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HERBAL MEDICINE FOR POLYCYSTIC OVARY SYNDROME MANAGEMENT: A REVIEW OF TRADITIONAL AND MODERN PERSPECTIVE

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ABSTRACT

Objectives: Polycystic ovary syndrome (PCOS) is a metabolic disorder characterized by increased androgen levels, irregular menstrual cycle, and excessive bleeding. Various synthetic compounds, such as metformin and clomiphene citrate, are used to treat PCOS. However, these medicines often cause side effects and complications, to overcome these limitations, women suffering from PCOS are attracted to herbal remedies. **Methods:** Data for this study were acquired from research and review articles published in reputed databases such as Science Direct, PubMed, Google Scholar, and Sci-Hub on medicinal plants from 2011 to 2023. **Results:** In this present review, we reviewed the various natural therapies and brief mechanisms of action of these plants for managing PCOS, as well as the phytoconstituents that cause plants to exhibit anti-PCOS activity. In addition, we have explored the other therapeutic properties of these herbal remedies. **Conclusion:** This review, attempts to study various medicinal plants used to treat PCOS. These herbs have shown significant effects in managing PCOS symptoms with lesser side effects and are hence found to be safe alternatives for the treatment.

KEYWORDS: Polycystic ovary syndrome, anti-polycystic ovary syndrome, plant extract, metabolic disorder, insulin resistance, etc.

INTRODUCTION

Polycystic ovary syndrome (PCOS) is a complex endocrine metabolic disorder affecting 5-15% of women across the world at reproductive age.[1] PCOS is characterized by various symptoms such as sex hormone abnormalities (hyperandrogenism), ovarian poly-follicular morphology, ovulatory dysfunction, dyslipidemia, insulin resistance, metabolic syndrome, type 2 diabetes, and cardiovascular diseases. In most cases, PCOS is associated with an increase in androgen levels, which may cause anovulation.[2] Women suffering from PCOS require long-term treatment to normalize the level of androgen and the proper functioning of the reproductive system. Because PCOS is associated with various metabolic disturbances, which increase the risk of cardiovascular diseases. Multiple approaches have been employed to manage PCOS, such as pharmaceuticals, and surgical treatment. Among synthetic medications, commonly prescribed drugs includes oral contraceptives, insulin-sensitizing agents like metformin, and ovulation inducing agents such as clomiphene citrate, and tamoxifen. Despite its wide use, metformin's exact mechanism of action is not fully known. However, treatment with these drugs may lead to complications such as ovarian hyperstimulation, multiple pregnancies, ectopic pregnancies, and birth defects (e.g., neural tube defects), as well as side effects such as anorexia, diarrhea, and abdominal discomfort. To overcome these complications and side effects, new strategies such as acupuncture, herbal medicines, and dietary supplements are investigated to study their potential impact on PCOS.[3, 4] Hence, the present study is aimed to examine the effect of various plant extracts and their mechanism in treating PCOS.

MEDICINAL PLANTS USED TO TREAT POLYCYSTIC OVARIAN SYNDROME (PCOS)

The *Vitex agnus-castus* plant exhibited anti-PCOS activity by inhibiting testosterone secretion by interfering with insulin-like growth factor 1 in ovarian stomata due to the presence of active flavonoids. The extract also works by causing changes in hormones, lipid profile, oxidative stress, and hypoglycaemic effects in treating PCOS. In this way, the plant extract has shown potential in reducing symptoms related to PCOS. The plant also treats diseases such as menstrual irregularities, infertility, acne, inflammation, epilepsy, splenic disease, urination, premenstrual syndrome, and decreased lactation.[5, 6]

This study has suggested that the extract and ethyl acetate fraction of *Ocimum kilimandscharicum L.* enhanced insulin sensitivity by lowering fasting blood glucose and

insulin levels, which resulted in a significant reduction in the HOMA index. This effect is due to the presence of rutin and quercetin which increases the glucose uptake by target cells. Other phytoconstituents such as flavone, apigenin, and isorhamnethin glucoside are responsible for showing anti-hyperglycaemic effects. The extract and fraction showed a significant reduction in the level of total cholesterol (TC) and triglycerides (TG) compared to the groups of letrozole and metformin without treatment. These results support its potential for the treatment of PCOS. The plant *Ocimum kilimandscharicum L.* has been found to have several therapeutic applications such as antimalarial, insecticidal, antioxidant, antimicrobial, wound healing, and antifungal activity.[7, 8]

In this study researcher suggested that an aqueous or methanolic extract of *Phyllanthus muellerianus, (Kuntze) Eccell* showed the effect against PCOS by converting androgen to estrogen by improving the concentration of estradiol. These findings suggest that *Phyllanthus muellerianus* is effective in treating PCOS symptoms. It has been reported that *Phyllanthus Muellerianus* is utilized to treat microbial infection, inflammation, anemia, and cancer.[9, 10]

In this study researcher investigated the effect of hydroalcoholic extract of *Ulmus minor* bark which improved the number of corpus luteum in the treatment group. It showed an anti-PCOS effect by decreasing the number of follicles in different stages and the level of testosterone. Anti-PCOS activity of the plant is due to the presence of active phytochemicals such as lupeol, β-sitosterol, hydroxycoumarins (scopoletin, and isofraxidin), and triterpenes. *Ulmus minor* is used in the treatment of oxidative stress, allergies, inflammation, and cancer.[11, 12]

This study investigated the effect of *Moringa oleifera* extract on a rat model of PCOS induced by testosterone propionate. Testosterone propionate successfully induced PCOS, by ovarian enlargement and theca-interstitial hyperplasia. Plant extract significantly reduced the thickness of theca cell follicles and decreased oxidative stress in the PCOS model, through the inhibition of inflammatory factors and modulation of insulin resistance pathways. These plant leaves are rich in nutrients, including vitamins A, C, E, and flavonoids. Vitamin E and high levels of polyphenols, such as quercetin are known for their strong antioxidant properties. These phytoconstituents improved the health of theca cells in the PCOS model which is responsible for showing anti-PCOS activity of *Moringa oleifera.* This plant has numerous biological activities which include antidyslipidemic, anthelmintic,

antihyperglycemic, anti-inflammatory, antioxidant, antiproliferative, antiurolithiatic, and hepatoprotective activity.[13, 14]

This research suggested that *Betel leaf* extract significantly normalised serum testosterone levels and restored progesterone and estradiol levels to near normal, comparable to the effects observed with clomiphene citrate. Additionally, it demonstrated an anti-hyperlipidemic effect through the reduction of TC, TG, and low-density lipoprotein (LDL) levels. Leaf extract has shown enhancement in the activity of antioxidant enzymes, such as superoxide dismutase (SOD) and catalase (CAT). Furthermore, it displayed hepatoprotective properties by normalizing liver enzyme levels. Histopathological examination indicated that the use of extract led to the restoration of ovarian health by improving immature follicles to primary and secondary oocytes, also involved in the formation of normal corpus luteum and secondary follicles. In this way, *Betel leaf* extract has shown potential in reducing symptoms related to PCOS. This plant possesses various biological activities, which include anticancer, anti-diabetic, anti-fertility, anti-hypercholesteraemic, antioxidant, and antifungal activity.[15, 16]

The result of this study indicated that the herb *Salvia officinalis L.* (sage tea) is effective in treating PCOS by managing glucose levels, lowering LDL, and TC, and reducing oxidative stress. The presence of flavonoids such as kaempferol along with glycosides might contribute to the plant's efficacy against PCOS. However, it has not demonstrated a notable effect on insulin resistance. *Salvia officinalis* exhibits various biological activities such as antioxidant antiseptic, anti-inflammatory, and memory-enhancing effects.[17, 18]

This research demonstrated that the administration of *Chitosan-funnel* seed extract was effective in addressing complications associated with PCOS by lowering serum levels of insulin, LH, fasting blood sugar, testosterone, total TG, and total TC. Additionally, it increased the levels of follicle-stimulating hormone (FSH) and high-density lipoprotein (HDL). The presence of isoflavone and phytoestrogens in plants causes them to exhibit anti-PCOS activity. This study presents that the funnel seed extract is safe and effective for regulating the hormonal and biochemical alterations associated with PCOS. *Chitosan-funnel* exhibits antifungal, antithrombotic, oestrogenic, hepatoprotective, and antidiabetic activity.[19, 20]

Table 1: Details Of Plants Showing Anti-Pcos Activity.

Sr. No.	Medicinal Plant	Family	Extraction Method	Effective Phytoconstituents
1.	*Vitex agnus –castus*	Lamiaceae	Soxhlet extraction Leaves Distilled water	Flavonoid.[5]
2.	*Ocimum kilimandscharicum L.*	Lamiaceae	Solvent–solvent fractionation	Rutin and quercetin.[7]
3.	*Phyllanthus muellerianus*	Euphorbiaceae	Maceration Aqueous and Methanolic Extract	-.[9]
4.	*Ulmus minor*	Ulmaceae	Maceration Bark 70% ethanol	Lupenol (lupeol), β-sitosterol, hydroxy coumarins, scopoletin, isofraxidin, and Triterpenes (phytosterol).[11]
5.	*Moringa oleifera*	Moringaeceae	Leaf	Polyphenol(Quercetin).[13]
6.	*Betel*	Piperaceae	Betel leaf Ethanolic Extract	-.[15]
7.	*Salvia officinalis L.*	Lamiaceae	Maceration Leaves Boiling water	Flavonoids like kaempferol.[17]
8.	*Chitosan-fennel*	Apiaceae	Boil in water-bath Seeds 70% ethanol	Isoflavone, phytoestrogens.[19]
9.	*Majoram*	Lamiaceae	Alcohol Extract	-.[21]
10.	*Capparis spinosa*	Capparidaceae	Soxhlet extraction Aerial parts 85% methanol	Quercetin.[23]
11.	*Stachys sylvatica*	Lamiaceae	Soxhlet extraction Herbs 70% ethanol	Flavonoids, iridoids, and sesquiterpenes.[25]
12.	*Nigella sativa*	Ranunculaceae	Maceration Seed (96% ethanol)	Linoleic acid.[27]
13.	*Vitex agnus-castus*	Lamiaceae	Fruit 70% Ethanol	-.[29]
14.	*Caesalpinia bonduc (L.) Roxb*	Fabaceae	Soxhlet extraction Seeds	-.[30]
15.	*Azadirachta indica*	Meliaceae	Soxhlet extraction Leaves Ethanol	Quercetin.[32]
16.	*Cicer arietinum L.*	Leguminosae, Fabaceae	Maceration Seeds 70% ethanol	Phenolic compounds.[34]
17.	*Cyperus esculentus tubers*	Cyperaceae	Maceration Nuts Phosphate-buffered saline (PBS)	-.[36]
18.	*Teucrium polium*	Lamiaceae	Maceration Aerial parts 70% ethanol	Flavonoids (rutin and apigenin).[37]

19.	*Calendula officinalis*	Asteraceae	Percolation 70% ethanol	Phytosterol, polyphenolic polysaccharides, flavonoids, oligoproteins, polypeptides, steroids, alkaloids, and pectin.[39]
20.	*Iraqi Cressa cretica*	Convolvulaceae	Soxhlet extraction Whole Plant Methanol	polyphenol compounds (quercetin and Kaempferol).[41]
21.	*Tinospora cordifolia (Willd)*	Menispermaceae	Cold maceration Stem 70% ethanol	isoquinoline alkaloids, (palmatine, jatrorrhizine, and magnoflorine).[42]
22.	*Cedrus deodara (Roxb. ex D.Don) G.Don*	Pinaceae	Maceration Bark Methanol, water hydromethanol(1:1)	Flavonoids such as deodarin, cedrin, and deodardione.[44]
23.	*Centratherum anthelminticum*	Malvaceae	Maceration Seed ethanol	Phytochemicals (kaempferol, ferulic acid, malvidin, and quercetin).[46]
24.	*Saraca asoca*	Fabaceae	Maceration Bark Ethanol 95%	Flavonoid (kaempferol and rutin).[48]
25.	*Malva sylvestris*	Malvaceae	Shaking Leaves 80% ethanol	Flavonoids and saponins.[50]
26.	*Ziziphus mauritiana*	Rhamnaceae	Leaves	Quercetin.[52]
27.	*Orchid*	Orchidaceae	96% ethanol	Quercetin, daucosterol and sircinol.[54]

In a study, researchers examined the effect of *Majoram* (basil) on the dehydroepiandrosterone (DHEA)-induced PCOS model. The DHEA group showed insulin resistance, indicated by a decrease in serum adiponectin, without a significant change in body weight. DHEA treatment increased inflammatory markers (IL-6, TNF-α) and oxidative stress, through an increase in plasma thiobarbituric acid reactive substances (TBARS) and a reduction in antioxidant enzyme activity (GPx, SOD). Treatment with basil, metformin, or their combination significantly reduced estradiol levels, with metformin also reducing progesterone. *Majoram* treatment resulted in a reduction in ovarian weight compared to the DHEA group, suggesting a possible reduction of cysts. Although *Majoram* improved testosterone levels, the differences were not statistically significant. Additionally, this plant has several biological activities such as antioxidant, antimicrobial, anti-inflammatory, anticancer, antiplatelet, and antiulcerogenetic activity.[21, 22]

The research was conducted to examine the effect of *Capparis spinosa* on letrozole-induced polycystic ovary syndrome (PCOS) in rats. Letrozole administration led to a significant

increase in blood glucose, hyperinsulinemia, dyslipidemia, etc. Treatment with plant extract resulted in reduced blood glucose levels and improved lipid profiles, due to the presence of quercetin which enhances insulin sensitivity. The plant extract positively influenced hormonal profiles. Statistical analysis indicated significant improvement in follicle count, antral follicles, and a reduction in cystic follicles. These findings suggest that *Capparis spinosa* is effective in treating PCOS symptoms. It has been reported that this plant is utilized in the treatment of diabetes, obesity, and hypertension.[23, 24]

This investigation assessed the therapeutic efficacy of *Stachys sylvatica* extract in a PCOS model using Wistar rats induced with estradiol valerate. The extract significantly lowered estrogen levels, elevated FSH levels, and restored the LH/FSH ratio to near-normal values. These results suggest that *Stachys sylvatica* extract may serve as a potential treatment for PCOS, likely owing to its bioactive constituents like iridoids, flavonoids, and sesquiterpenes and its antioxidant activity, which may help to reduce oxidative stress linked to the disorder. Additionally, this plant has anti-proliferative activity.[25, 26]

This research examined the effect of *Nigella sativa*, on DHEA induced rat model. Treatment with extract shows decreased estrogen, LH, and testosterone levels, while increased FSH and progesterone levels. The extract shows potential by reducing insulin resistance, glucose levels, and weight gain. The active compounds in plant extract such as phytoestrogens and thymoquinone may exert their effects through various mechanisms, including hormone receptor modulation, insulin sensitivity enhancement, and increased antioxidant enzymes. These findings make *Nigella sativa* a selective candidate for treating PCOS. This plant exhibits antiviral, antifungal, wound healing, and anticonvulsant activity.[27, 28]

The study examined the effect of *Vitex agnus-castus* on KISS-1 gene expression in a letrozole-induced PCOS mouse model. The extract treatment regulated the LH/FSH ratio decreased testosterone and follicular cysts, and increased estrogen, antral follicle, and graafian follicle numbers. Kisspeptin expression increased in the arcuate nucleus and decreased in the anteroventral periventricular nucleus after letrozole treatment. The extract regulates KISS-1 expression through phytoestrogenic properties, modulating the hypothalamic-pituitary-gonadal (HPG) axis. These results support its potential to treat PCOS and associated menstrual disorders.[29]

In this study, the histological examination of ovaries showed that treatment with *Caesalpinia bonduc (L.) Roxb* had similar healthy follicles in different stages of development. The response of the corpus luteum was found to be identical to that of the pioglitazone treatment. Progesterone levels also increased significantly in all treatment groups. The plant extract showed a significant reduction in the levels of TG, LDL, very low-density lipoprotein (VLDL), and TC, with an increase in HDL. Additionally, *Caesalpinia bonduc* exhibits antidiabetic, anti-inflammatory, anti-filarial, anticonvulsant, antispermatogenic, anticancer, and antitumor activity.[30, 31]

It was found that *Azadirachta indica* is effective in relieving PCOS symptoms. The phytoconstituent present in plants, like quercetin, inhibits the PI3K pathway, which leads to the reduced expression of the CYP17A1 gene involved in steroidogenesis. Histopathological analyses revealed enhanced follicular development and reduced apoptosis markers in the ovaries of PCOS rats treated with plant extract. In addition, *Azadirachta indica* effectively reduced markers of dyslipidemia, including cholesterol and TG. Treatment with extract reduces both elevated testosterone and LH levels. In this way, *Azadirachta indica* has shown a significant effect in treating PCOS. This plant has been reported to possess larvicidal, antidiabetic, anti-HIV, antihypertensive, and anti-hypercholesteremic activity.[32, 33]

It was reported that *Cicer arietinum L.* was employed to examine its anti-PCOS activity. Treatment with extract significantly decreased ovarian weight, restored normal follicular formation, improved granulosa cell thickness, and reduced theca cell hyperplasia, due to its antioxidant and anti-androgenic properties. Immunohistochemical analysis showed increased Ki-67 in granulosa cells of control and extract-treated groups, while the PCOS group exhibited heightened cell proliferation. The plant extract also significantly lowered LH and testosterone levels in the letrozole-induced PCOS model, potentially by inhibiting the hypothalamic-pituitary-gonadal axis and increasing sex hormone-binding globulin. Additionally, Extract reduced Cyp11a1 mRNA expression and improved hyperglycemia and lipid profiles. Its phenolic compounds may help to mitigate oxidative stress. In summary, *Cicer arietinum L.* shows promise as an alternative treatment for PCOS. This plant exhibits anti-inflammatory, antifungal, and anticarcinogenic activity.[34, 35]

In this study, the researcher developed *Cyperus esculentus* tubers aqueous extract which effectively regulated testosterone, FSH, and LH levels while increasing progesterone and estradiol levels. Histopathological analysis revealed that treatment with extract effectively

promoted ovarian tissue regeneration and resolution of polycystic follicles, suggesting a restoration of ovulation. Moreover, the plant extract showed enhancements in insulin sensitivity, glucose levels, and lipid profiles through the increase in HDL and reduction in TG and LDL levels. These findings suggest that extract may be a promising natural dietary supplement for managing PCOS and enhancing reproductive health, offering a safe alternative for those affected by the disorder.[36]

This research investigated the effect of *Teucrium polium* extract on PCOS in a rat model induced by letrozole. The extract contains phytoconstituents which showed antiandrogenic activity that lowers the testosterone level. The LH/FSH ratio was increased in rats with PCOS, which was normalized after administration with *Teucrium polium.* The flavonoids, such as rutin and apigenin, present in the extract have improved hormonal profiles and ovarian function. Treatment with extract promoted follicular development and ovulation. Histological analysis showed that *Teucrium polium* improved ovarian morphology, increasing the number of developing follicles and reducing cysts. Overall, the hydroalcoholic extract has shown promise in enhancing hormonal indices, estrous cyclicity, and ovarian health, suggesting it could be a beneficial adjunct therapy for PCOS. It has been reported that Teucrium polium possesses anticancer, hypoglycemic, anti-inflammatory, hypolipidemic, antifungal, and antibacterial activity.[37, 38]

In this study, *Calendula officinalis* hydroalcoholic extract has been demonstrated to significantly reduce PCOS symptoms. Treatment with plant extract resulted in a reduction in oxidative stress by decreasing malondialdehyde (MDA) levels and enhancing antioxidant activity. The extract reduced testosterone levels, which lowered body weight and ovarian weight, by increasing sex hormone-binding globulin. Hormonal analysis has indicated elevated levels of LH and progesterone, due to the presence of phytosterol and polyphenolic compounds. Histological analysis revealed a diminished thickness of the theca and tunica albuginea layers, with a reduced number of cystic follicles. These findings suggest an enhancement in ovarian function. Overall, the extract of *Calendula officinalis* shows potential as a therapeutic option for managing PCOS. This plant is utilized in the treatment of inflammation, cancer, and HIV.[39, 40]

In this study, PCOS was induced through the administration of testosterone to study the effect of *Cressa cretica.* Treatment with the n-butanol fraction of *Cressa cretica* resulted in a notable decrease in both body weight and fasting blood sugar levels when compared to PCOS

models. The fraction contains bioactive compounds, such as flavonoids like quercetin and kaempferol that exhibit potential anti-obesity and antidiabetic effects. The treatment also normalized the estrous cycle, indicating restored ovarian function. Overall, the findings indicate that the extract of *Cressa cretica* may potentially provide therapeutic advantages in the management of symptoms associated with PCOS.[41]

In this study, *Tinospora cordifolia* extract has been demonstrated to effectively alleviate symptoms of PCOS. The treatment with plant extract resulted in an improvement in the regularity of the estrous cycle and restoration of hormonal balance. Extract significantly reduced testosterone levels, and increased estrogen and progesterone level. After treatment with plant extract, rats exhibited a decrease in body weight, enhanced metabolic regulation, reversal of hyperglycemia, and reduction in insulin resistance. Blood lipid profiles were also improved, demonstrating lower levels of TG and TC. Histological analysis indicated the restoration of normal ovarian morphology, an elevation in follicle counts, and a decrease in cysts. Overall, the extract demonstrates potential in the management of PCOS by improving both metabolic and ovarian function. *Tinospora cordifolia* is utilized for treating diabetes, cancer, HIV, and osteoporosis.[42, 43]

In this study, the researcher developed fraction F1 from *Cedrus deodara* which was demonstrated for anti-PCOS activity. The LC-MS analysis revealed the presence of flavonoids such as deodarin, cedrin, and deodardione, which are known for their uterine relaxant properties. Molecular docking studies have revealed promising interactions with androgen and insulin receptors, which are known to play a crucial role in the pathogenesis of PCOS. Treatment effectively restored levels of LH, DHEA, estradiol, and FSH. Moreover, fraction was found to improve insulin sensitivity and lipid profiles. *Cedrus deodara* bark has shown potential effects in the treatment of ovarian cysts and improved ovarian morphology. In addition, *Cedrus deodara* possesses numerous biological activities which include anticancer, antifungal, neuroprotective, insecticidal, antidiabetic, and antiasthmatic activity.[44, 45]

The study investigated the effectiveness of *Centratherum anthelminticum* extract in PCOS rat models. Extract significantly enhanced lipid profiles, insulin levels, liver function, and serum hormones. Key phytochemicals, such as kaempferol, ferulic acid, malvidin, and quercetin, have been found to possess anti-inflammatory and antioxidant properties. The plant extract can decrease insulin levels and enhance insulin sensitivity, which may be attributed to its

inhibition of enzymes responsible for glucose absorption. It additionally decreased TC and TG levels, possibly by influencing the activity of HMG-CoA reductase. Histopathological analysis indicated a reduction in the number of ovarian cysts and the presence of normal follicles and corpora lutea. These findings suggest that plant extract could be a promising therapeutic option for managing PCOS. It is been discovered *Centratherum anthelminticum* possesses other therapeutic benefits including anthelmintic, antifilarial, anti-inflammatory, and antidiabetic activity.[46, 47]

The plant *Saraca asoca* has been studied for its potential effect on the Letrozole-induced PCOS rat model. The plant extract improved insulin sensitivity and lowered insulin levels, potentially by reducing chemerin gene expression. Histopathological analysis showed that the total count of ovarian cysts was reduced and promoted follicular development, at higher doses. It increased FSH while decreasing testosterone and LH levels disrupted by PCOS. Flavonoids like kaempferol and rutin in the extract may be responsible to show antioxidant effects, by restoring MDA, SOD, CAT, and glutathione (GSH) levels. Overall, *Saraca asoca* extract effectively alleviated PCOS symptoms in a dose-dependent manner, indicating its potential as a therapeutic option. In addition, this plant is utilized to manage cancer, diabetes, and HIV symptoms.[48, 49]

The study was conducted to demonstrate the effect of *Malvia sylvestris* on testosterone enanthate-induced PCOS in rats. Treatment with hydroalcoholic extract at different doses significantly reduced serum testosterone, and LH levels and increased progesterone levels. The phytoconstituents present, especially flavonoids and saponins, may be responsible for showing an antiandrogenic effect. Histological analysis showed a reduction in normal antral follicles and an increase in atretic and cystic follicles in the PCOS control group. Treatment with extract improved ovarian morphology by increasing the number of healthy follicles and corpora lutea while decreasing cystic follicles. The extract's antioxidant properties likely contributed to its protective effects against hormonal and morphological disturbances associated with PCOS. Overall, *M. sylvestris L.* shows promising effects in managing PCOS. In addition, this plant has shown significant effects in treating ulcers, aging, and HIV.[50, 51]

In this study, the researcher evaluated the effect of the methanolic extract of *Ziziphus mauritiana* leaves on the letrozole-induced PCOS rat model. Treatment with the extract (100 and 200 mg/kg) and clomiphene citrate successfully reversed the diestrus phase. Rats suffering from PCOS had increased body and ovarian weight which was decreased by

administrating extract. Treatment with extract normalized the progesterone, and estradiol levels and reduced the elevated level of testosterone. The extract also normalized cholesterol levels, with 200 mg/kg demonstrating a potent effect. HPTLC fingerprinting analysis identified the various phytoconstituents. This analysis suggested that quercetin may be the key phytochemical, known for its potential to improve insulin sensitivity and may be effective against PCOS. Overall, these findings indicate that *Ziziphus mauritiana* could be a promising treatment for PCOS-related symptoms. This plant is employed to manage microbial infection, inflammation, oxidative stress, hyperlipidemia, cancer, and diabetes.[52, 53]

This study investigated the effect of *Orchid* root aqueous extract on animals with PCOS. The results showed that the extract can enhance graafian follicles and reduce the rate of atresia. It resulted in an elevation in serum levels of progesterone, gonadotropin-releasing hormone (GnRH), and FSH. The extract has been shown to normalize LH levels due to the presence of phytocomponents such as quercetin, daucosterol, and cercilinol, all of which demonstrate estrogenic effects. Furthermore, it also stimulated the production of insulin and insulin-like growth factor-1. Both of these substances have the potential to increase progesterone synthesis. These findings make *Orchid* an alternative treatment for PCOS. *Orchid* also possess additional therapeutic applications, including anti-inflammatory and antitumor activity.[54, 55] Table 1 depicts the details of plants showing anti-PCOS activity.

DISCUSSION

Polycystic ovary syndrome is a complicated endocrine metabolic condition that affects women of reproductive age including various complications like diabetes, infertility, ovulatory dysfunction cardiovascular diseases, etc. Synthetic medications have shown potential efficacy in treating PCOS symptoms however, these medications have reported more side effects as well as adverse reactions with other medicines, and hence they are less safe for the patient suffering from PCOS. In this scenario, herbal therapy is found to be a safe alternative for treating PCOS. In this review, an attempt has been made to study the medicinally potent and relevant plants and major phytoconstituents that are responsible for anti-PCOS activity.

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REFERENCES

1. Azziz R. Polycystic ovary syndrome. Obstet. Gynaecol., 2018; 1: 132(2): 321-36. https://doi.org/10.1097/aog.0000000000002698
2. Zeng X, Xie YJ, Liu YT, Long SL, Mo ZC. Polycystic ovarian syndrome: Correlation between hyperandrogenism, insulin resistance and obesity. Clin. Chim. Acta., 2020; 1: 502: 214-21. https://doi.org/10.1016/j.cca.2019.11.003
3. Jang M, Lee MJ, Lee JM, Bae CS, Kim SH, Ryu JH, et al. Oriental medicine Kyung-Ok-Ko prevents and alleviates dehydroepiandrosterone-induced polycystic ovarian syndrome in rats. PLoS One., 2014; 10: 9(2): e87623. https://doi.org/10.1371/journal.pone.0087623
4. Abasian Z, Rostamzadeh A, Mohammadi M, Hosseini M, Rafieian-Kopaei M. A review on the role of medicinal plants in polycystic ovarian syndrome: pathophysiology, neuroendocrine signaling, therapeutic status and prospects. Middle East Fertil. Soc. J., 2018; 1: 23(4): 255-62. http://dx.doi.org/10.1016/j.mefs.2018.04.005
5. Hamza AH, AlBishri WM, Alfaris MH. Effect of Vitex agnus-castus plant Extract on polycystic ovary syndrome complications in experimental rat model. Asian Pac. J. Reprod., 2019; 1: 8(2): 63-9. http://dx.doi.org/10.4103/2305-0500.254647
6. Kamal N, Mio Asni NS, Rozlan IN, Mohd Azmi MA, Mazlan NW, Mediani A, et al. Traditional medicinal uses, phytochemistry, biological properties, and health applications of Vitex sp. Plants., 2022: 26; 11(15): 1944. https://doi.org/10.3390/plants11151944
7. Khaled N, El-Bahy AA, Radwan R, Handoussa H, AbdelMaksoud S. Ocimum kilimandscharicum L. restores ovarian functions in letrozole-induced Polycystic Ovary Syndrome (PCOS) in rats: Comparison with metformin. Life Sci., 2019; 1: 232: 116640. https://doi.org/10.1016/j.lfs.2019.116640
8. Soni N, Gill D, Sagar BS, Raheja S, Agrawal S. Ocimum kilimandscharicum: A systematic review. J. Drug Deliv. Ther., 2012; 14: 2(3). https://doi.org/10.22270/jddt.v2i3.169
9. Ndeingang EC, Defo Deeh PB, Watcho P, Kamanyi A. Phyllanthus muellerianus (Euphorbiaceae) restores ovarian functions in letrozole-induced polycystic ovarian syndrome in rats. Evid Based Complement Alternat Med., 2019; 1: 2965821. https://doi.org/10.1155/2019/2965821

10. Ofokansi MN, Akah PA, Omewu JO. Phyllanthus Muellerianus,(Kuntze) Eccell.: Review of the Ethnomedical Uses, Phytochemistry and Pharmacological Activities. J Med Plant Herbs., 2023; 2: 1-2. http://dx.doi.org/10.17303/jmph.2023.2.105
11. Hoseinpour MJ, Ghanbari A, Azad N, Zare A, Abdi S, Sajadi E, et al. Ulmus minor bark hydro-alcoholic Extract ameliorates histological parameters and testosterone level in an experimental model of PCOS rats. Endocr. Regul., 2019; 1: 53(3): 146-53.
12. Park WS, Kim HJ, Khalil AA, Kang DM, Akter KM, Kwon JM, et al. Anatomical and Chemical Characterization of Ulmus Species from South Korea. Plants., 2021; 29: 10(12): 2617. https://doi.org/10.3390/plants10122617
13. Wulandari LP, Hapsari A. THE EFFECT OF Moringa oleifera LEAF EXTRACT ON THECA CELL IN POLYCYSTIC OVARY SYNDROME MODEL WITH INSULIN RESISTANCE. Jurnal Kedokteran Hewan. 2020 Sep 19; 14(3). DOI: https://doi.org/10.21157/j.ked.hewan. v14i3.16919
14. Maizuwo AI, Hassan AS, Momoh H, Muhammad JA. Phytochemical constituents, biological activities, therapeutic potentials and nutritional values of Moringa oleifera (Zogale): a review. J. Drug Des. Med. Chem., 2017; 28: 3(4): 60-6. http://dx.doi.org/ 10.11648/j.jddmc.20170304.12
15. Sunand K, Yellow M, Naveen P, Deepika Y, Mohan GK, Bakshi V. Betel Leaf Extract Amends Dehydroepiandrosterone Induced PCOS Related Hormonal Abnormality and Histopathological Alterations in Rat Model. Pharmacogn. J., 2019; 11(6s). http://dx.doi.org/10.5530/pj.2019.11.223
16. Umar RA, Zahary MN, Rohin MA, Ismail S. Chemical composition and the potential biological activities of Piper betel–a Review. Malays. J. Appl. Sci., 2018; 28: 3(1): 1-8.
17. Ghowsi M, Yousofvand N, Moradi S. Effects of Salvia officinalis L. (common sage) leaves tea on insulin resistance, lipid profile, and oxidative stress in rats with polycystic ovary: An experimental study. Avicenna J Phytomed., 2020; 10(3): 263. http://dx.doi.org/10.22038/ajp.2019.14005
18. Ghorbani A, Esmaeilizadeh M. Pharmacological properties of Salvia officinalis and its components. J Tradit Complement Med., 2017; 1: 7(4): 433-40. https://doi.org/10.1016/j.jtcme.2016.12.014
19. Bayrami A, Shirdel A, Pouran SR, Mahmoudi F, Habibi-Yangjeh A, Singh R, Raman AA. Co-regulative effects of Chitosan-fennel seed Extract system on the hormonal and biochemical factors involved in the polycystic ovarian syndrome. Mater. Sci. Eng. C., 2020; 1: 117: 111351. https://doi.org/10.1016/j.msec.2020.111351

20. Rather MA, Dar BA, Sofi SN, Bhat BA, Qurishi MA. Foeniculum vulgare: A comprehensive review of its traditional use, phytochemistry, pharmacology, and safety. Arab. J. Chem., 2016; 1: 9: S1574-83. https://doi.org/10.1016/j.arabjc.2012.04.011
21. Rababa'h AM, Matani BR, Ababneh MA. The ameliorative effects of Majoram in dehydroepiandrosterone induced polycystic ovary syndrome in rats. Life Sci., 2020; 15: 261: 118353. https://doi.org/10.1016/j.lfs.2020.118353
22. Bina F, Rahimi R. Sweet marjoram: a review of ethnopharmacology, phytochemistry, and biological activities. Evid Based Complement Alternat Med., 2017; 22(1): 175-85. https://doi.org/10.1177/2156587216650793
23. Al-mously SA, Gatea FK, Jawad EN, Qasim B. The Effect of Capparis spinosa Extract on Induced PCOS Mice. Int. J. Pharm. Res., 2020; 2: 12(2). https://doi.org/10.31838/ijpr/2020.SP2.326
24. Zhang H, Ma ZF. Phytochemical and pharmacological properties of Capparis spinosa as a medicinal plant. Nutrients., 2018; 24: 10(2): 116. https://doi.org/10.3390/nu10020116
25. Alizadeh F, Ramezani M, Piravar Z. Effects of Stachys sylvatica hydroalcoholic Extract on the ovary and hypophysis-gonadal axis in a rat with polycystic ovary syndrome. Middle East Fertil. Soc. J., 2020; 30: 25(1): 4. https://doi.org/10.1186/s43043-020-0015-9
26. Tundis R, Peruzzi L, Menichini F. Phytochemical and biological studies of Stachys species in relation to chemotaxonomy: A review. Phytochemistry., 2014; 1: 102: 7-39. https://doi.org/10.1016/j.phytochem.2014.01.023
27. Khani S, Abdollahi M, Khalaj A, Heidari H, Zohali S. The effect of hydroalcoholic Extract of Nigella Sativa seed on dehydroepiandrosterone-induced polycystic ovarian syndrome in rats: An experimental study. Int. J. Reprod. BioMed., 2021; 19(3): 271. https://doi.org/10.18502/ijrm.v19i3.8575
28. Islam MT. Biological activities and therapeutic promises of Nigella sativa L. Int J Pharm Sci & Scient Res., 2016; 2(6): 237-52. http://dx.doi.org/10.25141/2471-6782-2016-6.0237
29. Feyzollahi Z, Kouchesfehani HM, Jalali H, Eslimi-Esfahani D, Hosseini AS. Effect of Vitex agnus-castus ethanolic Extract on hypothalamic KISS-1 gene expression in a rat model of polycystic ovary syndrome. Avicenna J Phytomed., 2021; 11(3): 292. https://doi.org/10.22038/AJP.2020.17046
30. Ayyadurai T, Thiruppathi SK, Shanmugam A, Diana RK. Effect of aqueous seed Extract of Caesalpinia bonduc (L.) Roxb., on hormonal assay and lipid profile in induced polycystic ovary syndrome albino female rats. Int J Bot Stud., 2021; 6(3): 139-46.

31. Pandey DD, Jain AP, Kumar A. Caesalpinia bonducella: A pharmacological important plant. Pharma Innovation., 2018; 7(12): 190-3.
32. Patel SV, Maru H, Chavda VK, Shah JN, Patel SS. Ethanolic Extract of Azadirachta indica ameliorates ovarian defects through phosphoinositide-3 kinase inhibition in a rat model of polycystic ovary syndrome. Asian Pac. J. Reprod., 2021; 1: 10(1): 21-8. http://dx.doi.org/ 10.4103/2305-0500.306434
33. Hashmat I, Azad H, Ahmed A. Neem (Azadirachta indica A. Juss)-A nature's drugstore: an overview. Int Res J Biol Sci., 2012; 1(6): 76-9.
34. Ali SE, El Badawy SA, Elmosalamy SH, Emam SR, Azouz AA, Galal MK, et al. Novel promising reproductive and metabolic effects of Cicer arietinum L. Extract on letrozole induced polycystic ovary syndrome in rat model. J. Ethnopharmacol., 2021; 5: 278: 114318. https://doi.org/10.1016/j.jep.2021.114318
35. Faridy JC, Stephanie CG, Gabriela MM, Cristian JM. Biological activities of chickpea in human health (Cicer arietinum L.). A review. Plant Foods Hum Nutr., 2020; 75: 142-53. https://doi.org/10.1007/s11130-020-00814-2
36. Adelakun SA, Ojewale AO, Jeje SO, Adedotun OA. Histomorphometric and biochemical activities of bioactive component of Cyperus esculentus tubers Extract on letrozole-induced polycystic ovarian syndrome and cholesterol homeostasis in female Sprague-Dawley rats. Toxicol. Res. Appl., 2022; 11: 6: 23978473221109475. https://doi.org/10.1177/23978473221109475
37. Khosrowpour Z, Fahimi S, Jafari F, Tansaz M, Sahranavard S, Faizi M. Beneficial effects of Teucrium polium hydroalcoholic Extract on letrozole-induced polycystic ovary syndrome in rat model. Obstet Gynecol Sci., 2022; 28: 66(2): 107-17. https://doi.org/10.5468/ogs.22129
38. Bahramikia S, Gavyar PH, Yazdanparast R. Teucrium polium L: An updated review of phytochemicals and biological activities. Avicenna J Phytomed., 2022; 12(3): 224. https://doi.org/10.22038/AJP.2021.19155
39. Gharanjik F, Shojaeifard MB, Karbalaei N, Nemati M. 2022. The Effect of Hydroalcoholic Calendula officinalis Extract on Androgen-Induced Polycystic Ovary Syndrome Model in Female Rat. Biomed Res. Int., 2022; 1: 7402598. https://doi.org/10.1155/2022/7402598
40. Khalid KA, da Silva JT. Biology of Calendula officinalis Linn: focus on pharmacology, biological activities and agronomic practices. Med Aromat Plant Sci Biotechnol., 2012; 6(1): 12-27

41. Abdulhussein AJ, Mutlag SH. The therapeutic potential of Iraqi Cressa Cretica species on metabolic features and estrous cycle in PCOS model. NeuroQuantology., 2022; 20(5): 4433. http://dx.doi.org/10.14704/nq.2022.20.5.NQ22727
42. Rani R, Sharma AK, Chitme HR. Therapeutic Effect of Tinospora cordifolia (Willd) Extracts on Letrozole-Induced Polycystic Ovarian Syndrome and its Complications in Murine Model. Clin. med. insights, Endocrinol., 2023; 16: 11795514231203864. https://doi.org/10.1177/11795514231203864
43. Sharma P, Dwivedee BP, Bisht D, Dash AK, Kumar D. The chemical constituents and diverse pharmacological importance of Tinospora cordifolia. Heliyon., 2019; 1: 5(9). https://doi.org/10.1016/j.heliyon.2019.e02437
44. Bisht A, Gururani R, Jain S, Shukla R, Dwivedi J, Sharma S. Cedrus deodara (Roxb. ex D. Don) G. Don bark fraction ameliorates metabolic, endocrine and ovarian dynamics in rats experiencing polycystic ovarian syndrome. J. Ethnopharmacol., 2023; 24: 306: 116206. https://doi.org/10.1016/j.jep.2023.116206
45. Bisht A, Jain S, Misra A, Dwivedi J, Paliwal S, Sharma S. Cedrus deodara (Roxb. ex D. Don) G. Don: A review of traditional use, phytochemical composition and pharmacology. J. Ethnopharmacol., 2021; 28: 279: 114361. https://doi.org/10.1016/j.jep.2021.114361
46. Shoaib M, Saleem A, Zeb A, Khan MI, Akhtar MF. Chemical characterization and ameliorating Effect of Centratherum anthelminticum Extract against polycystic ovary syndrome in Wistar rats. Int. J. Endocrinol., 2023; 1: 4978562. https://doi.org/10.1155/2023/4978562
47. Paydar MJ, Moharam BA, Wong YL, Looi CY, Wong WF, Nyamathulla S, et al. Centratherum anthelminticum (L.) Kuntze a potential medicinal plant with pleiotropic pharmacological and biological activities. Int. J. Pharmacol., 2013 Apr 1; 9(3): 211-26.
48. Bu N, Jamil A, Hussain L, Alshammari A, Albekairi TH, Alharbi M, et al. Phytochemical-based study of ethanolic Extract of Saraca asoca in letrozole-induced polycystic ovarian syndrome in female adult rats. ACS omega., 2023; 1: 8(45): 42586-97. https://doi.org/10.1021/acsomega.3c05274
49. Urumarudappa SK, Rosario S, Ravikanth G, Sukrong S. A comprehensive review on Saraca asoca (Fabaceae)-Historical perspective, traditional uses, biological activities, and conservation. J. Ethnopharmacol., 2023; 28: 116861. https://doi.org/10.1016/j.jep.2023.116861

50. Bayat M, Rahimi-Feyli P, Azadbakht M, Moghaddam A, Goodarzi N. Therapeutic Effects of Malva sylvestris Extract on Polycystic Ovary Syndrome in a Rat Model. Ann Med Medical Res., 203; 6: 1055. http://dx.doi.org/10.20959/wjpr20246-31713
51. Paul ZA, Malla AT, Dar MA, Masoodi MH. Phytochemistry and pharmacological activity of Malva sylvestris L: a detailed insight. Comb. Chem. High Throughput Screen, 2024; 1: 27(16): 2309-22. https://doi.org/10.2174/0113862073269336231009110313
52. Shivanandappa TB, Chinnadhurai M, Kandasamy G, Vasudevan R, Sam G, Karunakarannair A. Ziziphus mauritiana Leaves Normalize Hormonal Profile and Total Cholesterol in Polycystic Ovarian Syndrome Rats. Plants., 2023; 9: 12(14): 2599. https://doi.org/10.3390/plants12142599
53. Mesmar J, Abdallah R, Badran A, Maresca M, Shaito A, Baydoun E. Ziziphus nummularia: a comprehensive review of its phytochemical constituents and pharmacological properties. Molecules., 2022; 30: 27(13): 4240. https://doi.org/10.3390/molecules27134240
54. Abedi H, Zarrin-Mehr A, Ebrahimi B, Haghshenas H, Parvin N, Jahromi HK. The effect of aqueous Extract of orchid root on the structure of the ovary and hypothalamic-pituitary-gonadal hormones in polycystic ovary syndrome rat model: An experimental study. Int. J. Reprod. BioMed., 2024; 15: 22(3): 203. https://doi.org/10.18502/ijrm.v22i3.16164
55. Singh S, Singh AK, Kumar S, Kumar M, Pandey PK, Singh MC. 2012. Medicinal properties and uses of orchids: a concise review. Elixir Appl. Botany., 2012; 522012: 11627-34.