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Exploring the Health Benefits of Green Tea Polyphenols

MGS. Sowjanya[1], B. Murali[2], B. Ramesh[1]*
[1]Department of Genetics & Genomics, Yogi Vemana University, Kadapa.
[2]Department of Computer Science and Engineering, YSR Engineering college, Proddatur,

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*Corresponding Author Email: adenoramesh@gmail.com

ABSTRACT

Camellia sinensis is a shrub whose leaf buds and leaves are used to manufacture tea. Next to water, tea is one of the most popular beverages consumed worldwide. The polyphenols (flavonoids) in green tea are the major source of its antioxidant and health benefits. The major polyphenols are catechins, EC, EGC, ECG, and EGCG. Among them, EGCG has significant health-promoting properties. Many research studies highlight the great benefits of green tea for various deteriorating conditions, such as cardiac diseases, skin disorders, cholesterol reduction, chronic hepatitis, and diabetes. This review focuses on the major health benefits linked to green tea polyphenols.

KEY WORDS: Green Tea, polyphenols, antioxidant, antibacterial, anticancer, antidiabetic, health benefits.

Introduction

Camellia sinensis is a shrub that belongs to the family *Theaceae*, whose leaf parts are used to make tea. Green tea is the most important antioxidant beverage consumed by a large portion of the world population. Among the many varieties of beverages, green tea consumption has shown remarkable and significant beneficial effects on human health (1). In countries like China, Japan, and Korea, green tea is imbibed as an important beverage. To understand the health benefits, many investigations have been conducted over the last fifteen years on the polyphenols found in green tea extract, which is unfermented (2-8). It is estimated that worldwide, nearly three million metric tons of tea leaves are produced annually, of which twenty percent are green tea leaves (9-10).

Ingestion of green tea has been associated with the prevention of various types of cancers (11). Many clinical trials and epidemiological studies have shown that green tea consumption decreases the risk of several chronic diseases (12). The connection between green tea consumption and human health benefits is well-established (13-14). The composition of green tea varies with climate change and the leaf position on the harvested shoot. Unfermented green tea fresh leaves undergo a steaming process that maintains the green color during processing by preventing the enzymes that break down leaf color pigments. Thus, polyphenols are preserved, which are beneficial for health maintenance. Flavonoids are the important polyphenols in green tea. The commonly important flavonoids known as catechins in green tea include catechins, epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (ECG), and epigallocatechin gallate (EGCG) (15). Among all flavonoids, EGCG is the most significant active compound. EGCG is abundant in the primary first leaves and leaf buds. Dried green tea leaves contain 8-12% polyphenols (16-18).

The chemical composition of green tea is very complex. It accounts for 15-20% protein content, 5-7% carbohydrate content, 5% minerals and minor trace elements, and small quantities of fatty acids, sterols, vitamins (especially B-complex vitamins, ascorbic acid, and tocopherol), pigments like carotenoids and chlorophyll, volatile compounds like alcohols, hydrocarbons, aldehydes, lactones, and xanthic bases like caffeine and theophylline (19). Many recent research studies have shown that green tea possesses antioxidant, antiviral, antifungal, and chemoprotective effects (20).

Effect on obesity and coronary disease

Excess weight and obesity are increasingly common medical problems leading to many diseases such as osteoarthritis, lung dysfunction, diabetes, hypertension, coronary heart disease, and certain types of cancers (21-23) in many developed countries. The effects of green tea on obesity and diabetes have gained more attention in recent years. Catechins in green tea, particularly EGCG, have both anti-diabetic and anti-obesity effects (24-25). Green tea can increase energy utilization and fatty acid oxidation, leading to weight loss. Green tea can induce weight loss by enhancing energy metabolism and fatty acid oxidation (24-26). In some clinical research studies, green tea's antioxidant properties may suppress coronary artery disease. Japanese research studies have shown that LDL cholesterol levels are suppressed by green tea ingestion, thereby preventing the risk of atherosclerosis, a heart disease. Regular ingestion of tea provides protection against coronary heart disease, reducing the risk by 36% (27). The inhibition of growth and synthesis of fatty acids and triglycerides in MCF-7 cells of breast cancer may be due to the downregulation of fatty acid synthase gene expression in the nucleus and an increase in cell energy utilization in the mitochondria (28-29). In a study, consumption of EGCG from green tea extracts suppressed obesity in mice by reducing energy absorption and increasing the breakdown of fatty acids (30). Elevated and prolonged activation of heat production by the combination of polyphenols and caffeine may be responsible for the maintenance of obesity (31).

Effect on skin

Research studies on both animals and humans have revealed that green tea contains polyphenols that are photoprotective and exhibit antioxidant properties. In one study, green tea polyphenols were used as pharmacological agents to inhibit ultraviolet-B (UVB) light, which commonly induces skin disorders such as melanoma, non-melanoma skin cancers, and photoaging (32). Recent studies show that EGCG may have the potential to reactivate epidermal cells of the skin (33). Moreover, green tea has been found to have anti-inflammatory properties that can aid in soothing and calming the skin, making it beneficial for conditions like acne vulgaris (34). The application of green tea extracts has also been associated with promoting DNA repair in the skin, which can be crucial for maintaining skin health and preventing skin cancer (35). Additionally, green tea polyphenols have been shown to stimulate the proliferation of keratinocytes, which can contribute to the anti-aging effects on the skin (36).

Effect on liver

The liver is an important organ where both the production and degradation of biomolecules take place. Over the last few decades, there has been an increasing risk of liver diseases such as fatty liver, liver cirrhosis, and hepatocellular carcinoma (HCC). HCC most commonly occurs in people suffering from liver disease, particularly those with chronic hepatitis B and C infections. Worldwide, HCC is the sixth most common cancer and the third leading cause of cancer deaths (37). Many research studies have shown the remarkable beneficial effects of green tea consumption on liver diseases, including a decreased risk of HCC, hepatitis, liver cirrhosis, fatty liver, and chronic disease (38). Long-term ingestion of green tea catechins may show protective effects against obesity, type II diabetes, and coronary diseases (39).

Green tea protection in dental carries and gums

Green tea, with its antibacterial and antioxidant properties, can be used as an adjuvant to maintain oral hygiene and manage periodontal gum diseases (40). Periodontitis is a serious gum infection usually resulting from poor oral hygiene, leading to tooth loss, gum damage, jawbone destruction, and an increased risk of lung and coronary diseases. Dental plaque is the cause of the initiation of gingivitis (40), which can progress to periodontitis. The treatment of periodontitis with synthetic chemical-based mouthwashes can have side effects, leading to restricted use. Therefore, green tea consumption, which is non-toxic, can help suppress periodontitis by promoting the production of beneficial compounds such as phosphoenol and flavonoids like catechins (41).

Green tea effect on cancerous cells

Green tea has garnered new attention in recent years for its health benefits, particularly its anti-cancer effects (1). The most common cancer in women is breast cancer, characterized by malignant proliferation and differentiation in the lining of epithelial cells and ducts of the breasts (42). The anti-cancer effects of green tea components on breast cancer have been observed in many animal research studies (43). Further research has been conducted to uncover the mechanisms at molecular and cellular levels. Green tea inhibits tumor growth and the metastasis stage by suppressing the activity of the urokinase enzyme (44). According to some studies, green tea polyphenols can inhibit the process of angiogenesis in cancer (25, 45-46). They also prevent ovarian cancer development by inversely affecting external genital warts and cervical lesions (48), as well as prevent colon cancer development (47) by decreasing the formation of pro-inflammatory compounds such as leukotriene A4 hydrolase and 5-lipoxygenase. Studies suggest that polyphenols induce DNA damage in cancer cells by triggering apoptosis (49).

Green tea as an antioxidant

Green tea and its ingredients contain high amounts of polyphenols, which act as antioxidants. EC, EGCG, EGC, and ECG are the important and major catechins present in green tea, known for their vigorous and strong antioxidant activity. The oxidative damage caused by free radicals in the body is mitigated by the potent antioxidant activity of green tea when consumed. Research studies have shown that these antioxidants can delay or stop the initiation of cancer, cardiac diseases, and immune system dysfunction, as well as prolong the aging process (50). EGCG is the most beneficial and potent catechin, exhibiting 10 times more activity than vitamin C and β-carotene in allyl peroxyl radical scavenging activity.

Green tea effect on blood pressure

Many investigations have been conducted on the effects of green tea in antioxidation and vasodilation related to blood pressure. Meta-analyses have revealed a remarkable inverse relationship between the consumption of green tea and the risk of heart diseases such as coronary artery disease, stroke, and myocardial infarction (51-53). Clear evidence shows that obesity is a major risk factor for increased mortality from hypertension and cardiovascular diseases (54-56). Green tea, rich in catechins and flavanols, exhibits vasodilatory effects (57, 1, 51), which contribute to cardiovascular health maintenance (58-60).

Antimicrobial activity

Green tea catechins exhibit pH-dependent antifungal activity. EGCG can inhibit the growth of *Candida albicans*, with pyrogallol catechins showing greater antifungal activity than catechol catechins (61). The antimicrobial effects of green tea have been demonstrated against both Gram-positive and Gram-negative bacteria, including multidrug-resistant strains (62-66). Moreover, green tea has shown efficacy against specific bacteria such as *Staphylococcus aureus*, *Escherichia coli*, *Streptococcus pneumoniae*, and *Helicobacter pylori* (62-63, 66-67). The mechanisms underlying the antimicrobial activity of green tea involve its polyphenolic compounds, particularly EGCG, which can interact with microbial proteins, disrupting their structure and function. Additionally, green tea catechins have been shown to have inhibitory effects on specific bacterial enzymes, contributing to their antimicrobial properties (68). Quantitative analysis shows that higher concentrations of EGCG and ECG suppress viral RNA synthesis, making them strong inhibitors of viral replication in influenza (69).

Effects on absorption of metal ions

Polyphenols, such as catechins in green tea, affect the absorption of iron, particularly in people at high risk of iron deficiency (70-71). As flavonoids chelate with metal ions (72), catechins can influence ion absorption and metabolism. Prolonged ingestion of green tea decreases zinc ion absorption and increases manganese absorption (73), while having no effect on copper ions. Catechin ingestion does not affect the plasma concentration of these ions (74).

Effects on carbohydrate metabolism/Effect of EGCG on diabetes

Several research studies on animals and humans have proposed that the flavonoids in green tea have many antidiabetic effects (75-77). These flavonoids have also shown the ability to enhance insulin activity (78) and exhibit insulin-like activities (79). EGCG in green tea was found to prevent the uptake of glucose by the sodium-dependent glucose transporter (SGLT1), demonstrating its role in blood sugar control (80). According to Waltner-Law et al. (79), in *in vitro* studies, EGCG in green tea reduced glucose production in H4IIE rat hepatoma cells. Several investigations on EGCG have shown that it mimics insulin by decreasing the expression of the gluconeogenic enzyme phosphoenolpyruvate carboxykinase through the phosphorylation of tyrosine in the insulin receptor and its substrate. In many recent experimental models of type II diabetes mellitus, green tea and its extracts have been shown to beneficially modify glucose metabolism (81-82). In *in vitro* studies, EGCG enhanced cytokine-induced β-cell damage (83) and inhibited the reduction of islet mass *in vivo* with multiple low doses of streptozotocin (84). Streptozotocin-treated diabetic rats showed increased sensitivity to thrombosis and platelet aggregation, a deformity that could be mitigated by the dietary intake of green tea catechins (85-86).

Effect on COVID-19

In the respiratory system, mucus plays an important role as a physical barrier against microbes and dust particles inhaled during respiration. Hypersecretion of mucus is often observed in patients suffering from COVID-19, possibly due to excessive inflammation, which can expedite the blockage of the airway (87). During COVID-19 therapy, patients are prescribed prophylactic and therapeutic medicines that increase the water content of respiratory mucus, thereby reducing airway obstruction (88). Research studies have shown that guaifenesin, a mucus diluent, plays an important and effective role in clearing mucus from the airways in COVID-19 patients (89). Along with guaifenesin, statins also show significant benefits for patients suffering from COVID-19 (90).

According to research experiments by Liang et al., (91) in rats, the polyphenol EGCG can ameliorate mucus production in the airways by blocking the signalling routes of the epidermal growth factor receptor. This suggests that EGCG, a polyphenol found in green tea, may act as a therapeutic component to reduce chronic inflammation in the airways and alter mucus production. The antioxidant properties of EGCG in reducing mucus secretion help decrease levels of H_2O_2 and superoxide, resulting in reduced mucus production.

Effect on epigenetic modifications

The potential epigenetic effects of green tea and its bioactive components, specifically catechins such as epigallocatechin-3-gallate (EGCG), have been studied in relation to cancer prevention and treatment (92-95). Research has demonstrated that green tea catechins can influence DNA methylation, histone acetylation, and other epigenetic mechanisms. This can result in the reactivation of genes that suppress tumour growth and the correction of abnormal epigenetic patterns linked to cancer (92-94). The ability of green tea catechins to affect DNA methylation, histone acetylation, and other epigenetic mechanisms in skin cancer cells has been linked to their anti-carcinogenic properties (92). Moreover, studies have shown that green tea polyphenols, such as EGCG, can modify the activity of DNA methyltransferase in different types of cancer cells, indicating a possible role in preventing epigenetic abnormalities associated with cancer development (93).

Conclusion

Green tea is the important unfermented beverage ingested worldwide. It is linked with many health promoting benefits such as reduction of hepatitis, cholesterol, blood pressure, breast cancer, maintenance diabetes. It also protects the skin from many disorders by acting as shield. It is used as mouth wash because of its antioxidant and antibacterial properties, and it prevents dental caries and protects the gums. Green tea is cost efficient. However, human clinical research data is still limited. More specific methods and models should be implemented along with targeted biomarkers for better understanding of the human endogenous and exogeneous factors.

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Conflict of Interests

The authors declare no conflict of interest.

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