

Tea as a Functional Food for Oral Health

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Tea is an aqueous infusion of dried leaves of the plant *Camellia sinensis* L. (family Theaceae) and is the most popular beverage consumed by human society worldwide, second only to water. The per-capita consumption worldwide averages 4 fluid ounces per day,¹ and approximately 2.5 million metric tons of dried tea is produced each year, mainly in India, China, Sri Lanka, Turkey, Russia, and Japan. The human use of *C. sinensis* is believed to have originated 4000 to 6000 y ago, and it is generally regarded as safe by the U.S. Food and Drug Administration. Depending on the manufacturing process, teas are classified into three major types: the non-fermented green tea, the semifermented oolong tea, and the fermented black tea (Annual Bulletin of Tea Statistics, 1990). The fermentation and heating of tea leaves during the manufacturing process can result in polymerization of monophenolic compounds (catechins), leading to conformational changes and thus contributing to the properties of various teas.

The chemical composition of tea is complex: polyphenols, catechins, caffeine, amino acids, carbohydrates, protein, chlorophyll, volatile compounds, fluoride, minerals, and other undefined compounds.¹ Among these, the polyphenols and catechins constitute the most interesting group of tea leaf components: (–)-epigallocatechin gallate, (–)-epicatechin gallate, (–)-epigallocatechin, (–)-epicatechin, (+)-gallocatechin, and (+)-catechins.^{1,2} The oxidized polyphenols are often called *tannins*, which is very different chemically from the commercial *tannic acid* or the plant tannins.³ It is estimated that a cup of green tea (2.5 g of green tea leaves/200 mL of water) may contain 90 mg of (–)-epigallocatechin gallate. Black tea has many more components than green tea, including bisflavanols, theaflavins, theaflagallins, epiflavins, and thearubigins. The fluoride content of green tea ranges between 1 and 2 parts per million,⁴ whereas that of black tea is reported to be five times

higher.⁵ Tea is also a dietary source of antioxidant nutrients such as carotenoids, tocopherols, ascorbic acid (vitamin C), and non-nutrients phytochemicals generally classified as flavonoids. The polyphenols may contribute to defenses against oxidative damages.

Numerous studies have demonstrated that aqueous extract or the major polyphenols of green tea possess antimutagenic, antidiabetic, antioxidant, antibacterial, anti-inflammatory, antitumor, hypocholesterolemic, and above all, cancer-preventive activities in a variety of experimental animal models system.^{2,6} Oral diseases including dental caries, periodontal disease, and tooth loss may significantly impact a person's overall health.⁷ Among these, dental caries is a multifactorial infectious disease in which diet, nutrition, microbial infection, and host response play important roles. Earlier reports suggested that tea consumption reduces dental caries in humans and experimental animals.⁸ In vivo animal studies have shown that specific pathogen-free rats infected with *Streptococcus mutans* and then fed a cariogenic diet containing green tea polyphenols have significantly lower caries scores.⁹ Supplementing drinking water of rats with 0.1% green tea polyphenols along with a cariogenic diet also significantly reduced total fissure caries lesions.¹⁰ Animal studies using oolong tea produced similar results. Cariostatic activity of oolong tea extract was effective even after the establishment of *Streptococcus sobrinus* in the oral cavity and was more effective in drinking water than in the diet.¹¹

Drinking tea (without added sugar) has been associated with lower caries levels in humans.^{12–15} Caries among children who drank a cup of tea immediately after lunch were found to be significantly lower. The data suggested that tea polyphenols may be responsible for the noted effects.¹⁶ Rinsing with 0.2% Chinese green tea while brushing has also been found to reduce plaque and gingival index significantly.¹⁵ Zhang and Kashket reported that tea extracts inhibits human salivary amylase and that tea consumption may reduce the cariogenic potential of starch-containing foods such as crackers and cakes because tea may reduce the tendency for these foods to serve as slow-release sources of fermentable carbohydrate.¹⁷ It is likely that the cariogenic challenge in a cariogenic diet is reduced by the simultaneous presence of green tea in the diet. Although tea is a source of fluoride

in addition to many other dietary trace elements, recent studies have demonstrated that tea polyphenols rather than fluoride contributes to the anticariogenic potential.^{18–22} Several mechanisms have been proposed for the observed anticariogenic properties of teas. These include tea's inhibitory effect on bacterial growth, bacterial viability, glucosyltransferase, and salivary α -amylase activities.^{9,12,23–25}

Thus far, most research on antimicrobial activity and oral health benefits of teas has focused on green tea or oolong tea^{12,24}; less attention has been directed to the fully fermented black tea. Worldwide, 80% of the tea consumed is black tea, which is also the more popular drink in Europe and Northern American countries. Recent studies in Wu's laboratory have demonstrated that black tea and its polyphenols inhibit growth, acid production, metabolism, and glucosyltransferase enzyme activity of *S. mutans* and dental plaque bacteria.^{26–29} Adults rinsing with black tea 10 times a day for 7 d had a significantly less pronounced pH fall, lower plaque index ($P < 0.05$), and numerically fewer *S. mutans* and total oral *Streptococci* in plaque but not in saliva. Fluoride concentrations in plaque and saliva increased, reaching a maximum at day 7.²⁸ It is evident that black tea and its polyphenols also benefit human oral health by inhibition of dental plaque, its acidity, and its cariogenic microflora.

Although there has been a substantial amount of research on teas and their health benefits, it has been difficult to compare in vitro and in vivo data across laboratories due to lack of standardized experimental procedures, i.e., documentation of types of tea, sources and manufacturing methods of tea; procedures for extraction; and standardization and analytical properties of tea. Improvement in these aspects and the design of controlled clinical and multidisciplinary research studies is warranted.

In recent years, the general population has demonstrated increased awareness and interest in "functional foods," i.e., foods with positive human health benefits or bio-regulatory functions. Researchers have explored not only desirable food habits but also beverages that may contribute to overall health and disease prevention. With the added dental health implication, tea may be considered a "functional food for oral health," by controlling through prevention,

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the most prevalent infectious disease of mankind, namely caries.

REFERENCES

- Graham HN. Green tea composition, consumption, and polyphenol chemistry. *Prev Med* 1992;21:334
- Mitscher LA, Jung M, Shankel D, et al. Chemoprotection: a review of the potential therapeutic antioxidant properties of green tea (*Camellia sinensis*) and certain of its constituents. *Med Res Rev* 1997;17:327
- Wheeler S. Tea and tannins. *Science* 1979;204:6
- Wei SH, Hattab FN, Mellberg JR. Concentration of fluoride and selected other elements in teas. *Nutrition* 1989;5:237
- Friedman M, Solouki S, Gurevitz S, et al. Fluoride concentrations in tea. Its uptake by hydroxyapatite and effect on dissolution rate. *Clin Prev Dent* 1984;6:20
- Hamilton-Miller JM. Antimicrobial properties of tea (*Camellia sinensis* L.). *Antimicrob Agents Chemother* 1995;39:2375
- National Institute of Dental Research. *Oral health of United States children. The national survey of dental caries in U.S. school children. 1986-1987*. Bethesda, MD: National Institute of Dental Research, 1989
- Elvin-Lewis M, Vitale MK, Opjas T. Anticariogenic potential of commercial teas. *J Prev Dent* 1980;6:273
- Otake S, Makimura M, Kuroki T, et al. Anticaries effects of polyphenolic compounds from Japanese green tea. *Caries Res* 1991;25:438
- Sakanaka S, Aizawa M, Kim M, et al. Inhibitory effects of green tea polyphenols on growth and cellular adherence of an oral bacterium, *Porphyromonas gingivalis*. *Biosci Biotech Biochem* 1996;60:745
- Ooshima T, Minami T, Matsumoto M, et al. Comparison of the cariostatic effects between regimens to administer oolong tea polyphenols in SPF rats. *Caries Res* 1998;32:75
- Ooshima T, Minami T, Aono W, et al. Oolong tea polyphenols inhibit experimental dental caries in SPF rats infected with mutans streptococci. *Caries Res* 1993;27:124
- Ooshima T, Minami T, Aono W, et al. Reduction of dental plaque deposition in humans by oolong tea extract. *Caries Res* 1994;28:146
- Parajas IL. Caries preventive effect of wild tea (tsaang-gubat) among school children. *J Philipp Dent Assoc* 1995;47:3
- You SQ. Study on feasibility of Chinese green tea polyphenols (CTP) for preventing dental caries. *Chung-Hua Kou Chiang Hsueh Tsa Chih Chinese* 1993;28:197
- Sakanaka S, Kim M, Taniguchi M, et al. Antibacterial substance in Japanese green tea extract against *Streptococcus mutans*, a cariogenic bacterium. *Agr Biol Chem* 1989;53:2307
- Zhang J, Kashket S. Inhibition of salivary amylase by black and green teas and their effects on the intraoral hydrolysis of starch. *Caries Res* 1998;32:233
- Yu H, Oho T, Xu LX. Effects of several tea components on acid resistance of human tooth enamel. *J Dent* 1995;23:101
- Rosen S, Elvin-Lewis M, Beck FM, et al. Anticariogenic effects of tea in rats. *J Dent Res* 1984;63:658
- Elvin-Lewis MR. The anticariogenic effects of tea drinking among Dallas school children. *J Dent Res* 1986;65:198
- Kashket S, Paolino VJ, Lewis DA, et al. In-vitro inhibition of glucosyltransferase from the dental plaque bacterium *Streptococcus mutans* by common beverages and food extracts. *Arch Oral Biol* 1985;30:821
- Onishi M, Ozaki F, Yoshino F, et al. An experimental evidence of caries preventive activity of non-fluoride component in tea. *Koku Eisei Gakkai Zasshi* 1981;31:158
- Hattori M, Kusumoto IT, Namba T, et al. Effect of tea polyphenols on glucan synthesis by glucosyltransferase from *Streptococcus mutans*. *Chem Pharm Bull (Tokyo)* 1990;38:717
- Nakahara K, Kawabata S, Ono H, et al. Inhibitory effect of oolong tea polyphenols on glycosyltransferases of mutans *Streptococci*. *Appl Environ Microbiol* 1993;59:968
- Saito N. Anti-caries effects of polyphenol compound from *Camellia sinensis*. *Nichidai Koko Kagaku* 1990;16:154
- Wei GX, Wu CD. Black tea extract and polyphenols inhibit growth and virulence factors of periodontal pathogens. *J Dent Res* 2001;80:73
- Wei GX, Wu CD, Nickelsen J, et al. Effects of black tea extract on oral pathogens. *J Dent Res* 1999;78:414
- Wu CD, Wefel JS, Lingstrom P. Anticariogenic potential of black tea. *Proceedings of the American Society for Microbiology Annual Meeting*. 2001:327
- Bhalla P, Srikantha R, Grigsby W, et al. Effect of green tea extracts on regrowth and metabolism of human plaque. *J Dent Res* 1997;76:267