

## Review Article

### Tea: An Oral Elixir

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**Abstract:** Tea, a traditional beverage originally from China, is the oldest, most popular, non-alcoholic caffeine-containing beverage in the world, and is prepared from the infusion of dried leaves of the tea plant, *Camellia sinensis*. The three main different kinds of tea produced from the plant *Camellia sinensis* based on the process of oxidation are: green tea – non-oxidized, oolong tea – partially oxidized and black tea – fully oxidized. In vitro studies have shown that tea possesses diverse pharmacological properties to promote general health but these responses cannot always be reflected in human studies due to the use of physiologically unattainable tea concentrations in these experiments. There is a growing amount of in-vitro and in-vivo research identifying tea's potential oral health benefits. Tea found to be anticariogenic, anti-microbial, anti-inflammatory, anti-carcinogenic, anti-oxidant, etc can be used as an effective preventive agent for common oral diseases. However, further longer term, well controlled human trials are required before any firm conclusions can be made. This review provides an insight on the multitude of actions of tea in oral cavity as a preventive and therapeutic agent.

**Keywords:** anticariogenic, anti-carcinogenic, anti-oxidant, oxidation, Tea

#### INTRODUCTION

The tea plant, *Camellia sinensis* (L.), family Theaceae, is a small evergreen, perennial, cross-pollinated plant that grows naturally as tall as 15m. However, under cultivated conditions, a bush height of 60-100cm is maintained for harvesting the tender leaves. Tea is the oldest, most popular, non-alcoholic caffeine-containing beverage in the world, and it is prepared from the dried leaves of the tea plant.

The cultivated taxa of tea comprise of three main natural hybrids. They are: *C. sinensis* (L.) O. Kuntze or China type, *Camellia assamica* (Masters) or Assam type and *C. assamica* sub spp. *lasiocalyx* (Planchon ex Watt) or Cambod or Southern type. Two types, which are well known, are the China and Assam, less common is the Cambod [1].

The favored conditions for tea cultivation included a suitable temperature (15-25°C), high relative humidity (80-90%), and high annual rainfall (around 1500-2000 mm). Soil for tea cultivation should be acidic (optimum pH 4.5-6.5) [2].

India is one of the largest tea-producing countries (about 28 % of the world production, 2233 Gg) as well as the largest tea-exporting (22% of the world exports, 932 Gg) and tea consuming (19 % of world production) country [3].

Tea, a traditional beverage originally from China, is prepared from the infusion of *Camellia*

*sinensis* leaves [4]. The Ancient Chinese Proverb 'Better to be deprived of food for three days, than tea for one' indicates the importance of tea in the day-to-day life of Chinese [5].

The three main different kinds of tea produced from the plant *Camellia sinensis* based on the process of oxidation are: non-oxidized – green tea, partially oxidized – oolong tea and fully oxidized – black tea (Hayacibara MF et al., 2004). About 78% of the tea production worldwide is black tea, whereas green tea, mainly consumed in China and Japan, constitutes about 20% and oolong tea constitutes about 2% of tea production [6].

#### Green tea

Green tea is a less fermented tea and has the highest quantity of tea catechins that are chemically defined as flavan-3-ols. The tea leaves are immediately heated with rolling after harvest to inactivate the enzyme, polyphenol oxidase, which is capable of oxidizing the tea catechins to oligomeric and polymeric derivatives, e.g., the aflavins and thearubigins [7]. The main chemical constituents of Green tea leaves is given in table 1 [5].

The polyphenols (fig. 1) most consistently found in green tea extracts are, in decreasing order of concentration [8]:

- (-)-epigallocatechin-3-gallate (EGCG)
- (-)-epigallocatechin (EGC)

- (-)-epicatechin-3-gallate (ECG)
- (-)-epicatechin (EC)

small amounts of:

- (-)-epigallocatechin-3 (3'methyl)-gallate (EGCMG)
- (+)-catechin (C)
- (+)-gallocatechin-3-gallate (GTG)

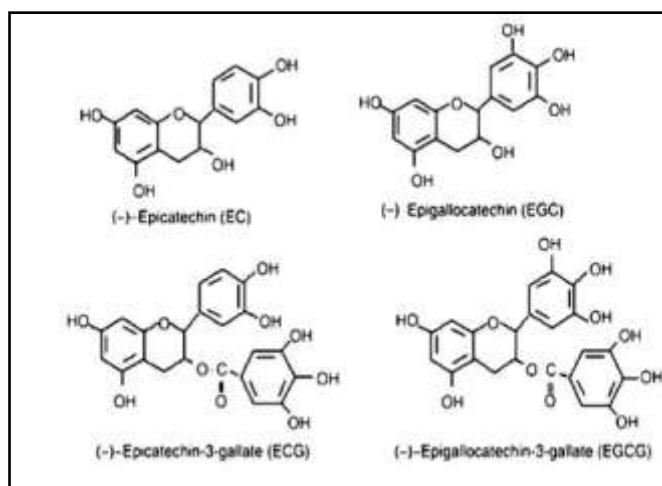
The (-) or (+) sign that precedes a compound's name is an indicator of its molecular conformation – each

molecule can exist in one of two stereo-isomeric shapes [8].

Epigallocatechin gallate is viewed as the most significant active component. The leaf bud and first leaves are richest in EGCG. The usual concentration of total polyphenols in dried green tea leaves is about 37%. Other compounds of interest in dried green tea leave include gallic acid, quercetin, kaempferol, myricetin, caffeic acid and chlorogenic acid. In general, the level of fluoride in tea is inversely related to the EGCG contents. The more natural EGCG in the green tea leaves, the less fluoride (F) it contains [5].

**Table 1: The main chemical constituent of Green tea leaves [5]**

Constituent	Percentage ( % of dried leaf)
Polyphenols	37
Carbohydrates	25
Caffeine	3.5
Protein	15
Aminoacids	4
Lignin	6.5
Organic acids	1.5
Lipids	2
Ash	5
Chlorophyll	0.5



**Fig.1: Major Polyphenols in Green tea [5]**

### Black tea

Black tea manufacture involves crushing the tea leaves to promote enzymatic oxidation and subsequent condensation of tea polyphenols in a process known as fermentation, which leads to the formation of theaflavins and thearubigins [6]. The catechins and (in black tea) theaflavins are the microbiologically active molecules [9].

There are three manufactured forms of black tea in today's world market. They are stick-shaped black tea, granular black tea and black tea bags. Although they are made by similar processing techniques, the appearance of the final products is

different. Stick-shaped black tea still keeps the original shape of tea leaves, which can be easily recognized that it was made of tender buds and leaves. Granular black tea comes from small bits ground mechanically, which makes the product lose the original shape of leaves. Black tea bags are granular black tea enclosed in a filter paper bags with or without added flavors [10].

The main chemical difference between green and black tea is that the former contains simple catechins (polyphenols with mol. wt < 450 Da) whereas in the latter many of these have been oxidized and condensed, during the manufacture process, to larger, dark-colored molecules including theaflavins (500-1000

Da)(fig. 2) and thearubigins (> 1 kDa)(fig. 3) [9]. It is now noted that 50% of unreacted precursors is composed of theasinensins (bisflavonols) formed by oxidative coupling of EGC or EGCG (fig. 4) [11]. However, black tea still contains simple catechins,

examples of which are epicatechin (EC), epicatechin gallate (ECG) and epigallocatechin gallate (EGCG). A cup of green tea prepared in the normal way contains 0.5-1 g of catechins/L and black tea contains about one-third of this figure [9].

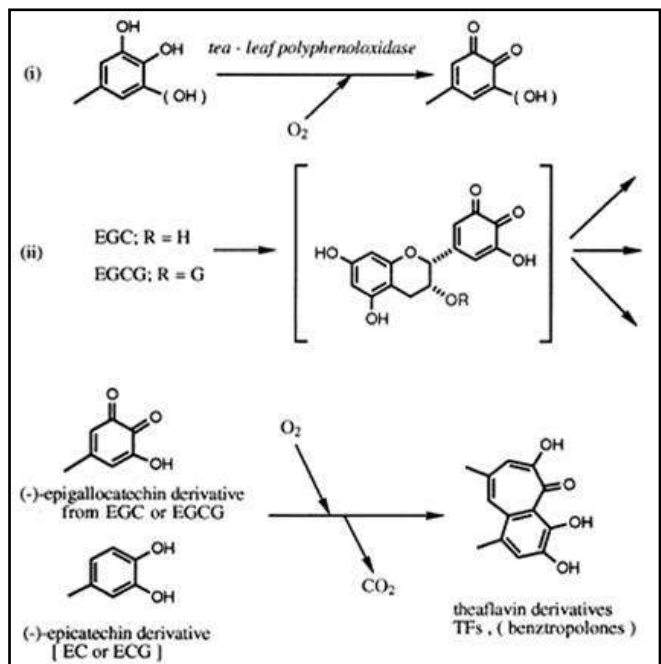


Fig. 2: Oxidation of phenolic flavan-3-ols Route of formation of principal theaflavins in black teas [11]

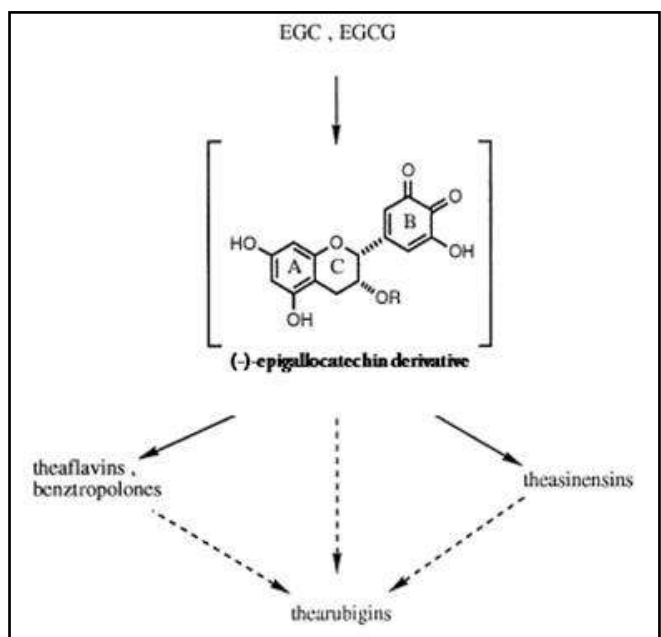


Fig. 3: Possible pathways to thearubigins [11]

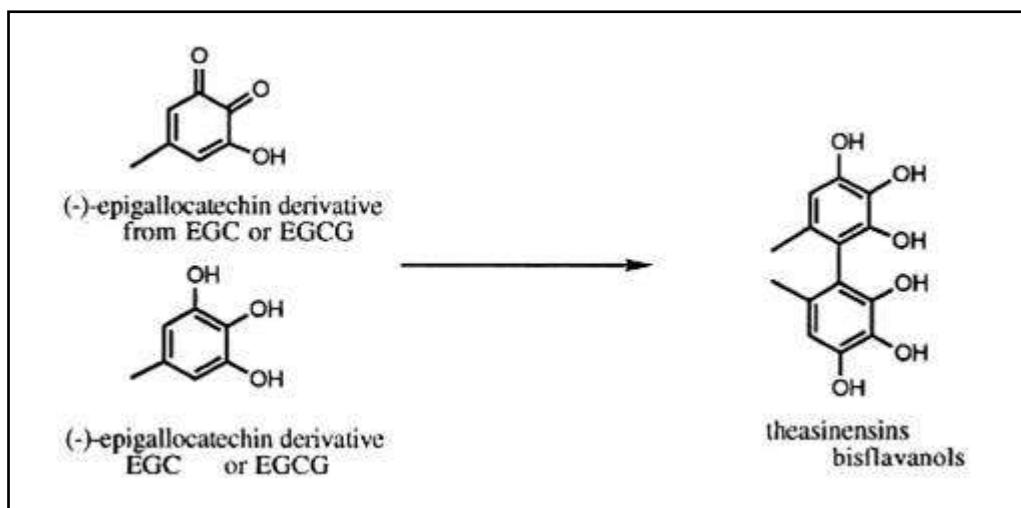


Fig. 4: Theasinensin (bisflavanol) formation by oxidative coupling [11]

#### Other types of tea

- The third type of tea, oolong, is described as 'semi-fermented'. It contains a mixture of monomeric and oligomeric catechins [9].
- Brick tea - Brick tea is made from fallen and old leaves, which is fermented and compressed into bricks and is not considered a quality tea [2, 10].
- White tea - Another form of tea which is made from new growth buds and young leaves that have been steamed to inactivate polyphenol oxidation and then dried. The buds may be shielded from sunlight to prevent formation of chlorophyll [5].
- Pureh/Pu-erh tea - Pureh tea goes through a post-fermentation process; thus, the fermentation degree varies greatly among different production areas and is greater than the initial fermentation degree (60–70%) [12].

In vitro studies have shown that tea possesses diverse pharmacological properties which include anti-oxidative, anti-inflammatory, anti-mutagenic, anti-carcinogenic, antiangiogenic, apoptotic, anti-obesity, hypocholesterolemic, anti-arteriosclerotic, anti-diabetic, anti-bacterial, anti-viral and anti-aging effects. However, these responses cannot always be reflected in human studies. This may be due to the limited bioavailability of tea components and the use of physiologically unattainable tea concentrations in some of the animal and in-vitro experiments [7].

Tea plants (*Camellia sinensis* L), nevertheless, can accumulate large amounts of fluoride (F) in mature leaves from soils of normal F availabilities without toxicity symptoms. The F contained in tea is readily released during infusion, and thus is one of the important dietary F sources. The normal content of F in tea (eg. 100–300mg/kg) was thought safe and could contribute to human health by protecting teeth from caries [13].

#### Tea and fluorides

Fluorine is the 13th most abundant element in earth's crust [14]. Tea (*Camellia sinensis*) is a naturally rich source of fluoride and other components including aluminium. The tea plant absorbs fluoride and aluminium from acid soil by passive diffusion, which are accumulated in the leaves during the plant's life span [4].

Fluoride content of 100–430 mg/kg can be found in the delicate buds and young leaves, which are usually made into green tea or black tea, while fluoride levels of 530–2350 mg/kg can be found in the oldest leaves, which are not used as tea [10].

The bioaccumulation coefficients of leaves are very high since fluoride content in leaves is 1000 times the soil water-soluble fluoride and 2-7 times to total F contents. It has been observed that about 97% F gets accumulated in leaves but only 3% in other parts of tea plant. Fluoride contents accumulated in leaves are proportionally related to the age of leaves (young leaves, 0.3-1.0 mg/g; fallen leaves, 0.6-2.7 mg/g) [2].

A study conducted to assess infusible fluoride levels in popular tea sold in Taiwan and potential exposure factors concluded that among six kinds of tea, black tea had the highest fluoride concentrations (8.64±2.96mg/L), whereas pureh (1.97±2.70mg/L) had the lowest levels. In addition, it was found that the critical step during the manufacturing process affecting the percentage of infusible fluoride was ball rolling rather than fermentation [12].

In black tea, the fluoride content was found to be 0.95–1.41 mg/L in black tea sticks, 0.70–2.44 mg/L in black tea granules and 1.15–6.01 mg/L in black tea bags revealing that black tea bags contain the highest amount of fluoride [10].

It is found that brewing time (5, 10 and 30 min) does increase the fluoride content, in which infusions of black tea (5 min brewing) was higher than the other types of tea, with contents ranging between 0.32 and 4.54 mg/L for black tea to 0.37-0.54 mg/L for white tea and with even lower values for herbal tea infusions of 0.02-0.09 mg/L [15].

Oral retention of fluoride from black tea was found to be significant. About 34% of the fluoride was retained in the oral cavity after rinsing with tea. Fluoride from tea also showed strong binding to enamel particles, which was only partially dissociated by solutions of ionic strength considerably greater than that of saliva. Thus, ingested fluoride from tea will potentially have both local topical effects in the oral cavity, and more generalized systemic effects arising from gastrointestinal absorption [16].

Each gram of tea exposes human body to 3.88–137.09  $\mu\text{g}$  of fluoride with a mean value of 63.51  $\mu\text{g}$  while same quantity of toothpaste exposes the human body to 53.5–338.5  $\mu\text{g}$  with a mean value of 183.78  $\mu\text{g}$ . Therefore on an average, a person who brushes once in a day (2 g per brushing) and consumes two cups of tea (2 g per cup) is exposed to 621.6  $\mu\text{g/day}$  of fluoride. Out of this 327.55  $\mu\text{g/day}$  is ingested, as there is 100% ingestion of fluoride for tea and 20% for toothpaste [14].

Daily ingestion of fluorides at the range of 1-2mg by children, 3mg by women and 4mg by men is considered adequate to prevent tooth decay. Bone mineral density is enhanced in habitual tea drinkers. Accordingly, fluoride in tea seems to have beneficial effects where water fluoride levels are low [17].

### Tea and fluorosis

The major intake of fluoride in the general public is from toothpaste, fish, and tea (WHO, 1996). High concentrations of fluoride have been reported in the tea drinks of India (1.55–3.21 mg/L), Tibet (2.59 $\pm$ 1.73 mg/L) and China (1.60–7.34 mg/l) [18].

In countries where regular tea consumption is culturally determined, tea plays an important role in triggering fluoride undesirable effects on tooth formation [19]. Excessive ingestion of fluoride causes dental and skeletal fluorosis [14]. In some Chinese villages, where dental fluorosis is endemic, fluoride intake from tea has been strongly correlated to this condition. Tea consumption has also spread all over the world through the industrialization of tea-based beverages [4]. Intakes of high amounts ( $\geq$ 51/week) of certain tea may result in excess risks of dental or skeletal fluorosis [12].

In the past, tea used to be grown in natural soil but nowadays fertilizers are used to boost production. It is known that fluoride and aluminium concentration in

tea depends on the soil, and plants can take up more fluoride when the soil is fertilized [4].

According to WHO's recommendation, fluoride exposure threshold for children is 2 mg of daily intake and for adult, 4 mg (WHO, 2002). Assuming that children's daily intake of black tea was 800 ml and adult's 1500 ml, black tea sticks and granules were considered safe but black tea bags which are made of low cost and older leaves which has high fluoride content were considered unsafe [10].

The ingestion of one cup of tea represents 50% of the upper limit dose of fluoride for a 1-3 year old child, which would be a valid concern in countries where tea is consumed daily irrespective of age, because the bioavailability of fluoride from tea is high [4].

Excessive intake of black tea, especially in the regions with high level of fluoride in drinking water, increases the risk of dental fluorosis in children during the years of tooth development. For adult and children tea drinkers consuming five cups of black tea per day the intake of fluoride will be in the range of 8.0-303% and 12-303% of the SAI (Safe and Adequate Daily Intake), respectively. The long-term exposure to large amounts of fluoride can lead to potentially skeletal fluorosis [15].

Adults typically consume <0.5 mg of fluoride daily in food. Water fluoridation increases intake by about 1 mg/dl. At least 80% of ingested fluoride is absorbed from the gastrointestinal tract: about 50% enters the skeleton primarily as fluoroapatite crystals and the remainder appears in the urine. About 99% of endogenous fluoride sequesters in calcified tissues, where it can enhance osteoblast action, but toxicity produces brittle, dense bones causing skeletal fluorosis, but, intake of at least 10 mg of fluoride daily for 10 years seems necessary for "preclinical skeletal fluorosis". Accordingly, fluoride exposure from drinking tea is in the "no-observed-adverse-effect level" for adults [17].

Tea leaves contain widely differing amounts of fluoride, and levels as high as 300 ppm can be induced artificially by feeding tea bushes with sodium fluoride. Black tea considered having high fluoride content, when blended from many components loses its fluoride content and before reaching the consumer it is extremely unlikely that the retail product ever contains much in excess of 100 ppm. When making tea between 40 and 80 % of the fluoride is extracted into hot water leading to a likely average of about 0.1 mg/cup and therefore it contributes less than 1 mg from a daily intake of 5-6 cups [20].

One may reasonably conclude that in areas where the water fluoride supplies are low, fluoride in

tea is likely to exert a beneficial effect, and feeding trials with rats support this view. The effect of tea in areas where the water contains high levels of fluoride (whether natural or artificial) will be small relative to the effects of the water itself, even if the tea contains abnormally high levels of fluoride. These conclusions are consistent with the authoritative view expressed by the UK Ministry of Health in 1962 which stated "The fluoride content of food, tea and other beverages is insufficient to have any ill effects in areas where water contains 1 part/10<sup>6</sup>F" [20].

### Tea and oral health

#### Anticariogenic properties of tea

Catechins originating from tea leaves have been suggested to possess various pharmacological activities. Among them, the anticariogenicity of catechins has been practically utilized for the prevention of dental caries. In Japan, green tea extracts containing catechins have been widely added to candy, chewing gum, food and mouth rinsing agents as a caries preventive additive [21].

Black tea extract when fed to hamsters on cariogenic diet significantly decreased caries formation by 63.7% indicating that the frequent intake of black tea can significantly decrease caries formation, even in the presence of sugars in the diet [22].

#### Anti-microbial activity

Green tea or black tea or catechins derived from such preparations were found to be inhibitory and bactericidal against *S.mutans* or *S.sobrinus*. The minimum inhibitory concentration of individual catechins was found to be between 50 and 500 mg/L leading to the consensus that a 'cup of tea' catechin concentration is inhibitory and often bactericidal [9]. Oolong tea extract was found to reduce the rate of acid production by *Mutans streptococci* accompanied with the retardation of its growth rate [23].

When used as a mouthwash green tea extract could significantly inhibit both *Mutans streptococci* and *lactobacilli* proving to be an effective adjunct to daily oral hygiene procedures especially for high caries risk patients [24].

#### Inhibition of adherence

Otake *et al* showed that a mixture of simple catechins extracted from green tea (consisting mainly of EGCG, EGC and its epimer gallocatechin, EC and ECG), at 100 mg/L (i.e., less than 'cup of tea' concentration), caused substantial inhibition of adherence of *S. mutans* to saliva-coated hydroxyapatite. Pretreatment of the substrate had little effect, showing that the phenomenon was a consequence of a specific interaction with the bacteria [25].

Both high and low mol. wt fractions from oolong tea bound to bacterial surface proteins,

decreased cell surface hydrophobicity of almost all oral streptococci and also induced cellular aggregation of *S.mutans*, *S.oralis*, *S.sanguis* and *S.gordonii* [23].

An *in situ* study conducted to investigate the effect of different polyphenolic beverages on initial bacterial adherence to enamel in the oral cavity showed that rinses with all beverages reduced the amount of detectable adherent bacteria. Lowest number of adherent bacteria was found following rinses with red wine, Cistus tea and black tea (up to 66% reduction of adherent bacteria vs. controls) thus concluding that polyphenolic beverages consumption can contribute to the prevention of biofilm induced diseases in the oral cavity [26].

#### Inhibition of glucosyl transferase

Several workers have demonstrated that the enzymatic activity of glucosyl transferase from *S. mutans* and *S. sobrinus* is inhibited by tea catechins [9]. Otake *et al.* found that EGCG and ECG were more active than other catechins. (EGCG at 167 mg/L caused 91% inhibition)[25].

#### Inhibition of salivary and bacterial amylases

Zhang and Kashket have shown that brews of several black and green teas also suppressed amylase activity from *S. mutans*. Black teas were more active against both types of enzyme, a finding that was interpreted as suggesting that higher mol. wt polyphenols (more abundant in black tea) were responsible [27].

It was also found that not only simple catechins but also theaflavins (present only in black tea) inhibited salivary amylase [9]. Zhang and Kashket also demonstrated that the fluoride content of the tea brews tested did not correlate with amylase inhibition, and further that the enzyme's activity was unaffected by NaF, added in concentrations up to 10 mg/L [27].

Pharmacokinetic studies have shown that following rinsing of the mouth with tea, catechins can be found in the saliva for up to 60 min [21], and that the enzymic breakdown of starch on food particles trapped in the mouth was markedly reduced [27].

Prospective trials done on school children showed a significant reduction of DMFT scores in the tea group when compared to the control group [9]. Ramsey *et al.* reported that there was a significant inverse correlation in children between amounts of tea drunk daily and DMFT score; they attributed this at the time to an increased fluoride intake [28].

#### Inhibition of acid production

Dental plaque, under which carious lesions may occur, contains acid-producing microorganisms, including the *mutans streptococci*. The acid production

from these bacteria is the main cause of enamel demineralization [29].

An *in vivo* study conducted to evaluate the inhibition of acid production from dental plaque and mutans streptococci by green tea catechins, revealed that EGCG may inhibit sugar transport and acid secretion by interfering with membrane-bound enzymes, and/or acid-producing enzymes such as LDH [29].

#### **Acid resistance of tooth**

Drinking tea led to only small and short-lived decreases in pH at the tooth surface when compared to other beverages indicating its less erosive potential [30]. Tannic acid in tea possessed a significant caries inhibitory effect in animals even at a very low concentration. Tannic acid may coagulate the proteins in dentine to make them more insoluble, and fluoride may react with calcium to form CaF<sub>2</sub>, for blocking up the dentinal tubules simultaneously.

Organic components of tea may act as bridge bonds to combine the calcium, phosphorus and organic substances in enamel with applied fluoride, resulting in the formation of insoluble substances on the enamel surface that induce high resistance to an acid attack.

A study conducted to investigate the effect of tea components on the acid resistance of human tooth enamel revealed that tea components such as tannin, catechin, caffeine and tocopherol were effective for increasing acid resistance and their effects increased dramatically when used in combination with fluoride. A mixed solution of tannic acid and fluoride showed the highest inhibitory effect (98%) on acid demineralization of enamel [31].

The organic degradation of dentin leading to dental caries might be affected by host-derived enzymes, such as matrix metalloproteinases (MMPs), which are present in saliva and dental hard tissues. An *in situ/ex vivo* study conducted to analyze the impact of possible MMP-inhibitors (chlorhexidine and green tea extract) on dentin wear induced by erosion or erosion plus abrasion revealed that chlorhexidine and green tea significantly reduced the dentin wear and can be used as a promising preventive measure to reduce dentin erosion-abrasion [32].

#### **Anti-inflammatory to pulp [33]**

Dental pulp cells (a major cell type in the dental pulp) also have the capacity to produce pro-inflammatory cytokines such as interleukin IL-6 and IL-8, and express adhesion molecules such as intercellular adhesion molecule-1 (ICAM-1) and vascular cell adhesion molecule-1 (VCAM-1) in response to inflammatory stimuli, including bacterial components.

The presence of EGCG and ECG significantly reduced, in a concentration-dependent manner, the expression of IL-6 and IL-8 in dental pulp cells exposed to LPS or PG. Increased expression of ICAM-1 and VCAM-1 on the dental pulp cells in response to bacterial components was also decreased by treatment with EGCG and ECG. These findings suggest that green tea catechins may prevent the exacerbation of pulpitis.

#### **Tea and periodontium**

*Prevotella intermedia* as a group, together with *Porphyromonas gingivalis*, have been implicated in the development of various forms of periodontal disease. These black-pigmented Gram-negative anaerobic bacteria are frequently isolated from periodontal lesions. Many of these periodontopathic organisms possess phosphatase activity and particularly members of the *Prevotella intermedia* group possess protein tyrosine phosphatase (PTPase) which has high correlation with periodontal disease [34].

*The efficacy of tea catechin derivatives (EGCG), proved to be similar to orthovanadate, a specific inhibitor for PTPase, in inhibiting the PTPase activity in P. intermedia [34]. They also have the potential to reduce periodontal breakdown resulting from the potent proteinase activity of P. gingivalis [35].*

Diet containing Japanese green tea extract when fed to canines inhibited both gingival inflammation and oral malodor. In addition, the percentages of *Porphyromonas* in the subgingival microbiotas were significantly decreased [36].

Alveolar bone resorption is the clinically most important issue in human periodontitis, because it leads to tooth loss. Osteoclasts, the cells principally responsible for this process, acidify the sub-osteoclastic resorption zone leading to the dissolution of minerals, while the organic matrix (mainly type I collagen) is degraded by proteolytic enzymes [37].

Collagenase (Matrix metallo proteinase (MMP)-1 and MMP-13) and gelatinase A (MMP-2) and B (MMP-9) have been considered the principal MMPs in the digestion of bone collagen by osteoblasts. EGCG may prevent the alveolar bone resorption that occurs in periodontal diseases by inhibiting the expression of MMP-9 in osteoblasts and the formation of osteoclasts [37].

#### **Anticarcinogenic effects of tea**

The potential health benefits associated with tea consumption have been partially attributed to the antioxidative property of tea polyphenols. Tea preparations have been shown to trap reactive oxygen species, such as superoxide radical, singlet oxygen, hydroxyl radical, peroxy radical, nitric oxide, nitrogen dioxide, and peroxynitrite. The radical quenching ability of green tea is usually higher than that of black tea [6].

Green tea has been found to be a potential chemopreventive agent for the treatment of oral leukoplakia, a precursor lesion to oral cancer [7]. Drinking green tea reduced the number of damaged cells in smokers by inducing cell growth arrest and apoptosis [38]. The concentration of tea catechins in the saliva can reach a higher value than in plasma. In vitro studies demonstrated that green tea induced G1 cell cycle arrest in oral leukoplakia and promoted apoptosis in oral squamous carcinoma cells [7].

It is also proved that holding green tea solution in the oral cavity or chewing green tea leaves results in dose-dependent production of H<sub>2</sub>O<sub>2</sub> due to the oxidative polymerization of EGCG in the mouth which may play an important role in prevention of oral cancer [39].

#### Disadvantages of tea consumption

Despite these possible advantages of tea, excessive consumption may lead to problems of staining of the dentition. Such staining is likely to be caused by interaction of components of the tea with both surface integuments like the acquired salivary pellicle and possibly, the mineral crystals of dental enamel [30].

Coffee and tea are considered as staining solutions for esthetic restorative materials due to their contents and frequent consumption [40] and especially discoloration by tea was due to adsorption of polar colorants onto the surface of materials, which can be removed by tooth brushing [41].

A study was conducted to examine the surface staining mechanism of a photopolymerized composite by coffee, oolong tea, and red wine. It was found that coffee and tea stained the composite specimens as much as wine when used with chlorhexidine because cationic antiseptics, such as chlorhexidine, can precipitate or bind to anionic chromogens from foods and beverages on tooth and resin surfaces [42].

A study conducted by Manabe *et al.* to investigate the effect of coffee and tea immersion on surface discoloration of two temporary resin coating materials. The resultant staining response produced by both coffee and tea immersion exceeded the clinically acceptable discoloration threshold value [40].

Another study conducted to determine the degree of surface staining of resin-based composites and glass-ionomer cements after immersion in various stains and food-simulating solutions showed that all materials were susceptible to staining by all stains especially coffee, red wine and tea and among the GICs, resin modified glass ionomers were more susceptible to staining than conventional GIC [41].

#### CONCLUSION

There is a growing amount of in-vitro research identifying tea's potential oral health benefits. It is clear

that tea is much more than a pleasant and mildly stimulating beverage, probably due to its therapeutic value in the prevention of dental caries and periodontal diseases and in treatment of oral precancerous lesions. However, further longer term, well controlled human trials are required before any firm conclusions can be made. In the mean time it is reasonable to conclude that tea consumption, without the addition of sugar, should be made a component of dietary advice to prevent oral diseases thereby helping to promote overall health and well being by the most economical means.

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