

Health benefits of black tea

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ABSTRACT

Tea is the most common beverage in the world. It is consumed mostly as green tea, oolong, or black tea. Depending on the manufacturing process, different varieties of tea can be produced. As tea is one of the most popular beverages, it could be a tremendously important source of polyphenolic constituents. Tea leaves are a source of polyphenols, especially catechins, which are known for their antioxidative activity. Various studies suggest that polyphenolic compounds present in black tea are associated with

beneficial effects in prevention of cardiovascular diseases. In addition, anti-aging, antidiabetic and many other health beneficial effects associated with tea consumption have been reported. The review highlights the potential of black tea, its health benefits in terms of antioxidative, antimutagenic and anticarcinogenic properties as well as protective agents against cardiovascular diseases.

Key words: Black tea, health, oxidative stress, polyphenols

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INTRODUCTION

Tea (*Camellia sinensis*) is the second most popular drink after water, consumed by over two-third of the world's population [1,2]. It is grown in over thirty countries exclusively in the subtropical and tropical zones. India is one of the main tea growers, exporting more than 12% of the world's tea and with over 521,000 ha under cultivation [3]. Tea is consumed mostly as green tea and black tea, approximately 20% of the tea is manufactured as green tea while 80% of the approximately 2.5 million metric tons of manufactured dried tea is black tea. A small percentage of tea is manufactured as oolong tea which is about 2% and usually consumed in Japan and China. The effect of tea consumption on human health has lately received much attention since tea has a high concentration of polyphenols which are known to possess antioxidant properties.

The health effects of tea have been examined ever since the first infusions of *Camellia sinensis* about 4700 years ago in China. Chemical compounds of tea, which are naturally occurring dietary components being mostly polyphenols, are known to exert strong influence on human body. Polyphenols, biologically active compounds of plant origin, are classified as non nutrients. An average daily intake of polyphenols with the diet is approximately 1 gram, which can be important in fighting free radicals activity in human body [4]. Tea contains catechins, a very potent antioxidant. In a freshly plucked tea leaf, catechins can compose up to 30% of the dry weight. Although tea contains various types of phenolics and tannin, tea does not contain tannic acid. Numerous epidemiological studies have indicated that food and beverages rich in polyphenols are an important factor in preventing diseases, decreasing mortality from cardiovascular and neoplastic diseases, and slowing down the aging processes [5].

This review article describes the major epidemiological and clinical studies on the black tea consumption and the beneficial role on humans and animals. We also present the available evidence linking tea drinking and its effects on diabetes, bone, dental, aging and oncogenic transformation.

Varieties of tea derived from C. sinensis

The common varieties of tea which are known for their potential health benefits are derived from the leaves and leaf buds of *C. sinensis*, a species of flowering plants in the family Theaceae. Harvested tea leaves are processed in the factory and accordingly there are two types of tea: Orthodox, and CTC (Crushing Tearing Curling). The Orthodox tea is the whole leaf tea whereas CTC tea is widely popular and processed through the crush, tear and

curl (CTC) method. Traditionally, tea is classified based on the method of processing tea in order to following types: green tea, oolong tea and black tea.

Green tea is unfermented or nonoxidised tea, produced by drying and steaming of the fresh tea leaves. It has a very complex composition with a maximum of protein content (15–20% dry weight) followed by soluble carbohydrates (5–7% dry weight) minerals and trace elements (5% dry weight) and amino acids such as 5-N-ethylglutamine, glutamic acid, tryptophan, glycine, serine, aspartic acid, tyrosine, valine, leucine, threonine, arginine, lysine [6]. Polyphenols constitute the most interesting group of green tea leaf components, and in consequence; green tea can be considered an important dietary source of polyphenols, particularly flavonoids. Flavonoids are phenol derivatives synthesized in substantial amounts (0.5–1.5%) and variety (more than 4000 identified), and widely distributed among plants [14].

Black tea is oxidized or fully fermented form of tea. It is manufactured as a fermented tea product following withering of the tea leaves [7]. Quality of black tea is a complex phenomenon and depends on inherent chemical composition of green leaf and chemical components produced during processing. The quality of CTC (crush, tear and curl) black tea mainly depends on flavanol composition present in the cell vacuole of green leaf, oxidised during processing leading to the formation of black tea pigments, theaflavins (golden yellow) and thearubigins (orange brown) which are largely responsible for brightness, briskness, colour and strength [1,8,9]. The typical composition of black tea beverage contains 8% catechins, 10% flavanol glycosides, 12% theaflavins, and 70% thearubigins [10]. Liang et al., [11] showed that theaflavin makes a greater contribution to the brightness of black tea infusion.

Oolong Tea is a partially fermented tea and lies between unfermented green tea and fermented black tea. It is produced through a unique process, including withering under the strong sun and oxidation before curling and twisting. Oolong tea is made by withering and then putting through a series of light rolling before firing, which arrests oxidation, this process is called as semi fermentation and results in partial oxidation. Oolong Tea shows anti-obesity effects [12] and has a role in prevention of diabetes [13].

White tea is another common variety of tea derived from the buds of *C. sinensis*, which are subjected to withering followed by drying. Care is taken to minimize the processing protocols as much as possible to prevent oxidation and to leave delicate white leaf air intact, which makes this tea “White” [14].

Polyphenols in tea: the key role

The polyphenolic content of tea is mainly attributed to flavanoids including flavan-3-ols and flavanols. Tea catechins are composed of epicatechin (EC), epigallocatechin (EGC) and their galloyl esters such as gallic catechin (GC), epicatechingallate (ECG), and epigallocatechin gallate (EGCG). Among teas, green tea contains the large amount of catechins and esters of gallic acid. Black tea contains several polyphenols such as bisflavanols, theaflavins (TFs) and thearubigins (TRs), whereas oolong tea contains the small amount of catechins and theaflavins. In recent years, TFs have attracted considerable interest because of their beneficial health properties, including anti-inflammatory, antimutagenic and anticlastogenic effects [15].

Absorption of black tea polyphenols and metabolism

Recent studies have investigated that after tea consumption, catechins are metabolized and transformed as sulfated, methylated, or glucuronidated derivatives by enzymes such as sulfotransferase, catechol-O-methyltransferase and glucuronosyltransferase respectively [16] and it has been hypothesized that breakdown of flavonoids into smaller phenolic acids takes place within the colon from bacterial degradation, absorption occurs through the small intestine. These phenolic acids can be absorbed in the circulatory system [17]. Black Tea is also known to affect some intestinal microflora that contribute to health by metabolizing pro-carcinogens, carcinogens and nutrients that reach the colon [18,19]. It significantly reduces the amounts of bacteria present in the intestine which may have health benefits for an individual [19].

Black Tea has been reported to possess a high concentration of tannins that is about 0.8 mg/ml [20]. The presence of tannins contribute to inhibition of absorption of non-haem iron to a significant extent by forming insoluble complexes with the ferric ion and subsequently affecting iron absorption in the lumen [21].

However, this characteristic of black tea that leads to reduction of intestinal absorption of dietary iron can be utilized to reduce iron uptake in iron overload syndromes such as genetic hemochromatosis or refractory anemia [22].

Although catechins are bioavailable to humans, their level in plasma is an important subject of research. Catechin levels in human plasma reach their peak 2 to 4h after ingestion [23]. Peak plasma levels of catechins are reported to reach micromolar concentrations [24].

Chow et al. [25] report a peak plasma level of 7.4 $\mu\text{mol/L}$ of EGCG after a dose of 1,200 mg of EGCG in the fasting condition.

Health benefit of black tea

Tea plays a significant role in protecting cell membranes from oxidative damage, improving intestinal microflora, which are beneficial to the body and also prevents dental caries [26]. Possible beneficial health effects of black tea polyphenols are antioxidative, antithrombogenic, and anti-inflammatory [15]. In vitro, studies by using animal models suggest that consumption of black tea contributes in the prevention of some cancers, cardiovascular diseases and to treat diabetes in clinical trials [27]. Moreover, a number of antioxidants present in green and black tea, mainly catechins and theaflavins have anti-carcinogenic, anti-mutagenic [28] and neuroprotective [29] properties. The health benefits of black tea are interesting, but more research on both animals and humans needed to be conducted. See table 1.

Tea with antioxidant property

In human body, different protection mechanisms are present to combat free radicals. Also, there is equilibrium between pro-oxidative and antioxidant process, and when this equilibrium is disturbed in favor of free radicals, it results in oxidative stress [39]. The oxidation of lipoproteins plays an important role in the development of atherosclerosis. The powerful antioxidant properties of the tea are generally attributed to its flavonoid components; theaflavins, bisflavanols and theaflavic acids [40]. These compounds are all potent antioxidants *in vitro* and when consumed, may act as the free-radical scavengers which remove endogenously generated superoxide, peroxy and hydroxyl radicals.

Recently, our research results have signified that black tea intake may contribute towards a significant antioxidative health-promoting effect, especially in conditions, which challenge the antioxidant defense of the body [41].

Earlier, we also reported the antiaging and antidiabetic role of tea catechins, which can be attributed to the strong antioxidant activity of these compounds [42,43]. The multimeric polyphenols of black tea, theaflavins and thearubigins, which are generated during the fermentation of tea leaves, possess even stronger antioxidant activity than their precursor catechins [44].

Table 1. Effect of black tea on health.

S.N.	Findings	Performing Experiments	Clinical Trial/Survey/Animal experiments	References
1	Subjects drinking 4480 ml tea/day had lower prevalence of CHD vs. non-tea drinkers (P <0.001) even when risk factors accounted for. Dose-response between tea and lower CHD risk (P < 0.001)	Saudi Arabia; N=3430; 30-70 years	Clinical Trial	[30]
2	Total cholesterol reduced by 3.8% in tea group compared to placebo (with or without caffeine) LDL reduced by 7.5% (P < 0.01)	USA; seven men, eight women; hypercholesterolaemic	Clinical Trial	[31]
3	Cancer Tea intake related to modest significantly lower incidence of combined cancers.	Mailed survey of tea drinking and lifestyle factors collected at baseline; FU = 8 years; 2936 cancer cases.	Survey	[32]
4	Less than 10% of subjects drank black tea daily. Daily intake of black tea positively associated with colon cancer risk (OR = 1.59, CI = 1.06-2.37)	Japan; N= 1706 digestive tract cancer cases vs. 21 128 non-cancer outpatients; > 40 years	Clinical Trial	[33]
5	Dental health Consumption of salt crackers followed by rinse with black tea vs green tea vs tap water. Maltose release monitored Black tea infusion significantly more effective than green tea.	15 Healthy subjects,	Clinical Trial	[34]
6	Bone Health BMD positively correlated with tea drinking (P <0.05)	US; women; N = 91 465; 50-59 years	Clinical Trial	[35]
7	Tea drinkers had significantly greater (5%) mean BMD measurements, adjusted for age, BMI and smoking	UK; women; N=1256; 65-76 years	Clinical Trial	[36]
8	Mood and cognitive performance Mood improved and anxiety decreased when caffeine and/or milk added to hot beverages. Tea related to increase in skin temp	16 healthy caffeine withdrawn subjects	Clinical Trial	[37]
9	Antioxidant effects	In Wistar stain rats	Animals experiments	[38]

Cancer

Cancer is the most common cause of human mortality worldwide. Cancer cells are capable of limitless replication potential due to their self-sufficient growth signals and are resistant to anti-growth signals from host defense that enable them to evade apoptosis. Furthermore, they can sustain

angiogenesis that can lead to tissue invasion and metastasis. There are many reports on the efficacy of the anti-tumor and cancer prevention activity of black tea. Studies from Baker et al. [45] and Doral et al. [46] support the cancer chemo-preventive effect of black tea in the development of prostate cancer, ovarian cancer and rectal cancer.

Daily consumption of black tea in women lowered the concentration of 17 β -estradiol (E2), which may reduce hormone-related cancer risk [47]. Regular black tea consumption is also associated with the reduced risk of ovarian and bladder cancer in female subjects [48-50]. Furthermore, several research groups have attempted to elucidate the molecular mechanisms of black tea and its polyphenols.

Drinking black tea reduced incidence and number of skin papilloma in 7,12 dimethylbenz[a]anthracene (DMBA)-treated mice through activation of detoxification enzymes and decreased lipid peroxidation [51]. Oral administration of black tea polyphenols delayed tumorigenesis, reduced tumor number and volume in DMBA-induced mouse skin carcinogenesis through induction of apoptosis in tumor cells [52]. Topical application of combined black tea polyphenols and resveratrol synergistically inhibited DMBA/TPA-induced skin carcinogenesis by reducing tumor incidence, number and volume. Mechanistic study showed that this combination down-regulated mitogen-activated protein kinases (MAPKs) and increased tumor suppressor gene *p53* and apoptosis [53]. Consistent with the results in skin cancer model, oral intake of black tea polyphenols or extract also suppressed DMBA-induced mammary tumors and oral tumors by scavenging reactive oxygen species (ROS) that reduced the oxidative stress [54] and down-regulating cyclooxygenase-2 (COX-2), nuclear factor kappa-B (NF- κ B) and protein kinase B (Akt) [54], and interfering with the activity of carcinogen metabolizing enzymes.

Effect of Black tea on cardiovascular health and neurodegenerative diseases

Cardiovascular disease (CVD) and stroke is a major cause of mortality in developed nations [55]. Numerous epidemiological and human intervention studies have suggested that regular consumption of polyphenol rich foods, such as fruits, vegetables, cocoa, tea and wine, may exert cardio - protective effects in humans [56]. Studies have indicated a correlation between the dietary intake of flavonols, flavones and flavanols and a reduced risk of coronary artery disease [57]. Supporting this hypothesis, three meta- analyses have confirmed the blood pressure lowering capacity of flavanol-rich cocoa [58-60]. The correlation between high black tea consumption and decreased blood pressure has also been reported [61,62].

The neurodegenerative disorders appear to be triggered by variety of events including neuro-inflammation, glutamatergic excitotoxicity, increase in oxidative stress, iron and/or depletion of endogenous antioxidants [63-65]. Flavonoids are implicated to protect the brain in a number of ways,

including by protection of neurons, enhancement of existing neuronal function or by stimulating regeneration process [66]. Polyphenols have been shown to protect neurons against oxidative stress [67]. There is also a growing interest in the potential of polyphenols to improve general cognitive ability [68-71]. Epidemiological studies have suggested that moderate wine consumption may reduce the incidence of certain age related neurological disorders including Alzheimer's disease [72-74]. Researches show that regular dietary intake of flavonoid rich foods and/or beverages associated with 50% reduction in the risk of dementia [75].

Other effects of black tea consumption

There have been suggestions that bone mineral density (BMD) may be influenced by chemical compounds in tea such as caffeine, fluoride and phytoestrogens. The available evidence suggested that black tea consumption had a moderately positive effect on BMD, particularly in older women. There was a significant increase in BMD with higher levels of tea consumption (four or more cups per day) [76]. Black tea was also identified as an independent protective factor for the risk of hip fractures in men in the Mediterranean Osteoporosis Study [77].

Fluoride is known to protect teeth from dental caries. The tea plant naturally accumulates fluoride from the soil and can contain 196 mg per 2 g of dry tea [78]. Despite knowledge of this, few studies have investigated the potential impact of tea on caries risk. The review by Gardner et al. [79] noted that tea inhibited plaque bacteria and suppressed salivary amylase activity, which would have the effect of slowing sugar release following starch consumption.

EGCG may protect normal cells from oncogenic transformation and could eliminate cancer cells through apoptosis. In hamster cells EGCG suppressed DNA changes and damage. [80]. Black tea has been reported to beneficially alter immune responses helping protect immune cells against harmful cancerous cells [81].

Future prospects

Several epidemiological studies suggest that theaflavins can prevent risk of disease such as cardiovascular disease and some cancers. On the basis of laboratory studies regular intake of black tea may improve the oxidative stress biomarkers. From several pharmacological observations, worldwide abundance and absence of toxicity, theaflavin supplement can be used as an important natural therapeutic agent in chemoprevention studies and in the field of medicine. Further research is needed to explain the bioavailability and evaluation

corresponding to the optimal amount of consumption of black tea in mammalian system.

CONCLUSIONS

Taken together, the evidence indicates a positive role for tea in human health although the final proof from intervention studies remains elusive. It is known from experimental research that black and green teas contain polyphenols, and that these act as antioxidants *in vitro* as well as *in vivo*. Various human studies have suggested that tea polyphenols beneficially modulate the biochemistry and physiology leading to CHD and cancer development.

Conflicts of interest

There are no conflicts of interest.

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