The antibacterial & therapeutic effects of green tea on oral & periodontal health - A review

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Abstract:

Green tea is one of the most ancient & popular beverages and is considered as a healthful beverage due to the biological activity of its polyphenols. This product is made from the leaf of the small bushy plant called "Camellia sinensis". It can be consumed as a drink which has many beneficiary systemic health effects or, it can be used as medicine by making green tea "Extract" from leaves. According to literatures, green tea contains a thousand of bioactive compounds amongst which polyphenols play an important role to prevent & treat various diseases. Green tea polyphenols are named "catechins". Among the polyphenols; EpigalloCatechin-3-gallate (EGCg) & EpiCatechin-3-Gallate (ECg) are the most predominant cathechins. Green tea polyphenols can play an important role to fight cavity producing effects of Streptococcus mutans by destroying them, reducing ability of Streptococcus mutans to produce the enamel damaging acid & inhibiting production of plaque by making tooth surface slippery, so that bacteria can't adhere to the tooth. The exact mechanism by which green tea can prevent dental caries is yet to known, but certain theories like bactericidal effects of green tea against Streptococcus mutans & prevention of bacterial adherence to teeth have been suggested. The aim of this present review is to describe antibacterial properties of the "Green Tea" along with medicinal properties on oral & periodontal health. In this review, first we introduced some information regarding plant morphology & active ingredients of tea. Then, we described some of the important oral & periodontal diseases along with the effect of green tea & its supplements to improve them in brief.

Keywords: *Green Tea, Catechins, Teeth, Caries, Periodontal Health.*

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Introduction:

Since ancient times, plants have been an exemplary source of medicine. According to Ayurveda and other ancient Indian literatures, plants are used in treatment of various human diseases. Indian subcontinent is one of the oldest civilizations which is known for rich repository of medicinal plants. Traditional system of medicine is found to have utilities as many accounts. Due to population rise adequate supply of drug and high cost of treatment in side effect along with drug resistance has been encountered in synthetic drugs, which has lead to an elevated emphasis for the use of plants to treat human diseases. The affordability of herbals has also drawn the attraction towards their use.[1] Plant extracts have been widely used in topical and oral applications for disease treatment. Examples of these include gingko biloba, echinacea, ginseng, grape seed, green tea, lemon, lavender, rosemary, thuja, sara, allantoin, fever wort, blood root, apache plume, papaya, and tragacanth.[2] Black tea is the second most commonly drunk liquid on earth after water. Green tea "*Camellia sinensis",* which is not fermented at all during the drying process, has numerous medicinal benefits mainly due to its antibacterial and antioxidant properties.[3] In oriental cultures, it has been widely believed for a long time that tea has medicinal efficacy in the prevention and treatment of many diseases. Compounds present in both green and black teas have been shown to inhibit the growth and activity of bacteria with tooth decay producing halitosis.[4,5] Tooth decay is the gradual breakdown of the tooth beginning with the enamel surface and eventually progressing to the inner pulp. Tooth decay and, eventually, halitosis are caused by acids produced by certain mouth bacteria in dental plaque. Factors that affect this process include oral hygiene, diet meal frequency, saliva production, and heredity. Teeth with significant decay are said to have caries or cavities.[4,6-7] Studies indicate dental caries is associated with modern civilization, since primitive isolated tribes are relatively caries-free. The malefic bacteria in our mouths can cause tooth decay and bad breath (halitosis). Carbohydrates play an important role in the

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development of dental caries, especially when it remains on tooth structure for significant period of time.[8-9] Fermentation of carbohydrates by bacteria mainly *Streptococcus mutans* results in a decrease in the pH of plaque and demineralization of enamel and finally formation of dental caries.[10-13] Plaque is another contributor to bad breath. Bad breath is caused by anaerobic sulfur producing bacteria that normally live on the surface of the tongue and in the throat. These bacteria are supposed to be there because they assist humans in digestion by breaking down the proteins found in specific foods, mucous, phlegm, blood, and diseased or "broken-down" oral tissues. Under certain conditions, these bacteria start to break proteins down at a very high rate. Proteins are made up of amino acids; two amino acids, cysteine and methionine, are dense with sulfur. When these "beneficial" bacteria come into contact with these compounds, the odorous and "lousy-tasting" sulfur compounds are released from the back of the tongue and throat as hydrogen sulfide, methyl mercaptan, and other odorous and bad tasting compounds. These "problem" compounds are often referred to as volatile sulfur compounds. Based on one article, the phenolic compound in green tea may block the growth of bacteria responsible for teeth cavity and plaque formation.[14]

History of tea

The history of tea is long and complex, spreading across multiple cultures over the span of thousands of years. Tea likely originated in southwest China during the Shang dynasty as a medicinal drink.[15] An early credible record of tea drinking dates to the 3rd century AD, in a medical text written by Hua Tuo.[16] Tea was first introduced to Portuguese priests and merchants in China during the 16th century.[17] In one popular Chinese legend, Shen-nong, the legendary Emperor of China and inventor of agriculture and Chinese medicine was drinking a bowl of just boiled water due to a decree that his subjects must boil water before drinking it.[18] Some time around 2737 BC, when a few leaves were blown from a nearby tree into his water, changing the color. The emperor took a sip of the brew and was pleasantly surprised by its flavor and restorative properties. A variant of the legend tells that the emperor tested the medical properties of various herbs on himself, some of them poisonous, and found tea to work as an antidote.[19] Shennong is also mentioned in Lu Yu's famous early work on the subject, *The Classic of Tea*.[20] A similar Chinese legend goes that the god of agriculture would chew the leaves, stems, and roots of various plants to discover medicinal herbs. If he consumed a poisonous plant, he would chew tea leaves to counteract the poison.

Historically, Bengal was the terminus of the Tea Horse Road connecting the subcontinent with China's early tea-growing regions in Yunnan. Atisa is regarded as one of the earliest Bengali drinkers of tea.[21] Black tea cultivation was introduced in Bengal during the British Empire.[22] European traders established the first subcontinental tea gardens in the port city of Chittagong in 1840, when plantations were set up beside the Chittagong Club using Chinese tea plants from the Calcutta Botanical Garden.[21,23] The first home-grown tea was made and tasted near the Karnaphuli River in Chittagong in 1843.[23,21] Commercial cultivation of tea began in the Mulnicherra Estate in Sylhet in 1857.[21]

Fig.-1: *Fresh leaves of Green Tea*

Morphology of tea

Chinese *Camellia sinensis* is native to mainland China, South and Southeast Asia, but it is today cultivated across the world in tropical and subtropical regions. 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 sinesis*) 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.[24] (Figure 1).

Classification of tea

Green tea, Oolong and black tea come from the leaves of the plant *Camellia sinensis*; however the processing that the leaves undergo to make the final tea is different. The leaves for black tea are fully oxidized and for oolong tea are partially oxidized, while those for green teas are lightly steamed before being dried.

Depending on the manufacturing process, teas are classified into 3 major types: (Figure 2)

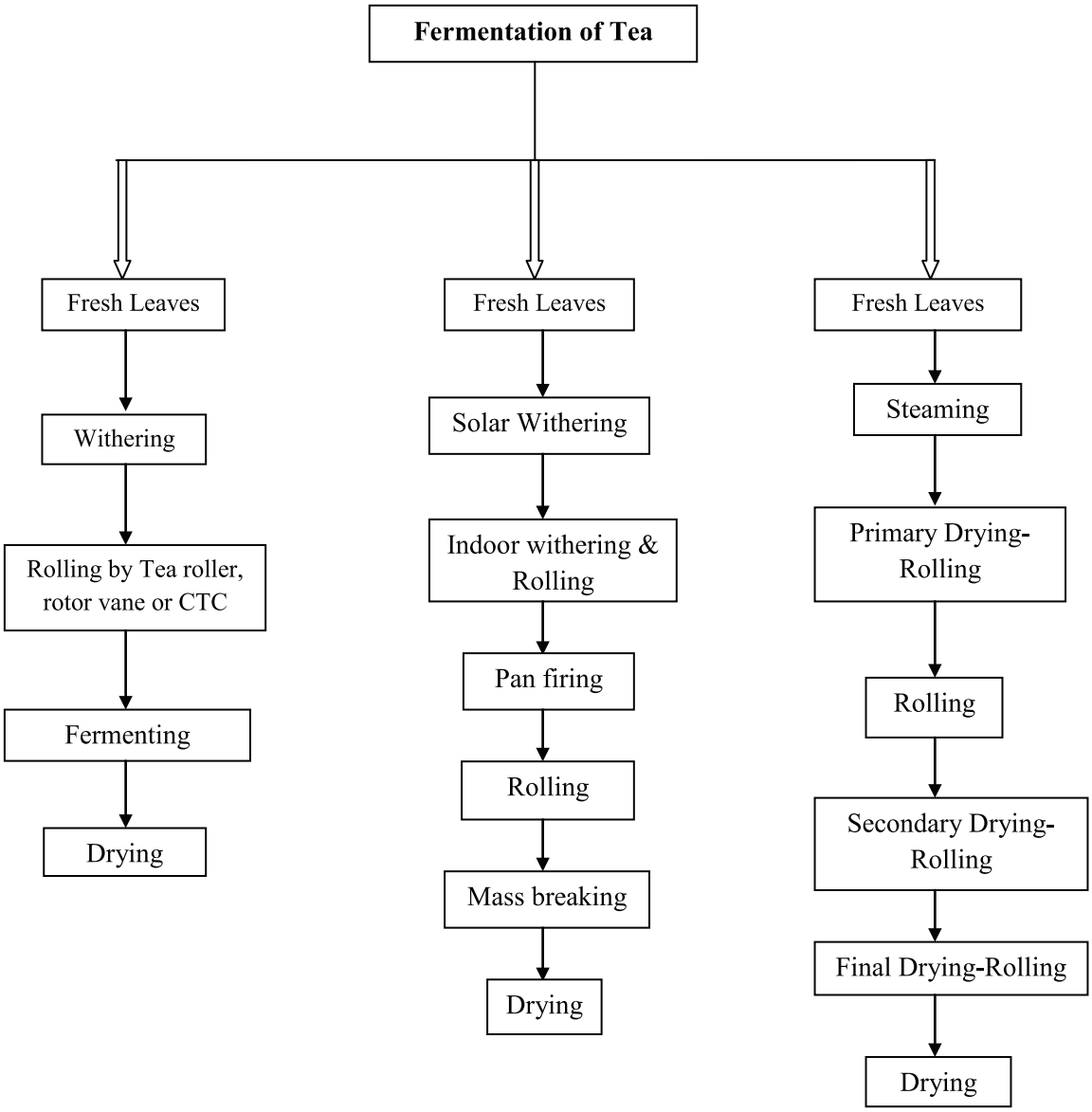

Fig. -2: *Fermentation of Tea: The manufacturing processes of tea: (A) black tea; (B) oolong tea; and (C) green tea.*

What does a tea leaf contain?

Tea is reported to contain nearly 4000 bioactive compounds of which one third is contributed by polyphenols.[25] Other compounds are alkaloids (caffeine, theophylline and theobromine), amino acids, carbohydrates, proteins, chlorophyll, volatile organic compounds (chemicals that readily produce vapors and contribute to the odor of tea), fluoride, aluminum, minerals and trace elements.[26]

Fresh-cut tea leaves consist of 75-80% water. A variety of green tea flavors are formed through the combination of three main taste components.

Catechin–Bitterness & Astringency;

Caffeine–Bitterness;

Theanine & Amino Acids–Flavor & Sweetness.[27] (Figure 3)

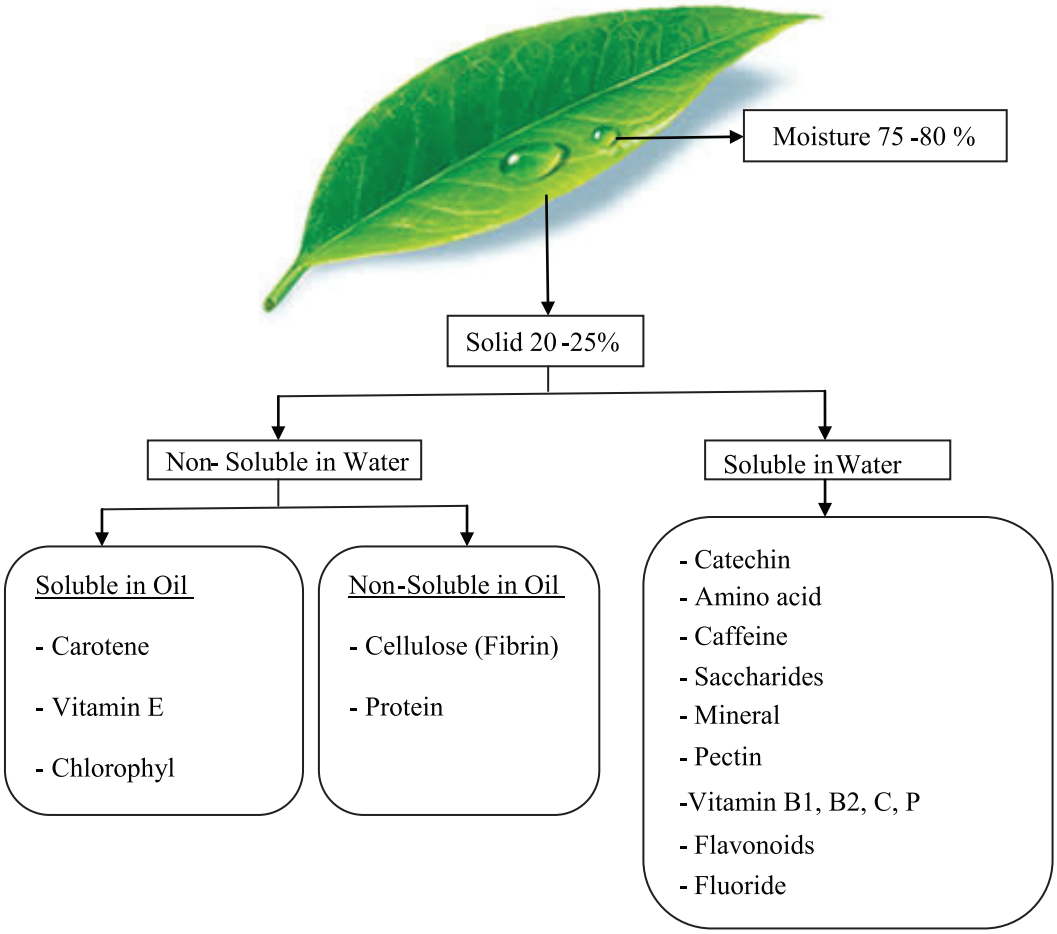

Fig.-3: ***Contents of tea leaf***

Tables-I and Table-II provides average values for the different constituents present in green and black tea although they will differ dependent on the variety of leaf, growing environment, manufacturing, particle size of ground tea leaves and infusion preparation.[28-29]

Table-I

Principle components of black tea[30]

	Black Tea (% weight of extract solids)
Catechins	3-10
Theaflavins	3-6
Thearubigens	12-18
Flavonols	6-8
Phenolic acids and depsides	10-12
Amino Acids	13-15
Methylxanthines	8-11
Carbohydrates	15
Protein	1
Mineral water	10
Volatiles	<0.1

Table-II

Principle components of green tea[30]

	Green Tea(% weight of extract solids)
Catechins	30-42
Flavonols	5-10
Other flavonoids	2-4
Theogallin	2-3
Other depsides	1
Ascorbic Acid	1-2
Gallic Acid	0.5
Quinic acid	2
Other organic acids	4-5
Theanine	4-6
Other amino acids	4-6
Methylxanthines	7-9
Carbohydrates	10-15
Minerals	6-8
Volatiles	0.02

The chemical history of tea:

While the history of tea drinking is ancient, investigation into the chemical components of tea is in comparison quite recent. Tea is composed of unique constituents among other plants. Caffeine is found only in a few other plants other than tea. Theanine, which is unique to tea, is a kind of amino acid constituting more than half the total amount of amino acids in tea. Major catechins in tea are also unique to tea. Vitamin C was found to be contained in tea after it was discovered in lemons. Tea aroma is an area that attracted the interest of scientists who had been seeking one single compound that represents tea, a search which has yet been in vain. In 1827 caffeine was discovered in tea. At that time it was given the name theanine, but when it was proven that the structure and properties of this substance were exactly the same as caffeine that was identified in coffee in 1820, the name theanine was dropped. In 1924, vitamin C was discovered in green tea by two Japanese scientists, M. Miura and M. Tsujimura, under Professor U. Suzuki. The astringency of tea, too, was investigated extensively by Tsujimura. In the years 1927 to 1935.

Tsujimura isolated epicatechin, epicatechin gallate, and epigallo catechin.[27]

Biosynthesis of Tea Catechins

The tea plant contains many kinds of polyphenols, Catechins being particularly prolific. Catechins belong to those groups of compounds generically known as flavonoids, which have a C6-C3-C6 carbon structure and are composed of two aromatic rings. Currently, the tea plant is known to contain seven kinds of major catechins and traces of various other catechin derivatives. (Figure 4)

They are divided into two classes:

1) The free catechins:

(+)-catechin, (+)-gallocatechin, (-)-epicatechin, (-)-epigallocatechin;

And,

2) The esterified or galloylcatechins:

(-)-epicatechingallate, (-)-epigallocatechingallate,

(-)-gallocatechingallate.

While the galloylcatechins are astringent (EGCg, ECg) with a bitter after taste (ECg), free catechins have far less astringency (EGC, EC), leaving a slightly sweet aftertaste (EGC) even at 0.1% aqueous solutions.[27]

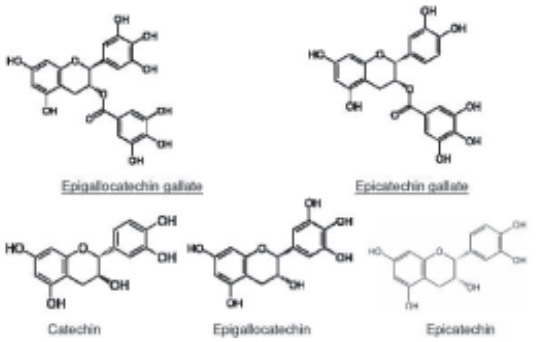

Fig.-4: *Basic structures of different green tea polyphenols*

This is the process of extracting polyphenolic constituent of tea leave as follows:

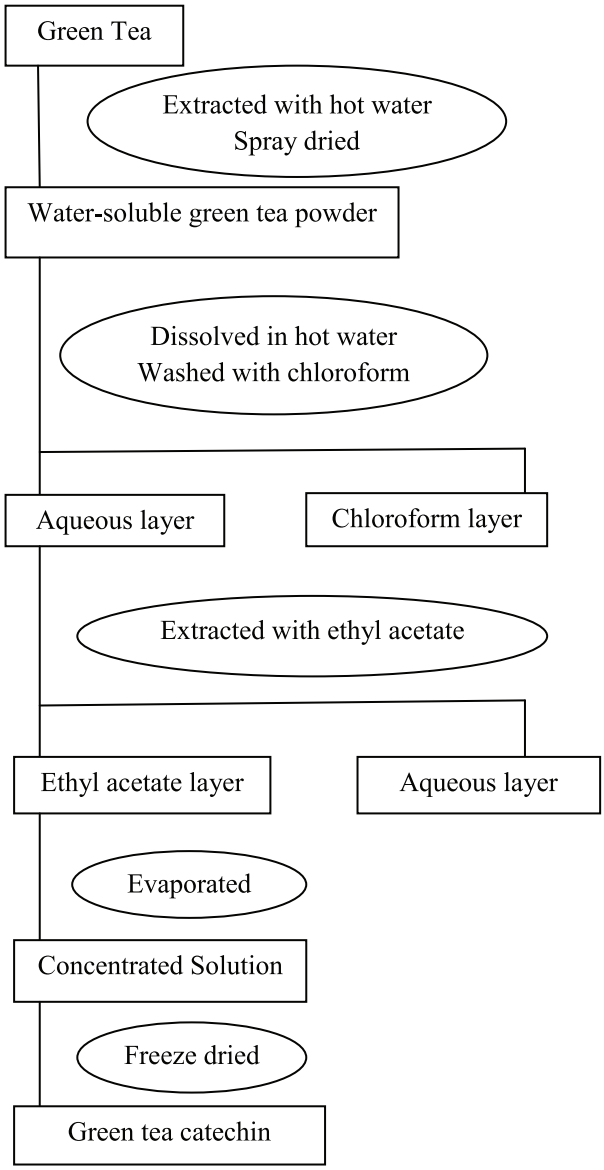

Fig. 5: *The preparation of green tea catechins*

Tooth Decay:

By the time the human mouth reaches maturity, most adult humans have thirty two teeth as is seen in (Figure 6). At the front of the mouth are incisors, the sharpest teeth, which are used to bite food and direct the food into the mouth. The canine teeth are located behind the incisors on either side of the mouth. They have long roots and grasp incoming food. The premolars are located even farther back into the mouth. These teeth are wide and flat, equipped for grinding food before it is fully digested. Finally, the molars grind food into particles small enough to be swallowed and broken down in human's digestive tracts. It is very important to keep all of these teeth clean, and cavities are a real concern for humans in today's society.

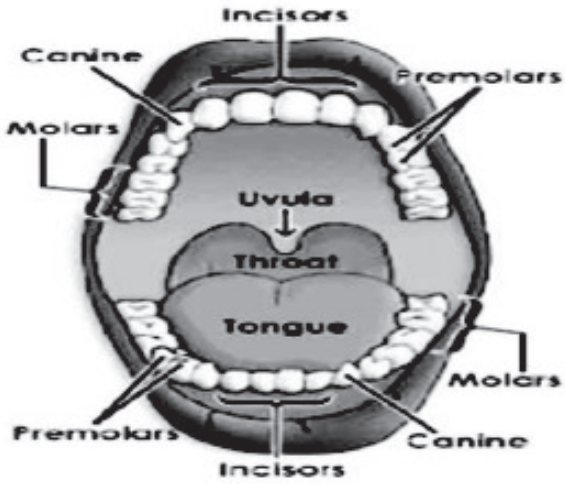

Fig.-6: *Anatomy of the Human Mouth*

After food enters the mouth, particles and bacteria are able to cling to the surface of the teeth. Many times, if the teeth are not brushed soon enough after eating, the bacteria can grow and form a film on the teeth. It is important to understand that cavities are not formed by the sugars consumed by humans, but instead by the bacteria that grow in the mouth if food particles remain on and between teeth for an extended period of time, (Figure 7). Certain bacteria thrive in the conditions found in the human mouth. The warm environment and constant source of food both make the teeth and gums ideal locations for bacterial cultures to grow. *Streptococcus mutan*s and *Streptococcus sobrinus* are two such bacteria commonly found in dental cavities. When they grow on the surfaces of teeth, they eat at the food particles and release acid as a waste product.

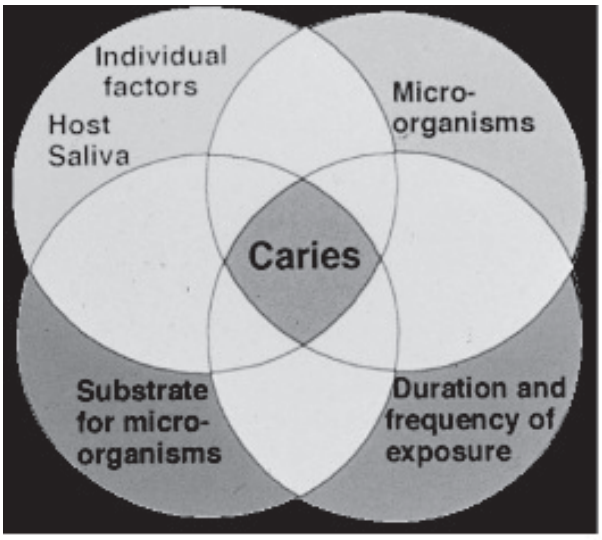

Fig.-7: *Dental Caries*

This acid eventually builds up, and breaks down the minerals in the teeth. Over time, when large amounts of acid have been released surrounding teeth, cavities begin to form. The acid initially leaves the surface of the tooth intact, while breaking down the enamel lying beneath the surface. When the tooth has enough damage, the surface also breaks down and a cavity is formed. The most common means to prevent tooth decay are to consistently brush and floss the teeth. Fluoride is usually present in toothpaste as a means to breakdown bacteria and prevent acid build-up. Fluoride is also present in green and black tea, one reason why drinking tea can prevent tooth decay.[31]

Bacterium Causing Tooth Decay

Ancient Japanese folklore tells how drinking tea leads to long life and clean teeth. At least the second part of this fable seems to be true. Recent research indicates that tea is able to counter some of the microorganisms, *Streptococcus mutans*, *Streptococcus sobrinus*, and *Lactobacillus* that can form plaque and bio-films on teeth, resulting in tooth decay. Microorganisms from the genus Streptococcus are gram-positive bacteria. They have a round shape and frequently grow in chains. They are anaerobes that thrive in a complex culture. *Streptococcus mutans* (Figure 8) is a species of Streptococcus that usually resides in the human mouth. It was discovered in 1924 by J K Clark. *Streptococcus mutans* is able to cling to the surface of teeth and feed on food particles, especially carbohydrates, that become trapped on and between teeth.

The acid released by this bacteria is the leading cause of tooth decay in the world. *Streptococcus sobrinus* is closely related to *Streptococcus mutans*, although it is less common in human beings.[32]

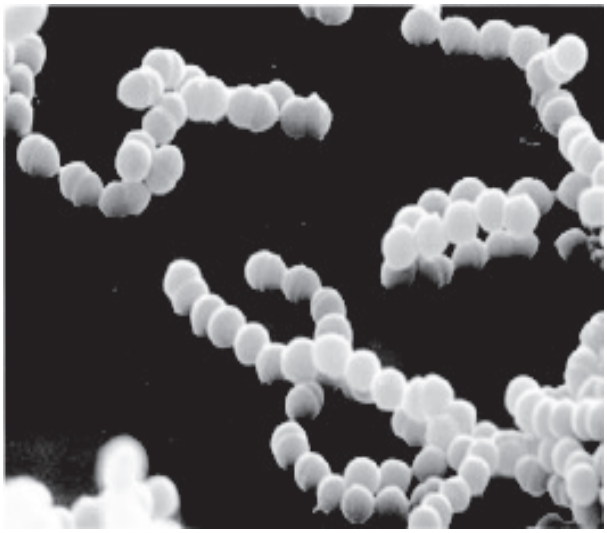

Fig.-8: *Scanning electron microscope image of Streptococcus bacteria*

Anticariogenic Effects of Green Tea Catechins:

Several studies have reported the efficacy of green tea on dental health. Tea leaves are rich in fluoride, which is known to enhance dental health and prevents dental caries. However, the possible dental health benefits of tea are not limited to fluoride, but involve other tea components. Dental caries are induced by oral microflora. Among hundreds of microorganisms in the oral cavity, only the cariogenic *streptococci*, especially *Streptococcus mutans*, play an important role in causing dental caries. Several green tea polyphenols have preventive effects on dental caries. Among the catechins; gallocatechin (GC) and epigallocatechin (EGC) are most active, inhibiting the growth of 10 strains of cariogenic bacteria.[33] Cariogenic bacteria synthesize water-soluble and water-insoluble glucans using glucosyltransferase (GTase). Highly branched glucans are responsible for bacterial cell adherence to the tooth surface.(34) EpiCatechin-3-gallate (ECg), GalloCatechin-gallate (GCg) and EpiGalloCatechin-3-gallate (EGCg) strongly inhibit GTase and inhibit adherence of the bacteria to dental surfaces. *Streptococcus mutans* is the strain of bacteria primarily responsible for causing cavities. It clings to teeth and uses the sugars in mouth to produce a sticky, water-insoluble substance called plaque that coats the teeth. *Streptococcus mutans* and other bacteria then hang on to the plaque and convert sugar to lactic acid, which eats away tooth enamel. The combination of plaque and acid causes cavities. Green tea catechins help fight dental cavities in these ways:

1) A direct bactericidal effect against *Streptococcus mutans* and *Streptococcus sobrinus* ;
2) Prevention of bacterial adherence to teeth; inhibition of glucosyl transferase (GTase), thus limiting the biosynthesis of sticky glucan ; and
3) Inhibition of human and bacterial amylases.[35]

Studies have shown these effects can occur with as little as one cup of green tea. No wonder that the Japanese people have long held that drinking green tea makes the mouth clean. Green tea extract applied topically inhibits *Streptococcus mutans* bacteria.[36] In a Chinese study, green tea extract was used to rinse and brush the teeth. This study's result indicated that *Streptococcus 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. In humans, a double-blind study showed that rinsing the mouth after meals with 0.05 to 0.5% green tea polyphenols for 3 days inhibits dental plaque formation by 30 to 43%. The effectiveness of green tea catechins against dental caries also has been observed in other countries.[37]

Inhibition of Plaque Formation

The inhibition of the plaque-forming enzyme glucosyl transferase (GTF) by tea polyphenols was investigated in vitro.[31] The enzyme GTF, sucrose, and tea polyphenols were mixed and incubated at 37°C for an hour. The sucrose carbon was labeled so that the fate of sucrose could be traced. Without tea poly-phenols, the enzyme catalyzes the formation of insoluble glucan, i.e., plaque.

In the solutions containing tea polyphenols a dose-dependent inhibition of insoluble glucan formation was noticeable. EGCg (and its isomer, GCg) and all theaflavins inhibited the glucan formation almost completely at the concentration of 10 mM. At 1 mM, about the drinking concentration of tea polyphenols, more than 50% inhibition was observed (Table-III).

Table-III

Effect of Tea Polyphenols on the Insoluble-Glucan Formations Catalyzed by GTF (glucosyl transferase)

Sample	Concentration (mM)	% incorporation of (^{14}C) glucose[a] insoluble glucar
(−)-Catechin	1.0	77.7 ± 5.9[b]
	10.0	38.3 ± 3.0
(−)-Epicatechin	1.0	94.5 ± 3.5
	10.0	57.7 ± 5.0
(−)-Epicatechin gallate	1.0	64.5 ± 6.2
	10.0	17.0 ± 3.2
(−)-Gallocatechin gallate	1.0	52.8 ± 2.6
	10.0	4.6 ± 0.1
(−)-Epigallocatechin gallate	1.0	58.4 ± 3.3
	10.0	25.0 ± 1.9
(−)-Free theaflavin	1.0	43.2 ± 1.4
	10.0	1.7 ± 0.2
Theaflavin monogallate A	1.0	35.5 ± 1.6
	10.0	2.7 ± 0.6
Theaflavin monogallate B	1.0	52.9 ± 7.1
	10.0	2.2 ± 0.4
Theaflavin digallate	1.0	44.1 ± 2.6
	10.0	1.8 ± 0.3

a. Incorporation ratios into insoluble-glucans relative to the respective control are expressed as follows: %incorporation = test(14C-incorporation)/control (14C-incorporation) X 100

b. Mean + S.E. (n=4)

So, the influence of tea beverages on the formation of plaque by *Streptococcus mutans* was observed. Tea leaves were drawn to make a tea extract of normal concentration (2g/200 ml hot water) containing about 1,000 ppm of polyphenol concentration and in thereafter diluted. Sucrose at 1% concentration was dissolved in the normal and the diluted brews. After adding drops of bacterial solution to the test beverage, a cover glass was immersed in the solution and incubated at 37ºC for 3 days. The bacterial plaque formed on the surface of the cover glass was observed. All tea beverages (black tea, oolong tea, green tea, and puer tea) at normal concentrations and up to 4 times dilution were found to inhibit plaque formation (Figure 9).

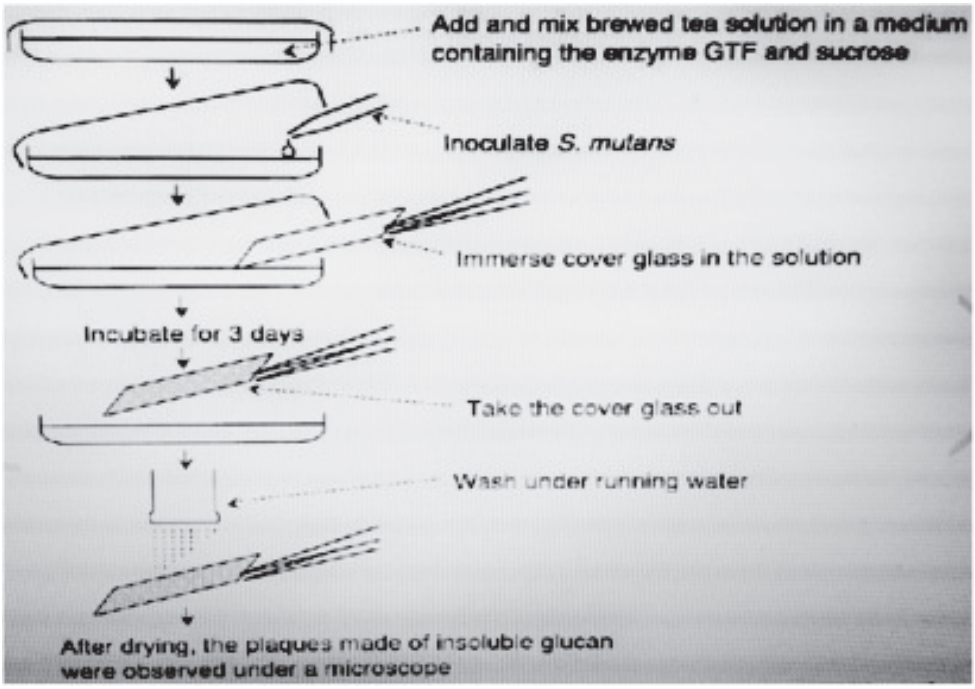

Fig.-9: *Method for microscopic observation of dental plaques (insoluble glucan).GTF, Glucosyl transferase*

Inhibition of the proliferation of *Streptococcus mutans*:
It was also confirmed that the inhibitory potency of various tea beverages extracted at normal drinking concentrations on the growth of *Streptococcus mutans*. The results in Figure 10 and Figure 11 show that green tea is most effective in suppressing the growth of the bacteria.[38]

Effects of Green Tea on Oral & Periodontal Health

Gingivitis & Periodontitis

Gingivitis and periodontitis are major forms of inflammatory diseases of the mouth. In gingivitis, the gums become red and swollen. They can bleed easily. Gingivitis is a mild form of gum disease. It can usually

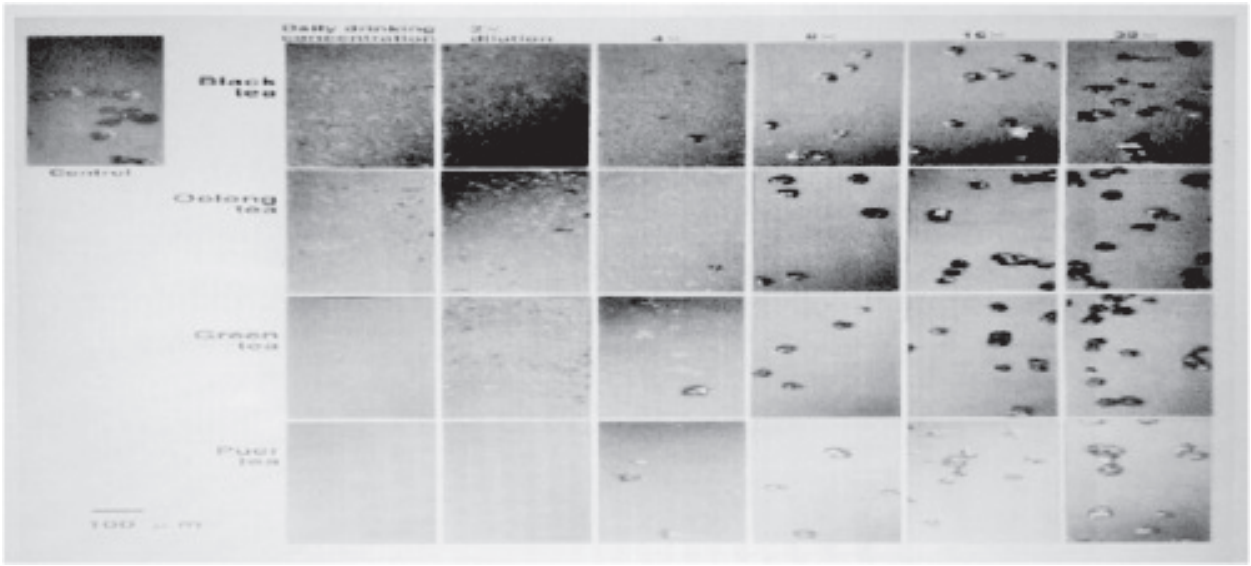

Fig.-10: *Anti-dental plaque effect of tea beverages.*

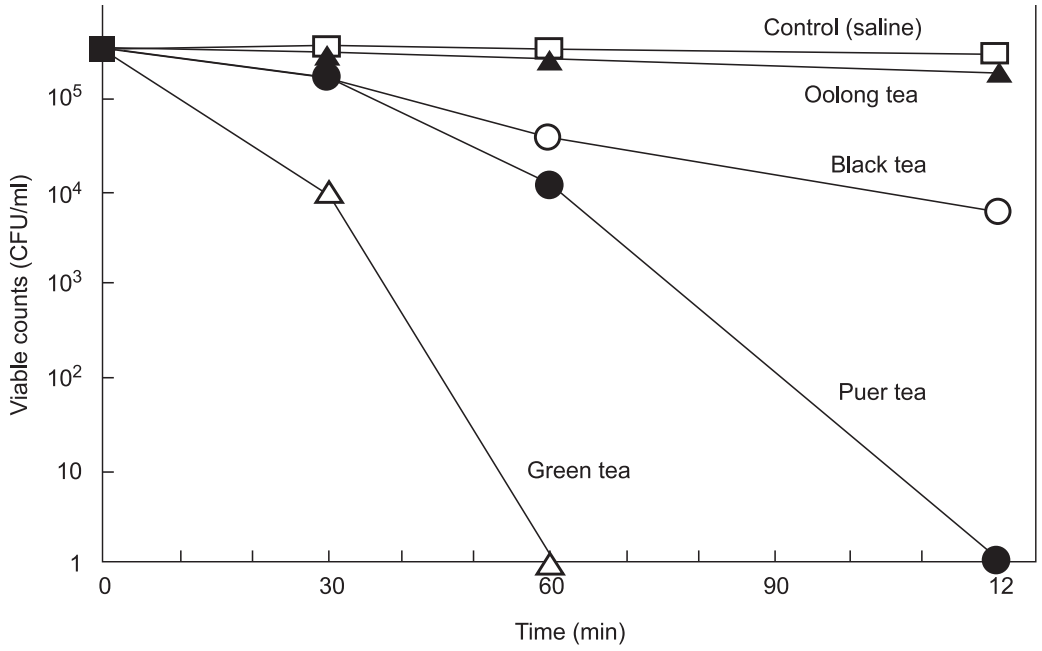

Fig.-11: *Antibacterial effect of tea beverages against cariogenic bacterium Strptococcus mutans*

be reversed with daily brushing and flossing and regular cleanings by a dentist or dental hygienist. Untreated gingivitis can lead to periodontitis. In periodontitis, the gums pull away from the teeth and form pockets that become infected. If not treated, the bones, gums and connective tissue that support the teeth are destroyed. Symptoms of gum disease include: Bad breath that won't go easily, red or swollen gums, tender or bleeding gums, painful chewing, loose teeth, sensitive teeth and receding gums or longer appearing teeth. Their primary etiology is bacteria, which can initiate destruction of the gingival tissues and periodontal attachment apparatus.[39] Reduction of the periodontopathic bacteria by scaling and supragingival plaque control can lead to an improvement of the periodontal status.[40-42] Complete removal of plaque and calculus is more difficult in deep than in shallow pockets. Hence, the failure of periodontal treatment may be the result of bacterial plaque and calculus remaining after scaling.[43] 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.[44]

A number of reviews addressed the local application of antimicrobial agents to the subgingival area for the treatment of periodontitis.[45] Green tea has been reported to be useful for prevention of periodontal disease and maintenance of oral health. 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 and breaks is a relatively easy habit to maintain a healthy periodontium.[46] Several in vitro studies have suggested that green tea catechins such as EGCg (EpiGalloCatechin-3-gallate) inhibit the growth of *Porphyromonas gingivalis*, *Prevotella intermedia* and *Prevotella nigrescens* and the adherence of *Porphyromonas gingivalis* onto human buccal epithelial cells.[47] In a clinical pilot study, hydroxypropyl cellulose 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 *Porphyromonas gingivalis* and *Prevotella spp*. and a reduction in pocket depth was observed.[48] 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.[49] EGCg completely inhibits the growth of three strains of P. gingivalis at a concentration of 250 or 500 ìg/ml and that of P. melaninogenicus at MICs of 2000 ìg/ml.[47] EGCg and ECg inhibit the production of toxic end metabolites of P. gingivalis.[44] EGCg inhibits protein tyrosine phosphatase activity in P. intermedia.[50] It also possesses bactericidal activity against a variety of microorganisms like *Helicobacter pylori*.[50] 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.[44] According to a study which was performed on 47 subjects for four weeks to investigate the effect of green tea catechins and polyphenols on inflammed gingiva, 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.[36]

Halitosis (Bad Breath)

The main constituents of bad breath are volatile sulfide compounds especially hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH) and dimethyl sulfide [$(CH_3)_2S$].These compounds are the result of proteolytic degradation of various sulfur-containing substrates in food debris, saliva, blood and epithelial cells by predominantly anaerobic gram negative oral bacteria.[51] Antimicrobial polyphenoles in green tea can improve bad breath by suppressing these bacteria.[52] Deodorant activity decreased in the following order: EGCg > EGC > ECg > EC. The deodorizing effect of EGCG involves a chemical reaction between EGCG and MSH. The reaction involves introduction of a methylthio and/or a methylsulfinyl group into the B ring of EGCG. During this reaction, a methylthio group is added to the orthoquinone form of the catechin generated by oxidation with atmospheric oxygen and helps in reducing halitosis.[53] According to a research, mouth washing with a dilute catechin solution for four weeks reduced halitosis associated with periodontal disease.[50] Chewing gum containing tea catechins significantly decreased MSH

production from saliva containing L-methionine and apparently was useful in reducing bad breath.[53]

Green tea extract as mouthwash

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.[54] 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.(44) 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.[55]

Conclusion:

Humans have many ways of keeping teeth looking bright and healthy. Brushing and flossing is common, along with more extreme methods of teeth whitening and bleaching. However, drinking tea is another method that could be employed by humans to prevent teeth decay. Studies have shown that countries in which tea drinking is widespread, such as India, Japan, and China, there is a lower incidence of dental problems. It can be concluded that there is strong evidence on caries prevention of tea and its components. Additional research is needed to determine the exact methods employed by green and black tea extracts to break down and inhibit the activity of *Streptococcus mutans*, *Streptococcus sobrinus*, etc. Since prevention is always better than cure, more research should be conducted to find the exact caries inhibitory mechanism of tea components, particularly at the cellular level and possible use of these components in oral hygiene products like tooth paste and mouth wash or chewing gum and even in certain dental restorative materials.

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