

UNIVERSITY OF BASRAH

COLLEGE OF PHARMACY

DETERMINATION OF SOME ELEMENTS  
IN GREEN TEA USED IN MEDICAL  
PURPOSES

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## INTRODUCTION

Since ancient times, plants have been an exemplary source of medicine. Ayurveda and other Indian literature mention the use of plants in treatment of various human ailments. India has about 45,000 plant species and among them, several thousands have been claimed to possess medicinal properties. Traditional system of medicine is found to have utilities as many accounts. Due to population rise adequate supply of drug and high cost of treatment in side effect along with drug resistance has been encountered in synthetic drugs, which has led to an elevated emphasis for the use of plants to treat human diseases. The affordability of herbals has also drawn the attraction towards their use. India is one of the oldest civilizations which is known for rich repository of medicinal plants. *Camellia sinensis* is the species of plant whose leaves and leaf buds are used to produce Chinese tea. It is of the genus *Camellia*, a genus of flowering plants in the family Theaceae. White tea, green tea, oolong and black tea are all harvested from this species, but are processed differently to attain different levels of oxidation. Kukicha (twig tea) is also harvested from *Camellia sinensis*, but uses twigs and stems rather than leaves. Common names include tea plant, tea tree and tea shrub.

**General information :** the green tea is obtained from the tea plant *Camellia sinensis* belongs to the family Theaceae. Tea is the most consumed drink in the world after water. Green tea is a 'non-fermented' tea and contains more catechins than black tea or oolong tea. Catechins are in vitro and in vivo strong anti-oxidants. In addition, its content of certain minerals and vitamins increases the antioxidant potential of this type of tea. Presently, it is cultivated in at least 30 countries around the world. Tea beverage is an infusion of the dried leaves of *Camellia sinensis*. It is a widely used medicinal plant by the trials throughout India, China and popular in various indigenous system of medicine like Ayurveda, Unani and Homoeopathy. Green tea has been consumed throughout the ages in India, China, Japan and Thailand.

#### Scientific Classification:

Kingdom : Plantae

Order : Ericales

Family : Theaceae

Genus : *Camellia*

Species : *C. sinensis*

Binomial name : *Camellia sinensis* (L.) Kuntze

#### Common Names:

India : Chha

China : Cha

Russia : Chai

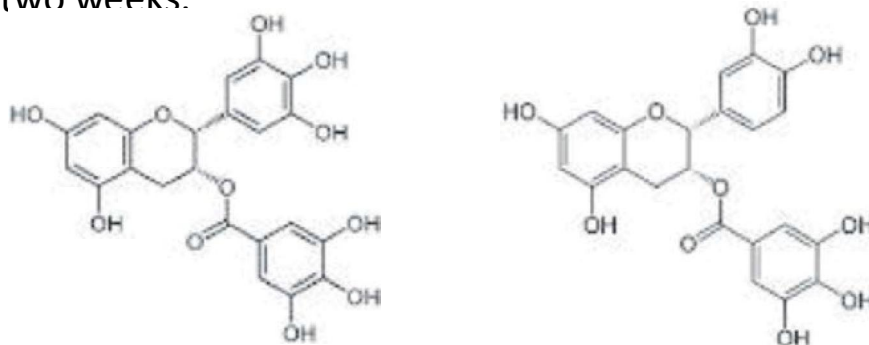
Africa :Itye

Italy :Te

England : Tea plant

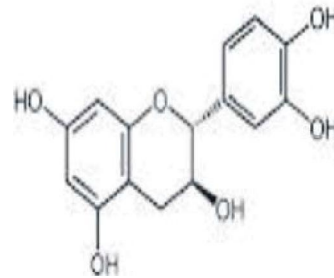
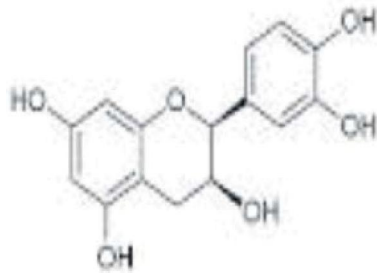
United State : Tea

**Description:** Chinese *Camellia sinensis* is native to mainland China, South and Southeast Asia, but it is today cultivated across the world in tropical and subtropical regions. It is an evergreen shrub or small tree that is usually trimmed to below two metres (six feet) when cultivated for its leaves. It has a strong taproot. The flowers are yellow-white, 2.5-4 cm in diameter, with 7 to 8 petals. The seeds of *Camellia sinensis* and *Camellia oleifera* can be pressed to yield tea oil, a sweetish seasoning and cooking oil that should not be confused with tea tree oil, an essential oil that is used for medical and cosmetic purposes and originates from the leaves of a different plant. The leaves are 4-15 cm long and 2-5 cm broad. The young, light green leaves are preferably harvested for tea production; they have short white hairs on the underside. Older leaves are deeper green. Different leaf ages produce differing tea qualities, since their chemical compositions are different. Usually, the tip (bud) and the first two to three leaves are harvested for processing. This hand picking is repeated every one to two weeks.



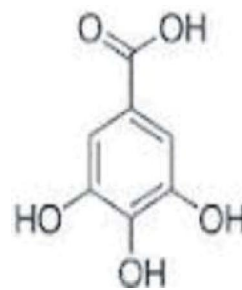
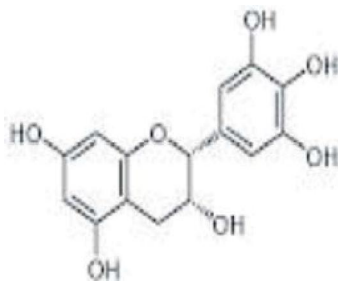
Epigallocatechingallate(EGCG)

Epicatechingallate (ECG)



Epicatechin

Catechin



Epigallocatechin (EGC)

Gallic acid

Fig. 2: Basic structures of different green tea polyphenols

## CHEMICAL CONSTITUTENTS OF GREEN TEA

The chemical composition of green tea varies with climate, season, horticultural practices, and age of the leaf (position of the leaf on the harvested shoot)<sup>9</sup>. The active constituents in green tea are powerful antioxidants called polyphenols. Tea is reported to

contain nearly 4000 bioactive compounds of which one third is contributed by polyphenols<sup>10</sup>. Among the polyphenols in tea, is a family of compounds called the flavanoids. Flavanoids (and their fraction, catechins) are the basic phenolic compounds in green tea responsible for antioxidant activities such as neutralization of free radicals that are formed in the process of metabolism<sup>11</sup>. These flavanoids contain a substance called catechins. Major catechins present in green tea are epicatechin (EC), epigallocatechingallate (EGCG), epigallocatechins (EGC) and epicatechingallate (ECG). The relative catechins content of green tea depends on how the leaves are processed before drying. A certain grade of fermentation and heating of tea leaves during the manufacturing process can result in polymerization of monopolyphenolic compounds such as the catechins, leading to conformational changes and thus modifying its properties. Other factors influencing catechin content are the geographical location and growing conditions (soil, climate, agricultural practices, and fertilizers), the type of green tea (e.g., blended, decaffeinated,) and the preparation of the infusion (e.g., amount of the product used, brew time, temperature).

Wu and Wei in 2002 indicated that a cup of green tea (2.5 g of green tea leaves/200 ml of water) may contain 90 mg of EGCG<sup>13</sup>. Green tea is said to contain over four times the concentration of antioxidant catechins than black tea, about 70 mg catechins per 100 ml compared to 15 mg per 100 ml of black tea. Antioxidant activity of EGCG is about 25-100 times more potent than vitamin C and E and is the single most studied catechins in relation to health contributing potential<sup>14</sup>. The mode of action of Epigallocatechingallate (EGCG) is supposed to be a consequence of its non-specific ability to denature protein. Epigallocatechin

(ECG) has a poor level of direct activity and cause severe disruption in the process of cell division in Methicillin resistant *Staphylococcus aureus*, MRSA 15. Epicatechin (EC) may improve blood flow and has potential for cardiac health. Epigallocatechin (EGC), one of green tea polyphenols, has been shown to inhibit growth of cancer cells. However its mechanism of action is poorly known. EGC strongly inhibit the growth of breast cancer cell lines (MCF-7 and MDA-MB-231) but not that of normal breast epithelial cells 16.\ In humans, ECG has been found to be more highly methylated than EGC and EGCG, and EGCG has been found to be less conjugated than EGC and EC17. Green tea extracts, containing polyphenols have biological activities including modulation of key signal transduction pathways; however, the possible significance of these activities in inhibition of carcinogenesis in vivo depends on the bioavailability of polyphenols .

The yellow color in green tea infusion is mainly determined by the water soluble flavonols (1.3 to 1.5% of the tea leaves dry weight), which include kaempferol, quercetine, isoquercetin, myricetin, myricitrin, rutin, kaempferitrin, etc and flavones (0.02% of the tea leaves in dry weight) which include apigenin, isovitexin, vitexin, saponarin, vicenin-2, etc as well as their glycosides; besides the water soluble anthocyanins 19 . Other polyphenols present in green tea are flavanols and their glycosides, as chlorogenic acid, coumarylquinic acid. Amino acid degradation is involved in the biogenesis of the tea aroma 20 . Chlorophyll, carotenoids, lipids and volatile compounds are not major constituents in a tea brew but they also play an important role in the development of the aroma 21 . Green tea also contains carbohydrates, vitamins E, K, A, low levels of B vitamins

and vitamin C. Metal analysis of Green tea reveals that it is rich source of mineral elements which are essential for health like zinc, manganese, iron, magnesium, silver, copper, titanium, aluminium, bromium, sodium, potassium as well as nickel, chromium and phosphorus 22-25,27 . These metal ions promote the antioxidant property of green tea. The concentration of non-toxic metals like Ag, Na, Cr in Green Tea lies within the acceptable daily intake. Among these Ag in tea samples is relatively higher than other heavy metals. Also the concentration of metals Ag, Na, Cr and Pb lies in the following order  $1.477 > 0.100 > 0.0096 > 0.00$  mg/ml

## Mechanism of Action

High concentrations of polyphenols are typically found in plants such as fruits, tea, and vegetables. Due to their multiple structure-conditioned interactions with various biomolecules, they exhibit a variety of roles, including modulation of various enzyme systems, antioxidant, and chelating properties. Research is beginning to highlight the important role these natural substances play in the promotion and maintenance of health. Despite the growing body of research demonstrating tea polyphenols to be powerful antioxidants with antiatherogenic and anticarcinogenic properties, understanding of the mechanisms involved in the biological effects of green tea is far from complete. Initial studies focused on: (1) antioxidant and free-radical scavenging activity which may play



role in lowering LDL-cholesterol, with a consequent decreased risk of cardiovascular disease; (2) stimulation of detoxification systems, specifically selective induction or modification of phase I and phase II metabolic enzymes which increase the formation and excretion of detoxified metabolites of carcinogens; (3) inhibition of biochemical markers of tumor initiation and promotion, including lowering the rate of cell replication and thus the growth and development of neoplasms; and (4) prevention of mutagenicity and genotoxicity. Yu et al suggested activation of the mitogen-activated protein kinase pathway (MAPK) by green tea polyphenols might be responsible for the regulation of the antioxidant responsive element (ARE). The ARE is believed to mediate the induction of phase II enzymes by many drugs and may be stimulated by green tea polyphenols in the transcription of phase II detoxifying enzymes.

13,14 Oral administration of 0.5 percent lyophilized green tea to female CD-1 mice for 18 days stimulated liver microsomal glucuronidation of estrone, estradiol, and 4-nitrophenol by 33-37 percent, 12-22 percent, and 172-191 percent, respectively. Another area which has been increasingly looked at is the role green tea catechins play in arresting abnormal cell growth or in inducing apoptosis. Apoptosis, also known as programmed cell death, is a normal biological process vital to an organism's ability to maintain homeostasis. It has been demonstrated that EGCG induces apoptosis and cell cycle arrest in human epidermoid carcinoma cells A431, human carcinoma keratinocytes HaCaT, human prostate carcinoma cells DU145, and mouse lymphoma cells LY-R. Apoptosis or cell arrest was specific only to cancer cells and not to normal epidermal keratinocytes.<sup>14,16</sup> Research suggests green

teapolyphenols also have an antiproliferative effect in vascular smooth muscle cells. EGC was found to inhibit, in a dose-dependent relationship, the induced proliferation response of rat aortic smooth muscle cells, human coronary artery smooth muscle cells, rabbit cultured aortic smooth muscle cells, and human CEM lymphocytes. The data suggest the antiproliferative effect of EGC may be mediated through inhibition of protein tyrosine kinase activity, reducing c-jun mRNA expression, and inhibiting JNK1 activation. The effect of EGCG on growth factor receptors, specifically epidermal growth factor receptor (EGFR) has also been examined. EGFR's tyrosine kinase activation is believed to initiate multiple cellular responses associated with mitogenesis and cell proliferation. The overexpression of EGFR might produce a neoplastic phenotype.

Liang et al found EGCG inhibited the autophosphorylation of EGFR by its ligand, EGF, and blocked the binding of EGF to its receptor. EGCG also significantly inhibited DNA synthesis and protein tyrosine kinase activities of EGFR. The results suggest EGCG might inhibit tumor development by blocking growth factor-associated signal transduction pathways.<sup>14,18</sup> It has been suggested that green tea catechins may have a hypolipidemic effect, and their ingestion has been associated with decreased serum triacylglycerols (TG) and cholesterol. Possible mechanisms of action include downregulation of liver fatty acid synthase (FAS), 3-hydroxy-3-methyl glutaryl co-enzyme A reductase (HMG-CoA-R) a key enzyme in cholesterol synthesis—and intestinal acyl Co-A:cholesterol acyltransferase (ACAT), which is believed to play an important role in intestinal cholesterol esterification before cholesterol is absorbed in the chylomicrons. It is also believed that antioxidant effects of these polyphenols help protect LDL-

cholesterol from oxidative damage. The evidence supporting the mechanisms of action for green tea catechins' role in risk reduction for cardiovascular disease is equivocal at best.<sup>10,19-21</sup>

Although literature suggests supplementation with green tea extract offers protection to low-density lipoproteins (LDL) against oxidation, Van Het Hof et al determined that after repeated oral consumption of green tea over three days, although present in LDL, the concentration of catechins was not sufficient to enhance the resistance of LDL to oxidation *ex vivo*.

## Dosage and Toxicity

Based on current literature there does not appear to be any significant side-effects or toxicity associated with green tea consumption. However, overconsumption of caffeine-containing substances may cause intoxication but not clinical dependence. Effects include insomnia, restlessness, flushing, diuresis, twitches, nervousness, rambling thoughts and speech, tachycardia, and psychomotor agitation, with symptoms lasting six to 16 hours. In general, the stimulatory effect from green tea is considerably less than that of coffee. On average, a cup of green tea contains less than 50 mg of caffeine, whereas coffee may contain up to 150 mg per cup. Although antiproliferative effects and inhibition of tumorigenesis at both the initiation and promotion stages have been demonstrated in human cancer cell lines by GTP, the concentrations used in many of the experiments are frequently higher than achievable in tissues *in vivo*.<sup>43</sup> Depending on the

source, the average infusion of green tea varies in its phenolic content, ranging from 50-400 mg of polyphenols per cup.<sup>9,44</sup> Recent human epidemiological studies suggest a total daily intake of approximately 10 cups of green tea per day has a chemopreventive effect. Based on this information, a recommended dose of 500 mg GTP three or four times a day may be necessary to achieve the desired effect.

## Medical purposes

### Effectiveness in skin damages

Green tea is effective in the area of skin care, particularly in alleviating the symptoms of acne and eczema. When used in a combination with sunscreen, green tea enhances sun protection. Due to the presence of antioxidants, green tea is also effective in slowing down the process of aging. Green tea extract has proved to be effective for the treatment of patients who have suffered from skin damage following radiotherapy for cancer. In a study conducted<sup>42</sup> at University of Rochester Medical Centre, USA, it has been shown that green tea acts at the cellular level and reduces inflammation by inhibiting the inflammatory pathways. In the same study it was revealed that tea extracts reduce the duration of radiation induced skin damage by up to 10 days in patients who received radiation treatment. There is preliminary

evidence that green tea may inhibit matrix metalloproteinase (MMP), the enzymes whose excessive activity contributes to age-related degradation of the skin matrix. Green tea has been found to reduce the release of pro-inflammatory cytokines such as IL-1 $\beta$ , IL-6, IL-8, TNF- $\alpha$  and prostaglandin E-2 (PGE-2) in human white blood cells in culture. RefThe in vitro and in vivo animal and human studies have suggested that GTP are photo protective in nature, and can be used as pharmacological agents for the prevention of solar UVB light-induced skin disorders including photo aging, melanoma and non-melanoma skin cancers .

## Oral Health

Among oral diseases like dental caries, periodontal disease, and tooth loss dental caries is a multifactorial infectious disease in which nutrition, microbiological infection, and host response play important roles. Streptococcus mutans is mainly responsible for causing dental caries. Green tea has proved to have anti-Streptococcus mutans activity 45 A study has uncovered yet another benefit of green tea consumption. It has been found that routine intake of green tea may also help in fighting against these oral diseases. It promotes healthy teeth and gums. The study analyzed the periodontal health of 940 men, and found that those who regularly drink green tea had superior periodontal health<sup>46</sup>. Apart from their polyphenols content, green is a natural source of fluoride and an effective vehicle for fluoride delivery to

the oral cavity. The mean fluoride concentration in green tea is ~ 2.1 ppm, which lies within the acceptable daily intake. According to a report, after cleansing the mouth with tea, approximately 34% of the fluoride is retained and shows a strong binding ability to interact with the oral tissues and their surface integuments<sup>47</sup>. This fluoride content may have a beneficial impact on caries and may carry out a wide range of biological activities including prevention of tooth loss and oral cancer <sup>43, 48</sup>. This trace fluoride mineral reacts with the enamel of the tooth and makes it 50-70% less susceptible to decay or gum damage and helps get beautiful white teeth<sup>28</sup>. A recent study suggests that there is an explicit association between the consumption of green tea and oral health. It is also evident that green tea products have been used for preventing and treating several oral and periodontal diseases<sup>49</sup>. Its frequent consumption greatly reduces bad breath (halitosis).

## Helps combat obesity

Green tea has recently become the latest weapon in fighting overweight conditions. It appears to fight obesity by increasing the rate of calories burning, reducing body fat levels and preventing excess weight gain. The consumption of green tea extract is associated with a statistically significant reduction in total and Low Density Lipoprotein cholesterol levels<sup>52</sup>. Green tea catechins enhance exercise induced abdominal fat loss in overweight and obese adults <sup>53</sup>. Green tea catechins and epigallocatechingallate (EGCG) have been shown to reduce adipocytes differentiation and proliferation, lipogenesis i.e., birth of new fat cells; fat mass, body weight, fat oxidation, plasma levels of triglyceride, free fatty acids, cholesterol, glucose, insulin and leptin and increased beta –

oxidation and thermogenesis 54. It has also been studied that green tea sends glucose to muscle, where it is used for energy rather than to fat tissue, where it is stored 55.

## Rheumatoid Arthritis and Osteoarthritis

Inflammation plays a key role in Osteoarthritis (OA) and Rheumatoid Arthritis. An approach that decreases inflammation may facilitate the development of effective strategies for its treatment and prevention. Green tea polyphenols offer a promising new option for the development of more effective strategies for the same. In a study it was found that EGCG, the major and most active component of green tea polyphenol (GTP), protects human chondrocytes from IL-1 $\beta$  induced inflammatory responses. Although the efficacy of EGCG or green tea extract in human RA or OA using the phase-controlled trials is yet to be tested, an extensive evaluation of the potential risks or benefits of using EGCG alone or together with anti-rheumatic drugs may open a new area of research wherein EGCG or its synthetic analogs could be developed to enhance its clinical appeal.

## Good vision

Green tea "catechins" are among a number of antioxidants such as vitamin C, vitamin E, lutein, and zeaxanthin thought capable of protecting the eye. A study conducted at Chosun University College of Medicine in Korea discovered that the green tea antioxidant EGCG can protect human retina against UV damage. They concluded that the administration of EGCG increased the cell count and the cell activity after UV irradiation in cultured human retinal pigment epithelial cells. This suggests that EGCG provided

protection against UV damage in cultured human retinal pigmented epithelial cells. In an animal trial it was found that green tea may protect against the formation of cataracts. The results suggest that green tea possesses significant anticataract potential and acts primarily by preserving the antioxidant defence system. Green tea may protect against age related macular degeneration and glaucoma. The cell culture study investigated whether green tea antioxidant EGCG could reduce free radical damage and therefore alleviate degeneration of the retina as occurs in age-related macular degeneration (AMD) and glaucoma. These findings in animal could be taken as a positive consideration for human trials and thus can enjoy this drink with an advantage.

## Prevents Hair Loss

So far, the benefit of green tea is known only to the body. But, green tea polyphenols are only recently understood as positive factors in hair growth and follicle health. They possess some of the mechanisms of action as including inhibition of apoptosis (programmed cell death), radioprotection of follicle cells, profound antioxidant activity, and potential follicular inhibition of TGF-beta. Green tea is an herbal dihydrotestosterone reliable contrarian. A high intake of green tea correlates to higher levels of sex hormone-binding protein globulin (SHBG) which carries hormones like testosterone around the body in a bound, unusable form so that tissues cannot use it directly. Testosterone is usually carried around the body by this binding protein, therefore, reducing levels of free testosterone, so that it cannot be converted to dihydrotestosterone (DHT) in the hair follicle, which is thought to shorten the hair cycle and cause hair loss in



men. Green tea is thought to affect the 5 $\alpha$ -reductase type I enzyme, which converts testosterone to DHT . Although these findings are at preliminary stage these studies suggest that further analysis in this regards can prove to promising in future.

## Antibacterial activity

Leaves extracts of green tea indicates the presence of potent antibacterial activity . The green tea polyphenols have been found to be inhibitory against *Escherichia coli*, *Enterococcus faecalis*, *Salmonella typhi*, *Staphylococcus aureus* and *Pseudomonas sp.*. In a similar study, antibacterial activity of the water and ethanolic extracts of green tea was found against *Streptococcus mutans* and *Lactobacillus acidophilus* .Polyphenols in green tea preferentially suppress the growth of pathogenic bacteria in the gut, but not the growth of friendly bacteria. Fairly high concentration of catechins does not harm bifidicts, bacillus (Probiotics), good bacteria which is necessary for the functioning of the intestinal tract. Green tea polyphenols are likely to benefit the host by inhibiting pathogens growth and regulating commensal bacteria including probiotics and therefore be considered as Prebiotic. The inclusion of green tea showed positive effects on the increase of lactic acid bacteria and aerobic bacteria counts in ruminants . Acidic, basic and neutral methanol extract fraction of *Camellia japonica* inhibited the growth of food borne pathogens in microbiological media and food . Green tea is also known to inhibit the reproduction and growth of medically important bacteria, like *Salmonella*, *Clostridium* and *Bacillus*. Inhibitory effect of green tea catechin on *Helicobacter pylori* infection has been reported . Recently antifungal activity of green tea catechins against *Candida albicans* and *Aspergillus*

fumigates has been explored. These findings suggest that regular consumption of green tea can help us to combat with frequent bacterial infections.

## Effective in Renal failures

The renal failure is also a condition where green tea has shown to have protective effects. Decreased kidney function due to aging and kidney failure are a frequent cause of death. A preliminary study in Mansoura University in Egypt has explored the possibility to protect kidney function from life threatening failure with the frequent use of green tea . They found that animals with kidney failure when treated with 50mg/kg EGCG from green tea showed significantly recovered glomerular filtration rate in 7 days, reduced

malondialdehyde and inflammatory cytokines and increased glutathione (antioxidant levels) as compared to resveratrol and quercetin. The study indicate that in streptozotocin (STZ)-induced diabetic nephropathy, kidney function appears to be improved with green tea (GT) consumption which also prevents glycogen accumulation in the renal tubules, probably by lowering bloodlevels of glucose. Therefore, GT could be beneficial additional therapy in the management of diabetic nephropathy .

## Improves Insulin sensitivity

The green tea has an antidiabetic effect. Its consumption has shown to bring alteration in metabolic response and cardiovascular autonomic modulation in STZ (Streptozotocin)-induced diabetic rats. STZ destroys pancreatic b cells, resulting in a diabetic syndrome in animals, similar to that seen in human type-1diabetes and characterized by hyperglycemia,

hypoinsulinemia, glucosuria, and loss in body weight. Population studies suggest that green tea consumption may help prevent type 2 diabetes. It improves glucose tolerance and insulin sensitivity in individuals with 2 diabetes. In a study, after receiving green tea for 12 weeks, diabetic rats had lower fasting blood levels of glucose, insulin, triglycerides and free fatty acids compared to controls, and the ability of their adipocytes to respond to insulin and absorb blood sugar greatly increased. Several human and animal-based studies suggested that green tea and its flavonoids have anti-diabetic effects .

## Protects Against Cardiovascular Diseases

Another gem associated with green tea is its ability to protect from cardiovascular diseases. Heart diseases and stroke are associated with a number of risk factors and are most prevalent in the Western world, probably as a result of the lifestyle in this part of the world, which includes a diet high in saturated fats and low physical activity, and the large proportion of the population who smoke cigarettes and have high blood pressure. Green tea appears to be cardio-protective . Regular consuming green tea also inhibits atherosclerosis. Ground green tea consumption decreased susceptibility of plasma and LDL to oxidation and also modulated cholesterol metabolism and might prevent initiation and progression of atherosclerosis .Green tea has been shown to effectively lower LDL Cholesterol, triglycerides, lipid peroxides and fibrinogen while improving the ratio of bad / good cholesterol i.e. Ratio of LDL to HDL cholesterol. The potent antioxidant effect of green tea inhibits the oxidation of LDL cholesterol in the arteries which plays a major contributor role in the formation of atherosclerosis. Those who drink at least three cups of green tea

every day, a 2% lower risk of suffering a stroke is observed as compared with those who drink less than a cup a day. Regular drinking of green tea seems to lower the chance of getting high blood pressure. The loss of arterial elasticity is one cause of high blood pressure. With age, this elasticity is lost and thromboxane is one cause of arterial constriction. Another cause of hypertension is an enzyme secreted by the kidneys called Angiotension converting enzymes (ACE). Green tea seems to block thromboxane as well as ACE production and appears to be their natural inhibitor which significantly reduces the blood pressure .

## Antiviral potentials

Research analysis show that green tea blocks viral attachment and entry into cells. It protects RNA and DNA integrity to reduce mutations that can lead to drug resistance. It has shown stimulated production of healthy lymphocytes up to 300% and stimulated production of immune system killer cells up to 400%. With the frequent consumption of green tea, AIDS- related dementia may be protected. In a new study, it has been shown that EGCG inhibits the JAK/STAT1 pathway of cytokine IFN- $\gamma$  neurotoxicity .In a preliminary study , AIDS/HIV prevention research has shown that green antioxidant catechins especially EGCG have anti-HIV activity in each step of the HIV life cycle . These studies were limited to cellular and animal analysis. EGCG binds with CD4 with a stronger chemical affinity than gp120, thus blocking gp120-CD4 binding. Green tea slows Reverse transcriptase (HIV-1 RT) and inhibits replication of two strains of HIV . Also in vitro studies have revealed that observed that adenovirus infection is inhibited by green tea catechins .Green tea also suppresses the adenovirus, Epstein-Barr, herpes simplex,

and influenza viruses. ECGC binds to the hemagglutinin of the influenza virus, which blocks it from attaching to (and infecting) target receptor cells. EGCG also alters the virus cell membrane, which further inhibits its ability to infect other cells. Effects of green tea catechins and theanine are effective in preventing influenza .

## Synergism with antibiotics

Treatment of many infections is hindered due to resistance of pathogenic micro-organism against several antibiotics. A recent investigation reported that the antibacterial activity obtained using boiled water green tea extract is enhanced in combination with Penicillin G against *Bacillus subtilis* bacterium . Catechins, in green tea have antimicrobial activity. The synergistic antimicrobial activity antibiotics could be useful in fighting emerging drug resistance problem especially among enteropathogens . Green tea extract in combination with probiotics significantly reduced the viable count of *Staphylococcus aureus* and *Streptococcus pyogenes*. Susceptibility of bacterial strains to the tea extract has been shown to be related to differences in cell wall compounds .Catechins partitioning in the lipid bilayer membrane result in loss of cell structure and function and finally cell death . Also synergy between green tea extract and levofloxacin against enterohaemorrhagic *Escherichia coli* have been reported. Similarly *Shigella dysenteriae* has been found to be more susceptible to growth inhibition by Chloramphenicol, gentamicin, methicillin and Nalidixic acid synergistically with organic solvent extracts of green tea .

## Therapeutic potentials against Parkinson's and Alzheimer's disease

Green tea has revealed considerable health promoting qualities for nerve degenerative diseases such as Parkinson's and Alzheimer's disease. Interestingly, synergistic effects of green tea with anti-Parkinson's drug "rasagiline" were observed. Low level doses of the green tea and rasagiline restores the activity and replenished level of dopamine, which is the affected neurotransmitter in Parkinson's disease. Thus in a combinational therapy, green tea catechins with anti-inflammatory drugs and antioxidants, along with other immune modulating compounds, might offer a more effective strategy for prevention and treatment of the disease. Also in a study conducted by a research team at Newcastle University in the U.K. it was found green tea have neuroprotective properties. They bind with two toxic compounds (hydrogen peroxide and a protein known as beta-amyloid) known to play a role in the development of Alzheimer's disease. Green tea polyphenols have been found to inhibit or diminish iron-induced epileptic seizures, and to inhibit the hyperactivity of dopaminergic neurons. It is in fact likely that green tea, especially the decaffeinated kind, acts as a mild sedative.

## Antiallergic potentials

EGCG, the major catechin in green tea, is believed to be the primary source of beneficial effects of green tea. However, the O-methylated derivative of EGCG, (-)-epigallo-catechin-3-O-(3-O-methyl)-gallate (EGCG''3Me), which was isolated from oolong tea,

is reported to have more inhibitory effects on type I and IV allergies in mice than does EGCG). Recent studies demonstrated beneficial effects of green tea in inflammatory allergy. It has been studied that green tea has immunoregulatory effects on human IgE responses in vitro. It suppresses the B cells production of IgE without inducing apoptosis . Although these antiallergy findings are based on in vitro studies, animal and human trials are yet to be conducted to further investigate the mechanism of inhibiting the IgE response by green tea extract. Seasonal allergic rhinitis (SAR) is a very common disease in developed countries and its occurrence has been increasing in recent years. Catechins in green tea play a significant role in anti- allergic responses. They strongly inhibit activation and degranulation of murine bone marrow derived mast cells and human basophilic cells through the inhibition of tyrosine phosphorylation of cellular proteins. According to their research analysis, 1.5 month consecutive intake of green tea prior to pollen exposure is necessary to produce the desired efficacy. Theophylline found in green tea relaxes the smooth muscles supporting the bronchial tubes and this can therefore reduce the severity of an asthma attack .

### Anticarcinogenic activity

Abundant experimental and epidemiological evidences accumulated mainly in the past decade from several research analysts worldwide provides a convincing argument that green tea polyphenols can reduce cancer risk in a variety of animal tumor bioassay systems. In the last ten years, cancer preventive effect of green tea have been widely supported by epidemiological, cell culture, animal and clinical studies. In a recent study, the extracts of green tea and green tea polyphenols

have exhibited inhibitory effects against the formation and development of tumors at different organ sites in animals. These include animal models for skin, lung, oral cavity, oesophagus, stomach, intestine, colon, liver, pancreas, bladder, mammary gland, and prostate cancers. EGCG can inhibit tumorigenesis during the initiation, promotion and progression stages in animal models of carcinogenesis. Green tea contains higher concentrations of monomeric polyphenols, which affect numerous intracellular signaling pathways involved in prostate cancer (CaP) development. The majority of in vitro cell culture, in vivo animal, and clinical intervention studies provided strong evidence that epigallocatechin-3-gallate (EGCG), in preventing prostate cancer, but results from epidemiological studies of green tea consumption are mixed. As per the analysis, role of green tea in breast cancer development in humans is still unclear. Part of the uncertainty is related to the relatively small number of epidemiological studies on green tea and breast cancer and that the overall results from case-control studies. Also, results from randomized clinical trials have demonstrated green tea catechin efficacy on treatment of cervical lesions and external genital warts. There is an inverse association for green tea intake and risk of ovarian cancer. Women that regularly drank green tea when the study began were 37% less likely to develop colorectal cancer compared to infrequent green tea drinkers even better, reducing their risk of colorectal cancer by 57%. Green tea lowers risk of gallstones and biliary tract cancers.



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