

GREEN TEA AND COMPREHENSIVE HEALING PROPERTIES OF POLYPHENOLS)

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Abstract

Tea, *Camellia sinensis* L. is the most widely drunk beverage in the world. Comprehensive healing properties of this refreshing, mildly stimulating drink are known in traditional medicine dating back almost 5000 years. Tea healing and disease prevention mechanism is mostly based on antioxidant properties. Tea beverage is a rich source of polyphenols, especially catechins which are very powerful antioxidants. The most abundant catechins in tea beverage are epigallocatechin 3-gallate (EGCG), epigallocatechin (EGC), epicatechin 3-gallate (ECG), and epicatechin (EC). Many investigations i.e. population-based, screening, involving patients and also with animal or cell models, show many valuable pharmacological properties of tea. It is proved by numerous studies that drinking tea or taking tea extracts can prevent chronic diseases, including coronary heart disease and many types of cancer. It can also help with diabetes, hypertension and obesity and may contribute to inflammation reduce. Better understanding of tea healing properties could help reduce high costs of medical care, improve treatment of lifestyle diseases, and transform tea beverage into an evidence based functional food.

Key words: polyphenols, tea, antioxidants

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Introduction

Tea is a beverage which has been known for almost 5000 years [9]. Tea consumption has its roots in China, and nowadays it's very popular around the world. Tea plant (*Camellia sinensis* L.), has been used in traditional Chinese medicine and is believed to have a positive effect on the five vital organs. Nowadays, more than 2.5 million tons of tea are produced each year, worldwide in India, China, Sri Lanka, Kenya, Indonesia, Turkey and many other countries (Fig.1).



Figure 1. World tea production; data from FAOSTAT

All types of tea are brewed from dried leaves and buds. The way leaves are processed determines individual characteristics of the three predominant types of tea: green, black and oolong [7,9,11].

Many studies suggest that tea indeed has numerous health benefits. Green tea drinkers appear to have a lower risk of wide range of diseases, from simple bacterial or viral infections to chronic conditions including cardiovascular disease, osteoporosis, stroke and periodontal disease. The compounds called polyphenols are thought to be associated with these comprehensive health benefits of tea. Green tea, the least processed of all tea types, is a rich source of polyphenols (catechins), especially flavanols and flavonols and their derivatives, which represent approximately 30% dry weight of the tea leaf (Tab.1).

Table 1. Flavonoids in black and green tea (mg/100g dry tea, water extraction data, mean values) [5]

Flavonoids	Black Tea	Green Tea
Epigallocatechin 3-gallate (EGCG)	1393	8975
Epigallocatechin (EGC)	1257	1712
Epicatechin 3-gallate (ECG)	923	1755
Epicatechin (EC)	316	793
Catechin (C)	167	24
Gallocatechin (GC)	126	-
Gallocatechin 3-gallate (GCG)	-	316
Total theaflavins	589	-
Total flavones	59	85
Total flavonols:	367	406
- Quercetin	210	175
- Kaempferol	132	130
- Myricetin	25	101

Predominant tea flavanols are: epigallocatechin 3-gallate (EGCG), epigallocatechin (EGC), epicatechin 3-gallate (ECG), and epicatechin (EC). In smaller amounts there are also present: catechin (C), galokatechin (GC), gallocatechin 3-gallate (GCG). Other components are three types of flavonoids, known as kaempferol, quercetin, and myricetin. Tea also contains alkaloids (caffeine, theophylline, theobromine), proteins, carbohydrates, chlorophyll and minerals [7]. 100 ml of green tea beverage contains 35-85 mg of total polyphenols including 20 mg EGCG, 15 mg EGC, 6 mg EC, 5 mg ECG, 3 mg GC and 2 mg C in average brew. However, polyphenol concentration in tea beverage depends on the tea type, amount used, brewing time and temperature. For best content of bioactive compounds one should use 2 g of tea leaf powder, 200 ml of hot water (80°C) and 5 minutes brewing time [2].

Flavonoids, phenolic compounds are present in a wide range of vascular plants and can play many different roles in plant ecology. They can act as antioxidants, antimicrobials, photoreceptors, visual attractors, feeding repellents, and for light screening. The basic flavonoid structure is the flavan core, which consists of 15 carbon atoms, arranged in three carbon rings (C6-C3-C6). Various classes of flavonoids differ in oxidation level and pattern of substitution of the Carbon ring (Fig.2).

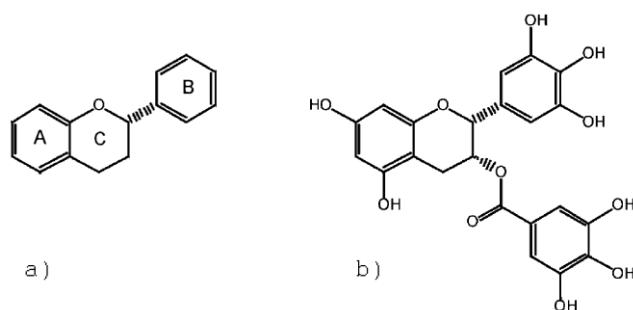


Figure 2. a) Basic flavonoid structure and b) epigallocatechin 3-gallate (EGCG)

Oxidative coupling of different catechins (monomers) forms theaflavins (dimmers). Polyphenols are important components of the human diet. Well known dietary sources of flavonoids are fruits, vegetables, red wine, and tea. They represent an important source of antioxidants, which intake may reach 800 mg/day. It is assumed that dietary flavonoids may display their antioxidant protection in the digestive tract and continue its antioxidant role after absorption [6,11].

Many studies focus on the antioxidant activity of flavonoids, due to their ability to reduce free radical formation and to scavenge free radicals. Reactive oxygen species (ROS) are oxygen-based free radicals, for example superoxide anion (O_2^-) and peroxy radical (R-O-O^+).

Oxidation processes take place in all living cells constantly, due to oxygen, which is the ultimate electron acceptor in the electron flow system that produces energy in the form of ATP. However, when electron flow becomes uncoupled (transfer of unpaired single electrons), free radicals are generated. Nowadays people are also highly exposed to UV radiation and omnipresent ROS like air pollutants, cigarette smoke so dietary antioxidants are needed for diminishing the cumulative effects of oxidative damage over the life span.

ROS are very devastating, since they rapidly attack lipids in cell membranes, proteins in tissues or enzymes and DNA. Damage caused by

ROS is considered to play a causative role in aging and several degenerative diseases such as cataracts and cognitive dysfunction.

Many scientists believe that the most common cause of chronic diseases including coronary heart disease, metabolic diseases and diabetes mellitus are free radicals. Most cancer types i.e. the colon, breast, prostate and pancreas may be caused by reactive oxygen species from different sources. During the development and growth of cancer cells there are distinct oxidation reactions that have been proved to play a key role in carcinogenesis. Some of these specific reactions involve the generation of ROS such as OH radicals and hydrogen peroxide that may affect control of cell duplication rates and also apoptosis of abnormal cells [3,8,9].

Both, flavonoids and their metabolites can display an antioxidant activity in vitro as well as in vivo. Mechanisms of antioxidant action of poliphenols include suppressing reactive oxygen species formation either by inhibition of enzymes or chelating trace elements involved in free radical production, scavenging reactive oxygen species. Poliphenols can also protect living cells against damage done by UV radiation. Flavonoids have been shown to inhibit the enzymes responsible for superoxide anion production, such as xanthine oxidase and protein kinase C and enzymes involved in reactive oxygen species generation such like cyclooxygenase, lipoxygenase, microsomal monooxygenase, glutathione S-transferase, mitochondrial succinoxidase, and NADH oxidase. A number of flavonoids efficiently chelate trace metals, which play an important role in oxygen metabolism because free iron and copper ions are potential enhancers of ROS formation i.e. highly aggressive hydroxyl radical. Flavonoids, due to their lower redox potentials (0.23-0.75 V) are thermodynamically able to reduce highly oxidizing free radicals such as superoxide anion, peroxy radical, alkoxy

radical, and hydroxyl radicals by hydrogen atom donation. Detailed research shows that especially EGCG and ECG are highly efficient antioxidants. Also a remarkably high concentration of myricetin may also have some implications with the bioactivity of tea and its extracts [3,8,11]. Many epidemiological studies indicated that tea beverages might help to prevent cancer. It is known that EGCG and other tea polyphenols can effectively affect cancer cells metabolism. Tea extracts have been shown to inhibit angiogenesis, tumor cell proliferation, invasiveness and may modulate immune system function. Several population-based clinical studies have shown that cancer rates tend to be low in countries such as China and Japan where people regularly consume green tea [4,9]. Detailed studies show that intake of tea extracts or beverages containing at least 400 mg of EGCG daily can help to cure and prevent many cancer types i.e. colorectal cancer, stomach cancer, urinary bladder cancer, skin cancer, lung cancer and more. In a study [4] on a large group of Japanese adults, the consumption of 5 or more cups of green tea per day was found to significantly reduce mortality due to all causes (16% compared to subjects consuming tea beverage occasionally). Results in this study clearly show minor effect of other factors like differing lifestyle and nutrition between subjects on tea consumption health benefits. It is proved that anti inflammatory, antibacterial and antiviral activity and even neuroprotective effect can be obtained by regular consumption of green tea. For example, regular drinking of tea beverage may help to prevent or lessen the duration of the flu. In some studies [10] EGCG have shown to inhibit influenza virus replication in cell culture in all influenza virus subtypes tested. Proposed mechanism of EGCG antiviral properties is its ability to suppress viral RNA synthesis. Several studies [13] on cardiovascular and metabolic diseases have demonstrated that

green tea reduces the risk of heart disease by lowering cholesterol and triglyceride levels. The rate of heart attack decreases by 11% with consumption of 3 cups of tea per day. Moreover, the beneficial effects of green tea on cardiovascular disease mortality rise with increasing consumption of green tea. Research over chronic smokers shows that green tea consumption may also prevent future cardiovascular events. Scientists investigated [10] effects of supplementation with 300 mg EGCG per day for 2 weeks on brachial artery flow-mediated dilation in cigarette smokers. They observed that taking EGCG supplements in short time may improve vascular function. In another study consumption of 200 mg green tea catechins per day for 2 months, resulted in increased antioxidant capacity and decreased plasma peroxides and reduced oxidative damage and glutathione peroxidase activity in lymphocytes. The influence of habitual green tea consumption in China on hypertension was investigated [14]. This research has shown that consumption of more than 600 ml of green tea daily may reduce the risk of developing hypertension by 65%, compared to not drinking tea control group. Different studies suggest that influence of tea drinking may be more pronounced in overweighted population where a significant proportion is obese and have a high risk of cardiovascular disease. A group of students had been asked not to alter their diet and to drink 4 cups of green tea per day for two weeks. The results showed that short-term consumption of green tea reduces blood pressure, total cholesterol level and may also reduce waist-to-hip ratio. These results suggest a role for green tea in decreasing frequent cardiovascular risk factors. Another research shows that daily consumption of tea containing 690 mg of catechins for 3 months reduced body fat. But in many similar studies no beneficial effects of the green tea extract were found. However, it was

demonstrated in rats obesity model that supplementation with green tea catechins reduced body weight, adipose tissue mass, liver fat content and plasma levels of cholesterol. EGCG supplementation can also improve insulin secretion and regulate blood parameters like glucose, plasma triglycerides and free fatty acids [9,13]. Green tea consumption may slow brain degeneration in dementia and Alzheimer's disease. In research a group of subjects over age 70 was studied [1], comparing their green tea intake and mental sharpness, using standardized tests for measuring cognitive function. Elderly Japanese who drank more than 2 cups of green tea a day had a 54% lower risk of age-related declines in memory, orientation, ability to follow commands and attention, compared with those drinking tea occasionally. EGCG also helps prevent the formation of B-amyloid, a protein which accumulation is recognized as a cause of Alzheimer's disease. Green tea is a beverage which has been consumed for centuries and is traditionally associated with various health benefits. Many studies proved that tea polyphenols, especially of EGCG, the most biologically effective green tea catechin can help in diseases, which are the major cause of worldwide death and disability (Fig.3).

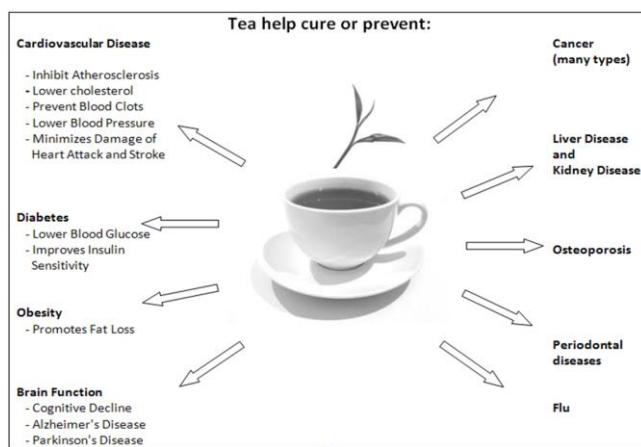


Figure 3. Summary of tea health benefits.

Tea catechins should be considered potent free radical scavengers right alongside with

better known antioxidants like vitamins E and C. Good habit of drinking tea may help to protect one's health and reduce current high cost of medical care. Therefore, consistent results from well designed and long term studies with standardized green tea products would greatly facilitate our understanding of the benefits linked to tea polyphenols. This could potentially transform a beverage traditionally associated with a number of health benefits into an evidence based functional food.

Resumo

Teo (*Camellia sinensis* L.) estas vaste diskonigita en la mondo trinkaĵo. Diversflanka kuracefiko de tiu ĉi refrešiga kaj iom stimuliga trinkaĵo, estas konataj en la popolmedicino depost preskaŭ kvin mil jaroj. La ĉefa kuracefiko de teo rilatas al ĝia antioksidanta efiko. La tea trinkaĵo estas riĉa fonto de polifenoloj, precipe katehinoj, kiuj estas fortaj antioksidantoj.

La plej gravaj katehinoj de teo estas galusano de epigalokatehino (EGCG), epigalokatehino (EGC), galusano de epikatehino (ECG) kaj epikatehino (EC). Multaj skriningaj ekzamenoj kun ĉeesto de malsanaj homoj, kun apliko de bestaj kaj ĉelaj modeloj konfirmas multajn valorajn farmakologiajn efikojn de teo. Faritaj ekzamenoj konfirmas, ke trinkado de teo kaj ĝia ekstrakto protektas kronikajn malsanojn, koronarian malsanon kaj iujn kancerojn. Oni ankaŭ scias, ke la teo helpas kuraci diabetan malsanon, hipertension, obezecon kaj reduktas inflaman staton. Pli bona ekkono de porsanaj proprecoj de teo povas redutki flegadkostojn de sanservo, precipe kuracante civilizaciajn malsanojn kaj trakti teon kiel utila funkcio nutradherbo kies efikoj estas bone science pruvitaj.

References

- 1 Bastianetto S et al. "Neuroprotective effects of green and black teas and their catechin gallate esters against beta-amyloid-induced toxicity", European Journal of Neuroscience 2006; 23(1):55-64.
- 2 Komes D et al. "Green tea preparation and its influence on the content of bioactive compounds", Food Research International 2010; 43:167-176.
- 3 Kumar S, "Free Radicals and Antioxidants: Human and Food System", Advances in Applied Science Research 2011; 2(1): 129-135.
- 4 Kuriyama S et al. "Green tea consumption and mortality due to cardiovascular disease, cancer, and all causes in Japan: the Ohsaki study", Journal of the American Medical Association 2006; 296:1255-1265.
- 5 Peterson J et al. "Major flavonoids in dry tea", Journal of Food Composition and Analysis 2005; 18:487-501.
- 6 Piatti P G "Flavonoids as Antioxidants", Journal of Natural Products 2000; 6: 1035-1042.
- 7 Reto M et al. "Chemical composition of green tea (*Camellia sinensis*) infusions commercialized in Portugal", Plant Foods for Human Nutrition 2007; 62(4):139-144.
- 8 Seeram N P et al. "Catechin and caffeine content of green tea dietary supplements and correlation with antioxidant capacity", Journal of Agricultural and Food Chemistry 2006; 54(5):1599-1603.
- 9 Sharangi A B "Medicinal and therapeutic potentialities of tea (*Camellia sinensis* L.) – A review", Food Research International 2009; 42:529-535
- 10 Song J M et al. "Antiviral effect of catechins in green tea on influenza virus", Antiviral Research 2005; 68(2):66-74.
- 11 Weisburger J H, Mechanisms of Action of Antioxidants as Exemplified in Vegetables, Tomatoes and Tea", USA Food and Chemical Toxicology 1999; 37:943-948.
- 12 Widlansky M E et al. "Acute EGCG Supplementation Reverses Endothelial Dysfunction in Patients with Coronary Artery Disease", Journal of the American College of Nutrition 2007; 26:95-102.
- 13 Wolfram S et al. "Effects of Green Tea and EGCG on Cardiovascular and Metabolic Health", Journal of the American College of Nutrition 2007; 26(4):373-388.
- 14 Yang Y C et al. "The protective effect of habitual tea consumption on hypertension", Archives of Internal Medicine 2004; 164:1534-1540..