



Green Tea: A Medicinal Gift from Nature

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ABSTRACT

Green tea is obtained from the plant *Camellia sinensis*, belonging to family Theaceae. From ancient times tea is drunk worldwide as a beverage. Green tea with increasing interest with special reference to health benefits has led to the addition of green tea in the class of beverages with functional properties. Green tea has always been considered by the Chinese and the Japanese as a potent medicine for the maintenance of health, capable with the power to prolong life. The major components of Green tea which are responsible for the potential pharmacokinetic properties, Antioxidant and other Health benefits are Polyphenols. Present review article focus on Green tea as important beverage shows beneficial properties or which is useful for Weight loss, Stress, Cold and flu, Antiaging effect, Hair loss, Asthma, HIV, Immunity, Food Poisoning, Cardiovascular diseases, Liver Diseases, Arthritis, Alzheimer's disease, Parkinson's Disease, Glaucoma, Cancer, Diabetes, Oral Health, Gargling effect, Antioxidant, Antithyroid, Candidiasis, Antibacterial, Antiviral, Antiallergic, Synergism with Antibiotics.

Keywords: Green tea, *Camellia sinensis*, Catechins, Flavonoids, Antioxidants.

INTRODUCTION

Green tea is one of the most popular beverages in the world, and it has received considerable attention because of its many scientifically proven beneficial effects on human health.¹ For the maintenance of health to prolong life Green tea has always been used as a potent medicine by the Chinese and the Japanese.² Human health always influenced from green tea while it is in its pure and unadulterated form. Now day by day many scientific evidences from all over the world are people aware of health associated benefits with this herbal drink.³ According to Chinese fable, the history of tea starts in 2737 B.C.E. when a skilled ruler and scientist Emperor Shen Nong, accidentally discovered tea. A leaf from an overhanging wild tea tree drifted into his pot while he boils water in the garden. The emperor enjoyed drinking the infused water so much that he was compelled to research the plant further and discovered tea's medicinal properties. Indian history attributes the discovery of tea to Prince Bodhi-Dharma, an Indian saint who founded the Zen school of Buddhism. However the first plant which is recorded as reference of tea which is used in India is Sanjeevani tea plant. However, in the India commercial production of tea did not begin until the entrance of the British East India Company, after its establishment large tracts of land in India were converted for large production of tea.⁴ The plant *Camellia sinensis* yields a variety of white, green, and black tea.⁵ Among all of these, however, the most significant effects on human health have been observed with the consumption of green tea.⁶ It is a refreshing and aromatic drink made from steeping the leaves of *Camellia Sinensis* in hot water. Now a day, the most consumed beverage in all over the world after water is tea. More than 75% of all tea produced in this world is

black tea, 20% is green and the rest is accounted for by oolongs, whites, and yellow tea.⁴ Plant of tea is an evergreen shrub or tree that can grow to a height of 30 feet, but is usually clipped to a height of 2.5 feet in cultivation. The tree or shrub is heavily branched with dark-green, hairy, oblong, ovate leaves cultivated and preferentially picked as young shoots. Green tea is produced from steaming fresh leaves at high temperatures, thereby inactivating the oxidizing enzymes and leaving the polyphenol content intact.⁷ The first green tea was exported from India to Japan during the 17th century. It is observed that about 2.5 million tons of tea leaves are produced each year all over the world, out of them 20% was produced as green tea, which is principally consumed in Asia, several parts of United States, North Africa, and Europe. The relationship between consumption of tea, mainly green tea and human health has long been appreciated. Black tea and green tea are processed separately during manufacturing. For the production of green tea, freshly harvested leaves are immediately steamed to avoid fermentation, which yields a dry and stable product. This steaming process destroy the enzymes which are responsible for breakdown of the color pigments in the leaves and allows the tea to retain its green color throughout the successive rolling and drying processes. Due to these processes natural polyphenols are preserving with respect to the health-promoting properties. As green tea is fermented to Oolong and then to black tea, polyphenol compounds (catechins) in green tea are dimerized to form a variety of theaflavins, such that these teas may have different biological activities.⁸ The chemical composition of green tea varies with season, climate as well as horticultural practices and position of the leaf on the harvested shoot. The major components of interest are

the polyphenols. The major polyphenols in green tea are flavonoids. Catechins are the main flavonoids in tea which makes up to 30-40% of the water-soluble solids in green tea. The different types of tea vary in the amount of catechins that they contain, with green tea containing the most, then Oolong tea, then black tea.⁹ Catechins epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (ECG), and epigallocatechin gallate (EGCG) are the four major flavonoids in green tea. From the above catechins Epigallocatechin gallate is found as the most significant active component. The leaf bud and first leaves are richest in EGCG. The usual concentration of total polyphenols in dried green tea leaves is about 8% to 12%.⁵ 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.¹⁰

Growth Conditions

Tea bush is a tropical and sub-tropical plant and thrives well in hot and humid climate. The optimum temperature for growth of tea is 20°-30°C and temperatures more than 35°C and less than 10°C are harmful for the shrub. It requires 150-300 cm annual rainfall for suitable growth, and rainfall should be well distributed throughout the year. While prolonged dry spell is unsafe for tea. For rapid development of young leaves high humidity, heavy dew and morning fog are useful. The best soil for green tea plantations is the virgin forest soils which is rich in iron content and humus. Relatively large proportion of phosphorus and potash in the soil gives special flavour to tea as is the case in Darjeeling Tea.⁴

Method of Cultivation

Tea gardens are set up on the cleared hill slopes where shade trees are planted in advance. Then Seeds are sown in the germination beds and after that the saplings transplanted to the garden. The garden is regularly handled with a thin metal blade for breaking up soil and removal of weed so that tea shrub grows without any interference. Manures and fertilizers are provided regularly to plant in the gardens. Green manures and oil cakes are used commonly. Pruning of the plant is an important part for cultivation of tea. It helps to maintain the proper shape of tea bush to a height of about one meter with near about the similar diameter. Tea has been cultivated for at least 1500 years. The Cultivation of tea is carried out in areas that has 120-150 cm of rainfall annually and have temperatures of 12-30°C. Optimum growth conditions are 150-300 cm annual rainfall and average temperatures of 18-20°C. Cultivation can be carried out from sea level to 2,200 meters, but some species of tea cultivars are found as high as 3,000 m. Higher altitudes are often related with superior tea quality. At least five hours of direct or 11 hours of indirect sunlight daily are required for tea cultivation. Soils must be sandy, well-drained, thoroughly aired, deep and nutritious with a healthy layer of humus and having low pH. Deficiency in water logging,

excessive heat, and frostiness are not beneficial for the growth of tea plants and which may affect growth and result in a lower quality product in terms of chemistry, aroma, taste and bioactivity. Tea plants are often grows in well controlled nursery conditions or other suitable environmental conditions for their first two to four years. They are classified as immature at this time and are not harvested. Once tea plants mature, they are transplanted to the field and are ready for harvest.^{4,11}

Green Tea Composition

The active chemical constituents of green tea are complex proteins (15-20% dry weight), whose enzymes composed of an important fraction; amino acids (1-4% dry weight) such as arginine, aspartic acid, glutamic acid, glycine, leucine, lysine, serine, 5-N-ethylglutamine or theanine, threonine, tryptophan, tyrosine and valine; carbohydrates (5-7% dry weight) such as glucose, fructose, sucrose, cellulose and pectins; minerals and trace elements (5% dry weight) such as calcium, magnesium, iron, copper, zinc, cobalt, nickel, aluminum, chromium, manganese, molybdenum, selenium, sodium, potassium, phosphorus, strontium and fluorine; and trace amounts of lipids (linoleic and α -linolenic acids), vitamins (B, C, E), sterols (stigmaterol), pigments (chlorophyll, carotenoids), xanthic bases (caffeine, theophylline) and volatile compounds such as alcohols, esters, aldehydes, hydrocarbons and lactones. Many studies have determined that the minerals are present in tea has great importance and their levels in tea leaves and their infusions was estimated by many researchers.⁸ Fresh leaves of green tea contain usually, 3-4% of alkaloids known as methylxanthines, such as theobromine, theophylline and caffeine. In addition to these, there are some characteristic amino acids such as theanine and phenolic acids such as gallic acids present. Green tea contains polyphenols such as flavonoids, flavanols, flavandiols and phenolic acids all up to 30% of the dry weight. The majority of the green tea polyphenols (GTPs) are flavanols called as catechins. Extracts of green tea in liquid or powder form are the products derived from green tea that are mainly vary in the proportion of polyphenols (45-90%) and caffeine content (0.4-10%). Catechins are the chief flavonoids which are found in greater amounts in green tea rather than in black or Oolong tea.¹² The method of preparation influence the catechins both by qualitatively and quantitatively; the amount of catechins also varies in the original tea leaves due to differences in variety, origin and growing conditions.¹³ In green tea mainly four kinds of catechins are found: epicatechin, epigallocatechin, epicatechin-3-gallate, and EGCG.¹⁴ The preparation of fresh green tea cannot extract total catechins from the leaves; therefore, the concentration found differs from the absolute values which are determined through the complete extraction of leaves. In addition, catechins are relatively not stable and could be qualitatively and quantitatively modified during the time framework of an experiment. Thus, it is not possible for comparison of ingested doses in animal studies because



the catechin quantification before administration is often unknown.⁸

Mechanism of Action

The endoplasmic reticulum and mitochondria release oxygen. This oxygen gets converted and forms hydrogen peroxide that releases reactive oxygen species molecules. These reactive oxygen species molecules can lead to damage of DNA, RNA, oxidize lipids, oxidize proteins (such as enzymes, histones) and it can also activate cell suicide. Intake of green tea can stop all these degenerative changes by inhibiting the action of the reactive oxygen species molecule.¹

Uses of Green Tea

Weight loss: Green tea has been known to have many beneficial properties that can help prevent atherosclerotic diseases via the regulation of obesity. Anti-obesity effect of green tea is probably due to its capacity in elevating thermogenesis and fat oxidation, lowering lipid peroxidation as well as suppressing appetite and nutrient absorption. Green tea has played an important role as weapon in fighting over weight conditions. It appears to fight obesity by enhancing the rate of burning of calories, dropping body fat levels and avoiding excess weight gain. A statistically significant reduction in total and low density lipoprotein cholesterol levels is associated by the consumption of green tea. Green tea catechins enhance exercise induced abdominal fat loss in overweight and obese adults. Green tea catechins and epigallocatechin gallate have been shown to decrease adipocytes differentiation and proliferation, lipogenesis, fat mass, fat oxidation, body weight, plasma levels of triglyceride, cholesterol, free fatty acids, glucose, insulin, leptin and increased beta-oxidation and thermogenesis.^{3,15-16}

Stress: Green tea drinking has a beneficial effect, by reducing the development or the enhancement of oxidative stress and, therefore, protecting the individual for oxidative stress diseases.¹⁷

Cold and flu: EGCG, a powerful catechin antioxidant found in green and white teas, can directly kill bacteria and viruses, including the influenza virus. EGCG is also highly anti-inflammatory. This activity is potentially important in cold and flu infections, because soluble mediators of inflammation cause symptoms. EGCG inhibits the production of pro-inflammatory mediators such as chemokines, prostaglandins and TNF.¹

Antiaging effect: Ultraviolet (UV) irradiation results in diverse clinical skin changes such as wrinkling, sunburn, immune-suppression, cancer, and premature skin aging (photoaging). UV exposure to skin induces extensive generation of reactive oxygen species (ROS). In vivo, ROS partly play a positive role such as energy production, phagocytosis, regulation of cell growth, and intracellular signaling. On the other hand, ROS can react with DNA, proteins, fatty acids, and saccharides causing oxidative damage. Number of harmful effects generated due to such

injuries are: morphological and ultrastructural changes, disturbed cell metabolism, attack on the regulation pathways and alterations in the differentiation, proliferation and apoptosis of skin cells. Characterization of photodamaged skin is done by epidermal hyperplasia and altered biomechanical properties of the dermis, ultimately which leads to formation of wrinkles. These effects in the wrinkle improvement by reducing dermal extracellular matrix damage and alleviating inflammation as well as skin barrier damage in an in-vivo hairless mouse photoaged model. These anti-wrinkle activities are likely attributable to the high levels of EGCG and polyphenols in green tea and white tea, and to theaflavins.¹⁸

Hair loss: Hair loss is a common and distressing problem among human and other mammals. Hair growth is regulated by a unique repetitive cycle which consists of three phases as anagen, catagen and telogen. A group of specialized fibroblasts within the hair follicle bulb called as Dermal papilla cells (DPCs), have an important function in the regulation of hair growth in the normal hair cycle as well as in the pathogenesis of certain conditions, for example in androgenetic alopecia. So, factors influencing the functions of DPCs in hair loss are of huge significance from the therapeutic viewpoint. An animal study by Esfandiari and Kelley found that 33% of randomly assigned female BALB/black mice (60 in total), which had developed spontaneous hair loss on the head, neck, and dorsal areas, and who received green tea extract in their drinking water, developed hair regrowth within a period of six months. The researchers did not observe any hair regrowth or spontaneous remission among the controls. Moreover, 8% of the control rodents showed progressive hair loss during the study, whereas none of the mice who received green tea extract showed any progressive hair loss. The control rodent produces secondary infections which results in widespread, progressive hair loss. Kelley comes to conclusion that anti-inflammatory and stress inhibitory effects of green tea polyphenols may affect hair regrowth among the mice. Further studies are in progress to explore the mechanisms and factors involved in hair regrowth in association with the polyphenols in green tea.^{5,19-20}

Asthma: The word 'Asthma' is derived from the Greek word which means panting or breathless. The characteristics of asthma consist of inflammatory cell penetration, of neutrophils mainly during paroxysmal attack of asthma, asthmatic exposure, occupational asthma and patients with smoking and drinking habits. Mostly socioeconomic, educational, cultural, atmospheric and genetic factors influence asthma and asthmatic symptoms. Symptoms of asthma includes cough, wheezing sound, chest tightness, breathlessness, fever, allergy to mites, pollens, animals, specific foods or medicine²¹. Theophylline in green tea relaxes the muscles that support the bronchial tubes, reducing the severity of asthma.²²

HIV: The human immunodeficiency virus (HIV) can invade vital cells in the human immune system and cause the progressive failure of the immune system named acquired

immunodeficiency syndrome (AIDS). In 1994, Chang et al. reported the anti-HIV activities of polyphenolic catechins from Chinese green tea. Green tea is useful for inhibition of HIV RT Inhibition of viral entry into target cells by interfering with the interaction of receptors with the HIV envelope. It also inhibits p24 antigen production. It helps in attenuation of neuronal damage mediated by HIV infection and counteraction of semen-mediated enhancement of HIV infection.²³

Immunity: The immune system is an essential mechanism to act against microorganism and its toxins. The defect in the immune system could lead to an immune-compromised condition that put patients at high risk of various infections of fungal, viral, and bacterial infections. Polyphenols and flavonoids found in green tea help boost our immune system, making our health stronger in fighting against infection. The characteristic behavior of EGCG (one of the more significant catechins in Green Tea) has been proven to have quite a number of health benefits. Recent studies suggest that EGCG can vary the strength of both the innate and adaptive defensive abilities of the immune system.^{1,24-25}

Food Poisoning: The diarrheal type of food poisoning is caused by enterotoxins produced during vegetative growth of bacteria in the small intestine, which act on the epithelial cells, causing massive secretion of fluid into the intestinal lumen, which leads diarrhea. The extracts of green tea plant or bitter almond and the plant compounds such as epicatechin or carvacrol were found to enhance the assay response to ~90% inhibition at the 50 ng/mL toxin concentration to a great extent increases the sensitivity of this assay. Catechin found in green tea can kill bacteria that causes food poisoning and kills the toxins produced by those bacteria.^{22,26}

Cardiovascular diseases: Cardiovascular disease can be the result of numerous stimuli, one being platelet aggregation. Platelets will aggregate in blood vessels for a variety of reasons, including vessel damage and disease. The primary purpose of platelets is to aid in the repair of the damaged blood vessel by forming clots that plug holes in the vessel wall preventing additional blood loss. Platelet aggregation can sometimes lead to adverse consequences, including strokes and myocardial infarctions. EGCG can act on platelets and other cells to prevent platelet aggregation. It can inhibit platelet-activating factor, decreasing the "stickiness" of platelets and decreasing the probability of platelet aggregation. The *Camellia sinensis* has a strong effect on heart rate, i.e. in normotensive female individuals it decreases the heart rate and in the normotensive male individuals it increases the heart rate. So the heart patients have blood pressure problems, must have to think about using the decoction in surplus quantity. Hypertension is a major risk factor for many disorders, including cardiovascular disease, stroke, and chronic renal failure. Antioxidants, like those found in green tea, are very useful in protecting and restoring endothelial function. The balance in the endothelium

between vasodilators, such as nitric oxide and ROS, and vasoconstrictors, such as thromboxane and isoprostane, contributes to vascular resistance and endothelium-dependent contraction. There is clinical and experimental evidence that tea phytochemicals can also improve endothelial function²⁷⁻³⁰. Green tea prevents heart disease and heart stroke by lowering the blood cholesterol level. Even after heart attack, it prevents cell deaths and speeds up the recovery of heart cells. Drinking green tea helps keep our blood pressure down by repressing angiotensin, which leads to high blood pressure. Catechins play an important role for the normal blood flow regulation in humans, by its effect on endothelium-dependent vasodilation. Green tea catechins may improve blood pressure, especially when systolic blood pressure is above 130 mmHg.^{1,4}

Liver Diseases: The liver is one of the key metabolic organs in the organ involved in the synthesis and degradation of key biological molecules such as carbohydrate, protein and lipids among others. The green tea has a certain degree of both preventive and therapeutic effects on liver disease. The green tea can help in the regulation of lipid metabolism, which reduces the accumulation of lipids in the liver. Green tea contains a large amount of polyphenolic antioxidants that can offer a protective effect against malignant change.³¹

Arthritis: Rheumatoid arthritis (RA) is an inflammatory disease that affects joints of the entire body. The main complaints include joint pain and swelling. Several lines of evidence suggest that oxidative stress, associated with the generation of free radicals, and insufficiency of antioxidant defense systems can be resulted in pro-oxidant/antioxidant imbalance and joint damage in RA. Day by day the number of patients increases that has started to use natural products to reduce symptoms of RA and related ailments. Green tea (*Camellia sinensis*) has several anti-inflammatory properties. Green tea benefits our health as it protects the cartilage by blocking the enzyme that destroys cartilage. The reason for this is the high fluoride content of green tea. This fluoride helps to keep bones physically powerful that is more strong and helps to conserve density of the bone. Another possible benefit of tea is it acts as an anti-inflammatory agent. The animal model studies show that green tea polyphenols reduces inflammation. A study reported that mice fed an extract of green tea polyphenols had decreased tumor necrosis factor- α (TNF α) production in response to an injection of lipopolysaccharide (LPS) and prohibited death after administration of an otherwise fatal dose of LPS. The intake of a green tea polyphenol extract decreased joint infection in mice with adjuvant-induced arthritis. One of the main bioactive molecules of green tea is epigallocatechin-3-gallate (EGCG), and it has been shown to target multiple inflammatory pathways.^{22,32-34}

Alzheimer's disease: Over 100 years ago, the first case of Alzheimer's disease (AD) was reported by Dr. Alois Alzheimer, in a German woman, Auguste Deter. It was

subsequently named “Alzheimer’s disease” by Dr. Emil Kraepelin and colleagues. The number of individuals which suffers from AD is gradually increasing day by day due to worldwide aging. Therefore, AD prevention and modification is important to improve the health status of older adults.³⁵ Oxidative stress is a component of the pathological mechanisms underlying AD. It is caused due to disruption of the balance between antioxidant molecules and reactive oxygen species. This imbalance also causes neuroinflammation. Catechins, one of the bioactive components of tea, have anti-inflammatory and antioxidative effects. This helps to prevent or cure the Alzheimer’s disease.³⁵ Recent studies suggested that green tea polyphenols might protect against Alzheimer’s diseases and other neurodegenerative diseases.⁸

Parkinson’s Disease: Parkinson’s disease (PD) is one of the most common neurodegenerative disorders, characterized by degeneration of dopaminergic neurons in the pars compacta of the substantia nigra of the basal ganglia. A broad spectrum of symptoms of psychomotor impairment such as gait disorder, slowness, tremors and an increased tendency to falling are involved in the clinical manifestations of this pathology. Green tea is rich in flavonoids, including catechins its beneficial effects are given by its phenolic compounds acting as free iron scavengers and antioxidants. The most important polyphenolic compound is (-)-epigallocatechin-3-gallate (EGCG), which is responsible for green tea’s antioxidant and neuroprotective properties. The most important compound within green tea is EGCG, has antioxidant effects, which makes it a potential therapeutic agent for the treatment of diseases where oxidative stress plays an important role such as PD. Green tea drinking was not linked to Parkinson’s disease risk. Diet had no strong influence on risk. Ingredients of black tea other than caffeine appear to be responsible for the beverage’s inverse association with Parkinson’s disease.³⁶⁻³⁷

Glaucoma: Glaucoma refers to a group of eye conditions that lead to damage to the optic nerve, the nerve that carries visual information from the eye to the brain. In various cases, increased pressure in the eye may cause damage to the optic nerve, and that pressure is known as intraocular pressure. A disease of the major nerve of vision is Glaucoma, that nerve is called the optic nerve. The optic nerve receives light-generated nerve impulses from the retina and transmits these to the brain, where we recognize those electrical signals as vision.³⁸ Catechins in green tea may also help to protect against glaucoma and other eye diseases. Number of scientists in USA, analyzed eye tissue of rats who drank green tea and found that eye tissues such as the lens and retina had in fact absorbed green tea catechins which had improved their eyesight by 20%.⁴

Cancer: Cancer is currently a major source of morbidity and mortality worldwide. Herbal anti-cancer compounds having anti-oxidant as well as immunostimulant activity preventing cancer growth along with a cytotoxic effect

towards malignant and/or other apoptotic cells. Green tea is best known and studied for its effects on cancer chemoprevention. Green tea catechins, the main bioactive constituent of green tea, significantly affected the ability of green tea on cancer prevention and their content varied considerably among different kinds of green tea. As per the various studies reports, the content of catechins varied from 14 to 31g per 100g of green tea. EGCG is the key component of green tea that has been studied in cancer research. There are several mechanisms of cancer that are related to EGCG. These include: DNA hypermethylation, inhibition of angiogenesis, tumor cell proliferation and metastasis; stimulation of tumor suppressor genes and promotion of tumor cell apoptosis. Green tea catechins may generally inhibit carcinogenesis through increasing levels of glutathione S-transferase pi (GST-pi), which catalyzes detoxification reactions that inhibit carcinogen-induced DNA damage.³⁹⁻⁴²

Diabetes: Some reports suggest that daily consumption of tea catechins may help in controlling type 2 diabetes. The proportions of people with obesity and/or type 2 diabetes have increased and recently reaching epidemic levels in Asia. Pharmacological modality is the basis treatment of diabetes, remedies using plants such as green tea, garlic, and psyllium have enthused a new interest in research. Diabetes mellitus is now a worldwide epidemic as well as without primary prevention, the epidemic will continue increasing. The pathology of diabetes mellitus is caused by reactive oxygen species that activate the non-enzymatic glycation of proteins which leads to structural as well as functional changes, the aldose reductase pathway which causes sorbitol accumulation and oxidative stress results in DNA, protein and lipid damage. The complications of diabetes mellitus, like retinopathy, nephropathy and neuropathy, are results of such pathologic mechanisms. The occurrence of such complications can be delayed or these complications can be prevented by strict controlling blood glucose level. Expert committee of World Health Organization on diabetes recommended that traditional medicinal herbs considered being less toxic and relatively free from side effects. In general, herbal medicines are complex mixtures of various compounds that frequently act synergistically to use their full advantageous effect on diabetes mellitus as well as some other diseases. Some components of green tea may affect metabolism of glucose by various mechanisms including glucose absorption in the intestine and inhibition of carbohydrate digestion, stimulation of insulin secretion from the pancreatic B cells, activation of insulin receptors, modulation of glucose release from liver and glucose uptake in the insulin-sensitive tissues, and modulation of hepatic glucose output.⁴³⁻⁴⁵

Oral Health: It has been found that daily intake of green tea may help in fighting against the oral diseases.

Dental Implications: Green tea extract mouthwash is used in protection of erosion and abrasion of dentin of the teeth. It also decreases the virulent action of cariogenic

pathogens like *Streptococcus mutans* and *lactobacilli*. Green tea extract decreases the amylase activity in saliva of human being and inhibits the lactate dehydrogenase enzyme action and reduces the production of acid. Green tea powder reduces the volatile sulphur compounds and prevents halitosis. Green tea plays an important role in maintaining oral health. Green tea also reduces the occurrence of dental caries by different mechanisms involving enzyme activity and bacterial growth. Green tea is a natural source of fluorides therefore green tea act as an effective vehicle for fluoride delivery to the oral cavity.⁴⁶⁻⁴⁸

Pulpitis: Inhibition of bacterial enzyme gyrase by binding to ATP-B subunit shows antimicrobial activity. It is also act as a good chelating agent. The exacerbation of pulpitis can be prevented by green tea catechins. Catechins are well-known to exhibit potent anti-inflammatory properties. The presence of EGCG and electrocardiogram (ECG) significantly reduced, in a concentration-dependent manner, the expression of interleukin (IL)-6 and IL-8 in dental pulp cells exposed to lipopolysaccharide (LPS) or peptidoglycan (PG). Enhanced appearance of intercellular adhesion molecule-1 and vascular cell adhesion molecule-1 on the dental soft tissue cells called pulp cells in response to bacterial components was also decreased by treatment with EGCG and ECG. These findings suggest that green tea catechins may prevent the exacerbation of pulpitis.⁴⁹

Leukoplakia: The majority of leukoplakia lesions were on the buccal mucosa near the oral commissure. The many study reports observed that green tea is useful to cure such oral diseases.⁵⁰

Gargling effect: Gargling with a catechin extract of green tea-inhibited influenza infection and application of green tea extract to the oral or nasal cavities suppressed various pathogenic bacteria. Green tea is a natural, anti-microbial, and harmless substance that can reduce the prevalence of sore throat. Sore throats and colds can be prevented by drinking green tea since it helps fight the bacteria refuting in the throat and various researchers have been carried out that discover the effect of green tea gargling on sore throat caused by intubation in patients after Coronary artery bypass graft (CABG) surgery.⁵¹⁻⁵²

Antioxidant: Green tea and its supplements generally contain higher amounts of disease fighting antioxidants called polyphenols. An excess of evidences suggest strong antioxidant potentials of flavonoids of green tea in suppressing the production of excess free radicals. Major catechins present in green tea i.e. epicatechin (EC), epigallocatechin gallate (EGCG), epigallocatechins (EGC) and epicatechin gallate (ECG) have strong antioxidant potentials. Green tea is more beneficial due to the higher antioxidant activity that protects the body from oxidative damage due to free radicals. It is recommended that these antioxidants slow or halt the beginning of heart disease, cancer, suppresses immune function and accelerated aging. The most potent catechin is the EGCG and it has also

been found to outperform β carotene and vitamin C 10 times in scavenging the allyl peroxy radical. A reverse correlation between the amount of phenolic compound in green tea and its antioxidant potentials was suggested by different researchers i.e., the quantity of these phenolic compounds is not always correlated with its quality.^{6,53}

Antithyroid: Thyroid stimulating hormone (TSH) considered the most important regulator of thyroid function, rapidly increases the rates of release and synthesis of thyroid hormones. Iodination of tyrosyl residues requires for the synthesis of thyroid hormone. This iodination is catalyzed by thyroid peroxidase and the conversion of T4 to T3 occurs via deiodinase so that thyroid-stimulating hormone level is increased as compared with hyperthyroidism group to stimulate thyroid cells and to secretion thyroid hormone. Deiodinase activity was significantly inhibited by flavonoids, therefore flavonoids have antithyroid effect and dietary administration of the green tea extract catechins induce goiters in normal rats. Antithyroid drugs are effective in controlling hyperthyroidism because they inhibit thyroid hormone production.⁵⁴

Candidiasis: The green tea polyphenols significantly decreased the ability of *C. albicans* to grow and sustain biofilms. Further investigation on the possible effects that these polyphenols had effect on *C. albicans* metabolism implicated proteasome involvement. The green tea catechins may also affect other metabolic pathways in addition proteasome disruption in *C. albicans*, that prevents the normal signals for growth and development of biofilm infections. Tea polyphenolic compounds are novel substances that have the potential to be used either alone or in combination with other antifungal drugs to combat *C. albicans* infections.⁵⁵

Antibacterial: It is reported that green tea leaves are known for antibacterial activity against numerous human pathogenic microorganisms. Green tea polyphenols (also known as catechins) are framework for about 30% -40% of the total extractable solids of the plant. Most of the antibacterial activity of green tea is attributed to these catechins, mainly to EGCG.⁵⁶⁻⁵⁷

Antiviral: Viral infections are among the most common types of infections encountered by mankind. Treating viral infections is limited by the availability of drugs. The approved drugs have so far narrow applications due to comparatively poorer cure rates, their side effects and the fast accumulation of drug resistant mutants. Plant-derived natural products are helpful in the prevention and treatment of various diseases. Green tea and its major constituent polyphenols are well known for antiviral activity. The part of catechin skeleton 3-galloyl group plays key role for antiviral activity, while the 5-OH at the trihydroxy benzyl moiety at second position plays a slight role. With regard to the antiviral activities, EGCG acts as a strong inhibitor of HIV replication in cultured peripheral blood cells, and EGCG and ECG were found more effective than EGC or EC in the inhibition of the HIV-1 reverse

transcriptase in vitro. Virus inactivated by EGCG in vitro by phospholipids deformation. Green tea is also effective against Adenovirus, Hepatitis B & C virus, Influenza virus, Bovine coronavirus, Epstein-Barr virus, Enterovirus, Herpes simplex virus, Chikungunya Virus, etc.⁵⁸⁻⁶⁰

Antiallergic: The epigallocatechin-3-*O*-(3-*O*-methyl) gallate (EGCG3"Me) and epigallocatechin-3-*O*-(4-*O*-methyl) gallate (EGCG4"Me) isolated from Taiwanese or Japanese tea (*Camellia sinensis* L.) leaves shows an anti-allergic effect. These catechins strongly inhibited mast cell activation and histamine release after Fc epsilon RI cross-linking through the suppression of tyrosine phosphorylation (Lyn) of cellular protein kinase, and the suppression of myosin light chain phosphorylation and high-affinity IgE receptor expression via the binding to 67kDa laminin receptor.⁶¹

Synergism with Antibiotics: Green tea shows the antimicrobial activity, but the combined use of tea and antibiotics could be useful in fighting emerging drug-resistance problem especially among enteropathogens.⁶²

Adverse Effects of Green Tea

There are several cases reported of hepatotoxicity linked to green tea extract products in the form of pills or beverages. The mechanism for this is unknown. Allergic reactions have been reported for topical green tea ointment, which may cause cervical and vaginal inflammation, irritation, and vulvar burning. Tea is generally safe, with a few caveats. In large amounts, it can interfere with blood clotting and thus may interact with warfarin (Coumadin) and other blood thinners. Tea can also obstruct the absorption of iron from vegetables and fruits. Adding lemon or milk to the tea or drinking it between meals will counteract this problem. As compared with coffee tea contains smaller amounts of caffeine, albeit. Evidence suggests that the adverse effects primarily include GI and central nervous system (CNS) disturbances. The beneficial effects of green tea and its constituents may be beneficial up to a certain dose and above that dose it may cause some unknown side effects. The effect of green tea catechins is different in all individuals. EGCG of green tea extract is cytotoxic and more consumption of green tea can cause acute cytotoxicity in liver cells which is a major metabolic organ in the body. Another study found that higher intake of green tea might cause oxidative DNA damage of hamster pancreas and liver. The EGCG acts as a pro-oxidant, rather than an antioxidant, in pancreatic b cells in vivo. Therefore, green tea intake in high proportion may be detrimental for diabetic animals for the control of hyperglycemia. At a high dose, thyroid enlargement (goiter) induced by green tea extract a in normal rats. This high-level treatment modified the thyroid hormones concentration in the plasma. However, even a very high dietary amount of green tea drinking would be unlikely to cause such adverse effects in human beings. Harmful effects of tea overconsumption (either black or green) are due to three important factors: first is its caffeine content, second is the presence of aluminum, and third is the effect

of tea polyphenols on iron bioavailability. Green tea should not be consumed by patients who are suffering from heart disease or major cardiovascular problems. Pregnant and breast feeding women should drink limited amount that is not more than one or two cups of green tea per day, because caffeine may causes an increase in heart rhythm. It is also important to limit the concomitant consumption of green tea as well as some drugs, because of diuretic effect of caffeine. Some studies show that the capacity of tea plants to accumulate aluminium at high levels. This characteristic is very important for patients with renal failure because aluminum can be accumulated by the body which may results in neurological disorders; therefore it is necessary to control the consumption of food with high amounts of this metal. Similarly, green tea catechins may have high affinity for iron and green tea infusions which can cause a significant loss of the iron bioavailability from the diet.^{2,6}

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