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Original Research Article

Lipid profile improving effect of *Coriandrum sativum* seed extract in rats

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ABSTRACT

Background: Hyperlipidaemia is a common disease in middle-aged and elderly people. It has received attention, as it indirectly affects the normal metabolism, blood viscosity and vital organ functions. It is a risk factor for cardiovascular and cerebrovascular diseases. Therefore, the aim of the present study was to evaluate the possible antihyperlipidemic effect of *Coriander sativum* seed extract (CSSE) in rats fed on high-fat diet.
Methods: A parallel study design was adopted on 42 albino rats, divided randomly into 7 groups with different treatments. After a 6 week-experimental course, blood samples were collected and analysed for lipid and organ function parameters. Phytochemical analysis was conducted on the used seed extract to detect the active principles underlying its effects.
Results: CSSE (150 and 300 mg/kg, orally, once daily) along with a high-fat (1.5% cholesterol+1.5% coconut oil, in diet) diet resulted in a significant ($p \leq 0.05$) improvement in plasma lipid parameters, including, total cholesterol, triacyglycerols and lipoproteins, compared to the high-fat group. group. The extract significantly ($p \leq 0.05$) improved hepatic (total proteins, albumin, globulins, total conjugated and unconjugated bilirubins, AST, ALT, GGT), cardiac (CK-MB and troponin-I) and renal (urea, creatinine & uric acid) biomarkers. Phytoanalysis of CSSE revealed presence of phlobatannin and flavonoids. The protection % produced by small and large doses of CSSE were dose-dependent and parallel to those of the standard antihyperlipidemic rosuvastatin (2 mg/dl orally, daily).
Conclusions: These data indicate that CSSE has a marked antihyperlipidemic effect and could be a source for a promising nutraceutical antihyperlipidemic drug depending on its high phenolic and flavonoid content.

Keywords: *Coriander sativum*, Hyperlipidaemia, Phytoanalysis, Seed extract

INTRODUCTION

Hyperlipidaemia is a common metabolic syndrome characterized by elevated risky lipids and/or decreased healthy ones. Two types of divided are there: primary and secondary. Primary hyperlipidaemia is of genetic origin applied to lipoprotein transport, receptors, enzymes. Secondary or acquired hyperlipidaemia, is caused by changes in blood lipids secondarily to other dysfunctions as nutritional disturbance, diabetes, hypertension, hypothyroidism, nephrosis, as well as the long term use of some drugs as corticosteroids, oral contraceptives and β-blockers.[1]

Treatment of hyperlipidaemia involves two approaches, non-pharmacological and pharmacological. The non-pharmacological therapy involves lowering total fat intake in order to achieve desirable body weight.[2] While pharmacological therapy involves the use of antihyperlipidemic drugs, which include: HMG-CoA reductase inhibitors as simvastatin and rosuvastatin; bile acid resins as cholestyramine and colestipol; fibric acid derivatives which activate lipoprotein lipase as clofibrate,

gemfibrozil, and fenofibrate; triglyceride synthesis and lipolysis inhibitors as nicotinic acid; and cholesterol absorption inhibitors as ezetimibe.[3]

Herbal treatment for hyperlipidaemia has no side effects that are common to appear upon the use of chemicals such as statins may cause gastrointestinal disturbances, myopathy and rhabdomyolysis.[4] The gastrointestinal disturbances, including constipation, indigestion, nausea, bloating, and flatulence are due to bile acid sequestrants, while osteoporosis due to calcium loss on long-term use.[5] An intense cutaneous flush, itching elevates liver enzymes and hyperuricemia which precipitates a gout attack and promotes glucose intolerance could be associated with niacin therapy.[6]

Coriandrum sativum belongs to the family *Apiaceae* and genus *Coriandrum*.[7] All parts of *C. sativum* plant are edible; however, its fresh leaves and dried seeds are most frequently used as a food spice and for medicinal extraction.[8] Different types of extracts from different parts of the plant have been shown to exhibit pharmacological effects, including, antioxidant, cardioprotective and antatherosclerotic effects in diabetic patients, growth promoting and improved carcass yield in broilers, stomachic and aphrodisiac effects, and antidote for heavy metals as arsenic and mercury.[9-13] The present study was designed to evaluate the antihyperlipidemic effect of *C. sativum* seed extract (CSSE) in albino rats fed on high-fat diet. To fulfil this aim, the following objectives have been conducted: the effect of CSSE on lipid biomarkers as total cholesterol, triglycerides and lipoproteins; the effect of CSSE on biomarkers indicating hepatic (total protein, bilirubins, aminotransferases), renal (urea, creatinine, uric acid) and cardiac (creatine kinase-myoglobin biomarker, troponin-I) dysfunction; and the qualitative phytochemical analysis of CSSE to determine the active principles underlying its effect.

METHODS

Coriander seeds and CSSE

The seeds of *C. sativum* were purchased from our local market in December 2021. The plant seed was identified by Dr. Mostafa Hamza Mohamed, Assistant professor of vegetable crops, horticulture department, faculty of agriculture, Benha University (Figure 1). Seeds were refluxed in running tap water and then with bi-distilled water, shade dried at room temperature. Extracts were prepared by macerating a weighed amount of the coriander seeds (500 gm) in a known volume (4 Litre) of water/organic solvent (bi-distilled water: absolute ethanol, 70: 30, v/v). Maceration continued for 72 hours in the refrigerator with intermittent shaking. The hydro-ethanolic extract was then strained through muslin mesh, filtered through Whatman paper. The obtained filtrate was then concentrated using a shaking water bath at 70°C in wide-mouthed containers. The obtained yield was 13%, and a weighed 65 gm were re-constituted by dissolving in a measured amount of isosaline. Two stock solutions were prepared 30 and 60 mg/ml. The prepared CSSE was administered to rats at a dosage rate of 150 (small dose; SD) and 300 (high dose; HD) mg/kg, daily, adjusted so that each rat (weighing 200 g) receives 1 ml of the corresponding CSSE concentration using a rat gastric tube to the corresponding groups as explained below.

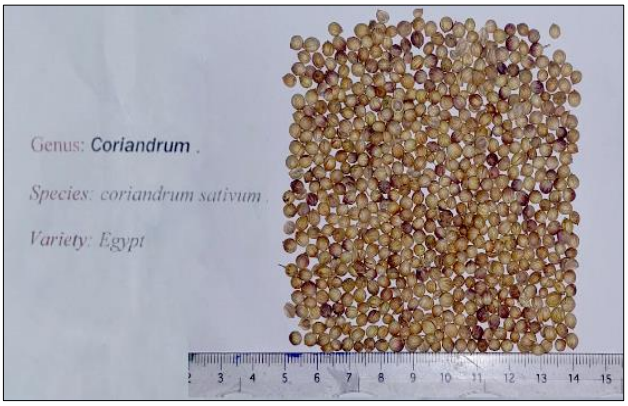

Figure 1: Identification of *Coriandrum sativum* seeds.

Experimental protocol

The study was performed on 42 male albino rats weighing 150±20 g, obtained from Animal house, Faculty of Veterinary Medicine, Benha University, Egypt. The animals were kept in a standard environment with controlled temperature (25°C), humidity (45-75 %), and photoperiod (12 h/12 h light / dark cycle). All animals had free access to chow and water *ad libitum*. Animals were housed in stainless steel wire mesh cages with bedding of ground wood chips. Rats were for 15 days for acclimatization before the beginning of the experiment. Acclimatized rats were divided into seven groups, each consists of six rats. To assess the aim of the present work, groups were treated differently as follows: Group I: rats were fed on a normal diet and received no drugs, but the vehicles, and kept as a negative control. Group II: rats fed on high-fat (1.5% cholesterol+1.5% coconut oil, w/w) diet, received no drugs but the vehicles, and kept as a positive control for all experimental Groups. Group III: Rats were fed on high-fat diet, received Rosuvastatin (2 mg/kg, orally, daily), and kept as a standard-treated Group. Group IV: Rats were fed on high-fat diet and received a small dose (150 mg/kg, orally, daily) of CSSE, and kept as CSSE-SD-treated Group. Group V: Rats were fed on a high-fat diet and received a large dose (300 mg/kg, orally, daily) of CSSE, and kept as CSSE-LD-treated Group. Group VI & Group VII: Rats were fed on normal diet and received small and large doses of CSSE, respectively, and kept as normal-treated groups.

Those doses of CSSE and Rosuvastatin were converted to rat doses from the corresponding human doses cited elsewhere in literature according to Barnes.[14] Blood for plasma was collected after 42 days from the start of the

experiment under light isoflurane® anaesthesia (Arab company for gelatine and pharmaceuticals, El-Amreya, Alexandria, Egypt). Blood was harvested into heparinized sampling tubes from the venous plexus located at the medial canthus of the eye by means of heparinized capillary tubes. Clear plasma samples were separated by centrifugation at 900 *xG* for 10 minutes and then collected in Eppendorf's tubes using automatic micropipettes. Plasma samples were kept in a deep freezer (-20°C) till analysis. The research protocol treatments, administration and sampling procedures were ethical to animals and performed in a merciful and humane manner in accordance with the committee of experimental animal care and procedure, faculty of veterinary medicine, Benha University, Egypt.

Clinicochemical analysis

Lipid biomarkers: The plasma total cholesterol was determined spectrophotometrically using a kit purchased from spectrum® (Hannover, Germany) according to the method described by Jung.[15] Triglycerides were determined spectrophotometrically using a kit purchased from Genesis® (Málaga, Spain) according to the method described by David.[16] LDL-cholesterol were determined using a kit purchased from Spectrum® (Hannover, Germany) according to the method described by Finley.[17] HDL-cholesterol were spectrophotometrically determined using kit purchased from Spectrum® (Hannover, Germany) according to the method described by Wood.[18] The assay procedures and wave lengths were done following instructions of the manufacturer. The plasma VLDL-cholesterol value was calculated using the following formula: VLDL-cholesterol=triglycerides/5= mg/dl.[19] Hepatic biomarkers: The plasma total proteins and albumin were spectrophotometrically determined using a kit purchased from Spectrum® (Hannover, Germany), according to the methods described.[17,20] The plasma globulins value was calculated using the formula as follow: Globulins=total protein–albumin.[21] albumin: globulin ratio (A/G ratio) was calculated using the formula as follows: A/G ratio=albumin/(total protein-albumin).[22] The plasma total, conjugated, and unconjugated bilirubins were spectrophotometrically determined using kits purchased from Diamond® (Hannover, Germany), according to the methods described.[23] The plasma aspartate and alanine aminotransferases were spectrophotometrically using kits purchased from Genesis® (Málaga-Spain) according to the methods described.[24] The plasma γ-Glutamyl transferase was spectrophotometrically determined using a kit purchased from Spectrum® (Hannover, Germany), according to the method described.[25]

Cardiac biomarkers: The plasma CK-MB was spectrophotometrically determined using a kit purchased from Spectrum® (Hannover, Germany), according to the method described.[26] Plasma troponin-I was spectrophotometrically determined using a kit purchased from Spectrum® (Hannover, Germany), according to the method described.[27] Renal biomarkers: the plasma urea was spectrophotometrically determined using a kit purchased from Diamond® (Hannover, Germany), according to the method described.[28] The plasma creatinine and urate were spectrophotometrically determined using a kit purchased from Spectrum® (Hannover, Germany), according to the methods described.[29,30]

Phytochemical analysis

Phytochemical screening of *C. sativum* extracts for the presence of active principal groups, including tannins/phenols and flavonoids was carried out. All tests were performed as triplicates and given marks from (-) to (+++) according to the strength of the colour or precipitate that appeared. Detection of tannins and phenols: About 2 g of the air-dried powder of coriander seeds were extracted with ethanol (50%) and tested for the presence of tannins and/or other Phenolic compounds using the following tests: Ferric chloride test: a few drops of ferric chloride solution (1%) were added to 2 ml of the extract, the appearance of bluish or greenish-black colouration indicates the presence of pyrogallol or catechol tannins, respectively.[31] Lead acetate test: fifty mg of the plant extract were dissolved in distilled water and to this, 3 ml of 10% lead acetate filtered clear solution were added. A bulky white precipitate indicates the presence of tannin and/or phenolic compounds.[32] Gelatin test: to the aqueous extract, 1% gelatin solution containing sodium chloride was added. The formation of a white precipitate indicates the presence of tannins.[33] Vanillin test: Five ml of the alcoholic extract of coriander seeds were mixed with 2 ml vanillin hydrochloric acid solution, precipitation indicates the presence of gallic acid.[33]

Detection of flavonoids: *C. sativum* seeds were tested for the presence of tannins flavonoid compounds using the following tests: Shinoda's test: one ml of 10% ethanolic extract of the coriander seeds was mixed with 0.5 ml of hydrochloric acid (10%) and a few mg of magnesium metal. Developing a reddish colour indicates the presence of flavonoids.[34] Lead acetate test: one ml of ethanolic extract was taken in a test tube and a few drops of lead acetate solution were added. The formation of a yellow colour precipitate indicates the presence of flavonoids.[34] Alkaline reagent test: one ml of aqueous solution of the extract is treated with 10% ammonium hydroxide solution. Yellow fluorescence indicates the presence of flavonoids.[35]

Statistical analysis

For the *in vivo* study, Data were expressed as mean±SE of 6 observations (n=6). The obtained data were statistically analysed by ANOVA followed by Tukey's post-hoc test ($p \leq 0.05$) using GraphPad prism® software. The pharmacological potential of CSSE was standardized against effect of Rosuvastatin as a %. Tests of

phytochemical analysis were done as triplicates; the qualitative positive results were expressed as +, ++, or +++ according to the intensity of coloration or precipitation.

RESULTS

Effects of CSSE on plasma lipid profile

Significant ($p \leq 0.05$) increase in plasma lipid (total cholesterol, TAGs, LDL, VLDL) levels have been recorded in samples collected from rats fed on a high-cholesterol diet, compared to those of negative control rats, with exception of HDL that have been decreased. Co-administration of rosuvastatin (2 mg/kg) and CSSE (150 and 300 mg/kg) along with a high-fat diet for 6 weeks resulted in a significant ($p \leq 0.05$) decrease in plasma lipids, compared to the hyper-cholesterolemic group (Table 1).

Effects of CSSE on hepatic function biomarkers

Significant ($p \leq 0.05$) decreases in plasma total protein and albumin levels have been detected in samples collected from rats fed on a high-cholesterol diet, compared to those of negative control rats, associated with insignificant changes in globulin levels. On the other hand, significant ($p \leq 0.05$) increases in plasma total and unconjugated bilirubins have been detected in samples collected from rats fed on a high-fat diet, compared to those of negative control rats, associated with decreased level of conjugated bilirubin. Liver enzymes (AST, LT and GGT) exhibited significant ($p \leq 0.05$ higher levels. Co-administration of rosuvastatin (2 mg/kg) and CSSE (150 and 300 mg/kg) along with a high-fat diet for 6 weeks resulted in significant ($p \leq 0.05$) reservations in these parameters, compared to the hyper-cholesterolemic group (Table 2-3).

Effects of CSSE on cardiac function biomarkers

Significant ($p \leq 0.05$) increases in plasma CK and Troponin-I levels have been detected in samples collected from rats fed on a high-cholesterol diet, compared to those of negative control rats. Significant ($p \leq 0.05$) decreases in these cardiac parameters have been obtained upon co-administration of rosuvastatin (2 mg/kg) and CSSE (150 and 300 mg/kg) along with a high-fat diet for 6 weeks, compared to the hyper-cholesterolemic group (Table 4).

Table 1: Effects of CSSE on plasma lipid profile.

Groups	Cholesterol (mg/dl)	TAGs (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)	HDL (mg/dl)
1	85.00±5.774	87.33±3.323	66.83±2.182	16.00±1.880	45.83±1.579
2	261.8±14.97	342.5±10.94	163.0±8.206	68.17±2.400	28.00±1.291
3	163.7±8.273	126.7±7.877	98.17±2.926	25.00±1.461	50.50±1.727
4	227.8±11.57	181.3±5.886	138.3±3.801	38.00±1.183	31.50±1.607
5	176.7±8.531	148.7±3.180	111.7±3.471	30.50±0.764	45.83±2.386
6	77.17±5.199	86.00±2.733	64.50±2.094	17.50±0.764	46.17±1.493
7	72.33±5.239	80.17±3.156	60.50±2.566	16.67±0.882	45.00±1.633

Values are presented as means±SE of 6 rats/group. Means within a column with different letter superscripts are significantly different ($p \leq 0.05$, ANOVA followed by Tukey's post-hoc).

Effects of CSSE on renal function biomarkers

Significant ($p \leq 0.05$) increases in plasma urea, creatinine and uric acid levels have been detected in samples collected from rats fed on a high-cholesterol diet, compared to those of negative control rats. Significant ($p \leq 0.05$) decreases in these renal parameters have been obtained upon co-administration of rosuvastatin (2 mg/kg) and CSSE (150 and 300 mg/kg) along with a high-fat diet for 6 weeks, compared to the hyper-cholesterolemic group (Table 3). For all results, the protection % produced by small and large doses of CSSE were dose-dependent and parallel to that of rosuvastatin. There were no significant differences among CSSE groups (at both doses) in comparison to the negative control group.

Detection of tannins/phenols and flavonoids in CSSE

Preliminary phytoanalysis of CSSEs revealed presence of tannins/phenols and flavonoids indicated positive results of the corresponding tests (Table 5).

DISCUSSION

Hyperlipidaemia is a disease condition characterized by elevated lipid levels in the blood. The increase in lipids like cholesterol, LDL, and triglycerides are mainly responsible for this condition. These lipids are associated with plasma proteins and remain in the blood (lipoproteins). The causes of hyperlipidaemia include a defect in lipoprotein lipase activity or the absence of the surface apoprotein C-II, nutritional disturbances, genetic abnormalities and environmental factors.[36] Blood lipids

originate from two sources, endogenous lipids, which are synthesized in the liver, and exogenous ones, which are ingested and absorbed. A subject's lipid profile is a panel of blood tests that serves as an initial broad medical screening tool for lipid abnormalities, the results may identify certain disease condition, determine risk factors for disease, and evaluate therapeutic agents.[37] Because of the risk of high hyperlipidaemia, researchers are doing their best to find medicines and solutions to treat this phenomenon. In the present study, it has been found that *Coriandrum sativum L.* seeds is a valuable antihyperlipidemic agent indicated by the following findings and may be used in the treatment of hyperlipidaemia.

Table 2: Effects of CSSE on hepatic function biomarkers (proteins and bilirubins).

Groups	Total protein (g/dl)	Albumin (g/dl)	Globulins (g/dl)	Total Bilirubin (mg/dl)	Unconju. bilirubin (mg/dl)	Conjug. bilirubin (mg/dl)
1	8.000±0.53	4.883±0.311	2.817±0.251	0.377±0.025	0.820±0.077	0.165±0.013
2	3.533±0.422	2.750±0.188	2.633±0.240	2.798±0.161	2.083±0.130	0.118±0.011
3	6.417±0.352	4.517±0.230	2.863±0.245	1.107±0.099	1.113±0.057	0.218±0.011
4	3.767±0.291	2.867±0.182	2.715±0.242	1.800±0.107	1.615±0.161	0.142±0.014
5	6.167±0.279	4.283±0.215	2.800±0.142	1.160±0.082	1.228±0.116	0.180±0.008
6	7.983±0.444	5.100±0.297	2.733±0.243	0.318±0.019	0.755±0.059	0.188±0.011
7	8.150±0.449	5.217±0.270	2.808±0.248	0.303±0.022	0.775±0.054	0.174±0.011

Table 3: Effects of CSSE on hepatic function biomarkers (Transferases).

Groups	AST (U/l)	ALT (U/l)	GGT (U/l)
1	30.17±1.167	33.33±2.028	28.17±1.815
2	60.67±2.171	79.00±2.781	29.67±1.542
3	41.00±2.436	43.17±1.493	28.33±1.706
4	53.50±2.349	65.50±2.187	28.83±1.740
5	44.50±2.849	47.00±2.436	27.50±1.875
6	30.83±0.946	32.67±1.978	28.33±1.926
7	29.00±1.183	33.17±2.023	27.17±1.470

Values are presented as means±SE of 6 rats/group. Means within a column with different letter superscripts are significantly different ($p \leq 0.05$, ANOVA followed by Tukey's post-hoc).

Table 4: Effects of CSSE on cardiac and renal function biomarkers.

Groups	CK-MB (U/l)	Troponin-I (ng/ml)	Urea (mg/dl)	Creatinine (mg/dl)	Uric acid (mg/dl)
1	122.0±11.65	0.050±0.009	32.67±2.459	0.975±0.095	3.917±0.273
2	229.3±8.015	0.215 ±0.022	64.00±4.619	2.033±0.149	7.700±0.227
3	135.7±7.182	0.082±0.011	38.00±1.317	1.080±0.084	4.533±0.255
4	196.7±10.54	0.143 ±0.013	53.83±4.126	1.867±0.145	6.983±0.149
5	153.3±6.791	0.113±0.014	40.17±1.493	1.245±0.174	5.250±0.195
6	114.2±9.167	0.042±0.008	30.50±2.527	0.943±0.087	3.867±0.318
7	104.5±10.78	0.038±0.007	29.17±2.414	0.913±0.081	3.683±0.309

Values are presented as means±SE of 6 rats/group. Means within a column with different letter superscripts are significantly different ($p \leq 0.05$, ANOVA followed by Tukey's post-hoc).

In the present study, hyperlipidaemia has been induced by 42-day supplementation of a high-cholesterol diet (cholesterol and coconut oil 1.5 % w/w, each). As expected, marked alterations in the measured lipid parameters of rat groups kept on such diet have been observed. This model of hyperlipidaemic animal was utilized to evaluate the possible protection mediated by a hydro-ethanolic extract prepared from CSS. In the present study, plasma cholesterol concentration in samples from rats kept on a high-cholesterol diet throughout the 42-day experimental period was elevated compared to that of the normal control animals However Administration of CSSE significantly decreased plasma cholesterol concentration in rats receiving a high-cholesterol diet compared to the diseased untreated ones. The hypo-cholesterolemic effect of CSSE could be attributed either improved metabolism and/or decreased absorption by the contained to its phytochemical groups, especially flavonoids that is proved in the present study. The activity of HMG COA reductase may be reduced by flavonoids.[38] These data may be consistent with those data reported by Dhanapakiam who found elevation in serum cholesterol

concentration in samples from female albino rats kept on a high-fat diet (coconut oil 15% and cholesterol 2%) throughout the 75-day experimental period.[7] Elevated serum cholesterol level is expected after high-fat diet supplementation and the inhibited clearing rate of LDL-C from the blood due to some defect in LDL receptors associated with elevated plasma total cholesterol values above normal levels. Additionally, these data may be consistent with those reported by Ramadan who found that the administration of coriander and oil blend a mixture of soybean oil, coriander oil and sunflower oil (4:2:4, w/w/w; blend) decreased profile of plasma lipids in 24 male albino rats placed on a cholesterol-rich (1%) basal diet as compared to rats on a cholesterol-free basal diet.[39] The levels of bioactive sterols and tocopherols were higher in coriander than in the blend.

Table 5: Detection of phenols and flavonoids in CSSE.

Active group	Test	Result
Tannin	Gelatin	-
	Lead acetate	-
	Phenazone	-
	$FeCl_3$ test	-
Phlobatannin	Hydrochloric acid test	±
Gallic acid	Vanillin test	++
Flavonoids	Shinoda's test	++
	Wilson's	++
	Lead acetate	++
	Alkaline reagent	++

Detection tests were performed as triplicates and given marks from (-) to (+++) according to the strength of the colour or precipitate that appeared.

In the present study, plasma TAG concentration was elevated in rats kept on a high-cholesterol compared to that of the control ones. However, administration of CSSE significantly decreased this effect. The hypo-triglyceridemic effect of CSSE could be attributed to its phytochemical content. This may produce significant increase in β-hydroxy, β-methyl glutaryl CoA reductase and plasma lecithin cholesterol acyltransferase activities that enhance hepatic bile acid synthesis and the increased degradation of cholesterol and triglycerides to faecal bile acids.[40] These data may be consistent with those reported by Parsaeyan who found that the coriander seeds powder consumption for 6 weeks in type 2 diabetic patients significantly reduced plasma triglycerides.[10] Additionally, these data may be consistent with those reported by Chithra who showed decreased concentrations of cholesterol and triglycerides, and increased phospholipid in rats with 1, 2-dimethyl hydrazine-induced colon cancer.[41]

Lipoproteins are specialized particles responsible for transportation of lipids throughout the bloodstream. These are transport carriers for fatty acids, cholesterol, and their esters. They are categorized according to their lipid/protein proportions into chylomicrons, VLDL, LDL, and HDL. The different lipoproteins combined with protein molecules known as apolipoproteins which act as lipid transfer proteins.[42] In the present study, plasma LDL & VLDL concentrations in samples from rats kept on a high-cholesterol diet throughout the 42-day experimental period were elevated compared to that of the normal control animals. Administration of CSSE significantly decreased plasma LDL and VLDL concentration in rats receiving a high-cholesterol diet compared to the diseased untreated ones. The improving effect of CSSE could be attributed to its phytochemical content. These data may be consistent with those data reported by Asgarpanah who detected flavonoids among other phytochemicals from *C. sativum*.[43] On the other hand, these data may not be consistent with those data reported by Mohammed who found that coriander powder had no significant effects on cholesterol, HDL, LDL and VLDL, while it significantly decreased triglycerides in Awassi ewes considered for the experimental duration of 56 days.[44] Ewes were divided randomly into four representative groups each including four ewes fed on concentrate: rough ration and two concentrates (30:70 and 70:30) with or without the addition of 6 g/head/day to the concentrate feeding of the ewes at 8 am every day after feeding Alfalfa hay. The authors attributed this finding to the volatile oils, tannins and saponins of the coriander which are very important in the inhibition of the build-up of triglycerides to prevent their accumulation in the blood. In the present study, liver enzymes (AST, ALT, GGT) in samples from rats kept on a high-cholesterol diet throughout the 42-day experimental period were increased compared to that of the normal control animals. However, administration of CSSE significantly decreased plasma liver enzyme activities in rats receiving a high-cholesterol diet compared to the diseased untreated ones. The hepatoprotective effect of CSSE could be attributed to its flavonoid phytochemical content which has antioxidant activity. These data may be consistent with those data reported in Thioacetamide-hepato-intoxicated rats, normal broiler chickens [11] and alloxan-diabetic rabbits.[9,45] The hepatoprotective effect of coriander may be contributed to the high content of active components especially phenolics and flavonoids. Non-enzymatic hepatic markers, including protein and bilirubins have been also improved upon coadministration of CSSE. The decreased albumin synthesis and conjugation capacities observed in diseased rats, have been maintained by CSSE.

In the present study, plasma CK-MB and troponin-I have been increased in hyperlipidaemic rats. Administration of CSSE significantly decreased these elevated cardiac parameters. The markers are increased after cardiac myocyte injury caused by elevated cholesterol level.[46] These data may be consistent with those of Patel who reported the effect of *C. sativum L. (CS)* in Isoproterenol-induced cardiotoxicity model in male Wistar rats.[47] Rats were pre-treated with methanolic extract of CS seeds at a dose of 100, 200 or 300 mg/kg orally for 30 days and they were subsequently administered (subcutaneous) with the cardiotoxin (85 mg/kg body weight) for the last two

days. Cardiac-injured rats showed increased plasma lipids and markers of cardiac damage and while methanolic extract of CS prevented myocardial infarction by inhibiting myofibrillar damage. The authors added that such cardioprotective effect is attributed to the rich polyphenolic content of CS extract.

In the present study, plasma creatinine, urea and uric acid have been elevated in high-fat-fed rats indicating renal dysfunction. This dysfunction is markedly restored upon co-administration of CSSE based on its phytochemical content. These data may be consistent with those conducted on human study showed that coriander can enhance urinary excretion of toxic metals like mercury, lead, and aluminium. The study recommended that the whole plant of coriander from seeds, leaves, and stalks seems to be a promising natural chelating agent for toxic heavy metals.[13] The data may be supported by those reported by Donia who found that coriander increased the serum levels of vasodilator factors (PGI2, NO, and eNOS), decreased Na+ retention and serum uric acid (UA) level, and ameliorated glucolipid profiles in high-fructose and high-salt diet-induced hypertension by mitigating abnormal changes in vascular endothelial function, renal and intestinal sodium absorption, glucolipid homeostasis, and gut microbiota in rats.[48]

CONCLUSION

In conclusion, data of the present study may indicate that CSSE has a marked antihyperlipidemic effect and could be a source for a promising nutraceutical drug with improving effects on lipid profile, cardiac function, and hepatorenal function based on its high phenolic and flavonoid content.

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