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Chemical, Nutritional, And Biological Studies of (Foeniculum Vulgare) Plant and Its Positive Effects in Experimental Animals.

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Abstract

Background: Medicinal plants were utilized in medicine from the beginning of time. Worldwide investigations were performed to test their efficacy, with certain results resulting in the development of plant-based medicines. The worldwide industry for medical plant products is over $100 billion annually.

Aims of study: Conducting a set of chemical, nutritional, and biological studies on the plant (Foeniculum vulgare) and determining its positive effects on experimental animals.

Materials and Methods: Thirty-six Sprague-Dawley albino rats, aged 10 weeks, with a weight of 150 ±10, were split into six groups: the 1st was a control negative nourished on slandered diet alone, while the other 5 groups nourished on basal diet plus different level of Foeniculum vulgare plant (5%,10%, 15%, 20% and Foeniculum vulgare) for 28 days. The experiment concluded with a blood sample and biochemical examination.

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Results: The positive results lower blood glucose level, improve blood hemoglobin and serum lipid and minerals patterns and the negative findings lowering FER can direct the attention for more work to investigate the biological efficacy and safety aspects of Foeniculum vulgar before use for human consumption.

Keywords: Foeniculum vulgare - Positive effects – Nutritional and Chemical studies

1- Introduction

Foeniculum vulgare is the scientific name for the plant known as fennel, a hardy perennial herb with a distinctive anise-like flavor and aroma, used in cooking, as a medicinal plant, and as an ornamental garden plant. It is characterized by its feathery, aromatic foliage, yellow flower clusters, and seeds, all of which are edible and possess various culinary and pharmacological properties, comprising anti-inflammatory & antimicrobial influences **(Su et al., 2022).** Fennel has a long history in conventional medicine and is recognized for its potential pharmacological properties, involving anti-inflammatory, antimicrobial, antispasmodic, in addition memory-enhancing **influences (Ghorbani et al., 2021).** Fennel thrives in full sun and prefers well-drained soil. Seeds are best sown in early spring or autumn, directly outdoors after the danger of frost has passed. It is a relatively low-maintenance plant that is hardy and drought-tolerant once established. **(Zhao et al., 2023).** F. vulgare was stated to include 6.3 percent moisture, 9.5 percent protein, ten percent fat, 13.4 percent minerals, 18.5 percent fibre, and 42.3 percent carbohydrates. The vitamins and minerals found in F. are a potassium, calcium, iron, sodium, thiamine, phosphorus, niacin vulgare, riboflavin, and vitamin C**. (Yalcın et al., 2021)** Common fennel may grow as much as six feet, however it frequently grows shorter. The dark green, smooth leaves are finely dissected with narrow lobes, providing a feathery appearance to the foliage, comparable to that of dill. Plants develop a deep great white tap root. Fennel usually doesn't bloom until its 2nd year (in mild climates where it will survive the winter) nevertheless, dry weather can trigger bolting in 1st year plants. The small, bright yellow flowers develop in a terminal compound umbel at the hollow, jointed, smooth stems. Each umbel section has between twenty and fifty flowers on short pedicels. The flowers are very attractive to numerous useful insects, involving small wasps, bees, syrphid flies, lacewings, in addition butterflies. **(Luo et al., 2021).** Multiple mechanisms. Fennel's volatile oils can improve the producation of insulin from cells of the pancreas. Phenolic chemicals & Flavonoids in fennel has the ability mitigate oxidative stress in pancreatic cells & enhance sensitivity to insulin. Alkaloids in fennel might mitigate chronic inflammation associated with diabetes. Although a significant portion of the proof derives from preclinical investigations, clinical trials indicate that fennel has the ability to enhance regulation of blood sugar & reduce consequences such as neuropathy & nephropathy. (**Oguntibeju et al ., 2019).** Fennel was utilized in conventional medicine for managing different conditions associated with the reproductive, endocrine, digestive, in

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addition respiratory systems. F. vulgare is one of the most common herbal remedies, managing above 40 identified ailments, and is reinforced by both scientific & conversional utilization. Phytochemical investigations have revealed valuable components involving phenolic compounds, volatile components, flavonoids, amino a`, as well as fatty a`. Research has aromatic compounds, isolated lipids, volatile chemicals, petroleum products, & other 2^{ry} metabolites from numerous parts of F. vulgare. The majority of these phytochemicals are present in its essential oil. Certain phytoconstituents derived from F. vulgare are utilized as anti-aging agents & pigments. Furthermore, they possess significant biochemical & pharmacological characteristics. **(Adams et al., 2021**). Flavonoids are essential antioxidants, & the Apiaceae family, which included fennel, contains numerous varieties. F. vulgare comprises flavonoids such as quercetin-3-rutinoside, rosmarinic a`, & eriodictyol-7-rutinoside. Additional prevalent flavonoids involve kaempferol derivatives & isorhamnetin glucoside. Methanol extracts illustrated supplementary flavonoids, involving quercetin 3-O-beta-glucoside. Ethyl acetate extracts included flavonoids such as quercetin & kaempferol. These flavonoids have potent anti-inflammatory characteristics & exhibit immunomodulatory influences. **(Asbaghi et al ., 2021).** Ennel's water extract is abundant in phenolics, numerous of that have antioxidant & hepatoprotective characteristics. The majority of abundant ones are flavonoid glycosides, flavonoid aglycones, in addition hydroxyl cinnamic a` derivatives. These compounds are related to the prevention of conditions connected to oxidative stress, such as inflammation, cancer, & cardiovascular disease. As a result, they attracted interest from food scientists, nutritionists, as well as consumers. **(Tanvee et al., 2024).** Studies illustrates that methanol extract from F. vulgare have anti-inflammatory characteristic. This extract may reduce acute and subacute inflammation, in addition to type four allergic reactions when consumed orally. It rises plasma HDL-c concertation and boosts the activities of superoxide dismutase & catalase. Moreover, it decreases the concentration of malondialdehyde, a biomarker of lipid peroxidation, signifying significant inflammation reduction. Mostafa et al. observed that the methanol extract from fennel seeds also reduces inflammatio. Choi et al. further explored the antiinflammatory effects of methanol extract from F. vulgare, concluding that its actions involve both central and peripheral pathways **(Khan et al ., 2021).** Central pathways of inflammation involve neuroinflammation and cytokine production in the central nervous system, affecting systemic responses, while peripheral pathways include immune cell activation and vascular responses at injury sites. Both pathways interact bidirectionally, influencing inflammation and healing processes in diabetes. This strong anti-inflammatory activity may be due to the high levels of flavonoids in the extract. GC-MS analysis confirmed the presence of linalool and fatty acids (palmitic and oleic acids), which are known for their potential anti-inflammatory effects. **(Koppula et al., 2024).**

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2) AIM OF STUDY

Conducting a set of chemicals, nutritional, and biological studies on the plant (Foeniculum vulgare) and determining its positive effects on experimental animals.

3- MATERIALS & METHODS

Materials

- **preparation** Foeniculum vulgare **plant :** has been attained at the Jeddah KSA market, washed, dried in fifty-degree Celsius oven for three days, crushed & ground into a finest powdered form.
- **Experimental animals:** Thirty-Six Dawley Albino rat males weighed 150±10g) were utilized.

METHODES

- **Experimental design**

Rats have been kept on basal diet for 3 days, then experimental diets for 4 weeks. They were distributed on (4) groups besides the control negative, each with comparable total body weight & have been housed separately in the wire cage - All the group of mice have been nourished the experimental diet regarding **Campbell, (1961).** Showed in table (a) having the following composition:

Table (a): The composition of standard (basal) diet:

Compound	Amount
Casein (protein)	15%
Corn oil	10%
Mineral mixture	4%
Vitamin mixture	1%
Corn starch	Up to 100%

- **Studied Groups:**

A. Control Group:

- Group 1: (control negative): Nourished on standard diet (casein diet).

B. Experimental diet:

- Group 2: Nourished on standard diet plus Foeniculum vulgare plant five percent.
- Group 3: Nourished on basal diet plus Foeniculum vulgare plant ten percent.

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- Group 4: Nourished on basal diet plus Foeniculum vulgare plant fifteen percent.
- Group 5: Nourished on basal diet plus Foeniculum vulgare plant twenty percent.
- Group 6: Nourished on basal diet plus Foeniculum vulgare plant.
- **Basal diet:**

The basal diet involved: Casein (fifteen percent protein), (Corn oil ten percent), (Mineral mixture four percent), (Vitamin mixture one percent) & (Corn starch as much as one hundred percent). The composition of mineral mixture as regards Hegsted et ah, (1941) and vitamin mixture according to Muller, (1964) showed in table (b) respectively having the following composition:

Table (b): The composition of mineral mixture:

Compound	Amount (mg)
Ca CO3	600
Ca HpO4.2H2O	150
K2 HpO4	645
Mg SO4.2H2O	204
Na Cl	334
Fe (C6 H5 O7)2 6 H2O	55
KI	106
Mn SO4.4H2	10
Zn Cl2	0.5
Cu SO4.5H2O	0.06

According to **Hegsted; et al., (1941).**

Table (c): The composition of vitamin mixture:

Compound	Amount
Vit A	200 (international unit)
Vit D	100 (international unit)
Vit E	10 (international unit)
Vit K	0.50 (international unit)
Thiamin	0.5 (international unit)
Riboflavin	1.0 (milligrams)
Pyridoxine	0-4 (milligrams)

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Calcium Pantothenic acid	4.00 (milligrams)
Niacin	4.00 (milligrams)
Choline Chloride	200 (milligrams)
Inositiol	25 (milligrams)
Para - amino - benzoic a`	0.02 (milligrams)
Biotin	0.02 (milligrams)
Vit B12	2.00 (milligrams)
Folic acid	0.02 (milligrams)

According to Muller, (1964).

The composition of each experimental diet showed in table (D).

Table (d): The composition of standard diet & experimental diet:

Diets / Ingredients	Negative control	Foeniculum vulgare	Foeniculum vulgare	Foeniculum vulgare	Foeniculum vulgare
Sample	-	3	5	10	15
Casein (gm)	15	15	15	15	15
Corn oil (gm)	10	10	10	10	10
Mineral mixture (gm)	4	4	4	4	4
Vitamin mixture (gm)	1	1	1	1	1
Corn starch	70	67	65	60	55
Total	100	100	100	100	100

- **Blood Samples:**

At the end of the experimental time, mice have been fasted to a twelve-hour fast & sacrificed under diethyl ether anesthetized. Blood samples have been gathered from the retro-orbital region using clean, dry tube from a centrifuge. A part of blood has been gathered in heparinized plastic vial & examined directly to have CBC.

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- **Separation of blood serum**

The end of experimental, Animals have been sacrificed & blood samples have been gathered from the retro-orbital subsequently kept at room temperature for fifteen minutes. Following that samples have been centrifuged at four thousand / rpm, Serum separated in clean glass well - stoppered & kept at (minus twenty degrees Celsius) until examined.

- **Chemical methods:**

Moisture content: The moisture has been calculated as regards the technique suggested by AOAC, (2005) utilizing air oven at hundred to hundred and two degrees Celsius for around three hours.

Total nitrogen and crude protein: The total nitrogen has been calculated utilizing Marco kjeldahl techniques, according to AOAC, (2005). Crude protein subsequently determined as T.N.X6.25.

Fat content: The Fat content has been calculated after the technique given by the AOAC, (2005). Soxhlet device has been utilized. The extraction continued for sixteen hours utilizing n-hexane as the extraction solvent.

Ash content

Content of ash has been assessed regarding the technique defined by the **(AOAC, 2005)** following charring. The samples have been situated in muffle g furnace at 525 degrees Celsius until light grey or white ash has been gained.

Crude fiber: Crude fiber has been measured regarding the technique of **Pearson, (1970).** Sample has been digested in boiling 0.128 M. sulphuric a` for 45minutes, rinsed utilizing distilled water 3 folds, digested with boiling 0.223 M potassium hydroxide, rinsed utilizing distilled water 3 folds, then washing utilizing acetone (cold extraction) 3 folds, subsequently dried at 150 degrees Celsius for an hour & finally weight.

Carbohydrates content: The carbohydrate has been assessed through the variance as follows:

% carbohydrates = 100 – (%fat +% protein +% fiber +%ash + % moisture) with regard to FAO (1982).

Energy value

Total calories: have been measured through multiplying one-gram protein & carbohydrates by 4.0 & one-gram fat by 9.0 as regards **FAO (1982).**

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Determination of active compounds:

Identification of phenolic compounds:

The extract has been analyzed utilizing HPLC utilizing an Agilent 1200 chromatograph, which included a PDA model G1315B, a Bin pump type G1212A, an auto-sampler model G1313A, & an RR Zorbax Eclipse plus C18 column (1.8 millimeters, 150 millimeters x 4.6 millimeter). The mobile phase A consisted of 0.2 percent formic a` in water, while mobile phase B comprised acetonitrile. Elution has been conducted at a flow rate of 0.95 milliliter min-1 with the subsequent gradient program for solvent B: zero to twenty minutes, five to sixteen percent; twenty to twenty-eight minutes, sixteen to forty percent; twenty-eight to thirty-two minutes, forty to seventy percent; thirty-two to thirty-six minutes, seventy to ninety-nine percent; tirty-six to forty-five minutes, ninety-nine percent; and forty-five to forty-six minutes. 99-5%30.

The injection volume was ten ml. wave lengths of 280 nanometers (for benzoic a` & flavones derivatives) & 360 nanometers (for flavones & cinnamic a` derivatives) have been chosen for recognition. Quantifications of the compounds were realized utilizing calibration curves gathered via HPLC of pure standards: caffeic a`, Gallic a`, (+)-catechin, (-)- epicatechin, & ellagic a` rotini has been applied as an internal standard. Certain compounds have been quantified as equivalents of the majority of comparable chemical structures: ellagic a` for ellagic a` pent side. the HPLC method has been utilized with regard to **Radovanovic and Radovanovic, (2010).**

- **Biological Evaluation:**

Biological evaluation of the various diets has been earned out by calculation of body weight gain % (BWG%) food efficiency ratio (FER) regarding Chapman et al., (1959) utilizing the following formulas:

Weight gain (g) = Final weight (g) - Initial weight (g).

BWG % = Final weight (g) - Initial weight (g)/ Initial weight (g)×100.

FER = Final in body weight (g)/ Food intake (g).

- **Biochemical analysis:**

A- Serum:

1- calculation of serum glucose: Glucose has been analyzed regarding **Titez (1995).**

2- Determination of some hepatic Functions:

- Determination of Serum Glutamate Pyruvat Transaminase (S. GPT): Serum GPT has been determined as regards the technique of **Tietz, (1976).**

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- Determination of Serum Glutamate Oxalate Transaminase. (S.GOT): Serum GOT has been determined as regards the method defined by **Murray (1984).**

- Determination of Serum Alkaline Phosphates: Alkaline Phosphates has been analyzed out with regard to **Tietz, (1986).** Determination of some renal Functions:

3- Determination of Serum Urea nitrogen: Serum Urea nitrogen was calculated with regard to the method described by **Schultz (1984).** Determination of Serum Creatinine: Creatinine formed a colored complex with picrate in alkaline medium which has been determined Spectrophotometer **Patton & Crouch, (1977).**

4- Determination of Serum Lipids:

- Determination of Serum Triglycerides (T.G.): Triglycerides Liquicolor mono was analyzed regarding **Koditscek (1969).**

- Determination of Serum Total cholesterol: Cholesterol Liquicolor has been analyzed according to **Young (2001).**

- Determination of Serum High Density Lipoprotein Cholesterol (HDL-c): Serum HDL-c has been measured regarding the technique defined by (**Lopez, 1977).**

- Determination of Serum Very Low-Density Lipoprotein Cholesterol (V LDL-c): Very Low-Density Lipoprotein Cholesterol has been measured with regard to **(Lee & Nieman, 1996).**

- Determination of Serum Low Density Lipoprotein Cholesterol (LDL—c): Serum Low Density Lipoprotein Cholesterol has been calculated with regard to **(Lee and Nieman, 1996).**

- **Statistical Analysis:**

Statistical analyses have been performed by Lenovo 3000N500, under Windows Microsoft Office 2010 by using Microsoft excel 2010. All attained outcomes have been tabulated and appropriate recommendation was given. **(Snedecor and Cochran, 1967)**

* significant variances (p under 0.05).

** high significant variances (p under 0.01).

*** very high significant variances (p under 0.001).

- **Ethical Approval**

The Science Research Ethics Committee of the Faculty of Home Economics accepted the protocol of the research #15-SREC-06-2025.

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4) RESULTS & DISCUSSION

Conducting a set of chemicals, nutritional, and biological studies on the plant (Foeniculum vulgare) and determining its positive effects on experimental animals.

Chemical composition of (Foeniculum vulgare) **powder:**

The chemical composition of (Foeniculum vulgare) powder: moisture, carbohydrate ash, crude protein, total lipid (fat), & crude fiber of dried algae in terms of g/100g are illustrated in Table 1.

The outcomes illustrated that Foeniculum vulgare contains a great amount of carbohydrate (42.1%), followed by crude fat (15.2%), then ash (12.3%). In contrast, the Foeniculum vulgare showed to contain a moderate amount of protein and fiber, being 12.1% and 11.1%, respectively. The result illustrated that the Foeniculum vulgare is a rich source of crude fat and carbohydrate and provides energy.

Table 1: Chemical composition of Foeniculum vulgare:

Component	Content (g/100g)
Moisture	7.1
Protein	12.1
Fat	15.2
Fiber	11.1
Ash	12.3
Carbohydrate	42.1

DW= Dry Weight

Antioxidant activity, phenols & flavonoids content of Foeniculum vulgare:

Antioxidant activity, flavonoids, & phenols content in Foeniculum vulgare. Antioxidant activity, flavonoids & phenols of Foeniculum vulgare are illustrated in table (2). The whole antioxidant activity, which has been calculated by DPPH, demonstrated that, the DPPH score was 56.60 percent for Foeniculum vulgare. DPPH is a free radical compound that was commonly utilized to determine the free radical capability of numerous samples. Antioxidants are substances that might reduce or inhibit oxidizable substrate action **(Amarowicz et al., 2003)**It might be found that the mean value of total flavonoids was 54.38 milligram /100gram in Foeniculum vulgare. Flavonoids and total phenolic compounds a milligram /100 gram of Foeniculum vulgare are demonstrated in table (2) . Flavonoids are a

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group of polyphenolic compounds, varied in features & chemical structure, discovered ubiquitously in plant.

Table (2): Antioxidant activity, phenols & flavonoids content of Foeniculum vulgare:

Parameters	Foeniculum vulgare
Total flavonoids (milligram /100gram)	54.38 ± 0.40
DPPH scavenging activity (percent)	56.60 ± 0.44
Total phenols (milligram /100gram)	76.5 ± 0.05

Biological effects

Foeniculum vulgare was subjected to an animal biological experiment to examine the influence of adding several concentrations of Foeniculum vulgare was subjected to an animal biological experiment to examine the influence of adding numerous concentrations of Foeniculum vulgare was subjected to an animal biological experiment to examine the influence of adding diverse concentrations of Foeniculum vulgare was subjected to an animal biological experiment to examine the influence of adding diverse concentrations of Foeniculum vulgare (5, 10, 15, 20%) to casein diet, as well as Foeniculum vulgare diet on feed and growth performance and determine the biochemical variables in comparison with casein control diet.

Feeding & growth performance, illustrated by food intake, gain in body weight GBW and food efficiency ratio FER of all examined diets are illustrated in Table 3.

Animal survival:

The Biological experiment was planned to include six mice each group and fed the assigned diet for twenty-eight days. It was observed that the number of animals among three tested diets remain the same to the end of experiment. In two tested diet (5% & 20% Foeniculum vulgare), five animals remain to the end of the study.

Food Intake:

Results in Table 3, illustrated that the mean value of food intake (gram per day) varied from 12.32 up to 16.83g, being the highest value for Foeniculum vulgare diet group, and the lowest for casein control group. This result might be due to high content of fiber in Foeniculum vulgare diet. However, the differences were not statistically significant between all tested diets.

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Body Weight Gain (BWG):

Following nourishing the experimental animals with various examined diets for 28 days, the rate of BWG (gram per day) has been measured and the outcomes are presented in Table 3. It can be found that the mean values of BWG was the highest for casein control group (2.71g/day) and the values significantly decreased to reach 1.08g/day as algae level increased in casein diet. The least BWG was recorded for Foeniculum vulgare diet group (0.74 g / day) and significantly reduced than casein control group.

Food Efficiency Ratio (FER):

The calculated FER for all tested diets is presented in Table 3. Results illustrated that casein control gave a significantly high value (0.22) than almost all tested diets, particularly diets containing more than 5% Foeniculum vulgare**.** FER values had decreased from 0.1 down to 0.04 in Foeniculum vulgare diet group.

Similar observations were reported by (Bae **et al., 2015),** where the decrease in FER was justified by the effect of high content of fiber on the protein digestibility and pepsin activity. In contrast, **(Nafiseh et al., 2017) ,** reported that comparison between the fennel & placebo groups didn't illustrate any significant effect with regard BMI, body weight, hip and waist circumferences, or distribution of fat. The findings of the paired t-test didn't indicate difference in these variables across groups prior to and following the twelve-week management.

Table(3): Food intake, Body weight gain & food efficiency ratio of rat nourished casein diet supplemented with different level of Foeniculum vulgare.

Animal group	Number of Rat	Food intake (g/day) Mean ± standard deviation	BWG (g/day) Mean ± standard deviation	FER Mean ± standard deviation
Casein diet (control)	6	12.32 ± 1.05 a	2.71 ± 0.06 a	0.22 ±0.01 a
Casein + 5% Foeniculum vulgare	5	12.67 ± 0.07b	1.45 ± 0.04 b	0.12 ± 0.0 lab
Casein + 10% Foeniculum vulgare	6	13.12 ± 2.17c	1.33 ±0.06 be	0.10 ± 0.03 b
Casein +15% Foeniculum vulgare	6	13.92 ± 1.1d	1.27 ± 0.01 bc	0.09± 0.0011
Casein +20% Foeniculum vulgare	5	14.34± 4.98e	1.08±0.004bc	0.08 ± 0.004 b
Casein + Foeniculum vulgare	4	16.83 ± 3.11f	0.74 ± 0.002 c	0.04 ±0.01 b
L. S. D		6.135	0.651	0.115 l

*The various letters in the same column mean statistically significant at P-value under 0.05

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Biochemical Evaluation

The biochemical evaluation of the tested diets was extended from the same animal experiment, to study the effects on the following different parameters: lipid and mineral profiles, kidney functions, liver function, glucose and hemoglobin levels.

Lipid Profile:

Serum lipid profile includes determination of triglycerides (TG), high density lipoprotein cholesterol HDL-c, & calculated very low-density lipoprotein cholesterol VLDL-c, total cholesterol, low density lipoprotein cholesterol LDL-c, & LDL/HDL ratio & the findings are presented in Table 4 .

The total cholesterol concentration in casein control was 100.3 mg/dl and the levels remain almost the same, with no significant change, in all casein diet supplemented with different percentages of Foeniculum vulgare . The cholesterol levels in Foeniculum vulgare diet was 89.7 mg/dl and significantly lower than casein control diet group (100.3 mg/dl).

The serum triglycerides level of casein control was 43.4 mg/dl, and the level for casein diet supplemented with 5, 10, 15 & 20% Foeniculum vulgare were 42.8, 42.7, 42.6 and 42.1 mg/dl, respectively. The difference was not significant. However, it was observed that Foeniculum vulgare diet group significantly lower TG level to reach 39.4 mg/dl, than all other group including casein control group.

The mean value of HDL-c for casein control group was 53.19 mg/dl, and the levels tended to increase by adding Foeniculum vulgare to casein diet. But the increase was significant only between control group and casein diet with 20% Foeniculum vulgare. Foeniculum vulgare diet group recorded HDL-c level of 60.58 mg/dl, and the value was significantly lower than all tested diets including control group.

The mean value of LDL-c for casein control group was 34.4 mg/dl, and the levels for all casein diet supplemented with Foeniculum vulgare up to 20% showed decreases, but the decrease was not significant. LDL-c level of Foeniculum vulgare diet was 20.86 mg/dl, and was significantly lower than all tested casein and casein supplemented with Foeniculum vulgare.

The results of the calculated value of serum VLDL-c level for all tested group are illustrated in Table 4. The casein control group illustrated a level of 8.68 mg/dl, and the levels were slightly decreased by increasing Foeniculum vulgare in casein diets. The VLDA-c levels range for all tested diets between 8.68 and 7.92 milligrams per deciliter. In contrast, the calculated LDL/HDL ratios for the tested diets, showed that the ratio reach 0.63 for casein control, and slightly decreased by adding algae to casein diet, but the ratio decreased to reach 0.34 in case of algae diet.

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Even though, the experiment was carried out using the ordinary casein control diet (10% fat), and animals were not of hyperlipidemic or hyper-cholesterolimic, to have obvious effects of Foeniculum vulgare on serum lipids, it can be concluded that incorporating Foeniculum vulgare by 5, 10, 15 & 20% into casein diet did not significantly affect serum lipid pattern. **(Forogh et al,. 2021)** reported that significant reduction has been detected in the cholesterol dose of one hundred milligram per kilogram per day, triglycerides in 100 and 200 milligram per kilogram per day, and LDL in 50 and 100 milligram per kilogram per day. Serum HDL was elevated significantly in a dose of one hundred milligram per kilogram per day.

Table 4: Serum lipid profile (milligrams per deciliter) of mice fed casein diet supplemented with different level of Foeniculum vulgare.

Animal group	Total cholesterol Mean ± SD	Triglycerides Mean± SD	HDL-C Mean± SD	LDL-C Mean ± SD	VLDL-C Mean± SD	LDL/ HDL
Casein diet (control)	100.34±6.92$_a$	43.40±2.04$_a$	53.19±3.62$_a$	34.41±2.74$_a$	8.68±0.19	0.63
Casein + 5% Foeniculum vulgare	100.14±1.44$_a$	42.98±0.07$_a$	54.49±3.26$_{ab}$	34.23l±0.17$_a$	8.61±3.14	0.63
Casein + 10% Foeniculum vulgare	99.86±4.94$_a$	42.76±1.513$_a$	54.98±0.30$_{ab}$	34.0±0.11$_a$	8.57±1.46	0.62
Casein +15% Foeniculum vulgare	99.12±6.15$_a$	42.63±0.523$_a$	55.11±0.57$_{ab}$	33.56±0.21$_a$	8.43±1.24	0.61
Casein +20% Foeniculum vulgare	98.62±1.34$_a$	42.11±3.11$_{ab}$	56.45±0.17$_b$	32.97±0.09$_a$	8.36±0.08	0.58
Casein + Foeniculum vulgare	89.70±5.28$_b$	39.40±0.96$_b$	60.58±8.07$_c$	20.86±0.19$_b$	7.92±0.64	0.34
L. S. D	4.806	2.6948	2.8	6.4	3.986	2.39

Liver Function:

Liver functions indicators used in this study were the concentration of serum albumin; Alanine amino transferees (ALT)& Aspartate amino transferees (AST). The results on the influence of Foeniculum vulgare on liver function are presented in Table 5.

The mean value of serum albumin for casein group was 2.9 mg/dl, and slightly but not significantly increased for all casein supplemented with Foeniculum vulgare diet groups, whereas the values ranged from 2.9 up to 3.41 mg/dl.

The level of serum AST for casein control group was 27.25 mg/dl, and the levels tended to decreased, but not significant, to 27.10, 26.66, 26.12 & 24.87 mg/dl for casein diet

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supplemented with 5, 10, 15 and 20% Foeniculum vulgare, respectively. However, Foeniculum vulgare diet group showed significant low AST value (18.06 mg/dl) than all tested diets, including casein control group.

The mean serum ALT values for casein control group, casein with 5 and 10% Foeniculum vulgare were almost similar (range from 12.41 to 12.29 mg/dl). In casein diet of higher, Foeniculum vulgare 15 and 20%, the ATL values were 11.07 and 10.53 milligrams per deciliter, correspondingly, and significantly lower than casein control. Foeniculum vulgare diet group recorded significantly lower ATL level (9.51 mg/dl) than all tested groups**.(Zahra et al ,. 2020),** they illustrated that in the STZ-induced diabetic mice, biochemical and morphological changes happened in hepatic tissue. The STZ injection resulted in a large elevation of serum glucose concentrations and glucose excretion rates, thereby leading to elevated water and food consumption, along with substantial weight loss. The administration of fennel, TA, or metformin to diabetic mice reduced blood glucose concentrations and the severity of weight loss, corrected the serum lipid profile, and mitigated damage to the liver and oxidative stress in tissue of liver.

Table 5: Serum albumin and liver function enzymes ASI and ALT (mg/dl) of rats fed casein diet supplemented with different level of Foeniculum vulgare.

Animal group	Albumin Mean ± standard deviation	AST Mean ± standard deviation	ALT Mean ± standard deviation
Casein diet (control)	2.9±0.32[a]	27.25±5.82[a]	12.41± 1.10[a]
Casein + 5% Foeniculum vulgare	2.9 ± 0.32 [a]	27.10±4.92[ab]	12.43±1.21 [a]
Casein + 10% Foeniculum vulgare	3.02 ± 0.03 [a]	26.66±1.76[ab]	12.29±0.26[a]
Casein +15% Foeniculum vulgare	3.12±0.03[a]	26.12±0.51[ab]	H.07±0.21 [b]
Casein +20% Foeniculum vulgare	3.15±0.21[a]	24.87±2.42 [b]	10.53±0.66[b]
Casein + Foeniculum vulgare	3.41±0.02[a]	18.06±1.07[c]	9.51± 0.94 [c]
L. S. D	1.034	2.56	0.613

Kidney Function:

Serum uric a`, creatinine & urea concentrations have been used to reflect kidney functions and the outcomes are presented in table 6.

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The mean value of uric a` for casein control group was 1.48 mg/dl. It was observed that there were significant decreases in uric acid values for casein diet supplemented with more than 10% Foeniculum vulgare. However, for Foeniculum vulgare diet uric acid was significantly lower than all tested groups.

The mean urea levels for casein control group and casein supplemented with different percentages of Foeniculum vulgare, recorded almost similar ranged between 21.9 and 22.6 mg/dl, and significantly higher than the level found for Foeniculum vulgare diet group being 14.7 mg/dl.

Creatinine value for casein control group was 0.47 mg/dl, while the values for all casein diet supplemented with different levels of Foeniculum vulgare were similar with no significant changes observed. Foeniculum vulgare diet group showed significant low value (0.36 mg/dl) than all tested groups**. (Asgharpour et al ., 2021)** They showed that foeniculum vulgare extract presented better effectiveness as a nephroprotection agent compared to FS extract. In conclusion, FSS may more effectively restore oxidative stability & enhance renal function following acute CCl4 renal injury compared to FS. Consequently, FSS and FS extracts may be utilized for their possible nephroprotective properties & to help prevent illnesses related to oxidative stress. Investigation into their utilization in humans is strongly recommended.

Table 6: Serum uric a`, Creatinine & urea (milligram per deciliter) of rats fed casein diet supplemented with different levels of Foeniculum vulgare.

Animal group	Uric acid Mean ± standard deviation	Urea levels Mean ± standard deviation	Creatinine Mean ± SD
Casein diet (control)	1.48±0.012^{a}	22.6 ± 2.2 ^{a}	0.47 ± 0.2 ^{a}
Casein + 5% Foeniculum vulgare	1.44±0.09^{a}	22.6 ± 0.6 ^{a}	0.47 ± 0.02 ^{a}
Casein + 10% Foeniculum vulgare	1.41±0.01^{ab}	22.1 ±0.8 ^{a}	0.45±0.01^{a}
Casein +15% Foeniculum vulgare	1.36±0.010^{b}	22.1±0.6^{a}	0.41± 0.02 ^{ab}
Casein +20% Foeniculum vulgare	1.31±0.014^{b}	21.9± 1.2^{a}	0.39±0.031^{ab}
Casein + Foeniculum vulgare	1.05±0.011^{c}	14.7 ± 0.9 ^{b}	0.36 ± 0.021b
L. S. D	0.0765	1.1520	0.0954

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Blood Glucose:

Results of fasting blood glucose concentration of mice fed casein control, casein supplemented with different percent of Foeniculum vulgare presented in Table 7. It was observed that the highest glucose level 119 mg/dl has been documented for casein control group, while the Lowest level (89.4 mg/dl) was for Foeniculum vulgare group and the difference was significant. Glucose levels for casein supplemented with 5, 10, 15 and 20% Foeniculum vulgarewere slightly decreased by 1, 4, 6.2 and 9.5%, respectively **.(Anka** These studies demonstrate fennel extracts might aid diabetic cases in regulating blood sugar concentrations & might be useful in decreasing chronic complications related to diabetes. **Mehra et al. (2020).** Fennel extract significantly decreased blood glucose concentrations. This influence is thought to be associated with fennel's antioxidant characteristics, marking it as a potential candidate for the development of anti-diabetic drugs. A methanolic extract of fennel fruit demonstrated decreases in cholesterol and blood sugar concentrations.

Table 7: Blood glucose level (milligrams per deciliters) of rats fed casein diet supplemented with various levels of Foeniculum vulgare.

Animal groups	Glucose level Mean ± SD
Casein diet (control)	119 ± 6.27 [a]
Casein + 5% Foeniculum vulgare	117.79 ± 9.12 [a]
Casein + 10% Foeniculum vulgare	114.15±5.21[a]
Casein +15% Foeniculum vulgare	111.66 8.16 [ab]
Casein +20% Foeniculum vulgare	107.66 ± 6.02 [b]
Casein + Foeniculum vulgare	89.40 ± 6.27 [c]
L. S. D	9.8446

Blood Hemoglobin:

The brown algae showed to contain high amount of iron, and the effect of feeding experimental animals on casein control diet and casein diet containing different percentage of Foeniculum vulgare is shown in Table 8. It was found that the blood hemoglobin levels of the casein control group was 12.8 g/dl, and significantly lower than all tested diets. The blood hemoglobin level was increased as Foeniculum vulgare percent in casein diet increased. The mean values recorded for 5, 10, 15, and 20% Foeniculum vulgare in casein diets were 12.97, 13.31, 13.67, 13.89 g/dl, respectively. The highest hemoglobin level (15.3 g/dl) was found

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among Foeniculum vulgare group, and significantly higher than all tested groups. The results agreement with **(Asbaghi et al ., 2021),** they found that fennel supports healthy blood hemoglobin levels due to its iron and histidine content, helping in hemoglobin production and preventing iron-deficiency anemia. The vitamin C in fennel also aids in iron absorption, while folate supports red blood cell formation. Additionally, studies have shown fennel can increase red blood cell counts and overall hemoglobin levels in various study groups

Table 8: Blood hemoglobin level (g/dl) of rats fed casein diet supplemented with various concentrations of Foeniculum vulgare .

Animal groups	Hemoglobin Mean ± SD
Casein diet (control)	12.8±0.561 [a]
Casein + 5% Foeniculum vulgare	12.97 ± 0.056 b
Casein + 10% Foeniculum vulgare	13.31 ±2.13[c]
Casein +15% Foeniculum vulgare	13.67 ±0.031 [d]
Casein +20% Foeniculum vulgare	13.89 ± 0.663 [e]
Casein + Foeniculum vulgare	15.3± 1.56[f]
L. S. D	0.123

Mineral pattern:

Results on the effect of feeding Foeniculum vulgare on serum minerals content (phosphorus, calcium, magnesium and iron) are presented in Table 9.

The calcium level of casein control group was 1.7 millimoles per liter and the levels of all tested groups did not show significant changes (range from 1.74 to 2.1 mmol/L). This might be due to that the tested Foeniculum vulgare contain low amount of calcium.

The mean serum phosphorus level for casein control was 0.66 and significantly lower than casein supplemented with more than 10% Foeniculum vulgare, including Foeniculum vulgare.

The serum magnesium levels for all casein/ Foeniculum vulgare tested groups were significantly higher reduced than casein control group. This is mainly due to the high magnesium content in Foeniculum vulgare (526 mg/100g).

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The effect of feeding Foeniculum vulgare on serum iron content showed that Foeniculum vulgare diet group recorded significant high serum iron level (74.3 mmol/L) than other all tested diet including casein control. The mineral composition showed that Foeniculum vulgare are good source of iron (12 mg/100g).

Table 9: Blood minerals content ratio (mmol/L) of mice fed casein diet supplemented with various levels of Foeniculum vulgare.

Animal groups	Calcium Mean ± standard deviation	Phosphorus Mean± standard deviation	Magnesium Mean ± standard deviation	Iron Mean ± standard deviation
Casein diet (control)	1.71±0.03	0.66±0.012^{a}	0.68±0.03^{a}	58.11±4.5^{a}
Casein + 5% Foeniculum vulgare	1.74±0.03	0.69±0.05^{ab}	0.71 ±0.03^{b}	60.75±2.25^{a}
Casein + 10% Foeniculum vulgare	1.79±0.01	0.71±0.02^{ab}	0.73± 0.02^{bc}	61.5±4.53^{a}
Casein +15% Foeniculum vulgare	1.82±0.01	0.74±0.03^{bc}	0.74±0.12^{c}	62.11± 2.1 ^{a}
Casein +20% Foeniculum vulgare	1.88±0.36	0.76±0.01^{bc}	0.75± 0.02^{c}	63.52± 4.1^{a}
Casein + Foeniculum vulgare	2.1 ±0.10	0.78 ± 0.01^{c}	0.79± 0.04 ^{d}	74.30±3.14^{b}
L.S.D	1.023	0.0524	0.0231	6.0145

Conclusion and recommendation

Conclusion:

Fennel (Foeniculum vulgar)e has a long history in conventional medicine and is recognized for its potential pharmacological properties, involving anti-inflammatory, antimicrobial, antispasmodic, and memory-enhancing effects contains high amounts of carbohydrates and fiber and some important minerals (iron and magnesium).

Foeniculum vulgare diet as compared to casein control diet caused lower FER, and blood glucose level increased blood hemoglobin and improved serum lipid and minerals pattern, but negatively affected liver and kidney histology. While, adding different levels of Fennel to a normal casein diet gave the same trends of change but the changes were not significant.

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Recommendation:

The positive results lower blood glucose level, improve blood hemoglobin and serum lipid and minerals patterns and the negative findings lowering FER can direct the attention for more work to investigate the biological efficacy and safety aspects of Foeniculum vulgar before use for human consumption.

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