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Original Research Article

Therapeutic potential of *Garcinia cambogia* and *Emblica officinalis* in the management of obesity and lipid profiles in a rat model of diet induced obesity

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ABSTRACT

Background: Obesity has emerged as one of the significant public health burdens across the globe, which predisposes the risk of cardiovascular diseases and metabolic dysfunctions. Medicinal plants can be possible therapeutic measures for managing obesity. *Garcinia cambogia* and *E. officinalis* have been used for their anti-obesity and hypolipidemic properties. The objective of this study was to evaluate and compare the anti-obesity and hypolipidemic effects of *Garcinia cambogia* and *E. officinalis* in a high energy diet-induced obese rat model.
Methods: A total 36 albino rats were included in the study. The animals were randomly divided into 6 groups of 6 rats each. Group 1 (control) received distilled water orally, Group 2 received Garcinia cambogia extract orally in dose of 200 mg/kg/day, Group 3 received Garcinia cambogia extract orally in dose of 400 mg/kg/day, Group 4 received E. *officinalis* extract orally in dose of 20 mg/kg/day, Group 5 received *E. officinalis* extract orally in dose of 40 mg/kg/day and Group 6 (standard) received Orlistat in dose 20 mg/kg/day. Parameters assessed included body weight and lipid profile (total cholesterol, triglycerides, LDL cholesterol, and HDL cholesterol).
Results: Both Garcinia cambogia and *Emblica officinalis* interventions demonstrated significant reductions in body weight gain and improvements in lipid profile compared to the HED group. The intervention groups exhibited notable decreases in total cholesterol, triglycerides, and LDL cholesterol levels, along with an increase in HDL cholesterol levels.
Conclusions: Our findings suggest that Garcinia cambogia and *Emblica officinalis* possess anti-obesity and hypolipidemic effects in a high energy diet-induced obese rat model. These naturals show promise as potential therapeutic agents for combating obesity and associated dyslipidemia. Further research is needed to understand and validate their efficacy in human populations.

Keywords: Anti-obesity agents, Hypolipidemic, High energy diet, Natural remedies for obesity

INTRODUCTION

Obesity means abnormal or excessive fat accumulation. It has become a major health issue worldwide, affecting even the healthiest people. It's also spreading to developing countries, making it a global problem.[1] This onset of increase in the prevalence of obesity has immense consequences, which impacts an individual health-related perspective, lifespan, and an excess cost load on the respective healthcare system.[2] The clinical implications of obesity are multilateral and include being linked to a whole spectrum of comorbidities, such as diabetes mellitus, cardiovascular diseases, and respiratory disorders.[3] Despite the plethora of interventions available, including pharmacological treatments like Orlistat and Phentermine, the development of safe and efficacious anti-obesity drugs

remains a significant challenge. This has prompted a shift towards exploring natural remedies as potential alternatives.[4] In natural remedies that can be used, among which the major contribution was made by the South Indian fruit, Garcinia cambogia, known to people for its use in Indian culinary and folk medicine.[5,6] Garcinia is a plant in the Clusiaceae family, often used for its flavor. It contains different natural compounds like flavonoids and organic acids. One of these acids, called hydroxycitric acid (or (-) hydroxycitric acid), is believed to help manage weight and fight obesity.[7] Another such example is *E. officinalis*, which is known as Indian gooseberry and is revered in the world of Ayurveda, and is popularly treated as a panacea. This study investigates some of the basic therapeutic potential for these naturally occurring remedies, with specific reference to the management of obesity-linked dyslipidaemias.

METHODS

The study was conducted in the Department of Pharmacology and Department of Biochemistry, Moti Lal Nehru Medical College, Prayagraj. The study was carried out in albino rats of either sex weighing between 100 and 125 g. The study period was 12 months (from July 2022 to June 2023). This research was a randomized, controlled, experimental study conducted to evaluate and compare the anti-obesity and hypolipidemic effects of Garcinia cambogia and *E. officinalis* in a rat model. Animals were obtained from registered animal sellers (B-37/0605003769) and were kept in the animal house of Moti Lal Nehru Medical College under the supervision of the veterinary doctor. The animals were housed at an ambient temperature of 25˚C±2˚C with a 12-hour light/dark cycle and provided with a standard pellet diet or high-energy diet and water ad libitum. The maintenance of the animals and the experimental procedures followed the guiding principles of the Institutional Animal Ethics Committee and CCSEA guidelines.

Test drugs

All the drugs were given orally as suspensions in 1 ml distilled water. Commercially prepared extracts of Garcinia cambogia and *E. officinalis* were procured from Himalaya Drug Company, Makali, Bangalore. Orlistat was purchased from Meyer Organics Pvt Ltd, Thane, Mumbai. The cholesterol and triglyceride estimation kit, used for the estimation of total cholesterol, HDL-Cholesterol, LDL-cholesterol, and triglyceride, was purchased from Span Diagnostics Ltd. Surat, India. All the chemicals and reagents used were of analytical grade.

Animals

A total of 36 albino rats were included in the study. The body weight of all the groups was recorded on day 0 and simultaneously blood sample was drawn to measure baseline lipid levels.

Animal model establishment

Obesity was induced in rats of all the groups by feeding them with high energy diets (energy%=carbohydrate 51.4%, fat 31.8%, and protein 16.8%) for 3 months. Rats with a weight gain of more than 40% were considered obese. Weight measurement and lipid profiling were again done after 3 months when obesity had been established. After 3 months all the rats were given normal rodent chow till the end of the study.

Experimental design

The animals were randomly (Table 1) divided into 6 groups of 6 rats each. The individual groups were caged separately and individuals in each group were marked using colour code to enable identification and follow-up. Each group was then administered respective drugs once daily for 3 months. The drugs were dissolved in distilled water and administered with respective drugs as under. Group 1- Obese rats received only distilled water (1 ml), and the vehicle (Obese control), Group 2-Obese rats received Garcinia cambogia at a dose of 200 mg/kg/day. Group 3- Obese rats received Garcinia cambogia at a dose of 400 mg/kg/day. Group 4- Obese rats received *E. officinalis* at a dose of 20 mg/kg/day. Group 5- Obese rats received *E. officinalis* at a dose of 40 mg/kg/day. Group 6- Obese rats received Orlistat at a dose of 20 mg/kg/day (Standard control).

Drug administration

The dosage of the drug to be administered to each animal was calculated based on body weight. The calculated dose was dissolved in 1 ml of distilled water and then loaded in a syringe fitted with a 16 G feeding needle. The rat was restrained, and while it was lying on the palm, a feeding needle was introduced from the side of the mouth into the pharynx and then let into the oesophagus, and drug was then injected into it.

Blood collection and biochemical assessment

For sampling, the rat was restrained using a rat restrainer. For warming of the rats, the animals were kept in the restrainer, under the 200 Watts electric bulb for about 20 mins before sampling. Blood from the lateral tail vein using a syringe with a 23G needle was collected. For the estimation of the Lipid Profile, CHOD-PAP method (for total cholesterol), PEG-CHOD-PAP method (for HDL), and GPO-PAP method (for triglycerides) were used.

Statistical analysis

The observations and results were analysed statistically using ANOVA and student t-test. For the study design, ANOVA and unpaired t-test have been used. ANOVA has been used to reveal that groups in the beginning of the study and after induction of obesity and hyperlipidemia, belong to the same population. Unpaired t-test has been

used to compare each group individually with control and standard. In the study, rats were divided into 6 groups of 6 rats each (n=36). At the beginning of study baseline values of body weight and lipid profile were done, which showed no significant difference from each other. Obesity was experimentally induced in all the groups by giving a high energy diet for 3 months, as mentioned in materials and methods. After this, rats were given rodent chow till the end of study i.e. total 6 months.

Table 1: Distribution of the animals in 6 groups and the administration of different combinations of drugs.

G. no.	Group description	Treatment	Dose
1	Obese control group	Distilled water	1 ml
2	*G. cambogia* low dose group	*G. cambogia*	200 mg/kg/day
3	*G. cambogia* high dose group	*G. cambogia*	400 mg/kg/day
4	*E. officinalis* low dose group	*E. officinalis*	20 mg/kg/day
5	*E. officinalis* high dose group	*E. officinalis*	40 mg/kg/day
6	Standard control group	Orlistat	20 mg/kg/day

RESULTS

Throughout the study period, all groups were under observation. Initial measurements of their body weight and lipid profile were taken at the commencement of the study. After a 3-month period of a high energy diet (HED), their body weights were recorded again and their lipid profiles were reassessed.

The animals received their respective medications for a duration of 3 months. The rats' weights were noted and their lipid profiles were evaluated at the conclusion of the 3rd, 6th, 9th, and 12th weeks. In every comparison made, the test group was treated as the second sample and was compared against the OC (vehicle) and standard (Orlistat) groups. A p-value of less than 0.05 was considered significant, while values greater than 0.05 were deemed not significant.

Baseline measurement of body weight and lipid levels among obese rats groups, control, and Orlistat treated group.

The baseline measurement of body weight and lipid levels among obese rats groups, control, and Orlistat treated group was monitored (Table 2). The body weight (gm) in obese control (OC), Groups 2-5, and orlistat control (OR) had mean (±SD) 116.33±5.35, 116.5±5.01, 115.5±5.08, 119±3.46, 117±3.57 and 114.5± 1.87 respectively.

Table 2: Baseline body weight and lipid profile summary (Mean±SD, n=6) in rats of 6 groups.

Variable	Obese control (OC)	Group 2	Group 3	Group 4	Group 5	Orlistat control (OR)	F value
Weight	116.33±5.35	116.5±5.01	115.5 ±5.08	119±3.46	117±3.57	114.5±1.87	0.770^{ns}
TC	36.04±3.23	36.2±2.89	37.64±1.31	34.33±2.41	37.67±2.41	34.21±2.67	2.180^{ns}
TG	28.62±2.95	27.16±1.08	28.83±2.06	27.09±1.44	29.12±1.72	26.76±1.03	1.913^{ns}
HDL	18.7±0.87	19.43±1.24	20.42±1.69	19.80±2.57	20.43±1.39	18.98±1.18	1.251^{ns}
LDL	11.60±3.35	11.34±3.48	12.45±2.26	9.09±3.56	11.21±2.96	9.87±3.01	0.918^{ns}

ns-p>0.05

On comparing the mean body weights together, ANOVA revealed similar mean body weight among the groups (F=0.770, p>0.05) i.e. mean baseline body weight did not differ significantly between the groups. (Table 2) The basal TC (mg/dl) in OC, Group 2-5, and OR had mean (±SD) 36.04±3.23, 36.2±2.89, 37.64±1.31, 34.33±2.14, 37.67±2.41 and 34.21±2.67 respectively. On comparing the TC levels of groups together, ANOVA revealed similar mean among the groups (F=2.180, p>0.05) i.e. mean baseline TC levels did not differ significantly between the groups. (Table 2)

The basal TG (mg/dl) in OC, groups 2-5, and OR had mean (±SD), 28.62±2.95, 27.16±1.08, 28.83±2.06, 27.09±1.44, 29.12±1.72 and 26.76±1.03 respectively. On comparing the mean TG of groups together, ANOVA revealed similar mean among the groups (F=1.913, p>0.05) i.e. mean baseline TG levels did not differ significantly between the groups (Table 2). The basal HDL (mg/dl) in OC, groups 2-5, and OR had mean (±SD), 18.7±0.87, 19.43±1.24, 20.42±1.69, 19.80±2.57, 20.43±1.39 and 18.98±1.18 respectively. On comparing the mean HDL levels of all groups together, ANOVA revealed similar mean among the groups (F=1.251, p>0.05) i.e. mean baseline HDL levels did not differ significantly between the groups (Table 2)

The basal LDL (mg/dl) in OC, groups 2-5, and OR had mean (±SD), 11.60±3.35, 11.34±3.48, 12.45±2.26, 9.09±3.56, 11.21±2.96 and 9.87±3.01 respectively. On

comparing the mean LDL levels of all groups together, ANOVA revealed similar mean among the groups (F=0.918, p>0.05) i.e. mean baseline LDL levels did not differ significantly between six groups (Table 2).

Body weight and lipid profile over the period of treatment

Observations of the rats' weight profiles across various groups over time showed a significant difference in the weight of the G1 group (*G. combogia*) rats, who were given a high energy diet (HED) of 200 mg/kg/day, compared to the OC group at the end of the 6th week (Table 3). This difference became highly significant (p<0.01) at the end of the 9th and 12th weeks. For the G2 group (*G. combogia*), which was fed with a HED of 400 mg/kg/day, the weight difference was highly significant (p<0.01) at the end of the 6th, 9th, and 12th weeks compared to the OC group (Table 3). The E1 (*E. officinalis* at 20 mg/kg/day) and E2 (*E. officinalis* at 40 mg/kg/day) groups also showed a significant weight difference at the end of the 9th and 12th weeks (Table 3).

Table 3. Weight (grams) of rats in various groups over the period of treatment.

Groups	Day 0	End of 3rd week	End of 6th week	End of 9th week	End of 12th week	Change in mean weight (in gm)	% change
OC	189.16	192.23	195.82	197.31	198.23	+9.07	4.71
G1	192.33	190.91	186.37$^{\alpha}$	181.75$^{\beta}$	175.31 $^{\beta}$	-17.02	8.84
G2	190.5	187.62	181.32$^{\beta}$	173.12$^{\beta}$	166.27$^{\beta}$	-24.23	12.71
E1	191.16	190.92	188.57	186.32$^{\alpha}$	185.12$^{\beta}$	-6.04	3.15
E2	190.16	189.31	187.12	184.23$^{\beta}$	181.57$^{\beta}$	-8.59	4.51
OR	190.5	180.18	172.57	166.58	159.83	-30.67	16.09

α: difference is significant (p<0.05) as compared to OC, β: difference is highly significant (p<0.01) as compared to OC, +: gain in weight, -: loss in weight, OC-Obese control (receiving vehicle), G1- G. combogia (200 mg/kg/day), G2- G. combogia (400 mg/kg/day), E1-E. officinalis (20 mg/kg/day), E2- E. officinalis (40 mg/kg/day), OR- Orlistat (20 mg/kg/day).

However, the administration of a high energy diet (HED) to the G1 and G2 groups (*G. combogia*) and the E1 and E2 groups (*E. officinalis*) resulted in significant differences in weight compared to the OC group. These differences were particularly pronounced at the end of the 6th week for the G1 group and at the end of the 6th, 9th, and 12th weeks for the G2 group. The E1 and E2 groups showed significant weight differences at the end of the 9th and 12th weeks (Table 3).

Monitoring of lipid profile

A monitoring in the total Cholesterol level showed that a reduction in values of total cholesterol is observed in all the test groups. G1 shows highly significant reduction by the 9th week while G2 shows highly significant reduction by the 6th week as compared to OC group (Table 4) whereas there was no significant difference found in G2 group at the end of 12th week as compared to OR.

Table 4. Total cholesterol (mg/dl) of rats in various groups over the period of treatment.

Groups	Day 0	End of 3rd week	End of 6th week	End of 9th week	End of 12th week	Change in mean weight (in gm)	% change
OC	102.55	103.71	103.95	104.12	103.21	+0.66	0.64
G1	102.60	101.53	99.87	96.83$^{\beta}$	92.73 $^{\beta}$	-9.87	9.61
G2	106.35	99.71	95.22$^{\beta}$	90.92$^{\beta}$	85.12$^{\beta,\gamma}$	-21.23	19.96
E1	100.60	100.25	100.15	99.57	98.92	-1.68	1.66
E2	101.84	100.32	99.75	97.21$^{\alpha}$	95.32$^{\beta}$	-6.52	6.4
OR	99.61	94.56	89.37	85.72	80.32	-19.29	19.36

α: difference is significant (p<0.05) as compared to OC, β: difference is highly significant (p<0.01) as compared to OC, γ: difference is non-significant (p>0.05) as compared to OR, + increase in TC -reduction in TC.

Table 5: Triglyceride values (mg/dl) of rats in various groups over the period of treatment.

Groups	Day 0	End of 3rd week	End of 6th week	End of 9th week	End of 12th week	Change in mean triglyceride values	% change
OC	87.59	87.94	88.12	89.32	88.18	+0.59	0.67
G1	88.37	88.12	86.31	85.18$^{\alpha}$	83.92 $^{\beta}$	-4.45	5.03
G2	88.59	85.23	81.15$^{\beta}$	78.14$^{\beta}$	75.13$^{\beta,\gamma}$	-13.46	15.19
E1	86.51	85.92	85.22	84.78$^{\alpha}$	83.98$^{\alpha}$	-2.53	2.92
E2	88.37	87.12	86.22	84.92$^{\alpha}$	83.71$^{\alpha}$	-4.66	5.27

Continued.

Groups	Day 0	End of 3rd week	End of 6th week	End of 9th week	End of 12th week	Change in mean triglyceride values	% change
OR	87.48	80.12	76.95	73.78	71.97	-15.51	17.72

Table 6: HDL-C (mg/dl) of rats in various groups over the period of treatment.

Groups	Day 0	End of 3rd week	End of 6th week	End of 9th week	End of 12th week	Change in mean HDL-C values	% change
OC	14.69	14.92	15.12	15.31	15.62	+0.93	6.33
G1	15.86	15.92	15.98	16.12	16.18	+0.32	2.01
G2	16.67	16.92	16.97	17.03	17.11	+0.44	2.63
E1	15.66	15.53	15.83	15.75	15.68	+0.02	0.12
E2	16.41	16.42	16.52	16.75	16.68	+0.27	1.64
OR	14.73	15.31	15.94	16.96	17.12	+2.39	16.22

+: increase in HDL-C

Table 7. LDL-C (mg/dl) of rats in various groups over the period of treatment.

Groups	Day 0	End of 3rd week	End of 6th week	End of 9th week	End of 12th week	Change in mean LDL-C	% change
OC	70.34	70.93	71.03	71.04	70.65	+0.31	0.44
G1	69.06	68.02	66.32^{α}	63.70^{β}	59.76^{β}	-9.3	13.46
G2	71.95	$65.80^{\alpha, \gamma}$	$62.71^{\beta, \gamma}$	$58.09^{\beta, \gamma}$	$53.65^{\beta, \gamma}$	-18.3	25.43
E1	67.63	67.59	67.27	66.93	66.46	-1.17	1.73
E2	67.75	66.90	66.03	63.92	62.27^{β}	-5.48	8.08
OR	67.38	63.36	58.37	54.22	48.12	19.26	28.58

$^{\alpha}$: difference is significant ($p<0.05$) as compared to OC, $^{\beta}$: difference is highly significant ($p<0.01$) as compared to OC, $^{\gamma}$: difference is non-significant ($p>0.05$) as compared to OR, +: increase in LDL-C, -: reduction in LDL-C

Table 8. Body weight and lipid profile summary (Mean SD, n=6) in rats of 6 groups after 3 months of HED

Variable	Obese control	Group 2	Group 3	Group 4	Group 5	Orlistat control	F value
Weight	189.16±8.15	192.33±6.02	190.5±7.28	191.16±7.02	190.16±6.79	190.5±5.08	0.145^{ns}
TC	102.55±3.43	102.60±3.88	106.35±3.84	100.60±3.36	101.84±4.94	99.61±3.85	2.102^{ns}
TG	87.59±2.54	88.37±1.99	88.59±2.40	86.51±2.67	88.37±2.82	87.48±3.79	0.487^{ns}
HDL	14.69±0.96	15.86±1.65	16.67±1.83	15.66±2.28	16.41±1.29	14.73±1.64	1.492^{ns}
LDL	70.34±3.41	69.06±3.39	71.95±4.20	67.63±4.91	67.75±4.95	67.38±3.31	0.180^{ns}

Monitoring of triglyceride values (mg/dl) of rats in various groups over the period of treatment revealed that G1, E1 and E2 groups resulted in significant reduction in triglyceride values from the 9th week as compared to OC (Table 5). On the other hand, G2 showed highly significant results from the 6th week itself. G2 also showed results comparable to OR in the 12th week (Table 5) showing no significant difference in triglyceride levels.

A monitoring of HDL-C revealed a slight increase in the values of HDL-C in all the six groups whereas the results were not significantly different from each other (Table 6). The LDL-C values were also monitored in all six groups and G1group showed significant reduction in the values of LDL-C in the 6th week while highly significant reductions from 9th week. G2 showed significant results right from the 3rd week, while highly significant results were seen from 6th week. The reductions brought about by G2 were also comparable to those of OR right from the end of the 3rd week, as they showed non-significant differences. E1 showed non-significant reductions in the LDL-C values. E2 managed to bring about highly significant reductions by the end of the 12th week 9 (Table 7).

Analysis of body weight and lipid levels across groups after obesity induction and high energy diet

During the study, the body weight and lipid profile of the rats (all six groups) were monitored after 3 months of high energy diet (HED). After 3 months of a (HED), the TC (mg/dl) in OC, Group 2-5, and OR were measured as 102.55±3.43, 102.55±3.43, 106.35±3.84, 100.60±3.84,

101.84±4.94 and 99.61±3.85 respectively. ANOVA revealed no significant difference in the mean TC levels among the groups (F=2.102, p >0.05), suggesting that the mean TC levels were consistent across all groups. (Table 8). The TG (mg/dl) in OC, groups 2-5, and OR were recorded as 87.59±2.54, 88.37±1.99, 88.59±2.40, 86.51±2.67, 88.37±2.82 and 87.48±3.79 respectively. ANOVA showed no significant difference in the mean TG levels among the groups (F=0.487, p>0.05), indicating that the mean TG levels were similar across all groups. (Table 8). After 3 months of HED, the HDL (mg/dl) in OC, groups 2-5, and OR were measured as 14.69±0.96, 15.86±1.65, 16.67±1.83, 15.66±2.28, 16.41±1.29 and 14.73±1.64 respectively. ANOVA revealed no significant difference in the mean HDL levels among the groups (F=1.492, p >0.05), suggesting that the mean HDL levels were consistent across all groups after obesity induction. (Table 8). The LDL (mg/dl) in OC, groups 2-5, and OR after 3 months of HED were recorded as 70.34±3.41, 69.06±3.39, 71.95±4.20, 67.63±4.92, 67.75±4.95 and 67.38±3.31 respectively. ANOVA showed no significant difference in the mean LDL levels among the groups (F=1.18, p>0.05), indicating that the mean LDL levels after 3 months of HED did not significantly differ among these groups. (Table 8).

From these results, we observed that there were no significant differences in the mean lipid levels (TC, TG, HDL, LDL) among the groups after obesity induction and 3 months of a high energy diet. This suggests that the respective treatments administered to each group did not significantly affect these parameters. We observed that the body weight in grams for OC, Groups 2-5, and OR were recorded as 189.16±8.15 g, 192.33±6.02 g, 190.5±7.28 g, 191.16±7.02 g, 190.16±6.79 g and 190.5±5.08 g respectively. Statistical analysis using ANOVA showed no significant difference in the mean body weights among the groups (F=0.145, p>0.05), indicating that the average weight after obesity induction was similar across all groups (Table 8) at the end of 3rd month indicating that HED from Garcinia cambogia and *E. officinalis* showed an approximately similar effect as of the standard drug Orlistat. A detailed comparative analysis showed that in the case of *E. officinalis*, both low (E1) and high dose (E2) groups showed significant weight reductions from the 9th week. Total cholesterol values showed significant reductions with the high dose (E2) from the 9th week but were not comparable to Orlistat. Triglyceride values showed significant reductions in both E1 and E2 from the 9th week but were not comparable to Orlistat. Slight, non-significant increases were observed in HDL-C values. LDL-C values showed significant reductions with the high dose (E2) by the 12th week but were not comparable to Orlistat.

Thus, our study shows that both Garcinia cambogia and *E. officinalis* possess anti-obesity and hypolipidemic effects, with Garcinia cambogia generally showing more pronounced effects compared to *E. officinalis*. The results indicate the potential therapeutic benefits of these natural remedies in managing obesity and associated dyslipidaemia.

DISCUSSION

Obesity is a major public health threat, and obesity rates have been alarmingly increasing in the last few decades. The estimates for global levels of overweight and obesity (BMI ≥25 kg/m²), suggest that over 4 billion people may be affected by 2035, compared with over 2.6 billion in 2020. This reflects an increase from 38% of the world's population in 2020 to over 50% by 2035 (exclude children under 5 years old). The prevalence of obesity (BMI ≥30 kg/m²) alone is anticipated to rise from 14% to 24% of the population over the same period, affecting nearly 2 billion adults, children and adolescents by 2035. The rising prevalence of obesity is expected to be steepest among children and adolescents, rising from 10% to 20% of the world's boys during the period 2020 to 2035, and rising from 8% to 18% of the world's girls.[7]

There are several drugs which are used to treat obesity but only few drugs are approved to treat obesity. Orlistat and Liraglutide are the most readily available and commonly prescribed anti-obesity medications. Semaglutide for diabetes is also available and used off-label for weight management. Other medications like Phentermine/Topiramate, Naltrexone/Bupropion, Lorcaserin, and Setmelanotide are not widely available or commonly prescribed for obesity treatment.[8,9] Conventional treatments for obesity typically use medications that either decrease appetite or prevent fat absorption. Although these drugs can provide short-term benefits, they often come with negative side effects, risk of regaining weight once the medication is stopped, and potential for misuse.[10] At present, due to high cost and potentially hazardous side effects of available drugs, the potential of natural products for treating obesity is under exploration and may be an excellent alternative strategy for developing future effective, safe anti-obesity drugs. A variety of natural products including crude extracts and isolated compounds from plants can induce body weight reduction and prevent diet-induced obesity. Therefore, they have been widely used in treating obesity.[11]

The plants chosen in this study *G. cambogia* and *E. officinalis*, claim to have anti-obesity effect as well as beneficial effects on lipid profile.[11,12,13] In this study, we investigated the anti-obesity and hypolipidemic effects of Garcinia cambogia and *E. officinalis* in a high-energy diet-induced obese rat model. Our findings are supported by numerous studies that have explored the efficacy of these natural remedies in managing obesity and dyslipidaemia. After 3 months of HED, the results have shown that all the groups showed an increase in mean body weight along with an increase in mean lipid levels as compared to the baseline values, except for HDL which showed a decline in levels. Garcinia cambogia, rich in hydroxy citric acid (HCA), has shown promising results in weight management and lipid profile improvement. In our study, significant reductions in

body weight and lipid levels were observed with both low and high doses of Garcinia cambogia. These results align with the findings of Onakpoya et al (2011), who reported that HCA significantly reduces body weight compared to a placebo.[13] Additionally, Vasques et al (2014) demonstrated that Garcinia cambogia effectively lowered lipid levels in obese women.[14] The primary mechanism by which Garcinia cambogia exerts its effects is through the inhibition of ATP-citrate lyase, an enzyme crucial for fatty acid synthesis. This inhibition reduces de novo lipogenesis and promotes glycogen synthesis, contributing to weight loss and improved lipid profiles.[15] Our study's findings confirm these mechanisms, as significant reductions in total cholesterol, triglycerides, and LDL-C levels were observed, particularly in the high-dose Garcinia cambogia group.

E. officinalis, commonly known as Indian gooseberry or amla, also exhibited significant anti-obesity and hypolipidemic effects in our study. The high-dose group showed notable reductions in body weight, total cholesterol, and triglycerides, consistent with the findings of Nazish and Ansari (2017), who reported significant anti-obesity and lipid-lowering effects of *E. officinalis* in high-fat diet-induced obese rats.[12] The lipid-lowering effects of *E. officinalis* are attributed to its rich antioxidant content, particularly vitamin C, tannins, and flavonoids. These bioactive compounds enhance lipid metabolism, reduce oxidative stress, and improve cholesterol catabolism, leading to significant improvements in lipid profiles.[16] Variyaa et al (2018) also reported that *E. officinalis* upregulates peroxisome proliferator-activated receptors (PPARs) and increases the activity of lipid oxidation enzymes, contributing to its hypolipidemic effects.[17]

While both Garcinia cambogia and *E. officinalis* demonstrated significant anti-obesity and hypolipidemic effects, *G. cambogia* generally showed more pronounced effects, particularly in weight reduction and lipid profile improvement. This difference in efficacy may be due to the distinct mechanisms of action of the active compounds in these plants. *Garcinia cambogia's* HCA primarily inhibits lipogenesis and suppresses appetite, while *E. officinalis* exerts its effects through antioxidant activity, enhancing lipid metabolism and reducing oxidative stress.[18,19] According to Uygun et al (2000), leptin may aggravate hepatic steatosis by increasing insulin resistance and affecting hepatocyte insulin signaling, both of which lead to elevated intracellular fatty acid levels. Therefore, downregulation of leptin, TNF-alpha, and PPARy2 gene expression may contribute to visceral fat accumulation in rat models of obesity caused by a high-fat diet Thus, pharmacological treatment of rats with HFD prevents an increase in these levels due to a decrease in body fat content.[20] The significant findings of our study suggest that Garcinia cambogia and *Emblica officinalis* could be potential natural alternatives for managing obesity and dyslipidemia. Their efficacy in reducing body weight and improving lipid profiles, along with their safety profile, highlights their therapeutic potential. These plant extracts offer a holistic approach to obesity management, targeting multiple metabolic pathways and providing a safer alternative to conventional pharmacotherapies.

Table 9: The trend of percentage (%) change in the mean values.

The trend of percentage	
Weight reductio	OR>G2>G1>E2>E1
Total cholesterol reduction	G2>OR>G1>E2>E1
TG values reduction	OR>G2>E2>G1>E1
HDL-C increment	OR>G2>G1>E2>E1
LDL-C reduction	OR>G2>G1>E2>E1

Thus, in our study, we have found that both Garcinia cambogia and *Emblica officinalis* possess anti-obesity and hypolipidemic activities.

Despite the promising results, our study has several limitations. The study was conducted on a small sample size of albino rats, and the results may not directly translate to humans. Additionally, the underlying mechanisms of action were not explored in detail, necessitating further research to elucidate the biochemical pathways involved. Future studies should focus on larger sample sizes and include clinical trials in human populations to confirm the efficacy and safety of these natural remedies. Investigating the molecular mechanisms and potential synergistic effects with other natural or synthetic agents could provide a deeper understanding of their therapeutic potential. Moreover, exploring the long-term effects and optimal dosing strategies will be crucial for their effective implementation in clinical practice.

CONCLUSION

In this study conducted on albino rats weighing between 100-125 g, we evaluated the anti-obesity and hypolipidemic effects of Garcinia cambogia and *Emblica officinalis* in HED-induced obese rats, comparing them with orlistat. The study's trend analysis indicated that both herbs possess therapeutic potential, with Garcinia cambogia generally outperforming *Emblica officinalis* in most parameters. These findings suggest promising avenues for natural remedies in managing obesity and dyslipidaemias. Nonetheless, further extensive studies are warranted to ascertain optimal dosing and elucidate the underlying mechanisms of action for these herbal agents.

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