

Green Tea Catechins: Role in Oral Health and Disease. An Overview

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ABSTRACT

Tea is being consumed since ages mainly by Asian population. The ongoing research in recent years have well established the role of tea as an important agent providing various systemic and oral health benefits besides being consumed as popular beverage. It exists mainly in three forms namely green, oolong and black, which differ from each other in their method of processing. Green tea is considered the most effective in this regard because of large amount of polyphenols present in it mainly in the form of catechins. The systemic health benefits include prevention of cancer and cardiovascular diseases, anti-inflammatory, anti-arthritic, anti-bacterial, anti-angiogenic, anti-oxidative, anti-viral, neuroprotective and cholesterol lowering effects. Green tea polyphenols do have a significant role in pathogenesis of several oral diseases like tooth decay, oral cancer, periodontal diseases and so on. This article will emphasise the beneficial effects of green tea particularly in oral health with a word of caution against its excessive use.

Keywords: Green tea, Catechins, Epigallocatechin gallate, Polyphenols, Anti-oxidative, Anti-inflammatory, Dental Caries

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INTRODUCTION

The role of traditional herbs and plants in the field of medicine is not new. Since ancient times many drugs derived from medicinal plants have been used both in Eastern and Western countries. There has been rising interest in naturally-derived biologically-active compounds that have potential therapeutic uses both in medicine and dentistry^[1]. In rural areas of the developing countries, they continue to be used as the primary source of medicine. About 80% of the people in developing countries use traditional medicines for their health care^[2]. *Camellia sinensis* (tea) is one such herb which has significant role in oral and systemic health. Tea is being consumed since ages mainly by Asian population^[3]. It is the most popular beverage consumed worldwide next to water well ahead of coffee, beer, wine and carbonated soft drinks. The credit of origin of tea goes to China and India about 2000 years back^[4]. For thousands of years,

tea has been considered to have health-giving properties, which has been significantly established in recent years by an accelerating research effort^[5]. The health benefits of green tea includes chemopreventive effects against various tumours^[6], cardiovascular and lifestyle-related diseases by inhibiting TNF α and IL-6^[7], anti-inflammatory by blocking neutrophil-mediated angiogenesis^[8], anti-arthritic^[9], anti-bacterial by enhancing the intracellular retention of the drug^[10], anti-angiogenic by inhibiting vascular endothelial growth factor [VEGF] transcription^[11], anti-oxidative^[12], antiviral^[13], neuro-protective in neurodegenerative disorders^[14] and cholesterol-lowering effects as it decreases lipid absorption^[15]. Green tea polyphenols have a significant role in pathogenesis of several oral diseases like tooth decay and oral cancer^[16]. Recent researches have established it as an effective agent which can alter the progression of periodontal diseases through its anti-oxidant and anti-microbial effect^[17]. The aim of this article is to evaluate its role in oral health.

Tea is made up from leaf and bud of the plant *C. sinensis*. This plant is grown in about 30 countries worldwide^[18]. It exists mainly in three forms which differ from each other in their method of processing. Green tea is produced by immediately steaming the freshly harvested

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leaves to prevent fermentation. Steaming destroys the enzymes responsible for breaking down the coloured pigments in leaves and allows maintaining its green colour during subsequent rolling and drying processes. The natural polyphenols in the tea leaves which are mainly responsible for imparting the various health benefits are preserved by manufacturing tea by this process. Green tea is partially fermented to produce oolong tea and further to black tea which is completely fermented. The oxidation process which involves in manufacturing black tea converts these flavonoids into theaflavins and thearubigins^[19]. Therefore, green tea which is rich in catechins is most effective with regard to its medicinal value. Approximately, 76–78% of tea produced is black tea, 20–22% is green tea and 2% is oolong tea. Black tea is consumed principally in Europe, North America and North Africa except Morocco while green tea is widely drunk in China, Japan, Korea and Morocco, and oolong tea is popular in China and Taiwan^[20,21] **Table 1.**

COMPOSITION

The chemical composition of green tea is complex. It contains polyphenols, catechins, caffeine, amino acids, carbohydrates, protein, chlorophyll, volatile compounds, fluoride, minerals and other undefined compounds^[18].

The polyphenols mainly catechins constitute the most interesting group of tea leaf components^[22]. There are four kinds of catechins mainly found in green tea: epicatechin, epigallocatechin, epicatechin 3 gallate and epigallocatechin gallate (EGCG)^[23]. The oxidised polyphenols called *tannins*, which is very different chemically from the commercial *tannic acid* or the plant tannins are also an important component of tea^[24]. The fluoride content of green tea ranges between 1 and 2 parts per million^[25], whereas that of black tea is reported to be five times higher^[26] (Table 2).

Biological Activity of Green Tea

The health-promoting effect of green tea is mainly attributed to its polyphenol content particularly flavanols or catechins and these flavanols represent 30% of fresh leaf dry weight^[27,28]. Green tea contains six primary catechin compounds: catechin, gallic acid, epicatechin, epigallocatechin, epicatechin gallate (ECG) and EGCG. The main catechin, which is extensively studied in this regard and is considered most effective, is EGCG and is one of the major constituent of green tea^[17]. Green tea extracts are more stable than pure EGCG because of presence of other anti-oxidant constituents in the extract^[29]. The other components include alkaloids, carotenoids, tocopherols, ascorbic acid, minerals like chromium, manganese, selenium, zinc and fluoride.

Table 1: Classification of tea

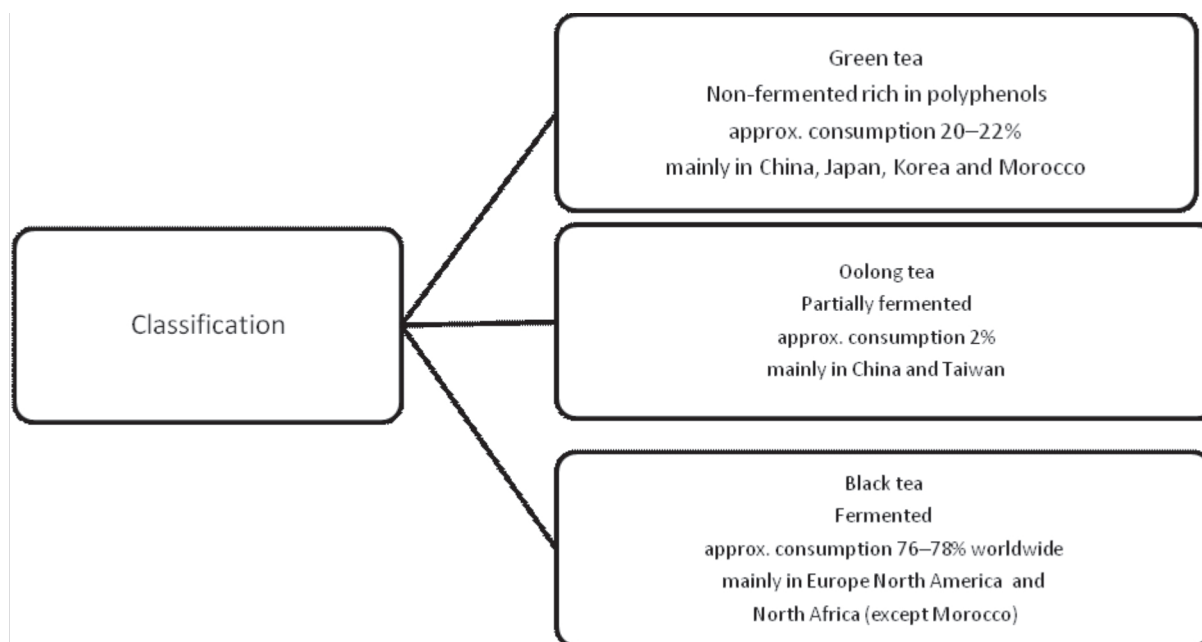


Table 2: Composition of tea^[18,22]

Contents	% Dry Weight	Compound in Tea
Proteins	15–20	Mainly in form of enzymes
Amino acids	1–4	Theanine, 5-nethylglutamine, glutamic acid, tryptophan, glycine, serine, aspartic acid, tyrosine, valine, leucine, threonine, arginine, lysine
Carbohydrates	5–7	Cellulose, pectins, glucose, fructose, sucrose
Minerals and trace elements	5	Ca, Mg, Cr, Mn, Fe, Cu, Zn, Mb, Se, Na, P, Co, Sr, Ni, K, F, Al
Lipids	Traces	Linoleic acid and linolenic acid
Sterols		Stigmasterol
Vitamins		B, C, E
Pigments		Chlorophyll, carotenoids
Volatile compounds		Aldehydes, alcohols, esters, actones, hydrocarbons
Alkaloids	3–4 in fresh leaves	Caffeine, theobromine, theophylline
Phenolic acids		Gallic acid

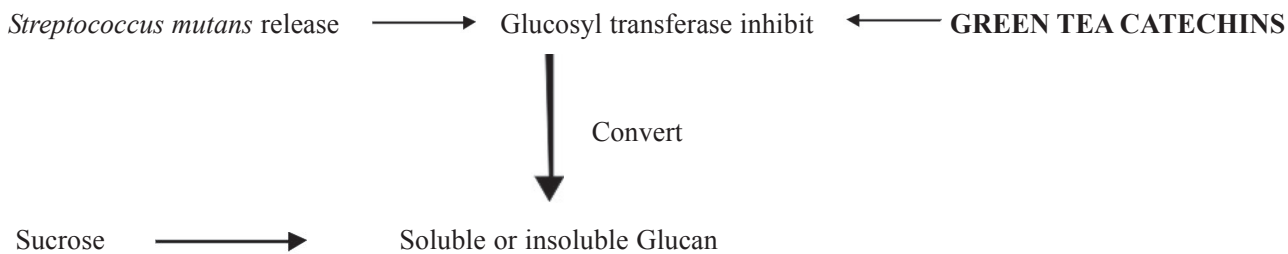
Role of Green Tea in Oral Conditions

Oral health implies the health of the teeth and its associated structures. It is integral to general well-being of a person and is important not only to the routine functions of craniofacial complex like mastication, aesthetics and others but also relates to the quality of life. There is considerable evidence linking poor oral health to chronic conditions, for example, there is a strong association between severe periodontal diseases and diabetes^[30]. Recent researches have established the significant role of green tea in various dental pathologies like caries, periodontal disease, oral cancers, malodours and so on.

Anti-carious Effect

Dental caries a multi-factorial disease involving interplay of three main factors, nutrition, micro-biological infection and host response, has still remained intractable

despite the extensive research in this field. Tea consumption has shown decline in the cariogenic potential by modulating these factors. Green tea can significantly decrease caries formation even in the presence of sugars in diet^[31]. Green tea decoctions inhibit alpha amylase in human saliva; reducing maltose release by 70% and thereby lowering the cariogenic potential of starchy food^[32]. Tannins in tea are also helpful in producing this effect of green tea^[23]. Green tea polyphenols inhibit growth of oral bacteria such as *Streptococcus salivarius* and *Streptococcus mutans* thus altering the microbial flora mainly responsible for causing dental caries^[20]. The crude tea polyphenolic compounds were found to be inhibitory to water-insoluble glucan formation from sucrose by crude glucosyltransferase of *S. mutans*. Among the tea catechins tested, EGCG and ECG showed the most potent inhibition of the glucosyltransferase activity^[33].



Tea is also considered an effective source of fluoride. The tea plant extracts fluoride from the soil, which then accumulates in its leaves. For this reason, tea is a very rich natural source of fluoride; dry tea leaves may contain 4–400 ppm fluoride, the brewed tea 0.34–6 ppm resulting in one cup of tea containing between 0.3 mg and 0.5 mg of fluoride^[34,35]. So, anti-cariogenic properties of tea include inhibitory effect on glucosyl transferase and salivary alpha amylase activity, prevention of bacterial growth and modification of tooth surface by fluoride uptake.

Anti-Plaque Effect

Tea catechins without added sugars have been shown to inhibit plaque deposition^[36], reduce plaque and gingival index^[37] and inhibit acid production in dental plaque bacteria^[38]. This includes inhibitory effect on bacterial growth and bacterial viability, inhibition of glucosyltransferase which limits the biosynthesis of sticky glucan (glucan synthesis allows the bacteria to firmly attach to the tooth surface), and inhibition of salivary amylase activities and the consequent inhibition of starch hydrolysis^[39]. Rinsing with 0.2% Chinese green tea while brushing significantly reduces plaque and gingival index^[40].

Anti-carcinogenic Effect

The role of green tea in prevention of oral cancer is also documented by many researchers. One randomised intervention trial suggested that treating patients with mixture of black and green tea components could improve the clinical manifestations of precancerous lesions too^[41]. A pilot study conducted on heavy smokers who consumed five cups of green tea a day for four weeks showed significant reduction in number of damaged cells in the mouth^[42]. In another study, dimethylbenzanthracene induced hamster model of oral carcinogenesis showed; treatment with 0.6% green tea as the sole source of drinking fluid reduced the number of visible tumours by 35% and tumour volume by 57%. Also immunohistochemistry showed that tea increased the apoptotic index of the tumours while decreasing the proliferation index and micro-vessel density^[43]. Masuda *et al.* have shown that treatment of human head and neck squamous cell carcinoma (HNSCC) cells with 20 μ mol/L of EGCG results in transforming growth factor (TGF)-mediated EGF-R, ERK and Stat-3 phosphorylation

accompanied by G0/G1 blockade of the cell cycle and induction of apoptosis^[44]. Several investigators have demonstrated that EGCG inhibits the expression of vascular endothelial growth factor (VEGF) by head and neck squamous cell carcinoma, breast and colon carcinoma cells^[44–46].

Anti-oxidant Effect

Anti-oxidants such as polyphenols in green tea can neutralise free radicals and may reduce or even help to prevent some of the damages they cause^[47]. EGCG is the most studied polyphenols component in green tea. The scavenging capacity of this molecule depends on its hydrogen-donating ability. It is observed that polyphenols have inhibitory effect on the generation of reactive oxygen species as well as on the release of lysosomal enzymes^[17]. In various in-vitro tests, catechins are able to protect biological molecules for example endogenous anti-oxidants, lipids and proteins, against the adverse effects of reactive oxygen and reactive nitrogen species^[48]. An 8-week animal study was conducted to examine the effects of a dentifrice containing green tea catechins on gingival oxidative stress and periodontal inflammation. Researchers concluded that adding green tea catechins to a dentifrice may contribute to prevention of periodontal inflammation by decreasing gingival oxidative stress and expression of pro-inflammatory cytokines^[49].

Anti-microbial Effect

The green tea catechins produced bactericidal activity at 1 mg/mL concentration against species of *Prevotella* and *Porphyromonas gingivalis*, and reduction in markers of gingivitis after the use of a slow-release buccal delivery system applied over a period of 8 weeks^[38]. The effects of the EGCG and its derivatives from Japanese green tea on the activities of Rgp and Kgp in *P. gingivalis* was investigated, and the findings suggested that green tea catechins may have the potential to reduce periodontal breakdown resulting from the potent proteinase activity of *P. gingivalis*^[50]. EGCG and ECG inhibited lactate dehydrogenase and proved effective in reducing acid production in dental plaque and *S. mutans*^[39].

Halitosis

Mouth rinsing with a dilute catechin solution reduced

the mouth odour (halitosis) associated with periodontal disease; it was subsequently established that tea catechins also have the ability to deodorise methyl mercaptan, the main cause of halitosis^[51].

Role in Alveolar Bone Resorption

Alveolar bone resorption is a characteristic feature of periodontal diseases and involves the removal of both the mineral and organic constituents of the bone matrix, which is caused by multinucleated osteoclast cells. It has been reported that EGCG could induce the apoptotic cell death of osteoclast^[52]. It has been found that EGCG inhibits the osteoclast formation induced by 1-alpha, 25(OH) 2D3, investigation based on TRAP staining in the co-culture system^[53]. Findings suggest that EGCG remarkably reduced the number of TRAP-positive multinucleated cells at a concentration of 20 mM. Further it was suggested that EGCG might prevent alveolar bone resorption by inhibiting osteoclast survival through the caspase-mediated apoptosis^[54].

Role in Periodontitis

Recently, Mitoshi Kushiya investigated the relationship between the intake of green tea and periodontal disease. In multivariate linear regression models, every one cup/day increment in green tea intake was associated with decrease in the mean probing depth, decrease in the mean clinical attachment level and decrease in bleeding on probing^[55]. The anti-microbial efficacy of Triphala, green tea polyphenols, MTAD (a mixture of doxycycline, citric acid and Tween-80 detergent) and 5% sodium hypochlorite was investigated against *Enterococcus faecalis* biofilm formed on tooth substrate. 5% sodium hypochlorite showed maximum anti-bacterial activity against *E. faecalis* biofilm formed on tooth substrate. Triphala, green tea polyphenols and MTAD also showed statistically significant anti-bacterial activity^[56].

Harmful Effects of Green Tea

Although green tea has several beneficial effects on health, the effects of green tea and its constituents may be beneficial up to a certain dose yet higher doses may cause some harmful effects. Harmful effects of tea overconsumption are due to three main factors: its caffeine content, the presence of aluminum and the effects of tea polyphenols on iron bioavailability. Green

tea should not be taken by patients suffering from heart conditions or major cardiovascular problems. Pregnant and breastfeeding women should drink no more than one or two cups per day, because caffeine can cause an increase in heart rhythm. It is also important to control the concomitant consumption of green tea and some drugs, due to caffeine's diuretic effects^[57].

CONCLUSION

Drinking tea at meals can be proved to be effective in maintaining a healthy periodontium. Though the definitive conclusions concerning the protective effect of green tea are still awaited and human clinical evidence is limited, the results definitely seem to be very promising. The development of biomarkers for green tea consumption, as well as molecular markers for its biological effects, will facilitate future research in this area. Hence it is concluded in light of various researches that there is a substantial association between regular intake of green tea and its role in maintaining oral health^[19].

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