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REVIEW PAPER

Tea: Production, Composition, Consumption and its Potential an Antioxidant and Antimicrobial Agent

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Abstract

Tea is the most common beverage consumed after water. It is brewed from the leaves of *Camellia sinensis* (family: Theaceae). Different types of tea manufactured are: oolong, green, black and Ilex tea depending on the post-harvest treatment and palatability of a particular region. Being rich in natural antioxidants, tea is reported to be effective against colon, oesophageal, and lung cancers, as well as urinary stone, dental caries, etc. Tea found to be anticariogenic, anti-microbial, anti-inflammatory, anti-carcinogenic, anti-oxidant can be used as an effective preventive agent. Healthy Foods' containing active scavengers of free radicals are very popular nowadays. The chiefly chemical components of green tea include polyphenols, caffeine and amino acids. Tea also contains flavonoids compounds reported to have anti-oxidant properties having many beneficial effects. It is widely accepted that phenolic compounds of certain foods have potential health benefits. Tea is linked to beneficial effects on human health with the polyphenols as the responsible constituents. India is one of the largest tea-producing, exporting and consuming country. The present review focuses on the production, composition and the beneficial effects of tea consumption on human health.

Keywords: Tea, Health, Polyphenols, Free radical, oolong, green tea, black tea, ilex tea, white tea

Tea, a traditional beverage originally from China, is the oldest, most popular, non-alcoholic caffeine containing beverage in the world, and its infusion is prepared by brewing of processed leaves of the tea plant, *Camellia sinensis* (Kumar and Shruthi, 2014). Tea is the second most widely consumed beverage in the world following water. The most commonly consumed teas are black, green, and oolong which are all derived from the plant *Camellia sinensis*, a member of the *Theaceae* family. Approximately 3.0 million metric tons of dried tea is produced annually, 20% of which is green tea, 2% is oolong, and the remainder is black tea. Green tea and oolong tea are predominantly consumed in Asian countries, whereas black tea is widely consumed in India and Western countries (Anonymous, 2002). Tea is grown in 16 Indian States, out of which four states viz, Assam, West Bengal, Tamil Nadu and Kerala account for about 96% of the total tea production of country whereas land utilization pattern under tea cultivation show that North East India represents 78% of total area under tea in India. The tea is originated and famous for coming from Darjeeling, Assam and Nilgiris which are well known for their distinctive quality

worldwide. Tea exports contribute significantly to the amount of foreign exchange of country. Assam is the only region in the world that has its own variety of tea, called *Camellia assamica*. It has a malty sweetness and an earthy flavour, as opposed to the floral aroma of highland (e.g. Darjeeling, Taiwanese) teas. Tea found to be anticariogenic, anti-microbial, anti-inflammatory, anti-carcinogenic, anti-oxidant, etc., can be used as an effective preventive agent against infections. This review provides an insight on the multitude of actions of tea as a preventive and anti-infectious agent besides production and consumption.

Tea History: historical events associated with the proliferation and development of tea are given below:

- In fourth century i.e. 650 AD 'T Sang dynasty' is considered to be the period for the emerging of tea industry in China.
- The origin of the tea bush has been contested by scholars. It is native to certain areas ranging from the interior of Southern China to the border of Assam.
- Tea has only one species which is called *Camellia sinensis.*
- The Dutch Merchants established a trading base at Benton by 1596.
- The first consignment of tea from China was transported to Benton in 1606, then onwards tea reached non-tea – conscious Europe.
- In India, tea industry originated after 1823 as result of discovery of tea plant in Assam. The discovery of indigenous tea in Assam in 1823 led to the origins of the tea industry in India.
- It is important to mention here that one of the most famous tea is cultivated and manufactured in North-east region of India and known as Darjeeling tea which is registered under geographical indicator by the Government of India.
- It has consistently held that in the early 1700's, the ships of the East India Company frequently brought the tea plants in the country by way of curiosity. Col. Kyd, a Resident of Calcutta and a famous botanist, saw tea plants growing in his garden in 1780. In 1788, Sir Joseph Bank recorded the existence of indigenous tea growing wild in Coochbehar and Rangpur districts of Bengal and suggested the cultivation of this plant. The wild teas of Coochbehar confirmed the first discovery of indigenous tea in India. (Karmakar and Banerjee, 2005).
- Literature shows that tea is indigenous to eastern and northern India, and was cultivated and consumed there for thousands of years.
- In the early 1820s, the British East India Company began large-scale production of tea in Assam. In 1837, the first English tea garden was established at Chabua in Upper Assam; in 1840, the Assam Tea Company began the commercial production of tea in the region and thereafter, the tea industry rapidly extended to other parts of the country.
- Today, India is one of the largest tea producers in the world and about 70% of tea produced is consumed within India itself. By the turn of the century, Assam became the leading tea-producing region in the world. However, due to certain specific soil and climatic requirements its cultivation was confined to only certain parts of the country. (Arya, 2013).
- The cultivated taxa of tea comprise of three main natural hybrids. They are: C. sinensis (L.) O. Kuntze or China type, *Camellia assamica* (Masters) or Assam type and *C. assamica* sub-spp. Lasiocalyx (Planchon ex Watt) or Cambod or Southern type. Two types, which are well known, are the China and Assam, less common is the Cambod (Yemane *et al*. 2008).

Development in Tea Industry

- The birth of Indian tea industry was marked by the discovery of indigenous tea plant in Assam in 1823 by Robert Bush.

- Tea production received momentum when the East India Company in 1833 lost the tea trading monopoly in China. In 1835, a scientific deputation was sent to Assam to report on prospects of the tea industry and the team saw tea plants in many parts in the hills between Assam and Burma. In 1836, C.A. Bruce was made the Superintendent of Tea Forests.
- In 1839, the first consignment of tea from India (eight chests) was shipped to London and it was auctioned at a price ranging from six to thirty four shillings per pound. In 1840, two thirds of experimental teas were handed over to new company. In 1852, the first tea company in India paid its final dividends.
- The second limited company in 1859 was formed in Assam called Jorhat Company. During 1862-67, tea cultivation started in Chittagong and Chotta Nagpur.
- Ultimately tea cultivation was commissioned in many districts in India wherever there was some hope of a success. Within a few months, India along with Sri Lanka dominated the world tea trade/market (Karmakar and Banerjee, 2005).
- Further, the regions which are associated with small business with this industry are Karnataka, Tripura, Himachal Pradesh, Uttarakhand, Arunachal Pradesh, Manipur Sikkim, Nagaland, Meghalaya, Mizoram, Bihar and Orissa.
- A different variety of tea though of a small quantity comes from small growers of Kangra Valley in the picturesque Himachal Pradesh. This valley is famous for its green teas which is the specialty of the region.
- Tea industry contribute a large proportion of foreign exchange in agriculture sector. As a result, increase in number of tea producing countries took place since 1950 at global level. It is important to mention here that India ranked first in term of area under tea plantation at international level (Arya, 2013).

Production: World tea production (Black, Green and Instant) increased significantly by 6% to 5.07 million tonnes in 2013. Black tea output increased by 5.4% in response to continued firm prices while green tea output increased by 5.1% (Fig. 1). Growth in world output was due to significancant increases in the major tea producing countries. China remained the largest tea producing country with an output of 1.9 million tonnes, accounting for more than 38% of the world total, while production in India, the second largest producer, also increased to reach 1.2 million tonnes in 2013. Output also increased in the two largest exporting countries where production reached 436 300 tonnes in Kenya and 343 100 tonnes in Sri Lanka. Apart from the 7.5% decline in Vietnam to 185 000 tonnes, production in other major producing countries increased: Indonesia to 152 700 tonnes; Bangladesh to 66 200 tonnes; Uganda to 58 300 tonnes; Malawi to 46 500 tonnes; Tanzania to 32 400 tonnes; and Rwanda to 25 200 tonnes. Other producers in Africa recorded slight increases: Burundi to 8 800 tonnes; Zimbabwe to 8 500 tonnes; and South Africa to 2 500 tonnes (Chang, 2015).

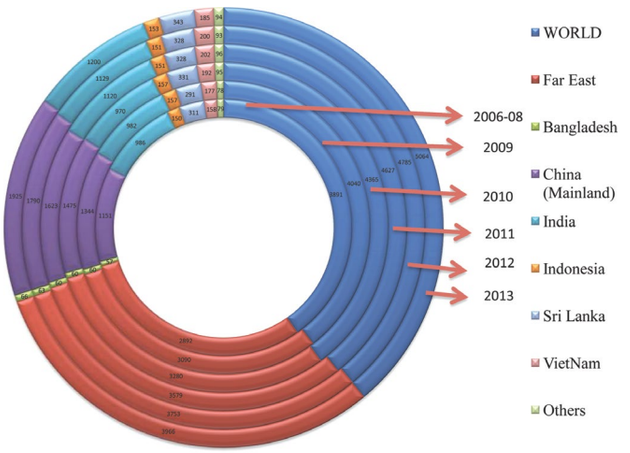

Fig. 1: World tea production (thousand tonnes)
Source: Chang, 2015

Consumption

Chang (2015) reported that, World the tea consumption continued to increase in 2013. Total tea

consumption increased by nearly 5% in 2013 to 4.84 million tonnes, which was underpinned by the rapid growth in per capita income levels, particularly in China, India and other emerging economies. Growth in demand was particularly marked in China. After a spectacular rise in consumption in recent years exceeding 8% annually, total consumption increased by 9% in 2013, on a year-to-year basis, to reach 1.61 million tonnes, the largest in the world. In India, consumption expanded by 2.4% in 2009 and 6.6% in 2013 to reach 1 million tonnes.

Indian tea in Global Scenario

Apart from the largest consumer of tea, India is the largest producer of black tea in the world. Currently, India produces 23% of total world production and consumes about 21% of total world consumption of tea. This shows that nearly 80% of the tea produced is consumed within the country. Over the last 20 years, India's world ranking as an exporter has declined from number one to number four, in the phase of stiff competition from Sri Lanka, Kenya, and China. Due to increase in population, income and the consumption of the beverage within India, the exports of tea are declining (Wagh, 2014).

Table 1: Indian Tea Scenario

Particulars	World	India	Rank	% of Share
Area under Tea (Million hectors)	3.94	0.58	2nd	15
Production (Million Kg.)	4162	966	2nd	23
Yield (Kg/Hector)	1143	1668	1st	-
Export (Million Kg)	1738	193	4th	11
Consumption (Million Kg)	3980	837	2nd	21

Source: Wagh, 2014.

Tea: Chemical composition of tea and activities of polyphenols

Fresh leaf: Fresh tea leaf is rich in water soluble polyphenols, particularly flavanols, flavanol gallate and flavanol glycosides (Graham1992; Willsoz and Clifford 1992; Bors 1996).The major tea catechins: α-epigallocatechin-3-gallate (EGCG), α-epigallocatechin (EGC), α- epicatechin-3-gallate (ECG), α-epicatechin (EC), α-epicatechin-3-gallate (ECG), α-epicatechin (EC), α-gallocatechin and β-catechin; constitutes 30 to 42% of the green tea solids by weight (Chung *et al.* 2005). Caffeine accounts for 3 to 6%. The composition however varies with the cultivation conditions and subsequent processing of the tea (Table 2).

Table 2: The main chemical constituent of Green tea leaves

Constituent	Percentage (% of dried leaf)
Polyphenols	37
Carbohydrates	25
Caffeine	15
Protein	4
Aminoacids	6.5
Lignin	1.5
Organic acids	2
Lipids	5
Ash	0.5

****Source:*** Sinija VR and Mishra HN (2008) Green tea: Health benefits, Review. *Journal of Nutritional and Environmental Medicine.*

Green Tea: Main objective to manufacture green is the preservation of natural polyphenols in the tea leaf in such a way that maximum amount of tea polyphenols valuable in a cup of tea for good health. Farm green tea manufacturing fresh leaf from garden subjected to steaming or pan roasting as soon as possible to avail polyphenols (antioxidant). During steaming/roasting, polyphenol oxidizing enzymes are deactivated due to high temperature and leaves become biologically inactive. Different steps involve: Plucking, Steaming, Rolling, Drying, Grading and Packing. In making green tea, the tea leaves are steamed or pan roasted to inactivate the enzymes and dried. Thus, the constituents of the tea leaves are preserved in the dried tea leaves. When the tea leaves are brewed, for example 2.5 g in 250 ml of hot water for 3 minutes, about 30% of the solid materials

are extracted into water. The spray-dried powder of the water extract, known as green tea solids, has been used for animal experiments.

All teas are rich in polyphenolic compounds which are also present in red wine, fruit and vegetables (Hertog, 1993). Green tea is a less fermented tea and has the highest quantity of tea catechins. The tea leaves are immediately heated with rolling after harvest to inactivate the enzyme, polyphenol oxidase, which is capable of oxidizing the tea catechins to oligomeric and polymeric derivatives, e.g., the aflavins and thearubigins (Koo and Cho, 2004). The main chemical constituents of Green tea leaves are given in table 2 (Sinija and Mishra 2008).

Black Tea: Black tea manufacture involves crushing the tea leaves to promote enzymatic oxidation and subsequent condensation of tea polyphenols in a process known as fermentation, which leads to the formation of theaflavins and thearubigins (Yang *et al*. 2002). The catechins and theaflavins (in black tea) are the microbiologically active molecules (Hamilton-Miller, 2001). There are three manufactured forms of black tea in today's world market. They are stick-shaped black tea, granular black tea and black tea bags. Although they are made by similar processing techniques, the appearance of the final products is different. Stick-shaped black tea still keeps the original shape of tea leaves, which can be easily recognized which is made up of tender buds and leaves. Granular black tea comes from small bits ground mechanically, which makes the product lose the original shape of the leaves. Black tea bags are granular black tea enclosed in a filter paper bags with or without added flavors (Cao *et al*. 2006).

Difference between green tea and black tea: The main chemical difference between green and black tea is that the former contains simple catechins (polyphenols with mol. wt < 450 Da) whereas in the latter, many of these have been oxidized and condensed, during the manufacture process, to larger, dark-colored molecules including theaflavins (500-1000Da) and thearubigins (> 1 kDa) (Hamilton-Miller, 2001). It is now noted that 50% of unreacted precursors is composed of theasinenins (bisflavonols) formed by oxidative coupling of EGC or EGCG (Haslam 2003). However, black tea still contains simple catechins, examples of which are epicatechin (EC), epicatechin gallate (ECG) and epigallocatechin gallate (EGCG). A cup of green tea prepared in the normal way contains 0.5-1 g of catechins/L and black tea contains about one third of 0.5-1 g of catechins/L (Hamilton-Miller, 2001). The see differences have also been reported by Sharangi (2009), given in table 3.

Table 3: Difference between green tea and black tea

	Green tea	Black Tea
Process	Short, no fermentation	Longer Fermentation
Colour	Green or yellow	Red or black
Taste	Sweet after bitter	Distinct flavour, added in sugar and/ or milk
Antioxidant	In general, more Polyphenols	More Flavonoids
Caffeine	Less	More
Quality	Better in fresh	Depend on produced location
Health benifits	More in general: may irritate to empty stomach	Cardiovascular system

Source: Sharangi, 2009.

Other types of tea

White Tea: Another form of tea which is made from new growth buds and young leaves that have been steamed to inactivate polyphenol oxidation and then, dried. White tea is considered one of most expensive tea for consumer and more remunerative to the producers. Since white tea made from unfolded tea bud having pubescence which give silvery appearance to final product hence called as white tea. Polyphenols percentage is highest in the bud and gradually decline with age of leaves so due to highest percentage of polyphenols in bud. White tea is considered to have high therapeutic value. Due to characteristic, white tea is very famous amongst the health conscious people especially in America and Europe.

Oolong Tea: Oolong tea is 'semi-fermented' and also known as hybrid of black and green tea. Oolong tea possesses characteristic of both black and green tea.

Brick Tea: Brick tea is made from fallen and old leaves, which is fermented and compressed into bricks and is not considered as a quality tea. Nothing goes without commercial values in tea gardens. During dormancy when tea plantation is put under maintenance through different kind of cleaning and pruring operation as a result of which old leaves or leaf from pruning litter is used to black or green tea and compressed to bricks. Though brick tea is not comparable in term of quality, appearance and market value with normal black/ green tea. But this tea is palatable to certain people in certain region especially in African country.

Fig. 2: Schematic diagram of the conventional manufacture process of green, black, oolong and white tea
(Source: Karori *et al*. 2007)

Manufacturing Process: The manufacturing process for semi-fermented oolong tea consists of solar withering, panning, rolling and drying. During this process, the characteristic floral aroma of oolong tea is produced. White tea is a rare specialty tea that gets its name from a specific tea plant variety, as well as a particular post-harvest processing method that raises small silvery hairs on the dried buds. White tea contains a higher proportion of the buds that are covered with fine "silvery" hairs that impart a light white colour to the tea. The brew from white tea is pale yellow in colour with no "grassy" undertones sometimes associated with green tea.

True white tea is lightly fermented, rapidly steamed and dried leaving the leaves "fresh". Unlike black, green and oolong teas, white tea is not rolled or crushed but it is steamed rapidly and air-dried to preserve most of the polyphenols. This unique processing produces a rare and expensive but highly refreshing drink. The differences between the various processes of manufacture result in differences in the polyphenol profile between black, green, oolong and white tea. Figure 2 Outlines the processing of tea in more details.

Tea health benefits on human beings

Tea with antioxidant property

In human body, different protective mechanisms are present to combat the free radicals. Also, there is equilibrium between pro-oxidative and antioxidant process, and when this equilibrium is disturbed in favour of free radicals, oxidation stress results (Rohdewald, 1998). The oxidation of lipoproteins plays an important role in the development of atherosclerosis by means of oxidation process of low density lipoproteins (LDL) of vascular walls. LDLs are very rich in cholesterol causing change in structure of vascular walls. These structural modifications encourage macrophages to pick up the oxidized LDL, promoting a change into foam cells. A collection of these cells in the vascular walls leads to the first noticeable change of cellular tissue, called fatty streaks. These changes can result in the total closure of the artery, which could cause angina or vascular occlusion. It is well established that other pathological

states such as cancer, rheumatoid arthritis, ischaemic reoxygenation injury of the liver and other organs, are set of by oxidation processes (Rohdewald, 1998; Cross, 1987). The powerful antioxidant properties of the tea are generally attributed to its flavonoid components; theaflavins, bisflavanols and theaflavic acids (Rice-Evans, 1999*)*. These compounds are all potent antioxidant *in vitro* and, when consumed, act as the free radical scavengers which remove endogenously generated superoxide, peroxyl and hydroxyl radicals. The antioxidant property of tea is also associated with several other mechanisms e.g. depolarization of electrons, formation of intramolecular hydrogen bonds, rearrangement of the molecular structure (Salah *et al.* 1995; Jovanovic *et al.* 1994). These compounds may also prevent oxidative reactions by chelating free copper and iron, which may catalyze the formation of reactive oxygen species *in vitro* (Halliwell, 1997; Weisburger, 1999). The antioxidant flavanoids appear to be readily taken up by the human gastrointestinal tract Van het Hoff *et al*. 1999 have demonstrated that tea catechins, from both green and black teas, appear in human plasma and in circulating lipoprotein fractions. Five cups of tea consumed at 2-hours intervals was sufficient to elevate plasma catechin concentrations by up to 12-fold in a UK based study. The consumption of black tea with milk did not impair the bioavailability of the tea catechins. Conversely, Serafini *et al.* (1996) have reported that green and black teas significantly elevated plasma antioxidant potential, as measured using a fluorescence assay. Beverage tea, rich in antioxidant polyphenols, affects host biochemistry and carcinogenesis at important target organs such as colon or mammary glands in rats (Chen *et al*. 1998). This depletion of antioxidant power is observed with soya milk as well as cow's milk but is less marked with skimmed and semi skimmed milks. It suggests that the depletion of antioxidant effect is due to associations between the tea flavanoids and milk fat rather than proteins (Langley-Evans, 2000)**.**

Anticariogenic properties of tea

Catechins originating from tea leaves have been suggested to possess various pharmacological activities. Among them, the anticariogenicity of catechins has been practically utilized for the prevention of dental caries. In Japan, green tea extracts containing catechins have been widely added to candy, chewing gum, food and mouth rinsing agents as a caries preventive additive (Tsuchiya *et al.* 1997).

Black tea extract when fed to hamsters on cariogenic diet significantly decreased caries formation by 63.7% indicating that the frequent intake of black tea can significantly decrease caries formation, even in the presence of sugars in the diet (Linke and LeGeros, 2003).

Anti-microbial activity

Catechins derived from Green tea / black tea were found to be inhibitory and bactericidal against *S. mutans* or *S. sobrinus*. The minimum inhibitory concentration of individual catechins was found to be between 50 and 500 mg/L leading to the consensus that a cup of tea catechin concentration is inhibitory and often bactericidal (Hamilton-Miller, 2001). Oolong tea extract was found to reduce the rate of acid production by Mutans streptococci accompanied with the retardation of its growth rate (Matsumoto *et al*. 1999). When used as a mouthwash, green tea extract could significantly inhibit both streptococci and lactobacilli, proving to be an effective adjunct to daily oral hygiene procedures especially for high caries risk patients (Kuchari, 2006).

There are four main catechins (Polyphenols) in green tea but three of these (-)-epicatechin-3-gallate (ECG), (-)-epigallocatechin (EGC), EGCG), (-)-epigallocatechin (EGC), hane been shown to have antimicrobial effects against a variety of microorganisms. These catechins have exhibited a variety of antimicrobial mechanisms. Green tea has been shown to have antimicrobial effect against a Gram negative and Gram positive bacteria (e.g., E.coli. *salmonella* spp, *Staphylococcus aureus*, *Enterococcus* spp).

Anti-cancerous activity

Green tea polyphenols have been extensively studied as cancer chemo preventive agents. The catechins are

major polyphenols consisting of (-)-epigallocatechin-3-gallate (EGCG), (-)-epigallocatechin (EGC), (-)-epicatechin-3-gallate (ECG), and (-)-epicatechin (EC), out of these EGCG is the most abundant and active compound that can block cancer progression (Jankun *et al.* 1997; Kanwar *et al.* 2012).

According to a case study of Xue-Jun Wang *et al.* (2012), there is association between Green Tea and Colorectal Cancer Risk. A Meta-analysis of 13 Case-control Studies, the results indicate a weak lower tendency for colorectal cancer development with green tea consumption, but available epidemiologic data are insufficient to conclude that green tea may protect against colorectal cancer in humans. The anti-carcinogenic activities of tea polyphenols are generally believed to be related to their antioxidative properties. Tea may also affect the metabolism of carcinogens by induction or inhibition of various cytochrome P450s. In Table 4, effects of consumption of tea on combating different types of cancer is summarized.

Other effects

Tea (*Camellia sinensis*) is a naturally rich source of fluoride and other components including aluminium. The tea plant absorbs fluoride and aluminium from acid soil by passive diffusion, which are accumulated in the leaves during the plants life span (Hayacibara *et al.* 2004). Oral retention of fluoride from black tea was found to be significant. About 34% of the fluoride was retained in the oral cavity after rinsing with tea. Fluoride from tea also showed strong binding to enamel particles, which were only partially dissociated by solutions of ionic strength considerably greater

Table 4: Effect of consumption of tea on combating different types of cancer

Type of Cancer	Effect of consumption of tea	Reference
Lung cancer	One population-based study found that Okinawan tea (similar to green tea but partially fermented) was associated with decreased lung cancer risk, particularly among women	Ohno, Wakai, and Genka (1995)
Pancreatic Cancer	Major tea drinkers were less likely to develop pancreatic cancer compared to nondrinkers. However, further studies are needed to recommend it strongly	Ji *et al.* (1997) and Lyn-Cook *et al.* (1999)
Prostrate Cancer	Laboratory studies have found that green tea extracts prevent the growth of prostrate cancer cells in test tubes. However, neither black nor green tea should be taken while receiving chemotherapy as both of them were less sensitive during that period	Lyn-Cook *et al.* (1999)
Esophageal cancer	One large-scale population-based study found that green tea offered significant protection against the development of esophageal cancer (particularly among women). Another population-based study revealed just the opposite. In fact, the stronger and hotter the tea, the greater is the risk. So, further research is needed before green tea can be recommended for the prevention of esophageal cancer	Hu, Nyren, Wolk, and Bergstrom (1994), Gao, McLaughlin, and Blot (1994)
Stomach cancer	In two studies that compared green tea drinkers with non-drinkers, researchers found that people who drank tea were about half as likely to develop stomach cancer and gastritis (inflammation of the stomach) as those who did not drink green tea. However, a recent study in Japan found no association between green tea consumption and stomach cancer risk. Further research in this line can only confirm whether green tea reduces the likelihood of developing this disease.	Yu *et al.* (1995), Setiawan, Zhang, and Yu (2001) and Tsubono, Nishino, and Komatsu (2001)

than that of saliva. Thus, ingested fluoride from tea will potentially have both local topical effects in the oral cavity, and more generalized systemic effects arising from gastrointestinal absorption (Simpson, 2001a). A study conducted by Lung *et al.* (2008) to assess infusible fluoride levels in popular tea sold in Taiwan and potential exposure factors concluded that among six kinds of tea, black tea had the highest fluoride concentrations (8.64±2.96mg/L), whereas pureh (1.97±2.70mg/L) had the lowest levels. In addition, it was found that the critical step during the manufacturing process affecting the%age of infusible fluoride was ball rolling rather than fermentation.

Each gram of tea exposes human body to 3.88–137.09 μg of fluoride with a mean value of 63.51 μg while the same quantity of toothpaste exposes the human body to 53.5–338.5 μg with a mean value of 183.78 μg. Therefore, on an average, a person who brushes once in a day (2 g per brushing) and consumes two cups of tea (2 g per cup) is exposed to 621.6μg/day of fluoride. Out of this 327.55μg/day is ingested, as there is 100% ingestion of fluoride for tea and 20% for toothpaste (Yadav *et al.* 2007). It is also proved that lever holding green tea solution in the oral cavity or chewing green tea leaves results in dose-dependent production of H_2O_2 due to the oxidative polymerization of EGCG in the mouth which may play an important role in prevention of oral cancer (Lambert *et al.* 2007).

A cross-sectional study of 1276 older women aging 65 to 76 years in the U.K., found that the tea drinkers had significantly higher bone mineral density (BMD) at the lumbar spine and hip than non-drinkers of tea (Hegarty *et al.* 2000). The oxidative stress-responsive transcription factor, NF- has been found recently to play a role in bone resorption, and increased levels of urinary 8-iso-PGF2α, a biomarker for oxidative stress, were significantly associated with decreased lumbar spine and total body BMD in a cross-sectional study of 101 men and women (Basu *et al.* 2001). High fluid intake, including tea intake, is generally considered the most effective and economical means of preventing kidney stones (Borghi *et al.* 1999). However, tea consumption has been found to increase urinary oxalate levels in healthy individuals (Massey *et al.* 1993), and some experts continue to advise those prone to calcium oxalate stone formation to limit tea consumption (Massey, 2000).

Disadvantages of tea consumption

- Excessive consumption of the may lead to problems of staining of the dentition. Such staining is likely to be caused by interaction of components of the tea with both surface integuments like the acquired salivary pellicle and possibly, the mineral crystals of dental enamel (Simpson *et al.* 2001).
- Coffee and tea are considered as staining solutions for esthetic restorative materials due to their contents and frequent consumption and especially discoloration by tea was due to the adsorption of polar colorants onto the surface of materials, which can be removed by tooth brushing.

Conclusion

Tea is an important worldwide consumed natural health drink proven by many scientific studies in the World. Encouraging scientific results at tea consumption on human health make the tea popular in human society. Though tea is yet to be recognized as a medicinal agent, it is one of the most researched plant-based remedies. There is a growing amount of *in-vitro* research identifying potential of the for oral health benefits. It is clear that tea is much more than a pleasant and mildly stimulating beverage, probably due to its therapeutic value in the prevention of dental caries and periodontal diseases. However, further long term, well controlled human trials are required before any firm conclusions can be made. In the mean time it is reasonable to conclude that tea consumption, without the addition of sugar, could be made a component of dietary advice to prevent oral diseases, thereby helping to promote overall health and well being by the most economical means. Now, that we have rediscovered this ancient wonder, we need to grab hold of it and use it to our advantage. Overall tea is an affordable beverage with natural with medicinal value as compared to modern

beverage hard drink of low value in terms of human health.

References

Anonymous. 2002. International Tea Committee. Annual bulletin of statistics. London: International Tea Committee.

Arya Nizara, 2013. Indian Tea Scenario. *International Journal of Scientific and Research* Publications, **3**(7): 1-10.

Basu, S., Michaelsson, K., Olofsson, H., Johansson, S. and Melhus, H. 2001. Association between oxidative stress and bone mineral density. *Biochem. Biophys. Res. Commun.* **288**: 275–279.

Borghi, L., Meschi, T., Schianchi, T., Briganti, A., Guerra, A., Allegri, F. and Novarini, A. 1999. Urine volume: stone risk factor and preventive measure. *Nephron. 81 Suppl* **1**: 31–37.

Bors, W., Heller, W., Michel, C. and Stettmaier, K. 1996. Flavonoids and polyphenols: Chemistry and biology. In. Cadenas E, Des, PL (eds.). *Handbook of Antioxidants. New York: Marcel Dekker, Inc.* 409-466.

Cao, J., Zhao, Y., Li, Y., Deng, H.J., Yi, J. and Liu, J.W. 2006. Fluoride levels in various black tea commodities: Measurement and safety evaluation. *Food and Chemical Toxicology*, **44**: 1131–1137.

Chang Kaison, 2015. World tea production and trade Current and future development. Food and Agriculture Organization of the United Nations Rome, pp. 1-17.

Chen, W., Sohn, S.H., Fiala, E.S. and Weisburger, J.H. 1998. Effect of tea on the formation of DNA adducts by azoxymethane. *Xenobiot*, **28**(2): 213- 217.

Chung, S., Liao, Y.J., Yang, G.Y. and Lu, G. 2005. Inhibition of lung tumorigenesis by tea. Exp. *Lung Res*. **31**: 135–144.

Cross, C.E., Halliwell, B., Borish, E.T., Pryor, W.A., Ames, B.N., Saul, R.L., McCord, J.M. and Harman, D. 1987. Oxygen radicals and human disease. *Ann. Intern. Med*. **107**: 526.

Karmakar, K.G. and Banerjee, G.D. 2005. The Tea Industry In India: *A Survey. Published by the National Bank for Agriculture & Rural Development, Department of Economic Analysis and Research, Mumbai.*

Gao, Y.T., McLaughlin, J.K. and Blot, W.J. 1994. Reduced risk of esophageal cancer associated with green tea consumption. *Journal of the National Cancer Institute*. **86**: 855–858.

Graham, H.N. 1992. Green tea composition, consumption and polyphenol chemistry. *Preventive Med.,* **21**: 334-350.

Halliwell, B. 1997. Antioxidants and human disease: a general introduction. *Nutr Rev.,* **55**: S44-S52.

Hamilton-Miller, J.M.T. 2001. Anti-cariogenic properties of tea (*Camellia sin en sis*). *J Med Microbiol.,* **50**: 299-302.

Haslam, Edwin. 2003. Thoughts on the arubigins. *Phytochemistry,* **64**(1): 61–73.

Hayacibara, M.F., Queiroz, C.S., Tabchoury, C.P.M. and Cury, J.A. 2004. Fluoride and aluminum in teas and teabased Beverages. *Rev Saúde Pública,* **38**: 100-105.

Hegarty, V.M., May, H.M. and Khaw, K.T. 2000. Tea drinking and bone mineral density in older women. *Am. J. Clin. Nutr.* **71**: 1003–1007.

Hertog, M.G., Feskens, E.J.M., Hollman, P.C.H., Katan, M. and Kromhout, D. 1993 Dietary antioxidant flavonoids and risk of coronary heart disease: the Zutphen Elderly Study. *Lancet. b.* **342**: 1007–1011.

Hu, J., Nyren, O., Wolk, A. and Bergstrom, R. 1994. Risk factors for oesophageal cancer in northeast China. *International Journal of Cancer,* **57**: 38–46.

Jankun, J., Selman, S.H. and Swiercz, R. 1997. Why drinking green tea could prevent cancer. *Nature*. **387**: 561.

Ji, B.T., Chow, W.H. and Hsing, A.W. 1997. Green tea consumption and the risk of pancreatic and colorectal cancers. *International Journal of Cancer,* **70**: 255–258.

Jovanovic, S., Steenken, S., Tosic, M., Marjanovic, B. and Simic, M.G. 1994. Flavonoids as antioxidants. *J Am Chem. Soc*. **116**: 4846-4851.

Karori, S.M., Wachira, F.N., Wanyoko, J.K. and Ngure, R.M. 2007. Antioxidant capacity of different types of tea products. *African Journal of Biotechnology*, **6**(19): 2287-2296.

Kanwar, J., Taskeen, M. and Mohammad, I. 2012. Recent advances on tea polyphenols. *Front Biosci (Elite Ed)*, **4**: 111-31.

Koo, M.W.L. and Cho, C.H. 2004. Pharmacological effects of green tea on the gastrointestinal system. *European Journal of Pharmacology*, **500**: 177– 185.

Kuchari, M.G., Hassan, M.A. and Ghulman, M.A. 2006. Antimicrobial effect of green tea extract on cariogenic microorganisms isolated from high caries risk patients: A clinical study. *Egyptian Dental Journal,* **52**: 2099-2106.

Kumar Vinodh, P. and Shruthi, B.S. 2014. Tea: An Oral Elixir. *Scholars Academic Journal of Pharmacy (SAJP) Sch. Acad. J. Pharm*. **3**(1): 9-18.

Lambert, J.D., Kwon, S.J., Hong, J. and Yang, C.S. 2007. Salivary hydrogen peroxide produced by holding or chewing green tea in the oral cavity. *Free Radical Research*, **41**: 850–853.

Langley-Evans, S.C. 2000. Consumption of black tea elicits an increase in plasma antioxidant potential in humans. *Int. J. Food Sci. Nut;* **51**: 309–315.

Linke, H.A.B. and LeGeros, R.Z. 2003. Black tea extract and dental caries formation in hamsters. *International Journal of Food Sciences and Nutrition,* **54**: 89-95.

Lung, S.C.C., Cheng, H.W. and Fu, C.B. 2008. Potential exposure and risk of fluoride intakes from tea drinks produced in Taiwan. *Journal of Exposure Science and Environmental Epidemiology*, **18**: 158–166.

Lyn-Cook, B.D., Rogers, T., Yan, Y., Blann, E.B., Kadlubar, F.F. and Hammons, G.J. 1999. Chemopreventive effects of tea extracts and various components on human pancreatic and prostate tumor cells in vitro. *Nutrition and Cancer*, **35**: 80–86.

Massey, L.K., Roman-Smith, H. and Sutton, R.A. 1993. Effect of dietary oxalate and calcium on urinary oxalate and risk of formation of calcium oxalate kidney stones. *J. Am. Diet. Assoc.*, **93**: 901–906.

Massey, L.K. 2000. Tea oxalate. *Nutrition Review,* **58**: 88– 89.

Matsumoto, M., Minami, T., Sasaki, H., Sobue, S., Hamada, S. and Ooshima, T. 1999. Inhibitory effects of oolong tea extract on caries-inducing properties of mutans streptococci. *Caries Res.* **33**: 441-445.

Mukhtar, H. and Ahmad, N. 2000. Tea polyphenols: prevention of cancer and optimizing health. *American Journal of Clinical Nutrition,* **71**: 1698S–1702S.

Ohno, Y., Wakai, K. and Genka, K. 1995. Tea consumption and lung cancer risk: A case-control study in Okinawa, Japan. *Japan Journal of Cancer Research*, **86**: 1027–1034.

Rice-Evans, C. 1999. Implications of the mechanisms of action of tea polyphenols as antioxidants in vitro for chemoprevention in humans. *Proc. Soc. Exp. Biol. Med.,* **220**: 262–266.

Rohdewald, P. Pycnogenol. In. Rice-Evans, C.A. and Packer, L. 1998. Flavonoids in Health and Disease, *New York; Marcel Dekker, Inc.* 405-419.

Salah, N., Miller, N.J., Paganga, G., Tijburg, L., Bolwell, G.P. and Rice-Evans, C.A. 1995. Polyphenolic flavanols as scavengers of aqueous phase radicals and as chain-breaking antioxidants. *Arch Biochem Biophys.* **322**: 339-346.

Sharangi, A.B. 2009. Medicinal and therapeutic potentialities of tea (*Camellia sinensis* L.) – A review. *Food Research International*, **42**: 529–535

Serafini, M., Ghiselli, A. and Ferro-Luzzi, A. 1996. In vivo antioxidant effect of green and black tea in man. *Eur. J. Clin. Nutr.* **50**: 28–32.

Setiawan, V.W., Zhang, Z.F. and Yu, G.P. 2001. Protective effect of green tea on the risks of chronic gastritis and stomach cancer. *International Journal of Cancer*, **92:** 600–604.

Simpson, A., Shaw, L. and Smith, A.J. 2001. The bio-availability of Fluoride from black tea. *Journal of Dentistry*, **29**: 15-21.

Simpson, A., Shaw, L. and Smith, A.J. 2001a. Tooth surface pH during drinking of black tea. *Br Dent J.* **190:** 374–376.

Sinija, V.R. and Mishra, H.N. 2008. Green tea: Health benefits, Review. *Journal of Nutritional and Environmental Medicine,* **17**: 232–242.

Tsuchiya, H., Sato, M., Kato, H., Okubo, T., Juneja, L.R. and Kim, M. 1997. Simultaneous determination of catechins in human saliva by high-performance liquid chromatography. *J Chromatog Biomed Sci Appl.* **703**: 253-258.

Tsubono, Y., Nishino, Y. and Komatsu, S. 2001. Green tea and the risk of gastric cancer in Japan. *New England Journal of Medicine*, **344**(9): 675–676.

Van het Hof, K.H., Wiseman, S.A., Yang, C.S. and Tijburg, L.B.M. 1999. Plasma and lipoprotein levels of tea catechins following repeated tea consumption. *Proc. Soc. Exp. Biol. Med.,* **220**: 203– 209.

Wagh Ashok, 2014. Indian Tea Industry: It's Status In Global Scenario. *Abhinav International Monthly Refereed Journal of Research in Management & Technology* **3**(12): 32-36.

Weisburger, J.H. 1999. Tea and Health: The underlying Mechanisms. *Proc. Soc. Exp. Biol Med.* **220**: 203-209.

Willson, K.C. and Clifford, M.N. 1992. Tea: Cultivation to Consumption *(London: Chapman & Hall),* pp. 25-51.

Xue-Jun Wang, Xian-Tao Zeng, Xiao-Li Duan, Huan-Chao Zeng, Rui Shen and Ping Zhou. 2012. Association Between Green Tea and Colorectal Cancer Risk: A Meta-analysis of 13 Case-control Studies. *Asian Pacific Journal of Cancer Prevention,***13**: 3123-3127.

Yadav, A.K., Kaushik, C.P., Haritash, A.K., Singh, B., Raghuvanshi, S.P. and Kansal, A. 2007. Determination of exposure and probable ingestion of fluoride through tea, toothpaste, tobacco and pan masala. *Journal of Hazardous Materials*, **142**: 77– 80.

Yang, C.S., Maliakal, P. and Meng, X. 2002. Inhibition of carcinogenesis by tea. *Annu Rev Pharmacol Toxicol,* **42**: 25–54.

Yemane, M., Chandravanshi, B.S. and Wondimu, T. 2008. Levels of essential and non-essential metals in leaves of the tea plant (*Camellia sinensis L.*) and soil of Wushwush farms, Ethiopia. *Food Chemistry;* **107**: 1236–1243.

Yu, G.P., Hsieh, C.C., Wang, L.Y., Yu, S.Z., Li, X.L. and Jin, T.H. 1995. Green-tea consumption and risk of stomach cancer: A population-based case-control study in Shanghai, China. *Cancer Causes Control*, **6**: 532–538.