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Green Tea: Empowering Women's Health Naturally

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Green tea, derived from Camellia sinensis, has been recognized for its medicinal properties since ancient times. Rich in catechins, particularly (−)-epigallocatechin-3-gallate (EGCG), green tea is known for its diverse health benefits. While extensively studied for its antioxidative, neuroprotective, and anti-cancer effects, limited research has explored its potential in female reproductive disorders. This review highlights the bioactive components of green tea and their roles. Specifically, it delves into the potential benefits of green tea, particularly EGCG, in managing conditions such as endometriosis, dysmenorrhea, uterine fibroids, polycystic ovary syndrome (PCOS), and menopause. Experimental evidence suggests promising effects, including apoptosis induction, anti-angiogenic and antifibrotic properties. Human studies also indicate potential improvements in weight, insulin sensitivity, and bone health. However, conclusive clinical evidence is lacking, necessitating further research to establish the efficacy and safety of green tea in addressing benign gynaecologic disorders.

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Keywords: Green tea; camellia sinensis; (−)-epigallocatechin-3-gallate (EGCG); catechins; female reproductive disorders; endometriosis; dysmenorrhea; uterine fibroids; polycystic ovary syndrome (PCOS); menopause; antioxidative; anti-angiogenic; antifibrotic; clinical studies; women's health.

1. INTRODUCTION

Plants have been widely recognized as a valuable source of medicine since ancient times. Ayurveda and other Indian literature have documented the use of plants for treating various human ailments. India, being one of the oldest civilizations, possesses a rich repository of medicinal plants [1]. One such plant species is Camellia sinensis, which is used to produce Chinese tea. Belonging to the genus Camellia in the family Theaceae, this plant's leaves and leaf buds are utilized for tea production. Tea is a highly consumed beverage, ranking second only to water in many societies [2].

Green tea, in particular, is known for its health benefits, which can be attributed to its natural antioxidants called catechins. These phenolic compounds have diverse positive effects on human health. The major bioactive component of green tea, (−)-epigallocatechin-3-gallate (EGCG), has been associated with antioxidative, osteoprotective, neuroprotective, anti-cancer, anti-hyperlipidaemia, and anti-diabetic effects. However, there is limited research on the benefits of green tea, specifically in relation to female reproductive disorders such as polycystic ovary syndrome (PCOS), endometriosis, and dysmenorrhea. Therefore, further clinical intervention studies are necessary to establish clear evidence regarding the potential benefits of green tea in managing these conditions [3].

2. GENERAL INFORMATION

Green tea is derived from the tea plant Camellia sinensis, which belongs to the family Theaceae. Unlike fermented teas, green tea is classified as a "non-fermented" tea and contains higher levels of catechins. Catechins are known for their strong antioxidant properties, both in vitro and in vivo. Furthermore, green tea also contains certain minerals and vitamins that contribute to its antioxidant potential. The tea beverage is prepared by infusing the dried leaves of Camellia sinensis. It has been widely used as a medicinal plant in various traditional systems of medicine, including Ayurveda, Unani, and Homoeopathy. Green tea has a long history of consumption in countries such as India, China, Japan, and Thailand [4].

Scientifically, the classification of the tea plant is as follows:

- Kingdom: Plantae
- Order: Ericales
- Family: Theaceae
- Genus: Camellia
- Species: Camellia sinensis
- Binomial name: *Camellia sinensis* (L.) Kuntze

3. DESCRIPTION

The Camellia sinensis plant is an evergreen shrub or small tree that is typically pruned to a height below 2 meters when cultivated for its leaves. It possesses a strong tap root. The flowers of this plant are yellow-white and have a diameter of 2.5-4cm, with 7 to 8 petals. The leaves, which are 4-15cm long and 2-5cm wide, play a crucial role in tea production. The young leaves, which are light green in colour, are preferred for harvesting as they exhibit short white hairs on the underside. In contrast, older leaves are characterized by a deeper green colour. It is important to note that different ages of leaves contribute to the production of tea with varying qualities due to their distinct chemical compositions. Typically, for processing purposes, the tip (bud) and the first two to three leaves are handpicked from the plant. This selective harvesting is repeated every one to two weeks to ensure a continuous supply of fresh leaves for tea production [5].

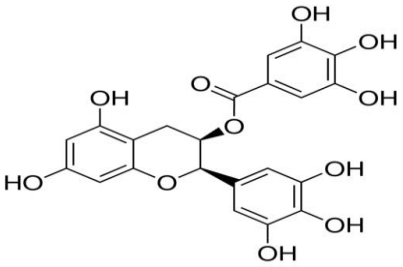
4. CHEMICAL CONSTITUENTS

Tea is known to contain a wide range of bioactive compounds, with nearly 4000 compounds identified. Among these, polyphenols make up approximately one third of the total content. In addition to polyphenols, tea also contains various other compounds such as alkaloids (including caffeine, theophylline, and theobromine), amino acids, carbohydrates, proteins, chlorophyll, volatile organic compounds (which contribute to the aroma of tea), fluoride, aluminium, minerals, and trace elements. These components contribute to the overall composition and properties of tea [6].

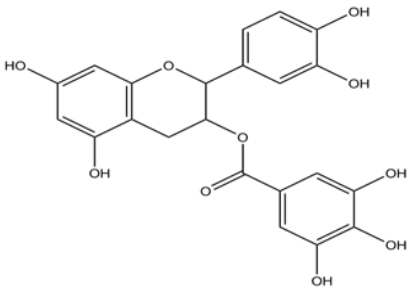
Catechins: “Numerous studies have confirmed the high antioxidant potential of tea beverages,

which can be attributed to the significant content of catechins. Catechins are a type of phenolic compound that have beneficial effects on human health. Green tea, in particular, contains four main catechins: (−)-epicatechin (EC), (−)-epicatechin-3-gallate (ECG), (−)-epigallocatechin (EGC), and (−)-epigallocatechin-3-gallate (EGCG)" [24]. "Among these, epigallocatechin-3-gallate (EGCG) is considered the most active and abundant catechin in green tea. Catechins derived from tea exhibit remarkable antioxidant activity by neutralizing free radicals and enhancing the detoxification activity of enzymes such as glutathione peroxidase, catalase, and glutathione reductase. These properties contribute to their ability to combat oxidative stress in the body" [7].

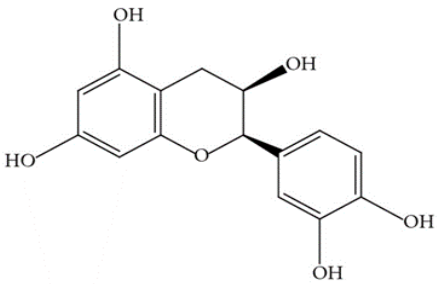
Caffeine: Caffeine, an integral component of tea beverages, plays a crucial role in contributing to their distinct and desirable taste. Additionally, it serves as a potent antioxidant, further enhancing the overall antioxidant potential of the beverage. Caffeine functions by neutralizing reactive oxygen species and promoting the activity of antioxidant enzymes within the body. Furthermore, it has been observed to inhibit the secretion of proinflammatory cytokines, thereby exhibiting anti-inflammatory effects [8].



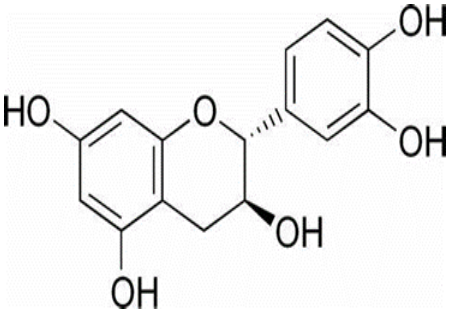
Epigallocatechin gallate



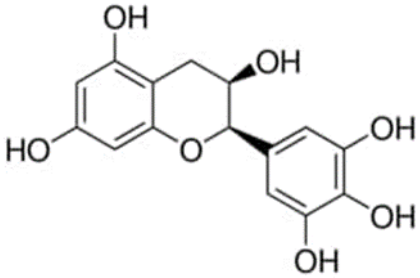
Epicatechin gallate



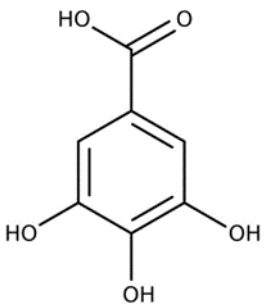
Epicatechin



Catechin



Epigallocatechin (EGC)



Gallic Acid

Scheme 1. Checmical structure of compounds

Phenolic Acids: Phenolic acids are a type of secondary plant metabolites that possess notable characteristics such as high antioxidant and anti-inflammatory properties. Additionally, they have been found to exhibit neuroprotective effects and have the potential to lower blood sugar levels (hypoglycaemic effects). Studies have also reported their ability to inhibit the growth of cancer cells and prevent metastasis. Certain phenolic acids have been observed to regulate lipid and carbohydrate metabolism, thereby potentially aiding in the management of metabolic disorders. These compounds offer a wide range of health benefits and continue to be an area of interest in scientific research [9].

Rutin: Rutin, a polyphenolic compound, exhibits strong antioxidant properties. When combined with ascorbic acid (vitamin C), it can have a synergistic effect, enhancing the protective effects of both substances on the cardiovascular system. This combination helps strengthen blood vessels and promote cardiovascular health. Additionally, rutin possesses antidiabetic properties and exhibits anti-inflammatory effects, which can help prevent complications related to diabetes. Its antioxidant and anti-inflammatory actions make it a potential candidate for preventing conditions that arise from free-radical damage or inflammation, including neurodegenerative disorders [10].

Quercetin: Quercetin, a natural plant-derived compound classified as a flavonoid, has garnered attention for its multifaceted health benefits. Renowned for its potent antioxidant properties, quercetin plays a pivotal role in neutralizing harmful free radicals in the body, thereby mitigating oxidative stress and reducing the risk of various chronic diseases. Beyond its antioxidant prowess, quercetin has been identified as a neuroprotective agent [11].

Vitamin C: Vitamin C, also known as ascorbic acid, an exogenous antioxidant that plays a crucial role in supporting and strengthening the immune system. Recognized as an essential micronutrient in human nutrition, vitamin C is integral for various physiological functions, and its regular intake is vital for maintaining optimal health [12].

Chlorophyll: Chlorophyll, the green pigment present in plants and responsible for their vibrant colour and its derivatives have been identified for their antioxidant and anti-inflammatory activities [13].

Theanine: Theanine, an amino acid primarily found in the tea plant Camellia sinensis, contributes to the distinctive flavour profile of tea. Unlike other amino acids, theanine imparts a non-bitter taste to tea, enhancing its palatability. Moreover, when combined with caffeine, theanine is responsible for providing a unique taste sensation and the characteristic umami flavour associated with certain types of tea [14].

5. BENEFICIAL EFFECTS OF GREEN TEA IN FEMALE REPRODUCTIVE DISORDERS

Endometriosis: Endometriosis, characterized by the implantation of endometrial glands and stroma outside the uterine cavity, is a chronic disorder that often leads to pelvic pain and infertility. The growth of endometrial lesions is known to be estrogen-dependent. Epigallocatechin gallate (EGCG), a polyphenol found in green tea, has been identified for its potential protective role against endometriosis, primarily through its induction of apoptosis, a process of programmed cell death.

Studies investigating the impact of EGCG on endometriosis have consistently demonstrated its ability to enhance apoptosis. Experimental models, involving the transplantation of mouse or human endometrial tissues into mouse models to induce endometriosis, revealed that EGCG treatment for 2-4 weeks consistently suppressed endometrial growth. This included inhibiting neovascularization and fibrosis, reducing the size and weight of endometriotic implants, and preventing the development of new lesions.

The protective effects of EGCG were associated with the upregulation of apoptotic factors such as NF-KB and mitogen-activated protein kinase 1 (MAPK1). These factors play a crucial role in promoting apoptosis, contributing to the inhibition of endometrial lesion growth. Furthermore, EGCG demonstrated its anti-angiogenic properties by downregulating the expression of pro-angiogenic factors, including Vascular Endothelial Growth Factor A & C (VEGF-A and VEGF-C). Notably, EGCG did not affect the expression of hypoxia-inducible factor 1, suggesting a specific targeting of angiogenesis without interfering with other essential cellular processes.

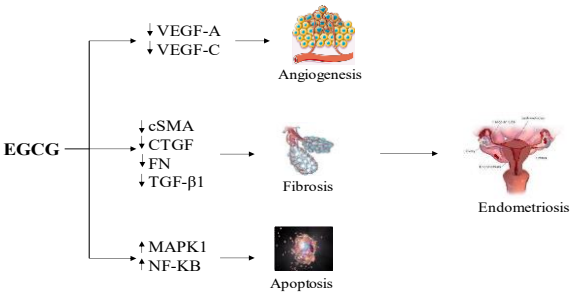


Fig. 1. EGCG in mitigating fibrosis associated with endometriosis

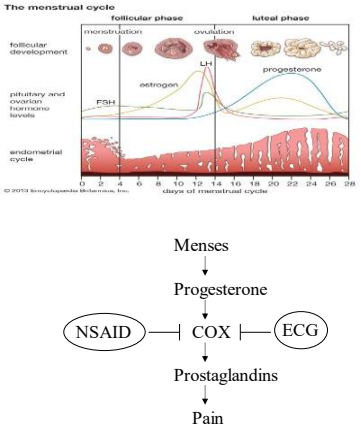


Fig. 2. Primary dysmenorrhea

In addition to its anti-angiogenic effects, EGCG exhibited antifibrotic properties, as evidenced by the suppressed expression of fibrotic markers such as Alpha-smooth muscle actin, Type 1 collagen, Connective Tissue Growth Factor, and fibronectin. These findings underscore the potential of EGCG in mitigating fibrosis associated with endometriosis, contributing to its overall therapeutic effects [15].

Dysmenorrhea: Dysmenorrhea, a pelvic pain condition occurring before or during menstruation, is categorized into two types: primary dysmenorrhea and secondary dysmenorrhea. Primary dysmenorrhea involves painful menstruation without an underlying gynaecological disorder, while secondary dysmenorrhea is associated with pelvic pain resulting from such disorders.

In the case of primary dysmenorrhea, the pain is linked to the overproduction of prostaglandins in the endometrium. Prostaglandins are synthesized from arachidonic acid through the cyclooxygenase (COX) pathway. During menstruation, a natural drop in progesterone activates the COX pathway, leading to increased prostaglandin production. This, in turn, triggers uterine hypercontractility, resulting in pain. Current treatment options for dysmenorrhea include over-the-counter contraceptive pills and nonsteroidal anti-inflammatory drugs (NSAIDs). NSAIDs work by inhibiting the COX pathway, thereby reducing prostaglandin synthesis and alleviating pain.

Epigallocatechin gallate (EGCG), found in green tea, offers a natural alternative to NSAIDs for managing dysmenorrhea. EGCG may function

through similar mechanisms by inhibiting microsomal prostaglandin E synthase-1, an enzyme crucial in catalysing the COX pathway. This inhibition of prostaglandin synthesis could provide relief to women experiencing dysmenorrhea, offering a potential natural remedy without the side effects associated with NSAID use [16].

Uterine Fibroids: Uterine leiomyomas, commonly known as uterine fibroids, stand as the most prevalent benign gynaecological tumours, originating from monoclonal cells in the smooth muscle of the uterus. While hormonal medications are often employed for temporary symptom relief, the primary treatment for uterine fibroids remains surgical, involving procedures such as myomectomy or hysterectomy.

Epigallocatechin gallate (EGCG), the principal antioxidant compound in green tea, has been extensively researched for its antitumor properties in various cancers, both gynaecologic and non-gynaecologic. The anti-proliferative and anti-angiogenic effects of EGCG on cancer cells have prompted investigations into its potential protective role against benign tumours, including uterine fibroids.

“In a particular study, mice treated with a daily dose of 1.25 mg of EGCG for 4-8 weeks exhibited a notable reduction in fibroid size and weight. These findings underscore the potential of EGCG to impede the growth of uterine fibroids. However, the precise mechanism through which EGCG exerts its inhibitory effect is yet to be fully elucidated. One proposed mechanism involves the regulation of catechol-O-methyltransferase (COMT) enzyme activity and protein expression by EGCG. COMT is responsible for converting the antiestrogen compound 2-hydroxyestradiol to a proestrogen form, 2-methoxyestradiol, contributing to an estrogen-rich environment. By modulating COMT, EGCG may influence the balance of estrogen metabolism, potentially hindering the growth of uterine fibroids” [17].

PCOS: Polycystic Ovarian Syndrome (PCOS) stands as a prevalent cause of infertility among women, characterized by an endocrine disorder marked by a hyperandrogenic state and insulin resistance. Green tea components, particularly catechins, have emerged as potential contributors to improving the health of women with PCOS.

Studies investigating the impact of green tea on rats with induced PCOS have shown promising outcomes. These studies revealed a decrease in rat weight, improved insulin resistance, and positive changes in ovarian morphology. Additionally, green tea consumption resulted in decreased testosterone levels, addressing the hyperandrogenic aspect of PCOS.

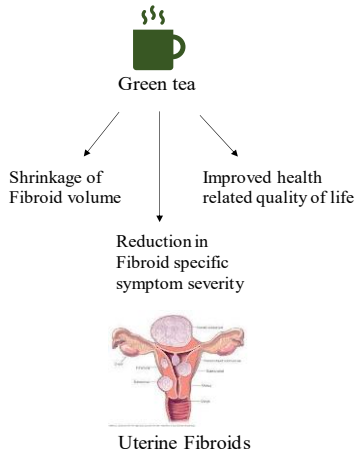


Fig. 3. Potential of EGCG to impede the growth of uterine fibroids

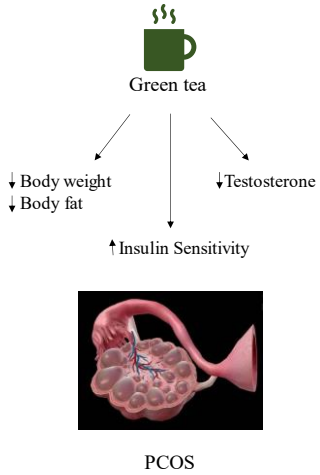


Fig. 4. Green tea in mitigating some of the key aspects associated with PCOS

In relation to weight loss and insulin sensitivity in human subjects, a study observed that overweight and obese women who received a daily dose of green tea experienced a significant reduction in body weight. This suggests a potential role for green tea in managing weight and improving insulin sensitivity in individuals with PCOS.The findings collectively indicate that green tea components, particularly catechins, may offer health benefits to women with PCOS. The positive effects on weight, insulin resistance, and hormonal levels suggest a potential role for green tea in mitigating some of the key aspects associated with PCOS, potentially providing a natural and supportive approach for individuals facing this condition [18].

Menopause: Menopause, diagnosed after 12 consecutive months without menstruation, brings about a range of symptoms such as hot flashes, mood changes, weight gain, and osteoporosis, largely attributed to the decline in estrogen levels. Regular green tea consumption in postmenopausal women has demonstrated various health benefits, addressing concerns related to cardiovascular health, body composition, and bone health.

Studies have indicated that habitual green tea intake in postmenopausal women is associated with a reduction in body fat, particularly visceral fat, along with improvements in lipid profiles. This reduction in total cholesterol and LDL levels contributes to a decreased risk of cardiovascular diseases, a significant concern for postmenopausal women. In addition to its cardiovascular benefits, green tea has shown promise in enhancing bone health in postmenopausal women. The decline in estrogen levels during menopause increases the risk of osteoporosis, a condition characterized by accelerated bone resorption. Postmenopausal women who regularly consume green tea exhibit strengthened bone metabolism, reducing the risk of fractures. Green tea achieves this by reducing oxidative stress, promoting osteoblastogenesis (bone formation), and inhibiting osteoclastogenesis (bone resorption).

“Interestingly, a study conducted on postmenopausal women found lower estrogen levels in those who regularly consumed green tea. While this may raise concerns in the context of osteoporosis, it is suggested that this lower estrogen level might be beneficial in reducing the risk of breast cancer in postmenopausal women. Lower estrogen levels are often associated with a decreased risk of estrogen-sensitive cancers, such as certain types of breast cancer” [19].

6. CONCLUSION

In conclusion, green tea, enriched with the major bioactive component EGCG, exhibits promising potential for offering health benefits in the management of benign gynaecologic disorders. In vitro studies have indicated that EGCG may influence intracellular signalling pathways

implicated in the pathogenesis of uterine fibroids and endometriosis. Animal studies have further substantiated the therapeutic role of EGCG in reducing the size of fibroids and endometriotic lesions.

Human studies support the beneficial effects of EGCG in alleviating symptoms associated with conditions such as fibroids, polycystic ovarian syndrome (PCOS), and menopausal sequelae like osteoporosis and weight gain. However, the role of green tea in the treatment of infertility, specifically in the context of adenomyosis, remains contentious, necessitating further research for definitive conclusions.

It's important to note that while substantial evidence has been derived from in vivo and in vitro experimental studies, the translation of these findings to clinical settings requires more comprehensive clinical studies. Assessing the effects of EGCG on the development and growth of benign gynaecological diseases in human subjects will contribute significantly to our understanding of the therapeutic potential of green tea in the field of gynaecology essence, green tea, particularly its bioactive component EGCG, holds promise as a natural intervention for various benign gynaecologic disorders. The culmination of evidence from experimental studies suggests a potential role in mitigating the impact of these conditions, but further clinical investigations are warranted to establish the efficacy and safety of green tea in the context of women's health.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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