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A Comparative Review of Herbal Medicinal Plants and Synthetic Drugs in the Treatment of Polycystic Ovarian Syndrome (PCOS)

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ABSTRACT

Due to shifting diagnostic criteria, PCOS, a complicated endocrine disorder that affects 5 - 15% of women globally, is becoming more prevalent. Polycystic ovarian morphology, ovulatory dysfunction, and hyperandrogenism are the hallmarks of PCOS.

These conditions can lead to metabolic, reproductive, and psychological issues such as obesity, type 2 diabetes, insulin resistance, infertility, and anxiety. Even while genetic and environmental factors have a role in the development of PCOS, its underlying pathogenic etiology is still unknown, which makes treatment strategies more difficult. The limited efficacy, adverse effects, and poor adherence to conventional therapy, including insulin sensitizers, oral contraceptives, and lifestyle modifications, underscore the need for novel treatments.

In order to treat PCOS, this review looks at the therapeutic landscape of both synthetic drugs and herbal medicinal plants. Limited human trials and animal studies have demonstrated the positive benefits of important herbs on hormones and metabolism, including licorice, cinnamon, flaxseed, chamomile, and aloe vera. These herbs may help cure PCOS side symptoms like hirsutism, hyperinsulinemia, and irregular menstruation because of their hypoglycemic, anti-inflammatory, and anti-androgenic properties. Advances in synthetic drugs, such insulin sensitizers (metformin), anti-androgens, and ovulation-inducing medicines, offer specialized relief for certain problems simultaneously. However, there are still limitations in effectiveness, safety concerns, and contraindications.

The analysis highlights the therapeutic potential of integrative approaches that incorporate lifestyle changes along with herbal and pharmaceutical treatments. Herbal alternatives have less side effects and higher metabolic benefits, but additional study is needed for clinical validation. A synergistic approach that leverages the benefits of both natural and synthetic options could revolutionize PCOS treatment by addressing unmet clinical needs and improving patient outcomes.

KEYWORDS: Polycystic Ovary Syndrome (PCOS), Herbal Medicine, Synthetic Drugs, Endocrine Disorders, Ovulatory Dysfunction.

I. INTRODUCTION

Polycystic ovary syndrome (PCOS) is one of the most common disorders of endocrinology in reproductive-age women[1,2].Depending on the diagnostic criteria applied, the prevalence of polycystic ovarian syndrome (PCOS), a prevalent endocrine condition affecting women of reproductive age, ranges from 5% to 15% worldwide.

Numerous health problems, such as type 2 diabetes (T2D), obesity, insulin resistance, and beta cell malfunction in the pancreas, are linked to this illness[3]. Women with PCOS, as defined by the National Institutes of Health (NIH), typically have very serious metabolic problems. Furthermore, although the exact mechanisms underlying the metabolic, mental, and reproductive characteristics of PCOS are not entirely understood, it is commonly associated with moderate to severe anxiety and despair.

Anovulation is very common and has several different clinical manifestations, including amenorrhea, oligomenorrhea and abnormal uterine bleeding.[4]

Instead of exhibiting the cyclical hormone patterns typical of ovulating women, women with PCOS are sometimes characterized as being in a "hormonally steady state," with gonadotropin and sex steroid levels comparable to those seen in the early follicular phase. These women experience an abnormally high amount of luteinizing hormone (LH) due to the increased frequency and amplitude of gonadotropin-releasing hormone (GnRH) pulses. The feedback effects of persistently high levels of

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estrone and inhibin B then cause follicle-stimulating hormone (FSH) levels to decrease, leading to an elevated LH/FSH ratio.

PCOS is typically diagnosed when at least two of the three criteria—high blood androgen levels, clinical signs of hyperandrogenism, or polycystic ovaries evident on ultrasonography—are met[5]. Often starting in the early reproductive years, common symptoms include infertility, irregular menstrual cycles, and hyperandrogenic manifestations such as hirsutism, acne, and androgenic alopecia.

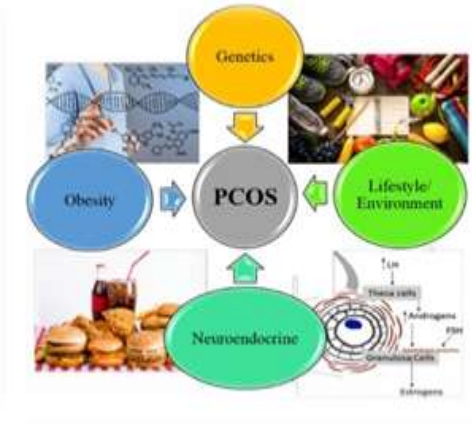

Fig. 1.PCOS risk change factors.

The neuroendocrine aspects of PCOS are reflected in its hallmark symptoms, which include polycystic ovarian morphology, hyperandrogenism, and ovulatory dysfunction[6]. These include higher LH levels, a higher ratio of LH to FSH, and more frequent and pronounced LH pulses. Gonadotrophs produce more LH and FSH when GnRH from the hypothalamus attaches to receptors on adenohypophysis secretory cells. Development, growth, puberty, and reproductive processes are all regulated by this mechanism. Through a negative feedback loop, FSH and LH cause the ovaries to produce more estrogen, which prevents the creation of more GnRH.

Infertility, gestational diabetes, miscarriage, premature birth, metabolic syndrome, irregular uterine bleeding, and an elevated risk of endometrial cancer are just a few of the issues that PCOS can cause[7]. Although the main pathogenic driver of PCOS is unknown, low-grade inflammation, genetic susceptibility, increased androgen levels, and excessive insulin are contributing factors.

Clinical treatments, such as hormone therapy and surgical treatment, have side effects[8].

Treatments include ovulation induction, oral contraceptives to control menstruation, and lifestyle modifications including exercise to control weight, reduce testosterone, and improve insulin resistance. Typically, the Rotterdam criteria are used for diagnosis. However, there is a need for more effective alternatives because standard treatments are frequently hampered by low compliance, limited efficacy, negative side effects, and contraindications[9].

Both genetic and environmental factors can contribute to polycystic ovarian syndrome (PCOS), with exposure to infectious agents, dietary choices, and lifestyle decisions all raising the likelihood of the illness[10,11]. Ovarian dysfunction, which boosts androgen levels and causes anovulation, is exacerbated by insulin resistance and high insulin levels. Hormonal abnormalities also impact prolactin, luteinizing hormone (LH), follicle-stimulating hormone (FSH), and gonadotropin-releasing hormone (GnRH) in women with PCOS. Numerous genetic variables are implicated in the etiology of PCOS, in addition to environmental factors. According to existing genetic databases, studies have found single nucleotide polymorphisms (SNPs) and candidate genes, with over 241 gene variants linked to PCOS. Polymorphisms in androgen receptors, LH receptors, FSH receptors, and leptin receptors are examples of gene sequence changes that can interfere with biochemical processes and ovarian function. PCOS has been associated with specific gene polymorphisms, such as StAR, FSHR, FTO, VDR, IR, IRS, and GnRHR.

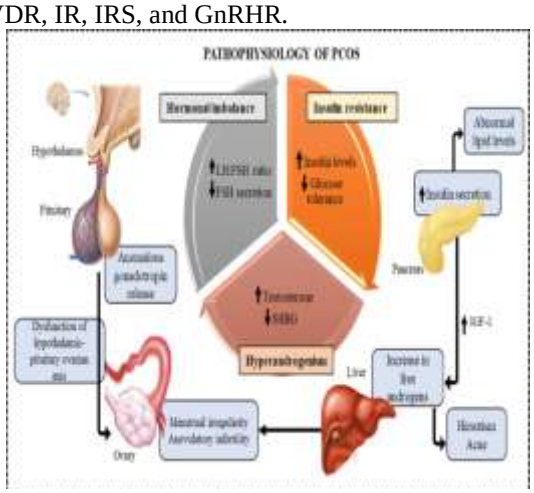

Fig. 2. Schematic depiction of PCOS linked mechanism. Abbreviations – IGF-1- insulin-like growth factor, LH-luteinizing hormone, FSH-follicle stimulating hormone.

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Polycystic ovary syndrome (PCOS) is the most common endocrinopathy affecting women of childbearing age causing not only reproductive but also metabolic anomalies[12].

Rising insulin and androgen levels frequently worsen the course and severity of PCOS. In addition to decreasing the hepatic manufacture of sex hormone-binding globulin (SHBG) and insulin-like growth factor-binding protein-1 (IGFBP-1), hyperinsulinemia also affects ovarian theca cells, which raises androgen levels even more. The way that genetic predisposition, hyperinsulinemia, and hyperandrogenism interact to cause PCOS development and progression is demonstrated by the way that elevated androgens in turn stimulate visceral adipose tissue, which produces free fatty acids that contribute to insulin resistance.

Monitoring and management of long-term metabolic complications is also an important part of routine clinical care[13,14].

According to studies done in Greece, Spain, and the USA, between 4% and 8% of people have PCOS. However, as demonstrated by the first community-based prevalence survey based on the most recent Rotterdam diagnostic criteria, which revealed a prevalence of 18% (17.8 ± 2.8%), the prevalence of PCOS has increased since the criteria were adopted. Notably, 70% of the women in this study had never received a diagnosis before. The estimated prevalence, excluding imputed data, was 11.9 ± 2.4%. Women without an ultrasound had their polycystic ovaries (PCO) imputed in order to obtain the highest prevalence limit for this study. According to other studies, PCOS affects roughly 28% of unselected obese women and 5% of lean women. The economic burden of PCOS in Australia was estimated at AU$400 million in 2006 using demographic statistics and historical prevalence estimates. These costs represented a substantial financial and health burden, with menstrual disruption accounting for 31%, infertility for 12%, and diabetes due to PCOS for 40%. Overweight Australian women with PCOS are predicted to have significant fertility costs per child. Nonetheless, a lifestyle regimen that incorporates exercise, food modifications, and behavioral therapy shows promise in increasing fertility and lowering the expense of PCOS-related pregnancies.

THERAPEUTIC POTENTIAL OF MEDICINAL PLANTS : INSIGHTS INTO NATURAL ORIGINS

ALOE VERA

Fig. 3. Aloe-vera

Aloe vera is a perennial herbaceous plant belonging to the Liliaceae family[15]. It is also known as Aloe arborescens or Aloe barbadensis Mill. Vitamins A, C, and E found in aloe vera, which is well-known for its medicinal uses, help to boost its antioxidant qualities by lowering lipid peroxidation. Minerals, enzymes, tannins, salicylic acid, and a range of polysaccharides are all abundant in the plant. Aloe, barbaloin, asmodin, aloe asmodine, and polymonosaccharides like sterols and organic acids are among the active ingredients found in aloe vera gel, which is mostly made up of water and polysaccharides such pectins, cellulose, hemicellulose, glucomannan, and derivatives of mannose. These elements have antibacterial, antimicrobial, and anti-inflammatory qualities.

Natural substances such as Aloe vera, cinnamon, green tea, fenugreek, and silymarin can be used as a new supportive care for PCOS.

Ovarian tissue and folliculogenesis have been shown to benefit from aloe vera, which helps the ovaries' germ cell levels return to normal. Its high fiber content improves nutritional absorption, speeds up food transit, and controls hemostasis, all of which contribute to its hypoglycemic qualities. Polycystic ovarian syndrome (PCOS) symptoms may be lessened by the phytosterols in the plant, which affect steroidogenic responses by expressing estrogen receptor proteins, decreasing androgens, and raising estrogens. For example, in PCOS-affected mice, phytosterols such as sitosterol can restore normal 3β-Hydroxysteroid dehydrogenase (3βHSD) activity and lower blood cholesterol.

An Aloe vera gel formulation was given to a rat model of PCOS in order to investigate its effects on the condition[16,17,18]. Letrozole, a non-steroidal aromatase inhibitor, was used to produce PCOS in female Charles Foster rats that were five

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months old. Following induction, the rats were given an oral dose of 1 milliliter of the Aloe vera gel formulation every day for 45 days. By restoring steroidogenic activity, glycemic sensitivity, and estrous cyclicity, the therapy successfully stopped the development of the PCOS phenotype. Restoring ovarian steroid status and changing primary steroidogenic behavior produced this protective effect, indicating that phyto-components of aloe vera are essential.

CINNAMON

Fig. 4. Cinnamon

One of the most important and traditional herbal treatments in traditional medicine is cinnamon, or Cinnamomum zeylanicum, a member of the Lauraceae family[15,19].

Numerous polyphenols (flavonoids and isoflavones) such as eugenol, pyrogallol, cinnamic acid, ferulic acid, caffeic acid, gallic acid, protocatechuic acid, oleic acid, p-hydroxybenzoic acid, quercetin, epigallocatechin, daidzein 7-O-D-glucoside, epicatechin, succinic acid, biochanin A-7-glucoside, gallocatechin, strictinin, apigenin glucosyl arabinoside, myricetin, genistein, and apigenin-7-O-glucoside are among the primary constituents of cinnamonomum[19].

Studies have shown that one of the main contributing factors to polycystic ovarian syndrome (PCOS) is insulin resistance[15]. For eight weeks, fifteen PCOS-afflicted women received oral capsules containing 333 mg of cinnamon extract three times a day. Before and after the treatment, tests for insulin sensitivity were conducted. The findings showed that the subjects' insulin levels dramatically dropped two hours after ingesting the cinnamon extract, proving that cinnamon lowers insulin levels by raising phosphatidylinositol 4-kinase activity.

Cinnamon has been shown in numerous trials to be effective in treating PCOS[20].

In one trial, the control group was given a placebo, whereas the intervention group was given capsules containing 333 mg of cinnamon extract three times a day. The intervention group's fasting blood sugar (FBS) and insulin resistance were significantly decreased, according to the data. Cinnamon also improved insulin sensitivity and decreased oral glucose tolerance test scores.

FLAX SEED

Fig. 5. Flax seed

Flax, scientifically known as Linum usitatissimum, is a member of the Linaceae family. With 30–40% fat, 20–25% protein, 20–28% fiber, 4–8% moisture, and 3–4% ash, flaxseed is a nutrient-dense food(15).Its health advantages are further enhanced by the presence of vital vitamins (A, B, D, and E), minerals, and amino acids. Important substances like mucilage, lignans, omega-3 fatty acids, and linolenic acid are prevalent in flaxseed oil. Interestingly, 40–60% of it is α-linolenic acid, an omega-3 fatty acid with anti-cancer effects. Flaxseed is also useful as a health supplement because it possesses antifungal, antibacterial, and antiviral properties. Additionally, it contains a lot of lignans, which have antioxidant and hypolipidemic properties. About 27 different kinds of cancer inhibitors, such as matairesinol and secoisolariciresinol diglucoside (SDG), are found in flaxseed.

Polycystic ovarian syndrome (PCOS) is a neuroendocrine metabolic disorder characterized by an irregular menstrual cycle[21].

Flaxseed's impact on hormone balance, particularly in those with polycystic ovarian syndrome (PCOS), is one of its most noteworthy health advantages. According to research, flaxseed's lignans may help reduce androgen levels, which are often higher in PCOS. Symptoms of high testosterone levels include hirsutism, irregular menstruation, and obesity. Flaxseed has the potential to alleviate PCOS symptoms by reducing these levels.

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The benefits of consuming 30 grams of flaxseed everyday for four months were investigated in a case study involving a 31-year-old woman with PCOS[15,17,18]. Eighty-three percent of the prescribed dosage was followed by the patient. Measurements, including height, weight, and fasting blood samples, were taken at the start and after four months. The findings showed notable declines in important indicators: Insulin levels fell and BMI slightly decreased (from 36 to 35.7 kg/m²). Additionally, the percentage of free testosterone plummeted from 3.1% to 1.1%, total serum testosterone went from 150 ng/dl to 45 ng/dl, and free serum testosterone reduced from 4.7 ng/dl to 0.5 ng/dl. Reduced testosterone levels were associated with a decrease in hirsutism, according to the patient.

CHAMOMILE

Fig. 6. Chamomile

Scientifically known as Chamomilla matricaria, this medicinal herb is native to North Africa and Western Europe and is a member of the Asteraceae family. Gallic acid, kamazelin, farnesene, matricin, coumarin derivatives, apigenin, and choline are among the flavonoid components and antioxidants found in chamomile extract, according to Srivastava et al. (2009)[15,19]. Because of these substances' antispasmodic, anti-inflammatory, and antioxidant qualities, chamomile can be used for a number of medical purposes.

Due to the side effects of drugs, the tendency to use natural antioxidants and anti-inflammatory agents to regulate metabolism, hyperinsulinemia, and hyperlipidemia in PCOS patients has been increased[20].

Chamomile's antispasmodic properties ease period cramps and may lower the chance of premature birth. Additionally, chamomile helps heal eczema and other skin disorders because of its stimulating effect on leukocytes, which include B-lymphocytes and macrophages. Apigenin, one of its primary flavonoids, plays a special function in preventing the brain from attaching to the benzodiazepine derivative flunitrazepam. Benzodiazepines are associated with gamma-aminobutyric acid (GABA), a neurotransmitter that occurs naturally in the brain and can inhibit the release of luteinizing hormone (LH). By altering hormone feedback loops, the phytoestrogens in chamomile may also aid in the regulation of menstruation problems. Chamomile dramatically lowers insulin, total cholesterol, triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and hemoglobin A1c (HbA1c), according to research by Rafraf etal. A study was conducted on 30 adult Wistar rats to examine the effect of chamomile on PCOS[18].

The animals were divided into two groups, the first of which was used as the control group and the second of which was given an injection of estradiol valerate to cause PCOS. The PCOS rats received intraperitoneal injections of chamomile alcoholic extract at different levels (25, 50, and 75 mg/kg) for ten days. Studies on hormones and tissues have shown that chamomile may boost the production of LH, increase the number of uterine follicles, and lessen the symptoms of PCOS in ovarian tissue.

LIQUORICE

Fig. 7. Liquorice

A Member of the Fabaceae family, liquorice (scientifically known as Glycyrrhiza glabra L.) is used extensively in traditional medicine to cure wounds, gastritis, coughing, and other discomforts[15,21]. This plant's roots contain a wealth of medicinal substances, such as sterols, flavonoids, gums, starches, and essential oils. Interestingly, it has steroidal chemicals and phytoestrogens that lower cholesterol and

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triglyceride levels. The main active ingredient in liquorice root, glycyrrhizin, is around 50 times sweeter than sucrose. As part of its action, glycyrrhizin inhibits the enzyme 11β-hydroxysteroid dehydrogenase type 2 (11βHSD2), which has an effect similar to that of a mineralocorticoid. Because of this inhibition, blood glucocorticoid levels rise, which encourages the release of insulin and lowers blood sugar.

Extensive evidence indicates that PCOS is a genetic disease and numerous biochemical pathways have been linked with its pathogenesis[15].

50 Sprague-Dawley rats with polycystic ovarian syndrome (PCOS) participated in an experimental investigation to assess the effects of liquorice root hydroalcoholic extract on blood glucose, triglycerides, and cholesterol levels. Letrozole (1 mg/kg) was administered orally to treatment groups 1 and 2 for 21 days, and then they were given daily saline (2 ml/kg) for 30 days. One letrozole group was given saline every day for 21 days, while the other group was given merely saline as a standard control. The findings showed that while treatment groups 1 and 2 had lower serum glucose levels than the letrozole group ($p > 0.05$), the letrozole group's mean serum glucose level was greater than that of the normal group ($p < 0.01$). Triglyceride and cholesterol levels did not significantly differ across groups.

Some plants are rich in polyphenolic compounds (isoflavones and flavonoids) and other compounds which are beneficial to reproductive health in women[16,21,19].

Spain, Italy, Turkey, Iran, Iraq, Central Asia, and Northeast China are among the places where liquorice is native. It is helpful in treating menopause since it possesses estrogen-like qualities and has minimal effects on the metabolism of endogenous hormones. Its mechanism involves regulating α5 and β5 reductase, activating aromatase, and inhibiting 17-hydroxyl esterase dehydrogenase and 17,20-lyase. Moreover, licorice suppresses tyrosinase activity, which lowers excessive hair growth and modifies the melatonin cycle.

Liquiritin, glabridin, glabrene, and isoliquiritigenin are phytoestrogens found in liquorice that have anti-androgen properties. These substances have estrogenic action and interact with estrogen receptors. They might also improve insulin release, which would help lower blood sugar and treat PCOS.

By reducing serum testosterone levels, liquorice can also be used as an adjuvant treatment for hirsutism and polycystic ovarian syndrome[17].

For instance, licorice consumption (3.5 g of a commercial preparation containing 7.6% glycyrrhizic acid per day) during the luteal phase dramatically decreased serum testosterone levels in a study involving nine healthy women. This effect was ascribed to the inhibition of the enzymes 17-hydroxysteroid dehydrogenase and 17-20 lyase.

ADVANCEMENTS IN SYNTHETIC DRUG THERAPIES FOR POLYCYSTIC OVARY SYNDROME (PCOS).

INSULIN SENSITIZATION THERAPY

METFORMIN

Insulin sensitization drugs are a new treatment modality for PCOS[22].

Metformin, the most popular insulin sensitizer for PCOS, reduces the amount of glucose the liver produces, inhibits gluconeogenesis and adipogenesis, raises peripheral insulin sensitivity, and prevents the ovary from overproducing insulin. Numerous studies have shown that metformin not only reduces weight and metabolic illnesses but also improves menstrual cycles, ovulation, and even the chance of becoming pregnant. According to evidence-based guidelines, women with PCOS who are obese and insulin-resistant should utilize metformin in addition to lifestyle modifications to assist manage their weight and endocrine and metabolic disorders.Metformin improves insulin sensitivity, lowers metabolic disorders, and alleviates polycystic symptoms in mice with PCOS by increasing the translocation of the glucose transporters GLUT1 and GLUT4 to cell membranes, activating the AMPK signaling pathway, and restoring the function of endogenous insulin-sensitizing molecules, such as adiponectin, in endometrial tissues under pathological conditions. However, metformin use may be restricted due to gastrointestinal adverse effects.

ORAL CONTRACEPTIVES

According to the World Health Organization (WHO) estimation revealed over 116 million women (3.4%) are affected by PCOS worldwide[23].

OCPs fall into two categories: progesterone-only tablets and combination pills that contain progesterone (norethisterone, desogestrel) and estrogen (estradiol dosage up to 50μg). They are the first-line treatment for women who do not want to ovulate and have irregular

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periods. OCPs decrease blood levels of androgens by raising SHBG. Women with PCOS are still susceptible to cancer even though OCPs lower the incidence of ovarian cancers. OCP use has little effect on insulin resistance, although lipid profile fluctuations can lead to metabolic issues. OCP use should therefore be determined by risk assessment and should be stopped immediately if there is a discrepancy.

ANTI-ANDROGENS

The management of PCOS is challenging and current interventions are not able to deal with outcomes of this syndrome[24].

To treat hyperandrogenism, anti-androgens including finasteride, flutamide, and spirolactone function by systemically reducing androgen levels. Since antiandrogens reduce hirsutism and other androgen-related problems, they are primarily used to treat PCOS. Although they do so in somewhat varied ways, all anti-androgens block the effects of testosterone. The antiandrogen spirolactone primarily acts as an antagonist by binding to the androgen receptor, which also results in irregular menstruation. Additionally, a male fetus may become feminized if the patient becomes pregnant. Spirolactone is commonly used in combination with OCPs to treat symptoms associated with PCOS. CPA, a progestional antiandrogen, competitively inhibits the binding of testosterone and 5a-dihydrotestosterone, its conversion product, to the androgen receptor.It is generally highly accepted. Flutamide, a nonsteroidal antiandrogen that has no progestogenic effects, is an effective treatment for hirsutism. It is rarely used alone due to its high cost and possibility for hepatocellular toxicity. Finasteride, a type 2 (5-a-reductase) inhibitor, stops dihydrotestosterone from being synthesized. The hirsutism scores have dropped since taking finasteride.

OVULATION INDUCERS
CLOMIPHENE CITRATE

Treatment focuses on reducing hyperandrogenism symptoms, restoring menstrual regularity, and achieving conception[25].

Clomid citrate (CC) is the drug of choice for ovulation induction in adolescents with polycystic ovarian syndrome. By inhibiting the hypothalamic estrogen receptors, CC acts as an anti-estrogen by increasing the anterior pituitary's production of follicle-stimulating hormone (FSH) and the gonadotropin-releasing hormone's (GnRH) pulse width. Luteinizing hormone (LH) is one hormone that stimulates the growth of follicles. CC is frequently given for five days between the second and fifth days of the period at a dose of 50 mg day, then increasing to 150 mg daily. CC can be administered in addition to metformin for PCOS-afflicted women who are resistant to it (conditional evidence-based recommendations, moderate-quality data).

VITAMIN D

Various medical options are used, alone or in combination, to treat subfertility associated with polycystic ovary syndrome[26].

Between 45 and 90 percent of women who are of reproductive age are likely to be vitamin D deficient. Vitamin D deficiency and PCOS are both associated with IR. A study found that vitamin D deficiency was associated with considerably lower rates of ovulation, pregnancy, and ultimately a reduced likelihood of a live delivery in women with PCOS who underwent ovarian stimulation to treat infertility. Vitamin D supplements may be recommended as a potential adjuvant therapy for the ovulatory dysfunction and metabolic abnormalities observed in women with PCOS. Conducting controlled prospective randomized studies is necessary to ascertain the precise effect of vitamin D supplementation on female fertility.

II. CONCLUSION

PCOS, or polycystic ovarian syndrome, has a complicated pathophysiology that includes metabolic dysfunction, hormone abnormalities, and psychological anguish. Limited efficacy and unfavorable side effects limit the available therapy choices, requiring creative approaches. Aloe vera, cinnamon, flaxseed, chamomile, and licorice are among the herbal therapeutic plants that have shown promise in this review. The benefits of these natural medicines, which are abundant in bioactive components, are numerous and include regulating inflammatory pathways, testosterone levels, and insulin sensitivity. Notwithstanding their promise, the majority of results are based on preclinical research, highlighting the necessity of thorough clinical trials to confirm their effectiveness and safety in a range of groups.

Conversely, developments in synthetic medications, ranging from ovulation inducers to insulin sensitizers and anti-androgens, offer precisely tailored treatments for PCOS symptoms. These pharmacological treatments target important PCOS symptoms, but their use is frequently limited

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by adverse effects, contraindications, and exorbitant prices. Integrative therapies provide a comprehensive approach to PCOS management by combining synthetic medicines, herbal remedies, and lifestyle changes. In addition to treating symptoms, these approaches tackle underlying hormonal and metabolic disorders, resulting in long-lasting health benefits.

In order to clarify the mechanisms behind both synthetic and herbal therapies, future research should give priority to extensive clinical trials and molecular studies. Incorporating genetic and environmental risk variables into personalized medicine approaches may also improve PCOS therapy. A patient-centered, evidence-based strategy that bridges the gap between conventional knowledge and contemporary science can emerge, revolutionizing PCOS treatment and improving the lives of those who are impacted.

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