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Antidiabetic and antihyperlipidemic activities of *Cucumis melo* var. *momordica* fruit extract on experimental animals

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Abstract

Background: Diabetes mellitus is a major public health issue related to the irregular metabolism of carbohydrates, protein, and fat. It occurs due to insufficient insulin production and insulin action. *Cucumis melo* possesses several biological properties including antioxidant, anti-inflammatory, antibacterial, antihypothyroidism, and antiangiogenic activities. The objective of the present study was to determine the antidiabetic and antihyperlipidemic activities of *Cucumis melo* var. *momordica* fruit extract on experimental animals.

Result: Results show that treatment with *C. melo* fruit extract and fraction caused a reduction in blood glucose levels. *Cucumis melo* toluene fraction (CMTF) exhibited a significant ($*P < 0.05$) reduction of blood glucose level on the 28th day, i.e., 122 mg/dL, in comparison with the positive control group (streptozotocin (STZ)). However, the extract of *C. melo* showed less significant results in comparison with CMTF. Triglyceride, LDL, and VLDL levels were increased chronically due to STZ and were significantly ($*P < 0.05$) restored to 84.16, 86.97, and 19.73, respectively, by CMTF in comparison with the positive control group (STZ in the dose of 55 mg/kg). The extract-treated groups also showed similar results as CMTF, but their efficacy was lesser than CMTF.

Conclusion: It can be concluded that *C. melo* fruits can be used as an effective antidiabetic and antihyperlipidemic drug.

Keywords: *Cucumis melo*, Streptozotocin, Diabetes, Triglyceride, Lipoproteins

Background

Diabetes mellitus is a metabolic syndrome, characterized by high blood glucose levels that affect life's standard, and imposes a huge economic burden in society [1]. It occurs it is due to insufficient insulin production and insulin action. It has become one of the major public health issues [2]. It has become the seventh leading cause of death worldwide [3]. Diabetes mellitus can be divided into two categories: type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM) [4]. T1DM is an autoimmune disorder in which pancreatic β cells are unable to produce sufficient insulin due to its destruction [5]. In T2DM, sufficient insulin is produced

from β cells, but cells become tolerant to use the available insulin, i.e., insulin resistance [6]. One of the major metabolic syndrome associated with diabetes is hypertriglyceridemia. It is the condition of increased triglyceride levels in the blood that makes the condition worse. Noticeably, the major adverse effect of hypertriglyceridemia is acute pancreatitis, in addition to other lipid abnormalities such as hypercholesterolemia, cardiovascular diseases, and obesity [7, 8]. Diabetes is associated with lipid abnormalities in the body with reduced high-density lipoprotein (HDL) and raised low-density lipoprotein (LDL), very low-density lipoprotein (VLDL), and triglycerides (TG) levels [9].

Cucumis melo var. *momordica* (Roxb.) Duthie et Fuller is an ancient herb that belongs to the family Cucurbitaceae. It is a horticulture crop found across the globe [10, 11]. *C.*

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melo is a native herb of India and used as a vegetable [12]. It has several varieties of fruit traits found in nature and largely cultivated for fruit production all over the world [13, 14]. It has been used in the treatment of ulcers, bronchitis, eye infection, and fever due to the presence of active phytoconstituents [15]. The phytoconstituents present in *C. melo* are β -carotenes, multiflorenol, and a range of secondary metabolites including glycolipids, terpenoids, flavonoids, carbohydrates, and apocaretonoids [16, 17]. It possesses several biological properties including antioxidant, anti-inflammatory, antibacterial, antihypothyroidism, and antiangiogenic activities. The fruit peel extract of *C. melo* also possesses lipid-lowering properties [18]. Thus, the present study was designed to determine the antidiabetic and antihyperlipidemic activities of *C. melo* fruits based on its traditional medicinal uses by the ethnic groups and interrelationship between the pathophysiology of both diseases.

Methods

Collection, identification, and authentication

The ripe fruits of *Cucumis melo* var. *momordica* were collected from the gangatic areas of district Allahabad during the spring season. The fruits were identified and authenticated by the Botanical Survey of India with voucher specimen number GC 950221.

Extraction of *Cucumis melo* fruits

The fruits were peeled off, sliced, and dried under shade then grounded to make powder and sieved through a mesh size of 20 (0.841 mm). The coarse fruit powder of *Cucumis melo momordica* Duthie and Fuller was defatted with petroleum ether and extracted with ethanol as a solvent. The dried powder sample (20 g) was added into the solvent (300 ml) and stirred for 24 h. The solution was filtered using Whatman filter paper and evaporated the filtrate in an incubator at 40 °C. The extract was dried in a rotary evaporator (Buchi) and stored at 40 °C until further use [19].

Physicochemical evaluation

Physicochemical parameters of *Cucumis melo* evaluated in this study were foreign matter, moisture content, total ash, water-soluble ash, acid insoluble ash, and swelling index. It was determined according to Mushtaq et al. [20].

Reaction of different reagents with powdered drugs

The powdered drug of *C. melo* was treated with several reagents such as sodium hydroxide (NaOH), nitric oxide (HNO₃), hydrochloric acid (HCl), sulfuric acid (H₂SO₄), acetone, and chloroform (CHCl₃). It was further observed under UV and visible light to note the color produced after treatment using a microscope [21].

Fluorescence analysis of *C. melo* powder

Fluorescence analysis of *C. melo* powder was performed by exposing the powder to sunlight and UV rays (254 and 366 nm), then it was treated with different reagents as described above.

Experimental protocols

Animals

A total of 48 male Wistar rats were used in the study weighing 200–240 g (14 weeks old). They were obtained from the animal house of the institute. The study was approved by the Institutional Animals Ethical Committee (No. UIP/IAEC/2014/April/23). Animals were fed with pelleted diet and water ad libitum.

Acute toxicity study

Acute toxicity study was performed according to the OECD guideline 423.

Design of experiment

Animals were randomly divided into eight groups, and six animals were assigned to each group. Group 1 was the negative control (NC) group, which was a vehicle-treated group; group 2 was the positive control (PC) group, which was a toxicity-induced group; group 3 was the standard group, which was a group treated with glibenclamide, 10 mg/kg; groups 4 to 8 were the combined drug-treated groups in which group 4 was a *Cucumis melo* toluene fraction-treated (CMTF, 50 mg/kg) group, group 5 was a *Cucumis melo* ethanolic extract-treated (CMEE 1, 400 mg/kg) group, group 6 was a *Cucumis melo* ethanolic extract-treated (CMEE 2, 200 mg/kg) group, group 7 was a *Cucumis melo* aqueous extract-treated (CMAE 1, 400 mg/kg) group, and group 8 was a *Cucumis melo* aqueous extract-treated (CMAE 2, 200 mg/kg) group.

Induction of diabetes

Streptozotocin (STZ) was used for the induction of diabetes in animals; for this, the animals were kept fasting overnight. STZ was given i/p, in a dose of 55 mg/kg. STZ was prepared in 10 mM citrate buffer (pH 4.5) and maintained on a high-fat diet [carbohydrate (48%), fat (22%), and protein (20%)] with the total calorific value of 44.3 kJ/kg throughout the study. The administration of STZ caused a raised blood glucose level in 1 week. Animals showing increased blood glucose levels of more than 250 mg/dL were included in the study [22]. It has been reported that low-dose STZ with a high-fat diet produced a natural pattern of diabetes. Single-injection of STZ has shown the highest successful rate (100%) in rats with increased fasting blood glucose levels and reduced plasma insulin levels [23].

Lipid profile

The lipid profile of animals was determined by collecting the blood from the retro-orbital route of STZ-induced diabetic animals on the 0th, 7th, 14th, 21st, and 28th days. The blood was centrifuged at 4000×g for 15 min to collect the serum and analyzed using enzymatic diagnostic kits (Cell Biolabs Inc., USA). The serum was analyzed for lipid profiles such as triglyceride (TG) and high-density lipoprotein (HDL). However, low-density lipoprotein and very low-density lipoprotein (VLDL) cholesterol were also determined using the Friedewald formula, i.e., LDL cholesterol = total cholesterol – (HDL + VLDL) [24]. All the analyses were done using an auto-analyzer (Merck, Germany).

Euthanasia

The animals were given i.v. injection of pentobarbital to depress the central nervous system followed by the stopping of breathing and then by cardiac arrest.

Statistical analysis

All the values are represented as mean ± standard error ($n = 6$), significantly different at $*P < 0.05$ in comparison with the positive control group and $\Delta P < 0.05$ in comparison with the negative control group analyzed by one-way ANOVA followed by Tukey's multiple comparison test.

Results

Physicochemical analysis

The physicochemical parameters of *Cucumis melo* fruit powder are shown in Table 1. The results exhibited that foreign matter 0.1% w/w, moisture content 9.5% w/w, total ash 26.92% w/w, water-soluble ash 21.0% w/w, acid insoluble ash 10.0% w/w, and swelling index 4.04 were present in the fruit powder of *C. melo*.

Reaction of reagents with powdered drugs

The powdered drug of *C. melo* was treated with different solvents and reagents such as water, NaOH, HNO₃, H₂SO₄, acetone, and CHCl₃. Mostly, the dark brown color was obtained. Table 2 shows the different color variations of *C. melo* in daylight and under UV light while treated with different reagents.

Table 1 Physicochemical investigation of *Cucumis melo* fruit powder

Parameter	Value (% w/w)
Foreign matter	0.1
Moisture content	9.5
Total ash	26.92
Water-soluble ash	21.0
Acid insoluble ash	10.0
Swelling index	4.04

Fluorescent analysis of *Cucumis melo* dried fruit powder

Separation of flavonoid

Yellow needle-shaped crystalline powder with sharp melting at 357 °C, soluble in alcohol and chloroform. UV spectrum showed maxima at 256 and 378 nm. The mass spectrum exhibited a molecular ion peak at 318.18 nm and a prominent base peak at 318.18 nm (Fig. 1).

Antidiabetic activity of *C. melo*

The administration of STZ caused a significant rise in blood glucose levels of more than 250 mg/dL in all treated groups. Treatment with *C. melo* fruit extract and fraction caused a reduction in blood glucose level from day 7 to the last day of treatment, i.e., the 28th day. *C. melo* toluene fraction (CMTF) of ethanolic extract exhibited significant ($*P < 0.05$) reduction of blood glucose level on the 28th day, i.e., 122 mg/dL in comparison with the positive control group. The order of glucose-lowering capacity of extract-treated groups was CMEE 1 > CMAE 1 > CMEE 2 > CMAE 2 (Table 3).

Antihyperlipidemic activity of *C. melo*

STZ caused dyslipidemia in all treated animals, which was restored by the treatment with *C. melo* fraction and extract. Triglyceride, LDL, and VLDL levels were increased chronically due to STZ, and were significantly ($P < 0.05$) restored to 84.16, 86.97, and 19.73, respectively, by CMTF in comparison with the positive control group (Table 4). However, HDL level was decreased in diabetes-induced animals, which was restored to 38.76 by CMTF. The extract showed dose-dependent restoration property as 92.22, 38.61, 97.01, and 22.83 of TG, HDL, LDL, and VLDL, respectively, by CMEE 1. Figures 2, 3, 4, and 5 show the graphical representation of TG, LDL, VLDL, and HDL profile, respectively, of animals after treated with *C. melo* extract and fraction.

Discussion

In the present study, *C. melo* fruit extract was used for the evaluation of antidiabetic and antihyperlipidemic activities. The phytochemical results obtained in our study followed the work of Alagar et al. [25] based on ash values and moisture content. The reaction of crude drug with reagents revealed mostly dark brown color in daylight. Our results are in agreement with Fahamiya et al. [26]. Fluorescent analysis of *C. melo* shown yellow crystalline powder with UV maxima between 256 and 378 nm. Similar results were reported by Ahmad et al. [21].

In this study, STZ in a dose of 50 mg/kg body weight was utilized as a diabetogenic operator to prompt diabetes in albino Wistar rats; loss in body weight was observed in STZ-induced diabetic rats. Antidiabetic study of *C. melo* fruit extract revealed that the toluene fraction of ethanolic extract was very potent in lowering

Table 2 Reaction of different reagents with powdered drugs

S. no.	Materials/treatment	Daylight (254 nm)	UV light (366 nm)	Color
1	Dried powder	Light brown	Light brown	Brown
2	Powder treated with dist. water	Light brown	Light brown	Dark brown
3	Powder treated with 1 N NaOH in water	Dark brown	Light black	Black
4	Powder treated with 1 N NaOH in methanol	Dark brown	Light green	Black
5	Powder treated with 50% HNO ₃	Brown	Green	Black
6	Powder treated with 50% HCl	Light brown	Light green	Dark brown
7	Powder treated with conc. HCl	Dark brown	Light black	Dark black
8	Powder treated with H ₂ SO ₄	Dark brown	Dark black	Black
9	Powder treated with acetone	Light green	Green	Light brown
10	Powder treated with CHCl ₃	Light green	Green	Dark brown

increased blood glucose levels. This effect of *C. melo* may be due to the enhanced insulin secretion, more absorption of glucose by skeletal muscle and adipose tissues, inhibition of absorption of glucose from the intestine, and inhibition of glucose production from liver cells [27]. Other reported works on herbal extracts hypothesized that the antidiabetic mechanisms are due to the pancreatic activity of beta cells, inhibition of insulin-degrading enzyme (insulinase), enhanced insulin sensitivity, and insulin-like activity [28]. *C. melo* leaf extract has reported antidiabetic and antihyperlipidemic activities [29].

The complications of diabetes originating from oxidative stress that may precipitate hypoglycemia postulated that its etiology involves oxidative stress perhaps as a result of hypoglycemia [30]. The elevated levels of blood glucose in diabetes produce oxygen free radicals, which cause membrane damage due to peroxidation of membrane lipids and protein glycation [31]. The action of diabetes-inducing agents produces reactive free radicals, which have been shown to be cytotoxic to the beta cells of the pancreas [32]. The diabetogenic action can be prevented by the superoxide dismutase, catalase, and other hydroxyl radical scavengers such as ethanol and

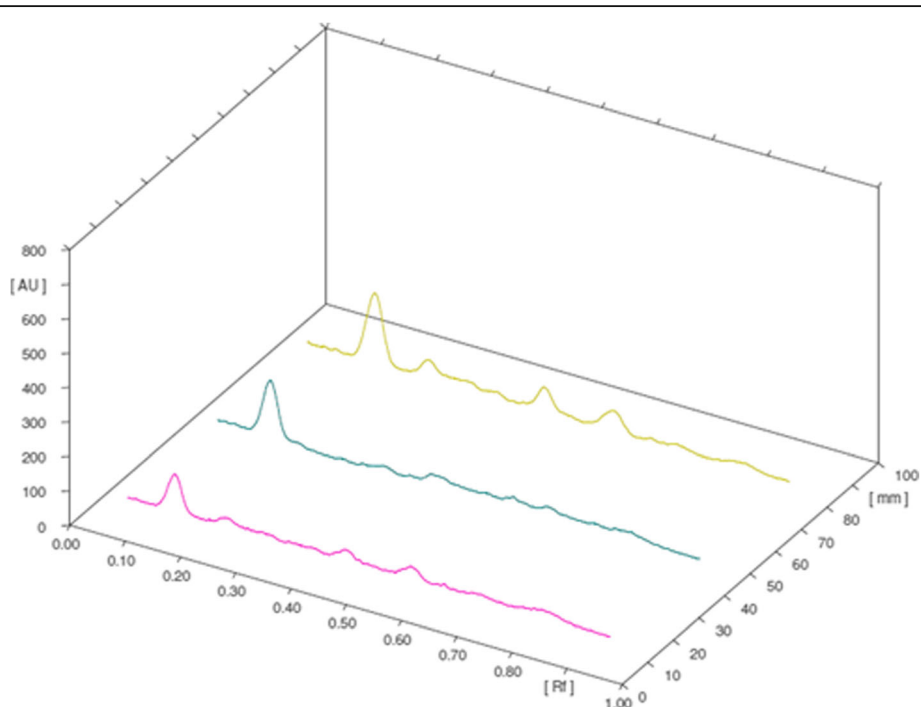


Fig. 1 HPTLC fingerprinting densitogram of *C. melo* fruit powder. Yellow line, ethanolic extract of *C. melo*; blue line, standard kaempferol; pink line, toluene fraction of ethanolic extract

Table 3 Antidiabetic activity of *C. melo* fraction and extracts

Treatment	Dose (mg/kg)	Blood glucose level (mg/dl)				
		Day 0	Day 7	Day 14	Day 21	Day 28
Negative control	–	88.83 ± 2.07	102.16 ± 2.18	109.66 ± 2.43	107.16 ± 1.78	76.50 ± 1.05
Positive control	–	299.66 ± 2.59*	287.66 ± 2.44*	287.00 ± 2.11*	288.66 ± 1.65*	279.50 ± 1.69*
References	10	278.50 ± 1.91	181.33 ± 2.29 ^Δ	144.00 ± 1.4 ^Δ	107.50 ± 1.4 ^Δ	76.16 ± 1.68 ^Δ
CMTF	50	279.16 ± 1.40	235.50 ± 1.34 ^Δ	200.16 ± 1.64	151.83 ± 1.62 ^Δ	122.00 ± 1.92 ^Δ
CMEE 1	400	285.83 ± 1.9	251.83 ± 2.09	214.66 ± 0.88 ^Δ	178.16 ± 0.98 ^Δ	160.16 ± 1.62
CMEE 2	200	293.13 ± 0.17	265.16 ± 0.70	230.12 ± 0.32	207.19 ± 0.25	195 ± 0.39
CMAE 1	400	254.35 ± 0.76	255.29 ± 0.14	238.94 ± 0.16	215.89 ± 0.72 ^Δ	190.69 ± 0.84
CMAE 2	200	278.67 ± 0.13	270.12 ± 0.32	250.31 ± 0.89	235.17 ± 0.54	224.94 ± 0.23

Values are expressed as mean ± standard error of mean (n = 6). *P < 0.05, vs the positive control group; ^ΔP < 0.05, vs the negative control group analyzed by one-way ANOVA followed by Tukey’s multiple comparison test
 CMTF *Cucumis melo* toluene fraction (ethanolic extract), CMEE 1 *Cucumis melo* ethanolic extract (400 mg/kg), CMEE 2 *Cucumis melo* ethanolic extract (200 mg/kg), CMAE 1 *Cucumis melo* aqueous extract (400 mg/kg), CMAE 2 *Cucumis melo* aqueous extract (200 mg/kg)

dimethyl urea; hence, there is evidence to suggest that the incidence of diabetes involves superoxide anion and hydroxyl radicals. There is clear cut evidence to show the role of free radicals in diabetes, and studies indicate that tissue injury in diabetes may be due to the free radicals.

Thus, the fruit extract of *C. melo* was evaluated for these biological activities. The active constituents found in *C. melo* seeds are phenolic acid (caffeic acid, gallic acid, rosmarinic acid, and protocatechuic acid), flavonoids (naringenin, apigenin, secoiridoids, luteolin-7-*O*-glycosides, pinoselinol, and amentoflavone), fatty acid (myristic acid, palmitic acid, stearic acid, arachidic acid, plamitoleic acid, oleic acid, linoleic acid, and linolenic acid), sterols (campesterol, stigmasterol, β-sitosterol, cholesterol, and brassicasterol), and tocopherol contents [33].

Especially, insulin deficiency provokes diabetic patients more prone to hypercholesterolemia and hypertriglyceridemia [34]. One of the major pathogenesis of lipid metabolism disturbances in diabetes is the increased mobilization of fatty acids from adipose tissue and

secondary elevation of the free fatty acid levels in the blood. One of the consequences of excessive mobilization of fatty acid is the production of ketone bodies in the liver. Excessive lipolysis remnants, i.e., free fatty acids, enter the liver and are esterified to form triglycerides [35]. Fatty acids are required for both the structure and function of every cell in the body, and they form an important component of cell membranes. Several authors have reported that the fatty acid compositions of various tissues are altered in both experimental and human diabetes [36, 37].

It has been reported that there is a direct correlation between diabetes and dyslipidemia. Diabetic patients have two- to fourfold higher risk of coronary artery disease; this condition is also termed as diabetic dyslipidemia [38]. Diabetic dyslipidemia is associated with raised triglycerides level and reduced HDL level. It is due to insulin resistance or deficient lipid metabolism in diabetes [39]. In our study, *C. melo* fruit extract significantly reduced blood glucose levels due to its antidiabetic potential and thus restored the

Table 4 Antihyperlipidemic activity of *C. melo* fraction and extracts

Groups	Dose (mg/kg)	TG (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)	HDL (mg/dl)
Negative control	–	71.83 ± 0.7	72.83 ± 0.72	10.65 ± 0.49	48.32 ± 1.9
Positive control	–	117.66 ± 1.47*	159.55 ± 1.03*	47.12 ± 0.93*	18.08 ± 1.28*
Reference	10	78.16 ± 1.56 ^Δ	76.26 ± 0.32 ^Δ	14.09 ± 0.69 ^Δ	45.86 ± 1.47 ^Δ
CMTF	50	84.16 ± 0.7 ^Δ	86.97 ± 0.34 ^Δ	19.73 ± 1.2 ^Δ	38.76 ± 2.68 ^Δ
CMEE 1	400	92.22 ± 0.84 ^Δ	97.01 ± 1.05 ^Δ	22.83 ± 0.33 ^Δ	38.61 ± 63 ^Δ
CMEE 2	200	102.33 ± 0.29	113.16 ± 0.89	38.87 ± 1.13	44.33 ± 0.32
CMAE 1	400	100.13 ± 0.23	105.16 ± 0.56	29.45 ± 0.05	42.05 ± 0.14
CMAE 2	200	105.12 ± 0.46	116.49 ± 1.10	41.54 ± 0.45	44.1 ± 0.43

Values are expressed as mean ± standard error of mean (n = 6), significantly different at *P < 0.05, vs the normal control group; ^ΔP < 0.05, vs the diabetic control group analyzed by one-way ANOVA followed by Tukey’s multiple comparison test
 CMTF *Cucumis melo* toluene fraction (ethanolic extract), CMEE 1 *Cucumis melo* ethanolic extract (400 mg/kg), CMEE 2 *Cucumis melo* ethanolic extract (200 mg/kg), CMAE 1 *Cucumis melo* aqueous extract (400 mg/kg), CMAE 2 *Cucumis melo* aqueous extract (200 mg/kg)

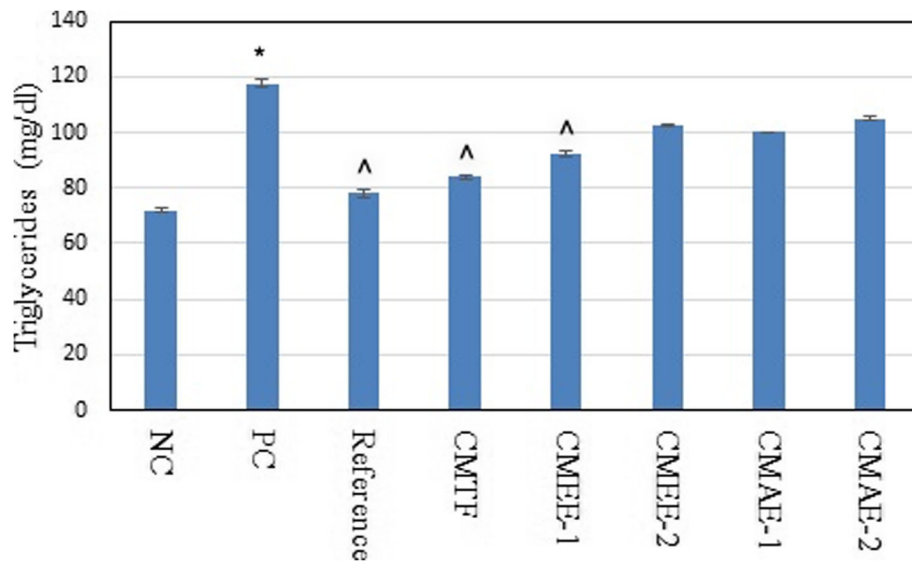


Fig. 2 Effect of *C. melo* fraction and extracts on the TG level of animals. Values are expressed as mean ± standard error of mean (n = 6), significantly different at *P < 0.05, vs the normal control group; [^]P < 0.05, vs the diabetic control group analyzed by one-way ANOVA followed by Tukey's multiple comparison test. CMTF, *Cucumis melo* toluene fraction (ethanolic extract); CMEE 1, *Cucumis melo* ethanolic extract (400 mg/kg); CMEE 2, *Cucumis melo* ethanolic extract (200 mg/kg); CMAE, *Cucumis melo* aqueous extract (400 mg/kg); CMAE, *Cucumis melo* aqueous extract (200 mg/kg)

lipid profile of diabetic rats. Our results were in agreement with Ahmed et al. [40], who reported that fruit extract possesses the ability to normalize blood glucose levels with a hypotriglyceridemic effect in STZ-induced diabetic rats.

Diabetes is also known to be associated with an increase in the synthesis of cholesterol, which may be due to the increased activity of HMG CoA reductase. A number of observations indicate that plasma HDL cholesterol is low in untreated insulin-deficient diabetics [41, 42], which was

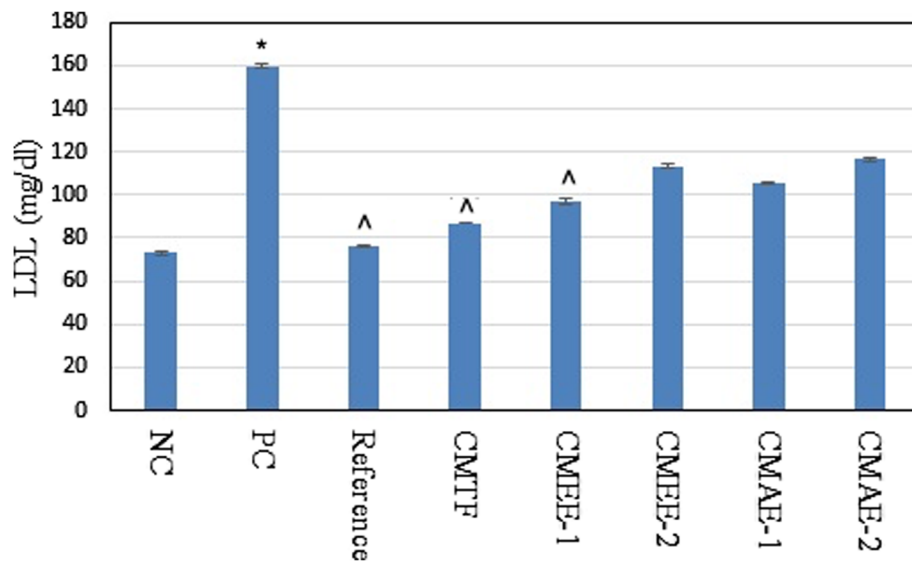


Fig. 3 Effect of *C. melo* fraction and extracts on the LDL level of animals. Values are expressed as mean ± standard error of mean (n = 6), significantly different at *P < 0.05, vs the normal control group; [^]P < 0.05, vs the diabetic control group analyzed by one-way ANOVA followed by Tukey's multiple comparison test. CMTF, *Cucumis melo* toluene fraction (ethanolic extract); CMEE 1, *Cucumis melo* ethanolic extract (400 mg/kg); CMEE 2, *Cucumis melo* ethanolic extract (200 mg/kg); CMAE, *Cucumis melo* aqueous extract (400 mg/kg); CMAE, *Cucumis melo* aqueous extract (200 mg/kg)

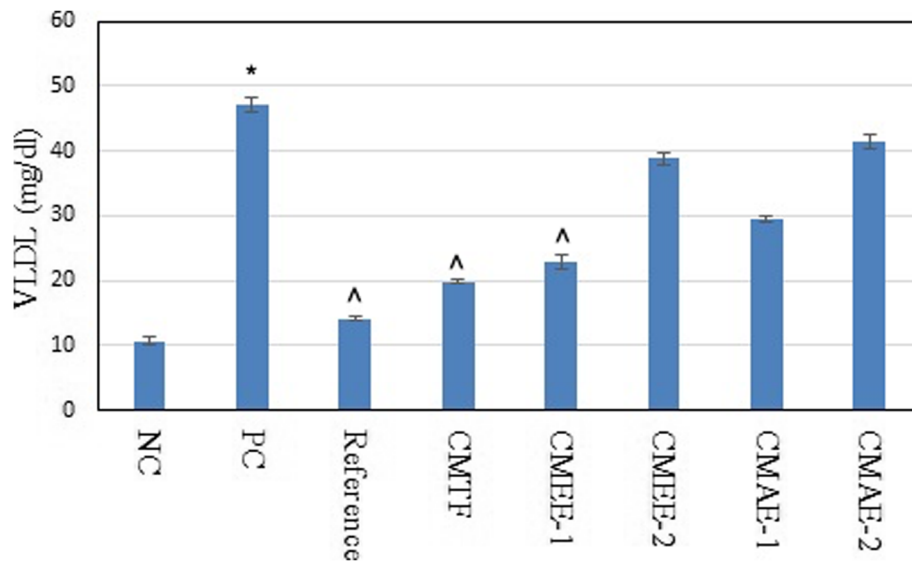


Fig. 4 Effect of *C. melo* fraction and extracts on the VLDL level of animals. Values are expressed as mean ± standard error of mean (n = 6), significantly different at *P < 0.05, vs the normal control group; ^P < 0.05, vs the diabetic control group analyzed by one-way ANOVA followed by Tukey's multiple comparison test. CMTF, *Cucumis melo* toluene fraction (ethanolic extract); CMEE 1, *Cucumis melo* ethanolic extract (400 mg/kg); CMEE 2, *Cucumis melo* ethanolic extract (200 mg/kg); CMAE, *Cucumis melo* aqueous extract (400 mg/kg); CMAE, *Cucumis melo* aqueous extract (200 mg/kg)

associated with a decline in HDL turnover rate. Further, the HDL cholesterol levels correlate with lipoprotein lipase (LPL) levels in IDDM patients. It is shown that VLDL and chylomicrons contribute surface apoproteins and lipids to HDL during hydrolysis by LPL. Increased LDL cholesterol from glycosylation has the ability to form lipid

peroxides which was found specifically responsible for the atherogenesis in diabetic patients [43]. There are reports that hypercholesterolemia in streptozotocin-induced diabetes in rats results from increased intestinal absorption and synthesis of cholesterol. Lipoproteins from diabetic rats are oxidized and demonstrate cytotoxicity, a feature

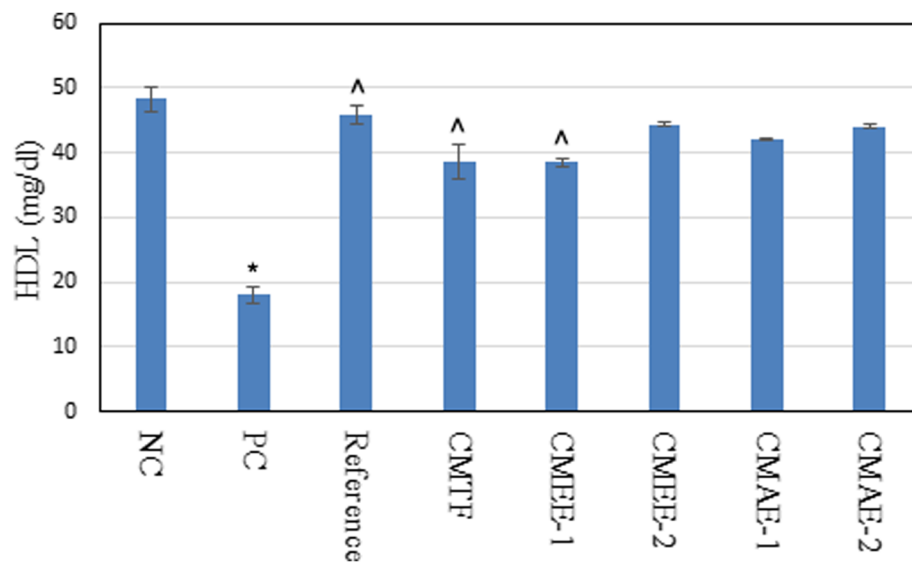


Fig. 5 Effect of *C. melo* fraction and extracts on the HDL level of animals. Values are expressed as mean ± standard error of mean (n = 6), significantly different at *P < 0.05, vs the normal control group; ^P < 0.05, vs the diabetic control group analyzed by one-way ANOVA followed by Tukey's multiple comparison test. CMTF, *Cucumis melo* toluene fraction (ethanolic extract); CMEE 1, *Cucumis melo* ethanolic extract (400 mg/kg); CMEE 2, *Cucumis melo* ethanolic extract (200 mg/kg); CMAE, *Cucumis melo* aqueous extract (400 mg/kg); CMAE, *Cucumis melo* aqueous extract (200 mg/kg)

which can be prevented by insulin or antioxidant treatment [44]. Oral administration of plant extracts normalized these effects, possibly by controlling the hydrolysis of certain lipoproteins and their selective uptake and metabolism by different tissues. The breakdown product of fat causes hypertriglyceridemia in diabetes mellitus and is responsible for vascular complications [45]. Bruan and Severson [46] have reported that deficiency of lipoprotein lipase (LPL) activity may contribute significantly to the elevation of triglycerides in diabetes. Lopes-Virella et al. [47] reported that treatment of diabetes with insulin served to lower plasma triglyceride levels by the restoration of triglycerides levels following extract treatment which is supported by the above reports. Thus, it may be concluded plant extracts may have a stimulatory effect on insulin. The elevated serum phospholipid levels are a consequence of elevated lipoproteins. The serum cholesterol/phospholipid ratio is one of the important markers of the development of atherosclerosis. The restoration of phospholipids by plant extract may be controlled mobilization of serum triglycerides; controlling the tissue metabolism and improving the level of insulin secretion and action presumably mediate cholesterol and phospholipids.

Conclusion

It was found that toluene fraction of *C. melo* fruit extract and ethanolic extract in 400 mg/kg was most effective against diabetes and dyslipidemia. A high level of TG with low levels of HDL exhibited a strong association with diabetes. It can be concluded that *C. melo* fruits can be used as an effective antidiabetic and antihyperlipidemic drug.

Abbreviations

T1DM: Type 1 diabetes mellitus; T2DM: Type 2 diabetes mellitus; LDL: Low-density lipoprotein; HDL: High-density lipoprotein; VLDL: Very low-density lipoprotein; TG: Triglycerides; CMTF: *Cucumis melo* toluene fraction; CME: *Cucumis melo* ethanolic extract; CMAE: *Cucumis melo* aqueous extract; STZ: Streptozotocin; HMG-CoA: 3-Hydroxy-3-methylglutaryl-coenzyme A; PPAR: Peroxisome proliferator-activated receptor-gamma

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Statement

The ripe fruits of *Cucumis melo* var. *momordica* were collected from the gangatic areas of district Allahabad during the spring season. The fruits were identified and authenticated by the Botanical Survey of India with voucher specimen number GC 950221.

Authors' contributions

All authors have read and approved the final manuscript. AKS designed the work. AM drafted the work or substantively revised it. AT contributed to the acquisition, analysis, and interpretation of the data.

Funding

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Availability of data and materials

All data and materials are available upon request.

Ethics approval and consent to participate

The animal study was approved by the Institutional Animal Ethical Committee (Approval No. UIP/IAEC/2014/April/23).

Consent for publication

Not applicable.

Competing interests

There is no competing interest.

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