TEA & HEALTH
An Overview of Research on the Potential Health Benefits of Tea

Introduction

Tea is an ancient beverage steeped in history and romance and loved by many. In fact, tea is the most commonly consumed beverage in the world after water. There are various legends about how tea was discovered, but the most famous is the story of Shen Nung, the ancient Emperor of China, who, in 2737 BC, was boiling his drinking water when leaves from a nearby tea bush tree blew into the cauldron. After drinking the brew, the emperor was pleasantly surprised by its flavor and restorative properties. Thus, tea was born. It quickly became the favorite beverage in China and spread to Europe and the Americas.

All tea is derived from one plant, *Camellia sinensis*. Green Tea is produced by heating the leaves shortly after harvesting through a process of steaming or pan-firing to prevent oxidation from occurring, and then rolling and drying the leaves. Black and Oolong Tea undergo full or partial oxidation, which makes the leaves—and subsequent brew—darker in color.

Throughout history, tea has been believed to help "purify the body" and "preserve the mind." Over the past several decades, thousands of published studies in leading medical journals have provided the proof to support tea's ancient health claims.

How Tea Works in the Body

Tea contains hundreds, if not thousands, of bioactive compounds, including amino acids, caffeine, lignins, proteins, xanthines and flavonoids. Tea flavonoids and the related polyphenols account for more than one-third of the weight of tea leaves; the health benefits of tea are most often attributed to tea flavonoids.[1]

Tea flavonoids are bioactive compounds that have specific cellular targets that are related to the cardiovascular, chemopreventive, metabolic, neuroprotective and other health benefits. Recent research has explored the potential health attributes of tea through human clinical trials, population-based studies, and *in vitro* laboratory research.

Additional research suggests tea flavonoids and related bioactive compounds in tea may play important roles in various areas of health and may operate through a number of different mechanisms still being explored.

Tea's Role in Cardiovascular Health

Human population studies have found that people who regularly consume three or more cups of Black Tea per day have a reduced risk of heart disease and stroke.[2-6] Clinical studies suggest that the risk reduction associated with tea consumption may be due to improvement in some risk factors for cardiovascular disease, including blood vessel function, platelet function and a reduction in oxidative damage.[4,7-24]

While researchers are still examining the various mechanisms by which tea flavonoids function, some studies suggest multifunctional mechanisms, meaning that several mechanisms work in tandem to collectively improve markers for cardiovascular health. Important areas of tea and cardiovascular health research include blood vessel and endothelial function, or the ability of the blood vessels to dilate to allow for proper blood flow, serum cholesterol levels and Low Density Lipoprotein (LDL) cholesterol oxidation.[12-24] Each of these factors impacts the risk of myocardial infarctions (heart attacks), stroke and cardiovascular disease. Study findings in the area of tea and the reduction in cardiovascular disease risk include the following:

Cardiac Events

- In a prospective study of more than 74,000 subjects who were followed for 10 years, an inverse relationship was found between tea drinking and risk of stroke. During that time, 4,089 cases of stroke were recorded. After adjusting for other risk factors, tea consumption was associated with a significantly lower risk of stroke. Those who consumed four or more cups of tea per day had a 21 percent reduced risk of stroke compared to those who did not drink tea.[2]
- A meta-analysis including data from nine studies involving 4,378 strokes among 194,965 subjects found that those consuming at least three cups of Green or Black Tea per day had a 21 percent lower risk for stroke compared to those consuming less than 1 cup per day.[3]

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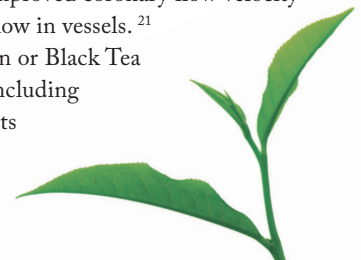kleonardis@pollock-pr.com • (212) 941-1414

- A total of 3,430 men and women aged 30 – 70 years from the Saudi Coronary Artery Disease Study were examined and 6.3 percent were found to have indications of coronary heart disease (CHD). The researchers found that those who drank more than six cups of tea per day (>480 mL) had significantly lower prevalence of CHD than non-tea drinkers, even after adjustment for risk factors such as age and smoking. The researchers also found that drinking six or more cups of Black Tea per day was associated with decreased serum cholesterol and triglyceride concentrations.
- Dutch researchers assessed 4,807 subjects aged 55 years or older without prior history of heart attack. After a four to seven year follow-up period, the researchers determined that subjects who drank three or more cups of tea per day (375 mL/day) were 43 percent less likely to develop myocardial infarction and 70 percent less likely to die from myocardial infarction than non-tea drinkers. [5]
- A recent meta-analysis discovered that consumption of three cups of tea per day was associated with an estimated decrease of 11 percent in the incidence of myocardial infarction (heart attack). [6]
- The Zutphen study, which assessed 805 male subjects over a period of five years, found that the incidence of fatal and nonfatal first myocardial infarction and mortality from stroke decreased significantly as intake of flavonoids, derived mainly from tea, increased in a dose-dependent manner. A follow-up to this study found that high intake of flavonoids significantly lowered the risk of stroke in study participants. [8]
- A Harvard study examined 340 men and women who had suffered heart attacks and compared them to matched control subjects. Researchers found that subjects who drank one or more cups of Black Tea daily had a 44 percent reduction in the risk of heart attack compared to non-tea drinkers. [9]
- Another Harvard study of 1,900 people found that those who consumed tea during the year prior to a heart attack were up to 44 percent more likely to survive over the three to four years following the event. Those who consumed fewer than 14 cups of tea per week experienced a 28 percent reduced death rate, and those who consumed more than 14 cups of tea per week were found to have a 44 percent reduced death rate, as compared to non-tea drinkers. [10]
- A large population study of more than 40,000 middle-aged Japanese men and women reported that those who drank just over two cups (about 17 ounces) of Green Tea per day reduced their risk of death from cardiovascular disease by 22 to 33 percent, compared to those who drank less than a half-cup (3.5 ounces) of Green Tea daily. [11]

Cholesterol Reduction

- Researchers from the United States Department of Agriculture (USDA) studied the effect of tea on 15 mildly hypercholesterolemic adult participants following a "Step I" type diet moderately low in fat and cholesterol, as described by the American Heart Association and the National Cholesterol Education Program. After three weeks, researchers found that five servings of Black Tea per day reduced LDL ("bad") cholesterol by 11.1 percent and total cholesterol (TC) by 6.5 percent compared to placebo beverages. Recent clinical trials have not confirmed these results, however additional work is being done in this area.

- The mechanism behind the blood cholesterol lowering effects of tea may be rooted in the effect of theaflavins, through interfering with the formation of dietary mixed micelles, which could result in reduced intestinal cholesterol absorption. Theaflavin-treated micelles/particles were analyzed and theaflavins were shown to have a dose-dependent inhibitory effect on the incorporation of cholesterol into micelles. The primary theaflavin identified for its effects was theaflavin-3-gallate. [13]

Cardiovascular Disease (CVD) Risk Factors

- Tea consumption improves endothelial function by increasing nitric oxide bioavailability and enhancing vasorelaxation. Tea catechins, epigallocatechin-3-gallate and epicatechin, provided at concentrations achievable in human tissues, relaxed blood vessel tone of isolated arterial walls in an animal model. [14]
- In a randomized, double-blind, placebo-controlled study of 19 males, daily Black Tea consumption increased flow mediated dilation (FMD) from an average of 7.8 percent to up to 10.3 percent, depending on flavonoid dosages. The flavonoids in as little as one cup of tea (about 100 mg flavonoids) were found to improve FMD. Black Tea decreased systolic blood pressure by 2.6 mm/Hg and diastolic by 2.2 mm/Hg. [15]
- Dutch researchers found that study participants who drank one to two cups of Black Tea daily had a 46 percent lower risk of severe aortic atherosclerosis, a strong indicator of cardiovascular disease. Those who drank more than four cups of tea per day had a 69 percent lower risk. [16]
- A recent clinical study showed that short- and long-term consumption of Black Tea by subjects with coronary artery disease restored endothelial and blood vessel function to levels similar to those of healthy subjects. Endothelial function is the ability of the inner lining of blood vessels to dilate in response to increased blood flow.
- Another clinical study found that regular ingestion of tea resulted in a significant and consistent increase in endothelium-dependent and endothelium-independent blood vessel dilation. Subjects with mild elevations in serum cholesterol or triglyceride concentrations consumed either five cups of Black Tea or hot water per day for four weeks. The researchers hypothesized that one mechanism for the apparent beneficial effects of tea on cardiovascular health could be this improved vasodilator function.
- *In vitro* studies have shown that tea flavonoids protect low-density lipoproteins from oxidation, inhibit plasma lipid peroxidation, platelet aggregation and thromboxane formation – all factors important for maintaining a healthy circulatory system., Studies in animals are promising, but human studies conducted to date on the effect of tea consumption on LDL oxidation are inconclusive.
- A double-blind crossover design clinical study found that Black Tea versus a caffeinated control beverage improved coronary flow velocity reserve, a measure of increased blood flow in vessels. [21]
- Animal model studies found that Green or Black Tea both improved risk factors for CVD, including reduced blood lipids, serum antioxidants levels and improvements in blood clotting factors. [22]

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- A longitudinal study with more than 1,500 Taiwanese subjects found that those who drank more than 2.5 cups of tea per day reduce their risk of developing high blood pressure by 65 percent compared to those who drank the least amount of tea. [23]
- An *in vitro* study found that Green Tea polyphenols inhibit the proliferation of aortic smooth muscle cells to prevent the development of atherosclerosis. [24]

Tea's Role in Cancer Risk Reduction

More than 3,000 published research studies exist that evaluate the role tea—whether white, green, oolong or black—and tea compounds, such as epigallocatechin gallate (EGCG), may play in cancers of various sites. The studies suggest that tea compounds have many mechanisms by which they provide chemo-protection: reducing free radical and DNA damage; inhibiting uncontrolled cell growth (cell proliferation) by promoting programmed cell death (apoptosis); and boosting the immune system to help fend off the development and promotion of cancer cells. [25-28] Leading scientists worldwide are actively studying these potential mechanisms, with clinical trials and population studies underway. More evidence is needed before any definitive conclusions can be drawn. Preliminary research suggests tea may provide protection against various types of cancer including digestive, skin, lung, prostate, breast and ovarian cancers. [29-61] Recent findings include:

DNA Damage
- Oxidative DNA damage is implicated in the development of various forms of cancer. Recent studies have found that smokers who drank four cups of decaffeinated Green Tea per day demonstrated a 31 percent decrease in biomarkers of oxidative DNA damage in white blood cells as compared to those who drank four cups of water after four months (P=0,001). [25, 26]
- Epigallocatechin gallate (EGCG) may protect normal cells from cancer-causing hazards and eliminate cancer cells though apoptosis. Researchers tested the potential anti-cancer benefits of the Green Tea polyphenol EGCG in hamster cells and discovered that EGCG suppressed DNA changes and damage from carcinogens. EGCG also protected against further damage from the carcinogens and inhibited growth and multiplication of cancer cells. [27]
- An animal study identified beneficial changes in immune function after Black Tea ingestion in cancer-bearing animals. Black Tea beneficially altered immune responses that helped protect immune cells against harmful cancerous cells. The study found Black Tea acted like anti-cancer drugs that help boost the immune system without promoting the proliferation of cancerous cells. [28]

Digestive Cancers
- In a meta-analysis of 24 case control and cohort studies with 7,376 subjects, Zhejiang University researchers reported an inverse association between the highest green tea consumption and esophageal cancer. The pooled data found a 30 percent reduction for those who reported the highest Green Tea consumption versus no consumption. [29]
- An epidemiological study conducted by the University of North Carolina found consumption of the equivalent of 2.5 cups or more of tea per day was associated with a 60 percent drop in rectal cancer risk among Russian women from Moscow, as compared to women who drank relatively less than 1.2 cups of tea per day. Those women who drank approximately 1.2 to 2.5 cups of tea per day had a 52 percent reduction in the risk of rectal cancer. [30]
- Based on data from the NHANES I Follow-Up Study (NHEFS), researchers found that tea drinkers had approximately a 42 percent reduced risk of colon cancer as compared to non-tea drinkers. Men who drank more than 1.5 cups of tea per day were found to have a 70 percent lower colon cancer risk. [31]
- Researchers who followed a group of more than 34,000 postmenopausal healthy women between 55 and 69 years of age for 12 years found that those who consumed high levels of catechins experienced up to a 45 percent decrease in the instances of rectal cancer. Catechins are a class of flavonoids found in tea, fruits and vegetables. Catechins derived from tea were most strongly linked to a decrease in rectal cancer. [32]
- The Iowa Women's Study, which followed postmenopausal women between the ages of 55 and 69 for eight years, found that participants who drank two or more cups of tea per day had a 32 and 60 percent reduced risk of developing digestive and urinary tract cancers, respectively. [33]
- A study conducted with members of the Shanghai Cohort (18,244 men aged 45 – 64 years at recruitment with up to 12 years of follow-up) discovered a statistically significant inverse relationship between positive tea polyphenol levels (as measured in urine) and gastric cancer. [34]
- A large population-based case-control study found an inverse relationship between Green Tea consumption and the risk of colon, rectal and pancreatic cancer. Male participants, who drank the equivalent of 4.5 servings of tea per day, had an 18 percent decrease in colon cancer risk and 28 percent decreased risk of rectal cancer. Female participants, who drank three servings of tea per day, were observed to have a decreased risk of colon and rectal cancer by 33 percent and 43 percent, respectively. Risk of pancreatic cancer was also reduced in both men and women by 37 percent and 47 percent, respectively. [35]
- Researchers examined whether a combination of two compounds known to exhibit anti-cancer activity, Green Tea polyphenol, EGCG, and sulindac (a non-steroidal anti-inflammatory drug), would work synergistically to prevent colon cancer carcinogenesis in rats. Findings suggested that EGCG and sulindac worked together to suppress pre-cancerous lesion formation by enhancing programmed cell death (apoptosis). [36]
- Researchers sought to investigate the effect of Black Tea polyphenols (BTP) on induced DNA damage to colon mucosa in an animal model. Findings suggest that induced DNA damage to the colon mucosa is prevented by consumption of Black Tea polyphenols. [37]
- Major compounds of Green and Black Tea, EGCG and theaflavins, respectively, are known to inhibit proteins which are closely associated with tumor growth and metastasis. These polyphenols exhibited apoptosis-inducing activity for human colon cancer cell lines. [38]
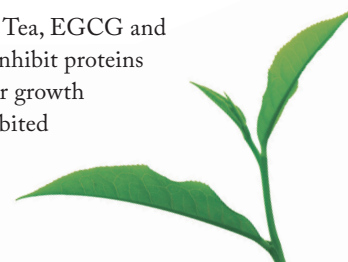
- Researchers in Taiwan discovered a link between EGCG and cancer risk reduction. The researchers found that the Green Tea polyphenol inhibited proliferation of the cancer cells by inducing cell death and blocking cell cycle progression. [39]
- Researchers at the University of South Carolina used animals with colon cancer and provided them with either water or Green Tea as their beverage. They subsequently found that those given Green Tea significantly reduced their risk of developing new colon cancer tumors, suggesting that Green Tea was effective in the initial stages of colon carcinogenesis. [40]

Prostate Cancer

- Researchers at the University of Wisconsin, Madison reviewed the existing literature about tea as a preventative measure for prostate cancer among men. Based on epidemiological in vitro and in vivo studies, the researchers suggest that tea—especially Green Tea—may be a good public health recommendation that may help prevent prostate cancer. [41]

Skin Cancer

- According to a study conducted by the University of Arizona, participants who drank iced Black Tea and citrus peel had a 42 percent reduced risk of skin cancer. [42]
- Hot Black Tea consumption is associated with a significantly lower risk of squamous cell carcinoma (SCC), a form of skin cancer; tea concentration (strength), brewing time and temperature all influence the potential protective effects of hot Black Tea on SCC. [43]
- Oral consumption of Green or Black Tea decreased the number of tumors in mice following exposure to UV radiation. [44]
- Green Tea polyphenols may have cancer prevention potential, especially in the case of solar UV-induced cancer. [45]
- Research suggests that compounds in Green Tea may protect skin from ultraviolet (UV) radiation-induced damage when applied topically. [46]
- Topical treatment of Green Tea polyphenols on human skin prior to UV exposure inhibited indicators of DNA damage, thus inhibiting photocarcinogenesis, or UV-induced skin cancer. [47]
- Experiments show that administration of Green Tea, Black Tea or specific flavonoids in tea inhibited the growth of established nonmalignant and malignant skin tumors in tumor-bearing mice. In addition, oral administration of Black Tea inhibited DNA synthesis and enhanced cell death (apoptosis) in both nonmalignant and malignant tumors in tumor-bearing mice. [48]
- In a human clinical trial, 16 healthy adults were given 540 mg Green Tea catechins with vitamin C for 12 weeks. The researchers then exposed their skin to UV radiation and they reported a reduction in UV-induced inflammation as a result of Green Tea polyphenols and vitamin C. [49]

Oral Cancer

- A human intervention trial examined the effect of treating superficial precancerous lesions (leukoplakia) in the mucosal lining of the mouth with a mixed tea product. After the six-month trial, partial regression of the lesions was observed in 37.9 percent of the group treated with tea as compared to only 10 percent of those treated with a placebo. [50]

- Researchers examined the effects of tea and curcumin, a spice and food-coloring agent, on oral cancer in hamsters. Hamsters were treated with a topical cancer-causing solution inside the cheek three times a week for six weeks. Two days after the last treatment of the solution, the hamsters were given Green Tea as drinking fluid or curcumin applied topically three times per week, the combination of Green Tea and curcumin treatment, or no treatment for 18 weeks. At the end of this period, the scientists observed that the combination of tea and curcumin significantly decreased the number of visible tumors and tumor volume. Furthermore, tea alone and in combination with curcumin increased cancer cell death (apoptosis). [51]

Lung Cancer

- In a review of observational studies on tea consumption, flavonoid intake and lung cancer risk, evidence suggests beneficial associations for Green and Black Tea, especially among never-smokers. The review notes studies reporting increased risk with high tea intake are older and that later published data have not confirmed these concerns. [52]
- Studies comparing groups of mice treated with a tobacco-specific carcinogen and receiving either water or water enriched with tea-derived polyphenols found that the tea-fed mice developed 24 percent fewer lung tumors and the average size of the tumors was 38 percent smaller as compared to the water-fed mice. [53,54]
- Tea catechins were evaluated for their effects on cell proliferation, apoptosis and associated gene expression in highly metastatic human lung cancer cells. A significant reduction in cell proliferation after exposure to tea catechins was noted. It is suggested that tea compounds can influence genetic alteration to reduce the grown and survival of human lung cancer cells. [55]
- In an *in vitro* study, researchers exposed highly metastatic lung cancer cell lines to tea polyphenols and found that tea polyphenols inhibited the expression of cancer cells to the endothelial cell walls. The mechanism of tea polyphenol prevention of human lung carcinoma metastasis might be through inhibiting adhesion molecule expression to block cancer cell adhesion. [56]

Ovarian Cancer

- A case-control study conducted in China, which employed 254 patients with histologically confirmed epithelial ovarian cancer and 652 control subjects, determined tea consumption based on a validated questionnaire and found that, after accounting for demographic, lifestyle and familial factors, ovarian cancer risk declined with increasing frequency and duration of overall tea consumption. [57]
- A population-based study involving more than 61,000 Swedish women aged 40 – 76 found that drinking Black Tea was associated with a reduced risk of ovarian cancer. The study found that women who drank the most tea—green or black—were least likely to develop ovarian cancer over the 15-year study follow-up. Women who drank two or more cups of tea daily experienced a 46 percent reduction in risk compared to women who reported not

drinking tea. Even small amounts of tea (less than one cup per day) reduced risk by 18 percent, while one cup per day reduced risk by 24 percent. Although previous studies evaluating the effects of tea consumption and ovarian cancer found inconsistent results, the researchers noted that the large size of this study and long-term follow-up provides compelling evidence that tea drinking may indeed offer protection against this type of cancer.

- A case-control study conducted in China compared tea-drinking habits among 500 patients with ovarian cancer versus controls. The control subjects reported higher consumption of tea, including green, black and oolong varieties. Regular tea drinking was associated with a 71 percent reduced risk for ovarian cancer among this population. [56]

Breast Cancer

- In a study with 10 women with advanced breast cancer undergoing radiation therapy for treatment, half were given radiation therapy plus 400 mg epigallocatechin-3-gallate (EGCG) three times daily. The results showed that the EGCG helped inhibit cell proliferation, cell invasion and angiogenesis. The authors concluded that EGCG may be an effective strategy to inhibit the spread of invasive breast cancer cells. [60]
- Results from a large epidemiologic study examining the association of regular tea consumption with the risk of breast cancer found that women under 50 years with moderate tea consumption (three or more cups per day) had a 37 percent reduced breast cancer risk. [61]

Tea's Role in Neurological Health

Age-related declines in memory and cognition occur naturally, but research suggests that modifiable factors, such as diet and exercise, may help slow the progression of age-related neurodegeneration., Research indicates recommendations to improve heart and cardiovascular function are also neuroprotective.[62,63] The benefits of tea that help improve biomarkers for reducing risk of heart disease may improve brain health too. The bioactive compounds found in tea may promote neurological health through various actions. [64-67] In addition, L-theanine in tea has been shown to directly affect areas of the brain that control attention and ability to solve complex problems. [68-70]

Neurological Diseases

- Research reports that tea polyphenols, particularly (-)-epigallocatechin-3-gallate, are bioavailable to the brain and can act via antioxidant, iron-chelation, signal transduction modulation, and other mechanisms to effect neuroprotective and/or neurorescue action, with potential implications for age-related dementia, and Alzheimer's and Parkinson's diseases. [64]
- In an animal model study, Japanese researchers found that theanine, the amino acid present almost exclusively in tea, may help prevent memory declines as we age by decreasing neuronal cell death. In their study, animals that were given theanine and were then subjected to repeated memory impairment, had less memory damage to their brains compared to animals who did not receive theanine. [65]
- Another animal model study found that the Green Tea catechin

EGCG was capable of reducing biomarkers associated with Alzheimer's disease. Using strains of mice transgenically bred to be prone to developing Alzheimer's disease, the researchers found that exposure to EGCG resulted in reduced production of amyloid protein, a marker for the development of plaques associated with Alzheimer's disease. [66]

- A prospective cohort study of nearly 30,000 Finnish adults aged 25 – 74 years old, who were followed for 13 years, found that tea drinking was associated with a reduced risk of Parkinson's disease. Among tea drinkers, those who reported drinking three or more cups of tea per day were 69% less likely to develop Parkinson's disease compared to those who reported not drinking tea. [67]

Cognitive Health

- A recent human study examined the effect of the unique tea amino acid L-theanine (-glutamylethylamide) on attention-related task performance. Task performance was measured by electroencephalographic (EEG), or the measurement of electrical activity produced by the brain as recorded from electrodes placed on the scalp. The results suggest L-theanine plays a role in attentional processing in synergy with caffeine. [68]
- A published randomized human clinical trial found that subjects given a daily supplement with green tea extract and L-theanine extracted from tea experienced improvements in mild cognitive impairments (MCI). In a test of attention and self-reported measure of alertness, subjects consumed two cups of tea (100 mg caffeine and 46 mg L-theanine) versus a placebo beverage. Results indicated that accuracy on the Attention Switching task was improved after tea as compared to the placebo, as well as performance on two of the four subtasks from the Intersensory Attention task. [70]
- Caffeine and L-theanine in tea may offer cognitive benefits and improve mental clarity and work performance. A cross-sectional study showed that participants who consumed more tea felt less tired and reported higher levels of subjective work performance. [71]

Tea and Metabolism, Obesity and Body Composition

Several studies suggest drinking calorie-free tea may help with weight management.[72-84] Preliminary research suggests that tea flavonoids help elevate metabolic rate, increase fat oxidation and improve insulin activity.[73,75,77, 82-84] Tea catechins can also provide modest shifts in metabolism that may improve weight loss and maintenance.[73,77,83,84] Key findings include the following:

- Using the National Health and Nutrition Examination surveys of 2003 – 2006, researchers identified a correlation between hot tea consumption and lower mean waist circumference and lower BMI among adult tea drinkers versus non-tea drinkers. In addition, hot tea drinkers had higher HDL cholesterol, lower C-reactive protein and women had lower levels of triglycerides. [72]

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- In a meta-analysis including six published tea research studies, 24-hour energy expenditure increased by 4.7 percent or 102 calories over 24 hours with a catechin-caffeine mixture and fat oxidation increased during the same period, revealing that tea may aid weight loss. [73]
- In a meta-analysis of 11 published clinical studies, catechins or epigallocatechin gallate (EGCG)-caffeine mixture have a modest positive effect on weight loss and weight maintenance. [74]
- Green Tea extract was found to significantly increase 24-hour energy expenditure and fat oxidation in healthy men. [75]
- After three months of consumption of Green Tea extract by moderately obese patients, body weight decreased by 4.6 percent and waist circumference decreased by 4.48 percent. [76]
- Average fat oxidation rates were 17 percent higher after acute green tea extract intake (890 +/- 13 mg polyphenols; 366 +/- 5 mg EGCG) during moderate exercise (30 minutes of cycling at 60 percent VO2max) in 12 healthy men, compared to a placebo (p<0.05). [77]
- Japanese researchers found that in a 12-week, double-blind and placebo-controlled study, Green Tea catechins led to a reduction in body fat, blood pressure and LDL cholesterol compared to the control group. The authors suggest that Green Tea catechins may help prevent obesity and reduce risk for cardiovascular disease. [78]
- A follow-up study of the effects of tea catechins on body fat reduction in humans was conducted by examining the effect of drinking Oolong Tea with added Green Tea extract in healthy, moderately overweight men. A double-blind study was performed in which the test subjects ingested one bottle of Oolong Tea containing 690 mg of catechins and control subjects ingested one bottle of Oolong Tea containing 22 mg of catechins for 12 weeks. Researchers found that body weight, body mass index (BMI), waist circumference, body fat mass and subcutaneous fat were all significantly lower in the high catechin-ingesting group as compared to the control group. Measures of LDL cholesterol oxidation were positively associated with the beneficial changes in body fat mass in the high catechin group. Researchers concluded that daily consumption of 690 mg of catechins, the equivalent of five cups of strong Green Tea, might be useful in preventing and improving obesity. [79]
- Researchers fed rats a high-fat diet and gave them green tea catechins while the researchers monitored adiponectin levels, insulin and visceral adipose tissue. Green tea catechins were found to decrease fat storage and help keep adiponectin levels normal on a high-fat diet. [80]
- Researchers examined mice that were fed either a low-fat diet, high-fat diet or high-fat diet supplemented with 0.1-0.5 percent tea catechins for 11 months. The scientists then measured body weight, fat tissue mass and liver fat content and discovered that supplementation with tea catechins resulted in a significant reduction of high-fat diet-induced body weight gain and visceral and liver fat accumulation. [81]
- Researchers compared the body weight and fat mass of mice that were fed a low-fat or high-fat diet, with swimming or not, and with or without tea catechins. They found that, when fed a high-fat diet, tea catechins helped reduce fat accumulation by 18 percent and exercise alone reduced accumulation by 14 percent. However, mice that exercised and had catechins reduced fat accumulation by 33 percent. This evidence suggests that tea catechins may increase fat metabolism, enabling the body to burn more fat as fuel and store less in the body. [82]
- Animals fed a high-fat, high-calorie diet to promote excessive weight gain and obesity were given Green Tea extract or placebo and their energy expenditure and fat oxidation were measured. The researchers found that Green Tea extract alone, as well as when combined with exercise, increased energy expenditure and stimulated fat catabolism. The researchers concluded that Green Tea extract combined with regular exercise stimulates fat metabolism and may attenuate obesity caused by a high-fat diet more effectively than Green Tea extract or exercise alone. [83]
- Animals fed a diet high in catechin-rich Green Tea extract were found to increase running times to exhaustion by up to 30 percent compared to a control animal. In addition, Green Tea extract appeared to shift metabolism so that the animals burned body fat and spared muscle glycogen, thereby increasing endurance time to exhaustion. [84]

Tea and Diabetes & Blood Sugar Control

Type 2 diabetes is considered a global epidemic. [85] Catechins in tea have been shown to help reduce blood sugar and provide insulin-boosting activity, which may be beneficial for people with both type 1 and type 2 diabetes, although further research is needed. [86-88] Some studies suggest a link between drinking tea and a reduced risk of type 2 diabetes. [87] The research includes:

- A meta-analysis of randomized controlled trials including 22 studies and 1,584 subjects found that Green Tea catechins (with or without caffeine) provided a reduction in fasting blood glucose. [86]
- Recent USDA research reviewed the effect of tea on insulin sensitivity and risk factors for diabetes. Epidemiologic studies suggest some relation between tea consumption and a reduced risk of type 2 diabetes. Some human clinical studies show tea and its components improved control of glucose metabolism and endothelial function, the decline of which is a marker for vascular diseases. [87]
- Researchers at the United States Department of Agriculture (USDA) conducted a study to examine the insulin-enhancing properties of tea and its components. An in vitro test using a fat cell assay found that tea, as normally consumed, increased insulin activity greater than 15-fold. Green, Black and Oolong Tea all yielded insulin-increasing results. The researchers separated the components of the tea using a high-performance liquid chromatography and discovered that several known compounds found in tea were shown to enhance insulin, helping cells recognize and respond to the hormone. The greatest activity was elicited by EGCG, followed by epicatechin gallate, tannins and theaflavins. [88]

Tea's Role in Immune Function

Researchers from Brigham and Women's Hospital and Harvard University published novel data indicating that tea contains a component that can help the body ward off infection and disease and that drinking tea may strengthen the immune system. [89]

The researchers identified a substance in tea, L-theanine, which primes the immune system in fighting infection, bacteria, viruses and fungi. A subsequent human clinical trial showed that certain immune cells of participants who drank five cups of Black Tea a day for two to four weeks secreted up to four times more interferon, an important part of the body's immune defense, than at baseline. Consumption of the same amount of coffee for the same duration had no effect on interferon levels. According to the authors, this study suggests that drinking Black Tea provides the body's immune system with natural resistance to microbial infection. [89]

Tea's Role in Oral Health

Tea may contribute to oral health through various characteristics, including anti-bacterial properties and fluoride content, that may help protect against cavities and gum disease and may strengthen tooth enamel. [90-95] Research results include:

- Tea flavonoids may inhibit the plaque-forming ability of oral bacteria, and the fluoride in tea may support healthy tooth enamel. [90, 91]
- A recent study conducted at the New York University Dental Center examined the effects of Black Tea extract on dental caries formation in hamsters. Compared to those who were fed water with their food, hamsters that were fed water with Black Tea extract developed up to 63.7 percent fewer dental caries. [92]
- Drinking tea is minimally erosive to tooth enamel according to a recent study comparing tea (green and black) to soda and orange juice using in vitro tests. Water was used as the non-erosive control, and vinegar was the erosive control. The 20-week study was conducted under controlled conditions, and results were categorized as highly, moderately, or minimally erosive. Soda and orange juice were shown to be moderately erosive and vinegar remained highly erosive. [93]
- Drinking Green Tea was inversely related to periodontal (gum) disease, per a modest drop in probing depth, clinical attachment loss and bleeding upon probing. The study analyzed 940 Japanese men, aged 49 – 59 years old who took part in a comprehensive health exam. The relationship seems to be dose-dependent. Each additional cup of tea was associated with a greater decrease in gum disease factors. [94]
- Based on a review of the evidence supporting Green Tea catechins for the prevention of periodontal disease, researchers recommend two to three cups of green tea per day. [95]

Tea and Reduced Risk of Kidney Stones

Increased intake of fluids is routinely recommended for people who have had kidney stones to reduce the likelihood of recurrence. A recent study that followed 81,093 women for eight years suggests that beverage choice may also affect kidney stone development. The study found that for each eight-ounce cup of tea consumed daily by female participants with no previous history of kidney stones, the risk of developing stones appeared to be lowered by eight percent. [96] An earlier study of 45,289 men reported a similar relationship, suggesting that for each eight-ounce serving of tea consumed daily, a 14 percent decrease in risk of stone development was observed. [97]

Tea and Reduced Risk of Osteoporosis

Although high caffeine intake has been suggested to be a risk factor for reduced bone mineral density (BMD), drinking tea has been linked to higher bone mineral density (BMD) and has been shown to boost bone-building markers and improve muscle mass, both of which may reduce the risk for osteoporosis and fracture. [98-103] Compared to non-tea drinkers, tea drinkers have been found to have a higher BMD. [98] Results of some of the evidence include:

- A study published in the American Journal of Clinical Nutrition found that older women who drank tea had higher BMD measurements than those who did not drink tea. [98]
- A recent study found that habitual tea-drinking was seen to have a significant beneficial effect on the BMD of adults (30 years and older), especially in those who had been habitual tea-drinkers for six or more years. [99]
- Drinking tea is associated with preservation of hip structure in elderly women as assessed by dual-energy X-ray absorptiometry (DXA) areal bone mineral density (aBMD), an independent predictor for osteoporotic hip fracture, based on cross-sectional results (n=1027) and prospective analysis over four years (n=164) in a population of women, aged 70–85 years ($p<0.05$ for both results). [100]
- Studies in adolescent [101] and postmenopausal women [102] found no relationship between caffeine intake and bone health.
- In a human clinical trial, Green Tea polyphenols significantly increased serum bone-specific alkaline phosphatase (bone formation biomarker), elevated the change of bone-specific alkaline phosphatase/tartrate-resistant acid phosphatase (bone resorption biomarker) and improved muscle strength at six months in postmenopausal women with low bone mass. [103]

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