# Health Effects of Tea Consumption

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## Keywords

Tea · Green tea · Oolong tea · Black tea · Catechin · Epigallocatechin gallate

## Key Points

- Tea is manufactured from the leaves of the Theaceae plant (*Camellia sinensis*).
- Various types of brewed tea are consumed worldwide and the types of tea vary with respect to clinical benefits.
- Tea exhibits beneficial effects on cancer, obesity, metabolic syndrome, type 2 diabetes, cardiovascular disease, and possibly some neurodegenerative diseases.
- A major component of tea catechins is (−)-epigallocatechin gallate. It may be responsible for many of the biological effects of tea.

## Introduction

Tea is the world's most popular beverage after water. Green, black, and oolong teas are all obtained from the leaves and buds of the Theaceae plant (*Camellia sinensis*) when the leaves are served following no fermentation, full fermentation, or a semi-fermentation process, respectively [1]. The three primary tea products are probably not equal with respect to health benefits. A search of the PubMed database carried out for the last 10 years is suggestive of the popularity of tea in human health research. This search (May 23, 2020) of "green tea," "black tea," and "oolong tea" yielded 5,692, 1,374, and 328 citations, respectively. Tea contains various constituents with potential health promoting effects, such as caffeine, polyphenols, vitamins, γ-aminobutyric acid, and theanine.

Tea polyphenols or catechins have been suggested to protect against cancer, obesity, metabolic syndrome (MetS), diabetes mellitus (DM), cardiovascular disease (CVD), and neurodegenerative diseases [2–5]. Tea consumption may also have antibacterial, antiviral, hepatoprotective, and microbiota-modulating effects [2–5]. Among the catechins, (−)-epigallocatechin gallate (EGCG, Fig. 28.1) appears to be the chemical with the greatest biological activity, with green tea containing the highest amount of EGCG. Black and oolong teas contain some EGCG as well as additional bioactive catechin

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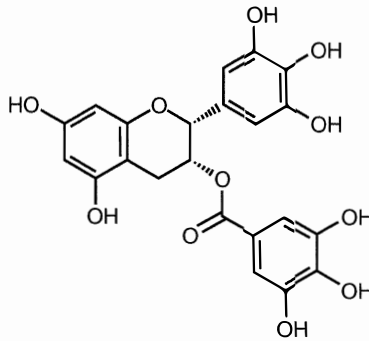saitok@u-shizuoka-ken.ac.jp; yori.naka222@u-shizuoka-ken.ac.jp

**Fig. 28.1** Chemical structure of EGCG

derivatives formed during fermentation, such as theaflavins, thearubigins, theasinensins, and chaflosides. This chapter mostly focuses on the human health promoting effects of consumption of green tea and/or green tea catechins (GTC).

## Green Tea Benefit for Obesity and Metabolic Syndrome

The MetS is a group of associated variables including elevated levels of body mass index (BMI), body fat, waist circumference, blood pressure, triglyceride, blood glucose, and hemoglobin A1c concentrations and reduced levels of high-density lipoprotein-cholesterol (HDL-C). The results of several epidemiological studies suggest that tea is a preventive agent for MetS, but confirmatory studies are required [4].

A cross-sectional population-based survey saw an inverse association of green tea consumption with MetS and some of its components. The high tea consumers (≥3 cups/day) exhibited lower BMI and waist circumference, but diastolic blood pressure was not affected [6]. After adjusting for confounding factors, higher tea consumption had a significant inverse association with MetS. In a study of 6,500 adults, an inverse association was observed between tea intake and MetS markers [7]. A more recent systematic review and meta-analysis of six observational studies concluded that there was a significantly reduced risk of MetS for individuals consuming more tea [8]. However, a study of 5,100 adults in Poland reported that tea consumption was related to some components but not to MetS [9]. The conflicting results could have been confounded by differences in the base diet and genetic background of these Polish subjects.

A recent pooled analysis of six human trials showed that consumption of GTC-containing beverages (540–588 mg GTC/beverage) for 12 weeks significantly reduced total fat area, visceral fat area, subcutaneous fat area, body weight, BMI, and waist circumference and improved blood pressure. Further analyses of pre-MetS and MetS studies indicated significantly improved MetS in the GTC consumers [10]. These encouraging findings indicate, therefore, that daily consumption of GTC reduces abdominal fat and improves MetS.

The anti-obesity effects of green tea have been investigated in 24 human studies published between 2002 and 2013 [11]. Five out of 11 trials in Asian populations showed significant weight loss of 1–2 kg, and three out of 13 trials in Western populations resulted in notable weight loss ranging from 1 to 9 kg. A randomized, double-blind, crossover, and placebo-controlled clinical trial in which green tea extract (GTE) was given to overweight or obese women for 6 weeks showed that it resulted in a significant 4.8% reduction in low-density lipoprotein cholesterol (LDL-C) and a 25.7% increase in leptin [12]. However, there was no significant effect on total cholesterol, triglycerides, and HDL-C.

In addition, a beneficial effect of green tea in overweight or obese peoples was demonstrated by a meta-analysis of 21 papers that included 1700 overweight or obese subjects. Green tea significantly decreased total plasma cholesterol (about $-3.38$ mg/dL) and LDL-C levels (about $-5.29$ mg/dL), but with no effect on plasma triglyceride and HDL-C levels [13].

Generally, regular consumption of green tea, and EGCG commonly found in GTE, seems to provide benefits for improved weight management and MetS management. These improvements probably contribute to reductions in CVD risk.

## Benefits of Green Tea for Cardiovascular Disease

Many studies have investigated the relationship between tea consumption and risk of CVD. Two of the studies mentioned above reported that GTE or green tea lowers LDL-C [12, 13].

According to a comprehensive review by Yang et al., tea may help reduce the risk of CVD and related diseases [2]. The evidence for this is as follows:

(a) A meta-analysis of 14 prospective cohort studies showed an inverse association between tea consumption and risk of stroke.
(b) A systematic review and meta-analysis of ten human trials observed that tea reduces systolic and diastolic blood pressure.
(c) A multiethnic study saw inverse associations between tea consumption and both coronary artery calcification and incidence of cardiovascular events.
(d) The Shanghai Men's Health Study reported an inverse association between green tea consumption and CVD mortality among non-smokers.

Other studies have provided additional weight to these findings. People consuming $\geq 5$ cups/day of green tea (vs $<1$ cup/day) had a lower mortality of approximately 18–25% for both heart disease and CVD [14]. Similarly, a study of 101,000 Chinese adults revealed that habitual tea drinkers had a 15–22% reduced risk of atherosclerotic CVD incidence, atherosclerotic CVD mortality, and all-cause mortality [15]. The findings also revealed that at age 50, habitual tea drinkers had 1.4 more years free of atherosclerotic CVD and 1.3 years longer life expectancy [15].

Taken as a whole, these results strongly indicate that green tea consumption is associated with reduced risk of CVD and related diseases.

## Benefits of Green Tea for Type 2 Diabetes Mellitus

Epidemiological studies have detected antidiabetic effects of green tea [1, 3]. For example, a large cohort study on 17,400 Japanese published in 2006 showed type 2 DM among drinkers of green tea of $\geq 6$ cups/day was improved relative to those who drank $<1$ cup/week [16]. Similarly, an analysis of a large cohort study from eight European countries revealed that tea consumption was inversely associated with the type 2 DM incidence which was improved for drinkers of $\geq 4$ cups/day compared to non-drinkers [17]. Remarkably, the result from an analysis indicated that replacing sugar-sweetened beverages with tea can lower type 2 DM incidence by 22%, whereas substituting fruit juice or milk did not alter type 2 DM incidence significantly [18].

Additional evidence for the beneficial effects of tea on type 2 DM comes from the following two studies. A hospital-based case-control study in Vietnam showed an inverse association of tea consumption with risk of type 2 DM; persons drinking $>2$ cups/day had a lower risk than those drinking $<1$ cup/day [19]. A Japanese intervention study on 60 subjects with mild hyperglycemia demonstrated

that ingestion of GTE reduced the blood level of hemoglobin A1c, an indicator of glucose control and a marker used to diagnose DM [20].

However, several studies failed to show this effect [21, 22]. For example, the results of a cohort study which monitored 47,000 participants aged 30–69 indicated no association between the intake of tea and the risk of type 2 DM [21]. These conflicting results indicate that the possible antidiabetic benefit of tea needs to be further investigated.

## Benefits of Green Tea for Neurodegenerative Diseases

Evidence suggests that tea has benefits for neurodegenerative disorders such as Alzheimer's disease (AD), dementia, cognitive impairment, and depressive symptoms. For example, a cross-sectional survey of 2,015 persons aged ≥65 in China demonstrated that the age-gender-standardized prevalence rates of dementia, AD, and vascular dementia were lower in green tea consumers [23]. However, a prospective study of 1,840 Japanese Americans in the USA failed to see an association for tea consumption with AD [24].

In the case of Parkinson's disease, a meta-analysis of eight studies including 345,000 participants found an inverse association and decreased smoking-adjusted risk by 26% when consumption was increased by 2 cups/day [25].

A small randomized, single-blind study reported that consumption of matcha tea (a kind of green tea), compared to placebo, significantly improved attention abilities and psychomotor speed in response to stimuli [26]. However, another double-blind, randomized controlled study failed to observe a favorable effect on cognitive function after green tea (2 g/day) was consumed for 1 year [27].

## Benefits of Green Tea for Cancer

Recent epidemiological studies, systematic reviews, and dose-response meta-analyses indicate that long-term and high-dose consumption of green tea reduces the risk of various types of cancer [1, 3, 4]. For example, in a study of Hong Kong Chinese men, habitual green tea consumption significantly reduced the risk of prostate cancer in a dose-dependent manner for intake of EGCG [28]. The possible beneficial effect of green tea consumption on cancer is also suggested by a pooled analysis of eight cohort studies in Japan which concluded that moderate consumption of green tea reduced woman's risk of total cancer [14]. Another cohort study indicated that green tea drinkers had reduced risk of hematologic neoplasms including acute myeloid leukemia and follicular lymphomas compared with the non-drinkers of green tea [29].

Conversely, some studies have failed to demonstrate such risk reduction, and therefore more research is needed to better understand the utility of green tea for cancer prevention [1]. It also should be noted that the inconsistencies in results may be due to several different factors, such as quantity of tea consumption, tea temperature, smoking, alcohol consumption, intestinal flora, and genetic polymorphisms [3].

Intervention studies can provide much useful information on the chemopreventive effects of tea in humans. Two Japanese studies showed that green tea extract is an effective supplement for the chemoprevention of metachronous colorectal adenomas [30, 31]. Similarly, a recent randomized clinical study carried out in Korea reported that among 143 patients the incidence of this adenoma was significantly lower in the group given 0.9 g/day GTE for a year than in the control group [32].

In an intervention study carried out in Italy on 30 men with high-grade prostate intraepithelial neoplasias, the proportion of men who developed prostate cancer was far lower in those treated with 600 mg of GTC daily for 12 months compared with those given a placebo [33].

## Green Tea Effects May Be Variable in Different People

There are many complicating factors with respect to the effect of green tea consumption on human health. While EGCG is probably one of the more important catechins associated with the health benefits of green tea, the amount of EGCG in different green tea products is variable [34]. The ability of the EGCG in tea leaves to be solubilized is related to the time of brewing which varies between individuals, with longer brewing times resulting in greater EGCG content in the tea. Before the EGCG and other catechins reach the bloodstream, there is considerable potential for these phenolic compounds to be modified by the gut microbiome [2]. All of these factors complicate a "one tea fits all" approach. However, one can generally suggest a safe upper limit of 3 to 5 cups of green tea per day with little risk of deleterious effects.

## Summary

Green tea has several potential health benefits with respect to weight management, type 2 DM, CVD, cancer, and possibly cognitive function. EGCG is probably the compound most responsible for the benefits of green tea consumption. Consumption of up to 3 to 5 cups per day can be recommended in clinical practice.

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