

# An Overview of Research on the Potential Health Benefits of Tea

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## INTRODUCTION

Tea is an ancient beverage steeped in history and romance and loved by many. In fact, so popular is tea that it is the most commonly consumed beverage in the world after water. Although tea had a modest beginning (it was discovered by accident), its popularity spread from its origins in China to Western Europe and the Americas. Throughout history, tea has been believed by many to aid the liver, destroy the typhoid germ, purify the body and preserve mental equilibrium. Over the past few decades, scientists have taken a closer look at the potential health benefits of tea and have discovered that much of the folklore about tea may actually be true.

## HOW TEA WORKS IN THE BODY

Tea contains flavonoids, naturally occurring compounds that are believed to have antioxidant properties. Antioxidants work to neutralize free radicals, which scientists believe, over time, damage elements in the body, such as genetic material and lipids, and contribute to chronic disease.

Recent research has explored the potential health attributes of tea through studies in humans and animal models, and through *in vitro* laboratory research. For the most part, studies conducted on Green and Black Tea, which are both from the *Camellia sinensis* plant, have yielded similar results. Recent research suggests that tea and tea flavonoids may play important roles in various areas of health and may operate through a number of different mechanisms still being explored. Recent findings include:

- The antioxidant properties of tea flavonoids may play a role in reducing the risk of cardiovascular disease by decreasing lipid oxidation<sup>1</sup>, reducing the instances of heart attacks and stroke<sup>2,3</sup>, and may beneficially impact blood vessel function, an important indicator of cardiovascular health.
- Tea flavonoids may lower the risk of certain cancers by inhibiting the oxidative changes in DNA from free radicals and some carcinogens<sup>1</sup>. Tea may also promote

- programmed cell death, or apoptosis<sup>5</sup>, and inhibit the rate of cell division, thereby decreasing the growth of abnormal cells<sup>1</sup>.
- Tea-drinking has been associated with oral health<sup>6</sup> and bone health<sup>7</sup>.
  - Compounds in tea other than flavonoids have been shown to support the human immune system<sup>8</sup>.

## **TEA'S ROLE IN CARDIOVASCULAR HEALTH**

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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. Clinical studies suggest that the risk reduction associated with Black Tea consumption may be due to improvement in some risk factors for cardiovascular disease, including cholesterol levels, blood vessel function and a reduction in oxidative damage.

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. Each of these factors impact 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:

### **Coronary Heart Disease (CHD)**

- 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 mg) had significantly lower prevalence of CHD than non-tea drinkers, even after adjustment for risk factors like age and smoking<sup>9</sup>. 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 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 a day had a 69 percent lower risk<sup>10</sup>.

### **Cardiac Events**

- 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<sup>2</sup>. A follow-up to this study found that high intake of flavonoids significantly lowered the risk of stroke in study participants<sup>3</sup>.
- A Harvard study examined 340 men and women who had suffered heart attacks and compared them to matched control subjects. They found that those who drank a cup or more of Black Tea daily had a 44 percent reduction in the risk of heart attack compared to non-tea drinkers<sup>11</sup>.
- Another recent 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<sup>12</sup>.
- o 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, or heart attack<sup>14</sup>.

## **Cholesterol**

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<sup>15</sup>.

## **Other CVD Risk Factors**

- 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 that of healthy subjects<sup>16</sup>. 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<sup>17</sup>. Subjects with mild elevations in serum cholesterol or triglyceride concentrations consumed either five cups of Black Tea per day for four weeks or hot water. The researchers hypothesized that one mechanism for the apparent beneficial effects of tea on cardiovascular health could be this improved vasodilator function.
- An *in vitro* study found that Green Tea polyphenols inhibit the proliferation of aortic smooth muscle cells to prevent the development of atherosclerosis<sup>18</sup>.

- 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<sup>19,20</sup>. Studies in animals are promising, but human studies conducted to date on the effect of tea consumption on LDL oxidation are inconclusive.

## **Tea's Role In Cancer Risk Reduction**

### Digestive Cancers

#### Skin Cancer

#### Oral Cancer

#### Lung Cancer

#### Ovarian Cancer

Preliminary research suggests that the flavonoids in tea could play a role in human cancer risk reduction possibly by combating free radical damage, inhibiting uncontrolled cell growth (cell proliferation), and by promoting programmed cell death (apoptosis). Leading scientists worldwide are actively studying these potential mechanisms and clinical trials and population studies are underway. More evidence is needed before any definitive conclusions can be drawn. Recent findings include:

- A recent study 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. Oxidative DNA damage is implicated in the development of various forms of cancer<sup>21</sup>.
- Epigallocatechin gallate (EGCG) may protect normal cells from cancer-causing hazards as well as eliminate cancer cells through apoptosis. Researchers tested the potential anti-cancer benefits of Green Tea polyphenol, EGCG, in hamster cells and discovered that EGCG suppressed DNA changes and damage from carcinogens. EGCG also protected from further damage from the carcinogens and inhibited growth and multiplication of cancer cells<sup>22</sup>.

### **Digestive Cancers**

- An epidemiological study conducted by the University of North Carolina found consumption of the equivalent of 2.5 cups of tea per day or more 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<sup>23</sup>.
- Based on data from the NHANES I Follow-Up study (NHEFS), researchers found that tea drinkers had about 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<sup>24</sup>.

- Researchers who followed a group of over 34,000 postmenopausal healthy women between 55 - 69 years of age for 12 years found that those consuming 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<sup>25</sup>.
- The Iowa Women's Study, which followed post-menopausal 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<sup>26</sup>.
- 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<sup>27</sup>.
- 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 3 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<sup>28</sup>.
- 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, or apoptosis<sup>29</sup>.
- 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<sup>30</sup>.
- 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<sup>31</sup>.
- 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<sup>32</sup>.
- 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<sup>33</sup>. 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<sup>34</sup>. Oral consumption of Green or Black Tea decreased the number of tumors in mice following exposure to UV radiation<sup>35</sup>. Green Tea polyphenols may have cancer preventive potential, especially in the case of solar UV-induced cancer<sup>36</sup>. Research suggests that compounds in Green Tea may protect skin from ultraviolet (UV) radiation-induced damage when applied topically<sup>37</sup>. 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<sup>38</sup>. Experiments that 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<sup>39</sup>.

## **Oral Cancer**

- A human intervention trial 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<sup>40</sup>.
- Researchers examined the effects of tea and curcumin, a spice and food-coloring agent, on oral cancer in hamsters. Hamsters were treated with a cancer-causing solution topically 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, or apoptosis<sup>41</sup>.

Studies comparing groups of mice treated with a tobacco-specific carcinogen and receiving either water or water enriched with tea-derived antioxidants 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<sup>42,43</sup>.

## **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<sup>44</sup>.

## **TEA'S ROLE IN IMMUNE FUNCTION**

Researchers from Brigham and Women's Hospital and Harvard University recently published novel new 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.

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<sup>45</sup>.

## **TEA'S ROLE IN ORAL HEALTH**

Tea may also contribute to oral health. The flavonoids in tea may inhibit the plaque-forming ability of oral bacteria and the fluoride in tea may support healthy tooth enamel<sup>46,47</sup>.

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 which were fed water with Black Tea extract developed up to 63.7 percent fewer dental caries<sup>48</sup>.

## **TEA AND OBESITY**

Preliminary research suggests that drinking tea may have effects on body weight, fat accumulation and insulin activity. While it may be premature to draw firm conclusions based on early research, key findings include the following:

- Green Tea extract was found to significantly increase 24 hour energy expenditure and fat oxidation in healthy men<sup>49</sup>.
- 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<sup>50</sup>.
- Researchers examined mice which 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<sup>51</sup>.
- 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 >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<sup>52</sup>.

## **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 stones 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<sup>53</sup>. 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<sup>54</sup>.

## **TEA AND REDUCED RISK OF OSTEOPOROSIS**

Although high caffeine intake has been suggested to be a risk factor for reduced bone mineral density (BMD), research indicates that that drinking tea does not negatively affect BMD, and while it may be too soon to state definitively, findings suggest that tea may even play a role in bone health. A study published recently 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. The researchers concluded that the flavonoids in tea might influence bone mass and that tea drinking may reduce the risk of osteoporosis<sup>55</sup>. Another 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<sup>56</sup>. Studies in adolescent<sup>57</sup> and postmenopausal women<sup>58</sup> found no relationship between caffeine intake and bone health.

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