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EVIDENCE-BASED HEALTH BENEFITS OF MULTIFACETED PLANT GREEN TEA: A REVIEW

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ABSTRACT: In response to the increasing popularity and greater demand for medicinal plants, several conservation groups recommend cultivating wild medicinal plants. Green Tea is among the most ancient and popular therapeutic beverages worldwide. This product is made from the plant leaf called *"Camellia sinensis*." It can be prepared as a drink, which can have many systemic health effects or an "extract" can be made from the leaves for medicine. Green tea contains thousands of bioactive ingredients, which are almost contributed by polyphenols, which play a key role in preventing and treating many diseases. This literature review aimed to illustrate the phytoconstituent and marketed products of the plant "Green tea".

INTRODUCTION: In past times, plants have been a good source of medicine. Ayurveda and other Indian literature mention the use of plants in the treatment of various human diseases. India has about 45,000 plant species, and several have been claimed to possess medicinal effects [1]. Population rise, inadequate supply of drugs, high cost of treatment, and drug resistance encountered in synthetic drugs have led to an elevated emphasis on using plants to treat human diseases. India is one of the ancient civilizations known for its rich repository of medicinal plants [2]. The Ancient Chinese Proverb 'Better to be deprived of food for three days than tea for one' shows the importance of tea in the day-to-day life of the Chinese. The Chinese have known about the medicinal benefits of green tea since ancient times, using it to treat everything from headaches to depression [3]. Tea is one of the most commonly consumed drinks on the earth, next to water and well ahead of coffee, beer, wine, and carbonated soft drinks. *Camellia sinensis* is a species of plant whose leaves and leaf buds are used to make Chinese tea. It is of the genus *Camellia*, a genus of flowering plants in the family *Theaceae*. Common names include tea plant, tea tree, and tea shrub [3, 4]. The cultivation of tea plants is economically important in many countries, and the tea plant *Camellia sinensis* is grown in as many as 30 countries, as shown in **Fig. 1** and **2.**

Four types of tea are produced from this same plant, depending on how the tea leaves are processed [4, 5]. These are white, green, oolong, and black tea. White tea is produced from very young leaves and buds that have not yet turned green, and the only processing is drying. Oolong tea is made from partially fermented mature leaves, and black tea is from fully fermented mature leaves. Green tea is produced from mature leaves with minimal processing (only drying) [6].

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Green tea, which makes up around 20% of tea production worldwide, is consumed mainly in China, Korea, and Japan. Black tea contains up to three times the amount of caffeine as green tea. Black, green, and oolong tea are all excellent sources of vitamin C [7].

FIG. 1: *CAMELLIA SINENSIS*

FIG. 2: FLOWER OF *CAMELLIA SINENSIS*

The chemical composition of green tea varies with climate, season, horticultural practices, and position of the leaf on the harvested shoot [8]. The most relevant components of green tea medicinally are the polyphenols, with the flavonoids being the most important. The most pertinent flavonoids are the catechins, which comprise 80% -90% of the flavonoids and approximately 40% of the water-soluble solids in green tea [9, 10, 11].

The health benefits of green tea depend on its bioavailability after consumption. The catechins and their metabolites may be detected in blood plasma, urine, and tissues. The four major catechins in green tea are (-) – epicatechin, (-) – epicatechin - 3-gallate, (-) – epigallocatechin and (-) – epigallocatechin-3- gallate (EGCG). EGCG is the primary component, accounting for 40% of the polyphenolic mixture [12]. One cup of green tea usually contains about 300-400mg of polyphenols, which are considered non-toxic. Polyphenols are quickly oxidized after harvesting due to the enzyme polyphenol oxidase, and tea leaves are steamed at high temperatures to evaluate this enzyme [13]. Other compounds are alkaloids (caffeine, theophylline, and theobromine), amino acids, carbohydrates, proteins, chlorophyll, volatile organic compounds, fluoride, aluminum, minerals, and trace elements [14].

Health Benefits of Green Tea: The importance of green tea lies in the fact that it is rich in catechin, polyphenols, and especially EGCG [1]. The EGCG is an important antioxidant: besides slowing the growth of cancer cells, it kills cancer cells without injuring healthy tissue. It has also successfully lowered LDL and cholesterol levels, inhibiting the unusual formation of blood clots, depletion of platelet aggregation, lipid regulation, and inhibition of proliferation and passage of smooth muscle cells [5, 6]. Inhibition of rare blood clot formation is important when considering that thrombosis (formation of abnormal blood clots) is the leading cause of heart attacks and stroke [15]. Green tea's chemical composition is highly complex due to the abundance of different classes of chemical compounds, which are illustrated below [16-20].

TABLE 1: CHEMICAL COMPOSITION OF GREEN TEA LEAVES

Constituent Percentage	(% of the dried leaf)	Constituent Percentage	(% of the dried leaf)
Polyphenols	37.0	Ash	5.0
Carbohydrates	25.0	Chlorophyll	0.5
Caffeine	3.5	Lignin	6.5
Protein	15.0	Lipids	2.0
Aminoacids	4.0	Organic acids	1.5

Polyphenols: These represent the most crucial group of green tea leaf constituents, and thus they are considered the approved dietary source of polyphenols that account for 50–70% of tea aqueous extract. Mostly, these polyphenols are flavonoids that are biosynthetically constructed in

considerable quantities ranging from 0.5% to 1.5%, with more than 4000varieties [21]. The most abundant flavonoids in green tea contain catechins (flavan-3-ols), which constitute about 30–40% of its dry weight [22].

Tannins are the second most significant polyphenols present in tea products. In inclusion, phenolic acids comprising caffein acid (5), chlorogenic acid (6), coumaric acid (7), gallic acid (GA) (8), and quinic acid ester (9), as well as flavanols represented mostly by kaempferol (10), myricetin (11), and quercetin (12), are also found [23, 24, 25]. Nagma Khan *et al.* researched (2018) on the anticarcinogenic effects of tea polyphenols [26]. She proved in *in-vitro* studies that (ECG) epicatechin-3-gallate, a natural polyphenolic component of green tea, inhibited the invasion of (NSCLC) non-small cell lung cancer cells by suppressing the levels of matrix metalloproteinase (MMP)-2 and urokinase-type plasminogen activator (uPA) [27].

Mukhtar and Ahmad, 2000; Khan *et al.,* 2006 researched green tea's anticarcinogenic properties. Some epidemiological studies also support tea's protective role against cancer development. Studies conducted in Asia, where green tea is consumed frequently and in large amounts, tend to show a beneficial effect on cancer prevention [38].

Nagma Khan researched (2018) on the antidiabetic effects of tea polyphenols. Diabetes is one of the major health problems worldwide. Type-1 diabetes is not preventable and is treated by insulin supplementation. However, type-2 diabetes can be prevented or reversed by altering diet and managing lifestyle factors. EGCG has been reported to inhibit starch hydrolysis and acted as an inhibitor by binding to the active site of α-amylase and α-glucosidase. The antidiabetic action of EGCG was explored in a high-fat diet and streptozotocin (STZ)-induced type-2 diabetes. Treatment with EGCG enhanced glucose homeostasis and repressed the process of gluconeogenesis and lipogenesis in the liver. It also activated PXR/CAR, accompanied by upgrading PXR/CAR-mediated phase II drug metabolism enzyme expression in the small intestine and liver, relating SULT1A1, UGT1A1, and SULT2B1b [29]. The antihyperglycemic effect of polyphenols was reported by Gomes *et al.* [93]. EGCG inhibited intestinal glucose uptake by the sodium-dependent glucose transporter SGLT1, indicating its increase in controlling blood sugar [94].

Logesh Rajan researched green tea polyphenols' activity for cardiometabolic health in 2022. Cardiovascular disease (CVD) is a chronic severe multifactorial disease that adversely affects an individual's health, well-being, and lifestyle. The world health organization (WHO) projected cardiovascular diseases as the primary cause of death [28].

Christy Tangney researched green tea polyphenols' activity on cardiovascular and inflammation in 2015. Atherosclerosis, the pathological condition often underlying cardiovascular disease (CVD), is a chronic inflammatory condition involved in initiating and perpetuating atherosclerotic lesions, which may erode or rupture, leading to clinical events such as angina, myocardial infarction or cerebrovascular attack. Because a poor quality diet, smoking, and physical inactivity account for much of the modifiable CVD risk, the role of diets rich in bioactive compounds in maintaining or improving cardiovascular health is of utmost interest. As this underlying chronic inflammation plays a crucial role in the development and progression of CVD, bioactive compounds with anti-inflammatory properties, such as polyphenols.

Sabu M. C. researched the antidiabetic activity of green tea polyphenols in November 2002. In his in vitro studies, he found that an aqueous solution of green tea polyphenols (GTP) would inhibit lipid peroxidation and scavenge hydroxyl superoxide radicals [29].

Badriyah Shadid Alotaibi researched green tea polyphenols' activity for cardiovascular diseases in 2021. Polyphenols have long been recognized as health-promoting entities, including beneficial effects on cardiovascular disease. Still, their reputation has been boosted recently following several encouraging clinical studies in multiple chronic pathologies that seem to validate efficacy. The health benefits of polyphenols have been linked to their well-established potent antioxidant activity.

Peter W. Taylor carried out a study on green tea polyphenols' activity for antimicrobial properties in 2009. Studies conducted over the last 20 years have shown that the green tea polyphenolic catechins, in particular (−)-epigallocatechingallate (EGCg) and (−)-epicatechingallate (ECg), can inhibit the growth of a wide range of Gram-positive and Gram-negative bacterial species with moderate potency. Evidence suggests these molecules may help control common oral infections, such as dental caries and periodontal disease. Sub-inhibitory concentrations of EGCG and ECG can suppress the expression of bacterial virulence factors and can reverse the resistance of the opportunistic pathogen *Staphylococcus aureus* to β-lactam antibiotics.

Jing Luo performed a study on green tea polyphenols' activity for anti-aging properties in 2021. Polyphenols are the largest, most studied group of naturally occurring antioxidants, which can be structurally categorized into phenolic acids, flavonoids, stilbenes, lignans, and other polyphenols with a hydroxyl group(s) attached to the carbon atom on the aromatic ring [10]. It was reported that the dietary consumption of polyphenols is much higher than the daily intake of several essential micronutrients, such as vitamins C, E, and carotenoids [11]. Over the past two decades, polyphenolic compounds have attracted considerable research interest because of their wide distribution in different foods and their potent antioxidant properties [11]. In addition, polyphenols were reported to modulate energy metabolism in a manner favorable for well-being and longevity and reduce the risk of aging-related chronic diseases [12].

Xanthine Bases/Purine Alkaloids: They are usually represented by caffeine, the second principal constituent of the dry leaf; its metabolites, theophylline, and theobromine, are also in minor amounts [36]. Xanthine alkaloids are a combination of an imidazole ring and pyrimidine rings. The class of xanthine alkaloids mostly contains caffeine, theobromine, and theophylline [37]. The caffeine content in coffee is about 0.4-2.4% dry weight. The content of caffeine in young leaves of *camellia sinensis*, camellia assamica, and camellia aliens is 2%-3% dry weight. Still, it presents less than 0.02% in camellia kissi, while caffeine content in tea (infusion) is between 1.0% and 3.5% of the composition [38, 39].

The interesting fact is that methylxanthines produce significant biological results. Caffeine is used as an analgesic, and it is used along with some other analgesics such as paracetamol, ibuprofen, or acetylsalicylic acid [40]. Methylxanthines also possess psychostimulatory activity. The procedure of adenosine receptor (A1 and A2A receptor) antagonism was suggested behind the neuroprotective effects of caffeine [41]. However, the useful effects justified the protection against blood-brain barrier dysfunction. It is clear from the more recent animal and epidemiologic studies that there is a link between midlife caffeine consumption and lower disease incidence. Methylxanthines have also been used for respiratory diseases [42, 43, 44].

Gangchen *et al.* (2015) researched green tea polyphenols showing that it decreases uric acid level through xanthin oxidase. Green tea is in Chinese material media, mainly inducing urination and quenching thirst [45].

Shu-Hua Ouyang (2021) studiedthe antidepressant purine effect on alkaloids from green tea. He investigated the antidepressant-like effects and mechanism of theacrine in chronic unpredictable mild stress [46].

Triterpenoid Saponins: They are constituted by floratheasaponin A, B, C, D, E, and F (21–26), which exist at high concentrations in seeds and flowers [47].

Tea plants have a collection of more than 70 different saponins with tissue-specific and maturation-specific distribution (Guo *et al.*, 2018) [48]. A recent study showed evidence of 50 putative saponins in tea extracts that could be detected with ultrahigh-performance liquid chromatography coupled tandem mass spectrometer (UPLC–MS/MS) (Wu *et al.* 2019). The researchers used LC–MS/MS to understand which tea saponin molecules are present in tea tissues and infusions that are taken up by beverage drinkers. They identified saponin molecules according to MS spectra of relative peaks and retention times (Wu *et al.* 2019) from two different types of green teas (YR and LGP) [49-55]. Since, there are reports on the anticancer effect of tea saponins from Camellia species and their bioactive mechanism (Murakami *et al.* 2000; Ghosh *et al.* 2006; Morikawa *et al.*

2007; Zhao *et al.* 2015; Matsuda *et al.* 2016; Jia *et al.* 2017; Cui *et al.* 2018), we then tested the anticancer activity of tea whole saponin extracts by measuring their cytotoxicity [56]. Some tea saponins were reported to have a potent result in inhibiting cancer cell proliferation and inducing apoptosis in cancer cells (Ghosh *et al.* 2006; Zhao *et al.* 2015; Cui *et al.* 2018) [57]. Saponins were used in a serial concentration study to treat human TSCC cell lines (TCA8113) and hepatocellular carcinoma cell lines (HepG2) and to examine their cytotoxicity activity [58]. They notice clear inhibitory effects of total tea saponins on the proliferation of both human cell lines, although at different sensitivities. When TCA8113 cells were treated with 0.025mg/mL solution made of tea total saponin extract powder, about 75% of the cells survived [59]. When the concentration reached 0.05mg/mL, only 20% of the cells survived. The calculated IC_{50} against TCA8113 cells was about 29.20lg/ml [60]. When HepG2 cells were treated with 0.01mg/mL total saponin extract solution, about 70% of cancer cells remained alive. When the concentration reached 0.05mg/mL, only 18% of the cells survived. When 0.05mg/mL was applied to HepG2 cells, the cell survival rate decreased rapidly to less than 12%. The IC50 for TCA8113 cells was much higher than that against HepG2 cells, which was 17.54lg/ml [61-66].

Amino Acids: Amino acids constitute about 1–4% of dry weight and are represented by arginine, aspartic acid, glutamic acid, glutamine, and serine**,** as well as theanineor 5-Nethylglutamine, which account for more than 90% of the whole amino acids present in the leaves of *C. sinensis* [67]. It is worth mentioning that theanine is the major amino acid that exists in the largest amounts, comprising about 1–2% of the dry weight of the green tea leaf, and thus it is considered the third major constituent of dry leaf. Furthermore, it is recognized to be the only amino acid that slowly exists in tea plants to which green tea's flavor and exotic taste are attributed [68, 69]. Tryptophan, glycine, tyrosine, valine, leucine, threonine**,** and lysineare also found [70].

L-THE was first isolated and identified in 1949 as a water-soluble non-proteinogenic amino acid predominantly found in the tea plant (*Camellia sinensis*) and responsible for a unique taste similar to the savory taste sensation that monosodium glutamate produces known as 'umami' [71]. According to the universal nomenclature of the International Union of Pure and Applied Chemistry, L-THE is '2-amino-4-(ethylcarbamoyl) butyric acid.' It is referred to by many different names, including 'gammaglutamylethylamide' and 'gamma-glutamyl-L-ethyl amide' reflecting the presence of glutamine, a conditionally essential amino acid found as a core unit in its structure [72, 73]. Theanine may occur as a racemic mix of its L- and D- enantiomers that compete for absorption and urinary excretion. D- enantiomer is reported to be metabolized faster, while L- is preferentially metabolized by kidneys [74].

The potential health benefits associated with the consumption of L-THE include improvements in emotional status, quality of sleep, suppression of hypertension, and improvements in mood and cognition [75]. Additionally, consuming L-THE in combination with caffeine promotes antioxidant and anti-inflammatory activity in the brain, possibly reducing the risk of cognitive impairment [75, 76]. The current evidence on the consumption of L-THE in humans and its effects on stress and anxiety is equivocal. To date, the majority of evidence is based on animal research, which has commonly used pure L-THE, and in combination with other bioactive such as caffeine and catechins that can potentially have synergistic and, in some cases, potentially antagonistic effects [77-80]. Essential amino acids are mainly responsible for stimulating muscle protein anabolism in the aged (Volpi *et al.*, 2003). It is considered that 15 g of essential amino acids taken as a bolus is required for maximum stimulation of muscle protein synthesis (Wolfe, 2002). This indicates that the quality of protein is critical in the diet of older people [80, 81, 101].

Studies on Beneficial Effects of Green Tea Extracts: Studies using animal models have shown that green tea catechins may offer some protection against degenerative diseases [29]. Several studies have shown that green tea has anti-hepatotoxicity [29], protective [29] hepatoma anti-inflammatory properties after cancer onset and hypolipidemic activity in mice treated with liver disease. Green tea catechins may also act as immunomodulators for immunosuppression therapy with antineoplastic

agents [30] and tumor modification or carcinogen therapy [29]. Additionally, green tea, extracts, and isolates effectively prevent oxidative stress [31] and neurological problems [32].

Green tea consumption has also been associated with preventing many types of cancer, including lung, colon, esophagus, mouth, stomach, small intestine, kidney, pancreas, and mammary glands [33]. Several epidemiological studies and clinical trials have shown that green tea (and, to a lesser extent, black tea and oolong tea) can reduce the risk of many chronic diseases [34]. This beneficial effect was attributed to many polyphenols, which are powerful antioxidants. In particular, green tea can lower blood pressure, reducing the risk of stroke and coronary heart disease. Some animal studies have suggested that green tea may protect against the development of coronary heart disease by reducing blood glucose levels and body weight [35]. However, all these data are based on middle-aged animal populations, not older populations, whose nutritional status tends to be more adversely affected by age-related biological and socioeconomic factors [36].

Tea components have antioxidant, antimutagenic, and anticarcinogenic effects and could protect humans from the risk of cancer caused by environmental agents [37]. Sano *et al.* [38] reported the inhibitory effects of green tea leaves against tert-butyl hydroperoxide-induced lipid peroxidation, and a similar antioxidant effect on the kidney was observed after the oral administration of the major tea polyphenol EGCG. The active oxygen method tested the antioxidant efficiency of raw catechin powder and individual catechins. Crude catechins reduced peroxide formation much more effectively than dl-α-tocopherol [39]. Shim *et al.* [40] studied the chemopreventive effect of green tea among cigarette smokers and found that it could block the cigarette-induced increase in sister chromatid exchange frequency.

In humans, Hirasawa and Takada [49] studied the antifungal activity of green tea catechins against *Candida albicans* and the benefit of combined treatment with catechins and lower doses of antifungals, which may help avoid antifungal side effects. Green tea consumption is also associated with increased bone mineral density. It has been identified as an independent protective factor against hip fracture risk, independent of smoking, hormone replacement therapy, drinking coffee, and adding milk to tea [50]. Park *et al.* [51] observed the positive effects of green tea extracts and GTP on bone cell proliferation and activity. The proliferation of hepatic stellate cells is closely related to the progression of liver fibrosis in chronic liver diseases, and EGCG has a potential inhibitory effect on the proliferation of these cells [52, 53].

Tea has been shown to have anticarcinogenic effects against breast cancer in experimental studies [62]. However, there has been conflicting epidemiological evidence that tea protects against breast cancer [62]. A case-control study was conducted in Southeast China between 2004 and 2005 [63]. Incident cases included 1009 patients aged 20-87 years with histologically confirmed breast cancer and 1009 age-matched controls of healthy women randomly selected from breast clinics.

Hsu *et al.* [64] demonstrated the effects of decaffeinated green tea extract (catechin) supplementation on hemodialysis-induced reactive oxygen species, atherosclerotic disease risk factors, and pro-inflammatory cytokines. The Pharma-cokinetics of a single oral dose of catechins were compared between healthy subjects and hemodialysis patients. The authors compared the antioxidant effects of three doses (0, 455, and 910 mg) of oral catechins with oral vitamin C (500 mg) during hemodialysis.In a study by Sabu *et al.* [85], the administration of GTP (500 mg/kg) to normal rats significantly increased glucose tolerance at 60 min. GTPs were also found to significantly reduce serum glucose levels in alloxan diabetic rats at a dose of 100 mg/kg. Continued daily administration (15 days) of the extract at a dose of 50 or 100 mg/kg resulted in a 29% and 44% reduction of the elevated serum glucose level caused by alloxan administration.

A study by Waltner-Law *et al.* [91] provided convincing in vitro evidence that EGCG reduces glucose production in H4IIE rat hepatoma cells. Researchers have shown that EGCG mimics insulin increases tyrosine phosphorylation on the insulin receptor and insulin receptor substrate, and decreases gene expression of the gluconeogenic

enzyme phosphoenolpyruvate carboxykinase. Recently, green tea and green tea extracts have been shown to beneficially modify glucose metabolism in experimental models of type II diabetes mellitus [35, 100]. Lambert *et al.* [102] demonstrated that intragastric administration of EGCG at a dose of 75 mg/kg resulted in a Cmax of 128 mg/L of total plasma EGCG and a terminal half-life of 83 min. Moreover, in humans, oral EGCG intake at a dose of 50 mg (0.7 mg/kg) resulted in a Cmax of 130 mg/L of total plasma EGCG and a terminal half-life of 112 min [100].

TABLE 2: EFFECTS OF GREEN TEA COMPONENTS

Component		Effect
Catechins (Astringency component in tea) [30]		Decreases blood cholesterol Body fat reduction Cancer prevention Antioxidant Tooth decay prevention Antibacterial Bad breath prevention [20]
Theanine (full-bodied flavor component in tea) [30]		Neuronal cell protection Relaxation effect Lowering of blood pressure [20, 21]
Vitamins [30]	Vitamin C	Maintenance of healthy skin and mucus membranes [22, 23]
	Vitamin B2	Maintenance of healthy skin Antioxidant
	Folic acids	Prevention of fetal neural tube defects
	Vitamin E	Antioxidant
	B-carotene	Maintenance of nighttime vision
Saponins [30]		Lowering blood pressure Anti-influenza effect [24]
Minerals (potassium, calcium, phosphorus, manganese, etc.) [30]		Biological regulators [24]
Chlorophyll [30]		Deodorizing effect [24]

TABLE 3: MARKETED PRODUCTS OF GREEN TEA EXTRACT

S. no.	Product	Name	Company name	Weight of extract	Use
1.	Tea bags	Green tea with Himalayan berries& herbs, Green tea lemon exquisite, Green tea, Kangra green tea, green tea	IMC, Himpure, Tetley, Himalayan brew, Lipton	40gm, 50gm, 65gm, 40gm, 45gm	Its herbal ingredients help balance Vata, Pitta & Kapha. It helps reduce weight and enhance immunity. It reduces the risk of cancer and prevents tooth decay.It lowers the risk of stroke. Increases bone density. Controls blood sugar [91]
2.	Green tea premix	Detox green tea, green tea, green tea, green tea, organic green tea	Senso Foods Pvt. Ltd., karting, Lipton, Tetley, jolly	1kg, 1kg, 1kg, 1.5kg, 1kg	It burns fat and reduces weight. Prevent heart disease. It helps maintain a healthy heart as it is thought to protect against all moods [92]
3.	Capsules	Green tea capsules, green tea, green tea, green tea	Inlife, ayurveda, nature, nutriherbs	640mg per capsule, 60 capsule, 120 capsules, 30 capsules	Increase the metabolism and helps lower blood sugar. It helps to reduce the risk of developing endometrial cancer. It helps to burn belly fat [93]
4.	Tablets	Green tea, green tea, green tea extract, green tea	GoingSx, country life, health nutrition, Dharavi herbs	60 tablets, 90 tablets, 120 tablets, 60 tablets	It helps reduce weight and enhance immunity. Reduces the risk of cancer and prevents tooth decay. It lowers the risk of stroke. Increases bone density. Controls blood sugar [94]
5.	Toner	Green tea, green tea, green tea, green tea	Plam, mamaearth, biotique, good vibes	120ml, 60ml, 120ml, 100ml	It helps in adjusting the skin's PH balance and limits the presence of pores. It lights up the skin tone [95]
6.	Gel	Green tea, green tea,	Plam,	45gm,	It improves skin health. It reduces redness

		green tea gel, green tea night gel	mamaearth, beaface, lotus	60gm, 100gm, 60gm	and irritation in the skin and provides the required moisturization. It protects against skin cancer and treats acne [96]
8.	Face wash	Green tea face wash, natural green tea, green tea face wash, green tea	m caffeine, the mom's co, WOW, good wives	50ml, 20ml, 60ml, 40ml	It helps profoundly clean and removes dirt and grime without drying out the skin [97]
9.	Green tea leaves	Green tea, green tea, green tea, green tea leafs	Lipton, Assam green tea, Kangra green tea, Tetley	100gm, 80gm, 60gm, 150gm	It improves mental alertness, relieves digestive symptoms and headaches, and promotes weight loss [98]
10.	Green tea face oil	Green tea, green tea oil, green tea, green tea	m caffeine, lotus, WOW, plam	20ml, 50 ml, 30ml, 20ml	It prevents wrinkles. Green tea oil contains anti-aging compounds and antioxidants, making skin tighter [99]

CONCLUSION: Green tea catechins have proved to be most versatile in providing health benefits. This means that there are potential health benefits for everyone in the consumption of green tea. Even moderate consumption (drinking 1–2 cups of tea per day) may have benefits. Fortunately, a wide variety of research has been performed using green tea catechins. This article shows that green tea has its place in both the conventional and alternative medical communities and in the modern world believing in the adage and preservative measures.

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REFERENCES:

1. Tariq MA, Naveed and K. Barkat Ali: The morphology, characteristics and medicinal properties of *'Camellia sinensis'* tea. J Med Plants 2010.
2. Cabrera C, Gimenez R and Lopez MC: Determination of tea components with antioxidant activity. J Agric Food Chem 2003.
3. Sumpio BE, Cordova AC, Berke-Schlessel DW, Levites Y, Weinreb O, Maor G, Youdim MB, Qin F and Chen QH: 2006.
4. Artacho CR and Gimenez R: Green tea, the Asian Paradox and cardiovascular disease. J Am Coll Surg Cabrera 2006; 202: 813-20.
5. Beneficial effects of green tea-a review. J Am Coll Nutr.
6. Wu AH and Yu MC: Tea, hormone-related cancers and endogenous hormone levels. Mol Nutr Food Res 2006; 50(2).
7. Mukhtar H and Ahmad N: Tea polyphenols Prevention of cancer and optimizing health. AJCN 2000; 71(6): 1698-02.
8. Junqueira VB, Barros SB, Chan SS, Rodrigues L, Giavarotti L, Abud RL and Deucher GP: Aging and oxidative stress. Molecular Aspects of Medicine 2004; 25(1-2).
9. Kitani K, Yokozawa T and Osawa T: Interventions in aging and ageassociated pathologies by means of nutritional approaches. Annals of the New York Academy of Sci 2004; 1019.
10. Luczaj W, Waszkiewicz E, Skrzydlewska E and Roszkowska-Jakimiec W: Green tea protection against age-dependent ethanol-induced oxidative stress. J. Toxicology and Environmental Health 2004; 67(7).
11. Choi YT, Jung CH, Lee SR, Bae JH, Baek WK, Suh MH, Park J, Park CW and Suh SI: The green tea polyphenol (-)-Epigallocatechin gallate attenuates beta-amyloid-induced neurotoxicity in cultured hippocampal neurons. Life Sci 2001; 70(5).
12. Levites Y, Amit T, Mandel S and Youdim MB: Neuroprotection and neurorescue against A beta toxicity and PKC-dependent release of nonamyloidogenic soluble precursor protein by green tea polyphenol (-)-epigallocatechin-3-gallate. FASEB J 2003; 17(8).
13. Jeon SY, Bae K, Seong YH and Song KS: Green tea catechins as a BACE1 (beta-secretase) inhibitor. Bioorganic Medicinal Chemistry Letters 2003; 13(22).
14. Kuriyama S, Shimazu T, Ohmori K, Kikuchi N, Nakaya N and Nishino Y: Green tea consumption and mortality due to cardiovascular disease, cancer and all causes in Japan: The Ohsaki Study. JAMA 2006; 296(10).
15. Sato Y, Nakatsuka H, Watanabe T, Hisamichi S, Shimizu H and Fujisaku S: Possible contribution of green tea drinking habits to the prevention of stroke. Tohoku J Exp Med 1989; 157(4).
16. Cheng TO: Will green tea be even better than black tea to increase coronary flow velocity reserve? Am J Cardiol 2004; 94: 1223.
17. Vinson JA: Black and green tea and heart disease: a review. Biofactors 2000; 13: 127–32.
18. Rietveld A and Wiseman S: Antioxidant effects of tea: evidence from human clinical trials. J Nutr 2003; 133: 3285–92.
19. Pastore RL and Fratellone P: Potential health benefits of green tea (*camellia sinensis*): a narrative review. Diet Nutr 2006; 2: 531–9.
20. The miracle of green tea. http://chinesefood.about.com/library/weekly/aa011400a.htm. Date of access 7 Nov 2007.
21. Graham HN: Green tea composition, consumption, and polyphenol chemistry. Preventive Med 1992; 21: 334–50.
22. Min Z and Peigen X: Quantitative analysis of the active constituents in green tea. Phytother Res 1991; 5: 239–40.

23. Katiyar SK and Elmets CA: Green tea polyphenolic antioxidants and skin photo protection (review). Int J Oncol 2001; 18: 1307–13.
24. US Department of Agriculture. USDA database for the flavonoid contents of selected foods. Beltsville, MD: US Department of Agriculture; March 2003.
25. Cheng TO: Tea is good for the heart. Arch Intern Med 2000; 60: 2397.
26. Cheng OT: All teas are not created equal the Chinese green tea and cardiovascular health. Int J Cardiol 2006; 108: 301–8.
27. Fujiki H, Suganuma M and Kurusu M: New TNF-alpha releasing inhibitors as cancer preventive agents from traditional herbal medicine and combination cancer prevention study with EGCG and sulindac or tamoxifen. Mutat Res 2003; 523–4: 119–25.
28. Fujiki H, Suganuma M and Okabe S: A New concept of tumor promotion by tumor necrosis factor-alpha, and cancer preventive agents (-)-epigallocatechin gallate and green tea—a review. Cancer Detect Prevent J 2000; 24: 91–9.
29. Bertolini F, Fusetti L, Rabascio C, Cinieri S, Martinelli G and Pruneri G: Inhibition of angiogenesis and induction of endothelial and tumor cell apoptosis by green tea in animal models of human high-grade non-Hodgkin's lymphoma. Leukemia 2000; 14: 1477–82.
30. Dulloo AG, Duret D, Rohrer D, Girardier L, Mensi N, Fathi M, Chantre P and Vandermander J: American Journal of Clinical Nutrition 1999; 70: 1040-5.
31. Katiyar S, Elmets CA and Katiyar K: Green tea and skin cancer: photo immunology, angiogenesis and DNA repair. J Nutr Biochem 2007; 18: 287–96.
32. Mukamal KJ, Maclure M, Muller JE, Sherwood JB and Mittleman MA: Tea consumption and mortality after acute myocardial infarction. Circulation 2002; 105: 2476–81.
33. Stangl V, Dreger H, Stangle K and Lorenz M: Molecular targets of tea polyphenols in the cardiovascular system. Cardiovasc Res 2007; 73: 348–58.
34. Lee MJ, Maliakal P and Chen L: Pharmacokinetics of tea catechins after ingestion of green tea and (-)-epigallocatechin-3-gallate by humans: formation of different metabolites and individual variability.
35. Cancer Epidemiol Biomarkers Prevent 2002; 11: 1025–32. Hirasawa M, Takada K. Multiple effects of green tea catechin on the antifungal activity of antimycotics against *Candida albicans*. J Antimicrobial Chemother 53, 225–9.
36. Song JM, Lee KH and Seong BL: Antiviral effect of catechins in green tea on influenza virus. Antiviral Res 2005; 68: 66–74.
37. http://www.northernohiorailfan.com/Green_Tea_Diet_Review.html. Accessed 10 Nov 2007.
38. Hirano-Ohmori R, Takahashi R and Momiyama Y: Green tea consumption and serum malondialdehyde modified LDL concentrations in healthy subjects. J Am Coll Nutr 2005; 24: 342–6.
39. Lill G, Voit S, Schror K and Weber AA: Complex effects of different green tea catechins on human platelets. FEBS Lett 2003; 546: 265–70.
40. Tokunaga S, White IR and Frost C: Green tea consumption and serum lipids and lipoproteins in a population of healthy workers in Japan. Ann Epidemiol 2002; 12: 157–65.
41. Dreosti IE: Bioactive ingredients: antioxidants and polyphenols in tea. Nutr Rev 1996; 54: 51–58.
42. Ahmad N, Feyes DK and Nieminen AL: Green tea constituent epigallocatechin-3-gallate and induction of apoptosis and cell cycle arrest in human carcinoma cells. J Natl Cancer Inst 1997; 89: 1881–1886.
43. Chen ZP, Schell JB, Ho CT and Chen KY: Green tea epigallocatechin gallate shows a pronounced growth inhibitory effect on cancerous cells but not on their normal counterparts. Cancer Lett 1998; 129: 173–179.
44. Conney AH, Lu YP and Lou YR: Inhibition effect of green and black tea on tumor growth. Proc Soc Exp Biol Med 1999; 220: 229–233.
45. Fujiki H, Suganuma M and Okabe S: Cancer inhibition by green tea. Mutation Res 1998; 402: 307–310.
46. Gupta S, Hastack K and Ahmad N: Inhibition of prostate carcinogenesis in TRAMP mice by oral infusion of green tea polyphenols. Proc Natl Acad Sci USA 2001; 98: 10350–10355.
47. Artacho R, Cabera C and Gimenez R: Beneficial effect of green tea, Chinese Journal of Medicine 2006; 25: 79-99.
48. Arab L, Peter C and Poole C: Does green tea effect cardiovascular diseases?. Am Journal of Epidemiology 2001; 154:
49. Chiu HC, Jee SH, Kre ML, Shen SC and Tseng CR: Curcumin induces a p53 dependent apoptosis in human basal cell carcinoma cell. The Journal of investigative dermatology 1998; 111: 656-661. 4. Bowden J: Most effective way to live long. Journal of Short Articles Notes and Reviews 2010; 26:
50. Dalluge JJ and Nelson BC: Determination of tea catechins. Journal of Chromatography Analysis 2000; 881.
51. Akhtar N, Khan BA and Mahmood T: The morphology characteristics and medicinal properties of *Camellia sinensis*. Journal of Medicinal Plant Research 2010; 4: 2028-2033.
52. Gruber S, Otto F, Perva U, Skerget M and Weinreich B: Extraction of active ingredient from green tea. Food Chemistry 2006; 96.
53. Biswas KP: Description of tea plant, in encyclopedia of medicine. Journal of Science of Food and Agriculture 2006:
54. Kemmler G: Nitrogen and potassium nutrition of tea in India, poc. Int. conf. management and fertilization of upland, soil in tropic and subtropic, Periodical House, 5th edition 1986.
55. Natesan S and Ranganathan V: Nutrient element and quality of tea. Journal of Science of Food and Agriculture 1987; 81: 55-59. 11. Dharmawijiya I: Tea manuring in Indonesia. United Plant Association on India Tea Science 1995; 40.
56. Chopra D and David S: Chopra handbook centre, Three Rivers Press United States of America", 4th edition; 2000:
57. Graham H.N: Green tea composition, consumption and polyphenol chemistry. Prevention Medicines 1992; 21: 334.
58. Chopra D and David S: Chopra handbook centre, Three Rivers Press United States of America", 4th edition 2000.
59. Gericke N, Van O and Van WB: Medicinal plants of South Africa, Briza Publications 1997.
60. Cartwright, R. A. and Roberts, E. A. H. 1954. l. Sci. Food Agric. 5:
61. Hashimoto F, Nonaka G and Nishioka I: Chem Pharm Bull 1992; 40: 1 383-1389.
62. Apostolide Z, Du TK and Volsteedt Y: Comparison of antioxidant content of vegetables, fruits and teas measured as vitamin C equivalent. Journal of Nutrition 2001; 19: 63-64.
63. Abe I: Enzymatic synthesis of cyclic triterpenes. Nat Prod Rep 2007; 24(6).

64. Chi X, Bi S, Xu W, Zhang Y, Liang S and Hu S: Oral administration of tea saponins to relive oxidative stress and immune suppression in chickens. Poult Sci 2017; 96(9).
65. Cui C, Zong J, Sun Y, Zhang L, Ho CT, Wan X and Hou R: Triterpenoid saponins from the genus Camellia: structures, biological activities, and molecular simulation for structure–activity relationship. Food Funct. 2018; 9(6).
66. Ghosh P, Besra SE, Tripathi G, Mitra S and Vedasiromoni JR: Cytotoxic and apoptogenic effect of tea (*Camellia sinensis* var. assamica) root extract (TRE) and two of itssteroidal saponins TS1 and TS2 on human leukemic celllines K562 and U937 and on cells of CML and AL Lpatients. Leuk Res 2006; 30(4).
67. Guo N, Tong T, Ren N, Tu Y and Li B: Saponins fromseeds of genus Camellia: phytochemistry and bioactivity. Phytochemistry 2018.
68. Jia LY, Wu XJ, Gao Y, Rankin GO, Pigliacampi A, Bucur H, Li B, Tu YY and Chen YC: Inhibitory effects of total triterpenoid saponins isolated from the seeds of the tea plant (*Camellia sinensis*) on human ovarian cancer cells. Molecules 2017; 22(10): 1649.
69. Kim JD, Khan MI, Shin JH, Lee MG, Seo HJ, Shin TS and Kim MY: HPLC fractionation and pharmacological assessment of green tea seed saponins for antimicrobial, anti-angiogenic and hemolytic activities. Biotechnol Bioproc Eng 2015; 20(6).
70. Kuo PC, Lin T, Yang C, Lin C, Chen G and Huang J: Bioactive saponin from tea seed pomace with inhibitory effects against Rhizoctoniasolani. J Agric Food Chem 2010; 58(15).
71. Li T, Zhang H and Wu C: Screening of antioxidant and antitumor activities of major ingredients from defatted Camellia oleifera seeds. Food Sci Biotechnol 2014; 23(3).
72. Matsuda H, Nakamura S, Morikawa T, Muraoka O and Yoshikawa M: New biofunctional effects of the flower buds of *Camellia sinensis* and its bioactive acylatedoleanane-type triterpeneoligoglycosides. J Nat Med 2016; 70(4).
73. Matsui Y, Kobayashi K, Masuda H, Kigoshi H, Akao M, Sakurai H and Kumagai H: Quantitative analysis of saponins in a tea-leaf extract and their antihypercholesterolemic activity. Biosci Biotechnol Biochem 2009; 73(7).
74. World Health Organization (2017) Depression and other common mental disorders: Global health estimates. World Health Organization, Geneva.
75. McEwen BS: The neurobiology of stress: from serendipity to clinical relevance. Brain Res 2000; 886: 1–2.
76. Pan Y, Cai W and Cheng Q: Association between anxiety and hypertension: a systematic review and meta-analysis of epidemiological studies. Neuropsych Dis Treat 2015; 11: 1121–1130.
77. Hagstrom E, Norlund F and Stebbins A: Psychosocial stress and major cardiovascular events in patients with stable coronary heart disease. J Intern Med 2018; 283(1).
78. Fitzsimmons EE and Bardone-Cone AM: Coping and social support as potential moderators of the relation between anxiety and eating disorder symptomatology. Eat Behav 2011; 12(1).
79. Myers B and Greenwood-Van Meerveld B: Role of anxiety in the pathophysiology of irritable bowel syndrome: importance of the amygdala. Front Neurosci 2009; 3: 47.
80. Durand MV and Barlow DH: Essentials of abnormal psychology. 5th edn. Wadsworth Cengage Learning Spielberger CD (1972) Profile of mood states. Prof Psychol 2010; 3(4).
81. Pfennings L, Cohen L and van der Ploeg H: Preconditions for sensitivity in measuring change: visual analogue scales compared to rating scales in a Likert format. Psychol Rep 1995; 77(2).
82. Hedberg AG: State-trait anxiety inventory. Prof Psych 1972; 3(4).
83. Dozois DJA, Dobson KS and Ahnberg JL: A psychometric evaluation of the Beck depression inventory-II. Psychol Assessment 1998; 10(2).
84. Katergaris N, Dufficy L and Roach PD: Green tea catechinsas neuroprotective agents: systematic review of the literature inanimal pre-clinical trials. AFTNS Open J 2015; 1(2).
85. Bursill CA, AbbeyM and Roach PD: A green tea extract lowers plasma cholesterol by inhibiting cholesterol synthesis and upregulating the LDL receptor in the cholesterol-fed rabbit. Atherosclerosis 2007; 193(1).
86. Bursill CA and Roach PD: A green tea catechin extract up regulates the hepatic low-density lipoprotein receptor in rats. Lipids 2007; 42(7).
87. Reto M, Figueira ME and Filipe HM: Chemical compositionof green tea (*Camellia sinensis*) infusions commercialized in Portugal. PFHN 2007; 62(4).
88. Vuong QV: Epidemiological evidence linking tea consumptionto human health: a review. Crit Rev Food Sci Nutr 2014; 54(4).
89. Naumovski N, Foscolou A and D'Cunha NM: The association between green and black tea consumption on successful aging: a combined analysis of the ATTICA and MEDiterrane an ISlands (MEDIS) Epidemiological Studies. Molecules 24(10): 2019; 1862.
90. Crichton GE, Bryan J and Murphy KJ: Dietary antioxidants,cognitive function and dementia-a systematic review. Plant Foods Hum Nutr 2013; 68(3).
91. Naumovski N, Blades BL and Roach PD: Food inhibits the oral bioavailability of the major green tea antioxidant epigallocatechingallate in humans. Antioxidants 2015; 4(2).
92. Fathy S, Emam M, Agwa SA, Zahra FA, Youssef F, Sami and R: The antiproliferative of Origanummajorana on human hepatocarcinoma cell line: Suppression of NF-kB. Cell Mol Biol 2016. [PubMed]
93. Ashour ML, Youssef FS, Gad HA, El-Readi MZ, Bouzabata A, Abuzeid RM, Sobeh M and Wink M: Evidence for the anti-inflammatory activity *of Bupleurum marginatum* (Apiaceae) extracts using *in-vitro* and *in-vivo* experiments supported by virtual screening. J Pharm Pharmacol 2018; 70.
94. Janibekov AA, Youssef FS, Ashour ML and Mamadalieva NZ: New flavonoid glycosides from two Astragalus species (Fabaceae) and validation of their antihyperglycaemic activity using molecular modeling and *in-vitro* studies. Ind Crop Prod 2018.
95. Thabet AA, Youssef FS, El-Shazly M, El-Beshbishy HA and Singab ANB: Validation of the antihyperglycaemic and hepatoprotective activity of the flavonoid rich fraction of Brachychitonrupestris using *in-vivo* experimental models and molecular modelling. FT 2018; 114.
96. Youssef FS, Labib RM, Eldahshan OA and Singab AN: Synergistic hepatoprotective and antioxidant of Artichoke, Fig, Mulberry Herbal mixture on HepG2 Cells and their metabolic profiling Using NMR coupled with chemometrics. Chem Biodivers 2017; 14: e1700206.
97. Talaat AN, Ebada SS, Labib RM, Esmat A, Youssef FS and Singab ANB: Verification of the anti-inflammatory activity of the polyphenolic-rich fraction of Araucaria bidwillii Hook. Using phytohaemagglutinin-stimulated

human peripheral blood mononuclear cells and virtual screening. J Ethnopharmacol 2018; 226.
98. Couturier FJ, Colemont LJ, Fierens H and Verhoeven VM: Toxic hepatitis due to a food supplement. "Natural" is no synonym for "harmless". Clin Res. Hepatol Gastroenterol 2016; 40: 38–43.
99. Aboulwafa MM, Youssef FS, Gad HA, Sarker SD, Nahar L, Al-Azizi MM and Ashour ML: Authentication and discrimination of green tea samples using UV-Visible, FTIR and HPLC techniques coupled with chemometrics analysis. Journal of Pharmaceutical and Biomedical Analysis 2018.
100. Ferrara L, Montesano D and Senatore A: The distribution of minerals and flavonoids in the tea plant (*Camellia sinensis)*. Il Farmaco 2001.
101. Chen Q, Guo Z and Zhao J: Identification of green tea's (*Camellia sinensis* L.) quality level according to measurement of main catechins and caffeine contents by HPLC and support vector classification pattern recognition. J Pharm Biomed Anal 2008.
102. Graham HN: Green tea composition, consumption, and polyphenol chemistry. Prev Med 1992; 21.

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