



GREEN TEA: A MAGICAL HERB WITH MIRACULOUS OUTCOMES

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ABSTRACT

Green tea in its purest and most unadulterated form has always influenced human health from generations and day by day scientific evidences throughout the world are making people aware of health benefits associated with this herbal drink. Though Green Tea is not officially recognized as a medical agent, it is one of the most researched plant-based remedies whose possible benefits include promotion of cardio-vascular health, cancer prevention, skin protection, and antioxidant activity, to fight high cholesterol levels, infection, impaired immune function, diarrhoea, fatigue and many more. Laboratory findings have revealed that notable health benefit of green tea is its powerful antioxidants potential which at the molecular level, helps prevent cellular damage from certain oxidation reactions in the body. The credit for their useful antioxidant property lies with their huge collection of chemical substances called polyphenols and catechins make the major contribution of them. Though catechins have been found in other plants derivatives such as grapes, pomegranates, those found in tea have proven to be the most effective antioxidants known. The catechins epigallocatechin gallate (EGCG) is found in the greatest concentration and most studied for its health benefits. There is an urgent need to check the efficacy, safety and translational guidelines for a green tea to be used as safe, effective drug. The main objective of this review is to enlighten some recent facts with relevance to the current status and advance in green tea benefits.

Key words: *Camellia sinensis*, green tea, magical herb,

INTRODUCTION

Green tea is the nature's treasure to the mankind. It is next to water as the most consumed beverage in the world¹. Green tea is derived from the leaves of the plant *Camellia sinensis* (L.) Kuntze, which is an angiosperm dicot plant (Fig.1). The plant is an evergreen shrub which is native to Southeast Asia. Its ancestry begins in China. China is credited with introducing tea to the world, though the evergreen tea plant is in fact native to Southern China, North India, Myanmar and Cambodia².

Classification	
Kingdom	Plantae – Plants
Subkingdom	Tracheobionta – Vascular plants
Superdivision	Spermatophyta – Seed plants
Division	Magnoliophyta – Flowering plants
Class	Magnoliopsida – Dicotyledons
Subclass	Dilleniidae
Order	Theales
Family	Theaceae – Tea family
Genus	<i>Camellia</i> L. – camellia
Species	<i>Camellia sinensis</i> (L.) Kuntze – tea

Tea is manufactured in four basic forms, green, white, oolong and black tea, all of which come from the leaves of *Camellia sinensis* plant (Table 1). White tea is the least processed type of tea and has the highest catechin content. It is made of young tea leaves or buds steamed immediately after harvesting to inactivate polyphenols oxidase, the enzyme that destroys catechins. As a result, white tea is richer in catechins than green tea.

About three billion kg of tea is produced and consumed every year. Green tea is mainly consumed in Japan, China and India. Of the tea produced worldwide 78% is black tea which usually consumed in western countries, 20% green tea, normally consumed in Asian countries, and 2% is Oolong tea which is produced by partial fermentation in Southern China³.

The first documented report of an antibacterial action of tea was made in 1906, when McNaught, a British Army surgeon, showed that tea killed the causal organisms of typhoid fever

(*Salmonella typhi*) and brucellosis (*Brucella melitensis*)⁴. Green tea not only captures the taste, aroma and colour of spring, but delivers its qualities along with the highest concentration of beneficial phytonutrients and the least caffeine of all the teas. Its secret lies with its rich source of catechins (polyphenols) which possess powerful antioxidant properties. The catechins have been found to possess antibacterial and antiviral as well as Anticarcinogenic and antimutagenic properties⁵.

Over the last years, numerous epidemiological and clinical studies have revealed several physiological responses to green tea which may be relevant to the promotion of health and the prevention or treatment of some chronic diseases. However, the results from epidemiological and clinical studies of the relationship between green tea consumption and human health are mixed. For example, conflicting results between human studies may arise in part, from ignoring socioeconomic and lifestyle factors as well as by inadequate methodology to define tea preparation and intake^{6,7,8}.

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)⁹. 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 polyphenols¹⁰. 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 metabolism¹¹. These flavanoids contains a substance called catechins. Major catechins present in green tea are epicatechin (EC), epigallocatechin gallate (EGCG), epigallocatechins (EGC) and epicatechin gallate (ECG) (Table 2 and Fig. 2).

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 monophenolic 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^{12,13}).

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 EGCG¹³. 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 potential¹⁴. The mode of action of Epigallocatechin gallate (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*, MRSA¹⁵. 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 cells¹⁶.

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 polyphenols¹⁸.

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, quercetin, 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 anthocyanins¹⁹. 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 aroma²⁰. 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 aroma²¹. 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/ml²⁸.

SOME IMPORTANT PROPERTIES OF GREEN TEA

Antioxidant properties

Green tea and its supplements generally contain higher amounts of disease fighting anti-oxidants called polyphenols. A plethora of evidence suggests strong antioxidant potentials of tea flavonoids 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. The higher antioxidant activity of green tea makes it more beneficial in protecting the body from oxidative damage due to free radicals. It is appeared that these antioxidants slow or halt the initiation of cancer, heart disease, suppresses immune function and accelerated aging²⁹ (Fig 3).

EGCG is the most potent one and has also been found to outperform vitamin C and β carotene 10 times in scavenging the allyl peroxy radical. However, at the same time evidences in a study suggests a reverse correlation between the amount of phenolic compound in green tea and its antioxidant potentials i.e., the quantity of these phenolic compounds is not always correlated with its quality³⁰ (Fig 4).

Nanoparticles

Nanotechnology has emerged as a promising technology that has been advocated for the delivery of antimicrobial phenolic compound extracts. There have been some recent efforts to enhance its bioavailability by delivering EGCG using lipid nanocapsules and liposome encapsulation, suggesting the possibility of this molecule being developed further by medicinal chemists³¹.

Phenolic compounds can be used as natural and safer alternatives to chemical disinfectants in food systems and delivery of antimicrobial agents using nanoparticles to better control pathogens for commercial food safety applications³². Green silver nanoparticles have been synthesized using various natural products like green tea *Camellia sinensis*³³ which is non polluted, environmentally acceptable, and safer for human health.

Various techniques, including chemical and physical means have been developed to prepare metal nanoparticles. In most cases, the surface passivator reagents are needed to prevent nanoparticles from aggregation. Unfortunately many organic passivator such as thiophenol, thiourea, mercaptoacetate, etc. are toxic enough to pollute the environment if large scale nanoparticle are produced from them^{34,35}.

Synthesis of nanoparticles using biological entities has great interest due to their unusual optical³⁶, chemical³⁷, photoelectro-chemical³⁸ and electronic properties³⁹. The synthesis and assembly of such nanoparticles would benefit from the development of clean, nontoxic and environmentally acceptable 'green chemistry' procedure, involving organisms ranging from bacteria to fungi and even plants^{40,41}.

The method improves the rate of inhibition compared with conventional delivery and retains the antimicrobial efficacy for a longer time. This hurdle technology using natural phenolic compounds as an antimicrobial agent and nanoparticle-mediated delivery system can effectively decontaminate food borne pathogens and improve food safety. Phenolic compounds can be used as natural and safer alternatives to chemical disinfectants in food systems and delivery of antimicrobial agents using nanoparticles to better control pathogens for commercial food safety applications³².

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 conducted⁴² 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 β , IL-6, IL-8, TNF- α and prostaglandin E-2 (PGE-2) in human white blood cells in culture. Ref

The *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^{6, 13, 43, 44}.

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* activity⁴⁵.

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 health⁴⁶.

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 integuments⁴⁷. 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^{43, 48}. 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 teeth²⁸.

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 diseases⁴⁹. Its frequent consumption greatly reduces bad breath (halitosis). Knowing the role of periodontopathic bacteria in producing volatile sulfur compounds, antimicrobial polyphenols in green tea can improve bad breath by suppressing these bacteria⁵⁰.

In consequence, green tea has been considered as functional food for oral health and is widely used in toothpaste formulation. Greater the concentration of catechins better the

health benefits. So the consumption of green tea in comparison to other beverages may be widely recommended⁵¹.

Helps combat obesity

Green tea has recently become the latest weapon in fighting over weight 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 levels⁵². Green tea catechins enhance exercise induced abdominal fat loss in overweight and obese adults⁵³. Green tea catechins and epigallocatechin gallate (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 thermogenesis⁵⁴.

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 stored⁵⁵.

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 eye⁵⁶. 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 cells⁵⁷. 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 cataracts⁵⁸. 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 glaucoma⁵⁹. 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 health⁶⁰. 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-beta⁶¹.

Green tea is an herbal dihydrotestosterone reliable contrarian. A high intake of green tea correlates to higher levels of sex hormone-binding protein globulin (SBGH) 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 α -reductase type I enzyme, which converts testosterone to DHT⁶⁰. 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.*⁵. In a similar study, antibacterial activity of the water and ethanolic extracts of green tea was found against *Streptococcus mutans* and *Lactobacillus acidophilus*²⁸.

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 Prebiotic⁶². The inclusion of green tea showed positive effects on the increase of lactic acid bacteria and aerobic bacteria counts in ruminants⁶³.

Acidic, basic and neutral methanol extract fraction of *Camellia japonica* inhibited the growth of food borne pathogens in microbiological media and food⁶⁴. Green tea is also known to inhibit the reproduction and growth of medically important bacteria, like *Salmonella*, *Clostridium* and *Bacillus*⁶⁵. Inhibitory effect of green tea catechins on *Helicobacter pylori* infection has been reported⁶⁶. Recently antifungal activity of green tea catechins against *Candida albicans* and *Aspergillus fumigates* has been explored⁵. 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 tea⁶⁷. 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 blood levels of glucose. Therefore, GT could be beneficial additional therapy in the management of diabetic nephropathy⁶⁸.

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 2diabetes. 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 absorbs blood sugar greatly increased⁶⁹.

Several humans and animal-based studies suggested that green tea and its flavonoids have anti-diabetic effects^{70, 71, 54}.

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^{72, 73}.

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 atherosclerosis¹. 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 KDK 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 day⁷⁴. 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 pressure⁷⁵.

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- γ neurotoxicity⁷⁶.

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 cycle⁷⁷. These studies were limited to cellular and animal analysis. EGCG binds with CD4 with a stronger chemical affinity than gp120, thus blocking gp120-CD4 binding⁷⁸. Green tea slows Reverse transcriptase (HIV-1 RT) and inhibits replication of two strains of HIV⁷⁹. Also *in vitro* studies have revealed that observed that adenovirus infection is inhibited by green tea catechins⁸⁰.

Green tea also suppresses the adenovirus, Epstein-Barr, herpes simplex, and influenza viruses. EGCG 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 influenza⁸¹.

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* bacterium⁸².

Catechins, in green tea have antimicrobial activity. The synergistic antimicrobial activity antibiotics could be useful in fighting emerging drug resistance problem especially among enteropathogens⁵.

Green tea extract in combination with probiotics significantly reduced the viable count of *Staphylococcus aureus* and *Streptococcus pyogenes*⁸³. Susceptibility of bacterial strains to the tea extract has been shown to be related to differences in cell wall compounds⁸⁴. Catechins partitioning in the lipid bilayer membrane result in loss of cell structure and function and finally cell death⁸⁴⁻⁸⁷. Also synergy between green tea extract and levofloxacin against enterohaemorrhagic *Escherichia coli* have been reported⁸⁸. 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 tea⁸⁹.

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 observed⁹⁰. 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 disease⁹¹. 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.

Rheumatoid Arthritis and Osteoarthritis

Inflammation plays a key role in Osteoarthritis (OA) and Rheumatoid Arthritis. An approach that decreases inflammation may facilitates 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 β induced inflammatory responses⁹². 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 appeal⁹³.

Antiallergic potentials

EGCG, the major catechin in green tea, is believed to be the primary source of beneficial effects of green tea⁹⁴. 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 EGCG⁹⁵. 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 apoptosis⁹⁶. 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 proteins⁹⁷. 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 reduces 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 systems⁹⁸⁻¹⁰⁰. 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 cancers¹⁰¹. EGCG can inhibit tumorigenesis during the initiation, promotion and progression stages in animal models of carcinogenesis¹⁰² (Table 3).

Green tea contains higher concentrations of monomeric polyphenols, which affect numerous intracellular signalling pathways involved in prostate cancer (CaP) development. The majority of *in vitro* cell culture, *in vivo* animal, and clinical intervention studies provided strong evidences supporting a chemopreventive effect of green tea extract or purifies epigallocatechin-3-gallate (EGCG), in preventing prostate cancer, but results from epidemiological studies of green tea consumption are mixed¹⁰⁹.

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 studies¹¹³. 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 cancer¹¹¹. Women that regularly drank green tea when the study began were 37%

less likely to develop colorectal cancer compared to infrequent green tea drinkers. Women who continued to drink green tea regularly throughout the study fared even better, reducing their risk of colorectal cancer by 57%¹¹⁴. Green tea lowers risk of gallstones and biliary tract cancers.

A human pilot study recently confirmed the protective effects of green tea against lung cancer seen in cell culture and animal studies. It has been shown that because of green tea consumption, DNA damage caused by smoking was decreased, cell growth was inhibited, and cellular triggers for apoptosis (cell suicide) in abnormal cells increased¹¹².

CONCLUSION

Currently there has been an increased interest globally to identify antioxidant potentials of green tea which is pharmacologically potent and have low or no side effects for use in protective medicine and the food Industry. Increasing knowledge in antioxidant phytoconstituents and include them in daily uses and diet can give sufficient support to human body to fight those diseases. Green tea is emerging as the natural remedy to almost all the health related issues. With the latest advancement in the technologies, various potentials of green tea have been explored. This has succeeded in fetching the consistent interest of people toward the health benefits associated with this herbal gift of nature to the mankind. It is not surprising that day by day green tea and its products are capturing the global market and its use has also increased incredibly. The credit for this remarkable achievement is linked with the high antioxidant components of green tea. From antibacterial to antifungal, antiviral potentials, from skin, vision, hair loss, over weight issues, diabetes, kidney disorders, to Parkinson's and Alzheimer's disease, cancer and many more, green tea has proved its potentials and still many parameters are still need to be explored.

Recent application of green tea in nanotechnology has suggested promising evidences in its bioavailability by delivering EGCG using lipid nanocapsules and liposome encapsulation. Further study in this regard can be useful in availing the healthy benefits of green tea. With successful outcomes of *in vivo*- studies of green tea as a potent anti rheumatic and anti – HIV agent, human trials of green tea for the same can be done in future to provide a novel pathway for the therapy.

Definitely, these findings are promising, but many of these properties of green tea have been revealed through several animal trials and still human clinical evidences are lacking on their behalf. It is very important to have future research with frequent epidemiological studies and to conduct human trials which can further explore the hidden credentials of green tea and confirm their actual magnitude of potential for humans. Also, random experiments worldwide have explored varied outcomes, it is essential to study the safe dose of green tea consumption to acquire their health benefits and to have better understanding of their mode of action. Development of more specific and sensitive methods with more representative models along with the development of good predictive biomarkers will give a better understanding of how green tea interacts with endogenous systems and other exogenous factors. The development of biomarkers for green tea consumption, as well as molecular markers for its biological effects, will facilitate future research in this area.

Thus, there is an urgent need to check the efficacy, safety and translational guidelines for a green tea to be used as safe, effective drug. Current IHC Harmonised Tripartite Guidelines (current step 2 version, 2008) may be followed to

study parameters like Cytotoxicity test, Comet assay, Biochemical analysis, Cytotoxicity assay (MTT test), Genotoxicity assay, carcinogenicity assay, percent protection test in challenged animal models.

Identification of active principal, screening of bio medicinal properties by appropriate *in vitro* assays, investigation of toxicological effects as per the regulatory guidelines will make **green tea a magical herb with miraculous outcomes.**

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Varieties of green tea	Processing
1. Green tea	Unwilted, unoxidized
2. White tea	Wilted, unoxidized
3. Oolong tea	Wilted, partially oxidized
4. Black tea	Wilted, fully oxidized

TABLE 1. VARIETIES OF TEA AND THEIR PROCESSING

CHEMICAL CONSTITUENTS	PERCENTAGE
1. Catechins:	
Epigallocatechin – 3- gallate (EPEC)	59 of total catechins
Epigallocatechin (EGC)	19
Epicatechin -3- gallate (ECG)	13.6
Epicatechin (EC)	6.4
2. Caffeine	3.5
3. Proteins	15-20
4. Amino acids	1-4
5. Fiber	26
6. Carbohydrates	7
7. Lipids	7
8. Pigments	2
9. Minerals	5
10. Phenolic compounds	30
11. organic acids	1.5
11. Oxidized phenolic compounds	0

TABLE 2. PERCENTAGE OF DIFFERENT CHEMICAL CONSTITUENTS PRESENT IN GREEN TEA.

MODE OF ACTION	EFFECT ON CANCER CELLS	REFERENCE
Inhibiting urokinase activity	Inhibits tumor growth and metastasis	103
Inhibiting Angiogenesis- development of new blood vessels	Starve cancer cells by	104, 105, 106
Enhances apoptosis inducing property of COX-2 inhibitors on prostate cancer cells	Premature killing of cancerous cells	107
Biochemical Modulator for anticancer drugs	Increases efficacy of cancer therapy with no side effects	108
Affecting intracellular signaling pathway bin prostate cancer	Inhibition of prostate cancer development (CaP)	109
Reducing production of proinflammatory compounds (5- lipoxygenase, leukotriene A4, Hydrolase, Leukotriene) in colon cancer	Preventing the growth of colon cancer	110
Acting inversely on cervical lesions and external genital warts	Preventing the progression of ovarian cancer	111
Triggering apoptosis	Causes DNA damage	112

TABLE 3: MODE OF ACTION OF GREEN TEA POLYPHENOLS AGAINST CANCEROUS CELLS.



Fig.1. *Camellia sinensis* (L.) Kuntze

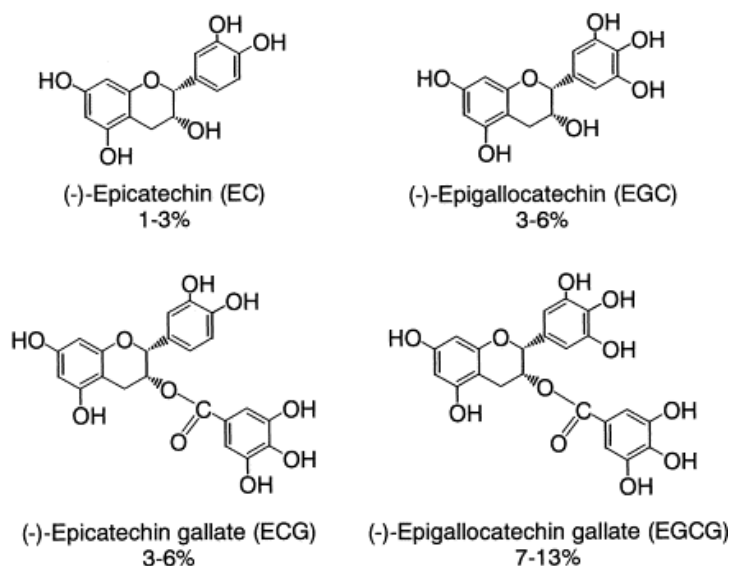


Fig. 2. Major Polyphenols in green tea

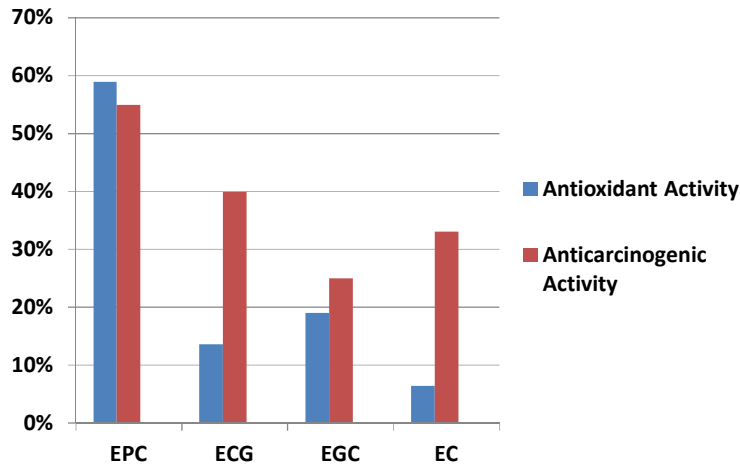


Fig 3. Graph representing antioxidant and anticarcinogenic activity of different catechins present in green tea.

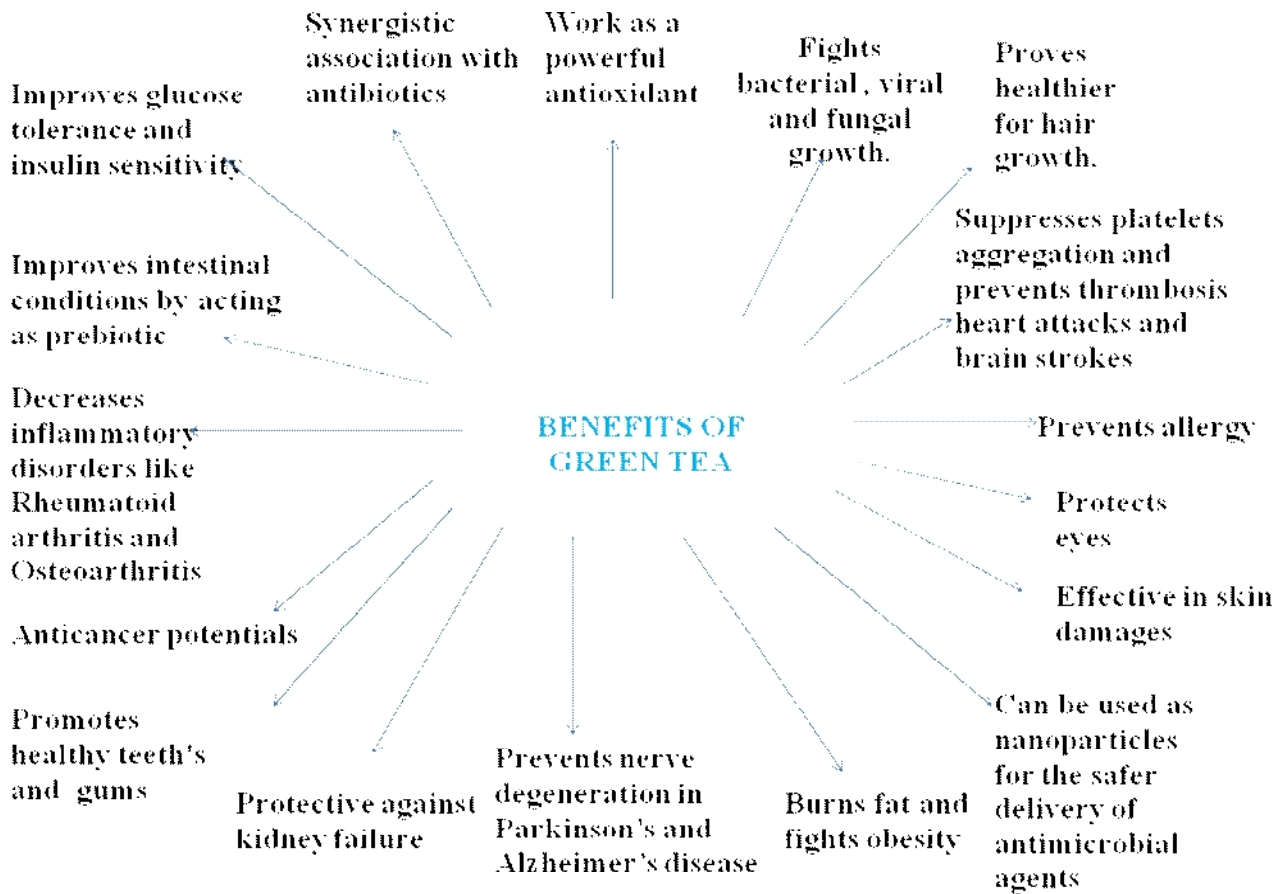


Fig. 4: Benefits of green tea