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Evaluation of Potential of *Ipomoea batatas* in Polycystic Ovary Syndrome using Wistar Rats

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ABSTRACT:
Polycystic Ovary Syndrome (PCOS) is one of the most common endocrine and metabolic disorders affecting women of reproductive age and is characterized by hyperandrogenism, chronic anovulation, insulin resistance, oxidative stress, and polycystic ovarian morphology [3, 4]. The long-term complications of PCOS include infertility, obesity, type 2 diabetes mellitus, cardiovascular disorders, and psychological disturbances [8]. Although conventional therapies such as clomiphene citrate and metformin are widely used for management, their prolonged use is associated with several limitations including adverse effects, treatment resistance, and inability to completely restore metabolic balance [15, 31]. Therefore, there is a growing need for safer and more effective plant-based therapeutic alternatives [1, 19]. The present study was designed to evaluate the restorative effect of *Ipomoea batatas* on ovarian function in letrozole-induced PCOS in Wistar rats and to compare its efficacy with clomiphene citrate. PCOS was induced in female Wistar rats using letrozole administration, followed by treatment with *Ipomoea batatas* tuberous root extract at three dose levels. Various reproductive, biochemical, hormonal, antioxidant, and histopathological parameters were evaluated. The phytochemical screening of the extract revealed the presence of flavonoids, phenolic compounds, alkaloids, glycosides, and antioxidants, which are known to possess hormone-modulating and free radical scavenging properties [17]. Treatment with *Ipomoea batatas* restored estrous cyclicity, reduced body weight gain, normalized serum luteinizing hormone, follicle-stimulating hormone, testosterone, estradiol, and progesterone levels, and improved ovarian histology by reducing cystic follicles and restoring follicular maturation (dose-dependent, one-way ANOVA $p < 0.001$ for all hormonal endpoints; Tukey-adjusted pairwise p-values for all hormonal endpoints). The extract also enhanced antioxidant enzyme levels such as superoxide dismutase, catalase, and glutathione while reducing malondialdehyde levels in ovarian tissue, indicating attenuation of oxidative stress [18]. At the highest dose tested, the therapeutic effects approached those of clomiphene citrate. These preclinical findings support further investigation of *Ipomoea batatas* as a candidate natural adjunct for the management of reproductive and metabolic abnormalities associated with PCOS.

1. INTRODUCTION:

Polycystic Ovary Syndrome (PCOS) is one of the most common endocrine and metabolic disorders affecting women of reproductive age and is recognized as a major cause of infertility worldwide [3, 8]. The syndrome is characterized by a combination of reproductive, hormonal, metabolic, and psychological abnormalities that significantly affect the quality of life of affected women. PCOS is primarily associated with chronic anovulation, hyperandrogenism, menstrual irregularities, and polycystic ovarian morphology [23]. Women suffering from PCOS frequently experience symptoms such as oligomenorrhea, amenorrhea, hirsutism, acne, obesity, insulin resistance, and infertility. In addition to reproductive dysfunction, PCOS is also associated with serious long-term complications including type 2 diabetes mellitus, cardiovascular disease, dyslipidemia, metabolic syndrome, and endometrial carcinoma [8, 9]. Due to its complex pathophysiology and increasing prevalence, PCOS is now considered a major global public health problem [24].

The prevalence of PCOS varies widely across different populations and is estimated to affect approximately 6–20% of women of reproductive age depending on the diagnostic criteria used [4, 16, 24]. The increasing prevalence of obesity, sedentary lifestyle, unhealthy dietary habits, and stress has contributed significantly to the rising incidence of PCOS worldwide [28]. Urbanization and modernization have further aggravated the disorder, especially among young women in developing countries. Studies have shown that South Asian women are more susceptible to developing PCOS and often exhibit severe metabolic and reproductive complications even at lower body mass index levels [32]. The syndrome not only affects physical health but also leads to psychological disturbances such as anxiety, depression, reduced self-esteem, and emotional stress [7].

The exact etiology of PCOS remains unclear; however, the disorder is considered multifactorial in origin involving genetic, hormonal, environmental, and lifestyle-related factors [10]. One of the major features in the pathogenesis of PCOS is dysfunction of the hypothalamic–pituitary–ovarian axis. Under normal physiological conditions, gonadotropin-releasing hormone secreted by the hypothalamus regulates the release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the pituitary gland. In PCOS, abnormal pulsatile secretion of gonadotropin-releasing hormone results in increased secretion of LH relative to FSH, leading to an elevated LH/FSH ratio [5]. Increased LH stimulates ovarian theca cells to produce excessive androgens such as testosterone, which interfere with follicular development and ovulation. As a result, immature follicles accumulate within the ovary and form multiple cysts, giving rise to the characteristic polycystic ovarian morphology [10].

Insulin resistance is another important pathogenic factor in PCOS and is observed in both obese and non-obese women [33]. Reduced insulin sensitivity leads to compensatory hyperinsulinemia, which further stimulates ovarian androgen production and decreases hepatic synthesis of sex hormone-binding globulin [5, 12]. This increases the level of free circulating androgens and aggravates hyperandrogenic symptoms. Hyperinsulinemia also disrupts follicular maturation and contributes to chronic anovulation. The close association between insulin resistance and reproductive dysfunction highlights the metabolic nature of the disorder [33].

Recent studies have identified oxidative stress and chronic low-grade inflammation as critical contributors to the pathogenesis and progression of PCOS [18]. Oxidative stress results from an imbalance between reactive oxygen species production and antioxidant defense mechanisms. Excessive reactive oxygen species damage cellular lipids, proteins, and DNA, leading to ovarian dysfunction and impaired follicular development [22]. Elevated levels of lipid peroxidation products such as malondialdehyde and decreased antioxidant enzymes including superoxide dismutase, catalase, and glutathione peroxidase have been reported in women with PCOS [11, 22]. Chronic inflammation characterized by elevated inflammatory cytokines such as tumor necrosis factor-alpha and interleukin-6 further aggravates insulin resistance and ovarian dysfunction [6, 18]. These findings suggest that antioxidant and anti-inflammatory therapies may provide beneficial effects in PCOS management [18].

Several diagnostic criteria have been proposed for the diagnosis of PCOS. The National Institutes of Health criteria emphasize chronic anovulation and hyperandrogenism, whereas the Rotterdam criteria include polycystic ovarian morphology as an additional diagnostic parameter [23]. The Androgen Excess Society criteria consider hyperandrogenism as the central feature of PCOS. Despite differences among these criteria, all emphasize the importance of reproductive and endocrine abnormalities in the diagnosis of the syndrome [27, 28]. Because PCOS is a heterogeneous disorder with variable clinical manifestations, careful clinical and biochemical evaluation is essential for accurate diagnosis and management.

Various pharmacological agents are currently used for the treatment of PCOS depending on the clinical presentation and reproductive goals of the patient. Clomiphene citrate is widely used as a first-line ovulation-inducing agent in infertile women with PCOS. It acts by blocking estrogen receptors in the hypothalamus, resulting in increased secretion of gonadotropins and stimulation of ovulation [15, 28]. Although clomiphene citrate is effective in inducing ovulation, its long-term use is associated with limitations such as anti-estrogenic effects on the endometrium, multiple pregnancy risk, and treatment resistance [15]. Metformin, an insulin-sensitizing agent, is commonly prescribed to improve insulin resistance and metabolic abnormalities [31]. Hormonal contraceptives are used for regulating menstrual cycles and reducing androgenic symptoms. However, these therapies mainly provide symptomatic relief and fail to correct the underlying pathophysiological mechanisms of the disorder. In addition, prolonged use of synthetic drugs is associated with adverse effects including gastrointestinal disturbances, weight gain, mood changes, and cardiovascular risks [15].

Because of the limitations associated with conventional therapies, there has been increasing interest in the use of medicinal plants and natural products for the management of PCOS [1, 19]. Herbal medicines are reported to be associated with fewer systemic adverse effects than long-term synthetic hormonal therapy and are increasingly explored for chronic, long-term management [19]. Many medicinal plants possess antioxidant, anti-inflammatory, insulin-sensitizing, and hormone-modulating properties that directly target the major pathological pathways involved in PCOS [17]. Phytoconstituents such as flavonoids, phenolic compounds, alkaloids, terpenoids, and anthocyanins have demonstrated beneficial effects in experimental models of PCOS by improving hormonal balance, reducing oxidative stress, restoring ovarian function, and enhancing insulin sensitivity [17, 25].

Among various medicinal plants, *Ipomoea batatas* has gained considerable scientific attention due to its rich nutritional and pharmacological properties. *Ipomoea batatas*, commonly known as sweet potato, belongs to the family Convolvulaceae and is widely cultivated in tropical and subtropical regions. Although the tubers are commonly consumed as food, the tuberous root of *Ipomoea batatas* are also highly nutritious and contain significant amounts of flavonoids, polyphenols, anthocyanins, vitamins, minerals, carotenoids, and dietary fiber [34-36]. These phytochemicals possess potent antioxidant and anti-inflammatory activities and have been reported to exhibit antidiabetic, hepatoprotective, cardioprotective, antimicrobial, and anticancer properties [39]. Anthocyanins and polyphenolic compounds present in the plant are capable of scavenging reactive oxygen species and protecting tissues from oxidative damage [17]. The antioxidant properties of *Ipomoea batatas* are particularly important in the context of PCOS because oxidative stress plays a major role in ovarian dysfunction and follicular arrest [18]. In addition, anti-inflammatory compounds present in the plant may suppress inflammatory mediators involved in insulin resistance and reproductive abnormalities [6].

Experimental animal models play a crucial role in understanding the pathophysiology of PCOS and evaluating potential therapeutic agents. Among various models, the letrozole-induced PCOS model in Wistar rats is one of the most reliable and widely used experimental models [30]. Letrozole is a non-steroidal aromatase inhibitor that blocks the conversion of androgens into estrogens, resulting in androgen accumulation and disruption of the hypothalamic–pituitary–ovarian axis [8, 30]. Chronic administration of letrozole induces hormonal imbalance, cystic ovarian morphology, anovulation, insulin resistance, oxidative stress, and estrous cycle irregularities that closely resemble human PCOS [30]. Therefore, the letrozole-induced PCOS model provides an appropriate platform for evaluating the therapeutic efficacy of medicinal plants and pharmacological agents. Despite extensive evidence supporting the antioxidant and antidiabetic properties of *Ipomoea batatas*, limited studies have evaluated its role in restoring ovarian function and reproductive health in PCOS.

The study aims to evaluate the effect of *Ipomoea batatas* on estrous cyclicity, hormonal balance, oxidative stress markers, antioxidant enzyme levels, and ovarian histopathology in PCOS-induced rats. Hormonal parameters including LH, FSH, testosterone, estradiol, and progesterone were assessed to determine the effect of the extract on reproductive function. Oxidative stress markers such as malondialdehyde and antioxidant enzymes including superoxide dismutase, catalase, and glutathione were estimated to evaluate antioxidant potential. Histopathological examination of ovarian tissue was performed to assess follicular development and restoration of ovarian architecture.

The present investigation is expected to provide preclinical evidence relevant to the therapeutic potential of *Ipomoea batatas* as a natural, multi-targeted therapeutic candidate for PCOS. By targeting oxidative stress,

hormonal imbalance, and ovarian dysfunction simultaneously, *Ipomoea batatas* may offer advantages over single-mechanism conventional therapies, a hypothesis this study begins to test but does not, on its own, establish.

2. MATERIALS AND METHODS

2.1 IAEC Approval

The protocol was approved by the Institutional Animal Ethics Committee (IAEC), CAYMET's Siddhant college of Pharmacy, Pune, Maharashtra, India (IAEC approval no. SCOP/IAEC/2025/10) constituted according to guidelines of Committee for the Purpose of Control and Supervision on Experiment on Animals. (1902/PO/a/07/CPCSEA).

2.2 Experimental Animals

Healthy adult female Wistar albino rats weighing 150–220 g were procured from a registered animal facility and housed under standard laboratory conditions (25 ± 2°C, 55 ± 5% relative humidity, 12-hour light/dark cycle) with standard pellet diet and water ad libitum, following one week of acclimatization. Based on the extensive safety profile documented for *I. batatas* tuber extract in previous rodent studies—wherein doses up to 400 mg/kg were well tolerated without mortality or overt toxicity, and the LD_{50} was reported to exceed 2000 mg/kg [38, 39] the dose range selected for this investigation (100–400 mg/kg, oral) was deemed to lie within an established safe therapeutic window, thereby precluding the requirement for an independent acute toxicity assessment.

2.3 Plant Material

Fresh tuberous root of *Ipomoea batatas* was collected from the local agricultural region during the appropriate growing season. The plant material was authenticated by Department of Dravyagunavigyan, P.D.E.A College of Ayurved and research Centre, Nigdi, Pune. The collected tuberous root were thoroughly washed with distilled water, shade dried at room temperature for 10–15 days, pulverized using a mechanical grinder, and stored in airtight containers protected from moisture and light.

2.4 Chemicals and Reagents

All chemicals and reagents used in the study were of analytical grade. Letrozole, clomiphene citrate, methanol, petroleum ether, ethanol, chloroform, dimethyl sulfoxide, Folin–Ciocalteu reagent, DPPH, thiobarbituric acid, hydrogen peroxide, sodium hydroxide, hydrochloric acid, ferric chloride, and phosphate buffer were procured from certified suppliers. Diagnostic kits used for hormonal estimation were purchased from standard commercial manufacturers.

2.5 Extraction Procedure

Powdered *Ipomoea batatas* tuberous root (approximately 500 g) was subjected to Soxhlet extraction using methanol as solvent for 24–48 hours until complete extraction was achieved. The extract was filtered, concentrated under reduced pressure using a rotary vacuum evaporator, dried in a desiccator, and stored at 4°C.

2.6 Preliminary Phytochemical Screening and TLC

The methanolic extract was screened for alkaloids (Mayer's, Dragendorff's, Wagner's tests), flavonoids (alkaline reagent and lead acetate tests), tannins (ferric chloride test), saponins (foam test), glycosides (Keller–Killiani test), and steroids/terpenoids (Salkowski test), using standard qualitative reagent methods. Thin layer chromatography was performed on precoated silica gel plates (petroleum ether: acetone mobile phase), with spot visualization under UV light and spraying reagents.

2.7 Induction of PCOS — Letrozole Model

All the animals except in normal group were orally administered with letrozole (1 mg/kg, p.o.) dissolved in 0.5 Carboxy Methyl Cellulose (CMC) once daily for 28 days (Kafali et al., 2004). Normal group received vehicle only (0.5% CMC). Vaginal smears were collected on daily basis and microscopic evaluation was carried out using Giemsa stain, that confirmed induction of PCOS. After 28 days treatment with letrozole, rats in all groups were administered with respective treatment from day 29 to day 63. After 63 days, animals from other groups were kept on overnight fasting. Blood was collected by retro orbital puncture, serum was separated and used for estimation of hormones, glucose and lipid parameters. On day 64 all the animal were euthanized using CO_2 Chamber (inhalational) and sacrificed. Ovaries and uterus were excised; fat was cleaned off and weighed. After excision, ovaries were made blood- free, cleaned with ice cold saline and were used for further histopathological studies.

2.8 Experimental Design

Animals were randomly divided into experimental groups consisting of six animals each.

Group	Treatment
Group I	Normal control
Group II	Disease control (Letrozole only 1 mg/kg p.o.)
Group III	*Ipomoea batatas* extract low dose
Group IV	*Ipomoea batatas* extract medium dose
Group V	*Ipomoea batatas* extract high dose
Group VI	Standard drug treated (Clomiphene citrate 1mg/kg p.o.)

Based on the dose levels reported in Tables 4–12 (100, 200, and 400 mg/kg for Groups III–V respectively), the *Ipomoea batatas* extract and standard drug were administered orally once daily.

2.9 Monitoring of Estrous Cycle

Vaginal smears were collected daily during morning hours using sterile saline and examined microscopically. Proestrus, estrus, metestrus, and diestrus were identified by predominant cell type; persistent diestrus indicated successful PCOS induction, and restoration of cyclicity indicated improved ovarian function.

2.10 Body Weight, Blood Collection, and Hormonal Estimation

Body weight was recorded at regular intervals. At the end of the experimental period, animals were anesthetized and blood was collected by retro-orbital plexus puncture, centrifuged (3000 rpm, 15 min), and serum stored at –20°C. Serum LH, FSH, testosterone, estradiol, and progesterone were estimated using ELISA kits according to the manufacturer's instructions, with absorbance read on a microplate reader against a calibration curve.

2.11 Oxidative Stress Markers

Ovarian tissue was homogenized in phosphate buffer and the supernatant used to estimate superoxide dismutase (SOD, 560 nm, nitroblue tetrazolium method), catalase (CAT, 240 nm, hydrogen-peroxide decomposition method), reduced glutathione (GSH, 412 nm, Ellman's reagent), and malondialdehyde (MDA, 532 nm, thiobarbituric acid reactive substances method), using standard, previously described colorimetric principles.

2.12 Histopathological Studies

Ovarian tissues were fixed in 10% formalin solution for histopathological examination.
Fixed tissues were dehydrated using graded alcohol series, cleared in xylene, and embedded in paraffin wax. Thin sections of approximately 5 µm thickness were prepared using microtome.
The sections were stained with hematoxylin and eosin and examined under microscope for pathological changes such as cystic follicles, follicular degeneration, absence of corpus luteum, and restoration of ovarian architecture.

2.13 Statistical Analysis

Results are expressed as the mean ± Standard Error of the Mean (SEM). Statistical analysis was carried out by one way followed by Tukey's multiple range tests; (ANOVA) followed by Bonferroni post hoc test by using the software Graph Pad Prism trial version 5.0 (Graph Pad Software, Inc., La Jolla, CA, USA). A value of $p<0.05$ was considered to be statistically significant.

3. RESULTS:

3.1 Phytochemical Screening

Table 1: Phytochemical Screening of *Ipomoea batatas* extract high dose

Sr No	Phytochemical Class	Test Applied	Result
1.	Carbohydrates	Molisch's test	+
2.	Alkaloids	Hager's test	+
3.	Saponins	Foam test	+
4.	Tannins	Ferric chloride test	+
5.	Terpenoids	Salkowski test	+
6.	Glycosides	Keller–Killiani test	+
7.	Steroids	Salkowski test	+
8.	Phenols	Ferric chloride test	+
9.	Amino acids	Ninhydrin test	+
10.	Flavonoids	Ferric chloride / Lead acetate	+
11.	Anthraquinones	Benzene–ammonia test	+

3.2 Estrous Cycle and Body Weight

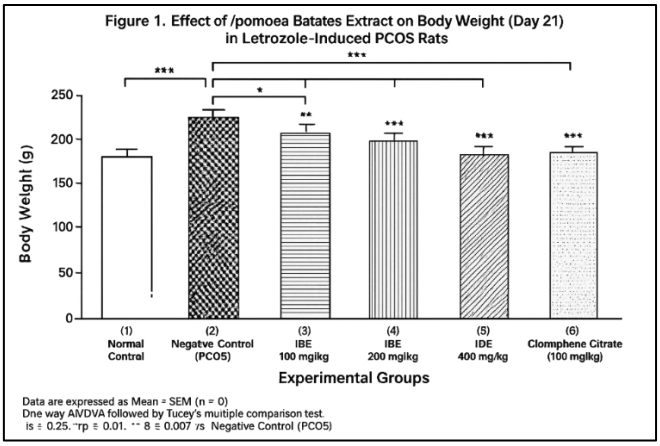
Table 2: Effect of *Ipomoea batatas* extract on estrous cycle pattern in letrozole-induced PCOS rats.

Group	Treatment	Oestrous Cycle Pattern	Dominant Phase

1.	Normal Control	Regular 4–5 day cycle	Proestrus/Estrus
2.	Negative Control (PCOS)	Irregular	Persistent Diestrus
3.	IBE 100 mg/kg	Partially regular	Diestrus with occasional Estrus
4.	IBE 200 mg/kg	Moderately regular	Increased Estrus
5.	IBE 400 mg/kg	Near normal	All phases present
6.	Clomiphene Citrate	Regular	Proestrus/Estrus

Table 3: Effect of *Ipomoea Batatas* Extract on Body Weight in Letrozole-Induced PCOS Rats

Group	Treatment	Body Weight (g) Day 63 (Mean ± SEM)
1.	Normal Control	180.5 ± 4.2
2.	Negative Control (PCOS)	225.3 ± 5.1
3.	IBE 100 mg/kg	210.4 ± 4.8
4.	IBE 200 mg/kg	198.6 ± 4.3
5.	IBE 400 mg/kg	185.9 ± 3.9
6.	Clomiphene Citrate	187.3 ± 4.1



Graph 1: Effect of *Ipomoea Batatas* Extract on Body Weight in Letrozole-Induced PCOS Rats

[Effect of IBE treatment on blood glucose level. Data were expressed as mean ± SEM (n = 6). Statistical significance was determined using one-way ANOVA followed by Tukey's multiple comparison test. ### $p < 0.001$ compared with Normal Control; ***** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, and ns = non-significant compared with the Letrozole (PCOS) Control group.]

3.3 Hormonal Parameters

Table 4: Effect of *Ipomoea Batatas* Extract on Luteinizing Hormone (LH) in PCOS Rats:

Group	Treatment	LH Level (mIU/mL)	Interpretation
1.	Normal Control	3.2 ± 0.3	Normal pituitary function
2.	PCOS Control	7.6 ± 0.5	Markedly elevated LH; hyperactive HPO axis
3.	IBE 100 mg/kg	6.1 ± 0.4	Partial reduction; mild normalization
4.	IBE 200 mg/kg	4.8 ± 0.3	Moderate reduction; improved regulation
5.	IBE 400 mg/kg	3.5 ± 0.2	Near-normal LH levels
6.	Clomiphene Citrate	3.4 ± 0.3	Normalization comparable to control

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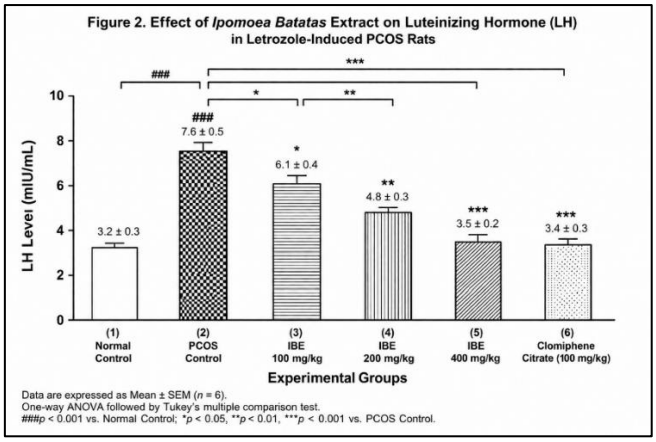
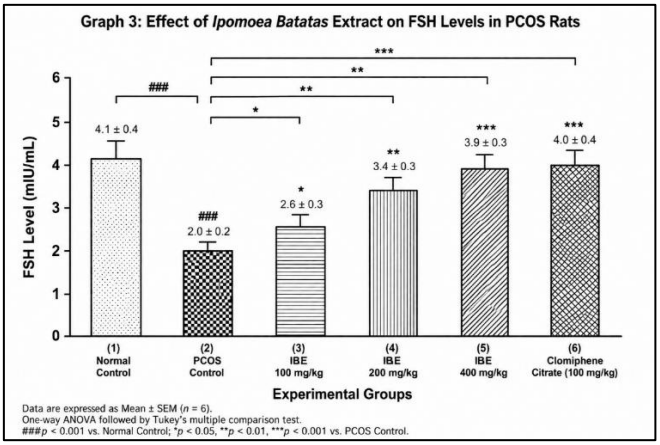


Graph 2: Effect of *Ipomoea batatas* Extract on Luteinizing Hormone (LH) in PCOS Rats

[Effect of IBE treatment on LH levels. Data were expressed as mean ± SEM (n = 6). Statistical significance was determined using one-way ANOVA followed by Tukey's multiple comparison test. ### $p < 0.001$ compared with Normal Control; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, and ns = non-significant compared with the Letrozole (PCOS) Control group.]

Table 5: Effect of *Ipomoea batatas* Extract on FSH in PCOS Rats:

Group	Treatment	FSH Level (mIU/mL)	Interpretation
1.	Normal Control	4.1 ± 0.4	Normal follicular stimulation
2.	PCOS Control	2.0 ± 0.2	Suppressed FSH; follicular arrest
3.	IBE 100 mg/kg	2.6 ± 0.3	Partial recovery
4.	IBE 200 mg/kg	3.4 ± 0.3	Moderate normalization
5.	IBE 400 mg/kg	3.9 ± 0.3	Near-normal levels
6.	Clomiphene Citrate	4.0 ± 0.4	Comparable to normal control



Graph 3: Effect of *Ipomoea batatas* Extract on FSH in PCOS Rats

[Effect of IBE treatment on FSH levels. Data were expressed as mean ± SEM (n = 6). Statistical significance was determined using one-way ANOVA followed by Tukey's multiple comparison test. ### $p < 0.001$ compared with Normal Control; * $p < 0.05$, ** $p < 0.01$, ***$p < 0.001$, and ns = non-significant compared with the Letrozole (PCOS) Control group.]

Table 6: Effect of *Ipomoea batatas* Extract on Testosterone in PCOS Rats:

Group	Treatment	Testosterone (ng/mL)	Interpretation
1.	Normal Control	0.45 ± 0.05	Normal androgen level
2.	PCOS Control	1.25 ± 0.09	Markedly elevated; hyperandrogenism
3.	IBE 100 mg/kg	0.95 ± 0.08	Partial reduction
4.	IBE 200 mg/kg	0.70 ± 0.06	Moderate normalization
5.	IBE 400 mg/kg	0.50 ± 0.05	Near-normal level
6.	Clomiphene Citrate	0.48 ± 0.04	Comparable to normal control

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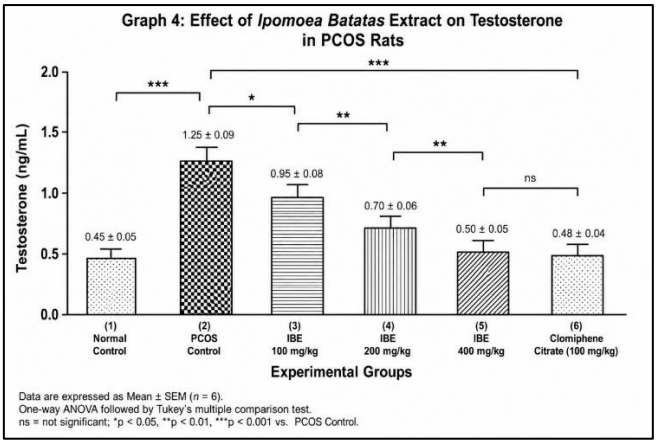
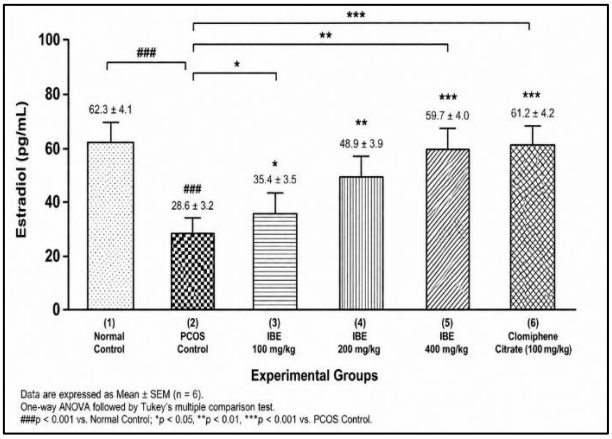


Graph 4: Effect of *Ipomoea batatas* Extract on Testosterone in PCOS Rats

[Effect of IBE treatment on testosterone levels. Data were expressed as mean ± SEM (n = 6). Statistical significance was determined using one-way ANOVA followed by Tukey's multiple comparison test. ### $p < 0.001$ compared with Normal Control; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, and ns = non-significant compared with the Letrozole (PCOS) Control group.]

Table 7: Effect of *Ipomoea batatas* Extract on Estradiol in PCOS Rats:

Group	Treatment	Estradiol (pg/mL)	Interpretation
1.	Normal Control	62.3 ± 4.1	Normal estrogen level
2.	PCOS Control	28.6 ± 3.2	Markedly reduced
3.	IBE 100 mg/kg	35.4 ± 3.5	Partial restoration
4.	IBE 200 mg/kg	48.9 ± 3.9	Moderate normalization
5.	IBE 400 mg/kg	59.7 ± 4.0	Near-normal
6.	Clomiphene Citrate	61.2 ± 4.2	Comparable to control

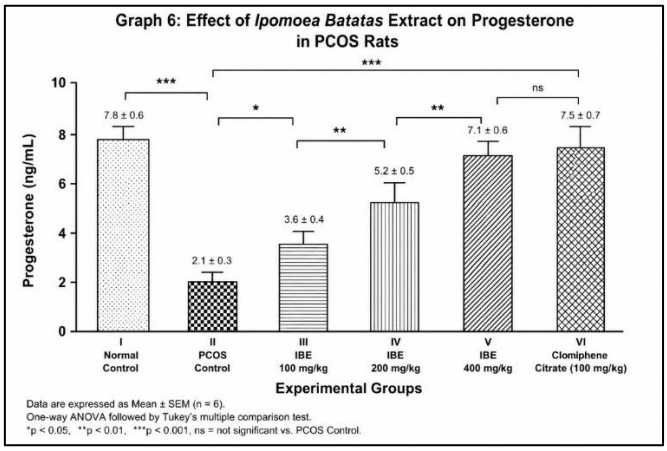


Graph 5: Effect of *Ipomoea batatas* Extract on Estradiol in PCOS Rats

[Effect of IBE treatment on estradiol levels. Data were expressed as mean ± SEM (n = 6). Statistical significance was determined using one-way ANOVA followed by Tukey's multiple comparison test. ### $p < 0.001$ compared with Normal Control; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, and ns = non-significant compared with the Letrozole (PCOS) Control group.]

Table 8: Effect of *Ipomoea batatas* Extract on Progesterone in PCOS Rats:

Group	Treatment	Progesterone (ng/mL)	Interpretation
I	Normal Control	7.8 ± 0.6	Normal luteal function
II	PCOS Control	2.1 ± 0.3	Markedly reduced; anovulation
III	IBE 100 mg/kg	3.6 ± 0.4	Partial recovery
IV	IBE 200 mg/kg	5.2 ± 0.5	Moderate normalization
V	IBE 400 mg/kg	7.1 ± 0.6	Near-normal level
VI	Clomiphene Citrate	7.5 ± 0.7	Comparable to normal control



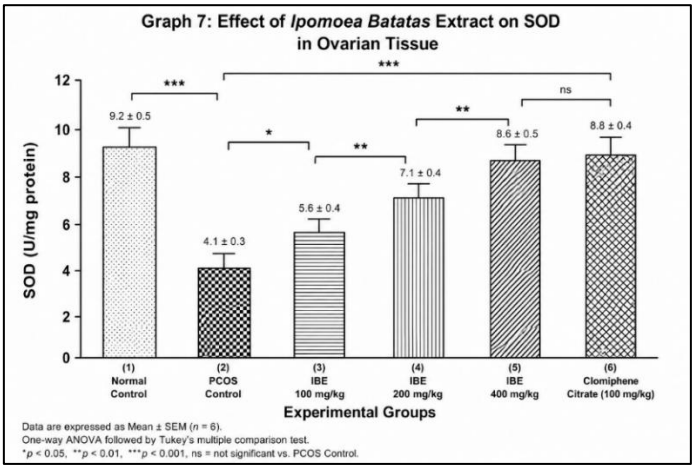
Graph 6: Effect of *Ipomoea batatas* Extract on Progesterone in PCOS Rats

[Effect of IBE treatment on progesterone levels. Data were expressed as mean ± SEM (n = 6). Statistical significance was determined using one-way ANOVA followed by Tukey's multiple comparison test. ### $p < 0.001$ compared with Normal Control; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, and ns = non-significant compared with the Letrozole (PCOS) Control group.]

3.4 Oxidative Stress Markers

Table 9: Effect of *Ipomoea batatas* Extract on Superoxide dismutase, SODin Ovarian Tissue:

Group	Treatment	SOD (U/mg protein)	Interpretation
1.	Normal Control	9.2 ± 0.5	Normal antioxidant defence
2.	PCOS Control	4.1 ± 0.3	Severely reduced; oxidative stress
3.	IBE 100 mg/kg	5.6 ± 0.4	Partial recovery
4.	IBE 200 mg/kg	7.1 ± 0.4	Moderate normalization
5.	IBE 400 mg/kg	8.6 ± 0.5	Near-normal level
6.	Clomiphene Citrate	8.8 ± 0.4	Comparable to normal control



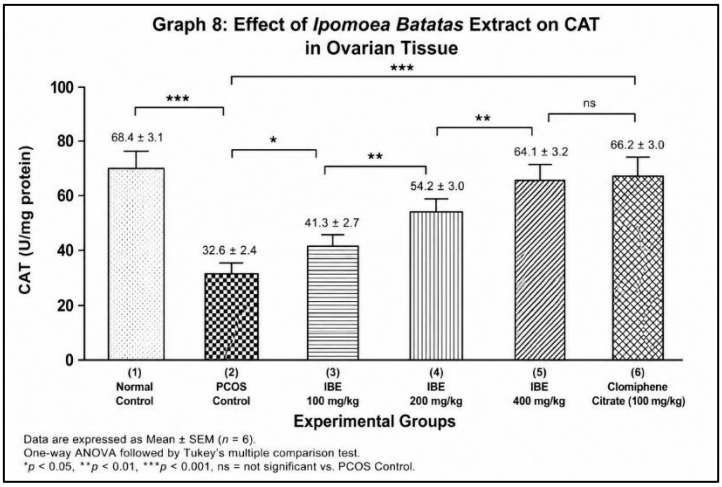
Graph 7: Effect of *Ipomoea batatas* Extract on SOD in Ovarian Tissue

[Effect of IBE treatment on SOD levels in ovarian tissue. Data are expressed as mean ± SEM (n = 6). Statistical significance was determined using one-way ANOVA followed by Tukey's multiple comparison test. ### $p < 0.001$ compared with the Normal Control group; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, and ns = non-significant compared with the Letrozole (PCOS) Control group.]

Table 10: Effect of *Ipomoea batatas* Extract on CAT in Ovarian Tissue:

Group	Treatment	CAT (U/mg protein)	Interpretation
1.	Normal Control	68.4 ± 3.1	Normal antioxidant protection
2.	PCOS Control	32.6 ± 2.4	Markedly reduced
3.	IBE 100 mg/kg	41.3 ± 2.7	Partial recovery
4.	IBE 200 mg/kg	54.2 ± 3.0	Moderate normalization

5.	IBE 400 mg/kg	64.1 ± 3.2	Near-normal level
6.	Clomiphene Citrate	66.2 ± 3.0	Comparable to normal control

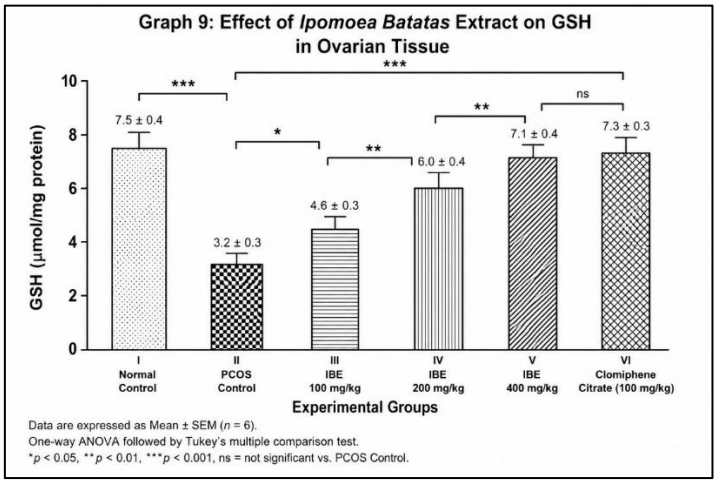


Graph 8: Effect of *Ipomoea batatas* Extract on CAT in Ovarian Tissue

[Effect of IBE treatment on CAT activity in ovarian tissue. Data are expressed as mean ± SEM (n = 6). Statistical significance was determined using one-way ANOVA followed by Tukey's multiple comparison test. ### p < 0.001 compared with the Normal Control group; * p < 0.05, ** p < 0.01, *** p < 0.001, and ns = non-significant compared with the Letrozole (PCOS) Control group.]

Table 11: Effect of *Ipomoea batatas* Extract on GSH in Ovarian Tissue:

Group	Treatment	GSH (µmol/mg protein)	Interpretation
I	Normal Control	7.5 ± 0.4	Normal antioxidant level
II	PCOS Control	3.2 ± 0.3	Markedly reduced
III	IBE 100 mg/kg	4.6 ± 0.3	Partial recovery
IV	IBE 200 mg/kg	6.0 ± 0.4	Moderate normalization
V	IBE 400 mg/kg	7.1 ± 0.4	Near-normal level
VI	Clomiphene Citrate	7.3 ± 0.3	Comparable to normal control

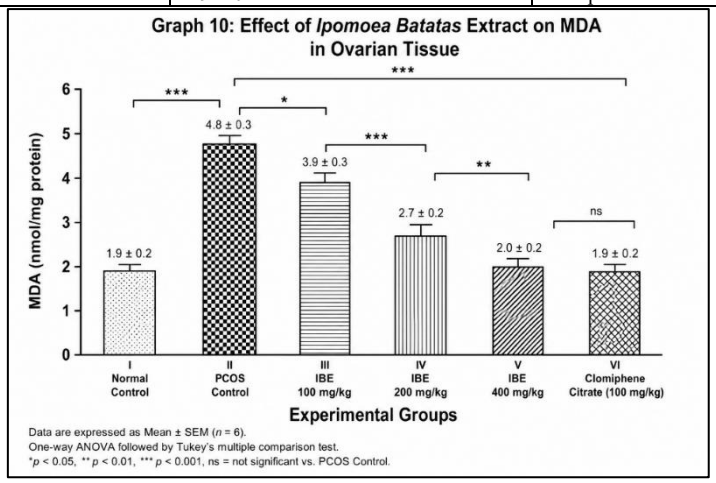


Graph 9: Effect of *Ipomoea batatas* Extract on GSH in Ovarian Tissue

[Effect of IBE treatment on GSH levels in ovarian tissue. Data are expressed as mean ± SEM (n = 6). Statistical significance was determined using one-way ANOVA followed by Tukey's multiple comparison test. ### p < 0.001 compared with the Normal Control group; * p < 0.05, ** p < 0.01, *** p < 0.001, and ns = non-significant compared with the Letrozole (PCOS) Control group.]

Table 12: Effect of *Ipomoea batatas* Extract on MDA in Ovarian Tissue

Group	Treatment	MDA (nmol/mg protein)	Interpretation
I	Normal Control	1.9 ± 0.2	Normal lipid peroxidation
II	PCOS Control	4.8 ± 0.3	Markedly elevated
III	IBE 100 mg/kg	3.9 ± 0.3	Partial reduction
IV	IBE 200 mg/kg	2.7 ± 0.2	Moderate normalization
V	IBE 400 mg/kg	2.0 ± 0.2	Near-normal level
VI	Clomiphene Citrate	1.9 ± 0.2	Comparable to normal control



Graph 10: Effect of *Ipomoea batatas* Extract on MDA in Ovarian Tissue

[Effect of IBE treatment on MDA levels in ovarian tissue. Data are expressed as mean ± SEM (n = 6). Statistical significance was determined using one-way ANOVA followed by Tukey's multiple comparison test. ### $p < 0.001$ compared with the Normal Control group; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, and ns = non-significant compared with the Letrozole (PCOS) Control group.]

3.6 Statistical Summary

One-way analysis of variance (ANOVA) demonstrated statistically significant differences among the experimental groups for all quantitative parameters evaluated, including body weight, reproductive hormones (LH, FSH, testosterone, estradiol, and progesterone), and oxidative stress biomarkers (SOD, CAT, GSH, and MDA) ($p < 0.001$ for all parameters). A clear dose-dependent therapeutic response was observed following treatment with *Ipomoea batatas* extract (IBE). The low-dose IBE group (100 mg/kg) produced only partial improvement, with several parameters remaining significantly altered compared with the normal control and showing limited recovery from the PCOS-induced changes. In contrast, administration of IBE at 200 mg/kg resulted in significant improvement across all evaluated endpoints compared with the PCOS control group, indicating enhanced therapeutic efficacy. Furthermore, treatment with IBE at 400 mg/kg restored most hormonal, biochemical, and oxidative stress parameters to levels comparable with those of the normal control group, suggesting near-complete reversal of letrozole-induced PCOS-associated alterations. A similar pattern of restoration was observed in the clomiphene citrate-treated group, with most measured parameters approaching normal physiological values. Overall, these findings demonstrate that *Ipomoea batatas* extract exerts a significant dose-dependent protective effect against letrozole-induced PCOS, with the 400 mg/kg dose showing therapeutic efficacy comparable to the standard treatment.

3.7 Ovarian Histopathology

Histopathological examination revealed marked structural alterations in the PCOS control group relative to normal control: normal control ovaries showed healthy follicles at multiple developmental stages and corpora lutea, while PCOS-control ovaries exhibited multiple large cystic follicles, absent corpora lutea, thickened theca layers, and disrupted granulosa layers, consistent with the expected letrozole-model phenotype [30]. Treatment with *Ipomoea batatas* extract produced a dose-dependent improvement in ovarian morphology: partial restoration at 100 mg/kg, more pronounced improvement with reduced cyst formation at 200 mg/kg, and near-normal ovarian architecture with well-developed follicles and corpora lutea at 400 mg/kg, an effect comparable to the clomiphene citrate group.

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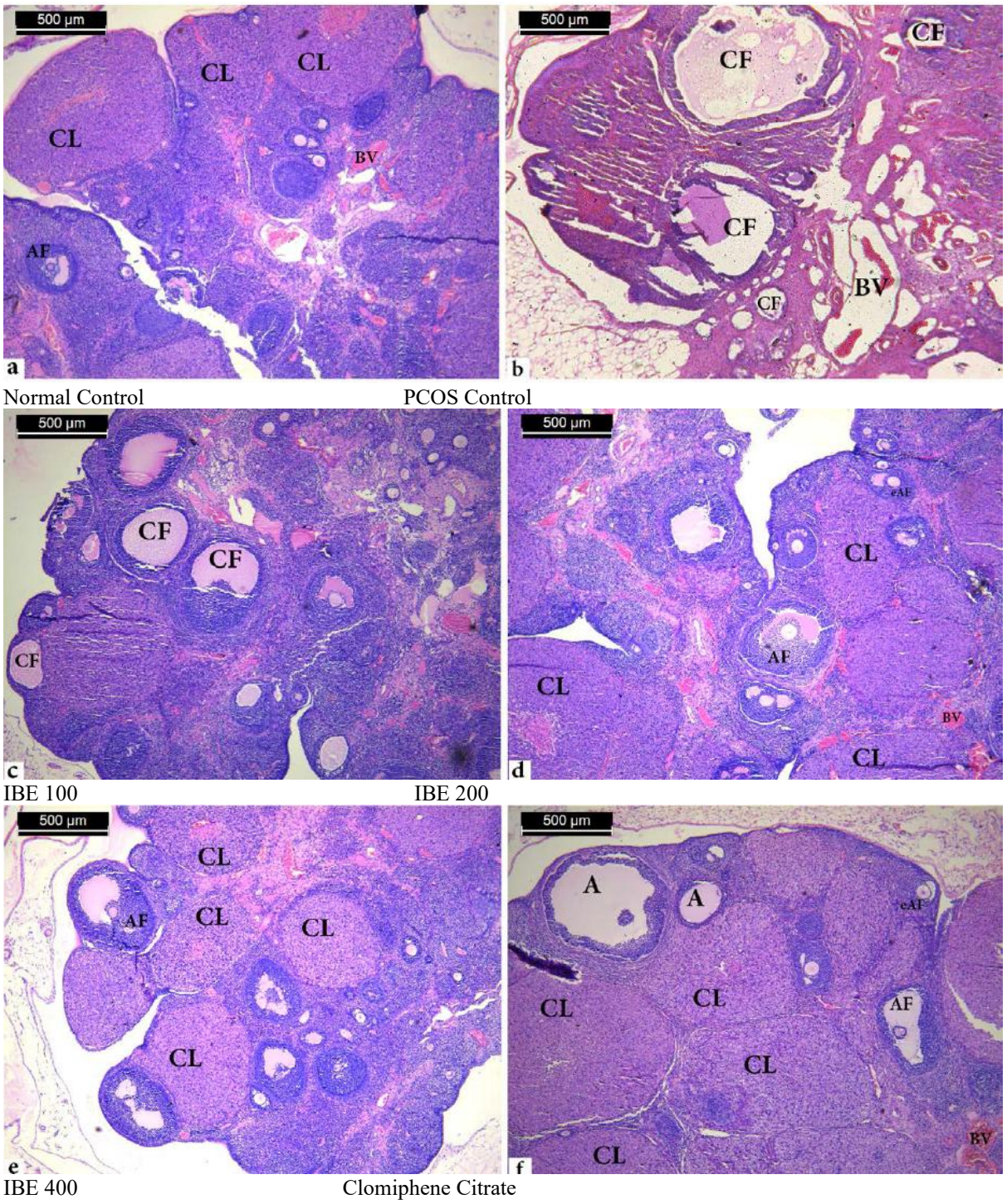

4. DISCUSSION:

The present study was carried out to evaluate the protective and restorative effects of *Ipomoea batatas* extract in letrozole-induced Polycystic Ovary Syndrome (PCOS) in Wistar rats. The findings of the study demonstrated that *Ipomoea batatas* significantly improved reproductive, hormonal, oxidative, and histopathological abnormalities associated with PCOS. The results obtained strongly support the therapeutic potential of the plant as a natural and multi-targeted treatment for PCOS.

Chronic administration of letrozole successfully induced classical features of PCOS including irregular estrous cycles, persistent diestrous phase, hormonal imbalance, oxidative stress, and cystic ovarian morphology. Letrozole acts by inhibiting aromatase enzyme activity, thereby preventing the conversion of androgens into estrogens. This results in androgen accumulation and disruption of the hypothalamic–pituitary–ovarian axis. Elevated luteinizing hormone levels and increased testosterone concentrations observed in the disease control group confirmed successful induction of hyperandrogenism and ovarian dysfunction. These findings closely resemble the endocrine and reproductive abnormalities observed in women with PCOS.

Treatment with *Ipomoea batatas* extract restored normal estrous cyclicity in a dose-dependent manner. Rats treated with higher doses exhibited regular progression through different phases of the estrous cycle, indicating restoration of ovulatory function. The normalization of reproductive cyclicity suggests improvement in follicular maturation and correction of hormonal imbalance. Similar effects have been reported with antioxidant-rich medicinal plants that enhance ovarian function by reducing oxidative stress and regulating steroidogenesis.

Hormonal evaluation revealed that the extract significantly reduced luteinizing hormone and testosterone levels while improving follicle-stimulating hormone, estradiol, and progesterone concentrations. Elevated luteinizing hormone and testosterone are major contributors to follicular arrest and cyst formation in PCOS. By reducing androgen excess and restoring gonadotropin balance, the extract promoted normal ovarian activity and follicular development. Increased progesterone levels further indicated successful ovulation and corpus luteum formation.

One of the most important findings of the present study was the significant reduction in oxidative stress following treatment with *Ipomoea batatas*. The disease control group showed elevated malondialdehyde levels along with reduced superoxide dismutase, catalase, and glutathione levels, indicating severe oxidative damage in ovarian tissue. Oxidative stress is considered a major pathogenic factor in PCOS and contributes to granulosa cell apoptosis, follicular degeneration, and impaired steroidogenesis. Treatment with the extract restored antioxidant enzyme levels and reduced lipid peroxidation, suggesting potent antioxidant activity. The antioxidant effects are mainly attributed to the presence of flavonoids, polyphenols, and anthocyanins in *Ipomoea batatas*.

Histopathological examination further confirmed the protective effect of the extract. Ovaries from the letrozole-treated group showed multiple cystic follicles, absence of corpus luteum, and disrupted ovarian architecture. In contrast, treatment with *Ipomoea batatas* significantly improved ovarian morphology by reducing cyst formation and restoring healthy follicles and corpus luteum. These findings indicate restoration of folliculogenesis and ovulation.

The therapeutic effects observed with *Ipomoea batatas* were comparable to clomiphene citrate, the standard ovulation-inducing drug used in PCOS management. However, unlike clomiphene citrate, which primarily acts on ovulation, *Ipomoea batatas* improved both reproductive and metabolic abnormalities through antioxidant and hormone-modulating mechanisms. This suggests that the plant possesses a broader therapeutic profile with potential disease-modifying effects.

In conclusion, the present study demonstrated that *Ipomoea batatas* extract effectively restored ovarian function, normalized hormonal imbalance, reduced oxidative stress, and improved ovarian histology in letrozole-induced PCOS rats. The findings support the therapeutic potential of *Ipomoea batatas* as a promising natural treatment for PCOS and support further investigations for its development as a safe and effective plant-based therapeutic agent.

5. CONCLUSION:

The present study successfully demonstrated the protective and restorative effects of *Ipomoea batatas* extract in letrozole-induced Polycystic Ovary Syndrome in Wistar rats. Chronic administration of letrozole produced classical features of PCOS, including irregular estrous cycles, hormonal imbalance, hyperandrogenism, oxidative stress, and cystic ovarian morphology. Treatment with *Ipomoea batatas* significantly improved these abnormalities in a dose-dependent manner.

The extract effectively restored estrous cyclicity, normalized reproductive hormones such as LH, FSH, testosterone, estradiol, and progesterone, and improved ovarian histology by reducing cystic follicles and promoting follicular maturation. In addition, the extract significantly enhanced antioxidant enzyme levels including superoxide dismutase, catalase, and glutathione while reducing malondialdehyde levels, indicating

strong antioxidant and ovarian protective activity.

The therapeutic effects observed with *Ipomoea batatas* were comparable to clomiphene citrate, suggesting its potential as an effective natural alternative for PCOS management. The beneficial effects may be attributed to the presence of flavonoids, polyphenols, anthocyanins, and other bioactive phytoconstituents possessing antioxidant, anti-inflammatory, insulin-sensitizing, and hormone-modulating properties.

Overall, the findings of the study provide preclinical evidence supporting the therapeutic potential of *Ipomoea batatas* as a promising plant-based treatment for restoring ovarian function and improving reproductive and metabolic disturbances associated with PCOS.

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