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Health benefits of green tea: A mini review

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Abstract
For gaining popularity and greater demand for medicinal plants, various medicinal plants are taken into considerations for therapeutic research. Green tea is the processed natural product consumed as a healthy drink for refreshment worldwide. Its leaf is consumed which has medicinal values such as antioxidant activity, antimicrobial activity and it has several phytochemical constituents. It contains 15-20% protein and 1-4% amino acids, 5-7% carbohydrates and 10-25% major antioxidant catching tannins. Thousands of bioactive components are present in green tea as polyphenols which is the key factor for preventing many diseases. The objective of this manuscript is to review of therapeutic properties of green tea.

Keywords: Green tea, phytochemical constituents, antioxidant properties, antimicrobial properties

Introduction
Green Tea is non-toxic, non-fermented and widespread therapeutic beverages consumed around the world produced from the leaf of the plant called "*Camellia sinensis*" which is found mainly in Chinaand in Southeast Asia (Molan, 2013) [1]. It tends to be devoured as a drink, which has many beneficial wellbeing effects or concentrate from its leaves can be made for medicinal use (Namita *et al.*, 2012; Narotzki *et al.*, 2012) [2, 3]. Green tea has been consumed over the centuries in India, China, Japan, and Thailand as tea which is a good source of various phytochemicals and the most common drink in the world after water (Fujiki *et al.*, 2002) [4]. Recently, green tea has been acquired great attention in pharmacological and food industries due to some beneficial effects including antimicrobial, antioxidant and prebiotic activities and promotes human health (Zou *et al.*, 2014; Su *et al.*, 2008) [5, 6].
Tea flavanols have recently received much attention owing to their various biological exercises (Chen *et al.*, 2001) [7]. Their beneficial properties are thought to be included antioxidants (Navas *et al.*, 2005) [8], antimutagenic (Halder *et al.*, 2005) [9], anticarcinogenic (Zhu *et al.*, 2005) [10] and antibacterial (An *et al.*, 2004) [11] effects (Erol *et al.*, 2009) [12]. Antioxidant has a significant job in lessening free radical-intervened debasement of cells and tissues in the organism (Jin *et al.*, 2004; Wongkham *et al.*, 2001; Almajano *et al.*, 2008) [13-15].
Green tea, which has mitigating, hostile to tumor, antioxidative and antimicrobial properties, is considered as a healthy product with its utilization connected to bring down rates of all these different obsessive conditions (Bansal *et al.*, 2013) [16]. Along with the thousands of bioactive compounds, the most significant bioactive constituents of green tea are polyphenols or flavonoids which play a key role in the prevention and treatment of many diseases. Green tea is framed when the freshly picked leaves are being steamed, rolled, dried and burned, therefore the chemical composition of it, including polyphenols, differs very little from the fresh tea leaves (Wheeler and Wheeler 2004) [17].
Tea polyphenols, especially the catechins are potent antimicrobial and antioxidant agents with positive effects on human health as well as fish health too (Boran *et al.*, 2015; Barbosa *et al.*, 2007) [18, 19]. Green tea contains between 30 and 40 percent of water-extractable polyphenols, while black tea has 3 to 10 percent which varies according to climate, season or variety (Wanasundara and Shahidi, 1998; Archana *et al.*, 2011) [20, 21]. The phytochemical screening of tea revealed the presence of alkaloids, saponins, tannins, catechin, and polyphenols (Mbata *et al.*, 2008) [22]. Studies have shown that the antioxidant property of green tea extract is present because of high quantity of catechins that are chemically defined as flavan-3-ols (Balentine *et al.*, 1997) [23] and four polyphenol compounds, Epigallocatechin gallate (EGCG), Epicatechin gallate (ECG), Epigallocatechin (EGC) and Epicatechin (EC) (Frei and Higdon, 2003; Zandiand Gondon, 1999) [24, 25]. Among them (-)-Epigallocatechin-3-gallate (EGCG) is the main and biologically most potent and the most luxuriant component. (Yang and Koo, 1997) [26].

The tea catechins are free radical scavengers, metal chelators, inhibitors of transcription factors, and enzymes. Therefore, green tea extracts have been used as natural antioxidants, antibacterial and antiviral agents (Manzocco *et al.*, 1998; Tang and Meydani, 2001) [27, 28]. Also, it has been reported that green tea extract has anticarcinogenic and antimutagenic activity (Yang *et al.*, 2000) [29]. Green tea extracts also contain caffeine, vitamins, amino acids, the anine, volatiles, and minerals (da Silva Pinto, 2013; Davidson *et al.*, 2005) [30, 31]. So, Green tea is beneficial to serve as a natural food antioxidant.

During the last decade, the effects of tea and tea polyphenols were extensively investigated and studies showed that tea is capable of lowering the risk of cardiovascular diseases and cancers (Huo *et al.*, 2008; Mukamal *et al.*, 2007) [32, 33], reducing body fat, systolic blood pressure (SBP), and low-density lipoprotein (LDL) cholesterol (Nagao *et al.*, 2007) [34]. Among age-associated pathologies and neurodegenerative diseases, green tea was shown to confer significant protection against Parkinson's disease and Alzheimer's disease (Chang and Jiang, 2007; Rezai-Zadeh *et al.*, 2005) [35, 36]. On the other way, continuous consumption of tea by mothers during pregnancy might be associated with an increased risk of preeclampsia, especially severe preeclampsia (Wei *et al.*, 2009; Dutta *et al.*, 2013) [37, 38].

Phytochemical constituents

There are mainly three types of tea variants available and consumed worldwide. Among them 78% is black, 20% is green, and 2% is oolong tea originates from the same Phyto-species (Chan *et al.*, 2011; Koech *et al.*, 2017) [39, 40]. Green tea has been widely studied, analyzed including all the varieties as it is the non-fermented retaining green color and almost all phytochemical contents (Manning and Roberts, 2003) [41].

The chemical composition of green tea is made up of 15-20% protein and 1-4% amino acids on a dry weight basis. Amino acids like glutamic acid, tryptophan, glycine, serine, aspartic acid, tyrosine, valine, leucine, threonine, arginine, and lysine and carbohydrates (5-7% in dry weight basis) such as cellulose, pectins, glucose, fructose, sucroseare partly included in green tea (Senanayake, 2013) [42]. Other green tea-compounds with interest in human health such as fluorine, caffeine, minerals, trace elements such as chromium and manganese. (Kristanti and Punbusayakul, 2008) [43]. It contains trace elements in lipid form (linoleic acid, alpha-linolenic acid), sterols (stigmasterol), vitamins (B, C, E), xanthine bases (caffeine, theophylline), pigments (chlorophyll, carotenoids), volatile compounds (aldehyde, alcohol, esters, lactones, hydrocarbons).

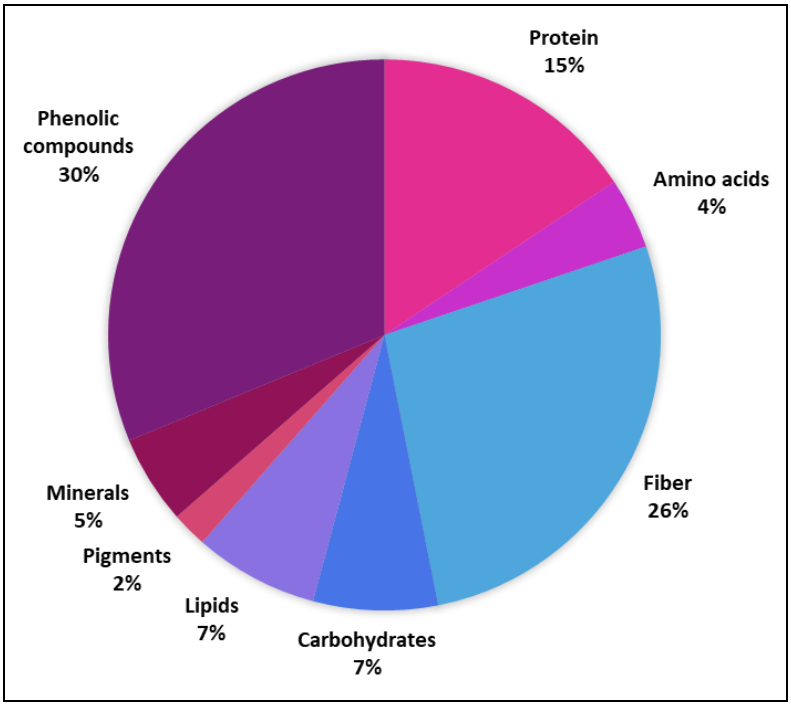

Fig 1: Composition (%) of green tea (Chacko *et al.*, 2010) [44]

Green tea contains polyphenols which include flavonols, flavonndiol, flavonoids, and phenolic acids (Jo *et al.*, 2012) [45]. The principal catechins present in green tea such as (-)-epicatechin (EC), (-)-epigallocatechin (EGC), (-)-epicatechin-3-gallate (ECG), (-)-epigallocatechin-3-gallate (EGCG) and (-)-gallocatechin gallate (GCG) are indicated as major part of biologically active substances (Ho *et al.*, 1994; Sharma *et al.*, 2014) [46, 47]. A large number of catechin tannins (10-25%) are available in green tea. EGCG is the most common polyphenol found in green tea and represents up to 10% of its dry weight and includes 60-70% of its total catechins. Many of the green tea has health promotion abilities that are attributed to EGCG (Patil *et al.*, 2016) [48]. EGCG and other catechins show strong antioxidant activities due to their reduction potential of single electrons. Free radicals are harmful and reactive molecules that become unstable from this unpaired electron. They are involved in diseases from blood clots to cancer (Bancirova, 2010) [49].

Table 1: Phenolic Components of Green Tea (% Dry Weight) (Rice-Evans, 1999) [50]

Catechins	**30-42% (i-v)**	i. Epigallocatechin gallate (11.2%)
		ii. Epigallocatechin (10.3%)
		iii. Epicatechin gallate (2.3%)
		iv. Epicatechin (2.5%)
		v. Catechin (0.5%)
Flavonols	2%	
Simple polyphenols	2%	

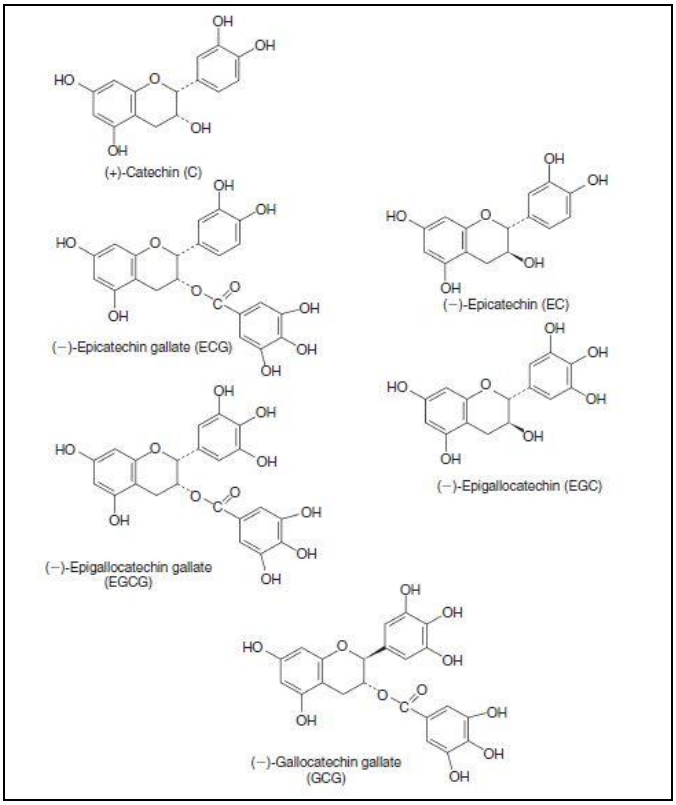

Fig 2: Structures of catechin constituents of green tea (*Camellia sinensis*). (Manning and Roberts, 2003) [41].

Antioxidant properties

An antioxidant is a substance that inhibits lipid oxidation by quenching the formation of free radicals or by producing more free radicals that can spread the oxidation reaction. (Senanayake, 2013) [42].The antioxidant activity of green tea polyphenols is predominantly due to the combination of aromatic rings and hydroxyl groups, which synthesize their chemical structure and consequently bind and neutralize lipid-free radicals by these hydroxyl groups. Numerous researches have been exhibited in different aspects on antioxidant activity of green tea polyphenols which are exceptional electron donors and are effective scavengers of physiologically reactive oxygen species (ROS) *in vitro*, including superoxide anions (Guo *et al.*, 1999; Yokozawa *et al.*, 2002; Nanjo *et al.*, 1996; Pon and Liu, 2008) [51-54], peroxyl radicals, and singlet oxygen. Consequently, green tea is the most effective against beta-carotene oxidation as far as the antioxidant property is concerned and can serve as a natural source of free radical scavengers and cancer prevention agent (Senanayake, 2013; Jo *et al.*, 2012) [42, 45]. The most potent antioxidant polyphenol of green tea is EGC (Zuo *et al.*, 2006; Koech *et al.*, 2017) [10, 40]. Significant levels of bioactive catechins are available in green tea that has the ability to stabilize the free radicals by providing hydrogen ions. The high antioxidative effect of polyphenols in green tea is because of the closeness of phenolic hydroxyl groups in their structures that make them potent free radical scavengers (Tariq and Reyaz, 2013) [55]. This hydroxylation built a higher volume of stability on the catechin phenoxyl radicals by participating in electron delocalization that is asignificant feature of the anti-radical potential. That is why radical scavenging is high in the gallocatechin including EGCG and EGC (Koech *et al.*, 2017) [40]. Green tea catechins are performed as water-soluble antioxidants as Trolox and ascorbic acid, have been shown to act as active antioxidants in bulk oils and as prooxidants in oil-in-water emulsions (Senanayake, 2013; Frankel *et al.*, 1997) [42, 56].

Green tea extract is a promising wellspring of natural antioxidants that has been effectively utilized not exclusively to enhance flavour in addition to broaden the shelf-life of various food products (Senanayake, 2013) [42]. Green tea otherwise acts as a preventative agent of some common human health disorders (Hossain and Mahmood, 2014) [57]. Green tea contains considerable amounts of catechin tannin which is a powerful, water-soluble polyphenol and antioxidant that is easily oxidized. From a single cup of green tea, one canbe benefitted from 10-40 mg of polyphenols (antioxidants) (http://www.greenteanutritionfacts.com.25 September, 2019) [58]. According to Cao *et al.* (1996) [59], green and black tea had much higher antioxidant activity against free radicals than all the commercially available vegetables (Senanayake, 2013) [42].

Many studies have been reported on green tea that has much higher antioxidant activities against free radicals which are not found in vegetables. It is measured mainly by the Oxygen Radical Absorbance Capacity (ORAC) assay, DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical scavenging assays and Trolox equivalent antioxidant capacity (TEAC) assay [Rice-Evans, 1999; Cao *et al.*, 1996; Tsai *et al.*, 2008) [50-60].

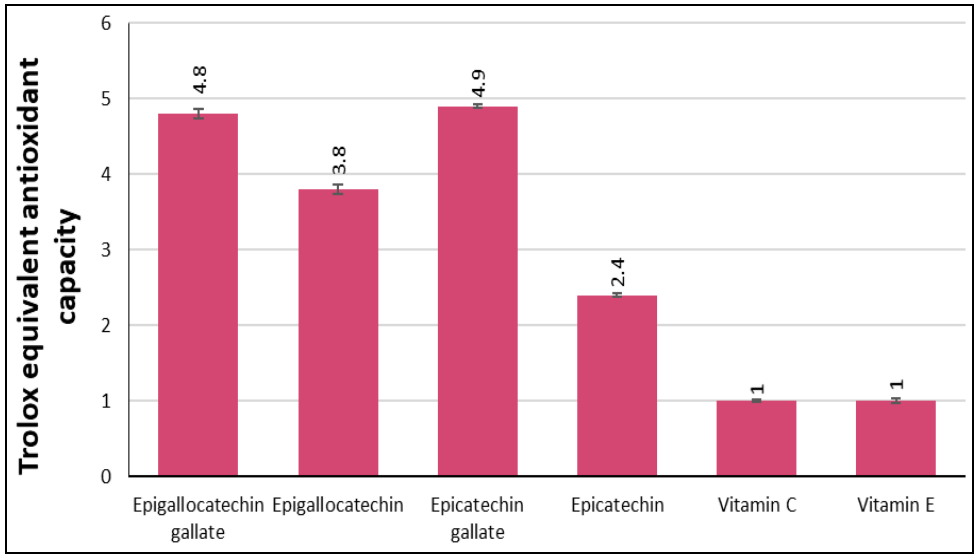

Fig 3: Reactive antioxidant properties of green tea (Rice-Evans, 1999) [50].

*TEAC is the millimolar concentration of Trolox (reference standard) having the equivalent antioxidant activity to a 1 m Mconcentration of the antioxidant compound or defined concentration or volume of food extract/beverage under investigation.

Antimicrobial properties

Resistance to antimicrobial agents has been becoming harmful to the environment and accelerating the global problem (Cushnie and Lamb, 2005) [61]. Nowadays many antimicrobial drugs cannot destroy their pathogenic microorganisms as they becoming resistant. Therefore, researchers are finding some new drugs from mangrove species to control the pathogens due to the presence of antimicrobial compounds (Clercq, 2001; Poole, 2001) [62, 63].

The accompanying review will look at the antimicrobial action of green tea polyphenols, characteristic natural compounds, possessing an assorted scope of pharmacological properties. The antimicrobial activity of tea was first established almost 100 years ago by McNaught (1906) [64] (Taylor *et al.,* 2005) [65]. Many clashing reports of presumptive antimicrobial activity detect that the specific antibacterial spectrum of green tea is actually difficult to assess.

Tea exhibits antimicrobial properties, which are ascribed predominantly to its polyphenols (Dias *et al.*, 2013) [66]. The degree of animation depends on the bacterial species and the polyphenol structure (Campos *et al.*, 2003; Taguri *et al.*, 2004) [67, 68]. The antibacterial activity of green tea is being gradually documented and first reported from Japan by using Japanese tea against various diarrheal pathogens (Hossain and Mahmood, 2014) [57]. The revelation of potent plant and plant seed extracts can effectively avert bacterial growth. Therefore, This has prompted an expanding enthusiasm among the researchers to evaluate the capability of green tea seed to inhibit the growth of some species of fish pathogenic bacteria (*Y. Ruckeri, P. Putida, P. Luteola, A. Hydrophila* and *L. Anguillarum*) with the intention of assessing them as possible disease preventive measures in aquaculture (Halder *et al.,* 2005) [9]. Good evidence suggests that the catechin components of green tea are responsible for the observed antibacterial activity owing to the presence of EGC, EGCG, and ECG constituents (Tsai *et al.,* 2008; Yam *et al.* 1997; Hara 2001) [59, 69, 70]. Gram-negative bacteria seem to be more resistant to polyphenols than Gram-positive bacteria, due to differences in the exterior membrane (Negi *et al.*, 2003) [71]. Yang *et al.* (2011) [72] reported no antibacterial activity occurred against Gram-negative *E. Coli, S. Typhi*, and *P. Aeruginosa*. This study also disclosed that green tea extracts inhibited the growth of Gram-positive *M. Luteus, S. Aureus,* and *B. Cereus*, with *M. Luteus* being most delicate (Bansal *et al.,* 2013) [16]. Su *et al.* (2008) [6] also are of the view that the antimicrobial activity of the green tea extract against the pathogenic bacteria *Staphylococcus aureus, Streptococcus pyogenes,* and *E. Coli*. Hara-Kudo *et al.* (2005) [73] revealed the antibacterial effects of major green tea polyphenols using *Clostridium* and *Bacillus* spores where *C. Botulinum* and *C. Butyricum* spores were diminished in number while no effect was shown in *Bacillus cereus* spores (Wongkham *et al.*, 2001) [14]. Only 100 mg green tea/ml is able to inhibit *S. Typhimurium*, whereas twice the tea concentration is needed for the inhibitory effect to be observed for *E. Coli* (Yam *et al.*, 1997; Kim and Fung, 2004) [69, 74]. The main components responsible for the antimicrobial activity are EGCG and EGC.EGCG at 10–100 μmhas shown to reduce *E. Coli* growth by approximately 50% (Gramzaand Korczak, 2005) [75]. Due to the highest antioxidant activity (TEAC values), the antimicrobial activity of nonfermented tea is higher than that of semi-fermented or fermented tea (Nazer *et al.,* 2005) [76].

Attributable to the far-reaching capacity of green tea to repress spore germination of plant pathogens and proposed for use against contagious fungal pathogens. The antifungal impacts of EGCG were mainly studied against yeasts such as *Candida spp*. and molds such as dermatophytes (Steinmann *et al.,* 2013) [77]. As of late, data relates between green tea polyphenols and irresistible aspergilli or other human-pathogenic zygomycetes which cause dysfunction of the local defense systemand infections of the skin, hair, and nails of humans and animals are lacking (Pappas *etal.*,2009) [78]. In an *in vitro* study, it was revealed that EGCG, EGC, and ECG cause metabolic instability of *C. Albicans* (Evensen and Braun, 2009) [79].

The mechanism of antiviral action of polyphenolic compounds is based on various capacities to go about as antioxidant agents, to inhibit proteinaceous enzymes, to disrupt cell membranes, to avoid viral binding and penetration into cells, and to trigger the host cell. EGCG hinders infections by direct authoritative to biological molecules and persuades agglutination of the flu infection preventing their adsorption to target (Friedman, 2007) [80]. The antiviral mechanism of EGCG has been analyzed against endemic HBV (Hepatitis B virus) infection (He*et al.,* 2011; Wang *et al.,* 2007) [81, 82]. Many reports demonstrated that green tea catechin, EGCG is the most active compound against HIV infectious diseases (Hamza and Zhan, 2006) [83]. Furthermore, the evaluation has also been done with herpes simplex virus (HSV) and bovine coronavirus (BCV) to realize the resistance power of antiviral activity and therapeutic efficiency of catechin polyphenols (Matsumoto *et al.,* 2005) [84].

Anticarcinogenic activity

With time, Polyphenols are turning into the issue of medicinal research. They have been accounted for to have numerous helpful properties, including mitigating action, compound hindrance, antimicrobial activity (Harborne and Baxter, 1999) [85], antiallergic activity, antioxidant activity (Elliott and Chithan, 2017) [86], cell reinforcement action, vascular action, and cytotoxic antitumor action (Harborne and Williams, 2000) [87]. It isn't bewildering, in this way, leading pharmaceutical organizations tend to focus their efforts on improving antimicrobial agents in established classes in setting up classes due to antimicrobial obstruction (Taylor *et al.,* 2002) [88].

Be that as it may, the accessible chemotherapy portfolio, it has been recognized that researchers are approaching the end of the activity in terms of alterations in the structure of parents. Thusly, an intrigue was made for the improvement of new classes of drugs that work in various objective destinations for those as of now being utilized (Cushnie and Lamb, 2005) [61]. Ongoing studies and others have found that isolated green tea polyphenols have anticarcinogenic activity. The effects of green tea as a malignant growth chemo-preventive agent in a wide range of animal models are of impressive intrigue. The oral administration of green tea inhibits the formation of chemically induced tumors in several models (Ho *et al.,* 1994) [46]. Green tea components can prevent the formation of carcinogens from forerunner substances by rummaging cancer-causing electrophiles. (Han

and Xu, 1990) [89]. Researchers have investigated that the freeze-dried green tea containing EGCG turns away carcinogenesis in rodents (Tariq and Reyaz, 2013) [55]. Various scientists have subsequently reported in this manner covered the preventive impacts of green tea, positive or negative, against human malignant growths, in view of epidemiological examinations. Specifically, esophageal cancer in urban Shanghai was averted with green tea consumption (over 150 g tea leaves per month) (Amarowicz *et al.,* 2005) [90]. Dr Waun Ki Hong started his clinical investigations of green tea extricate with a part of U.S. population that had not recently been expending green tea. In 1997, the US Federal Drug Administration (FDA) conceded consent for a Phase I clinical preliminary with green tea containers, which were produced by a Japanese Tea Company, ITO EN (Molan, 2013) [1]. Green tea is an exceptional cancer-preventive prescription with two features as refreshment and medication. Herbal remedies, including green tea, are the same old thing, yet by presenting the idea of malignant growth counteractive action that green tea spares individuals' lives.

Conclusion

It can be concluded that green tea has several health benefits. It is the reach source of phytonutrients like flavonoids, phenolic acids, polyphenols, and catechin tannins. Green tea also has several hydrophilic antioxidants properties as Trolox and free radical scavengers. Green tea is very good in consumption as a morning drink. It has a sufficient amount of caffeine to give you a good morning energy boost. Unlike coffee, tea contains an amino acid L-theanine, that prevents caffeine rush and gives you the energy to sustain throughout several hours instead.

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