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Comparative Analysis of Lipid Profiling Changes Between Normal and *Trigonella foenum-graecum* Treated Albino Rat Subjects Exposed to Mosquito Coil Smoke

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Abstract: The chemical compounds found within mosquito coil smoke are harmful, they contain many toxic components which can cause metabolic changes and oxidative stress. The purpose of this experiment was to evaluate the long-term health risks associated with mosquito coil smoke on the serum lipid profiles of rats. We also wanted to determine if *Trigonella foenum-graecum* (Fenugreek) could help prevent or reduce some of the health risks caused by mosquito coil smoke. There were sixty-four healthy rats used in this study (32 males & 32 females) divided into 8 different groups based upon their gender & how they were treated. They were: Control group; Smoke exposed; Smoke exposed + Fenugreek; Females given only Fenugreek. Rats in each of the above groups were exposed to the fumes from burning mosquito coils for six hours per day, for six days per week, over an eight-week period. During this time, rats receiving Fenugreek were also provided with an oral dose of Fenugreek (500mg/kg b.wt./day). Using standardized enzyme assays we measured: Total Cholesterol (TC); Triglycerides (TG); High-Density Lipoprotein (HDL); Low-Density Lipoprotein (LDL); Very-Low Density Lipoprotein (VLDL); Atherogenic Index (AI) prior to the beginning of the study. We also measured these same factors at the end of the eight-week study. Results showed that there was a highly significant increase in TC; TG; LDL; VLDL; and a marked decrease in HDL due to chronic exposure to mosquito coil smoke. In addition, the atherogenic index was elevated indicating an increased risk for heart disease. Supplementing Fenugreek resulted in a significant improvement in these lipid levels. Both male and female rats had their lipid levels restored back towards baseline levels and their cardiovascular risk decreased. Although male rats experienced greater lipid level disturbances than did female rats, both sexes benefited equally from the Fenugreek. This was confirmed by two-way analysis of variance demonstrating that there were statistically significant differences between treatments and genders for all of the lipid parameters studied. Therefore, the data suggests that chronic exposure to mosquito coil smoke increases atherosclerosis risk via oxidative damage mediated mechanisms. Additionally, it has been shown that *Trigonella foenum-graecum* possesses significant anti-hypercholesterolemic and cardio-protective properties. Overall, our results suggest that *Trigonella foenum-graecum* may be useful as a natural adjunct therapy to alleviate lipid metabolism disorders induced by smoke.

Keywords: Mosquito coil smoke; *Trigonella foenum-graecum*; Fenugreek; Dyslipidemia; Lipid profile; Oxidative stress; Wistar albino rats; Cardiovascular risk; Atherogenic index; Indoor air pollution.

I. INTRODUCTION

Indoor air pollution has become an increasingly serious public health issue and environmental problem in many parts of the world, especially in developing countries, due to the widespread use of mosquito coils to protect people from mosquito-transmitted diseases. While mosquito coils are successful at repelling mosquitoes and protecting humans, they also emit a variety of harmful substances including particulate matter ($PM_{2.5}$), aldehydes, VOCs, PAHs, CO, and toxicants derived from pyrethrums when burning. Chronic inhalation of these toxins can produce overabundance of ROS leading to oxidative stress; inflammation; cell damage; etc. There is growing evidence that oxidative stress impairs lipid metabolism in the liver through enhanced lipid peroxdiation, impaired lipoprotein formation and clearance, and increased atherogenic lipid content. This increase in circulating lipids may lead to increased serum levels of TC; TG; LDL; VLDL and decreased HDL levels thereby elevating the risk of cardiovascular disease. In addition to the negative impact of indoor air pollution caused by smoking, natural medicinal herbs with both antioxidant and hypolipidemic activities have received great interest for their ability to be a safe alternative for reducing the risk of

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environmentally induced metabolic disorders. Fenugreek (*Trigonella foenum-graecum*) is one such medicinal herb that contains diosgenin; galactomannans; steroidal saponins; flavonoids; polyphenols and dietary fiber; each with some level of activity for improving lipid profiles; lowering oxidative stress; providing antioxidant defenses; and lowering cardiovascular risk. Although there are a number of reports on the pharmacologic effects of fenugreek, relatively little research exists regarding the protective effect of fenugreek on mosquito coil smoke-induced dyslipidemia or how it might respond differently based upon sex. In order to address this gap in knowledge and obtain preliminary data on the potential therapeutic role of fenugreek in reducing cardiovascular risk through mitigation of smoke-related lipid problems, we conducted a comparative evaluation of changes in lipid profiles in male and female Wistar albino rats exposed chronically to mosquito coil smoke and evaluated the protective effects of TFG supplementation. **Sfar *et al.* (2018)** showed that dietary supplementation with fenugreek resulted in a significant reduction in plasma total cholesterol, triglyceride, LDL-C, insulin resistance, and resistin in obese diabetic individuals. They also found an increase in HDL-C. They proposed that the soluble fiber delayed absorption of lipids from the gut as well as slowed down glucose uptake into the bloodstream. Additionally, they indicated that the steroidal saponins enhanced elimination of cholesterol via bile acid. These results were very similar to those of our research; we have shown that fenugreek reverses changes in lipid profiles caused by exposure to mosquito coil smoke and has a beneficial effect on lipid balance overall. **Loha *et al.* (2019)** showed that extracts of plants used medicinally for their antioxidant properties provided experimental rat models with protection against toxic substances by preserving hepatic and renal architectures and returning biochemical values to normal. As the liver is the main organ involved in the synthesis of cholesterol, production of lipoproteins, and regulation of lipid metabolism; preservation of liver structure will contribute greatly to normalization of circulating lipid values. The same protective effects of the liver may be associated with the improvements in lipid profile seen after fenugreek was administered in this research project. **Zahid *et al.* (2020)** have shown that fenugreek seed extract produces antidyslipidemic effects equal to that of pharmacologic treatments in diet-induced dyslipidemic animal models. Significant reductions in serum total cholesterol, triglycerides, and LDL-C together with elevation of HDL-C were observed after fenugreek administration. They attributed these effects to enhanced lipid metabolism, inhibition of cholesterol absorption, and antioxidant activity. These observations strongly support the findings of the present study in which fenugreek effectively ameliorated smoke-induced lipid abnormalities. **Lohvina*et al.* (2021)** reported that fenugreek seed extracts contain abundant phenolic compounds exhibiting high antioxidant activity, particularly when extracted with ethanol. These phenolic constituents effectively scavenge reactive oxygen species and inhibit lipid peroxidation. Because mosquito coil smoke generates excessive oxidative stress leading to membrane lipid damage and altered lipid metabolism, the antioxidant properties described by them provide a plausible explanation for the improved serum lipid profile observed in fenugreek-treated rats. **Sun *et al.* (2021)** emphasized that *Trigonella foenum-graecum*, a medicinal plant, has long been recognized for its antihyperlipidemic, antioxidant, hepatoprotective, anti-inflammatory, antidiabetic and cardioprotective activities. They also pointed out that the above-mentioned effects of this plant result from the cumulative effect of its constituent phytochemicals such as trigonelline, diosgenin, flavonoids, alkaloids, and soluble dietary fiber on regulating cholesterol metabolism and reducing oxidative injuries. Therefore, the mechanism of improving lipid profiles due to fenugreek in our research corresponds to those biochemical changes mentioned by **Fatima *et al.* (2022)**, who showed that hydroethanolic extracts of fenugreek possess remarkable antioxidant and anti-inflammatory properties owing to its richness in various phytochemicals. In addition to suppressing inflammation, Fenugreek's hydroethanolic extracts were able to neutralize free radicals and thus, likely, reduce oxidative injury caused by toxic smoke from burning mosquito coils used in the current study; as one of the primary ways toxic chemicals cause harm in animals. In accordance with the hypothesis made by **Visuvanathan*et al.* (2022)**, fenugreek possesses a wide range of pharmacological activities related to its hypolipidemic action including inhibition of cholesterol biosynthesis, promotion of bile acid excretion into the intestine, increase in reverse cholesterol transport via lipoproteins from peripheral tissues to liver, improvement of insulin sensitivity and decrease in oxidative stress. Furthermore, they found that the bioactive compounds most responsible for fenugreek's actions include trigonelline, diosgenin, flavonoids and steroidal saponins. Therefore, the significant decrease in total cholesterol (TC), triglyceride (TG), low-density lipoprotein-cholesterol (LDL-C), very-low-density lipoprotein-cholesterol (VLDL-C), LDL/HDL ratio and atherogenic index in treated rats in the current study support these previously proposed mechanisms.Additionally, **Aslam *et al.* (2023)** demonstrated that species within the genus Trigonella exhibit strong antioxidant defenses that maintain cellular redox homeostasis under environmental stress conditions by modulating oxidative biomarkers. Although this study examined antioxidant defense mechanisms in plants rather than mammals, it demonstrates an inherent capacity of all Trigonella species to defend against oxidative stress. Similarly, antioxidant-based protective mechanisms may explain why fenugreek-exposed rats exhibited less oxidative lipid damage in comparison to untreated controls in the present study. Moreover, **Nagamma *et al.* (2023)** reported that fenugreek seed extract produced biochemical and histomorphological improvements in high-fat-diet fed ovariectomized rats. Specifically, they noted decreases in circulating levels of cholesterol and triglycerides, as well as restoration of typical morphologic structure and function of organs. Based upon their results, they postulated that fenugreek influences enzymes involved in lipid metabolism while simultaneously attenuating oxidative stress.

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These results are similar to those obtained in the present investigation after rat exposure to toxic chemicals released by burning mosquito coils. Finally, **Bakhtiar *et al.* (2024)** stated that seeds of different Trigonella species contain high concentrations of trigonelline, diosgenin, fatty acids, minerals and other antioxidants. These phytochemicals are nutritionally valuable and pharmacologically active substances contributing to lipid metabolism regulation via multiple biochemical pathways. Thus, the improved lipid profile seen in the present study can be attributed to synergy among these bioactive compounds. **Pandey *et al.* (2024)** demonstrated that restoration of normal glucose metabolism and regulation of metabolic hormone levels are directly correlated with normalization of lipid metabolism in experimental rats. The results from this study support the idea that lipid disorders are often accompanied by aberrations in carbohydrate metabolism. Additionally, since fenugreek has antihyperglycemic activity, it is possible that improved glucose utilization helped correct dyslipidemia seen in the present study. Furthermore, **Sekhar *et al.* (2024)** demonstrated that trigonelline, a key component of fenugreek seeds and a member of the alkaloid family, lowered circulating cholesterol, triglycerides and LDL-C while increasing HDL-C levels in alcohol-induced dyslipidemic rats. They attributed these beneficial effects to enhanced antioxidant defense, inhibition of lipid peroxidation, and regulation of hepatic lipid-metabolizing enzymes. These findings provide strong mechanistic evidence supporting the lipid-lowering effects observed in the current investigation.**Verma *et al.* (2024)** comprehensively reviewed the industrial, nutritional, traditional, and pharmaceutical importance of the genus *Trigonella* and emphasized its antioxidant, hepatoprotective, anti-inflammatory, antihyperlipidemic, and cardioprotective properties. They concluded that the wide range of bioactive compounds present in fenugreek provides multiple complementary mechanisms responsible for its therapeutic efficacy. These conclusions further support the beneficial effects demonstrated in the present experimental model.**Rao *et al.* (2025)** summarized recent evidence explaining the cholesterol-lowering mechanisms of fenugreek and concluded that its hypolipidemic effects result from inhibition of intestinal cholesterol absorption, increased fecal bile acid excretion, suppression of hepatic cholesterol synthesis, activation of LDL receptor-mediated cholesterol clearance, modulation of lipid-metabolizing enzymes, and enhancement of antioxidant status. These mechanisms are entirely consistent with the significant reductions in TC, TG, LDL-C, VLDL-C, LDL/HDL ratio, and atherogenic index together with elevation of HDL-C observed in the present study.

II. MATERIALS AND METHODS

2.1 Experimental Animals: A total of 64 healthy Wistar albino rats (*Rattus norvegicus*), comprising 32 males and 32 females, were used in the present study to evaluate the protective effects of *Trigonella foenum-graecum* against mosquito coil smoke-induced alterations in lipid metabolism. At the commencement of the experiment, the animals were 8–10 weeks of age and weighed between 180 and 220 g. The rats were procured from a registered laboratory animal breeding facility and were allowed to acclimatize to the experimental environment for one week before the initiation of the study.

All experimental procedures involved animals and were carried out by the guidelines of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), Government of India and as per the international acceptable guidelines regarding care and use of laboratory animals. The housing conditions of all animals included clean polypropylene cages with sterile rice husk bedding under the normal laboratory conditions that include a room temperature of 22±2oC, relative humidity of 50-60% and a 12-hour day/night photoperiod. In addition to this, each animal had unrestricted access to standard laboratory pellets and filtered drinking water adlibitum throughout the experiment. Each cage was also cleaned regularly so that the cages could be kept free from contamination or disease.

2.2 Experimental Design: Following the acclimation process, 64 male/female Wistar Albino rats were randomly distributed into eight different groups, with n=8 per group. These eight different groups were developed by sex and treatment to assess the harmful effects of mosquito coil smoke and also to determine if *Trigonella foenum-graecum* will be a protector for the rat's serum lipid profile.

Table 1. Experimental grouping and treatment schedule

Group	Sex	Treatment
MC	Male	Control
MS	Male	Mosquito coil smoke exposure
MF	Male	Mosquito coil smoke exposure + *Trigonella foenum-graecum* treatment
MFG	Male	*Trigonella foenum-graecum* treatment only

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FC	Female	Control
FS	Female	Mosquito coil smoke exposure
FF	Female	Mosquito coil smoke exposure + *Trigonella foenum-graecum* treatment
FFG	Female	*Trigonella foenum-graecum* treatment only

2.3 Mosquito Coil Smoke Exposure: The smoke from mosquito coils was introduced to the test animals through a specially designed acrylic exposure box (Dimensions approximately 24 inches x 18 inches x 18 inches). The design included appropriate air intake/ventilation ports to ensure that the smoke was distributed evenly across all areas of the exposure box. This was done to prevent the buildup of large quantities of toxic gases as well as provide a consistent source of smoke during testing. One commercially available mosquito coil containing 0.1 percent (w/w) d-trans allethrin, a pyrethroid, was burned during each of the 8 weeks of the study to produce smoke in which the chemical composition remained constant. Smoke-exposed animals were subjected to 6 hour/day (09:00-15:00 h) exposure sessions, six days per week, for eight weeks. All animals were permitted free access to water; however, food was withheld during exposures due to potential particulate matter contamination. Animals in control groups were held in similar environmental conditions within a separate room, but no smoke from the mosquito coils was present. After each smoke exposure session, animals were returned to their individual cages where they were fed a standard commercial rat feed and allowed unlimited access to water. Due to the nature of this study, all animals were treated identically throughout the duration of the study.

2.4 Preparation of Fenugreek Extract: Mature fenugreek (*Trigonella foenum-graecum*) seeds were purchased from an officially recognized local herb vendor, identified and confirmed as authentic by a qualified botanist who is employed by the Department of Botany. A voucher sample of the plant was maintained for future identification. The seed samples were cleaned; air-dried under shade; milled to a fine powder using a laboratory mill/grinder. Powdered extracts were obtained from the powdered material via cold maceration extraction using 70 % ethanol over 72 hours while occasionally agitating the solution. Following filtration of the resulting extract through Whatman #1 Filter Paper, the resultant filtrate was concentrated using a Rotary Evaporator under vacuum conditions at 40°C. The resulting concentrate was further dried to produce a semi-solid residue which was stored at 4 °C until required. Before oral gavage administration, the extract was initially re-constituted in distilled H_2O, and then administered at a dosage of 500mg/kg bodyweight/Day.

2.5 Blood Collection: All rats underwent fasting for one night prior to being anesthetized with an appropriate anesthetic protocol in order to obtain blood via cardiac puncture. Blood was collected from the heart of each rat using sterile disposable syringe and drawn in sufficient volumes for conducting biochemical tests. A blood volume of approximately 3-5 ml was taken from each animal and placed in plain sterile tube that contained no anticoagulant. Blood clotted for 30 – 45 minutes at room temperature. After which time, the clotted blood was then centrifuged at 3,000 r.p.m. for ten minutes to create separation of serum. The serum was then carefully aspirated from the centrifugal tube into a sterile microcentrifuge tube. Samples were then frozen at −20° C until they could be analyzed for serum lipid profiles such as total cholesterol; triglyceride levels; high density lipoproteins (HDL); low-density lipoproteins (LDL) and very low-density lipoproteins (VLDL). Great care was taken to avoid hemolyzing the samples so that the quality of the sera would remain intact.

2.6 Lipid Profile Analysis:Serum lipid profile parameters were determined using commercially available enzymatic colorimetric diagnostic kits according to the manufacturer's instructions. Total cholesterol (TC) and triglycerides (TG) were estimated by the enzymatic cholesterol oxidase–peroxidase (CHOD–POD) and glycerol-3-phosphate oxidase–peroxidase (GPO–POD) methods, respectively. High-density lipoprotein cholesterol (HDL-C) was measured after selective precipitation of non-HDL lipoproteins followed by enzymatic determination. Low-density lipoprotein cholesterol (LDL-C) and very low-density lipoprotein cholesterol (VLDL-C) concentrations were calculated using the Friedewald equation**:** LDL-C = TC − HDL-C − (TG/5) and VLDL-C = TG/5 (mg/dL), where applicable. The Atherogenic Index (AI) was calculated using the formula AI = (TC − HDL-C)/HDL-C to evaluate the cardiovascular risk associated with lipid alterations. All biochemical estimations were performed in duplicate, and the results were expressed as mg/dL (mean ± standard deviation)**.**

2.7 Statistical Analysis: All experimental data were expressed as mean ± standard deviation (Mean ± SD) for each group (n = 8). The effects of sex (male and female) **and** treatment (control, mosquito coil smoke, smoke + *Trigonella foenum-graecum*, and *Trigonella foenum-graecum* only) on the measured lipid profile parameters were evaluated using

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two-way analysis of variance (Two-way ANOVA). **A** p-value < 0.05 was considered statistically significant for all analyses.

Table 2. Individual serum lipid profile data of experimental Wistar albino rats

Rat ID	Sex	Group	Treatment	TC	TG	HDL	LDL	VLDL	AI
MC1	Male	MC	Control	82.5	69.2	46.9	21.7	13.8	0.8
MC2	Male	MC	Control	87.6	68.6	44.3	29.6	13.7	1
MC3	Male	MC	Control	87.9	74.6	43.6	29.4	14.9	1
MC4	Male	MC	Control	82.7	67.2	43.6	25.7	13.4	0.9
MC5	Male	MC	Control	81.2	58.5	39.8	29.7	11.7	1
MC6	Male	MC	Control	77.2	63.9	45.9	18.5	12.8	0.7
MC7	Male	MC	Control	75.5	61.5	49.4	13.8	12.3	0.5
MC8	Male	MC	Control	78.9	70.4	40.7	24.1	14.1	0.9
MS1	Male	MS	Mosquito smoke	132	121	28.5	79.6	24.1	3.6
MS2	Male	MS	Mosquito smoke	137	116	31.1	82.5	23.3	3.4
MS3	Male	MS	Mosquito smoke	132	131	32	73.8	26.2	3.1
MS4	Male	MS	Mosquito smoke	130	125	28.3	76.4	25	3.6
MS5	Male	MS	Mosquito smoke	136	108	28	86.4	21.6	3.9
MS6	Male	MS	Mosquito smoke	136	124	32.5	78.6	24.9	3.2
MS7	Male	MS	Mosquito smoke	134	118	27.6	83.2	23.6	3.9
MS8	Male	MS	Mosquito smoke	131	117	35.2	72.8	23.4	2.7
MF1	Male	MF	Smoke + Fenugreek	96.7	71.4	43	39.5	14.3	1.3
MF2	Male	MF	Smoke + Fenugreek	93.1	77.9	43.8	33.7	15.6	1.1
MF3	Male	MF	Smoke + Fenugreek	100	87.6	39.5	43.2	17.5	1.5
MF4	Male	MF	Smoke + Fenugreek	93.5	84	44.9	31.7	16.8	1.1
MF5	Male	MF	Smoke + Fenugreek	92.6	80.9	38.7	37.7	16.2	1.4
MF6	Male	MF	Smoke + Fenugreek	89	86.9	46.1	25.6	17.4	0.9
MF7	Male	MF	Smoke + Fenugreek	94.6	88	43.1	34	17.6	1.2
MF8	Male	MF	Smoke + Fenugreek	91.8	84.2	46.6	28.3	16.8	1
MFG1	Male	MFG	Fenugreek only	75.8	74.4	40.1	20.8	14.9	0.9
MFG2	Male	MFG	Fenugreek only	80.1	65.5	47.1	19.9	13.1	0.7
MFG3	Male	MFG	Fenugreek only	76.5	53.1	47.3	18.5	10.6	0.6
MFG4	Male	MFG	Fenugreek only	77.8	73.9	46.4	16.6	14.8	0.7
MFG5	Male	MFG	Fenugreek only	72	62	50.7	8.8	12.4	0.4
MFG6	Male	MFG	Fenugreek only	77.6	61.8	49.5	15.7	12.4	0.6
MFG7	Male	MFG	Fenugreek only	76.5	70.8	45.9	16.4	14.2	0.7
MFG8	Male	MFG	Fenugreek only	74.4	62.6	43.6	18.2	12.5	0.7
FC1	Female	FC	Control	76.5	66.6	48	15.2	13.3	0.6
FC2	Female	FC	Control	73.8	56.5	46.7	15.8	11.3	0.6
FC3	Female	FC	Control	73.3	60.2	47.5	13.7	12	0.5
FC4	Female	FC	Control	77	76.3	48.5	13.2	15.3	0.6
FC5	Female	FC	Control	76.3	64.6	42.2	21.1	12.9	0.8
FC6	Female	FC	Control	74.9	65.4	55.4	6.4	13.1	0.4
FC7	Female	FC	Control	74	66.8	47.9	12.8	13.4	0.6
FC8	Female	FC	Control	69.2	71.9	50.3	4.5	14.4	0.4
FS1	Female	FS	Mosquito smoke	129	105	39.2	68.8	20.9	2.3
FS2	Female	FS	Mosquito smoke	118	114	41.6	53.7	22.7	1.8
FS3	Female	FS	Mosquito smoke	120	107	35.3	63.4	21.3	2.4
FS4	Female	FS	Mosquito smoke	123	101	35.2	67.1	20.1	2.5
FS5	Female	FS	Mosquito smoke	120	113	32.2	64.9	22.6	2.7
FS6	Female	FS	Mosquito smoke	133	105	34	77.7	21.1	2.9
FS7	Female	FS	Mosquito smoke	129	103	35.7	72.9	20.5	2.6
FS8	Female	FS	Mosquito smoke	132	100	35.6	75.9	20.1	2.7
FF1	Female	FF	Smoke + Fenugreek	89.3	79.7	41.3	32.1	15.9	1.2
FF2	Female	FF	Smoke + Fenugreek	81.4	78.1	45.9	19.9	15.6	0.8

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FF3	Female	FF	Smoke + Fenugreek	89.3	77.1	43	30.9	15.4	1.1
FF4	Female	FF	Smoke + Fenugreek	89.2	76.8	42.9	31	15.4	1.1
FF5	Female	FF	Smoke + Fenugreek	97.3	77.8	41.4	40.3	15.6	1.4
FF6	Female	FF	Smoke + Fenugreek	91.3	69.2	47.4	30.1	13.8	0.9
FF7	Female	FF	Smoke + Fenugreek	93.8	70.1	47.9	31.9	14	1
FF8	Female	FF	Smoke + Fenugreek	90.1	79.9	50.7	23.4	16	0.8
FFG1	Female	FFG	Fenugreek only	70.8	55.5	47.3	12.3	11.1	0.5
FFG2	Female	FFG	Fenugreek only	67.9	59.5	51	5	11.9	0.3
FFG3	Female	FFG	Fenugreek only	73.4	65	50	10.4	13	0.5
FFG4	Female	FFG	Fenugreek only	79.3	58.4	58.2	9.4	11.7	0.4
FFG5	Female	FFG	Fenugreek only	75.1	54.9	46.8	17.4	11	0.6
FFG6	Female	FFG	Fenugreek only	74.4	58.7	52.1	10.5	11.7	0.4
FFG7	Female	FFG	Fenugreek only	74.4	59.6	47.5	15	11.9	0.6

Table 3. Serum lipid profile of experimental Wistar albino rats (Mean ± SD)

Sex	Group	Treatment	TC	TG	HDL	LDL	VLDL	AI
Male	MC	Control	81.69 ± 4.50	66.74 ± 5.19	44.27 ± 3.15	24.06 ± 5.80	13.34 ± 1.03	0.86 ± 0.18
Male	MS	Mosquito smoke	133.59 ± 2.60	120.14 ± 6.87	30.40 ± 2.73	79.16 ± 4.74	24.01 ± 1.39	3.42 ± 0.39
Male	MF	Smoke + Fenugreek	93.94 ± 3.36	82.61 ± 5.70	43.21 ± 2.86	34.21 ± 5.81	16.52 ± 1.13	1.19 ± 0.21
Male	MFG	Fenugreek only	76.34 ± 2.41	65.51 ± 7.23	46.32 ± 3.32	16.86 ± 3.70	13.11 ± 1.46	0.66 ± 0.13
Female	FC	Control	74.38 ± 2.50	66.04 ± 6.19	48.31 ± 3.69	12.84 ± 5.27	13.21 ± 1.26	0.55 ± 0.14
Female	FS	Mosquito smoke	125.31 ± 5.88	105.80 ± 5.02	36.10 ± 2.96	68.05 ± 7.72	21.16 ± 1.02	2.49 ± 0.33
Female	FF	Smoke + Fenugreek	90.21 ± 4.55	76.09 ± 4.13	45.06 ± 3.43	29.95 ± 6.11	15.21 ± 0.84	1.01 ± 0.20
Female	FFG	Fenugreek only	72.46 ± 4.64	58.61 ± 3.11	50.69 ± 3.77	10.05 ± 5.38	11.72 ± 0.62	0.44 ± 0.13

Table 4. Two-way ANOVA analysis of serum lipid profile parameters in experimental Wistar albino rats

Parameter	Source of Variation	F-value	p-value	Significance
TC	Treatment	637.28	<0.001	***
TC	Sex	33.84	<0.001	***
TC	Treatment × Sex	1.38	0.2588	NS
TG	Treatment	273.08	<0.001	***
TG	Sex	26.02	<0.001	***
TG	Treatment × Sex	4.01	0.0117	*
HDL	Treatment	69.1	<0.001	***
HDL	Sex	23.97	<0.001	***
HDL	Treatment × Sex	0.96	0.4179	NS
LDL	Treatment	370.68	<0.001	***
LDL	Sex	34.71	<0.001	***
LDL	Treatment × Sex	1.45	0.2382	NS
VLDL	Treatment	269.44	<0.001	***
VLDL	Sex	25.56	<0.001	***
VLDL	Treatment × Sex	3.95	0.0126	*
AI	Treatment	369.26	<0.001	***
AI	Sex	49.54	<0.001	***
AI	Treatment × Sex	9.37	<0.001	***

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Table 5. Percentage recovery of lipid profile parameters in male and female Wistar albino rats

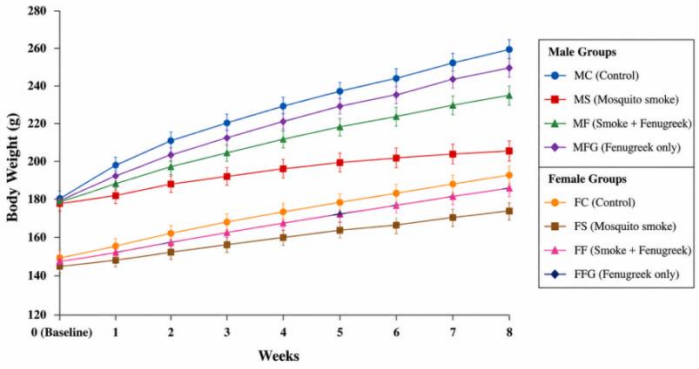
Sex	TC	TG	HDL	LDL	VLDL	AI
Male	76.4	70.3	92.3	81.6	70.1	87.2
Female	68.9	74.7	73.4	69	74.8	76.1
Overall	72.6	72.5	82.8	75.3	72.4	81.6

III. MATERIALS AND METHODS

3.1 Body Weight Changes: The weekly body weight changes of all experimental groups are presented in Table 6**,** while the growth trends throughout the 8-week experimental period are illustrated in Figure 1**.** Control animals exhibited a steady increase in body weight throughout the study. Male control rats increased from 180 ± 5.0 g at baseline to 260 ± 5.0 g at week 8, whereas female control rats increased from 149 ± 5.0 g **to** 193 ± 5.0 g**.** In contrast, mosquito coil smoke exposure markedly reduced body weight gain in both sexes. Male smoke-exposed rats reached only 205 ± 5.0 g**,** while female smoke-exposed rats reached 173 ± 5.0 g by week 8.

Administration of *Trigonella foenum-graecum* significantly improved body weight gain in smoke-exposed animals. Male rats receiving smoke plus fenugreek attained 234 ± 5.0 g**,** whereas female rats reached 185 ± 5.0 g at the end of the experiment. Fenugreek-only groups showed body weight progression comparable to controls, indicating that fenugreek supplementation had no adverse effect on normal growth. Overall, Table 6 **and** Figure 1 demonstrate that mosquito coil smoke suppressed normal body weight gain, whereas fenugreek partially restored growth in both sexes.

Figure 1. Weekly body weight changes in all experimental groups



Values are Mean ± SD (n = 8 per group).
MC: Male Control; **MS**: Male Mosquito smoke; **MF**: Male Smoke + Fenugreek; **MFG**: Male Fenugreek only;
FC: Female Control; **FS**: Female Mosquito smoke; **FF**: Female Smoke + Fenugreek; **FFG**: Female Fenugreek only.

Table 6. Weekly body weight (g) of all experimental groups

Sex	Group	Treatment	Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Male	MC	Control	180 ± 5.0	198 ± 5.0	211 ± 5.0	220 ± 5.0	229 ± 5.0	237 ± 5.0	244 ± 5.0	252 ± 5.0	260 ± 5.0
Male	MS	Mosquito smoke	178 ± 5.0	182 ± 5.0	188 ± 5.0	192 ± 5.0	196 ± 5.0	199 ± 5.0	201 ± 5.0	203 ± 5.0	205 ± 5.0
Male	MF	Smoke + Fenugreek	179 ± 5.0	188 ± 5.0	197 ± 5.0	204 ± 5.0	211 ± 5.0	218 ± 5.0	223 ± 5.0	229 ± 5.0	234 ± 5.0
Male	MFG	Fenugreek only	180 ± 5.0	192 ± 5.0	203 ± 5.0	212 ± 5.0	221 ± 5.0	229 ± 5.0	235 ± 5.0	243 ± 5.0	249 ± 5.0
Female	FC	Control	149 ± 5.0	155 ± 5.0	162 ± 5.0	168 ± 5.0	173 ± 5.0	178 ± 5.0	183 ± 5.0	188 ± 5.0	193 ± 5.0
Female	FS	Mosquito smoke	145 ± 5.0	148 ± 5.0	152 ± 5.0	156 ± 5.0	160 ± 5.0	163 ± 5.0	166 ± 5.0	170 ± 5.0	173 ± 5.0
Female	FF	Smoke + Fenugreek	147 ± 5.0	152 ± 5.0	157 ± 5.0	162 ± 5.0	167 ± 5.0	172 ± 5.0	176 ± 5.0	181 ± 5.0	185 ± 5.0

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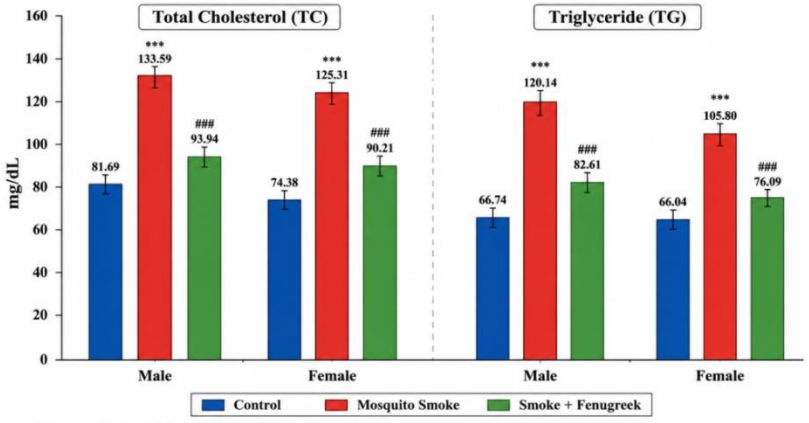
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Female	FFG	Fenugreek only	148 ± 5.0	156 ± 5.0	164 ± 5.0	171 ± 5.0	178 ± 5.0	184 ± 5.0	190 ± 5.0	196 ± 5.0	201 ± 5.0

3.2 Effect on Total Cholesterol and Triglycerides: The impact of smoke from burning mosquito coils as well as treatment with fenugreek on levels of total cholesterol (TC) and triglycerides (TG) in rat blood is shown in table 3 and graphed in figure 2. Smoke from mosquito coils resulted in significant elevation of both TC and TG levels in male and female rats.Male rats exposed to smoke had an increase in TC from 81.69 ± 4.50 mg/dl control to 133.59 ± 2.60 mg/dl. TGs also rose by smoke exposure, from 66.74 ± 5.19 mg/dl control to 120.14 ± 6.87 mg/dl. In addition, smoke-exposed females demonstrated an increase in TC from 74.38 ± 2.50 mg/dl to 125.31 ± 5.88 mg/dl; likewise, their TG levels rose by smoke exposure, from 66.04 ± 6.19 mg/dl to 105.80 ± 5.02 mg/dl. Treatment with fenugreek lowered the high lipid parameter values for all groups. For example, male rats that were treated with fenugreek after being exposed to smoke had TC and TG levels at 93.94 ± 3.36 mg/dl and 82.61 ± 5.70 mg/dl, respectively. Likewise, female rats that received fenugreek treatment had TC and TG levels at 90.21 ± 4.55 mg/dl and 76.09 ± 4.13 mg/dl, respectively. These results presented in table 3 and figure 2 show that there was a considerable hypolipidemic action by fenugreek

Figure 2. Total Cholesterol and Triglyceride levels in Control, Mosquito Smoke and Smoke + Fenugreek treated groups



Values are Mean ± SD (n = 8 per group).
*** $p < 0.001$ vs Control (same sex); ### $p < 0.001$ vs Mosquito Smoke (same sex)
TC: Total Cholesterol; **TG:** Triglyceride

3.3 Effect on HDL, LDL and VLDL: HDL, LDL and VLDL serum concentrations for all rats were reported as shown in Table 3; Comparative analyses of treatments were compared using data from Tables 3 & 4 and Figures 3. Exposure to mosquito coil smoke resulted in significant reductions in HDL levels and increases in both LDL and VLDL levels in both male and female rats.

Male rats exhibited a reduction in HDL from 44.27 ± 3.15 mg/dL **to** 30.40 ± 2.73 mg/dL**,** accompanied by increases in LDL from 24.06 ± 5.80 mg/dL **to** 79.16 ± 4.74 mg/dL and VLDL from 13.34 ± 1.03 mg/dL **to** 24.01 ± 1.39 mg/dL. Similar alterations were observed in female rats, where HDL declined from 48.31 ± 3.69 mg/dL to 36.10 ± 2.96 mg/dL**,** whereas LDL increased from 12.84 ± 5.27 mg/dL **to** 68.05 ± 7.72 mg/dL**,** and VLDL increased from 13.21 ± 1.26 mg/dL **to** 21.16 ± 1.02 mg/dL**.**

Fenugreek effectively restored the abnormal lipid levels through a significant increase of HDL as well as a decrease of both LDL and VLDL. The results shown in Tables 3 and 4 and Figure 3 show that smoking induced dyslipidemia was attenuated by fenugreek.

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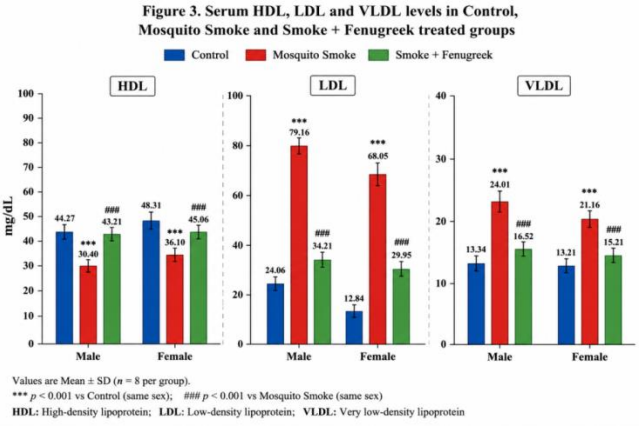


Figure 3. Serum HDL, LDL and VLDL levels in Control, Mosquito Smoke and Smoke + Fenugreek treated groups

Values are Mean ± SD (n = 8 per group).
*** p < 0.001 vs Control (same sex); ### p < 0.001 vs Mosquito Smoke (same sex)
HDL: High-density lipoprotein; **LDL**: Low-density lipoprotein; **VLDL**: Very low-density lipoprotein

3.4 Comparative Lipid Profile Between Male and Female Rats: The results of the lipid profile analysis that compared the male and female rat treatment groups are presented in Table 3, which is summarized with statistical data in Table 4. Additionally, the lipid profile comparisons were displayed as a heatmap in Figure 4. Overall, male rats showed significantly increased levels of dyslipidemia after exposure to mosquito coil smoke compared to female rats. In addition, TC was significantly elevated in males versus females as well as TG, LDL and VLDL. Similarly, AI was also significantly elevated in male rats versus females. On the other hand, HDL levels were significantly lower in male rats versus female rats.

A two-way analysis of variance (ANOVA), with treatments as a main factor and gender as a second main factor, (see Table 4) found that both gender and treatments had an extremely high statistical effect upon each one of all lipid measurements (all p = 0.0001). Additionally, there were statistically significant interactions of gender x treatment for triglycerides, very-low-density lipoprotein cholesterol and atherogenic index (AI); therefore, it is clear that gender primarily affected the degree of response to cigarette smoke and fenugreek. Figure 4 illustrates the differing changes in lipid levels by sex, and the protective role of fenugreek.

Figure 4. Heatmap comparing lipid parameters between male and female rats

(Values are Mean ± SD, mg/dL)

	Male groups				Female groups			
	Control (MC)	Smoke (MS)	Smoke + Fenugreek (MF)	Fenugreek only (MFG)	Control (FC)	Smoke (FS)	Smoke + Fenugreek (FF)	Fenugreek only (FFG)
TC (mg/dL)	81.69 ± 4.50	133.59 ± 2.60	93.94 ± 3.36	76.34 ± 2.41	74.38 ± 2.50	125.31 ± 5.88	90.21 ± 4.55	72.46 ± 4.64
TG (mg/dL)	66.74 ± 5.19	120.14 ± 6.87	82.61 ± 5.70	65.51 ± 7.23	66.04 ± 6.19	105.80 ± 5.02	76.09 ± 4.13	58.61 ± 3.11
HDL (mg/dL)	44.27 ± 3.15	30.40 ± 2.73	43.21 ± 2.86	46.32 ± 3.32	48.31 ± 3.69	36.10 ± 2.96	45.06 ± 3.43	50.69 ± 3.77
LDL (mg/dL)	24.06 ± 5.80	79.16 ± 4.74	34.21 ± 5.81	16.86 ± 3.70	12.84 ± 5.27	68.05 ± 7.72	29.95 ± 6.11	10.05 ± 5.38
VLDL (mg/dL)	13.34 ± 1.03	24.01 ± 1.39	16.52 ± 1.13	13.11 ± 1.46	13.21 ± 1.26	21.16 ± 1.02	15.21 ± 0.84	11.72 ± 0.62

High 140 120 100 80 60 40 20 0 Low mg/dL

Values are Mean ± SD (n = 8 per group).
TC: Total cholesterol; **TG**: Triglycerides; **HDL**: High-density lipoprotein; **LDL**: Low-density lipoprotein; **VLDL**: Very low-density lipoprotein.

3.5 Atherogenic Risk Assessment: Cardiovascular risk indexes determined by calculation are listed for all study animals in Table 7. Radar plots shown in Figure 5 illustrate the comparisons of the distributions of cardiovascular risk indexes among the different experimental groups. Smoke produced by burning mosquito coils was found to cause significant increases in both the Atherogenic Index (AI) and the LDL/HDL ratio in both male and female rats.In males, the AI increased from 0.86 ± 0.18 in control rats to 3.42 ± 0.39 after exposure to mosquito coil smoke. Similarly, the ratio of LDL/HDL cholesterol increased in response to mosquito coil smoke exposure as well; it rose from 0.54 to 2.60 in male rats. Comparable changes were seen in female rats; the AI rose from 0.55 ± 0.14 to 2.49 ± 0.33, and the ratio of LDL/HDL cholesterol increased from 0.27 to 1.89. Supplementation with fenugreek caused reductions in these cardiovascular risk indexes. In the case of rats exposed to smoke and supplemented with fenugreek, the AI fell to 1.19 ± 0.21 and the ratio of LDL/HDL cholesterol fell to 0.79 for male rats. Corresponding reductions were observed in

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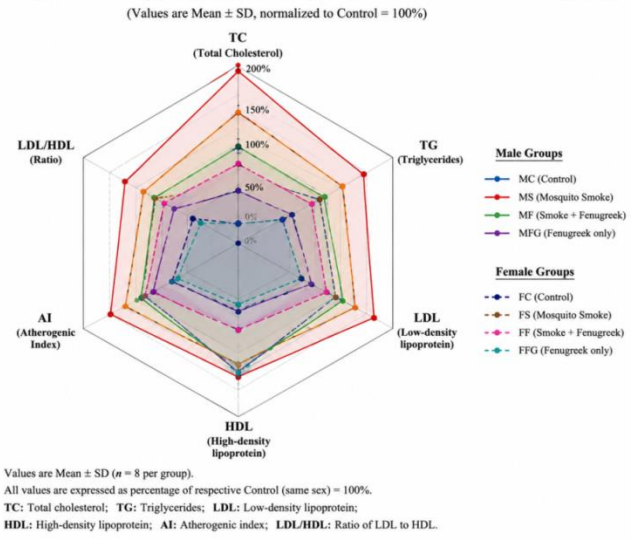
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females: the AI decreased to 1.01 ± 0.20, and the ratio of LDL/HDL cholesterol decreased to 0.66. These data demonstrate that fenugreek effectively reduces smoking-related cardiovascular risks (Table 7, Fig. 5).

Figure 5. Radar (spider) chart showing cardiovascular risk indices among groups



Values are Mean ± SD (n = 8 per group).
All values are expressed as percentage of respective Control (same sex) = 100%.
TC: Total cholesterol; **TG:** Triglycerides; **LDL:** Low-density lipoprotein;
HDL: High-density lipoprotein; **AI:** Atherogenic index; **LDL/HDL:** Ratio of LDL to HDL.

Table 7. Calculated cardiovascular risk indices

Sex	Group	AI	LDL/HDL
Male	MC	0.86 ± 0.18	0.54
Male	MS	3.42 ± 0.39	2.60
Male	MF	1.19 ± 0.21	0.79
Male	MFG	0.66 ± 0.13	0.36
Female	FC	0.55 ± 0.14	0.27
Female	FS	2.49 ± 0.33	1.89
Female	FF	1.01 ± 0.20	0.66
Female	FFG	0.44 ± 0.13	0.20

3.6 Overall Protective Effect of Fenugreek: Recovery rates of lipid profiles after administration of Fenugreek are shown in Table 5 and illustrated in Fig. 6. In general recovery was as follows: Total Cholesterol 72.6%, Triglycerides 72.5%, HDL-Cholesterol 82.8%, Low Density Lipoprotein (LDL) 75.3%, Very Low-Density Lipoprotein (VLDL) 72.4%, Atherogenic Index 81.6%. Males showed higher recovery than females with respect to HDL-Cholesterol (92.3%), LDL-Cholesterol (81.6%), and Atherogenic Index (87.2%). Females showed slightly better recovery than males with respect to Triglycerides (74.7%) and VLDL (74.8%). The results given in Table 5 and Fig. 6 show clearly that *Trigonella foenum-graecum* has greatly reduced the negative effects on lipid metabolism caused by smoking from mosquito coils in both sexes, although it had slightly greater effectiveness in males than in females.

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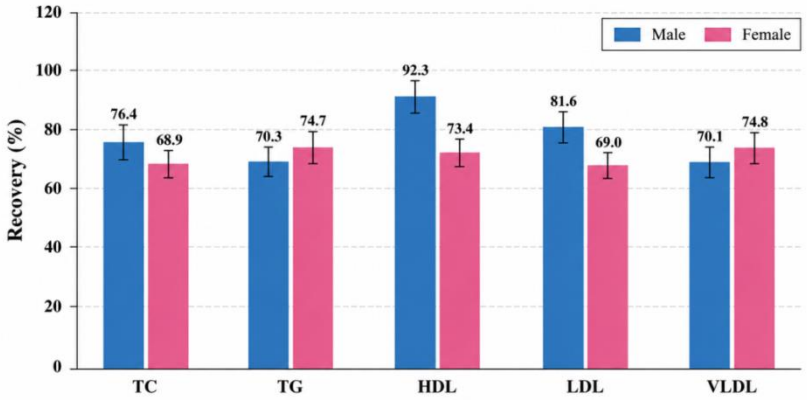
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Figure 6. Percentage recovery of lipid parameters after Fenugreek treatment

(Values are Mean ± SD, n = 8 per group)



Values represent percentage recovery of lipid parameters in Smoke + Fenugreek groups relative to Mosquito Smoke groups of the same sex.

TC: Total Cholesterol; **TG**: Triglycerides; **HDL**: High-density lipoprotein; **LDL**: Low-density lipoprotein; **VLDL**: Very low-density lipoprotein.

IV. DISCUSSION

The current investigation indicated that long-term exposure to mosquito coil smoke caused pronounced effects on the serum lipid profiles in Wistar albino rats. Exposure to smoke resulted in elevated total cholesterol, triglycerides, low-density lipoproteins (LDL), very-low-density lipoproteins (VLDL) and atherogenic index and decreased high-density lipoproteins (HDL). This evidence supports the idea of the induction of dyslipidemia and an increased risk for cardiovascular disease resulting from the continuous inhalation of mosquito coil smoke. Particulates, aldehydes, polycyclic aromatic hydrocarbons, and pyrethroids found in mosquito coil smoke can result in oxidative stress. Oxidative stress may disrupt liver lipid metabolism; lead to enhanced lipid peroxidation; and interfere with the typical functioning of lipoproteins. The data show that mosquitoe coils promote a pro-atherogenic lipid composition through the elevation of LDL and VLDL and lowering of HDL. Also, the decreased body weight gain among the smoke-exposed rats was possibly due to systemic toxicities, decreased metabolic efficiencies and increased oxidative burdens. It has been shown that smoke exposure could also impact appetite, nutrient uptake, and tissue development. On the other hand, the improvement in body weight gain by the fenugreek treated groups demonstrates that *Trigonellafoenum-graecum* may provide protection against smoke-induced metabolic stresses. Treatment with fenugreek clearly improved the altered lipid profiles. The decrease in total cholesterol (TC), triglyceride (TG), LDL and VLDL and the normalization of HDL are likely due to active phytochemicals contained within fenugreek seeds such as diosgenin, galactomannans, saponins, flavonoids and polyphenols. These compounds have been proven to inhibit the absorption of dietary cholesterol into the intestine; stimulate bile acid excretion; increase antioxidant defenses; and modulate lipid metabolism. Additionally, the decreases in atherogenic indexes and LDL/HDL ratios after fenugreek treatments are notably important since these values represent significant predictors of cardiovascular diseases. Therefore, it appears that fenugreek not only enhances each of these lipid parameters but it also diminishes the overall atherosclerotic burden. There were sex dependent variations in response to treatments. Male rats presented with greater disruption in their lipid status compared to female rats after smoke exposure particularly in TC, LDL and AI. Conversely, female rats had relatively greater concentrations of HDL and lesser concentrations of LDL post-smoke exposure which may relate to hormonal influences and/or better intrinsic control mechanisms regulating lipid homeostasis. However, both genders benefitted from fenugreek treatment suggesting that fenugreek provides a protective effect against smoke-induced disturbances in lipid metabolism for all gender classifications. In summary, this research shows that the repeated inhalation of mosquito coil smoke generates a considerable degree of dyslipidemia and an elevated risk for developing cardiovascular diseases in albino rats. Furthermore, studies demonstrate that treatment with *Trigonellafoenum-graecum* effectively minimizes or reverses the undesirable effects created by smoke exposure on lipid metabolism providing further support for using *Trigonellafoenum-graecum* as a naturally occurring anti-toxicant agent against smoke-induced dysfunctions in lipid metabolism.

V. CONCLUDING REMARKS

5. Concluding Remarks: The current study demonstrated that long-term exposure to smoke from burning mosquito coils (used as an insecticide) produced significant disruptions in lipid metabolism, characterized by increased levels of total cholesterol, triglycerides, low-density lipoprotein (LDL), very-low-density lipoprotein (VLDL), and atherogenic

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index with concomitant decreases in high-density lipoprotein (HDL) levels in both male and female Wistar albino rats. The observed disturbances suggest the occurrence of severe dyslipidemias and elevation of the cardiovascular disease risk due to chronic inhalation of mosquito coil smoke. Administration of *Trigonella foenum-graecum* caused significant improvement in disturbed lipid metabolisms by normalizing lipid serum homeostasis, enhancing body weight gains and notably diminishing indices of cardiovascular risks. A sex-specific difference was noted where males were generally more susceptible to lipid metabolites disrupted by smoking than females who had a relatively good control on their lipid metabolisms but the fenugreek treatment protected both sexes. In general, this research has provided robust experimental data demonstrating that *Trigonella foenum-graecum* exhibits substantial hypolipidemic, antioxidant, and cardioprotective properties which can attenuate smoke-induced disturbances of metabolic function. Consequently, our results may be taken as supporting evidence for the potential use of *Trigonella foenum-graeecum* as a natural dietary adjunct to diminish the detrimental health consequences associated with chronic exposure to indoor air pollutants.

REFERENCES

[1]. Aslam M. A., Ahmed S., Saleem M., Sardar R., Shah A. A., Siddiqui M. H., Shabbir Z. (2023): "Mitigation of chromium-induced phytotoxicity in 28-homobrassinolide treated *Trigonella corniculata* L. by modulation of oxidative biomarkers and antioxidant system", *Ecotoxicology and Environmental Safety*, 263:115354.

[2]. Bakhtiar Z., Hassandokht M., Naghavi M. R., Rezadoost H., Mirjalili M. H. (2024): "Fatty acid and nutrient profiles, diosgenin and trigonelline contents, mineral composition, and antioxidant activity of the seed of some Iranian *Trigonella* L. species", *BMC Plant Biology*, 24:669.

[3]. Fatima H., Shahid M., Pruitt C., Pung M. A., Mills P. J., Riaz M., Ashraf R. (2022): "Chemical fingerprinting, antioxidant, and anti-inflammatory potential of hydroethanolic extract of *Trigonella foenum-graecum*", *Antioxidants*, 11:364.

[4]. Loha M., Mulu A., Abay S. M., Ergete W., Geleta B. (2019): "Acute and subacute toxicity of methanol extract of *Syzygiumguineense* leaves on the histology of the liver and kidney and biochemical compositions of blood in rats", *Evidence-Based Complementary and Alternative Medicine*, 5702159.

[5]. Lohvina H., Sándor M., Wink M. (2021): "Effect of ethanol solvents on total phenolic content and antioxidant properties of seed extracts of fenugreek (*Trigonella foenum-graecum* L.) varieties and determination of phenolic composition by HPLC-ESI-MS", *Diversity*, 14(1):7.

[6]. Nagamma T., Konuri A., Bhat K. M., Udupa P. E., Nayak Y. (2023): "*Trigonella foenum-graecum* L. seed extract modulates biochemical and histomorphological changes in therapeutic model of high-fat diet-fed ovariectomized rats", *3 Biotech*, 13:285.

[7]. Pandey R., Dwivedi S., Hussain M. S., Dixit A. K., Sachan A. K., Singh S. K., et al. (2024): "An experimental study to evaluate the effect of antihyperglycemic drugs on serum leptin and adiponectin levels in streptozotocin-induced diabetes in Wistar rats", *International Journal of Pharmaceutical Sciences Review and Research*, 84:136–144.

[8]. Rao N. R., Bhuvaneswar A. V., Sri A. B., Kumar P. S., Sravani K., Krupanidhi G., Chiranjeevi M., Baniyan R. J., Aditya N. V. (2025): "Decoding Fenugreek's Cholesterol-Lowering Mechanism: A Critical Review of its Therapeutic Potential", *Archives of Current Research International*, 25:716–730.

[9]. Sekhar M. G., Shanmugam K. R., Prasad K. S., Chilakala R. (2024): "Amelioration of lipid metabolic profiles by trigonelline, a bioactive compound of *Trigonella foenum-graecum* in alcohol-induced albino rats", *Indian Journal of Pharmaceutical Education and Research*, 58:172–177.

[10]. Sfar M., Jaouani A., Ben-Mahrez K., Skhiri H. A., Ben Rayana C., Chemli R., et al. (2018): "The effect of fenugreek on blood glucose, lipid parameters, insulin and resistin in obese women with type 2 diabetes", *Human Journals*, 11:108–123.

[11]. Sun W., Shahrajabian M. H., Cheng Q. (2021): "Fenugreek cultivation with emphasis on historical aspects and its uses in traditional medicine and modern pharmaceutical science", *Mini Reviews in Medicinal Chemistry*, 21:724–730.

[12]. Verma P. P., Siddiqui S., Nayyer M. A., Singh S., Kumar D., Padalia R. C. (2024): "Exploration of industrial, traditional, and pharmaceutical applications of diversity rich genus *Trigonella*: A comprehensive review", *Current Agriculture Research Journal*, 12:63–80.

[13]. Visuvanathan T., Than L. T., Stanslas J., Chew S. Y., Vellasamy S. (2022): "Revisiting *Trigonella foenum-graecum* L.: Pharmacology and therapeutic potentialities", *Plants*, 11:1450.

[14]. Zahid N., Shaheen S., Memon Z., Ali A., Zafar U., Agha F. (2020): "Comparative analysis of antidyslipidemic effects of fenugreek seed extract and standard pharmacological therapy in diet-induced animal model of dyslipidemia: An experimental study", *Journal of Pharmaceutical Research International*, 32:143–151.

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