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FILE: ▪Green Tea (*Camellia sinensis*)

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RE: Constituents of Tea and Their Health Benefits

Cooper R, Morré J, Morré DM. Medicinal benefits of green tea: part I. Review of noncancer health benefits. *J Altern Complement Med.* 2005;11(3):521–528.

Tea, as white tea, green tea, or black tea, comes from *Camellia sinensis*. It is the method of drying and preparation of these teas that differentiates them. Tea consumption began about 5000 years ago in southwest China, where it was used medicinally to treat various illnesses. Practitioners of Traditional Chinese Medicine (TCM) started recommending tea for the prevention of disease between 1100 BCE and 200 BCE, but it was the during the T'ang dynasty (618–907 BCE) that tea became venerated and the Chinese trade in tea flourished. The medicinal use of tea in TCM continues today. More recently the constituents of tea and their health benefits have been the subject of a growing amount of research, which is the focus of this article.

Constituents

The medicinal properties of green tea are attributed to its polyphenols, a class of chemicals produced in many different plants. Highly prized is "tea flush," which are young shoots consisting of a terminal bud and two adjacent leaves. Tea flush contains 20%–35% polyphenols by weight, 60–80% of which are catechins. Processing of fresh tea leaves into green tea by steaming the leaves or panfiring them decreases the polyphenols to approximately 15%; however, age of the leaf, harvest season, climate, environmental stress, horticultural practices, processing and storage all affect the polyphenol content.

Catechins are the major polyphenols in green tea, and include (-)-epigallocatechin gallate (EGCg), catechin (C), epicatechin (EC), gallocatechin (GC), gallocatechin gallate (GCG), epigallocatechin (EGC) and epicatechin gallate (ECG). During processing, green tea polyphenols are partially converted to theaflavins. Other constituents present in smaller amounts include caffeine, theanine, theobromine, theophylline, and phenolic acids (e.g., gallic acid). Green tea has approximately twice the catechins as black tea. One cup of green tea contains 60–125 mg catechins compared to 30–60 mg in black tea. A cup of green or black teas contain similar amounts of caffeine (20–50 mg vs 30–60 mg, respectively) and L-theanine (20–40 mg for each). A cup of green tea does not contain detectable amounts of theaflavin while a cup of black tea has 3.0–6.0 mg theaflavins.

Weight loss

Animal and human studies have shown that green tea and isolated catechins promote weight loss and increase thermogenesis. Female mice fed diets containing 1–4% catechins for four months "had a

significant suppression of food intake, body weight gain, and fat tissue accumulation." Serum leptin (a hormone that stimulates feeding behavior) also decreased. In a second study, 10 volunteers consumed green tea extract (concentration of polyphenols not reported), which resulted in a significant 4% increase in energy expenditure ($P < 0.01$) and a significant decrease in respiratory quotient (ratio of the volume of carbon dioxide produced during cellular metabolism to the volume of oxygen consumed). Urinary excretion of norepinephrine also increased compared to placebo. In contrast to catechins, treatment with 50 mg of caffeine "had no effect on energy expenditure or fat oxidation."

The proposed mechanism for green tea catechins' thermogenic action is their inhibition of catechol-o-methyl-transferase (COMT), the enzyme responsible for breaking down norepinephrine. Decreasing COMT activity increases norepinephrine concentrations, which increases thermogenesis. The authors conclude that "these studies on the thermogenic properties of green tea extract have demonstrated a synergistic interaction between caffeine and catechin polyphenols that appears to prolong sympathetic stimulation of thermogenesis." This conclusion, however, is not supported by the research they included in their review. No studies analyzing the interactions between catechins and caffeine were included. The fact that 50 mg of caffeine failed to increased energy expenditure or fat oxidation appears to contradict their conclusion. Additional research might provide clarification. In the meantime, the animal and human studies cited in this article support the use hypothesis that green tea can increase energy expenditure and might promote weight loss. Further human clinical trials are necessary to confirm this effect.

Cardiac health and theaflavins

Theaflavins are produced when tea leaves are fermented to make black tea. The authors cite epidemiological evidence and clinical trials to support the use of theaflavins in reducing cardiovascular disease (CVD) risk factors and mortality. Elevated total- and low-density lipoprotein (LDL)-cholesterol and oxidation of cholesterol are involved in the development of atherosclerosis.

Two long-term prospective Dutch studies concluded men and women who consumed as little as 3 cups (~13 ounces) per day of black tea reduced myocardial infarction risk by 68% compared to nontea drinkers. Drinking more than 4.7 cups per day (~20 ounces/day) of black tea cut the risk of stroke in men by 31% compared to men who drank less than 2.6 cups per day (~11 ounces/day). A Japanese study found that consuming 10 cups (~32 ounces) per day of green tea reduced the risk of death from coronary heart disease in men and by 58% compared to those who drank 3 cups per day (~10 ounces) or less. These results were supported by a meta-analysis that showed that "regular, frequent consumption of tea (3 or more cups daily) may reduce the risk of heart attack."

A 12-week placebo-controlled trial of 240 men and women 18 years or older analyzed the effect of 375 mg of theaflavin-enriched green tea extract on total cholesterol, LDL-cholesterol, high-density lipoprotein (HDL)-cholesterol (a.k.a. "good cholesterol") and triglyceride levels compared to placebo. Each capsule in the verum group contained 75 mg of theaflavins, 150 mg green tea catechins and 150 mg of "other tea polyphenols." The authors reported that "the theaflavin-enriched green tea extract was shown to be an effective adjunct to a low-saturated-fat diet to reduce LDL in hypercholesterolemic adult and was well tolerated." The authors did not report that this change was statistically significant compared to placebo or whether the theaflavin-enriched green tea extract was compared to non-theaflavin-enriched green tea extract. It is difficult to conclude from this report if the theaflavin-component was responsible for the results and not the catechins or an interaction between the compounds.

One proposed mechanism by which green tea and tea catechins might reduce cardiovascular disease risk and mortality is by inhibiting LDL oxidation. When LDL becomes oxidized (damaged by free

radicals) it can injure the endothelium (inner lining of blood vessels). In the currently accepted theory of the pathogenesis of atherosclerosis, damage to the endothelium is an important step in the development of atherosclerosis. Additional steps include inflammation, deposition of cholesterol in the injured tissue, migration of macrophages (immune cells) to the site of injury, ingestion of cholesterol by macrophages (now called "foam cells"), and migration of smooth muscle over the injury during repair. Rats given green tea extracts (type of extract, dosages and duration of the study not reported) experienced "reduced" endothelial cell damage by oxidized LDL.

The authors conclude from this and other studies that "the potent antioxidant properties of polyphenols reduce free radical damage to cells and prevent the oxidation of LDL cholesterol, both of which would be expected to inhibit the formation of atherosclerosis." These results may provide a mechanism to explain why habitual consumption of green and black teas reduced the risk of myocardial infarction and death from coronary artery disease in epidemiological studies.

Arthritis
Green tea polyphenols may be helpful in the treatment of arthritis. One controlled animal study "reported positive benefits" (statistical significance not reported) in reducing expression of cyclooxygenase 2 (COX-2, an enzyme involved in inflammation), interferon-γ (IFN-γ, an immune system activator) and tumor necrosis factor-α (TFN-α, also involved in immune system activation and inflammation) in the arthritic joints of treated mice. The incidence of collagen-induced arthritis was 33% in treated mice compared to 50% in controls. The dosage, amounts of polyphenols, and whether the mice were pre-treated with the green tea extract or treated after they developed arthritis was not reported.

Bone density
Epidemiological evidence points to a supportive role of tea in preventing osteoporosis. A study of 1256 women, ages 65–76, in the United Kingdom concluded that "tea drinkers had significantly greater mean bone mineral density measurements (~5%, adjusted for age and body mass index)." The tannins in black tea, however, decreased calcium and iron absorption "to some extent" in an animal study (amount of decrease not reported). Although this epidemiological study is compelling, a prospective, randomized, controlled trial is needed to determine whether tea consumption prevents loss of bone mineral density.

Stress and theanine
The authors report that tea has been used in the Orient for years for its "calming and curative properties." L-theanine, an amino acid in green and black teas, has been studied for its anxiolytic effects. Theanine may decrease cortisol (a stress hormone) and anxiety. In clinical trials L-theanine increased alpha brain wave activity. Alpha waves are associated with a relaxed and alert mental state. Other brain waves are theta, associated with drowsiness; and beta, associated with stress and anxiety.

L-theanine might also be useful in treating hypertension. Studies (number unspecified) demonstrated the ability to theanine to normalize elevated blood pressure in rats. L-theanine had no effect on normal blood pressure. The pharmacokinetics of L-theanine have been studied. Peak blood concentration is reached between 30 minutes and 2 hours after consumption.

Antiviral properties
Tea catechins have shown promise in treating human immunodeficiency virus (HIV) infection in vitro, according to the authors, by decreasing virion (infectious virus particles). These effects have not been tested in humans.

Anticariogenic effect
Formation of dental caries (cavities) has been prevented in vitro and in vivo by green tea. Drinking green or black tea (amount not reported) decreases maltose release (a sugar that is easily fermentable by bacteria in the mouth and can contribute to periodontal disease) by 70%. Additionally, green tea extract (dose not reported) decreased gingival (soft tissue around the teeth) inflammation caused by dentures and "strongly inhibited" the growth of four bacteria which can cause cavities and other oral pathologies (*Escherichia coli*, *streptococcus salivarius*, and *S. mutans*). The antibacterial effects were comparable to the antibiotics amoxicillin and cepharadine, as well as eugenol (an alcohol extracted from cloves [*Syzygium aromaticum*]).

Ultraviolet skin protection
Topical extracts of green tea might protect the skin from ultraviolet (UV) radiation damage, the major contributor to skin cancer. A human clinical trial with topical EGCg applied prior to UV exposure prevented skin damage. It did so by restoring glutathione (GSH, the body's major endogenous antioxidant) that was normally destroyed by UV radiation. The authors caution, "Further studies are warranted to elucidate the preventive effects of EGCg against multiple exposures of human skin to UV light."

—John Neustadt, ND

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