green tea paper

Data · December 2013

4 authors:

Nishant Rai
Graphic Era University

Jigisha Anand
Graphic Era University

Navin Kumar
Graphic Era University

Pankaj Gautam
Graphic Era University

INTERNATIONAL RESEARCH JOURNAL OF PHARMACY
www.irjponline.com ISSN 2230 – 8407
Review Article

GREEN TEA: A MAGICAL HERB WITH MIRACULOUS OUTCOMES

Anand Jigisha, Rai Nishant*, Kumar Navin and Gautam Pankaj
Department of Biotechnology, Graphic Era University, Dehradun, UK, India

Article Received on: 06/04/12 Revised on: 28/04/12 Approved for publication: 09/05/12

*Email: nishantrai1@gmail.com

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 world [1]. 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 Cambodia [2].

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	Camellia L. – camellia
Species	*Camellia sinensis* (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 China[3].

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 properties [5].

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 polyphenols[10]. 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[11]. 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 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 [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 EGCG [13]. 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 [14]. 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*, 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 EC [17]. 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 [18].

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 [28].

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 aging [29](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 peroxyl 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 quality [30](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 chemists [31].

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 applications [32].

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, marcaptoacetate, 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 optical[36], chemical[37], photoelectro-chemical[38] and electronic properties[39]. 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 applications[32].

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[42] 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-1β, 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* 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 [46].

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 [47]. 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 teeth [28].

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[49]. 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 bacteria [50].

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 recommended[51].

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 levels [52]. Green tea catechins enhance exercise induced abdominal fat loss in overweight and obese adults [53].

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 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].

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 [56]. 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[57]. 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 [58]. 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 [59]. 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 [60]. 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 [61].

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 5α-reductase type I enzyme, which converts testosterone to DHT [60]. 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 Prebiotic[62]. The inclusion of green tea showed positive effects on the increase of lactic acid bacteria and aerobic bacteria counts in ruminants [63].

Acidic, basic and neutral methanol extract fraction of *Camellia japonica* inhibited the growth of food borne pathogens in microbiological media and food [64]. 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 reported [66]. Recently antifungal activity of green tea catechins against *Candida albicans* and *Aspergillus fumigates* has been explored[5]. 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 [67]. 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 nephropathy [68].

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 increased [69].

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 atherosclerosis [1.] 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 day [74.] 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 [75].

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-r neurotoxicity [76].

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 [77]. 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 [78]. Green tea slows Reverse transcriptase (HIV-1 RT) and inhibits replication of two strains of HIV [79]. Also *in vitro* studies have revealed that observed that adenovirus infection is inhibited by green tea catechins [80].

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 [81].

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 [82].

Catechins, in green tea have antimicrobial activity. The synergistic antimicrobial activity antibiotics could be useful in fighting emerging drug resistance problem especially among enteropathogens [5].

Green tea extract in combination with probiotics significantly reduced the viable count of *Staphylococcus aureus* and *Streptococcus pyogens* [83]. Susceptibility of bacterial strains to the tea extract has been shown to be related to differences in cell wall compounds [84.] Catechins partitioning in the lipid bilayer membrane result in loss of cell structure and function and finally cell death [84-87]. Also synergy between green tea extract and levofloxacin against enterohaemorrhagic *Escherichia coli* have been reported[88]. 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 [89].

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 [90]. 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 [91]. 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-Iβ induced inflammatory responses [92].

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 [93].

Antiallergic potentials

EGCG, the major catechin in green tea, is believed to be the primary source of beneficial effects of green tea[94]. 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) [95]. 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 [96]. 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 [97]. 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 systems[98-100]. 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 cancers [101]. EGCG can inhibit tumorigenesis during the initiation, promotion and progression stages in animal models of carcinogenesis [102] (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 mixed [109].

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 [113]. 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 [111]. 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 increased [112].

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.**

REFERENCES

1. Gomikawa S, Ishikawa Y, Hayase W, Haratake Y, Hirano N, Matuura H, Mizowaki A, Murakami A, Yamamoto M. Effect of ground green tea drinking for 2 weeks on the susceptibility of plasma and LDL to the oxidation ex vivo in healthy volunteers. *Kobe J. Med. Sci* 2008; 54(1): E62-72.
2. Hicks A. Review of Global Tea Production and the Impact on Industry of the Asian Economic Situation. *AU J.T* 2001; 5(2).
3. Milind Parley, Nitin Bansal, Seema Bansal. Is life- span under our control?? *IRJP* 2012; (2):40-48.
4. McNaught JG. On the action of cold or lukewarm tea on *Bacillus typhosus*. *Journal of the Royal Army Medical Corps* 1906; 7:372-373.
5. Archana S, Jayanthi A. Comparative analysis of antimicrobial activity of leaf extract from fresh green tea, commercial green tea and black tea on pathogens. *J App Pharmaceutical science* 2011; 01(08): 149-52.
6. McKay DL, Blumberg JB. The role of tea in human health: An update. *J Am Coll Nutr* 2002; 21:1–13.
7. Rietveld A, Wiseman S. Antioxidant effects of tea: Evidence from human clinical trials. *J Nutr* 2003; 133:3275–3284.
8. Il'yasova D, Martı´n C, Sandler RS. Tea intake and risk of colon cancer in African-Americans and Whites: North Carolina colon cancer study. *Cancer Causes Control* 2003; 14:676–772.
9. Pastore Robert. Green & White Tea Max: A Closer Look at the Benefits of Green and White Tea. *Pastore formulations* 2005.
10. Tariq M, Naveed A, Barkat Ali K. The morphology, characteristics, and medicinal properties of *Camellia sinensis'* tea. *J. Med. Plants Res* 2010; 4(19): 2028-2033.
11. Horzic D, Komes D, Belscak A, Ganic KK, Ivekovic D, Karlovic D. The composition of polyphenols and methylxantine in teas and herbal infusions. *Food Chem* 2009; 115: 441-448.
12. Hakim I, Harris R, Weisgerber U. Tea intake and squamous cell carcinoma of the skin: Influence of type of tea beverages. Cancer Epidemiol Biomarkers Prev 2000; 9:727– 731.
13. Wu CD, Wei GX. Tea as a functional food for oral health. *Nutrition 2002; 18:443–444.*
14. Cabrera Carmen, Reyes Artacho, Rafael Giménez,. Beneficial Effects of Green Tea—A Review. *J Am Coll Nutr* 2006; 25(2) 79-99.
15. Hamilton-Miller and S. Shah. Activity of the tea component epicatechin gallate and analogues against methicillin-resistant *Staphylococcus aureus. J. Antimicrob. Chemother* (1999); 46 (5): 852-853.
16. Vergote David, Cécile Cren-Olivé, Chopin Valérie, Toillon Robert-Alain, Rolando Christian, Hondermarck Hubert and Bourhis Xuefen Le (−)-Epigallocatechin (EGC) of Green Tea Induces Apoptosis of Human Breast Cancer Cells But Not of their Normal Counterparts. *Breast Cancer Research and Treatment* 2002; (76)3:195-201.
17. Chow HH, Cai Y, Alberts DS. Phase I pharmacokinetic study of tea polyphenols following single-dose administration of epigallocatechingallate and polyphenol E. *Cancer Epidemiol Biomarkers Prev* 2001; 10:53–58.
18. Xu H, Becker CM, Lui WT, Chu CY, Davis TN, Kung AL, Birsner AE, D'Amato RJ, Wai Man GC, Wang CC. Green tea epigallocatechin-3-gallate inhibits angiogenesis and suppresses vascular endothelial growth factor C/vascular endothelial growth factor receptor 2 expression and signaling in experimental endometriosis in vivo. *Fertil Steril* 2011*;* 96(4):1021-8.
19. Chaturvedula Venkata Sai Prakash and Indra Prakash. The aroma, taste, color and bioactive constituents of Tea. *Journal of Medicinal Plants Research* 2011*; 5(11): 2110-2124.*
20. Balentine DA. Introduction: tea and health. *Crit. Rev. Food Sci. Nutr* 1997; 8: 691-669.
21. Hara Y, Luo SJ, Wickremashinghe RL, Yamanishi T. VI. Biochemistry of processing black tea. *Food Rev. Int* 1995; 11: 457-471.
22. Hui YH. Encyclopedia of Food Science and Technology, A wiley *Interscience Publication. John wiley and Sons* 1992; 3-4.
23. Chu DC, Juneja LR, Kim M, Yamamotro T. Chemistry and applications of green tea. *CRC. press. New York, USA* 1997; 13-16.

24. Kok E, Tascioglu S. Temperature dependace of copper and chromium transfer into various black and green tea infusions. *J. Sci. Food Agric* 1998; 76: 200-298
25. Fernández-Cáceres PL, Martin MJ, Pablos F, González AG. Differentiation of tea (Camelia sinensis) varieties and their geographical origin according to their metal content. *J Agric Food Chem* 2001; 49:4775– 4779.
26. Ferrara L, Montesano D, Senatore A. The distribution of mineral and flavonoids in the tea plant (Camellia sinensis). *II Farmac* 2001*; 56(5-7):397-401*
27. Gramza Anna, Korczak Józef, Amarowicz Ryszard. Tea polyphenols – their antioxidant properties and biological activity-A review. *Pol. J. Food nutr. Sci* 2005; 14/55(3): 219–235.
28. Tahir Arifa and Moeen Rabia. Comparison of antibacterial activity of water and ethanol extracts of *Camellia sinensis (L.)* Kuntze against dental caries and detection of antibacterial components. *Journal of Medicinal Plants Research* 2011; 5(18): 4504-4510.
29. Hamilton- Miller JMT. Anticarcinogenic properties of tea (*Camellia sinensis)*. *Journal of medical Microbiology* 2001*;* 50:299-302.
30. Vilma Armoskaite, Kristina Ramanauskiene, Audrius Maruska, Almantas Razukas, Audrone Dagilyte, Algirdas Baranauskas and Vitalis Briedis . The analysis of quality and antioxidant activity of green tea extracts*. J. Med. Plant. Res* 2011; 5(5):811-816.
31. Barras A, Mezzetti A, Richard A, Lazzaroni S, Roux S, Melnyk P, Betbeder D, Monfi lliette-Dupont N .Formulation and characterization of polyphenolloaded lipid nanocapsules. *Int J Pharm* 2009; 379:270-277.
32. Ravichandran Madhuram, Navam S Hettiarachchy, Vijayalakshmi Ganesh, Steven C Ricke, Surendra Singh. Enhancement of antimicrobial activities of naturally occurring phenolic compounds by nanoscale delivery against *Listeria monocytogenes*, *Escherichia coli* o157:h7 and *salmonella* typhimurium in broth and chicken meat system. *Journal of Food Safety* 2011; 31(4): 462–471.
33. Gardea-Torresdey JL, Gomez E, Peralta-Videa J, Parsons JG, Troiani HE., Jose-Yacaman M. Alfalfa sprouts: a natural source for the synthesis of silver nanoparticles, *Langmuir* 2003; 19: 357- 1361.
34. Ravindran TR, Arora AK, Balamuragan B, Mehta BR .Inhomogeneous broadening in the photo luminescence spectrum of cds nanoparticles. *Nanostruct. Mater* 1999; 11:603-609.
35. Gericke M and Pinches A. Biological synthesis of meta Nanoparticles. *Hydrometallurgy* 2006*;* 83:132-140.
36. Lin S M, Lin F Q, GUO H Q, Zhang Z.H ,Wang ZG. Surface states induced photoluminescence from Mn2+ doped cds nano—particles. *Solid State Commum* 2000*;* 115:615–618.
37. Krolikowska A, Kudelski A, Michota A , Bukowska J. SERS studies on the structure of thioglycolic acid monolayers pn silver and gold. *Surf Sci* 2003*;* 532:227-232.
38. Ahmad A, Senapati S, Khan MI, Kumar R, Sastry M. Extracellular biosynthesis of monodisperse gold nanoparticles by a novel extremophilic actinomycete, *Thermomonospora* sp. Langmuir 2003; 19:3350-3553.
39. Chandrasekharan N, Kamat PV. Improving the photo-electrochemical performance of nanostructured TiO2 films by adsorption of gold nanoparticles. *J Phys Chem B* 2000*;* 104:10851-10857.
40. Roh Y, Lauf RJ, Mc Millan AD, ZhanJg C, Rawn C J , Bai J, Phelps. Microbiol synthesis and the characterization of metal substituted magnetites .*Solid state commun 2001;* 118:529-534.
41. Bhattacharya D and Rajinder G. Nanotechnology and potential of microorganisms. *Crit Rev Biotechnol* 2005; 25:199– 204.
42. Pajonk F, Riedisser A, Henke M, et al. The effects of tea extracts on proinflammatory signaling. *BMC Med 2006;* 4:28.
43. Lee MJ, Lambert JD, Prabhu S, Meng XF, Lu H, Maliakal P, Ho CT, Yang CS. Delivery of tea polyphenols to the oral cavity by green tea lavels and black tea extract. *Cancer Epidemiol Biomarkers Prev* 2004*;* 13:132–137.
44. Katiyar SK: Skin photoprotection by green tea: Antioxidant and immunomodulations effects. *Curr Drug Targets* 2003; 3:234–242.
45. Naderi N Jalayer, Niakan M, Kharazi Fard M J and Zardi S . Antibacterial Activity of Iranian Green and Black Tea on *Streptococcus Mutans*: An In Vitro Study. *J Dent (Tehran). Spring* 2011; 8(2): 55–59.
46. Kushiyama Mitoshi, Shimazaki Yoshihiro, Murakami Masatoshi, and Yamashita Yoshihisa. Relationship between Intake of Green Tea and Periodontal Disease. *Journal of Periodontology* 2009; 80(3): 372-377.
47. Simpson A, Shaw L, Smith AJ. The bio-availability of fluoride from black tea. *J Dent* 2001; 29:15–21.
48. Okamoto M, Sugimoto A, Legun KP, Nakayama K, Kamaguchi A, Maeda N.Inhibitory effect of green tea catechins on cysteine proteinases in Porphyromonas gingivalis. *Oral Microbiol Immunol* 2004; 19:118–120.
49. Hamidreza A, Ahmad M, Shayan, G, Hooman S, Keyvan S, Ali F. Review of The therapeutic effects of *Camellia sinensis* (green tea) on oral and periodontal health. *Journal of Medicinal Plants Research* 2011; 5(23): 5465-5469.
50. Liao S, Kao YH, Hiipakka RA. Green tea: biochemical and biological basis for health benefits. *Vitam. Horm* 2001; 62: 1-94.
51. Venkateswara Babu, Sirisha K and Chava Vijay K. Green tea extract for periodontal health. *J Indian Soc Periodontol 2011;* 15(1): 18–22.
52. Kim A, Chiu A, Barone MK, Avino D, Wang F, Coleman CI, Phung OJ . Green tea catechins decrease total and low-density lipoprotein cholesterol: a systematic review and meta-analysis. *J Am Diet Assoc* 2011;111(11):1720-9.
53. Maki Kevin C, Reeves Matthew S, Farmer Mildred, Yasunaga Koichi, Matsuo Noboru, Katsuragi Yoshihisa, Komikado Masanori, Tokimitsu Ichiro, Wilder Donna, Jones Franz, Blumberg Jeffrey B, and Cartwright Yolanda. "Green Tea Catechin Consumption Enhances Exercise-Induced Abdominal Fat Loss in Overweight and Obese Adults*". J. Nutr* 2009; 139:264-270.
54. Wolfram S, Raederstorff D, Preller M, Wang Y, Teixeira S R, Riegger C and Weber P. Epigallocatechin gallate supplementation alleviates diabetes ain rodents. *J Nuts* 2006; 136:3512-3518.
55. Murase T, Harmizu S, Shimotoyodome A, *et al*. Green tea extract improves running endurance in mice by stimulating lipid utilization during exercise. *Am J Physiol Regul Integr Comp Physiol* 2006; 290(6):1550-56.
56. Chu Kai On, Chan Kwok Ping, Wang Chi Chiu, Chu Ching Yan, Li Wai Ying, Choy Kwong Wai, Rogers Michael Scott and Pang Chi Pui. Green tea catechins and their oxidative protection in the Rat Eye. *J. Agric. Food Chem* 2010; 58 (3): 1523-34.
57. Yang SW, Lee BR, Koh JW. Protective effects of epigallocatechin gallate after UV irradiation in cultured human retinal pigment epithelial cells. *Korean J Ophthalmol 2007;* 21(4):232-7.
58. Gupta SK, Selvan V Kalai, Agrawal S S, and Saxena Rohit. Advances in pharmacological strategies for the prevention of cataract development. *Indian J Ophthalmol* 2009; 57(3): 175–183.
59. Zhang B, Osborne NN. Oxidative – induced retinal degeneration is attenuated by epigallocatechin gallate. *Brain Res* 2006*; 1124*(1): 176-87.
60. Patil SM, Sapkale GN, Surwase US, Bhombe BT. Herbal medicines as an effective therapy in hair loss – A review. RJPBCS 2010; 1 (2): 773-81.
61. Charles E Isaacs, Guang Y Wen, Weimin Xu, Jun Hua Jia, Lisa Rohan, Christopher Corbo, Vincenzo Di Maggio, Edmund C. Jenkins, Jr.,and Sharon Hillier. Epigallocatechin Gallate Inactivates Clinical Isolates of Herpes Simplex Virus. *Antimicrobial Agents and Chemotherapy* 2008; 962–970.
62. Yang, CJ, Yang Y C and Uuganbayar D. Effect of feeding diets containing green tea by-products on laying performance and egg quality in hens. *Kor. J. Poult. Sci 2003;* 30(3):183-189.
63. Bureenok S, M Tamaki, Y Kawamoto and T Nakada. Additive effects of green tea on fermented juice of epiphytic lactic acid bacteria (FJLB) and the fermentative quality of rhodesgrass silage. *Asian-Aust. J. Anim. Sci* 2007*;* 20:920-924.
64. Kim KY, Davidson PM, Chung HT. Antibacterial activity in extracts of *Camellia japonica* L. Petals and its application to a model food system. *J Food Prol* 2001; 64:1255-60.
65. Takabayashi F, Harada N, Yamada M, Murohisa B, Oguni I. Inhibitory effect of green tea catechins in combination with sucralfate on *Helicobacter pylori* infection in Mongolian gerbils. *J Gastroenterol* 2004; 39:61–63.
66. Yee YK, Koo MWL, Szeto ML. Chinese tea consumption and lower risk of Helicobacter infection. *J Gastroenterol Hepatol* 2002; 17:552–555.
67. Mowafy AM, Salem HA, Gayyar MM, Mesery ME, Azab MF. Evaluation of renal protective effects of the green-tea (EGCG) and red grape resveratrol: role of oxidative stress and inflammatory cytokines. *Nat Prod Res* 2011*;* 25(8):850-6.
68. Renno WM, Abdeen S, Alkhalaf M, Asfar S. Effect of green tea on kidney tubules of diabetic rats. *Br J Nutr* 2008.; 100(3):652-9.
69. Fiorino Patricia, Evangelista Fabiana Sant'Anna, Santos Fernando, Magri F´atimaMariaMotter, Jan CarloMorais O. B. Delorenzi, Ginoza Milton, and Farah Vera. The Effects of Green Tea Consumption on Cardiometabolic Alterations Induced by Experimental Diabetes. *Experimental Diabetes Research* 2012; Article ID 309231: 7.
70. Wu L Y, Juan C C, Ho L T, HsuY P and Hwang L S. Effect of green tea supplementation on insulin sensitivity in Sprague- Dawley rats. *J. Agric Food Chem* 2004; 52:643-648.
71. Iso H, Date C, Wakai K, Fukui M, Tamakoshi A and J.A.C.C study group. The relationship between green tea and total caffeine intake and risk for self reported type 2 diabetes among Japanese adults. *Ann Intern Med* 2006; 144,550-562.

72. Thelle DS. Coffee, tea and coronary heart disease. *Curr. Opin.Lipidol 1995; 6: 25-27.*
73. Weisburger JH. Tea antioxidants and health. In: Cadenas E,Packer L. *Eds. Handbook of antioxidants. New York: Marcel Dekker* 1996; 469–486.
74. Lenore Arab, Weiqing Liu and David Elashoff .Green and Black Tea Consumption and Risk of Stroke: A Meta-Analysis. *Stroke* 2009; 40:1786-1792.
75. Nileeka Balasuriya BW and Vasantha Rupasinghe HP. Plant flavonoids as angiotensin converting enzyme inhibitors in regulation of hypertension. *Functional Foods in Health and Disease* 2011; 5:172-188
76. Brian Giunta, Demian Obregon, Hauyan Hou, Jin Zeng, Nan Sun, Veljko Nikolic, Jared Ehrhart, Douglas Shytle, Francisco Fernandez, Jun Tan. EGCG mitigates neurotoxicity mediated by HIV-1 proteins gp120 and Tat in the presence of IFN-γ: Role of JAK/STAT1 signalling and implications for HIV-associated dementia. *Brain Research* 2006*; 1123 (1):216-225.*
77. Yamaguchi K, Honda M, Ikigai H, Hara Y, Shimamura T. Inhibitory effects of (-)-epigallocatechin gallate on the life cycle of human immunodeficiency virus type 1 (HIV-1). *Antiviral Res* 2002; 53:19-34.
78. Williamson Mike P, McCormick Theron G, Nance Christina L, Shearer William T. Epigallocatechin gallate, the main polyphenol in green tea, binds to the T-cell receptor, CD4: Potential for HIV-1 therapy. *Journal of Allergy and Clinical Immunology* 2006*;* 118(6):1369–1374.
79. Fassina G, Buffa A, Benelli R, Varnier OE, Noonan DM, Albini A. Polyphenolic antioxidant (-)-epigallocatechin-3-gallate from green tea as a candidate anti-HIV agent. *AIDS* 2002; 16:939-41.
80. Weber JM, Ruzindana-Umunyana A, Sicar S, Cowan J. Adenovirus infection is inhibited *in vitro* by green tea catechins. *J Clin Virol 2003; 28:S91.*
81. Matsumoto K, Yamada H, Takuma N, Niino H, Sagesaka YM. Effects of green tea catechins and theanine on preventing influenza infection among healthcare workers: a randomized controlled trial. *BMC Complement Altern Med* 2011*;*21; 11:15.
82. Smeeton Benjamin. The synergy of green tea and penicillin G against *Bacillus Subtilis. J App Pharma* 2011; 02 (03): 197-200.
83. Ping Su, Anders Henriksson, Christina Nilsson and Hazel Mitchell. Synergistic effect of green tea extract and probiotics on the pathogenic bacteria, *Staphylococcus aureus* and *Streptococcus pyogens*. *J.Microbiol and biotechnology* 2008; 24: 1837-42.
84. Ikigai H, Nakae T, Hara Y, Shimamura T. Bactericidal catechins damage the lipid bilayer. *Biochim Biophys Aeta* 1993; 1147:132-6.
85. Mabe K, Yamada M, Oguni I, Takahashi T. *In vitro* and *in vivo* activities of the catechins against *Helicobacter pylori. Antimicrobials Agents Chemother* 1996; 43:1788-91.
86. Tsuchiya H, Sato M, Miyazaki, Fujiwara S, Tanigaki S, Ohyama M. Comparative study on the antibacterial activity of phyochemical flavanones against methicillin resistant *Staphylococcus aureus. J Ethnopharmacol 1995; 50:27-34.*
87. Cox SD, Mann CM, Markham JL. Interactions between components of the essential oil of Melaleuca alternifolia. *J. Appl.Microbiol* 2001; 91:492-7.
88. Isogai E, Isogai, H, Hirose K, Hayashi S, Oguma, K. *In vivo* synergy between green tea extract and levofloxacin against enterohemorrhagic *Esherichia coli* 0157 infection. *Curr Microbiol* 2001; 42:248-51.
89. STiwari RP, Bharti SK, Kaur HD, Dikshit RP and Hoondal GS. Synergestic antimicrobial activity of tea and antibiotics. *Indian J Med Res 2005; 122: 80-84.*
90. Reznichenko L, Kalfon L, Amit T, Youdim MB, Mandel SA. Low dosage of rasagiline and epigallocatechin gallate synergistically restored the nigrostriatal axis in MPTP-induced Parkinsonism. *Neurodegener Dis 2010;* 7(4):219-31.
91. Okello E K, McDougallG K, Kumar S, Seal C J. In vitro protective effects of colon-available extract of Camellia sinensis (tea) against hydrogen peroxide and beta-amyloid (Aβ(1–42)) induced cytotoxicity in differentiated PC12 cells. *Phytomedicine 2011*; 18(8–9): 691–696.
92. Akhtar N, Haqqi TM. Epigallocatechin-3-gallate suppresses the global interleukin-1beta-induced infl ammatory response in human chondrocytes. *Arthritis Res Ther* 2011; 13:R93.
93. Ahmed S. Green tea polyphenol epigallocatechin 3-gallate in arthritis: progress and promise. *Arthritis Research & Therapy* 2010; 12:208.
94. Fujimura Y, Tachibana H, Maeda-Yamamoto M, Miyase T, Sano M, Yamada K. Antiallergic tea catechin, (−)-epigallocatechin-3-O-(3-O-methyl)-gallate, suppresses Fc-epsilonRI expression in human basophilic KU812 cells. *J Agric Food Chem* 2002; 50:5729–5734.
95. Tachibana H, Sunada Y, Miyase T, Sano M, Maeda-Yamamoto M, Yamada K. Identification of a methylated tea catechin as an inhibitor of degranulation in human basophilic KU812 cells. *Biosci Biotechnol Biochem 2000;* 64:452–454.
96. Hassanain Ehab, Silverberg Jonathan I, Norowitz Kevin B, Chice Seto, Bluth Martin H, Brody Neil, Joks Rauno, Durkin Helen G, Smith-Norowitz Tamar A. Green Tea *(Camelia sinensis)* Suppresses B Cell Production of IgE Without Inducing Apoptosis. *Ann Clin Lab Sci Spring* 2010; (40): 2 135-143.
97. Yamamoto Mari Maeda, Ema Kaori, Monobe Manami, Shibuichi Ikuo, Shinoda Yuki, Yamamoto Tomohiro and Fujisawa Takao . The efficacy of early treatment of seasonal allergic rhinitis with Benifuuki green tea containing o-methylated catechin before pollen exposure: An open randomized study. *Allergoloy International* 2009; 58:437-444
98. Katiyar SK, Mukhtar H. Tea in chemoprevention of cancer: epidemiologic and experimental studies. *Int. J. Oncol* 1996; 8: 221-238.
99. Dreaosti IE, Wargovich MJ, Yang CS. Inhibition of carcinogenesis by tea: the evidence from experimental studies. *Crit. Rev. Food Sci. Nutr* 1997*;* 37: 761-770.
100. Kohlmeier L, Weterings KGC, Steck S, Kok FJ. Tea and cancer prevention: An evaluation of the epidemiologic literature. *Nutr. Cancer* 1997*;* 27: 1-13.
101. Yang CS, Wang X. Green Tea and Cancer Prevention. *Nutr. Cancer* 2010; 62: 931-937.
102. Lambert JD, Elias RJ. The antioxidant and pro-oxidant activities of green tea polyphenols: A role in cancer prevention. *Arch. Biochem. Biophys* 2010; 501: 65-72.
103. Garbisa S, Sartor L, Biggin S, Salvato B, Benelli R, and Albini A. Tumor gelatinases and invasion inhibited by the green tea flavanol epigallocatechin-3-gallate. *Cancer* 2001; 91 (4):822–832.
104. Garbisa S, Biggin S, Cavallarin N, Sartor L, Benell R and Albini A. Tumor invasion: molecular shears blunted by green tea. *Nat. Med* 1999; 5:121.
105. Maeda K, Chung YS, Takatsuka S, *et al*. Tumour angiogenesis and tumour cell proliferation as prognostic indicators in gastric carcinoma. *Br J Cancer* 1995; 72:319–23.
106. Demeule M, Brossard M, Page M, Gingras D and Beliveau R. Matrix metalloproteinase inhibition by green tea catechins. *Biochim. Biophys. Acta* 2000; 1478, 51.
107. Adhami VM, Malik A, Zaman N, Sarfaraz S, Siddiqui IA, Syed DN, Afaq F, Pasha FS, Saleem M, Mukhtar H: Combined inhibitory eff ects of green tea polyphenols and selective cyclooxygenase-2 inhibitors on the growth of human prostate cancer cells both in vitro and in vivo. *Clin Cancer Res* 2007; 13:1611-1619.
108. Sadzuka Y, Sugiyama T, Hirota S. Modulation of cancer chemotherapy by green tea. *Clin. Cancer Res 1998;* 4: 153-156.
109. Henning SM, Wang P, Heber D. Chemopreventive effects of tea in prostate cancer: green tea versus black tea. *Mol Nutr Food Res* 2011. ;55(6):905-20.
110. Ju J Liu Y, Hong J, Huang MT, Conney AH, Yang CS. Effects of green tea and high-fat diet on arachidonic acid metabolism and aberrant crypt foci formation in an azoxymethane-induced colon carcinogenesis mouse model. *Nutr Cancer* 2003; 46, 172–178.
111. Butler LM, Wu AH. Green and black tea in relation to gynecologic cancers. *Mol Nutr Food Res* 2011;55(6):931-40.
112. Yuan JM. Green tea and prevention of esophageal and lung cancers. *Mol Nutr Food Res* 2011; 55(6):886-904.
113. Wu AH, Butler LM. Green tea and breast cancer. *Mol Nutr Food Res* 2011; 55(6):921-30.
114. Yang G, Zheng W, Xiang YB, Gao J, Li HL, Zhang X, *et al*. Green tea consumption and colorectal cancer risk: a report from the Shanghai Men´s Health Study. *Carcinogenesis* 2011; 32(11):1684-8.

.

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:	
Epigallactocatechin – 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

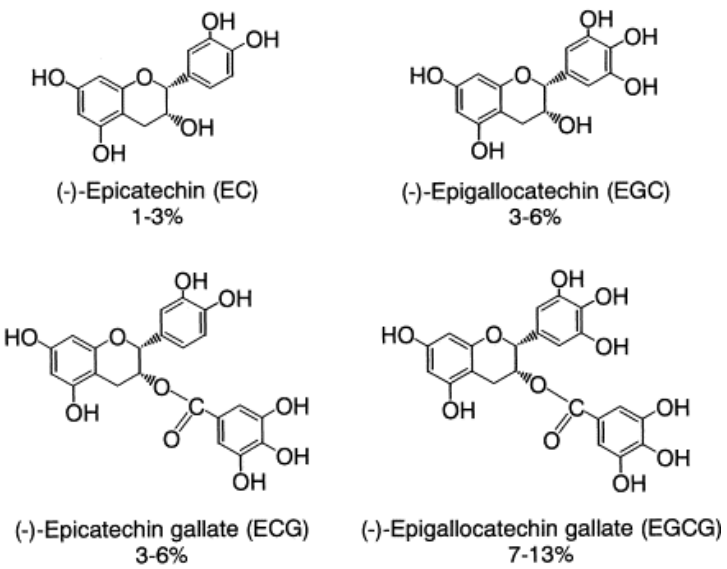

Fig. 2. Major Polyphenols in green tea

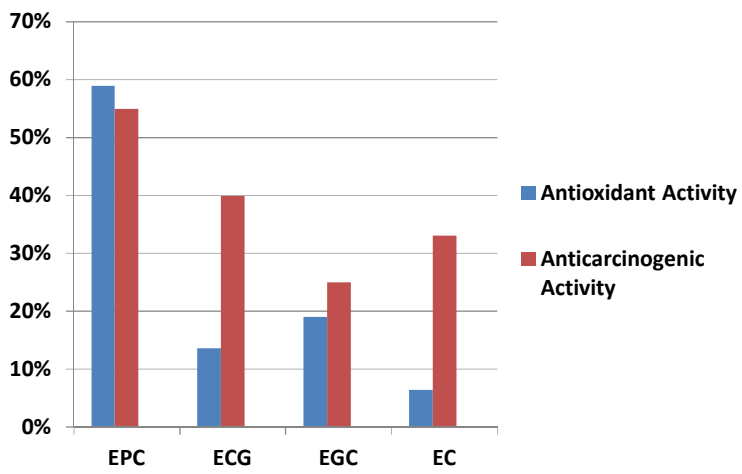

Fig 3. Graph representing antioxidant and anticarcinogenic activity of different catechins present in green tea.

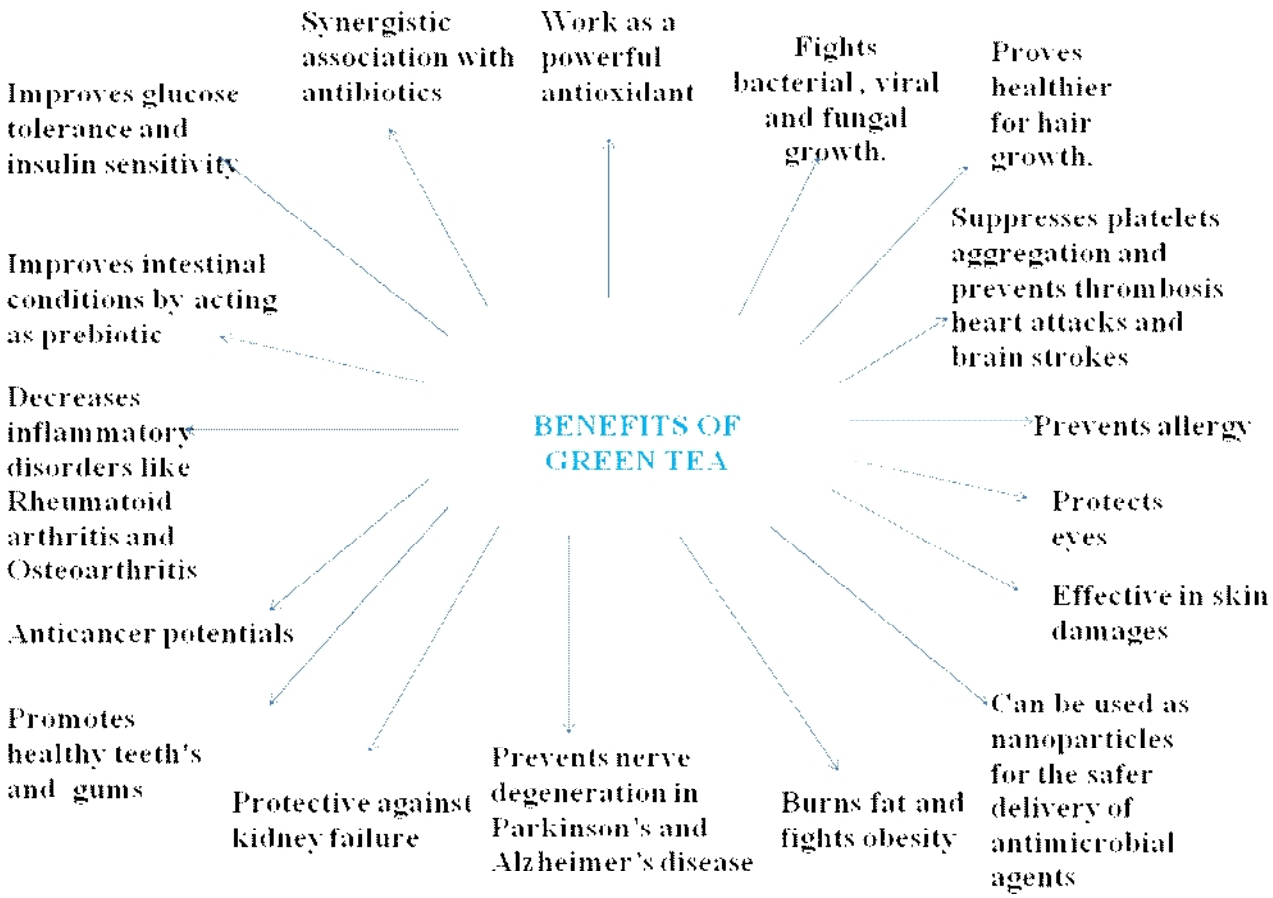

Fig. 4: Benefits of green tea