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Original Research

Garcinia gummi-gutta's Effect on Polycystic Ovary Syndrome-Induced in Rats and Its Anti-Obesity Properties

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Abstract

This study evaluated the effects of *Garcinia gummi-gutta* (L.) N.Robson (GG) on polycystic ovary syndrome (PCO)-induced in rats and its anti-obesity properties. Fifteen Wistar rats were divided into three groups: control, 10 mg/kg Aqueous Extract of *Garcinia gummi-gutta* (AEGG), and 20 mg/kg AEGG. PCO was induced using Letrozole-oestradiol, confirmed by vaginal smear tests and weight gain. AEGG was screened for phenol (125.66±1.07 µg/mL) and flavonoid (102.66 ± 0.38 µg/ml) content, with its highest concentrations at 20 mg/mL. Pancreatic lipase inhibition showed AEGG's anti-lipase effect (66.24%) at 100 µg/mL, compared to orlistat (98.7%) at 1 µg/ml. Rats received 20 mg/kg of AEGG demonstrated the highest significant reduction in body weight (203.8 g ±1.45 SD) and serum luteinizing hormone (LH) levels (1.24 mIU/mL) compared to the 10 mg/kg group and control group. Anatomical examination showed a normal uterus and reduced ovarian cysts in both AEGG-treated groups compared to the control. AEGG, particularly at 20 mg/kg, significantly reduced body weight, LH levels, and reproductive anatomy in PCO-induced rats, while demonstrating potential anti-obesity effects despite lower lipolytic activity compared to orlistat. The study suggests that AEGG at 20 mg/kg offers benefits in managing PCO and preventing obesity.

Keywords: *Garcinia cambogia*; Polycystic ovarian disease; Obesity; Luteinizing hormone; Uterus; Ovary; Pancreatic lipase

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Introduction

Polycystic Ovary Syndrome (PCO or PCOS), also known as Stein-Leventhal syndrome, is an endocrine disease characterized by elevated androgen levels, menstrual irregularities, and small cysts [1,2]. It affects 6.5-8.0% of women worldwide and is linked to insulin resistance and obesity [3]. Elevated levels of gonadotropin-releasing hormone (GnRH) and luteinizing hormone (LH) are indicative of PCO, a hormonal imbalance leading to anovulation through androgen production [4]. Laboratory rats, with their short 4-5-day estrous cycle, are ideal for studying PCO. This rapid cycle allows researchers to observe physiological changes across multiple reproductive cycles within a relatively short period. Changes in the reproductive cycle, ovarian morphology, hormones, and factors linked to PCO development were analyzed in these models [5]. Estrous cycle has four phases: proestrus, where follicles mature and estrogen rises; estrus, or "heat," during which ovulation occurs; metestrus, marked by corpus luteum formation and progesterone secretion; and diestrus, a quiescent phase preparing the uterus for potential pregnancy [6]. In PCO, rats develop multiple cystic follicles, with a thickened theca cell layer and reduced granulosa cells, impairing folliculogenesis. This is accompanied by hormonal imbalances such as elevated LH, reduced follicle-stimulating hormone (FSH), and increased androgens, closely resembling human PCO [7].

Treatment of PCO focuses on correcting hormonal imbalances and activating follicles for menstruation. Medications like clomiphene, antidiabetic medications, anti-androgens, and oral contraceptives are effective but have side effects like multiple pregnancies and psychological disturbances [8]. Alternative treatments like herbal remedies are popular and affordable [9–14].

Garcinia gummi-gutta (L.) N.Robson (GG), synonym of *Garcinia cambogia* Desr., belonging to the Clusiaceae family, is a green fruit native to Sri Lanka, Nepal, and India, and is known by several vernacular names such as Malabar tamarind (English), Kudampuli (Malayalam), Goraka (Sinhalese), and Kodukkapuli (Tamil). This fruit has long been used as a natural nutritional supplement and medicinal plant for treating various ailments, including edema, intestinal parasites, rheumatism, and constipation [15]. Phytochemical analysis of GG has revealed the presence of alkaloids, flavonoids, phenolic compounds, saponins, tannins, carbohydrates, and proteins [16]. The major compounds identified include xanthones, benzophenones, and organic acids. Xanthones, known for their diverse biological activities, have been isolated from various parts of the plant, including garbogiol from the roots and rheediaxanthone A from the bark [17]. The fruit contains polyisoprenylated xanthones like oxy-guttiferone I, K, K2, and M [18]. Benzophenones, recognized for their pharmacological properties, include garcinol and isogarcinol from the bark, as well as guttiferones I, N, J, K, and M from the fruit [17-19]. Organic acids, particularly hydroxycitric acid (HCA), are the primary active components of the fruit, with HCA being identified as the major acid and other acids such as tartaric, citric, and malic acids present in smaller quantities [20-23], although some studies suggest that only HCA is present [24]. HCA lactone, also referred to as Garcinia lactone, has also been isolated from the fruit [25]. Its active ingredient, HCA, is effective in treating PCO symptoms by slowing the conversion of carbohydrates into fats [26-31]. However, there are conflicting reports of its anti-obesity potential with several studies on human subjects and cats that did not reduce body weight [32-35]. A recent study in rats with letrozole-induced PCO showed that AEGG could improve the regulation of the estrous cycle and ovarian histomorphological alterations [14]. So, the current study aims to evaluate the phytochemical quantification of flavonoid and phenolic contents, as well as the efficacy of AEGG (aqueous extract of *G. gummi-gutta*) in attenuating PCO-induced rodent model and its potential for pancreatic lipase inhibition through *in vitro* assessment.

Materials and Methods

Collection and authentication of the plant material

Sun-dried GG was collected from Shontikuppa village, Medekeri district, Karnataka, India (latitude 12º45’25.01” N; Longitude 75º81’92.25E; Altitude 915 m). The plant was authenticated and verified by Dr. P. Santhan PhD (Bot) Taxonomist (QCI – NABET) with the herbarium voucher number A7223. Sample was stored at room temperature (Figure 1).

Preparation of the Aqueous Extract

The sun-dried GG (100 g) was washed and steeped overnight, then ground into a fine paste after add-

Figure 1. Sundried *Garcinia gummi-gutta*

ing 100 mL of water. Then the mixture was cooked at 40ºC for around 40 minutes. The solution was allowed to cool down adding 10 mg of baking powder. Then AEGG was strained to remove the residues and impurities from it (Figure 2) and concentrated which yielded 700 mg. A portion of the 80 mg of the sample was separated to analyze the phenolic and flavonoid content and the remaining portion was used for pharmacological evaluation.

Phytochemical study

Practical yield of the product - GG 100 g on aqueous extraction yielded 700 mg (0.7%w/w)

Determination of total phenol content

The Folin-Ciocalteu method was used to determine the phenolic content of AEGG. Solutions of 10 mg/mL and 20 mg/mL of AEGG were prepared in distilled water, and 0.5 mL of Folin-Ciocalteu reagent was added to each, followed by 1.5 mL of a 20% sodium bicarbonate solution. The volume was then adjusted to 10 mL with distilled water, and the solution was kept at 25°C. After a 2-hour incubation, the absorbance was measured at 750 nm. A calibration curve with gallic acid as the standard allowed the phenolic content to be expressed as micrograms of gallic acid equivalents (GAE) per 100 g of dry mass [36,37].

Determination of total flavonoid content

AEGG was tested for its flavonoid content by a colorimetric method where 1ml of 10 and 20 mg/ ml of AEGG were prepared separately, and to that distilled water (4 mL), and 5% sodium nitrite solution (0.3 mL) was added. Then 10% Aluminum chloride (0.3 mL) was added precisely five minutes later. In the sixth minute, 1 M Sodium hydroxide (2 mL) was added and the volume was made up to 10 mL with water and stirred thoroughly, then absorbance was measured at 510 nm versus a blank (distilled water). Standard measurement was performed with quercetin. Samples were performed in triplicates. Plotting the calibration curve with the standard was done and the flavonoid values were reported as µg equivalent of quercetin equivalent (QE) per 100 g of dry mass [38].

In vitro Study

Bioactivity: Assessing Enzymatic Inhibition Against Pancreatic Lipase (PL))

The procedure outlined in the literature was followed with minor adjustments to determine the degree of enzymatic inhibition of the AEGG against the PL enzyme[39]. P-nitrophenyl butyrate (p-NPB) was used as a substrate to assess the activity of porcine pancreatic lipase (PPL). Just before use, PPL solution was prepared by slowly combining 10 mg of the enzyme with 10 mL of buffer solution (1 mg/mL). The standard drug Orlistat was prepared in varying concentrations (0.1–1 µg/ml) using the solvent dimethyl sulfoxide (DMSO). AEGGs were also prepared in DMSO in amounts of 25–100 µg/mL. To test lipase inhibitory action, AEGG or Orlistat were pre-incubated with PPL for 1 hour in a potassium phosphate buffer (0.1 mM, pH 7.2, 0.1% Tween 80) at 30 °C. To initiate the reaction, add 0.1 µL of p-NPB to a 100 µL final volume. A wavelength of 405 nm was used to measure the amount of para-nitrophenol generated in the reaction after 5 minutes of incubation at 30°C. Both with and without an inhibitor, the activity of the negative control was assessed. Using the following formula, the inhibitory activity (I) was calculated: The inhibitory response (I%) is calculated as

$100 - [(Y - y)/(X - x) \times 100]$,

Where Y represents activity in the presence of inhibitor; y represents negative control with the inhibitor; and X represents activity without the presence of inhibitor; x=negative control without inhibitor. To assess the activity of the negative control, DMSO was used.

Figure 2. Aqueous extract of *Garcinia gummi-gutta*

In vivo Experiment

Ethical Approval

This study was approved by the ethical committee of MASS Biotech Pvt. Ltd IAEC (ethics code: MB/IAEC/2023/01/05).

Experimental Animal and Dose

Overall, 15 rats aged 4 to 5 weeks were obtained from MASS Biotech Pvt. Ltd. The present study used 15 female Wistar rats under the institutional animal ethics committee (protocol no: MB/IAEC/2023/01/05). The sample size (n=15) was divided into 3 groups with every 5 rats. The control group was observational without supplementation, AEGG 10 mg/kg, and AEGG 20 mg/kg groups with supplementation.

Pharmacological Evaluation

Induction of PCO in rats

To induce PCO, the following medication compound

was administered for 5 days

a. Administering letrozole tablets: 3 tablets (7.5 mg daily) crushed and dissolved in distilled water fed to all 15 rats for 5 days so, each rat gets approximately 0.5 mg per day for 5 days [40].

b. Estradiol benzoate injection (1 mL/day = 1 mg of dose daily i.p.) was given for 5 days. This led to weight imbalance and vital abnormalities in the experimental rats [29,41]

The body weights of the rats were recorded before inducing PCO and after inducing PCO and a vaginal smear test confirmed the induction of PCO.

Dosing schedule /Supplementation of Garcinia cambogia

The graded dosages of AEGG were prepared in increments of 10 mg and 20 mg in 1 mL. To minimize cross-contamination, oral administration was performed with the rodent oral gavage ball tip end, which was alcohol sterilized after each dose. The mentioned experimental doses were followed for 15 days; on the 15th day of the supplementation of AEGG, blood samples from each group of experimental Wistar rats were carefully collected via retro-orbital puncture and acquired blood from the retro-orbital plexus for biochemical examination and the animals were sacrificed to study the anatomical changes of internal organs such as intestine and reproductive organs.

Serum hormone analysis

The obtained blood samples were let to stand at 4ºC for two hours. Every sample was centrifuged for 15 minutes at 4ºC at 3000 rpm. For the studies that followed, the serum was separated into 1.5 mL Eppendorf tubes and kept at − 80ºC. Serum hormone tests on LH were assayed using ELISA kits on Cobas e411 immunoassay analyzers according to the maker's direction (Roche Diagnostics, India. The product code LH (03561097190)) [30].

Dissection of rats

This procedure was carried out by selecting the Wistar rat from various groups such as the control and the supplemented groups of AEGG (10mg and 20 mg /kg/ p.o.). Each rat was subjected to an anesthesia chamber for 5 minutes using isoflurane USP (inhalation anesthesia). After the execution of the rats, the abdominal or lower part was cleaned with saline solution and a small incision was given by lifting the fat muscle with the help of sterilized Metzenbaum scissors. After cutting it wide open from the abdominal part towards the larynx, the intestinal and reproductive parts were identified and presented for interpretation.

Statistical Analysis

Data analysis was performed using PRISM.8 software version 8.2. (GraphPad Software Inc., San Diego, USA). Phenolic and flavonoid content, as well as pancreatic lipase activity for the AEGG was analyzed by linear regression analysis. Each value represents n=3. Animal studies data (n=5) were subjected to a two-way analysis of variance (ANOVA) for statistical comparisons of body weight ($P<0.05$)*, followed by a paired t-test was used to analyze statistical differences in the levels of serum luteinizing hormone ($P<0.0001$)#. All values are expressed as the mean±standard deviation (mean±SD).

Results

Total Phenolic content

The phenolic content of AEGG was assayed by Folin Ciocalteu, which consists of phosphomolybdic acid and phosphotungstic acid. The phenolic constituents present in the extract reduce it to oxides of tungsten and molybdenum, which give it a blue color. The color produced is correlated with the overall number of phenolic compounds present and reaches its maximum absorption in the 750 nm region, in accordance with Beer's Law, showing a regression coefficient (R^2) of 0.9949 (Figure 3). The equation of the standard curve is y=0.0113x-0.0075. Table 1 and figure 3 represent the analytical data for the phenolic content of AEGG.

Table 1. Analytical data for phenolic content of the AEGG

Concentration of extracts	Phenolic content (µg of GAE/ g dry material)
10 mg/mL	62.00±0.33
20 mg/mL	125.66±1.07

Determination of total flavonoid content

Using quercetin as a reference, the total flavonoid content of AEGG was determined using the aluminum chloride colorimetric test. Aluminum chloride combines with the hydroxide (C3 or C5) and keto (C4) groups of flavones and flavonols to generate acid-stable complexes. Furthermore, the ortho dihydroxide group also forms a suitable combination with the flavonoid A/B rings. At 510 nm, the concentration solution of quercetin (100-1000 ppm) exhibited Beer's Law compliance, as indicated by a regression coefficient (R^2) of 0.984. The standard curve's equation is y = 0.0005x + 0.1293 (Figure 4). The analytical data regarding the flavonoid content of AEGG is shown in table 2.

Table 2. Results of total flavonoid content of AEGG

Concentration of extracts	Flavonoid content (µg of quercetin equivalent/ g dry material)
10 mg/mL	52.66 ± 0.509
20 mg/mL	102.66 ± 0.38

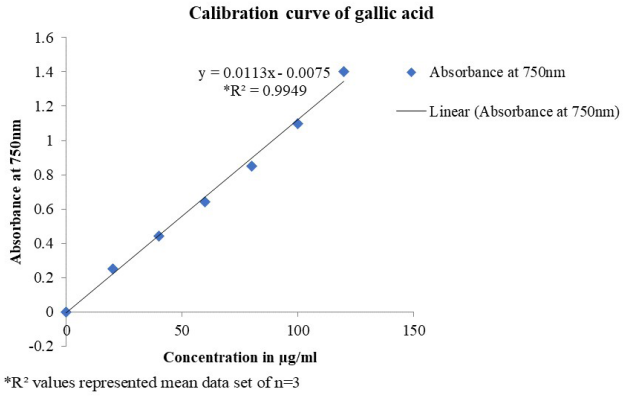


Figure 3. Calibration curve of standard gallic acid

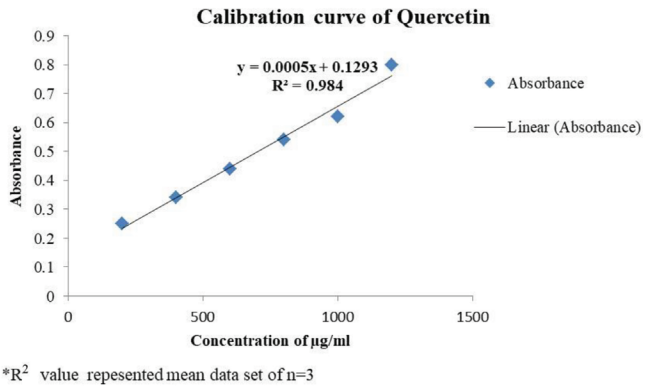


Figure 4. Calibration curve of standard Quercetin

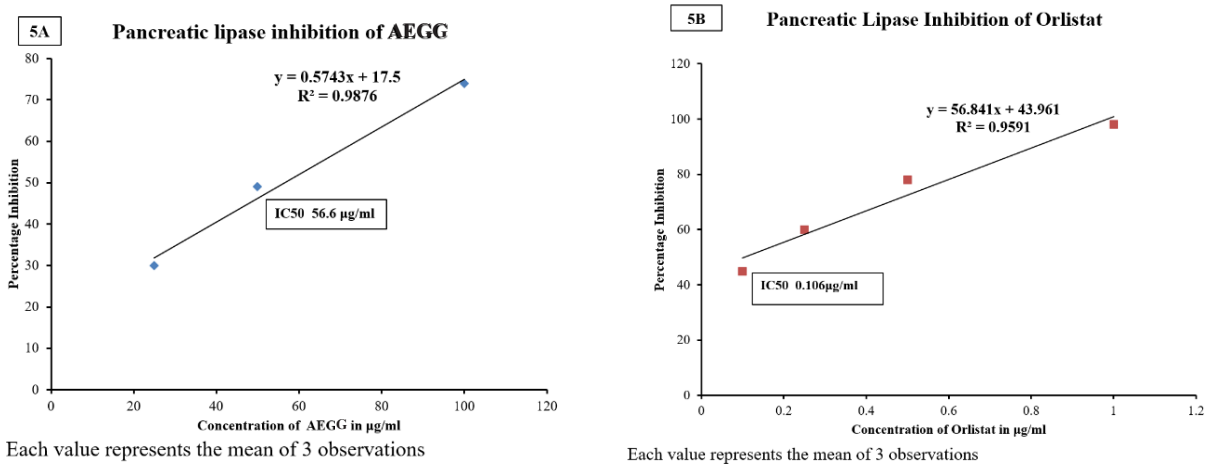


Figure 5. Anti-lipase activity of **A.** AEGG and **B.** Orlistat at different concentrations (µg/mL)

Pancreatic lipase inhibition assay

Anti-lipase activity was measured at varying concentrations using the AEGG (25, 50, and 100 µg/mL) standard drug Orlistat (0.1, 0.25, 0.5, and 1 µg/mL) for PPL inhibition. Figure 5A and 5B shows the inhibitory actions of pancreatic lipase. The AEGG, at a concentration of 100 µg/mL showed the highest decrease in PPL activity by (66.24%) and IC_{50} was 56.6 µg/mL *in vitro* study. Orlistat, a well-known anti-lipase drug, inhibited PPL activity by 98.7% and IC_{50} was 0.106 µg/mL when used as a positive control (final concentration 1µg/mL).

Garcinia cambogia decreases body weight in letrozole and estradiol-induced PCO-like rats

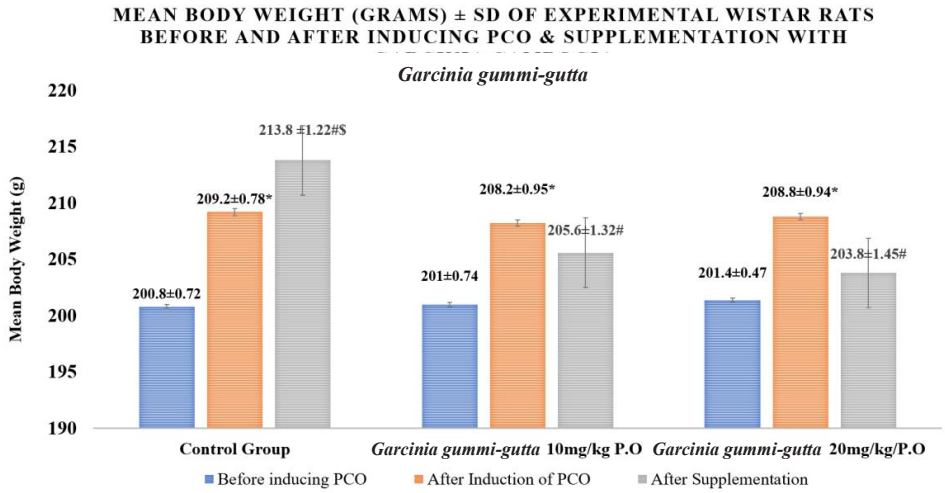
During the study, 5 rats in each group possessed an average (initial) body weight of 200.8 ± 0.72 (Control), 201± 0.74 (AEGG 10 mg/kg), and 201.4 ± 0.47 kg (AEGG 20mg/kg) respectively. After inducing PCOS using letrozole and estradiol benzoate in all groups, a significant increase (*p <0.05) in body weight was observed. Within the control group, the PCO-induced untreated rats exhibited a statistically significant rise in body weight ($P < 0.01). However, when supplementation of AEGG was provided to the groups of 10 mg/kg and 20 mg/kg after PCO induction, there was a noteworthy reduction in body weight across the treated groups (#P < 0.05) compared to the PCO-induced untreated or control group (Figure 6).

Vaginal smear test

The induction of PCO by combined administration of letrozole p.o. and estradiol benzoate
i.p. for 5 days of treatment was confirmed by a vaginal smear test. A vaginal smear study showed that before the administration of a drug, all the animals were in the estrous phase and post-treatment led to irregularity in the estrous phase and exhibited diestrus phase (Figure 7 A and 7 B)

Serum Luteinizing Hormones (LH)

The control groups showed significant differences in



*p<0.05 compared between before and after induction of PCO in each group; #p<0.05 compared between PCO untreated control and supplemented groups; $p<0.01 compared between control group

Figure 6. Mean body weight among groups before and after treatment with *Garcinia gummi-gutta*

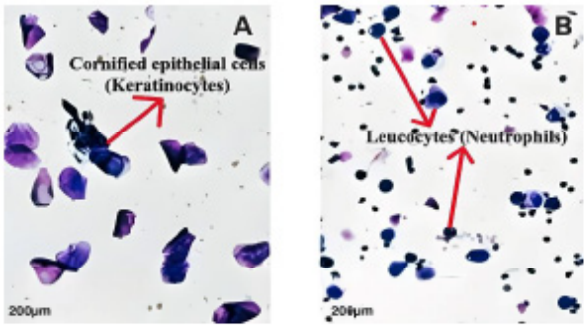
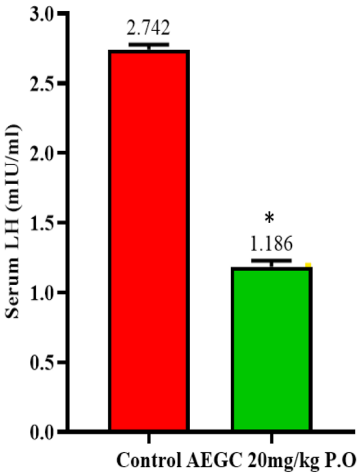


Figure 7. Vaginal smears displaying **A.** Estrous Phase (before inducing PCO) and **B.** Diestrus Phase (PCOD) under a microscope (100x) in Wistar rats.

the LH level (P<0.0001) before and after induction of PCO. In contrast to the PCO control group, the animals treated with AEGG (10 mg and 20 mg/kg/p.o., respectively) groups had significantly decreased levels of LH (P < 0.0001) (Figure 8A and 8 B).

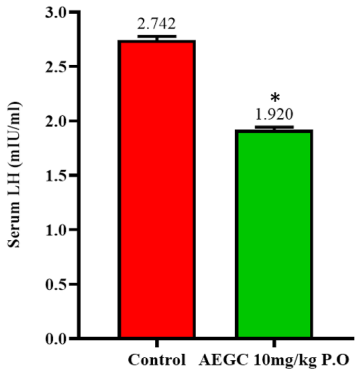
Interpretation of anatomical changes from dissection of rats

The experimental animal was subjected to dissection after supplementation for 7 days with AEGG. All experimental animals from each group were used. From the interpretation, the control group rat had a swollen gastrointestinal tube, uterine horn, and ovary (polycystic ovary) as left untreated. In both, AEGG 10 mg/kg and 20 mg/kg groups, normal uterine horn without swelling and normal ovary with reduced cysts resulted due to the supplementation of GG but their gastrointestinal tubes were little swollen due to the acidic pH of the sample (Figure 9A, 9B and 9C).



A

* P < 0.0001 compared to the control group



B

* P < 0.0001 compared to the control group

Figure 8. A. Serum Luteinizing Hormone (LH) levels in control and AEGG 10 mg/kg p.o. groups **B**. Serum Luteinizing Hormone (LH) levels in control and AEGG 20 mg/kg p.o. groups

A B C

Figure 9. A,B,C) Anatomical changes in PCO-rats after dissection

Discussion

Among all gynecological endocrinopathies impacting women of reproductive age, PCO is a complex endocrine disorder. In addition to cardiovascular hazards, it boosts the risk of type 2 diabetes, resistance to insulin, lipid disorders, weight gain, poor ovulation, and irregular menstrual cycle [31]. Many genetic and environmental variables contribute to the etiology of this condition. Unhealthy lifestyles and diets, as well as any infectious agents, increase the risk of developing PCO [42]. Literature reveals during PCO, the LH pulse frequency is greatly enhanced; while FSH production is suppressed, resulting in positive feedback on the GnRH pulse frequency. It exacerbates the problem by releasing more LH [8].

Obesity aggravates the genetic disorder known as PCO. According to epidemiological statistics, obesity and PCO are strongly linked. In the meantime, genetic probes have confirmed this relationship. Research has explored various approaches to treat obesity, including inhibiting pancreatic lipase enzymes, reducing hunger, promoting energy loss, scavenging free radicals, suppressing adipocyte growth, and stimulating lipid metabolism [43]. GG's anti-obesity impact was evaluated using various methods, including pancreatic lipase inhibition.

PCO treatment might involve multiple drugs and therapies, making it a complex issue. Weight loss through lifestyle modifications can enhance anovulation and insulin sensitivity in PCO patients. The management of hyperandrogenism symptoms involves the use of contraceptive pills, selective estrogen receptor modulators (SERM), and hypoglycemic agents. To enhance the effectiveness of treatment, these drugs may be used with antidiabetic medicines because they induce ovulation [44]. Antidiabetic medicines may help PCO patients lose weight and improve type 2 diabetes mellitus levels, as obesity and insulin resistance are important causes of problems [45]. PCO patients are at significant risk for metabolic syndromes such as heart disease and liver disease due to metabolic derangements. Commonly used OCPs increase the risk of dysglycemia and other cardiometabolic risk factors.

New research is required since the PCO treatment guidelines now in use do not adequately address these risk factors and consequences. It has been seen that using herbal treatments for PCO can effectively lower obesity and hyperandrogenism while also enhancing ovulation and insulin sensitivity, all without causing significant adverse effects. Many herbal remedies, complementary therapies, and dietary supplements have demonstrated efficacy in treating PCO. Seafood recipes are seasoned and tinged with *Garcinia gummi gutta* (L.) Roxb., also known as *Garcinia cambogia* Desr., is a plant belonging to the Clusiaceae family. This fruit is a prominent food supplement that helps people lose calories [15]. Hence the current study investigated GG's potential as a treatment for letrozole-estradiol benzoate-induced PCO in a rodent model and offered scientific justification for its traditional applications, including an examination of probable mechanisms.

The flavonoid and phenolic contents of the fruit were assessed. The results showed that the flavonoid content of the GG aqueous extract at concentrations of 10 mg/mL and 20 mg/mL was 52.66±0.509 and 102.66±0.38 mg QE/g dry material, respectively. The phenolic content at these concentrations was 62.00±0.33 and 125.66±1.07 mg GAE/g of dry material, respectively. Our findings were similar to a previous study, in which the 5 mg/mL of the prepared AEGG reported a total phenolic content of 75 ± 0.124 µg/g and a total flavonoid content of 45.10 ± 0.08 µg/g, expressed as QE. The marginal variation observed in the secondary metabolites may be influenced by the geographical origin of the study plant [14].

Pancreatic lipase is an essential digestive enzyme that facilitates the transformation and utilization of lipids into monoglycerides and free fatty acids. Suppression of the lipase enzyme results in a decrease in overall cholesterol levels in the body. This represents one potential approach to treating obesity. Orlistat is the in-

dustry standard for weight reduction medications and is sold as an over-the-counter medicine. It attaches by covalent bonding to the Serine 152 position of lipase 20 and is a permanent lipase antagonist. This inhibits the production of gastric and pancreatic lipases both *in vitro* and *in vivo* [46].

In the current study, the pancreatic lipase inhibitory effect of aqueous extract of *G. gummi-gutta* (AEGG) was compared to that of the prescription drug orlistat. At a concentration of 100 µg/mL, the maximum inhibitory efficacy of AEGG was 66.24%, with an IC_{50} value of 56.6 µg/mL, which was significantly lower compared to the standard drug orlistat, which exhibited 98.7% inhibition with an IC_{50} value of 0.106 µg/mL. Obesity and weight gain are common symptoms of PCO. Earlier report states that GG brought weight loss by suppressing appetite and inhibiting the enzyme citrate lyase, which is involved in the creation of fatty acids. The study confirms that the fruit rind contains α-β-dihydroxy tricarboxylic acid (HCA), which regulates serotonin release, inhibits lipogenesis (adenosine triphosphate-citrate-lyase), increases lipid oxidation, and decreases carbohydrate metabolism, improving exercise endurance and appetite suppression [28].

Several researchers developed the PCO rat model that was employed in this investigation. Letrozole pills and a shot of estradiol benzoate were given to rats concurrently for five days to induce illness. Vaginal smear tests (Diestrus phase) and a rise in body weight verified the induction. These findings are consistent with earlier reports, where letrozole administration resulted in both a rise in body weight and a prolonged diestrus phase [14]. Letrozole, also known as 4,40-[(1H-1,2,4-triazol-1-yl) methylene] bis-benzonitrile, is a non-steroidal aromatase inhibitor that is administered to produce hyperandrogenism by preventing the synthesis of testosterone to estrogen. As a prolonged-act estrogen, estradiol benzoate produces gonadotropin-releasing hormone (GnRH) imbalance in the hypothalamus and pituitary, which leads to undesirable LH secretion and storage, as well as the rapid onset of PCO because of disruptions in metabolic and biological functions [47]. Supplementation of AEGG at different doses (10 mg/kg and 20 mg/kg) showed a dose-dependent significant decrease in body weight and LH hormone levels. Anatomical studies on a seven-day AEGG supplementation dosage revealed that the rats in the control group, had enlarged ovaries (polycystic ovary), uterine horn, and gastrointestinal tube due to untreated conditions. On the other hand, normal ovarian function with fewer cysts and normal uterine horn without enlargement became apparent in 10 and 20 mg/kg AEGG ingested groups; however, the acidic pH of the sample caused slight swelling in their gastrointestinal tubes. The findings were parallel with the early findings [14].

Conclusion

The weight of the experimental Wistar rats and PCOS are significantly impacted by this Indian spice. In Indian medicine, this spice is regarded as new due to its immense health benefits. The main chemical components that give them their therapeutic qualities are their bioactive chemicals, such as flavanols and phenol. Today, PCO is regarded as a serious endocrine condition. The main causes of PCO in females of reproductive age include lifestyle choices, poor eating habits, stress, depression, and inactivity.

According to the study, the AEGG 20 mg/kg group showed significantly more physiological alterations than both the 10 mg/kg and control groups. Specifically, the AEGG 20 mg/kg treatment led to a statistically significant reduction in LH levels compared to the 10 mg/kg and control groups. Additionally, dissection findings indicated that both AEGG-treated groups (10 and 20 mg/kg) exhibited fewer polycystic ovarian cysts compared to the control group. Furthermore, the fruit extract demonstrated a significant *in vitro* inhibition of pancreatic lipase activity, suggesting its potential role in obesity management and weight reduction. Over time, this indicates a promising therapeutic benefit of AEGG in managing metabolic and reproductive health concerns.

Future Recommendations

GG, a natural supplement, has shown certain promise in treating obesity and metabolic disturbances in PCO-induced rats. However, more intriguing studies are needed to understand its molecular pathways, active component, and impact on hormone regulation. Long-term studies are needed to assess the safety and effectiveness of prolonged use, particularly in chronic conditions like PCO. Comparative studies with standard treatments like metformin and oral contraceptives, as well as combinational to other natural supplements are also essential so that its enhancing therapeutic potential can be investigated thoroughly. Careful clinical trials should investigate its role in weight management, insulin sensitivity, and reproductive health in women with PCO. Further research could reveal which patient populations could benefit most from its use based on genetic predisposition or epigenetic changes.

Conflict of Interests

The authors declare that there is no conflict of interest.

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