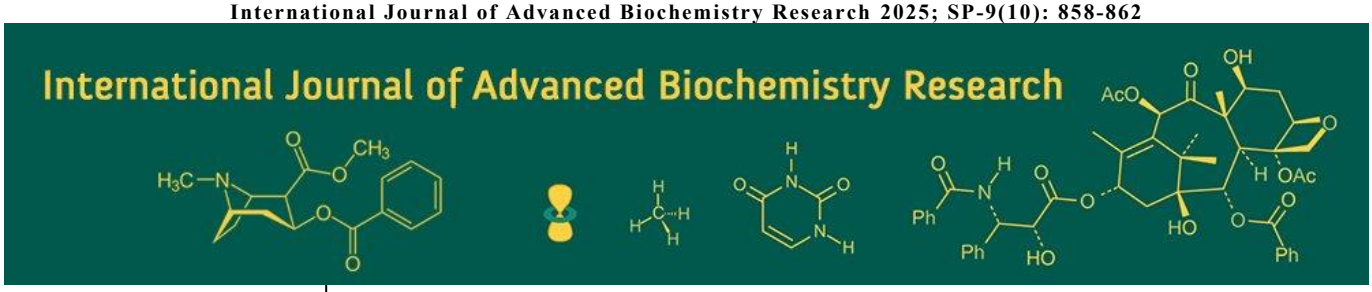

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The mysterious, two leaf and a bud

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Abstract
Tea is a plantation crop grown in large area for its two leaf and a bud which is processed and consumed as a beverage all over the world. Tea is the most consumed beverage followed by coffee and chocolate. It has mainly three types including fermented, unfermented and semi fermented teas. Among these, green tea contains higher polyphenols with lesser caffeine and tannins than black teas which are said to be good for health. Many of us has a notion that tea acts only as a stimulative but its applications are found mysterious to the community. In this regard, an effort was made to identify the applications of tea rather than a beverage. It has its leg in pharmaceutical industry as antidiabetic, anti-obesity, antioxidant, anticancer, antibacterial, also in dentistry, agriculture, post harvest management of food products *etc*. and excessive consumption also leads to few ill effects like stomach ache, insomnia, heartburn *etc*.

Keywords: Tea, beverage, polyphenols, applications

Introduction
Botanically tea is known as *Camellia sinensis* belongs to Camelliaceae/Theaceae family with diploid chromosome number 2n=30. It is originated from South East Asia. Economic part is two leaf and a bud (Kumar, 2020) [12]. It has mainly two species *i.e., Camellia sinensis* (China tea) and *Camellia assamica* (Assam tea). China tea is a small shrub with short leaves, produces good quality tea after processing and resistant to cold, mainly cultivated in India. Assam tea is a tree with broad leaves, produces poor quality tea and resistant to drought, mainly cultivated in China. Another type of tea *Camellia assamica ssp. Lasiocalyx* is said to be cross between China and Assam tea. It is also known as Cambod tea, the characteristics are intermediate to both of its parents.

Two leaf and a bud is considered as a golden tip, plucking of two leaf and a bud is known as fine plucking which is a symbol of perfection. It is concentrated with nutrients and natural antioxidants and rich in flavanols like catechins and amino acids like theanine. It has soft stem has no fibre which gives finer quality whereas lower leaves has harder stem with high fibre content produces poor quality tea after processing.

The first consumption of tea has been started from 5000-6000 years ago during Shen Nong era of China. Cha was the first term coined, meaning tea in Cantonese language. Chinese were the first to use tea as a medicinal herb to cure various ailments. During Zhou dynasty, tea became popular as a drink and Tang dynasty started its production and processing and first monograph 'the classic era of tea' has been written during this period. Song dynasty has started first tea house and Ming dynasty has created the first tea manual (Chen, 2012) [3].

In India during 1837, British East India company has brought the tea plants and planted in English tea garden in Assam. Tea cultivation has been started during 1840 and commercial tea plantation has been started in Darjeeling where they followed estate model. Red label was the first tea brand established in India by Brooke bond company. Presently India is the largest consumer of black tea (1168 M kg/year) accounts for 18 percent of total world's consumption (Tea Board of India, 2024). India is the second largest producer of tea (1344.40 M Kg) and forth major tea exporting country in the world (PIB, 2023).

In south India during 1878, James Finlay and Co. transformed the Kanan Devan Hills exclusively for tea crop. Due to widespread of coffee leaf rust led to an extensive planting of tea in south India. During 2022, Tamil Nadu (159.02 M kg) is the major producer followed by Kerala (67.70 M kg) and Karnataka (5.10 M kg) in south India (TRF, UPASI, 2024).

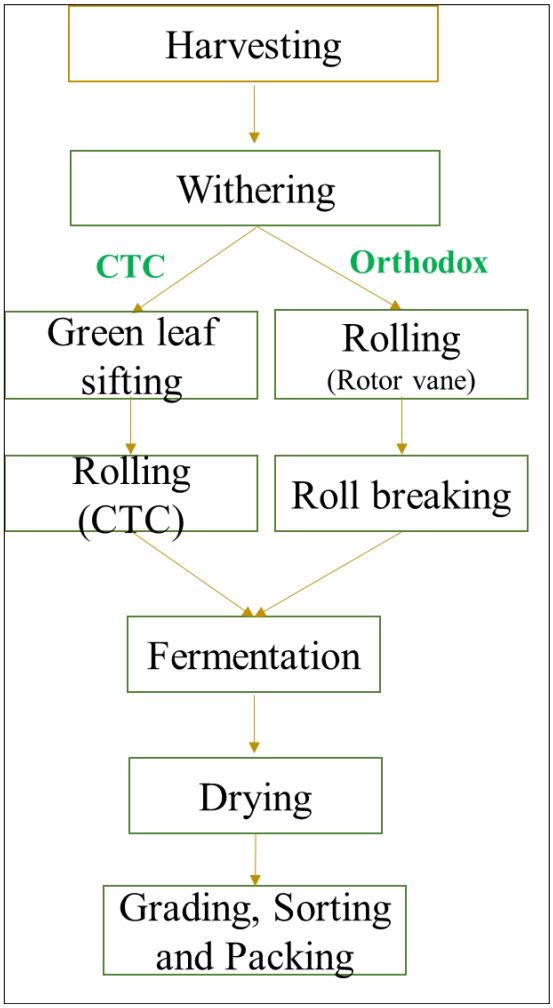
Processing of tea

- **Harvesting:** First and fore most thing is harvesting for processing, which means plucking in tea. Based on the method of processing, two leaf and a bud, three leaf and a bud and four leaf and a bud is harvested.
- **Withering:** After harvesting leaves are kept under withering chamber, is almost similar to drying, initial moisture content is reduced upto 65 percent.
- After withering there are two methods of processing of tea *i.e.,* CTC (Crush, Tear and Curl) and Orthodox.
- **CTC:** In this method, green leaf sifting is done which means removal of stems, iron particles *etc.,* then it is passed through CTC machine, which is a continuous process leaves are moving from one roller to another roller where leaves are crushed, torn and curled.
- **Orthodox:** Withered leaves are rolled in rotor vane, leaves get macerated, mixing up of enzymes and substrates will takes place. After rolling leaves will be in the form of clumps so roll breaking has to be done to break the clumps.
- **Fermentation:** In orthodox method, during fermentation, the leaf changes colour and turns into a dark coppery tone. Typical aroma develops at this stage. The ideal conditions for fermentation are temperature <30ºC, moisture ~55 percent, pH 4.5 to 5.0 and relative humidity >90 percent. In CTC method, it takes in about 60-90 minutes with conditioned air. There are different types of fermentation like drum method, tray method, floor fermentation and recently UV fermentation has also been developed. During this, rubbing of leaf against leaf takes place and the juices present in the micro cells of leaf are evenly coated on the exterior of the tea leaf.
- **Drying:** In conventional drying, fermented leaf is subjected to a blast of hot air in such a manner that the hottest air first comes in contact with the tea having the least moisture content. In these driers, the fermented leaf falls on a series of moving perforated trays on which it is passed and repassed through a moving stream of hot air. Mechanical driers are also employed. The moisture content is reduced upto 3 percent.
- **Grading, Sorting and Packing:** After drying based different size of leaves, graded into loose leaf, broken leaf, fannings and dust. Again these grades are sub graded into pekoe, Flowery orange broken pekoe, broken pekoe *etc*. then packed into bags.

Types of tea

Tea has been classified based on the fermentation time like yellow tea**,** white tea, green tea, oolong tea, black tea and dark tea. In yellow tea, after withering panning (light roasting) is done followed by sweltering where roasting is done in closed condition, green leaves are turned to yellow colour and then rolling and drying is done. In white tea, after withering, directly drying is done. It is the least processed tea. In green tea, after withering, panning, rolling and drying is done. These three are the unfermented teas.

In oolong tea, after withering short fermentation is done followed by panning, rolling, drying and firing. In black tea, Full fermentation is done then rolling and drying. In dark tea after full fermentation, it is left for natural aging which is responsible for its unique flavour. These three are the fermented teas (Vinci *et al*., 2022) [17].



Chemical composition of tea

Tea leaves consist of 20-35 percent of tea polyphenols. It contains flavanols like catechins, epicatechins, epigallocatechin, epigallocatechin 3- gallate and epicatechin 3- gallate. It has flavanols glycosides like kaempferol, quercetin and myricetin. Amino acids accounts for 4 percent, mainly include theanine which is responsible for antioxidant and neurotransmitter property of tea. Free sugars accounts for 3-5 percent including glucose, fructose, sucrose, raffinose and stachyose. In alkaloids, caffeine is the major one accounts for 2-5 percent, which is responsible for the stimulative property of tea. It also includes theobromine and theophylline which are colour and flavour compounds respectively. Tannin are the compounds responsible for the astringency of the tea. It includes ellagitannins like corilagin, strictinin and tellimagrandin I (Chen, 2012) [3].

Table 1: Difference between green and black tea (Xu and Chen, 2012) [3]

Tea type	Green tea	Black tea
Tea polyphenols	10-15 percent	5 percent
Pigment	Chlorophyll	Anthocyanins
Caffeine	35 mg/cup (Less)	39-109 mg/cup (High)
Minerals/ Vitamins	Iron and potassium; Vit A and Vit C	No/ less
Flavonols	Catechins	Oxidized to colour and flavour compounds
Amino acids	4 percent	2.5-3.5 percent
Tannins	2.65 percent (Low)	11.76-15.14 percent (High)

Preparation of tea

Everyone of us prepare tea by boiling tea leaves, milk, water and sugar together, but it a wrong way of preparing tea. Boiling of tea leaves will cause acceleration of oxidation where the free radicles are released in our body which makes our body susceptible to diseases. It also releases the tannins which loses the original flavour of tea and leads to more bitterness and causes digestive issues.

The right way of preparing tea includes, get 2g of dried tea leaves or powder take it in a beaker and add 10 ml hot water leave it for 3 minutes and then filter it to get a beverage. Adding of sugar and milk is optional (Ehoche *et al*., 2021) [4]. If a person consumes the tea in this manner, he can experience the health benefits of tea. Tea possesses many therapeutic properties like antidiabetic activity, anti-obesity, anticancer, antimicrobial, antioxidant, stimulative *etc.*

Health complications and related case studies

Antidiabetic

In the normal blood vessel, there will be proper proportion of red blood cells, white blood cells and glucose, whereas in diabetic/hyperglycaemic condition the glucose molecules are more in blood vessels which increases the unutilized sugar level in the body. In the normal functioning of the body, beta cells present in the pancreas will produce the insulin, which will bind to the insulin receptor, which opens the glucose channel of a cell then glucose is uptaken and utilized for the energy synthesis. In type 1 diabetes, due to loss of beta cells pancreas do not produce insulin, where the glucose channel will remain closed and the glucose cannot be utilized but remain in the blood vessels thus increasing the sugar level in blood. In type 2 diabetes, cell will develop a insulin resistance, where insulin cannot bind to the receptor, thus glucose channel is kept closed and increases the sugar level in the blood.

When tea is consumed, the tea bioactive compounds act in three ways by inhibition of α-amylase, enhancing the glucose transport across the membrane and stimulates the insulin secretion. By α- amylase inhibition will reduce the carbohydrates absorption in body where the starch is not digested and will directly enter the large intestine and then pass out through colon. By this the glucose is not absorbed by the blood and thus reducing the blood glucose level.

In second way bioactive compounds will act as insulin and it breaks the insulin resistance in the cell membrane and enters into the cell. Then it activates the p13k and AKT enzymes which activates the GLUT-4 protein to move to the cell membrane. Then GLUT-4 protein will absorb the glucose molecules from blood and thus reducing the type-2 diabetes. In third way these bioactive compounds will activates beta cells and increases the insulin secretion, thus reducing the type-1 diabetes (Zanzabil *et al*., 2023) [19].

A study conducted by Tolmie *et al.* (2023) [15] reported the antidiabetic property of green and purple tea extract, ellagitannins (Corilagin, Strictinin and Tellimagrandin I) inhibited the α-amylase and α-glucosidase activity, thus reducing the blood glucose level by strongly binding to antidiabetic protein targets than the acarbose.

Anti-obesity: Consumption of high fat food will lead to the accumulation of fat in adipose tissue where the accumulated fat is not used for energy production (low energy expenditure). Thus, the levels of adipokines, pro inflammatory cytokines and mitogenic factors will increase. This will lead to obesity and its related diseases. When the tea is consumed, it increases the adiponectin (gene contributes to the control of glucose uptake and lipid metabolism) levels by increasing the P-AMPK and Sirt-1 enzymes which regulates the cellular metabolism and lipid metabolism respectively. Through PPAR-γ-translation, increased expression of GLUT-4 protein will occur, it increases uptake and breakdown of lipid molecules which is known as lipolysis (Salem *et al*., 2023) [14]. In another way, it will reduce the adipokines leptin, TNF-α, vaspin, omentin which also increases the glucose uptake and lipolysis and thus reducing the obesity. Chen *et al.* (2015) [2] recorded anti-obesity property of high dose of green tea extract in women with central obesity by significant weight loss and consistent decreases in total cholesterol and Low Density Lipoprotein (LDL) and increase in adiponectin and alanine transaminase levels which can be used to overcome obesity.

Anticancer

Cancer causes in five different ways (Nimmakayala *et al*., 2018) [13],

- Fusion of cancer cell with normal stem cell will lead to the cancer stem cells.
- **Horizontal gene transfer:** When the mutation occurs, and mutant cell undergo replication, the fragment DNA of mutated cell is taken by another cell by phagocytosis which will cause cancer cells.
- Continuous systematic division of mutant cell will develop cancer cells
- **Metabolic reprogramming:** Variation in metabolism like hypoxia in presence of hypoxia inducible factor 1 a (HIF 1a) will convert oxyolytic to glycolytic which will cause metabolic shift and will develop cancer stem cells
- **Dedifferentiation:** By wounding or exposing of differentiated cancer cell to NO or ionizing radiations cancer cells will dedifferentiate into cancer stem cells

EGCG will increase the caspases protein which arrest cell cycle at G1 (growth) phase, further dividing of cancer cell will stop by the death of cancer cell. Polyphenon E will down regulate the proteins like VEGF, MMP9, STAT-3, HMVEC which are produced by cancer cells that forms new blood vessels (angiogenesis). EGCG will reduce the migration of cancer cells by inhibiting the nuclear factor NF-kB and activator protein AP-1, further proliferation is reduced and activates the cyclinD2 proteins which will reduce the metastasis (movement of cancer cell). Catechins as antioxidant will reduce the reactive oxygen species and free radicals and increase the radical scavenging activity, which will reduce the formation of cancer cells. As pro-oxidant, increase the ROS in cancer cells, causes decreased cancer cell growth and cell death (Chaudhary *et al*., 2023) [1]. A study reported that Green tea extract at 800 µg/ml inhibited the growth of Caco-2 cells (Colorectal cancer cell lines) and showed little effect on L929 normal cells. Expression of aquaporin-5 (AQP 5) protein was also decreased (Esghaei *et al*., 2018) [5].

Table 2: Cancer-related molecular targets of EGCG (*in vitro* and *in vivo* studies) (Farhan *et al*., 2023)

Type of cancer	Mechanism involved	Reference
Lung cancer	↑G0/G1 phase arrest	Bhardwaj *et al*., 2019
Thyroid cancer	↓EMT by regulating the TGF-β1/Smad signaling pathways	Li *et al*., 2019
Oesophageal cancer	↓Bcl-2 protein expression; ↑Bax and caspase-3 protein expression	Liu *et al.,* 2017
Colorectal cancer	↓Wnt/β-catenin pathway	Chen *et al*., 2017
Colon cancer	↓TRAIL cell death	Kim *et al*., 2016
Hepatocellular carcinoma	↓MMP-2; ↓MMP-9; alteration in levels of FUBP1, HSPB1, CH60 and NPM proteins	Zhang *et al.,* 2013
Breast cancer	↓Telomerase activity; ↓hTERT	Mittal *et al*., 2004
Lung cancer	CSC-like characteristics by modulating the hsa-mir-485-5p/RXRα axis	Jing *et al.,* 2018
Breast cancer	↓VEGF	Wei *et al*., 2018
Hepatocellular carcinoma	↑DNA breakage; pro-oxidant effect	Farhan *et al.,* 2015
Oesophageal carcinoma	Induced apoptosis and ↑ROS generation, ↓VEGF; ↑caspase-3	Liu *et al.,* 2015 [2]
Pancreatic cancer	Inhibited tumor growth with ↓p-ERK, p-PI3K, p-AKT, and pFKHRL1/FOXO3a,	Shankar *et al.,* 2013
Colon cancer	↓ HES1 and Notch2 induced the apoptosis	Jin *et al*., 2013
Skin cancer	↓ TPA-induced DNA binding of NF-kB and CREB	Kundu *et al.,* 2007

Antibacterial

Bacterial infection is common for all age groups, so taking antibiotics can cause many side effects on human health. So, consuming tea can be the best option to overcome bacterial infections. Consumption of tea will break the growth and development of bacterial cells and cause its death. Secondly, it will increase the activity of enzymes like phenyl alanine aminase, peroxidase, catalase, polyphenol oxidase *etc.* which will develop defence mechanism against the bacteria. Thirdly, it will cause electrolytic leakage from bacterial cell which will damage the cell membrane and cause the cell death (Yan *et al*., 2021) [18].

In an experiment, green tea and black tea extracts inhibited the growth of Methicillin-resistant *Staphylococcus aureus* bacterial strains at 80 µg/mL epigallocatechin 3- gallate (EGCG) concentration (Feilcke *et al*., 2023) [7]. Similar study with respect to streptococci and lactobacilli in the oral cavity of children has been carried out by Vilela *et al.* (2020) [16] which showed the microbial reduction and its application as mouthwash for children.

Antioxidant

Increase in free radicals in human body will make the body susceptible to diseases. Since is rich in natural antioxidants it will scavenge the free radicals. A study reported total phenolic content and antioxidants were higher at T = 100°C for 10 min, green tea (916.12-1169.81 mg GAE/g) and black tea (932.03-1126.62 mg GAE/g) in natural mineral water which sowed the antioxidant activity (Vinci *et al*., 2022) [17].

Rather than health benefits, tea polyphenols can be used to extend the shelf life of food products. A study confirms that chitosan oligosaccharides (0.1%) combined with tea polyphenols (0.08%) inhibited microbial growth with slight increase in pH, maintaining same level of amino acid nitrogen and overall likeness score even after 18 months of room-temperature storage. It can be used as practical method to inhibit the spoilage of soy sauce (Zhu *et al*., 2023) [20].

Another study revealed the utilization of green tea waste as soil amendments. It resulted that application of green tea waste (2.5%) has increased CO_2 accumulation and other leaf parameters (Zou *et al*., 2023) [21].

Limitations (Excessive consumption)

- Tannins bind to iron and reduce iron absorption in body and cause Fe deficiency
- It will cause irritative digestive issues like nausea and stomach ache
- Black tea has higher amount of caffeine, it will cause anxiety and restlessness
- Due to reduced melatonin, it will lead to insomnia
- Higher caffeine will cause heartburn
- It may cause miscarriage or low infant birth weight during pregnancy

Conclusion

Ellagitannins present in green tea extract will act as antidiabetic. Consumption of green tea will help to overcome obesity and also cancer. Tea will also act as antioxidant and antibacterial. Other than use of tea in pharmaceutical industry, it also has application in food industry in extension of shelf life of soy sauce. Green tea waste can also be used as soil amendment. It can also be used to treat cardiovascular diseases, Alzheimer's, Parkinson's, immunomodulatory *etc*.

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