Green Tea: A Friendly Oral Beverage?

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Introduction
Tea is a commonly consumed beverage. An oriental evergreen tree that can reach a height of thirty feet in the wild, the tea plant is pruned to a height of about three feet to promote new growth and easy plucking. The tea plant (botanical name- *Camellia sinensis*) produces abundant foliage, a camellia like flower and berries containing one to two seeds. Only the two leaves and bud at the tip of each new shoot are picked for tea [1].

History
The tea plant is believed to have originated in and around Tibet, western China and northern India. According to a Chinese legend, tea was discovered by the Chinese emperor Shen-Nung in 2737 B.C. when the leaves from a wild tea bush accidentally fell into a pot of water he was boiling. "Cha" means tea in Chinese. As this word moved westwards it became altered to “chai” [2].

India owes the discovery of tea to the Buddhist monk Siddhartha. In 519 A.D. while preaching Buddhism in Canton, he stumbled upon the leaves of a tree which helped to overcome drowsiness and provided him with a great sense of alertness and well-being [2].

According to a newspaper- ‘The Telegraph’ published from Calcutta dated 23.04.2012, today 83 per cent of Indian households drink tea. The annual consumption is 730 g per capita (while coffee is only 75 g) but is trailing the tea consumption of other countries like Britain (2.1 kg), Russia (1.64 kg) and Sri Lanka (1.39 kg). Plans to make tea the ‘National drink’ of India are in the pipeline.

Depending on the manufacturing process, teas are classified into 3 major types: (Table 1)

Abstract
Green Tea is one of the most ancient and popular beverage consumed around the world especially in India, China, Japan and Thailand. It is made from the leaves of the plant “*Camellia sinensis*”. Green tea contains thousands of bioactive ingredients mainly polyphenols which plays a key role in the prevention and treatment of many diseases. Of importance is the antioxidant potential of the green tea and mechanisms by which it acts as antioxidant. The aim of this article is to showcase the therapeutic properties of green tea in oral health.
Table 1: Classification of teas [3]

<table>
<thead>
<tr>
<th>Manufacturing process</th>
<th>NON- FERMENTED GREEN TEA</th>
<th>SEMI-FERMENTED OOLONG TEA</th>
<th>FERMENTED BLACK TEA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>produced by briefly steaming the just harvested leaves, rendering them soft and pliable and preventing them from fermenting or changing color. After steaming the leaves are rolled, then spread out and &quot;fired&quot; (dried with hot air or pan-fried in a wok) until they are crisp. The resulting greenish-yellow tea has a green, slightly astringent flavor close to the taste of the fresh leaf.</td>
<td>produced by partial fermentation of fresh leaves before drying</td>
<td>produced by post harvest fermentation before drying and steaming.</td>
</tr>
<tr>
<td>Major polyphenols</td>
<td>Epicatechin</td>
<td>Theaflavin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Epicatechin-3-gallate</td>
<td>Thearubigin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Epigallocatechin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Epigallocatechin-3-gallate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Countries primarily consumed</td>
<td>China, Japan, India, North Africa, Middle East</td>
<td>South-eastern China, Taiwan</td>
<td>Western countries, some Asian countries</td>
</tr>
</tbody>
</table>

We will be focusing on green tea in this paper. It is available in the form of beverage, mouthwash, chewing gum, dentifrices, gum paints and even in local drug delivery form.

Composition
Green tea is reported to have nearly 4000 bioactive compounds (Table2)

<table>
<thead>
<tr>
<th>Table 2</th>
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<tbody>
<tr>
<td>• Proteins (15–20% dry weight) whose enzymes constitute an important fraction.</td>
</tr>
<tr>
<td>• Aminoacids (1–4% dry weight) such as teanine or 5′-N-ethylglutamine, glutamic acid, tryptophan, glycine, serine, aspartic acid, tyrosine, valine, leucine, threonine, arginine, lysine.</td>
</tr>
<tr>
<td>• Carbohydrates (5–7% dry weight) such as cellulose, pectin, glucose, fructose, sucrose.</td>
</tr>
<tr>
<td>• Lipids (5-7% dry weight) as linoleic and linolenic acids.</td>
</tr>
<tr>
<td>• Sterols as stigma sterol.</td>
</tr>
<tr>
<td>• Vitamins (B, C, E).</td>
</tr>
<tr>
<td>• Xanthic bases such as caffeine, theophylline and pigments as chlorophyll and carotenoids.</td>
</tr>
<tr>
<td>• Volatile compounds as aldehydes, alcohols, esters, lactones, hydrocarbons, etc.</td>
</tr>
<tr>
<td>• Minerals and trace elements (5% dry weight) such as Ca, Mg, Cr, Mn, Fe, Cu, Zn, Mo, Se, Na, P, Co, Sr, Ni, K, F and Al.</td>
</tr>
</tbody>
</table>

Alkaloids including caffeine, bromine and theophylline provide green tea's stimulatory effects [4].

Among the 4000 bioactive compounds present in green tea, one third is polyphenols [3]. The most important green tea polyphenols are tannins and flavonoids. The main flavonoids present in green tea include catechins (flavan-3-ols). Polyphenolic flavonoids like tea catechins were once called vitamin P by Rusznyak and Szent (1936) [6].

The 4 major catechins are [6]:

• Epigallocatechin-3-gallate (EGCG) that represent approximately 59% of total catechins. It is the most studied polyphenol component in green tea and the most active.
  • Epigallocatechin (EGC) (19% approximately).
  • Epicatechin-3-gallate (ECG) (13.6% approximately) and
  • Epicatechin (EC) (6.4% approximately).
Effects Of Green Tea On Oral And Periodontal Health

- Gingivitis And Periodontitis

Rabbani et al., 1981 quoted that the failure of periodontal treatment may be due to the bacterial plaque and calculus missed during scaling [6]. Therefore the use of drugs to treat periodontal diseases is advocated. Green tea has been reported to be useful for prevention of periodontal disease and maintenance of oral health [6].

Effect on periodontal pathogens

Several in vitro studies have suggested that green tea catechins such as EGCG inhibit the growth of Porphyromonas gingivalis, Prevotella intermedia and Prevotella nigrescens and the adherence of Porphyromonas gingivalis onto human buccal epithelial cells [7]. In a clinical pilot study, hydroxypropylcellulose strips containing green tea catechins as a slow-release local delivery system were applied to the pockets in periodontal patients once a week for eight weeks. The green tea catechins inhibited the bacteria P. gingivalis and Prevotella spp. and a reduction in pocket depth was observed [8]. These bacteria have been strongly implicated in destruction of periodontal tissues and their reduction can lead to the improvement of periodontitis.

Green tea extract can inhibit the collagenase activity of oral bacteria [9]. EGCG completely inhibits the growth of three strains of P. gingivalis at a concentration of 250 or 500 μg/ml and that of P. melaninogenicus at MICs of 2000 μg/ml [7]. EGCG and ECG inhibit the production of toxic end metabolites of P. gingivalis [6]. EGCG inhibits protein tyrosine phosphatase activity in P. intermedia [1]. It also possesses bactericidal activity against a variety of microorganisms like Helicobacter pylori [3]. An epidemiologic study showed that there is an inverse association between the daily intake of green tea and periodontal disease and suggested that drinking green tea at meals is a relatively easy habit to maintain a healthy periodontium [6].

Krahwinkel and Willershausen (2000) performed a study for four weeks on 47 subjects to investigate the effect of green tea catechins and polyphenols on inflamed gingiva. While the treatment group showed a distinct improvement in both plaque index and sulcular bleeding index values, the placebo group showed deterioration in values. The results indicated that the oral application of
green tea catechins and polyphenols might have a positive influence on the inflammatory reaction of periodontal structures \[10\].

**Green tea in mouthwash form**

Moghbel et al. (2010) prepared a mouthwash from green tea extract and compared its antibacterial effects with chlorhexidine gluconate rinse on the mouth aerobic bacterial load. They concluded that the green tea mouthwash reported no evidence of irritation or burn, showed similar antibacterial effects as compared to chlorhexidine and was more safe and economical \[11\].

Maroofian (2011) prepared a herbal mouthwash from the dried green tea leaves grown in the northern part of Iran. Ebrahimi et al. (2011) in a clinical trial evaluated the effects of this mouthwash on patients with generalized marginal gingivitis and showed that the mouthwash could improve gingival status of patients suffering from gingivitis \[10\]. Previously studies by Tsuchiya H et al 1997 had shown that the plaque index and gingival index decreased significantly after green tea extract was used \[12\].

**Effect on halitosis**

The main constituents of bad breath are volatile sulfide compounds especially hydrogen sulfide (H\(_2\)S), methyl mercaptan (CH\(_3\)SH) and dimethyl sulfide (CH\(_3\)\(_2\)S). These compounds are formed from the proteolytic breakdown of various sulfur-containing substrates in food debris, saliva, blood and epithelial cells by predominantly anaerobic gram negative bacteria \[10\]. Polyphenols in green tea can improve bad breath by suppressing these periodontopathic bacteria \[13\]. Deodorant activity decreased in the following order: EGCG > EGC > ECG > EC.

Kaneko et al (1993) found that mouth washing with a dilute catechin solution for four weeks reduced halitosis associated with periodontal disease \[1\]. Chewing gum containing tea catechins significantly decreased methyl mercaptan (MSH) production from saliva and thus reduced bad breath. The deodorizing effect of EGCG is due to a chemical reaction between EGCG and MSH. In this reaction, a methylthio group and/or a methylsulfinyl group is added to the orthoquinone form of EGCG generated by oxidation with atmospheric oxygen and thus helping in reducing halitosis \[14\].

**Effect on host cells**

EGCG inhibits the activation of Nuclear Factor-kappa B (NF-κB) and the m-RNA expression of COX-2, MMP-1, and Interleukin (IL) 1, 6 and 8 by cultured cells and thus helps in preventing periodontal inflammation \[1\].

**Effect on bone**

The effects of green tea on bone include suppressing bone resorption, increasing apoptosis of osteoclasts via caspases and inhibiting the formation of osteoclasts \[15\]. Green tea can suppress the formation of osteoclasts by inhibiting the release of matrix metalloproteinases (MMPs) by osteoblasts. EGCG also prevents the increased MMP-9 expression from osteoblasts induced by P. gingivalis extracts \[16\].

Green tea catechins inhibit nuclear translocation of NF-κappa B activated by lipopolysacharide (LPS). Alveolar bone resorption and IL-1β expression induced by LPS were significantly reduced by oral administration or injection of green tea catechins \[15\].

- **Role Of Green Tea In Dental Caries**

*Streptococcus mutans* plays an important role in causing dental caries. Tea leaves are rich in fluoride which is known to prevent dental caries. Besides fluoride, several green tea polyphenols have preventative effects on dental caries. Among the catechins, EGC is most active in inhibiting the growth of 10 strains of cariogenic bacteria \[17\]. Cariogenic bacteria synthesize water-soluble and insoluble glucans using glucosyltransferase (GTase). Highly branched glucans help the bacteria to adhere to the tooth surface \[18\]. ECG and EGCG strongly inhibit GTase and thus inhibit adherence of the bacteria to tooth surfaces \[19\].
Green tea extract applied topically inhibits Streptococcus mutans bacteria \[10\]. In a Chinese study, green tea extract was used to rinse and brush the teeth. This study’s result indicated that S. mutans could be inhibited completely after contact with green tea extract for five minutes. There was no drug resistance after repeated cultures. The scientists hence concluded that green tea extract is effective in preventing dental caries \[10\].

A double-blind study in humans has showed that rinsing the mouth after meals with 0.05 to 0.5% green tea polyphenols for 3 days inhibited plaque formation by 30 to 43% \[17\]. In two primary schools, children who drank one cup of green tea daily after school lunch had reduced dental caries \[6\]. The effectiveness of green tea catechins against dental caries has been reported in other countries also \[19\]. Tea polyphenols added to chocolate and biscuits reduced the incidence of dental caries in rats previously infected with S. mutans. So tea polyphenols have been added to various sweets. In fact tea polyphenols added to chewing gum are effective in decreasing dental plaque formation in humans. \[17\]

### Role Of Green Tea In Oral Cancer

The predominant polyphenols in green tea - EGCG, EGC, ECG and EC have antioxidant activity. EGCG and ECG have substantial free radical scavenging activity and may protect cells from DNA damage caused by reactive oxygen species \[20\]. Tea polyphenols also have shown the capability to inhibit tumor cell proliferation and induce apoptosis in laboratory and animal studies \[21\]. They may modulate immune system function and so may reduce cancer risk in humans.

Several randomized trials evaluated the effects of tea extracts on premalignant oral lesions. One of the trials was a double-blind study involving 59 people with leukoplakia \[22\]. While one group received three gm of a mixed tea product given both orally and topically, other group received a placebo. After six months, 38% of the participants in the treatment group showed partial regression of their oral lesions compared to 10% of the participants in the placebo group. Besides this, 3% in the treatment group versus 7% in the placebo group reported an increase in lesion size. In addition, mucosal cell proliferation decreased in the treatment group suggesting a possible protective effect of tea on the development of oral cancer.

### Other Roles Of Green Tea

The polyphenols in green tea are responsible for its antioxidant activity either:

- Directly by scavenging reactive oxygen and nitrogen species and chelation of redox active transition of metal ions like iron and copper or
- Indirectly by inhibiting pro oxidant enzymes, redox sensitive transcription factors and inducing antioxidant enzymes \[1\].

Researchers refer to the “Asian paradox,” which is lower rates of heart disease and cancer in Asia despite high rates of cigarette smoking. They said that 1.2 liters of green tea that is consumed by many Asians each day provides high levels of polyphenols and other antioxidants \[23\]. Green tea may prevent the oxidation of LDL cholesterol and thus reduce the buildup of plaque in arteries thus improving the cholesterol levels and cardiovascular health.

EGCG inhibits the activities of MMPs involved in degradation of collagen and thus have suppressive effects on cartilage degradation in arthritic joints. Thus green tea may reduce the severity of rheumatoid arthritis \[4\]. Methicillin resistant Staphylococcus aureus, Helicobacter pylori and α-Hemolytic streptococcus are susceptible to EGC, EGCG and ECG \[1\].

A German study concluded that green tea extract applied externally on skin for 10 minutes, three times a day provided good results in people with damaged skin from radiation therapy after using it for 16-22 days \[4\]. Catechins promote fat oxidation and thus play a role in the prevention and improvement of obesity \[4\].
**Recommended Usage Of Green Tea**

[4] Depending on the brand, two to three cups of green tea per day (for a total of 240 - 320 mg polyphenols) or 100 - 750 mg per day of standardized green tea extract is recommended.

**Concerns Regarding Green Tea**

Green tea extract contains caffeine which may produce a variety of symptoms including restlessness, nausea, headache, muscle tension, sleep disturbances and rapid heartbeat. However, this problem may be overcome by either drinking decaffeinated green tea or since approximately 80% of the caffeine is released in the first infusion, the tea needs to be infused for 45 seconds in hot water and then the liquid poured off. More hot water is then added and steeped again. This method removes most of the tea’s caffeine but little of its flavor and aroma also. Two beneficial components in green tea - catechins and amino acid L-theanine lessen the impact of caffeine. When green tea is brewed, its caffeine combines with catechins in the water reducing the caffeine’s activity compared to coffee or cocoa.

- The tannins in green tea may decrease the absorption and thus the activity of the following drugs: atropine, codeine, ephedrine, pseudoephedrine, theophylline, aminophylline and warfarin. So taking green tea extract and aspirin or warfarin together can increase the risk of bleeding.
- Green tea extract should be discontinued 2 weeks before any surgical procedure as it decreases platelet aggregation.
- Due to their high tannin content green tea prevents iron absorption. So consuming several cups of green tea daily may not be good for persons deficient in iron or susceptible to iron deficiency.
- ECGC binds to dihydrofolate reductase (DHFR) and so women who drink large amounts of green tea around the time they conceive and early in their pregnancy may have an increased risk of having a child with spina bifida or other neural tube disorders. Women are prescribed folic acid supplements during the first trimester of pregnancy because folic acid ensures normal development and protects against spina bifida by enabling the production of the enzyme DHFR. While a cup or two of green tea should not pose a problem, drinking large amounts could decrease the activity of DHFR, increasing risk of neural tube defects.

**Scope For Research**

Tea tree oil used as an oral rinse has proven to kill bacteria [24]. A tea tree oil concentration of 0.6 percent inhibited 14 of 15 oral types of bacteria. In one study, 49 subjects aged 18 to 60 with severe, chronic gingivitis were divided into groups, one of which was given a gel containing tea tree oil to apply with a toothbrush twice daily. The tea tree oil group had improved gingival index and papillary bleeding index scores due to the herb’s anti-inflammatory properties [25]. As green tea extract has so many effects on periodontal pathogens and periodontal tissues, its application as local delivery systems in the form of strips, chips and fibers for the treatment of periodontal disease or in combination with regenerative materials to improve periodontal regeneration should be focused.

**Conclusion**

This article tries to associate consumption of green tea with oral health. Drinking green tea at meals and breaks is a relatively easy habit to maintain. More studies are necessary for the better understanding of green tea’s method of action, particularly at the cellular level.

**References**


