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GREEN TEA – A MIRACULOUS GIFT FOR THE PERIODONTIUM

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ABSTRACT

Green tea which is derived from the extracts of *Camellia sinensis* plant and which is minimally processed is a rich source of antioxidants. The main components of green tea associated with health benefits are catechins. The beneficial properties of green tea include anticarcinogenic, anti-inflammatory, antimicrobial and antioxidant properties and benefits in general and oral health. This article reviews the role of green tea especially in periodontal health and disease.

KEYWORDS

Camellia sinensis, green tea, antioxidants, catechins, epigallocatechin gallate, periodontal health, periodontitis

INTRODUCTION

An increasing number of people all around the world are turning to nature by using herbal products in both prevention & treatment of diseases. Tea has been linked to a group of medicaments called 'Rasayanas' that confer attainment of positive health, resistance to diseases and assured lifespan of quality of life[1].

Tea is the most popular beverage in the world after water[2]. Green tea has received considerable attention because of it's many scientifically proven beneficial effects on human health. Drinking green tea is gaining popularity in Asian countries as a health beverage because of it's rich source of antioxidants.

REACTIVE OXYGEN SPECIES (ROS)

Reactive Oxygen Species (ROS) or free radicals are highly toxic and destructive in nature and involved in the pathogenesis of periodontal disease[3].

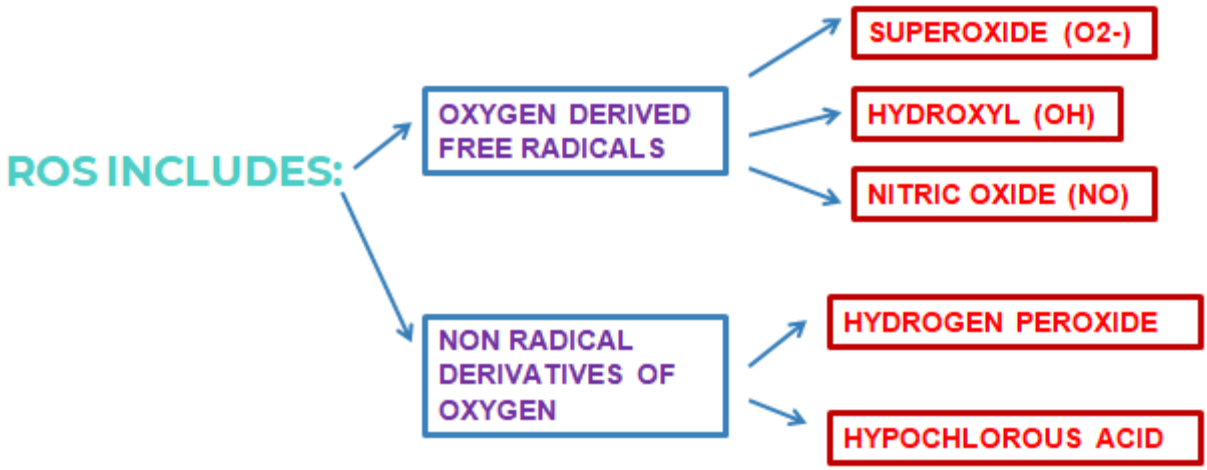

Figure 1. Components of Reactive Oxygen Species (ROS)

These free radicals either occur naturally in the body or the environmental toxins can give rise to them (eg. UV rays from sun, radiation, cigarette smoke, air pollution). These free radicals are damaging compounds. They alter cells, tamper with DNA and cause cell death. Normally a balance exists between oxidants and antioxidants. Pathologic conditions disturb this balance and result in oxidative stress due to ROS production[3].

For a healthy periodontium, removal of ROS by antioxidants is essential. Antioxidants are those substances which when present at low concentration as compared to oxidisable substrate will delay or inhibit the oxidation of that substrate[4].

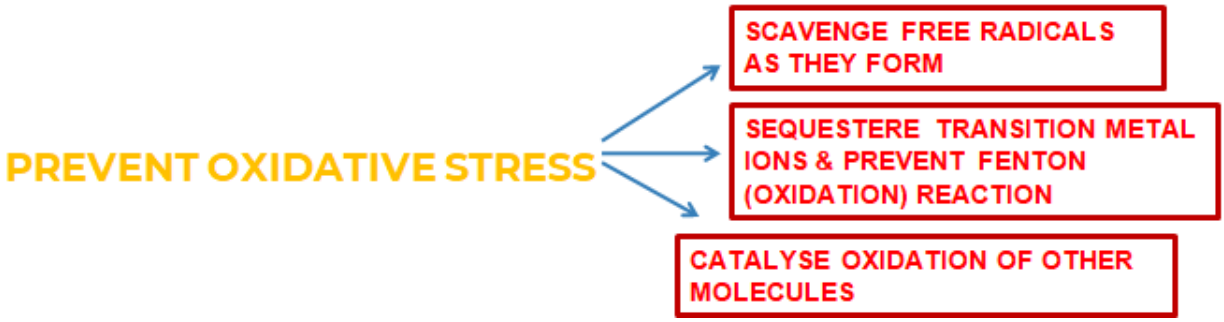

Figure 2. Mechanism of action of antioxidants

ORIGIN OF TEA

Tea plant originated in the landmass encompassing Tibet, western China and northern India. Ancient Chinese legend says that Tea was discovered by Emperor Shen Nung in 2737 BC when leaves from a wild tea bush accidentally fell into a pot of water that he was boiling[5].

The drink derives it's name from Chinese dialect word 't'e pronounced 'tay'. Today 'cha' means tea in Chinese. As this word moved westward into middle eastern languages, it became altered to 'chai'[5].

India attributes discovery of tea to Buddhist monk Siddhartha in 16th century. Inspired by divine intervention he picked up and chewed leaves of a nearby tree discovering a great sense of alertness and well being. That tree was called *Camellia sinensis*[5].

Figure 3. Origin of tea; (left) Emperor Shen Nung's discovery of tea (right) Indian discovery of tea by Buddhist monk Siddhartha

GROWING TEA

Camellia sinensis is shrub like and grown in semi-tropical environment on plantations in Southeast Asia. Heavy rainfall of 3000-7000 feet elevation is required. It is cloned or grown from seed from cuttings obtained from mother bush and rooted and grown in nursery for 1 or 2 years. Leaves are usually picked by hand[5].

They are steamed, rolled and dried immediately and completely. Then they are packed in foil lined chests which prevent absorption of pleasant odours and prevent loss of aroma. Tea should be served warm but not hot to keep medicinal value intact[5].

VARIETIES OF TEA

There are three varieties of tea and the difference in variety is due to the difference of processing mainly by fermenting & drying[2,6]:

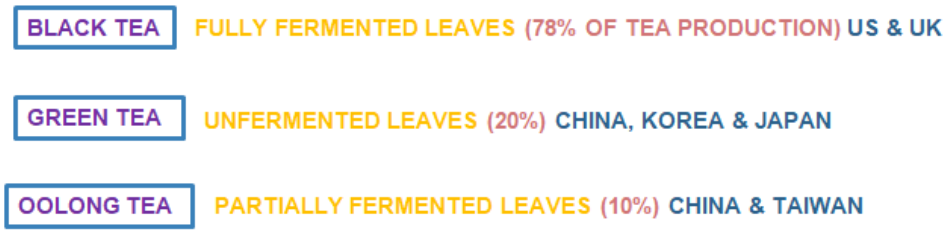

Figure 4. Three varieties of tea depending upon the method of processing, % of tea production and the countries where it is mainly produced

Fermentation leaches out some of the beneficial ingredients. Hence, green tea is made from unfermented leaves. It contains highest concentration of powerful antioxidants called as polyphenols[2,3].

Polyphenols are quickly oxidised after harvesting due to the enzyme polyphenol oxidase. To prevent loss of polyphenols, green tea leaves are heated rapidly (by steaming or pan frying) to inactivate polyphenol oxidase[6,7].

Black tea leaves are dried, rolled and crushed which promote oxidation. Hence black tea has fewer catechins than green tea. It also has 3 times more caffeine. Since white tea and green tea involve minimum processing, they are rich source of antioxidants[8].

GREEN TEA AND IT'S COMPONENTS

Catechins are the main ingredient in green tea. Healthful properties of green tea are due to polyphenols (chemicals with potent antioxidant properties). Catechins are nothing but the polyphenols in green tea. Polyphenols play a role in inhibition of generation of Reactive Oxygen Species (ROS) and the release of lysosomal enzymes[3]. The other ingredients are as depicted in the Figure5.

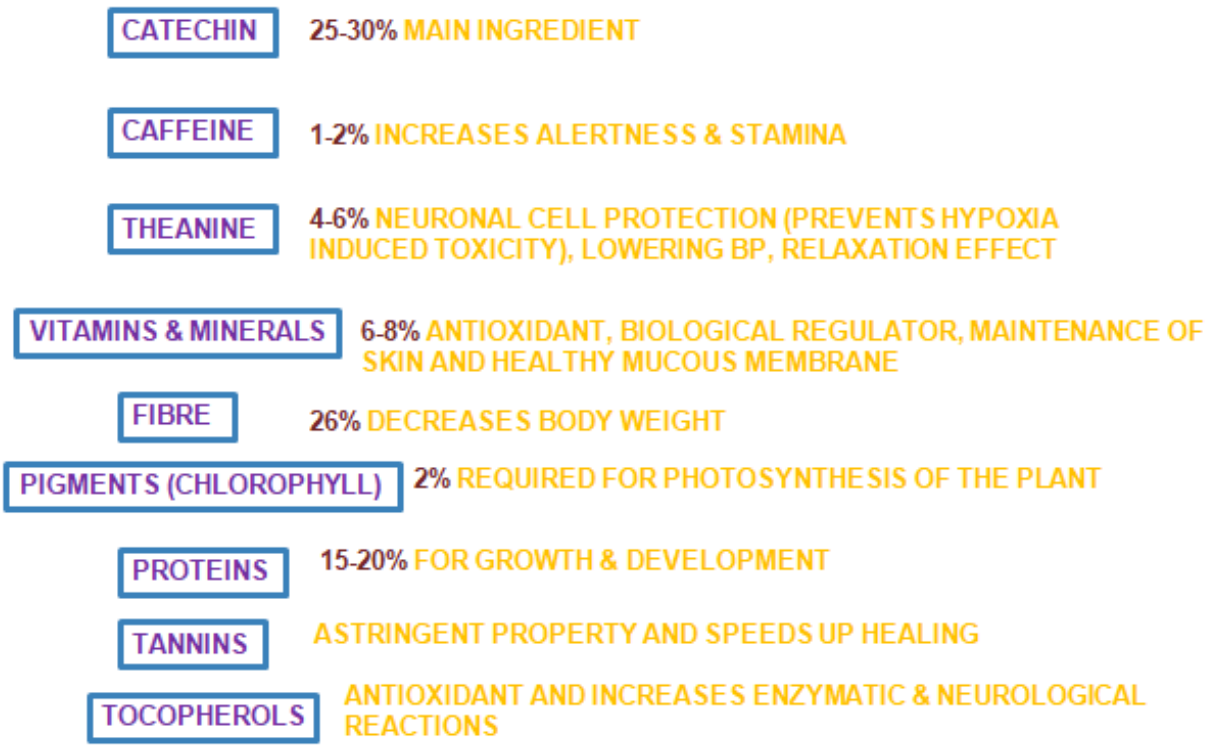

Figure 5. Composition of Green tea

Green tea contains 6 primary catechin compounds and the scavenging properties of catechin & epicatechin molecules depend upon their hydrogen donating ability[3].

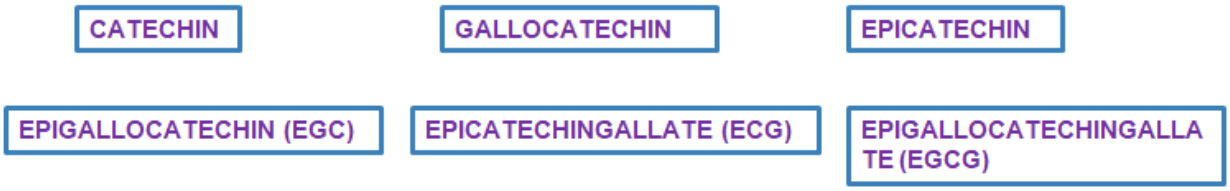

Figure 6. Components of Green tea

Amongst the green tea catechins, Epigallocatechingallate (EGCG) is the most abundant followed by Epigallocatechin (EGC), Epicatechingallate (ECG) and least include Epicatechin (EC)[2].

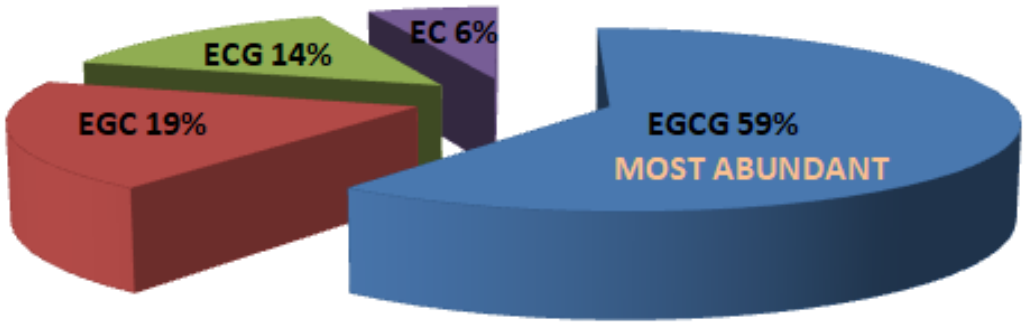

Figure 7. Relative composition of green tea catechins

Green tea contains caffeine half than that found in coffee. Caffeine in green tea is 20-45mg/8oz serving, whereas 47mg/8oz serving in black tea and 100-115mg/190ml serving in coffee. Amount of caffeine will vary depending upon the amount of tea used, length of time tea leaves are infused and if person drinks first or second infusion[5]. Caffeine has a corrosive effect on the tooth enamel and is responsible for staining.

Two beneficial components found in green tea include – catechin and amino acid L-theanine. They both lessen the impact of caffeine[5].

Figure 8. Beneficial property of green tea catechins

L-theanine which is only found in tea plants and some mushrooms stimulate production of alfa brain waves which calms body after promoting state of relaxed awareness[5].

Tea also consists of tannins which give the beverage its astringency property. Tea with high levels of tannins has a bitter taste accompanied by strong astringency seen especially in green tea and black tea. The tannins found in tea are thearubigins most

prominently theaflavins. When the anti-oxidising agents like catechins in the tea are oxidised, theaflavins are produced. Tannins in the tea are responsible for the antioxidant, anti-inflammatory, anti-bacterial, anti-carcinogenic and anti-mutagenic properties mostly due to its anti-oxidising nature. By speeding up blood clotting, tannins also have a healing effect. Tannins are also known to increase the staining potential of tea although to a lesser degree.

AVAILABILITY OF GREEN TEA

Green tea is available in 2 forms - dried leaf tea or liquid extracts from leaves and leaf buds. Average cup of green tea contains 50mg to 150mg of polyphenols. Recommended consumption is 2 to 3 cups per day (240mg to 320mg of polyphenols) or 100-750mg/day of standardized green tea extract[9].

GENERAL EFFECTS OF GREEN TEA

Weight loss: EGCG in green tea causes rise in metabolism. They inhibit gastrointestinal enzymes involved in nutrient uptake. A study done in men with similar BMI & waist circumference was divided into two groups – One group consumed 690mg catechins and another group consumed 22mg catechins. Average weight loss in group 1 was 2.4kg and in group 2 was 1.3kg. LDL levels reduced by 11.5% in group 1 and by 5.2% in group 2[10,11].

Anti-aging: Antioxidants in green tea protect skin from harmful effects of free radicals which can create wrinkling and skin aging[5].

Immunity: Polyphenols & flavanoids present in green tea boost immune system[5].

Cardiovascular system: Green tea improves CVS health by preventing platelets from coagulation, improves cholesterol levels and prevents oxidation of LDL cholesterol. Thus it reduces buildup of plaque in arteries[12].100 studies on health benefits of green tea show lower rates of heart disease & cancer in Asia despite high rate of smoking. They stated that 1.2 litres of green tea that is consumed by many Asians each day provides high levels of polyphenols and other antioxidants. Hence it is called as 'The Asian Paradox'[13].

Rheumatoid arthritis: The antioxidants in green tea may prevent and reduce the severity of rheumatoid arthritis[14]. It protects cartilage by blocking enzyme that destroys cartilage due to high fluoride content in green tea and thus keeps bones strong and preserves density of bone. Polyphenols in green tea reduce TNF-α and cause inhibition of nuclear factor κβ[15,16].

Skin disorders: The extract of green tea applied externally to the skin for 10minutes three times a day would help people with damaged skin from radiation therapy (after 16-22 days)[17].

Inflammatory conditions: The potential application of EGCG has a role in the prevention and treatment of inflammatory process[18].

Stress: The oral intake of 1-theanine amino acid found in green tea can cause anti-stress effects via inhibition of cortical neuron excitation[19].

Obesity: Ingestion of catechins is useful in the prevention and improvement of lifestyle related diseases mainly obesity since green tea has thermogenic properties and promotes fat oxidation[20].

Cancer: EGCG present in green tea inhibits angiogenesis of tumour cells thus not allowing them to become cancerous. Green tea polyphenols modulate NF-κβ in several cancer cell lines rendering them susceptible to apoptosis[21]. Green tea induced apoptosis increases normal cell growth while promoting programmed cell death[23,24]. Green tea reduces risk of oesphageal cancer by 60%. It causes inhibition of growth of cancer cells due to antioxidant and antiproliferative effect[22].

Liver diseases: Green tea protects liver from damaging effects of toxic substances like alcohol and destroys harmful radicals in the fatty liver. Population based clinical studies have shown that men who drink more than 10cups of green tea per day are less likely to develop disorders of liver[5].

Diabetes mellitus: Green tea improves lipid and glucose metabolism, prevents sudden increase in blood sugar levels and balances metabolic rate[5].

Asthma: Theophylline in green tea relaxes muscles that support bronchial tubes thus reducing severity of asthma[5].

Alzhiemer's disease: EGCG decreases production of β-amyloid- a protein that forms plaques that clogs brains of Alzhiemer's victims. It's treatment involves inhibition of enzyme acetylcholinesterase and β-amyloidosis[25].

Parkinson's disease: It is a progressive degenerative disorder of CNS resulting from loss of dopamine producing brain cells. Antioxidants present in green tea prevent cell damage in brain. It has neuroprotective effects. Polyphenols protect dopamine neurons which increase with the amount of green tea consumed due to the inhibition of ROS[26].

Cold & flu: EGCG directly kills bacteria and viruses including influenza virus. It has anti-inflammatory effect and inhibits production of pro-inflammatory mediators. Rowe et al 2007 had stated that Camellia sinensis formulation is a safe and dietary supplement for preventing cold & flu symptoms[27,28,29].

Food poisoning: The catechins can kill bacteria that cause food poisoning and kill the toxins produced by bacteria[5].

Human Immunodeficiency Virus: EGCG present in green tea acts as a block to HIV transport protein on host cell[5].

DENTAL IMPLICATIONS OF GREEN TEA

Dental caries: Fluoride in green tea may play a role in increasing cariostatic action[30]. Action of fluoride in green tea does not seem to be so important. Concentration is very low. The effect of green tea on caries inhibition and acid resistance correlates with nondialysable substances in tea[31].

Halitosis: Green tea showed largest reduction in hydrogen sulphide and methyl mercaptan (volatile sulfur compounds) especially in methyl mercaptan which also showed a better correlation with odor strength. However, no reduction was observed at 1, 2 and 3 hours after administration.

In an in vitro study, toothpaste, mints and green tea strongly inhibited volatile sulfur compounds production in a saliva putrefaction system, but chewing gum and parsley-seed oil product could not inhibit saliva putrefaction. Therefore, it was concluded that green tea was very effective in reducing oral malodor temporarily because of its disinfectant and deodorant activities, whereas other foods were not effective[32].

EFFECTS OF GREEN TEA ON PERIODONTAL HEALTH

Anti-plaque effect of green tea - The plaque inhibitory effect of green tea can be attributed to the catechin fraction which has certain therapeutic and biological properties. EGCG intercalates into phospholipid bilayers and they affect the virulence and antibiotic resistance by perturbing the function of key processes associated with the bacterial cytoplasmic membrane[33].

Various authors have studied the effects of catechins present in green tea on periodontal health and pathogens which may provide the basis for beneficial effect of daily intake of green tea on periodontal health (Table 1).

Table1. AUTHORS	RESULTS
Makimura M et al 1993[34]	Inhibits collagenase activity.
Sakanaka et al 1996[35]	Inhibition of growth and adherence of P.gingivalis to buccal epithelial cells.
Hirasawa et al 2002[36]	Reduction of markers of gingivitis by the use of slow release devices. Bactericidal activity of green tea catechins against P.gingivalis and Prevotella.
Okamato et al Sakanaka and Okada et al 2004[37,38]	Neutralises etiological agent like gingipains, protein tyrosine phosphatase.
Yun JH, Pang et al 2004[39]	Inhibits bone resorption by preventing expression of MMP-9 from osteoblasts induced by P.gingivalis extracts.
Nakamura, Ukai et al 2009[40]	Inhibition of bone resorption by inducing apoptotic cell death of osteoblasts via caspases. Inhibition of nuclear translocation of NF κβ activated by lipopolysaccharide. Inhibits IL-1β production & directly inhibits osteoclastogenesis. Inhibits IL-17 which induces CCL-20 production in human gingival fibroblasts.
Maryama T et al 2011[41]	Topical application of green tea catechin containing dentrifice reduced inflammatory cell infiltration in periodontal lesions. Gingiva showed lower level of expression of hexanoyllysine, nitrotyrosine and TNF-α.
Hara K et al 2012[42]	EGCG inhibited activity of α-amylase by non-competitive inhibition. Therefore, EGCG inhibits formation of fermentable carbohydrates involved in caries formation. α –amylase decreased antimicrobial activity of EGCG against periodontal bacteria A.actinomycetemcomitans.
Lei Zhao, Vu Dang La, Daniel Grenier 2013[43]	Inhibits secretion of IL-6, IL-8 and chemokine ligand S by P.gingivalis stimulated oral epithelial cells.
TB Lombardo Bedran et al 2014[44]	Induce hBD genes secretion by epithelial cells and to protect hBDs from proteolytic degradation by P.gingivalis and have potential to strengthen the epithelial antimicrobial barrier.

Thus, the studies show that green tea catechins inhibit growth of P.gingivalis, P.intermedia and P.nigrescens[45]. It inhibits production of toxic metabolites of P.gingivalis. It inhibits activity of P.gingivalis derived collagenase[38]. EGCG inhibits osteoclast

formation and induces apoptotic cell death of osteoclast like multinucleated cells[46]. EGCG inhibits activity or gene expression of collagenase and gelatinase (MMP-2 & MMP-9) and hence it is beneficial for the periodontium[39].

COMMERCIALLY AVAILABLE GREEN TEA PRODUCTS & ASSOCIATED STUDIES

GREEN TEA DRIED LEAVES OR BAGS

A study by Kushiyama M, Shimazaki Y, Murakami M, Yamashita Y in 2009 shows that there was a modest inverse association between the intake of green tea and periodontal disease. The intake of green tea was inversely correlated with the mean Probing Pocket Depth (PD), mean Clinical Attachment Level (CAL), and Bleeding on Probing (BOP). Every one cup/day increment in green tea intake was associated with a 0.023-mm decrease in the mean PD ($P < 0.05$), a 0.028-mm decrease in the mean clinical AL ($P < 0.05$), and a 0.63% decrease in BOP ($P < 0.05$)[47].

Another study involving thirty patients with Chronic Periodontitis was randomly divided into control and experimental groups after scaling. Experimental group consumed green tea herbal for 6 weeks and the control group received no intervention. Significant reduction in Probing Pocket Depth (PPD) and Bleeding Index (BI) and insignificant reduction in Periodontal Index (PI) was present[48].

A study involving thirty patients with Chronic Periodontitis was randomly divided into three groups – Group A – Scaling and Root Planing (SRP), Group B – SRP & green tea intake for 6months, Group C – Only green tea intake for 6 months. The patients were provided with green tea bags, each weighing 1.75g. The patients were asked to have four cups of green tea per day. Significant reduction in Plaque Index (PI), Bleeding Index (BI) & Periodontal Index (PI) was present[49].

GREEN TEA DENTRIFICE

A study involving use of a dentifrice containing green tea extracts showed a greater reduction in gingival inflammation and improved periodontal parameters along with improved biochemical parameters of total antioxidant capacity (TAOC) and glutathione-S-transferase (GST) activity in GCF in comparison with fluoride-triclosan dentifrice which was recorded at baseline and 4 weeks post-SRP[50].

GREEN TEA MOUTHWASH

A meta-analysis which includes seven randomised controlled clinical trials with a total of 292 patients demonstrated that green-tea mouthwashes were not significantly different as compared to the standard chemical-based chlorhexidine mouthwashes in reducing plaque and gingival inflammation. There was no significant evidence of any adverse event with green tea mouthwash. Green tea based mouthwashes can be considered as an alternative to chlorhexidine mouthwashes in sustaining oral hygiene especially because of the added advantages provided by such herbal preparations[51].

A meta-analysis by Mathur S et al 2016 showed that two studies favoured the use of herbal products and four studies favoured the use of chlorhexidine out of the 11 studies analysed[52].

GREEN TEA CHEWING GUM

The patients were asked to chew two gums for 15minutes daily for three weeks. Sulcus Bleeding Index (SBI) and Approximal Plaque Index (API) were studied at the baseline, 7 and 21 days later. Saliva sampling was conducted before and after 21 days for evaluation of IL-1β. The results showed that green tea chewing gum improved the SBI and API and effectively reduced the level of IL-1β[53].

Various formulations of 120mg green tea extract chewing gums with different sweeteners, flavouring agents and various gum bases were prepared & afterward release pattern, content uniformity, organoleptic results and other properties were characterised. The green tea chewing gum with sugar, maltitol, asparatame sweeteners and cinnamon flavour using the same rubber bases ratio was considered to be a desirable product[54].

GREEN TEA GEL

Thermo-reversible sustained-release green tea catechin gel was prepared and tested for its in-vitro & in-vivo characteristics for 4 weeks. Significant differences in Gingival Index (GI) & Probing Pocket Depth (PPD) was found due to anti-inflammatory effects of catechins. Catechins are the inhibitors of cysteine proteinases of P.gingivalis and protein tyrosine phosphatase of P.intermedia which are considered as potent virulence factors in the development of Chronic Periodontitis. He further stated that it could be due to absorption of green tea into oral epithelial cells in the subgingival pocket inhibiting the growth of black pigmented rods responsible for periodontal disease[55].

GREEN TEA LOCAL DRUG DELIVERY

Green tea catechin strips (catechin used from green tea powder and hydroxypropyl cellulose HPC as the carrier) were used in patients with 5-8mm pocket depth. Highly significant reduction in the clinical and microbiological parameters was seen when it was used as an adjunct to SRP[56].

DRUG INTERACTIONS[5]

Adenosine: Green tea inhibits the action of adenosine.

Beta Lactam Antibiotics: Green tea increases their effectiveness by reducing the bacterial resistance to treatment.

Benzodiazepines: Green tea reduces sedative effects of these drugs.

β Blockers (Propranolol & Metoprolol): Caffeine present in green tea increases BP.

Aspirin, Warfarin: Green tea contains Vitamin K. Hence makes warfarin ineffective.

Chemotherapy: In laboratory tests, combination of green tea and chemotherapy medications (Doxorubicin & Tamoxifen) decreases its effectiveness. Also in patients with prostate cancer, they should not drink black and green tea since these tea extracts stimulate a gene in prostate cancer and cause them to be less sensitive to chemotherapy drugs.

Clozapine: Antipsychotic effects of Clozapine are reduced if they are taken fewer than 40minutes after drinking green tea.

Ephedrine: When taken together they may cause agitation, tremors, insomnia and weight loss.

Lithium: Green tea reduces blood levels of lithium which is the medication used to treat depression.

Monoamine Oxidase Inhibitors (Phenelzine & Tranylcypromine): Green tea taken along with these medications cause severe increase in BP (hypertensive crisis).

Oral contraceptives: They prolong the amount of time caffeine stays in the body and may increase its stimulating effect.

Phenylpropanolamine: It interacts with caffeine and causes mania & severe increase in BP.

Also, Han K, Hwang E, Park JB 2016 stated that consumption of less than one cup of green tea per day was associated with a decrease in the prevalence of periodontal disease among Korean adults. Consumption of one cup or more increased the prevalence of periodontitis[57]. It was reported that a cup of tea contains 15 mg and excessive amounts of green tea consumption will lead to significant amount of caffeine consumption[58]. Caffeine is shown to increase bone loss and enhance the progression of periodontitis[59]. Also, the temperature of the green tea may damage the mucosa or accelerate metabolic reactions, including hastening the absorption of harmful substances in cigarette and alcohol[60]. A previous report has shown that concentrated green tea extract induces severe acute hepatitis[61].

SIDE EFFECTS

Green tea increases bleeding time. The components of green tea – caffeine, catechins, tannic acid are all linked to pregnancy crisis. Drinking a large amount of green tea may cause neural tube birth defects in babies due to folic acid antagonism. Hence, pregnant women should not consume the green tea. If a patient is sensitive to caffeine – watch out for restlessness, irritability, sleeping problems, tremors, heart palpitations, loss of appetite, upset stomach, nausea, frequent urination, skin rash[5].

Stomach upset is the second most common complaint – A 1984 study concluded that tea is a potent stimulant of gastric acid and this can be reduced by adding milk and sugar. Tea is a negative calorie beverage. It virtually contains no calories and blocks absorption of certain nutrients like iron and thiamine (Vitamin B12). People already at risk for iron deficiency show increased risk if they consume high amounts of EGCG. Drinking tea discolours or stains teeth[5].

TIPS ON PREPARING GREEN TEA

Green tea should be handled tenderly. Spring water is the ideal choice for brewing tea followed by filtered water. Distilled water should never be used since the brew it produces will be flat as the minerals removed from it are essential to bring out the flavours. Use 3g of tea to 5ounces ($1/8^{th}$ cup or 2 tablespoons) if brewing tea in a small teapot or 4g of tea to 8ounces (1 cup) for other methods.

Although heartily boiling water is used to brew black and oolong tea, green tea needs much lower temperature (160-170 F or 79-85°Celsius) & should be brewed for a lesser time. Let the water barely reach the boiling point to liberate its oxygen then allow it to cool slightly before pouring over the tea.

CONCLUSION

Drinking green tea is a relatively easy habit to maintain a healthy periodontium. Green tea when consumed in moderate amounts (drinking 1 to 2 cups per day) has versatile health benefits. A modest association exists between daily intake of green tea and its preventive role. The evidence is strong that green tea consumption is a useful dietary habit to lower the risk and treat chronic diseases like periodontitis. Therefore, more studies are required to understand the role of green tea's method of action particularly at cellular level.

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