabetic control; †, significant in comparison with non-diabetic+150 mg/kg b.w FAE; ±, significant in comparison with diabetic rats treated with 150 mg/kg b.w FAE; ‡, significant in comparison with diabetic rats treated with 250 mg/kg b.w FAE.

Fig. 5. Cross section of the testis from different groups showing the semineferous tubules with fibrosis. Arrows showing connective tissue and cells in different groups. The green arrow heads showing interstitial tissue (IT); the black single-side arrows show tunica albuginea (TA); the blue arrow head indicate germinal cell; the black arrow heads show connective tissue**.**

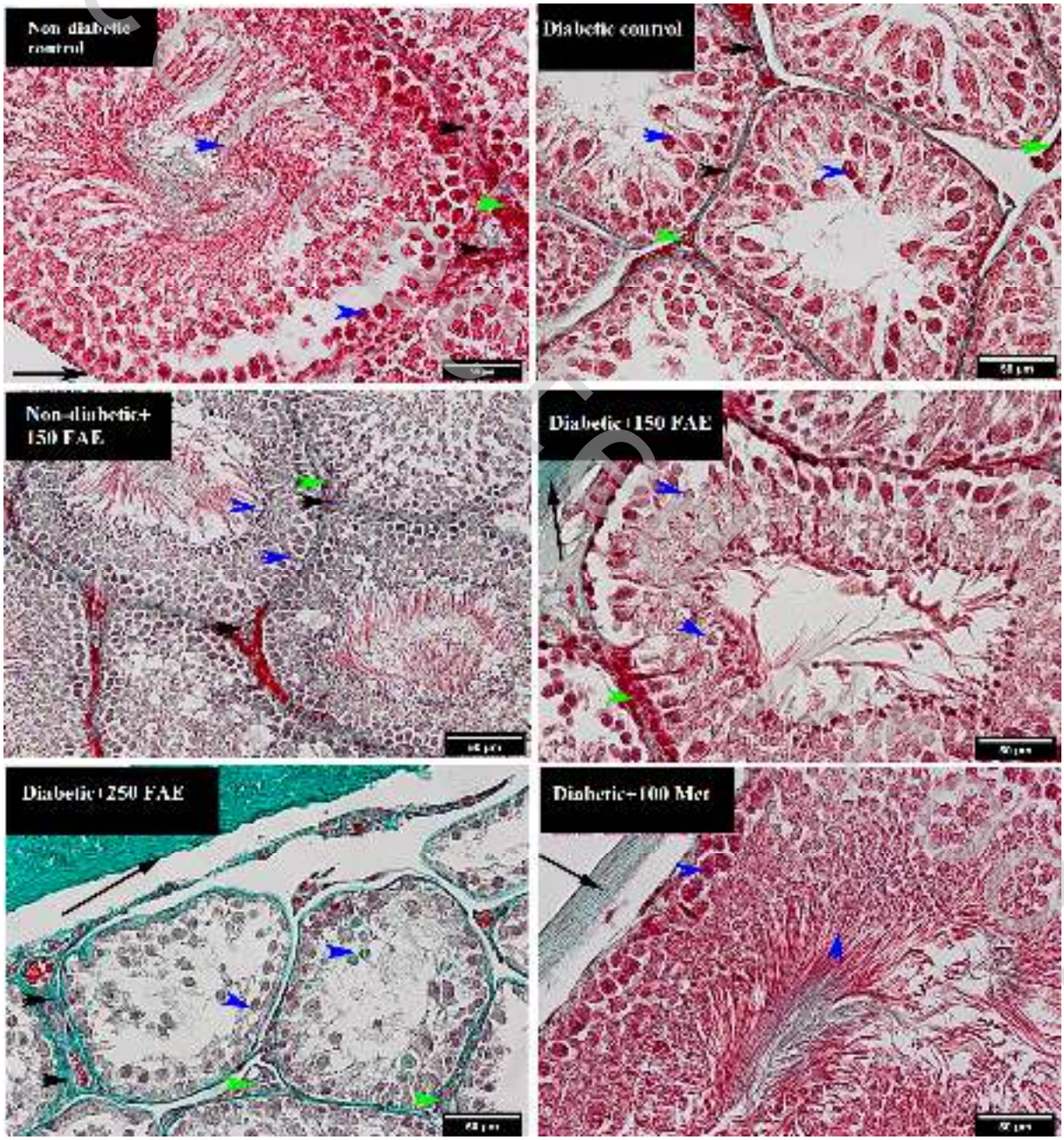


Table. 1 .FAE improves the morphometric features of the testis tubules in diabetes-induced rats.

Data showing the tubular diameter, epithelium thickness and Johnson′s Score in different experimental groups.

Statistics: Data are mean values ± SEM; One-way ANOVA with Tukey test; $P < 0.05$ was considered as significant; *, significant in comparisons with non-diabetic control; #, significant in comparison with diabetic control; †, significant in comparison with non-diabetic+150 mg/kg b.w FAE ; ±, significant in comparison with diabetic rats treated with 150 mg/kg b.w FAE; ‡,significant in comparison with diabetic rats treated with 250 mg/kg b.w FA; ¤, significant in comparison with diabetic rats treated with 100 mg/kg b.w Met.

	Johnson′s score	Tubule Diameter	Epithelium thickness
Group1	9.58±0.54$^{‡\#}$	168.83±9.06$^{\#‡}$	46.16±1.19
Group2	5.57±0.49$^{†¤±}$	114.66±4.84$^{†±¤}$	33.83±1.30$^{*†±}$
Group3	9.89±0.32	174.40±6.72‡	47.60±1.72‡
Group4	9.51±0.17‡	176.80±3.18‡	47.40±1.07
Group5	5.34±1.22$^{¤†}$	88.50±12.40	21.66±4.79$^{*\#±¤}$
Group6	9.41±0.40	163.00±8.61‡	40.80±2.78

Table. 1 .FAE improves the morphometric features of the testis tubules in diabetes-induced rats.

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Statistics: Data are mean values ± SEM; One-way ANOVA with Tukey test; $P < 0.05$ was considered as significant; *, significant in comparisons with non-diabetic control; #, significant in comparison with diabetic control; †, significant in comparison with non-diabetic+150 mg/kg b.w FAE ; ±, significant in comparison with diabetic rats treated with 150 mg/kg b.w FAE; ‡,significant in comparison with diabetic rats treated with 250 mg/kg b.w FA; ¤, significant in comparison with diabetic rats treated with 100 mg/kg b.w Met.

عنوان: اثرات ضد دیابتی و حفاظتی عصاره اتانولی آنغوزه بر بیضه موش های صحرایی دیابتی شده با استرپتوزوتوسین: یک مطالعه هیستوپاتولوژیکی.

دیابت یکی از شایع ترین بیماری های متابولیک در سراسر جهان است که همه اندام ها از جمله دستگاه تناسلی را درگیر می کند. امروزه بسیاری از محققین از گیاهان دارویی به جای داروهای شیمیایی برای کاهش عوارض آنها استفاده می کنند. آنغوزه یکی از گیاهان دارویی است که سال هاست برای درمان بسیاری از بیماری ها به طور سنتی مورد استفاده قرار می گیرد. مطالعه حاضر به بررسی اثرات ضد دیابتی و محافظتی آنغوزه بر بیضه موش های صحرایی نر دیابتی شده با استرپتوزوتوسین پرداخته است. بررسی هیستومورفولوژی موش‌های دیابتی تیمار شده با عصاره آنغوزه بهبود قابل توجهی در بیضه‌ها نشان می‌دهد. مطالعات بافت شناسی نشان می دهد که درمان با عصاره آنغوزه به طور قابل توجهی تعداد اسپرم را در لوله های اسپرم ساز افزایش می دهد و فیبروز را کاهش می دهد. مطالعه ما اثرات بهبود بخش آنغوزه بر پارامترهای هیستومورفومتریک و بیوشیمیایی در دیابت و آسیب بیضه ناشی از آن را تایید می کند که تا حدی به وجود ترکیبات فعال زیستی و آنتی اکسیدان ها در آنغوزه نسبت داده می شود.