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PHYTOCHEMICAL, PHARMACOLOGICAL AND BENEFICIAL EFFECTS OF *CAMELLIA SINENSIS (L.) KUNTZE*

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ABSTRACT

The medicinal plant *Camellia sinensis* also known as tea yields a variety of white, green and black tea. (Family-Theaceae). It is one of the most widely consumed beverages in the world, after water for enjoyment and health. In general, green tea has been found to be superior to black tea in terms of health benefits. The major constituents of interest are the polyphenols which are responsible for the antioxidant and other health benefits of green tea. The major polyphenols in green tea are flavonoids. The four major flavonoids in green tea are the catechins, epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (ECG) and epigallocatechin gallate (EGCG). Epigallocatechin gallate is referred as the most significant active component. Much research is available depicting the health benefits of green tea for a wide variety of implications, including different types of cancer, heart disease, liver disease, etc. There is also a wide range of uses for green tea in diabetes, exercise enhancement, inflammatory bowel disease, skin disorders, hair loss, weight loss and iron overload. The present review complies the existing literature related to botanical description, morphology, climate and soil, phyto-chemical constituents, biochemical properties, biological activity of *Camellia sinensis also* this paper will review the major health benefits of camellia sinensis.

KEYWORDS: Green tea, catechins, EGCG, polyphenols, *Camellia sinensis.*

INTRODUCTION

The modern era faces a number of growing ailments and diseases that are a serious concern to normal sustenance of an individual scenario. These include cancer, diabetes, hypertension, bacterial and fungal infections, dental caries, skin diseases like acne and many more. Control and cure of these diseases require a source that can overcome these health concerns and that has minimal potential to cause adverse effects. Catechin present in green tea is the solution for all problems.[1] This situation and need has brought *Camellia sinensis* (*C. sinensis*) into picture which is a potent antioxidant and antihypertensive agent existing in nature. Antioxidants are substances that may protect the cells against the effects of free radicals. Free radicals are molecules produced when your body breaks down food, or by environmental exposures like tobacco smoke and radiation. Free radicals can damage cells, and may play a role in heart disease, cancer and other diseases. Another study shows that green tea is also helpful in reducing stroke, myocardial infarction and coronary heart diseases.[2] The literature survey reveals that green tea polyphenols are more potent antioxidants than vitamin C, vitamin E, rosemary extract, and even curcumin in some systems. Curcumin, a potent antioxidant and chemopreventive agent, has recently been found to be capable of inducing apoptosis in human hepatoma and leukemia cells by way of an elusive mechanism, but green tea is proved to be more effective than curcumin.[3]

Green tea lowers blood pressure and helps prevent hypertension. Tea increases body's production of nitric oxide, which dilates arteries and thereby reduces blood pressure. Among persons consuming tea regularly for at least one year, the risk of developing high blood pressure was 46% lower among those who drank half cup to two and a half cups per day and 65% less among those consuming more than two and a half cups per day.[4] Tea contains catechins, a type of antioxidant. In a freshly picked tea leaf, catechins can compose up to 30% of the dry weight. Catechins are highest in concentration in white and green teas, while black tea has substantially fewer due to its oxidative preparation.[5]

MORPHOLOGY

C. sinensis, a member of theaceae family is an evergreen tree or shrub that attains a height of 10 - 15 m in the wild and 0.6-1.5 m when cultivated. The leaves are light green, short stalked, coriaceous, alternate, lanceolate, serrate margin, glabrous or pubescent beneath, varying in length from 5 - 30 cm and about 4 cm width.[6] Mature leaves are bright green colored, smooth and leathery while young leaves are pubescent. Flowers are white fragrant, 2.5 - 4 cm in diameter, found in solitary or in clusters of two or four. Flowers bear numerous stamens

with yellow anther and produce brownish red capsules. Fruit is a flattened, smooth, rounded trigonous three celled capsule, seed solitary in each, size of a small nut.[7,8] Climate and Soil: Tea is cultivated on well drained soil preferably with pH 4.5-5.0, but in practice it may range from 3 to 6.5. Tea is basically a rain fed crop which grows in humid climate of temperate, tropical and sub tropical regions.[9] The soil is maintained at pH of 4.5-5.0 by regular liming. Weeds growth can also be controlled by chemical methods. Fertilizers like N, P, K are added through broadcasting methods in field to reduce soil erosion. No tillage cultivation system helps in reducing erosion.[10,11] Chemical Constituents: Tea leaves contain many compounds, such as polysaccharides, volatile oils, vitamins, minerals, purines, alkaloids (caffeine) and polyphenols (catechins and flavonoids).

Health benefits

The secret of green tea lies in the fact that it is rich in catechin, polyphenols, particularly EGCG. The EGCG is a powerful anti-oxidant: besides inhibiting the growth of cancer cells, it kills cancer cells without harming healthy tissue. It has also been effective in lowering LDL cholesterol levels, inhibiting the abnormal formation of blood clots, reduction of platelet aggregation, lipid regulation and inhibition of proliferation and migration of smooth muscle cells. Inhibition of abnormal blood clots formation takes on added importance when you consider that thrombosis (the formation of abnormal blood clots) is the leading cause of heart attacks and stroke. Any of these factors might be promising in reducing cardiovascular diseases. The major and most chemo-preventive constituent in green tea responsible for these biochemical or pharmacological effects is (-)-epigallocatechin-3-gallate. Understanding the molecular mechanisms of these effects of green tea is a subject of investigation in many laboratories.[12]

Green, oolong and black teas all come from the leaves of the Camellia sinensis plant. What sets green tea apart is the way it is processed. Green tea leaves are steamed, which prevents the EGCG compound from being oxidized. In contrast, black and oolong tea are made from fermented leaves, which results in the EGCG being converted into other compounds that are not nearly as effective in preventing and fighting various diseases. In general, green tea has been found to be superior to black tea in terms of antioxidant activity, owing to the higher content of EGCG.[13] The processes used in the manufacture of black tea are known to decrease levels of the monometric catechins to a much greater extent than the less severe conditions applied to other teas. The production and consumption of the partially fermented oolong tea are confined to China.[14]

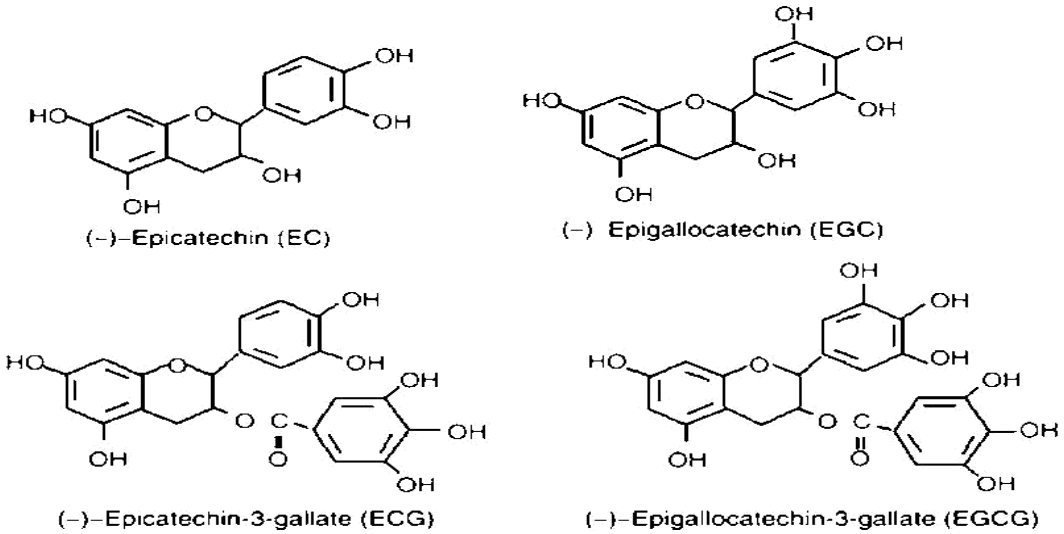

Figure 1: Major polyphenols in green tea.

Table I: Chemical composition of green tea leaves (http://www.bodyofmine.com).

Constituent	Percentage (% of dried leaf)
Polyphenols	37.0
Carbohydrates	25.0
Caffeine	3.5
Protein	15.0
Aminoacids	4.0
Lignin	6.5
Organic acids	1.5
Lipids	2.0
Ash	5.0
Chlorophyll	0.5

Pharmacological Activities of Green Tea

Hepatoprotective activity: The present study was undertaken to examine the inhibitory effect of the green tea *(C. sinesis)* on cadmium chloride induced hepatoprotective activity in liver. In rats injected with cadmium chloride, the activities of serum glutamate oxaloacetate transaminase (SGOT), serum glutamate pyruvate transaminase (SGPT), lactate dehydrogenase (LDH), γ-glutamyl transferase (GGT) was significantly ($p < 0.05$) increased when compared to those values in control rats. The rats administrated with green tea extract and cadmium chloride showed a significantly ($p < 0.05$) decreased levels of serum SGOT, SGPT, LDH and GGT.[17]

Antimicrobial activity: Extracts of leaves from the tea plant *C. sinensis* contain polyphenolic components with activity against a wide spectrum of microbes. Studies conducted over the last 20 years have shown that the green tea polyphenolic catechins, in particular (−)-epigallocatechin gallate (EGCG) and (−)-epicatechin gallate (ECG), can inhibit the growth of a wide range of gram-positive and gram-negative bacterial species with moderate potency. Evidence is emerging that these molecules may be useful in the control of common oral infections, such as dental caries and periodontal disease. Sub-inhibitory concentrations of EGCG and ECG can suppress the expression of bacterial virulence factors and can reverse the resistance of the opportunistic pathogen *Staphylococcus aureus* to β-lactam antibiotics.

Cholesterol reduction

Although green tea diet has a reputation for boosting health, scientific proof of it's health benefits are still somewhat mixed. However, in an article published in the Archives of Internal Medicine, American researchers collaborated with their Chinese counterparts to discuss the beneficial effects of green tea diet on cholesterol levels. Using 240 men and women (average age 55 years) who possessed mild-to-moderately high LDL cholesterol levels, the researchers instructed them to retain their usual low-fat diet, green tea diet intake and activity levels. After 12 weeks, it was found that those who consumed green tea diet extract with their regular meals lost more than 15% of their total LDL cholesterol levels. Although the researchers never explained how green tea diet influenced cholesterol levels, previous studies have shown that certain compounds in green tea diet play a role in reducing the amount of cholesterol absorbed by the body, increasing amount of cholesterol excreted and thus keeping cholesterol from being stored in the liver. Subsequent studies were made to test the findings of the first group of researchers. Their results were how-ever contradictory and they reported that green tea diet has no significant effect on the cholesterol profiles of their subjects.[15]

Population-based and clinical studies indicate that the antioxidant properties of green tea may help prevent atherosclerosis, particularly coronary artery disease. According to Japanese research, green tea reduces the levels of LDL cholesterol, thereby reducing the risk of coronary heart disease. Studies have found that regular consumption of tea protects against heart disease, with one study documenting that the risk was 36% lower for tea drinkers.[16]

Antioxidant activity: The antioxidant activity of the plant extracts and the standard was assessed on the basis of the radical scavenging effect of the stable 1, 1-diphenyl-2-picryl- hydrazyl (DPPH)-free radical activity by modified method.[18,19] The diluted working solutions of the test extracts were prepared in methanol. Ascorbic acid was used as standard in 1-100 µg/ml solution 0.002% of DPPH was prepared in methanol and 1 ml of this solution was mixed with 1 ml of sample solution and standard solution separately.[30] These solution mixtures were kept in dark for 30 min and optical density was measured at 517 nm using Cecil-Elect Spectrophotometer. Methanol (1 ml) with DPPH solution (0.002%, 1 ml) was used as blank. The IC50 values of green tea was 6.7 ± 0.1 The results indicate that the antioxidant activity of the crude extract of green tea is higher than that of ascorbic acid. The antioxidant activity showed that the percentage inhibition of 10 µg/ml of green tea (*C. sinensis* Linn.) extract was 69.4%, which is comparable with the standard antioxidant activity of ascorbic acid (55.8%).[20,21]

Antiobesity activity: Green tea catechins (GTC) are polyphenolic compounds present in the unfermented dried leaves of the plant, *C. sinensis*. Results from a number of randomized, controlled intervention trials have shown that consumption of GTC (270 mg to 1200 mg/day) may reduce body weight and fat. There are several proposed mechanisms whereby GTC may influence body weight and composition. The predominating hypothesis is that GTC influences sympathetic nervous system (SNS) activity, increasing energy expenditure and promoting the oxidation of fat. Caffeine, naturally present in green tea, also influences SNS activity, and may act synergistically with GTC to increase energy expenditure and fat oxidation. Other potential mechanisms include modifications in appetite, up-regulation of enzymes involved in hepatic fat oxidation, and decreased nutrient absorption. This article reviews the evidence for each of these purported mechanisms, with particular reference to studies in humans.[22]

Anticancer activity: Increasing observational evidence suggests that epigallocatechin gallate the major polyphenolic component of green tea is instrumental in suppressing the growth of cancer cells in various tumour models.[23,24] Prostate cancer is the most recently diagnosed malignancy and second leading cause of cancer related deaths, but this cancer can also be cured by green tea.[24,25] Tea polyphenols are known to exhibit cytotoxicity toward various tumour cell lines as well as growth inhibition that is accompanied by cell cycle

arrest.[26] Therefore, methods that promise to enhance the suppressive potential of green tea have the highest clinical relevance. Human cervical cancer cells, HeLa, the first continuous cancer cell line, represent a mainstay model in cancer research. Green tea inhibited their growth, whereas their exposure to moderate levels of laser light resulted in an opposite effect. Both effects are individually documented in the literature. HeLa cells were supplemented with green tea, irradiated with moderately intense laser light (670 nm) for 1 min, and incubated for 52 h. An extraordinary inhibition of HeLa cells by a combination of green tea and red light. An inhibition of 1,460%, compared with non-irradiated samples. Our result receives clinical relevance from a recent study in which epigallocatechin gallate suppressed the growth of melanoma *in-vivo*.[27] It has also been proved that daily oral EGCG in polyphenon E preparation was tolerated by chronic lymphatic leukaemia patient in Phase 1 trial.[28,29]

Effects of fluoride

In general, the level of fluoride in tea is inversely related to the EGCG contents. The more natural EGCG in the tea leaves, the less fluoride. According to Andreas Schuld of the Canadian 'Parents of Fluoride Poisoned Children' tea is very high in fluoride content much higher than the Maximum Contaminant.

Level (MCL) set for fluoride in drinking water. Decaffeinated teas have an even higher fluoride content as compared to their caffeinated counterparts. According to him, fluoride could possibly reduce the anti-cancer properties of tea or even cause cancer, as fluoride is considered a cancer promoter. For instance, he mentions a 1998 study which found positive correlation between colon cancer and tea intake. The high fluoride content could also cause neurological and renal damage, especially in the presence of aluminium. Additionally, the high fluoride content could cause osteoporosis, arthritis and other bone disorders.[30]

Anti spasmodic activity: Hot water extract and tannin fraction of the dried entire plant were active on the rabbit and rat intestines vs. pilocarpine-induced spasms and barium induced contractions.[31]

Anticataract activity: Tea, administered in culture to enucleated rat lens, reduced the incidence of selenite cataract *in-vivo.* The rat lenses were randomly divided into normal, control and treated groups and incubated for 24 hours at 37ºC. Oxidative stress was induced by sodium selenite in the culture medium of the two groups (except the normal group). The medium of the treated group was additionally supplemented with tea extract. After incubation, lenses were subjected to glutathione and malondialdehyde estimation. Enzyme activity of superoxide dismutase, catalase, and glutathione peroxidase were also measured indifferent sets of the experiment. *In-vivo* cataract was induced in 9-day-old rat pups of both control and treated groups by a single subcutaneous injection of sodium selenite. The treated pups were injected with tea extract intraperitonally prior to selenite challenge and continued for 2 consecutive days thereafter. Cataract incidence was evaluated on 16 postnatal days by slit lamp examination. There was positive modulation of biochemical parameters in the organ culture study. The results indicated that tea act primarily by preserving the antioxidant defence system.[32]

Skin disorder: Using different animal model, many laboratories have shown that green tea extract, taken orally or applied to the skin, inhibits skin tumour formation induced by chemical carcinogens or ultra-violet radiation (UVB). The extracts also possess anti-inflammatory activity that similarly to the anticancer forming activity.

Vitamin C: A recent study by[33] showed that black, green and oolong tea are all extremely good sources of vitamin C. They found that 1 or 2 cups a day provide the equivalent of three glasses of orange juice or two capsules (200 mg) of vitamin C.[34] Thearubigins are a heterogeneous group of phenolic pigments with relative molecular mass of 700-40000 Da.[35]

Anti fungal activity: Antifungal activity of green tea leaves sampled 3 different harvest time (May, July and September against a number of fungi (*Candida albicans, Candida glabrata, Candida kruseii, Candida parapsilosis* and *Candida dubliensis*) has been investigated. In addition, the catechin-based flavonoids in green tea leaves such as epigallocatechin-3-gallate (EGCG), epicatechin-3-gallate(ECG), epigallocatechin (EGC) and epicatechin (EC) were determined. All methanol extract of green tea samples showed a broad-spectrum antifungal activity against all *Candida* species in broth microdilution bioassays. However maximum activity of methanol extract (>17 mm inhibition zone) was observed against *Candida albicans* at 3rd harvest time.[36]

Anti-inflammatory activity and skin protection: Topical treatment or oral consumption of green tea polyphenols inhibits chemical carcinogen- or ultraviolet radiation-induced skin tumorigenesis in different animal models. Studies have shown that green tea extract also possesses anti-inflammatory activity. These anti-inflammatory and anti-carcinogenic properties of green tea are due to their polyphenolic constituents present therein. The major and most chemopreventive constituent in green tea responsible for these biochemical or pharmacological effects is (-)-epigallocatechin-3-gallate (EGCG). Treatment of green tea polyphenols to skin has been shown to modulate the biochemical pathways involved in inflammatory responses, cell proliferation and responses of chemical tumor promoters as well as ultraviolet (UV) light-induced inflammatory markers of skin inflammation. Topical treatment with

EGCG on mouse skin also results in prevention of UVB-induced immune suppression, and oxidative stress.

The protective effects of green tea treatment on human skin either topically or consumed orally against UV light-induced inflammatory or carcinogenic responses are not well understood. Based on documented extensive beneficial effects of green tea on mouse skin models and very little in human skin, many pharmaceutical and cosmetic companies are supplementing their skin care products with green tea extracts. Therefore, the focus of this communication is to review and analyze the photoprotective effects of green tea polyphenols to skin.[37] Antiviral activity: Polyphenolic compound catechins (−)-epigallocatechin gallate (EGCG), (−)-epicatechin gallate (ECG) and (−)-epigallocatechin (EGC)) from green tea were evaluated for their ability to inhibit influenza virus replication in cell culture and for potentially direct virucidal effect. Among the test compounds, the EGCG and ECG were found to be potent inhibitors of influenza virus replication in MDCK cell culture (*Madin-Darby canine kidney cell line)* and this effect was observed in all influenza virus subtypes tested, including A/H1N1, A/H3N2 and B virus.[38,39]

Antidiabetic activity: An aqueous solution of green tea polyphenols (GTP) was found to inhibit lipid peroxidation (LP), scavenge hydroxyl and superoxide radicals *in vitro*. Administration of GTP (500 mg/kg b.wt.) to normal rats increased glucose tolerance significantly ($P<0.005$) at 60 min. GTP was also found to reduce serum glucose level in alloxan diabetic rats significantly at a dose level of 100 mg/kg b.wt. Continued daily administration (15 days) of the extract 50, 100 mg/kg b.wt. produced 29 and 44% reduction in the elevated serum glucose level produced by alloxan administration. Elevated hepatic and renal enzymes produced by alloxan were found to be reduced ($P<0.001$) by GTP. The serum LP levels which was increased by alloxan and was reduced by significantly ($P<0.001$) by the administration of 100 mg/kg b.wt. of GTP. Decreased liver glycogen, after alloxan administration showed a significant ($P<0.001$) increase after GTP treatment.

GTP treated group showed increased antioxidant potential as seen from improvements in superoxide dismutase and glutathione levels. However catalase, LP and glutathione peroxidase levels were unchanged. These results indicate that alterations in the glucose utilizing system and oxidation status in rats increased by alloxan were partially reversed by the administration of the glutamate pyruvate transaminase.[40]

Antiasthamatic activity: Aqueous fraction of green tea using specific *in-vitro* and *in-vivo* assays in an ovalbumin-induced asthmatic model. Mice sensitized to ovalbumin were orally administered an aqueous extract of *C. sinensis*. The lungs of these mice were then examined by haematoxylin and eosin staining and ELISA analysis to measure cytokine expression. The aqueous extract of *C. sinensis* exhibited potent anti-asthmatic activity by increasing the expression level of tumor necrosis factor-beta, interferon-gamma and decreasing the expression of anti-asthmatic cytokines in the lung. Together, these results indicate that the aqueous fraction of *C. sinensis* is effective in alleviating asthmatic symptoms by increasing the expression of Th1 cell specific anti-asthmatic biomarkers.[41]

Antialzheimer Activity: Although there is no epidemiological evidence in human studies of the benefit of green tea for Alzheimer's disease, several studies in animal and cell culture models suggest that EGCG from green tea may affect several potential targets associated with Alzheimer's disease progression. EGCG protects against beta-amyloid induced neurotoxicity in cultured hippocampal neurons, an effect attributed to its antioxidant properties.[42]

Antiparkinson activity: Various studies have shown that green tea and EGCG significantly prevent these pathologies in animal models.[43] EGCG, administered orally in doses as low as 25 mg/kg, prevented loss of dopaminergic neurons in the substantia nigra and preserved striatal levels of dopamine.[44] Epidemiological studies on the prevalence of Parkinson's disease and green tea consumption do show 5- to 10-fold lower incidences of the disease in Asian populations.[45,46]

CONCLUSION

Nowadays tea is the most popular drink after water. Increasing interest in its health benefits has led to the inclusion of green tea in the group of beverages with functional properties. Green tea is considered one of the most promising dietary agents for the prevention and treatment of many diseases. The literature available suggests that aqueous extract of the green tea which mainly consists of catechins (EGCG, EGC, ECG and EC) possess antioxidant, antimutagenic, antidiabetic, anti-inflammatory, antibacterial and antiviral, and above all, cancer-preventive properties. Epidemiological studies suggest that consumption of green tea may have a protective effect against the development of several cancers. Green tea, on the other hand, is safe and widely available as a beverage and a nutritional supplement. Furthermore, growing scientific evidence suggests that green tea is effective in preventing many diseases associated with aging, including prostate and other cancers. Overall tea is an affordable beverage of natural origin compared to modern beverages such as soft drinks.

The years of safe consumption of this beverage, supported by numerous studies showing health benefits, warrant a general recommendation to consume it regularly. This article demonstrates the benefits of green tea for its antioxidant potential. It has been used to treat cardiovascular diseases, oral cavity diseases, cardiovascular uses and Parkinson’s disease. There is also a wide range of uses for green tea in diabetes,

exercise enhancement, inflammatory bowel disease and skin disorders. Most impressive are the well-controlled epidemiologic studies, aimed at altering the brain ageing process, which can serve as neuroprotective agents. Although the human clinical data is still limited, this article shows that green tea has its place in both the conventional and alternative medical communities. It is yet promising area of research for future human studies.

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