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Research Article

Antidiabetic activity of the aqueous extracts of *Foeniculum vulgare* on streptozotocin-induced diabetic rats

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ABSTRACT

Objective: Diabetes mellitus is a clinical syndrome associated with an abnormal high blood glucose concentration due to insufficient insulin secretion or defective in insulin action. The present study was attempted to evaluate the antidiabetic effects of *Foeniculum vulgare* in streptozotocin-induced diabetic rats. **Methods:** The effects of daily oral administration of an aqueous extract of *Foeniculum vulgare* (150 mg, 300 mg/kg) for 35 days on blood glucose, hemoglobin (Hb), HbA1c, liver glycogen and some carbohydrate metabolic enzymes were evaluated in normal and streptozotocin-induced diabetic rats. Various biochemical parameters such as hexokinase activity, succinate dehydrogenase, serum and tissue proteins, urea, creatinine were also determined as per the standard protocol available from the literature. **Results:** Administration of the aqueous extract of *Foeniculum vulgare* to diabetic rats corrected the hyperglycaemia from 339.3±0.48 mg/dl to 101.4± 0.34 mg/dl and the levels of HbA1c from 11.09 ± 0.56 mg/dl to 6.26 ± 0.2 mg/dl. Further the extract decreased total cholesterol, triglycerides, LDL, VLDL levels and increased HDL levels. Oral administration of 300 mg/ kg extract modulated all the parameters evaluated to levels seen in control rats. Also, improved the pathological changes noticed in their kidney and liver. **Conclusion:** The present investigation suggested that the treatment with *Foeniculum vulgare* exhibited antidiabetic activity in streptozotocin-induced diabetes in male albino rats and could be considered for further evaluation in drug development.

Key words: *Foeniculum vulgare*, antidiabetic activity, aqueous extract, Streptozotocin-induced diabetic rats.

1. INTRODUCTION

In folk medicinal practice many plants are used to treat diabetes mellitus in south India. Most of these medicinal plants are scientifically validated for their therapeutic efficacy and safety. In modern medicine no satisfactory and effective therapy is available to cure diabetes mellitus, which is a syndrome resulting from a variable interaction of hereditary and environmental factors and characterized by abnormal insulin secretion or insulin receptor or post receptor events affecting metabolism involving carbohydrates, proteins, and fats in addition to damaging β-cells of pancreas, liver and kidney in some cases[1]. Diabetes mellitus is a clinical syndrome associated with an abnormal high blood glucose concentration due to insufficient insulin secretion or defective in insulin action. Approximately more than 150 million

people were reported to have diabetes mellitus worldwide[2].

Fennel is one of the important spices that cure many diseases. Fennel (*Foeniculum vulgare*) is a plant species in the genus Foeniculum. It is highly aromatic and flavorful herb with culinary and medicinal uses, and is one of the primary ingredients of absinthe. It is a hardy, perennial, umbelliferous herb, with yellow flowers and feathery leaves, grow wild in most part of Europe, but are generally considered indigenous to the shores of the Mediterranean (botanical.com). Fennel contains and 90% trans anethole, up to 20% fenchone and also contain small amounts of limonene, camphor, alphapinene and about six additional minor volatile compounds[3]. The ethanolic extract of dried ripe fruit of *Foeniculum vulgare* (500 mg/kg) was tested for diuretic, analgesic, antipyretic, antimicrobial, cytotoxic activities and its effect on bile secretion in rats[4].

Multi herbal formulations containing aqueous extract of fennel were analyzed for glucose content by using glucose oxidase peroxidase (GOD-POD) method using a visible spectrophotometer at 505 nm[5]. The essential oils obtained from *Crithmum maritimum L.* (marine fennel) and two samples of *Foeniculum vulgare M.* (common fennel) were analyzed by GC-MS and assayed for their antioxidant and antibacterial activities[6]. The *in vitro* antioxidant activity of natural (essential oils, vitamin E) or synthetic substances (tert-butyl hydroxy anisole (BHA), trolox) has been evaluated by monitoring volatile carbonyl compounds released in model lipid systems subjected to peroxidation[7]. Hepatoprotective activity of fennel essential oil (FEO) was studied using carbon tetrachloride (CCl_4) induced liver injury model in rats[8]. Essential oil obtained from *F. vulgare*, and its main component anethole reported as a safe antithrombotic may be due to their broad spectrum antiplatelet activity, clot destabilizing effect and vasorelaxant activity[9]. The present study was aimed to evaluate the antidiabetic effects of *F. vulgare* in diabetic rats.

2. MATERIALS AND METHODS

2.1. Plant material

Seed materials were collected from local super market in Erode, Tamilnadu, India and kept it under shade for drying and crushed into a powder form using a blender. The powdered material was used for phytochemical analysis. *Foeniculum vulgare* were further dried over a polythene cover under shade drying method with the help of fan at room temperature (21°C) and pulverized using a mixer grinder. The coarse powder of the seed was used for the preparation of various extracts.

2.2 Chemicals

Streptozotocin was obtained from Sigma (St Louis, MO, USA). All other chemicals and reagents used were of analytical grade (Ranchem, Mumbai, India).

2.3. Experimental Animals

Adult male rats of swiss albino strain were procured from Salem, Tamilnadu, India. They were acclimatized to laboratory condition for one week in the animal housing facility owned by the Research & PG Department of Biochemistry of Muthayammal College of Arts & Science, Tamilnadu, India. Rats were housed in polypropylene cages (47x34x20 cm) lined with husk (renewed every 24 h) under a 12 h light-dark cycle at approximately 22 ^{o}C. Rats had free access to tap water and food (standard pellet diet; Pranav Agro Industries, Maharashtra, India). The pellet diet consisted of 23% protein, 5% lipids, 4% crude fiber, 8% ash, 1% calcium, 0.6% phosphorus, 3.4% glucose, and 55% nitrogen-free extract (carbohydrates). Experiments were performed according to the guidelines of the Committee for the Purpose of Control and Supervision of Experiment on Animals (CPCSEA), New Delhi, India, and were approved by the Animal Ethics Committee of Muthayammal College of Arts & Science, Tamilnadu, India.

2.4. Preparation of plant extract

The powdered materials are subjected for extraction using various solvents such as like petroleum ether, benzene, diethyl ether, chloroform, ethyl acetate, acetone, methanol, ethanol, butanol, water. The method involves soaking 30 gm dried powder of *Foeniculum vulgare* in 100 ml of selected solvent in a separating funnel for 24 h with intermittent shaking. The seed extracts were then collected and filtered through Whatmann No. 1 filter paper separately. From the filtrates, solvents were dried by heating on water bath. The dried powders of the seed extracts were stored at 40 °C in air tight bottle. These extracts were used for phytochemical analysis and aqueous extract was used for animal studies.

2.5. Phytochemical analysis

The extracts obtained as above were then subjected to qualitative chemical tests for the identification of various phytoconstituents present in the plant material. The tests include detecting alkaloids, flavanoids, tannins - phenolic compounds, saponins, steroids, thiols and resins. The test procedures are followed as per the standard protocol adopted from various literature reports. The test results indicated the presence of active

constituents in maximum proportion as reported earlier.

2.6. Experimental set up

The rats were weighed and divided into five experimental groups each of five rats as follows: (i) Group I, normal rats treated with saline; (ii) Group II, normal rats treated with 300 mg/kg of plant extract which serve as positive control; Group III, diabetic rats by an intra peritonial (ip) injection of single dose of streptozotocin (40 mg/kg body wt); Group IV, treated with the aqueous extract of *F. vulgare* at a dose of 150 mg/kg body wt; Group V, the same extract in different concentration (300 mg/kg body wt) was given. After 35 days of treatment, all rats were decapitated after an overnight fast. Blood was collected from the animals by retro-orbital bleeding at the end of the study period into heparinised tubes (plasma) and non-heparinized tubes (sera) for the determination of biochemical parameters. Tissues (liver and kidney) were also collected in ice-cold normal saline for the analysis of various biochemical parameters.

2.7. Preparation of tissue homogenate

Tissue samples from animals were rinsed thoroughly in cold physiological saline and blotted dry on filter paper. Tissues were then weighed and homogenized using a glass homogenizer with a Teflon pestle in 5 mL buffer solution (0.1 M Tris-HCl buffer, pH 7.4). The homogenate was centrifuged at 2500 rpm for 5 min. The supernatant was used for the estimation of various biochemical parameters.

2.8. Biochemical analysis

After 35 days, rats were killed by mild ether anesthesia and tissues were collected for the subsequent biochemical analysis. Blood samples were collected by cardiac puncture and were separated to obtain blood constituents. After autopsy under mild ether anesthesia, serum was separated and analyzed[10-30]. Various biochemical parameters evaluated in the present study was shown in Table-1.

2.9. Statistical analysis:

Statistical analyses were performed using one-way analysis of variance (ANOVA) in the SPSS software package (version 17.0; SPSS, Chicago, IL, USA). The results were expressed in mean $\pm$ SE for each parameter under for different groups was tested using student's t- test at 1% level and 5% levels. The result is significant at 1% level if $P<0.001$ and significant at 5% level if $P<0.05$. Results obtained at the end of the experiments were compared with those of the control and diabetic groups and differences were considered significant at $P < 0.001$.

3. RESULTS

The results of phytochemical analysis of the extracts were presented in Table-2 and scavenging activity of extract of *Foeniculum vulgare* was expressed in Table-3. Various biochemical parameters were evaluated and the results are presented in Tables 4-12. The aqueous extract of *F. vulgare* has showed hypoglycaemic activity in streptozotocin-induced diabetic rats. Administration of the extract to diabetic rats corrected the hyperglycaemia from 339.3$\pm$0.48 mg/dl to 101.4$\pm$ 0.34 mg/dl and the levels of HbA1C from 11.09 $\pm$ 0.56 mg/dl to 6.26 $\pm$ 0.2 mg/dl.

4. DISCUSSION

The present investigation was taken up to assess the antidiabetic effect of aqueous extract of *Foeniculum vulgare* against Streptozotocin induced diabetes in male albino rats. Phytochemical investigation revealed that there was high concentration of phytochemical constituents present in aqueous seed extract of *Foeniculum vulgare*. Present investigation showed that the presence of free radical scavenging activity in various seed extract of *Foeniculum vulgare.*

The level of serum glucose was significantly increased in Streptozotocin-induced diabetic rats, while the pretreatment of aqueous extract of *Foeniculum vulgare* leads to decrease in their levels. The level of liver glycogen was significantly increased in streptozotocin-induced diabetic rats, while the pretreatment of aqueous extract of *Foeniculum vulgare* leads to decrease in their levels. The level of insulin was significantly decreased in diabetic rats, while the pretreatment of aqueous extract of *Foeniculum vulgare* leads to the recovery of the normal levels.

Streptozotocin induced diabetic rats showed a significant increase in the level of glycosylated hemoglobin while the pretreatment of *Foeniculum vulgare* showed decrease in the glycosylated hemoglobin level. Streptozotocin-induced diabetic rats showed a significant decrease in the level of hexokinase, in liver and kidney, while the pretreatment of *Foeniculum vulgare* showed a siginificant increase in the hexokinase level. Streptozotocin-induced diabetic rats showed a significant decrease in the level of serum and tissue protein, while the pretreatment of *Foeniculum vulgare* showed a significant increase in the protein levels.

Streptozotocin induced diabetic rats showed a significant increase in the level of urea and creatinine, while the pretreatment of *Foeniculum vulgare* showed a significant decrease in the urea and creatinine levels. Streptozotocin induced diabetic rats showed a significant decrease in the level of succinate dehydrogenase, while the pretreatment of *Foeniculum vulgare* showed a

significant increase in the succinate dehydrogenase level.

In the present study, streptozotocin induced diabetic rats showed a significant increase in the liver, kidney and serum marker enzymes such as ALP, ACP, ALT, AST and LDH while the pretreatment of aqueous extract of *Foeniculum vulgare* showed a significant decrease in the marker enzymes which shows that the extract possess protective action against tissue damage. From the present investigation, streptozotocin-induced diabetic rats shows the serum lipid profile such as total cholesterol, triglycerides, LDL, VLDL levels, were significantly increased with a desirable feature of decreasing the HDL levels. Pretreatment of aqueous extract of *Foeniculum vulgare* leads to the recovery of the normal levels. This feature moderately shows the hypolipidemic effects.

Enzymatic antioxidants such as Catalase, SOD and GPX, were decreased significantly and the non-enzymatic antioxidant such as Vitamin C were also significantly decreased in streptozotocin-induced diabetic rats, while the oral pretreatment of aqueous extract of *Foeniculum vulgare* leads to significant increase in the enzymatic and non enzymatic antioxidants. In conclusion, our observation suggested that the treatment with *Foeniculum vulgare* exhibited antidiabetic activity in streptozotocin-induced diabetes in male albino rats. Further work need to be done to isolate and purify the active constituents present in the seed extract of *Foeniculum vulgare*, which is responsible for its antidiabetic activity.

Conflict of interest statement

We declare that we have no conflict of interest.

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Table-1.

Various biochemical parameters determined for the aqueous extract of *Foeniculum vulgare*

S. No.	Biochemical parameter	Reference
1	Serum glucose (GOD/POD method)	[10]
2	Liver glycogen	[11]
3	Plasma insulin (Ubi-Magiwel kit)	[12]
4	Glycosylated haemoglobin (monozyme Hemoglobin A_1C Chromatographic-Spectrophotometric method)	[13]
5	Hexokinase (rate of disappearance of glucose at 37 °C was measured)	[14]
6	Succinate dehydrogenase	[15]
7	Protein content	[16]
8	Urea	[17]
9	Creatinine	[18]
10	Acid phosphatise	[19]
11	Alkaline phosphatise	[19]
12	Aspartate transaminases	[20]
13	Alanine transaminases	[20]
14	Lactate dehydrogenase	[19]
15	Cholesterol (colourimetry method)	[21]
16	High density liprotein (HDL)	[22]
17	Triglycerides	[23]
18	Superoxide dismutase	[24]
19	Catalase	[25]
20	Glutathione peroxidase	[26]
21	Ascorbic acid	[27]
22	Scavenging of nitric oxide radical	[28]
23	Scavenging of hydroxy radical	[29]
24	Scavenging of superoxide anion	[30]

Table-2.
Phytochemical constituents present in various extract of *Foeniculum vulgare*

Phytoconstituent	Pet. ether	Chloroform	Acetone	Methanol	Water	Benzene	Ethanol	Butanol	Ethyl Acetate
Alkaloids	-	+	-	-	+	-	+	+	-
Flavanoids	-	-	-	+	-	+	+	-	-
Steroids	+	+	-	-	-	+	+	+	-
CardiacGlycosides	-	-	++	-	-	-	+	+	+
Saponins	+	-	+	+	+	+	-	-	-
Tannins	+	+	+	+	+	+	+	+	+
Phenols	-	+	+	+	+	-	+	+	+
Thiols	-	-	-	-	-	-	+	-	-
Resins	+	-	-	-	-	-	-	-	-
Glycosides	-	-	-	+	+	+	+	+	-
Triterpenoids	-	-	-	-	-	+	+	+	-

(++) – Dark colors; (+) - Presence; (-) - Absence

Table-3.
Scavenging activity of various extract of *Foeniculum vulgare*

S. No.	Scavenging activity	Petroleum ether extract	Chloroform extract	Methanol extract
1	Nitric oxide	+	+	+
2	Hydroxy radical	+	+	+
3	Superoxide anion	+	+	+

(+) – Presence; (-) – Absence

Table-4.
Effect of aqueous seed extract of *Foeniculum vulgare* pretreated on serum glucose, liver glycogen, serum insulin and HbA_1c levels in control & experimental rats

S. No.	GROUPS	GLUCOSE mg/dl	GLYCOGEN mg/g tissue	INSULIN µU/ml	HbA1C mg/dl
1	Group I (Normal control)	75.5 ± 0.15	53.5 ±0.13	11.3 ± 0.19	4.65 ± 0.17
2	Group II (positive control)	70.6 ± 0.08^{NS}	50.6 ±0.31^{NS}	11.6 ± 0.09^{NS}	4.10 ± 0.19^{NS}
3	Group III (Diabetic control)	339.3±0.48*	23.3 ±0.6**	14.9 ± 0.52**	11.09 ± 0.56**
4	GroupIV (Diabetic+Extract) (150mg/kgbw)	110.4 ±0.64**	39.1 ± 0.44**	17.7 ± 0.23**	7.57 ± 0.22**
5	GroupV (Diabetic+Extract) (300mg/kgbw)	101.4± 0.34**	42.2 ±1.25**	18.5 ± 0.28**	6.26 ± 0.2**

Statistical significance: * - P<0.05; ** - P<0.001; NS - Not significant
Values are expressed by mean ± SE (n = 5 rats in each group).

Table-5.
Effect of aqueous seed extract of *Foeniculum vulgare* pretreated on liver and kidney hexokinase and succinate dehydrogenase activities in control and experimental rats.

S. No.	GROUPS	HEXOKINASE		SUCCINATE DHase	
		LIVER[a]	KIDNEY[a]	LIVER[b]	KIDNEY[b]
1	Group I (Normal control)	266.6 ± 0.4	171.6 ±0.24	1.22 ±0.39	1.38± 0.27
2	Group II (positive control)	265.6 ± 0.23^{NS}	169.6 ±0.21^{NS}	1.05 ±0.06^{NS}	1.09 ±0.05^{NS}
3	Group III (Diabetic control)	131.5 ± 0.66**	120.4 ±0.40**	0.68 ±0.13**	0.74 ±0.04*
4	GroupIV (Diabetic+ Extract) (150mg/kg BW)	216.2 ± 0.54**	156.6 ±0.38**	0.85 ±0.03**	0.88 ±0.01**
5	Group V (Diabetic+ Extract) (300mg/kg BW)	204.5 ± 0.26**	160.8 ±0.40**	0.94± 0.01**	0.96 ±0.02**

a. n moles of glu-6-phosphate formed/hr/mg protein; **b**- n moles of SDHase liberated/litre
Statistical significance: * - P<0.05; ** - P<0.001; NS - Not significant
Values are expressed by mean ± SE (n = 5 rats in each group).

Table-6.
Effect of aqueous seed extract of *Foeniculum vulgare* pretreated on protein levels (serum, liver and kidney) and urea and creatinine levels in control and experimental rats.

S.No.	GROUPS	SERUM g/dl	LIVER mg/g tissue	KIDNEY mg/g tissue	UREA mg/dl	CREATININE mg/dl
1	Group I (Normal control)	7.09± 0.06	243.2± 3.07	216.1 ±0.16	15.2 ±0.12	0.66 ±0.44
2	Group II (positive control)	6.81± 0.11^{NS}	247.7 ±0.39^{NS}	216.3 ±0.19^{NS}	14.4 ±0.37 ^{NS}	0.63 ±0.05^{NS}
3	Group III (Diabetic control)	3.28 ±0.12**	131.8± 0.41*	139.9 ±0.67*	49.4 ±0.27**	0.95 ±0.03**
4	GroupIV (Diabetic+Extract) (150mg/kgBW)	5.26 ±0.10**	201.4± 0.18**	179.3 ±0.18*	28.3 ±0.08 *	0.74±0.02**
5	GroupV (Diabetic+Extract) (300mg/kg BW)	6.24 ±0.01**	219.5 ±0.27**	201.2 ±0.02*	30.5 ±0.04*	0.70 ±0.56**

Statistical significance: * - P<0.05; ** - P<0.001; NS - Not significant
Values are expressed by mean ± SE (n = 5 rats in each group).

Table-7.
Effect of aqueous seed extract of *Foeniculum vulgare* pretreated on serum marker enzymes (AST, ACP, ALT, ALP and LDH) in control & experimental rats.

S. No.	GROUPS	Serum Marker Enzymes				
		ALT[a]	AST[a]	ACP[b]	ALP[b]	LDH[a]
1	Group I (Normal control)	41.2 ±0.6	49.1 ± 0.77	17.9 ± 0.40	36.5 ± 0.23	122.6 ± 0.65
2	Group II (positive control)	43.4 ± 0.49^{NS}	51.4 ± 0.46^{NS}	19.4 ± 0.49^{NS}	38.8 ± 0.37^{NS}	125.7 ± 0.79^{NS}
3	Group III (Diabetic control)	114.5± 0.87*	68.3 ± 0.87*	41.4 ± 0.5**	63.1 ± 0.16**	246.9 ± 0.86**
4	GroupIV (Diabetic+Extract)(150mg/kgbw)	69.1 ± 0.64*	58.6 ± 0.79**	30.5 ± 0.48**	52.3 ± 0.69*	181.1 ± 0.50**
5	GroupV (Diabetic+Extract) (300mg/kgbw)	61.4 ± 0.58*	55.8 ± 0.74**	27.3 ± 0.40**	49.5 ± 0.86*	175.8 ± 1.22**

a- µ moles of pyruvate liberated/litre, b- µ moles of phenol liberated/litre
Statistical significance: * - P<0.05; ** - P<0.001; NS - Not significant
Values are expressed by mean ± SE (n = 5 rats in each group).

Table-8.
Effect of aqueous seed extract of *Foeniculum vulgare* pretreated on liver marker enzymes (AST, ACP, ALT, ALP, LDH) in control & experimental rats

S.No.	GROUPS	Liver Marker Enzymes				
		ALT[a]	AST[a]	ACP[b]	ALP[b]	LDH[a]
1	Group I (Normal control)	192.5 ± 0.34	30.5 ± 0.38	24.4 ± 0.24	24.4± 0.26	16.2 ± 0.29
2	Group II (positive control)	196.5 ± 0.33^{NS}	32.2 ± 0.67^{NS}	24.5 ± 0.37^{NS}	25.6± 0.39^{NS}	17.3 ± 0.31^{NS}
3	Group III (Diabetic control)	466 ± 0.40*	185.9 ± 0.97*	87.1 ± 0.18**	72.7± 0.14**	63.5 ± 0.07**
4	GroupIV (Diabetic+Extract) (150mg/kgbw)	312.5 ± 0.35*	86.1 ± 0.59**	39.5 ± 0.42**	42.6± 0.31**	17.6 ± 0.38**
5	Group V (Diabetic+Extract) (300mg/kgbw)	295.9 ± 0.65*	83.8 ± 0.19**	35.2 ± 0.11**	40.8± 0.36**	15.2 ± 0.39**

a- µ moles of pyruvate liberated/litre, b- µ moles of phenol liberated/litre
Statistical significance: * - P<0.05; ** - P<0.001; NS - Not significant
Values are expressed by mean ± SE (n = 5 rats in each group).

Table-9.
Effect of aqueous seed extract of *Foeniculum vulgare* pretreated on kidney marker enzymes (AST, ACP, ALT, ALP, LDH) in control & experimental rats

S. No.	GROUPS	Kidney Marker Enzymes				
		ALT[a]	AST[a]	ACP[b]	ALP[b]	LDH[a]
1	Group I (Normal control)	18.7± 0.37	56.3±0.22	24.4±0.24	83.6±0.42	12.5±0.5
2	Group II (positive control)	19.2 ±0.18^{NS}	64.3±0.23^{NS}	24.5±0.27^{NS}	81.4±0.78^{NS}	42.9±0.03^{NS}
3	Group III (Diabetic control)	55.8 ±0.14*	206.5±0.09**	57.2±0.62*	97.5±0.42**	13.7±0.19**
4	GroupIV (Diabetic+Extract) (150mg/kgbw)	38.5 ±0.11**	121.6±0.34*	39.6±0.3**	89.2±0.18**	24.3±0.35**
5	GroupV (Diabetic+Extract) (300mg/kgbw)	35.4 ±0.24**	177.8±0.22**	35.6±0.37**	87.2±0.14**	21.3±0.12**

a- µ moles of pyruvate liberated/litre, b- µ moles of phenol liberated/litre
Statistical significance: * - P<0.05; ** - P<0.001; NS - Not significant
Values are expressed by mean ± SE (n = 5 rats in each group).

Table-10.
Effect of aqueous seed extract of *Foeniculum vulgare* pretreated on lipid profile in control & experimental rats

S.No.	GROUPS	TC mg/dl	TG mg/dl	LDL mg/dl	VLDL mg/dl	HDL mg/dl
1	Group I (Normal control)	105.9± 0.13	64.2±0.08	21.5±0.23	21.3±0.65	26.1±0.82
2	Group II (positive control)	102.5±0.14 NS	66.5±0.07 NS	22.6±0.06 NS	20.3±0.19 NS	26.4±0.26 NS
3	Group III (Diabetic control)	184.3 ±0.25**	196.6±0.14**	136.4±0.25**	34.7±0.19**	13.5±0.04*
4	Group IV (Diabetic+Extract) (150mg/kgbw)	187.6 ±0.37**	126±0.10**	78.7±0.4**	30.6±0.18**	18.7±0.15**
5	Group V (Diabetic+Extract) (300mg/kgbw)	180.8 ±0.18**	121.9±0.97*	76.4±0.52**	27.3±0.87**	16.9±0.01*

Statistical significance: * - P<0.05; ** - P<0.001; NS - Not significant
Values are expressed by mean ± SE (n = 5 rats in each group).

Table-11.
Effect of aqueous seed extract of *Foeniculumvulgare* pretreated on enzymatic antioxidants (liver and kidney) in control and experimental rats.

S.No.	GROUPS	Enzymatic antioxidant in liver			Enzymatic antioxidant in Kidney		
		SOD[a]	CATALASE[b]	GPX[c]	SOD[a]	CATALASE[b]	GPX[c]
1	Group I (Normal control)	13.7 ±0.09	34.4 ±0.18	5.67 ±0.01	7.25 ± 0.09	29.4 ± 0.1	4.57 ± 0.03
2	Group II (positive control)	13.4 ±0.10NS	34.3 ±0.08NS	5.37 ±0.2NS	8.42 ± 0.03 NS	28.5 ± 0.18 NS	4.59 ± 0.07 NS
3	Group III (Diabetic control)	7.7 ±0.06**	20.6 ±0.18**	3.46 ±0.3**	5.52 ± 0.16**	22.5 ± 0.2**	2.57 ± 0.02**
4	GroupIV (Diabetic+Extract) (150mg/kgBW)	11.7 ±0.05**	30.6 ±0.17**	4.14 ±0.06*	7.37 ± 0.09*	25.6 ± 0.07**	3.63 ± 0.03**
5	GroupV (Diabetic+Extract) (300mg/kgBW)	9.5 ±0.15**	32.1± 0.04**	3.30 ±0.19*	6.5 ± 0.16*	27.5 ± 0.04**	4.04 ± 0.10**

a. 50% inhibition of nitrite/min/mg protein; **b.** n moles of H_2O_2 decomposed/min/mg protein;
c. µ moles of GSH/min/mg protein
Statistical significance: * - P<0.05; ** - P<0.001; NS - Not significant
Values are expressed by mean ± SE (n = 5 rats in each group).

Table-12.
Effect of aqueous seed extract of *Foeniculum vulgare* pretreated on liver and kidney Non enzymatic anti oxidants in control and experimental rats

S.No.	GROUPS	Vitamin - C	
		LIVER µg/mg protein	KIDNEY µg/mg protein
1	Group I (Normal control)	3.36 ±0.20	2.68 ±0.31
2	Group II (positive control)	3.35 ±0.12NS	2.62 ±0.31 NS
3	Group III (Diabetic control)	2.53 ±0.14**	1.59 ±0.2**
4	GroupIV (Diabetic+ Extract) (150mg/kg BW)	3.52 ±0.26**	2.51 ±0.24**
5	Group V (Diabetic+ Extract) (300mg/kg BW)	2.89 ±0.31**	1.96 ±0.14**

Statistical significance: * - P<0.05; ** - P<0.001; NS - Not significant
Values are expressed by mean ± SE (n = 5 rats in each group).

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