



Review Article

SECRETS OF GREEN TEA AND ITS POTENTIAL HEALTH BENEFITS

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ABSTRACT

Green tea, which is produced from the leaves of the *Camellia sinensis* plant, is one of the most popular beverages consuming worldwide. Numerous health benefits associated with this herbal drink promotion of cardio vascular health, prevention of cancer (due to antioxidant property), prevention of skin disorders (antibacterial), promote immune system, anti-inflammatory action, useful in maintenance of cholesterol and weight management etc. which proved by scientific evidences by scientists. The main objective of this review paper is to clarify the health benefits/ side effects and responsible chemical constituents with its action. This review covers classification of Green tea, details about manufacturing process, chemical components with its pharmacological action, comparison of green tea with white tea, adulteration and its identification tests. Present article focus on an International standard for tea, function of tea board, ISO recommendation for green tea, various manufacturing plant in India. This review is done to spread cognizance among general population about the benefits of green tea.

KEYWORD: ISO Recommendation, Manufacturing process, Pharmacological action, International standards, Adulteration identification tests, Health benefits.

INTRODUCTION

Tea is the majority consumed drink in the globe after water. Regularly uptake of green tea may reduce your risk of rising heart disease by lowering cholesterol which help for controlling the brain related diseases like Alzheimer's disease by improving blood flow, eye diseases, maintain bone mineral density, stabilized blood sugar level etc.

1. *Camellia sinensis* plant:

Commonly referred as a tea plant, tea bush or tea tree. *Camellia sinensis* shows following distinguished actions.

It contains some special chemical constituents like amino acid l-theanine; caffeine; catechin polyphenolslike: epigallocatechin gallate (EGCG) (more effective than Vitamine C), catechins, theaflavins, tannins, and Flavonoids; epigallocatechin gallate; oxalates; fluoride; tannin. Tannins present in *Camellia sinensis* showed astringent activity, and help tone or tighten the gaps leading to healthier digestion which act supportive ease in diarrhea and vomiting. Also bitter flavor of *Camellia sinensis* stimulate liver secretions, enzymatic productions which help in digestion food, clear phlegm, and persuade proper elimination. It is also used asthmatic attack, bronchitis. Also lower cholesterol levels, and inhibiting the abnormal formation of blood clots that can cause heart attacks and strokes. Theanine constituents present help reduce levels of stress and anxiety. epigallocatechin gallate beneficial effects on body mass index (BMI), blood pressure, total antioxidant status (TAS), lipid profiles, and glucose concentrations [2-4].

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* E-Mail: priyatama.powar@gmail.comDOI: <https://doi.org/10.5281/zenodo.1789576>**❖ Anti-cancer, antioxidant activity and Chemoprotective activity:**

The anticancer activity of di- and tri-terpenes and other polyphenol compounds present in tea is already reported. The cytotoxic and apoptogenic effect of tea root extract (TRE) and two of its steroidal saponins named as TS1 and TS2, on human cell lines and on cells from leukemia patients [5]. Polyphenols, catechins of EGCG and EGC show ability to scavenge free radicals, inhibit lipid peroxidation, and chelate metal ions [6,7]. *Camellia sinensis* catechin (flavanols) especially epigallocatechin gallate, epigallocatechin, epicatechin gallate and epicatechin which have been identified as active components responsible for antioxidant property [8]. Green tea polyphenols and epigallocatechin-3-gallate (EGCG) have potent chemo preventive and therapeutic effect against numerous cancers of skin, lung, breast, colon, liver, stomach and prostate [9]. Epigallocatechin gallate (EGCG), as a natural product has enormous potential to be an anticancer agent capable of enhancing tumor cell sensitivity to therapy [10] may be due to EGCG can modulate gene expression by influencing epigenetic processes such as DNA methylation and/or histone modification [11].

❖ Antibacterial activity: *Camellia sinensis* catechins, particularly EGCG and EGC, have antibacterial activity against both Gram-positive and Gram-negative bacteria [12]. *Camellia sinensis* can prevent tooth decay by inhibiting oral bacteria [13]. The antibacterial activity of black tea has also been reported [14-16].**❖ Hepatoprotective activity:** *Camellia sinensis* contains six primary catechins or polyphenol compounds. These polyphenols prevent oxygen-free radicals-induced hepatocyte lethality, reduce the risk of liver disease, and protect against liver injury [17,18].**❖ Cholesterol-lowering Action:** EGCG and EGC increased CYP7A1 promoter activity, and EGCG increased CYP7A1 message expression, as well as reducing the activity of the apical sodium-dependent bile acid transporter of enterocytes in the distal intestine which disrupts bile acid recycling, promotes bile acid synthesis and thereby reduces cholesterol levels. Catechins (gallate ester components) affect lipid metabolism by various mechanisms

and prevent the appearance of atherosclerotic plaque, LDL receptor synthesis is increased in response to decreased intracellular cholesterol levels [19].

❖ **Anxiolytic Action:** *Camellia sinensis* contains methyl xanthines (caffeine, theophylline), polyphenols and ascorbic acid. Methyl xanthines are central nervous system stimulants and have adenosine antagonistic activity. Adenosine agonists and antagonists produce anxiogenic and anxiolytic effects [20].

❖ **Effect on obesity:** EGCG, GTC (Green Tea Catechin) may show related action to certain pathways, such as through the modulations of energy balance, endocrine systems, food intake, lipid and carbohydrate metabolism, redox status and inhibits the absorption of cholesterol. GTC upregulate the LDL (Low density lipoprotein) receptor mediated by activation of SREBP-2 and reduce plasma cholesterol level by enhancing fecal bile acid, cholesterol excretion [21].

High Dose side effect: Heart issues (tachycardia, high blood pressure, cardiac failure, drop in iron levels).

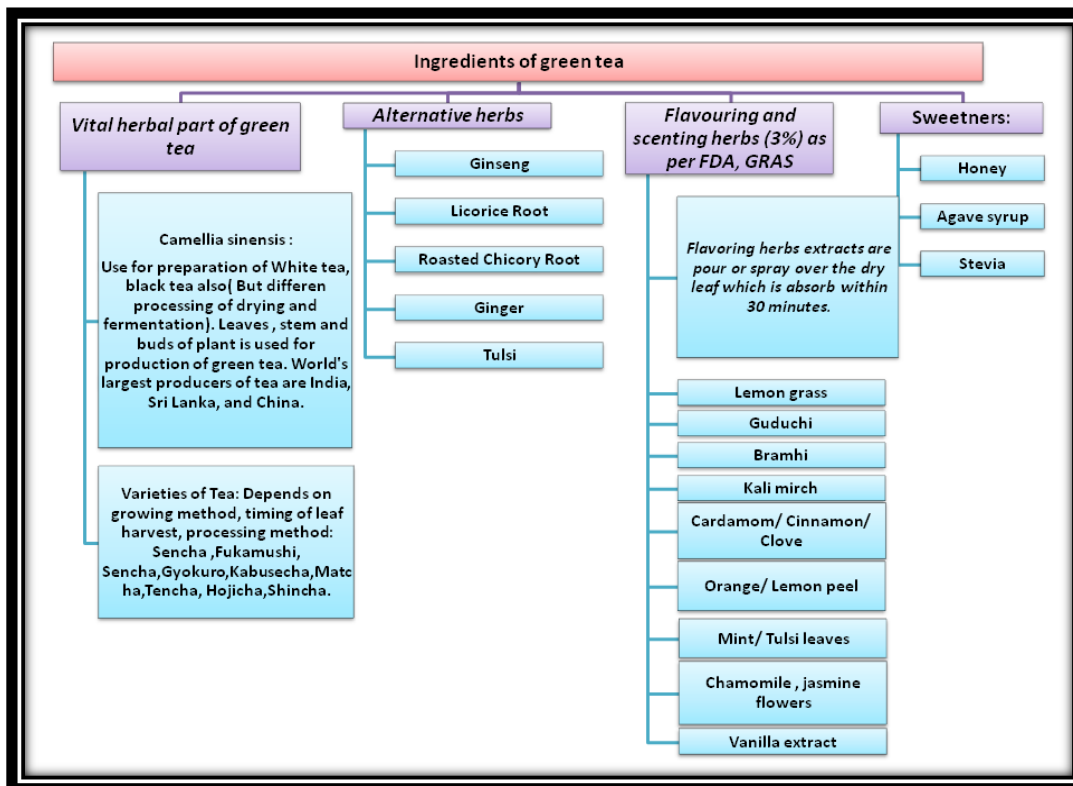


Fig. 1: Various contents of green tea [1]

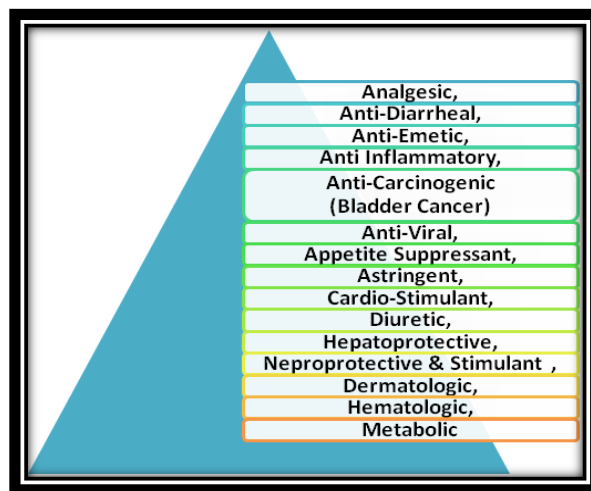


Fig. 2: Diverse health benefits of green tea

2. Ginseng:

Diverse species of Ginseng are available like *Panax ginseng*, *Panax japonica*, *Panax notoginseng*, *Panax quinquefolium*. Ginseng consists of several ginseng saponin glycosides like ginsenosides, panaxosides and chikusetsusaponin; aglycone dammarol, panaxosides;

ginseng oils; phytosterol; carbohydrates; sugars; organic acid; vitamins(B1, B2 and B12); minerals (zinc, copper, magnesium, calcium, iron, manganese, vanadium); volatile oil and certain enzymes etc. [22, 23].

- ❖ **Thyroid dysfunctioning , Diabetes :** Ginsenosids used in Useful for thyroid dysfunctioning , Diabetes which help in Insulin metabolism. The Rb1 and Rb2 which act on Lipoprotein lipase (which is regulated by LPL gene located as 8p22) which affects triglycerides metabolism by hydrolysis and generates free fatty acids and supply to adipose tissue. Also increase the Insuline sensitivity. Ginsenoside Rg1 significantly enhanced the glucose uptake in myocytes by Adenosine monophosphate kinase (AMPK) mediated GLUT4 translocation and glucose uptake help of reducing glucose level. Which is supported by reducing hypothalamic neuropeptide Y leads to less food intake and reduce alpha- glucosidase activity which increases glucose absorption leads to Antioxidant activity and improve glucose activity [24, 25].
 - ❖ **Myocardial infarction:** Ginsenoside Rb1 preconditioning protects against myocardial infarction in a case of regional ischemia and reperfusion. Compound K, a metabolite of ginsenosides, bestows nitric oxide-mediated cardiac protection via the Akt/phosphoinositol-3-kinase (PI3K) pathway [26, 27].
 - ❖ **Regulating Vascular Endothelial Cells:** Ginsenoside Rb1 effects on umbilical vein endothelial cells; exhibits angiogenesis by activating the PI3K/Akt-dependent extracellular signal-regulated kinase 1/2 and eNOS pathways [28]. Also show angiomodulatory and neurological effects. Compound K inhibits basic fibroblast growth factor-induced angiogenesis through regulation of p38 mitogen-activated protein kinase and Akt in human umbilical vein endothelial cells. [29].
 - ❖ **Regulating Vasomotor Functions:** Ginsenoside Rb1 stimulate production of NO (Nitric oxide) production (contributes to the control of vascular smooth muscle tone) by stimulating phosphorylation of glucocorticoid receptor, PI3K, Akt/protein kinase B, and eNOS [30].
 - ❖ **Improving blood circulation:** Ginsenoside Rg3 inhibits platelet aggregation and intravascular coagulation also protective action for erythrocytes against hemin-induced hemolysis by stimulating PI3K/Akt-eNOS signaling [31].
Dihydroginsenoside Rg3 potently inhibited platelet aggregation through the modulation of downstream signaling components such as cyclic adenosine monophosphate and extracellular signal-regulated kinase 2 [32].
 - ❖ **Use in stress-related depression, anxiety and Immunomodulatory action:** Ginseng regulates the hypothalamic-pituitary-adrenal (HPA) axis is vital pathway by stimulating secretion of corticotrophin-releasing hormone (CRH) ,arginine vasopressin (AVP) from the master pituitary gland. CRH stimulates the pituitary gland to release adrenocorticotrophic hormone (ACTH) which triggers the release of glucocorticoids, such as cortisol, from the adrenal cortex. Glucocorticoids and norepinephrine modulate proinflammatory cytokine production by immune cells. As well as it is effective in memory improvement, prevention of degenerative brain diseases (Alzheimer's disease) [33-35].
 - ❖ **Useful in Osteoporosis:** Ginsenoside Rg₁, Rb₁, Rb₂ upregulate the estrogen receptor in bone tissue by regulating expression of interleukin (IL)-6, a proinflammatory cytokine and promotes osteogenesis in the bone marrow stromal cell [36, 37].
 - ❖ **Useful in Allergic asthma:** Ginsenoside Rb₁, Rh₂ acts as an anti-inflammatory and antiallergic agent by activating (mitogen-activated protein kinase)MAP kinase pathway and inhibiting the CD40 signaling that stimulates the interaction between antigen-presenting cells and T lymphocytes, and show anti-inflammatory and antiallergic effects. [38, 39].
- 3. Licorice root:** Botanical name is Glycyrrhiza glabra which is most widely used medicinal plants. Licorice contains extensive assortment of flavonoids and nutrients like vitamins (B & E) ,minerals (calcium, iron, phosphorus, potassium, choline, magnesium, selenium, zinc ,silicon). Its main constituent, glycyrrhizic acid, mimics mineralocorticoids, liquiritin, isoliquiritin, isoflavones, glabridin and hispaglabridins [40, 41].
- ❖ **Useful in Skin Care and Yeast / bacterial Infections:** Improve the antioxidant levels, minimize signs of aging useful in psoriasis or eczema, vaginal yeast infections also due to presence of potential flavonoids. Glabridin , glabrene, Licochalcone A, Isoliquiritin inhibits tyrosinase activity in melanoma cells which responsible for skin lightening activity. Glabridin, glabridin, glabrol show potential activity against Mycobacterium smegmatis and Candida albicans [42]. Phenolic compounds like glycyrrhizic acid, glycoisoflavanone, licochalcone A, isoflavones show antibacterial activity against methicillin resistance S.aureus. Glabridin show activity against M. tuberculosis, gram positive, negative bacteria. Glycyrrhizic acid(GA), liquiritigenin can reduce IgE induced allergic reaction, by reducing lung inflammation, infiltration of eosinophils.
 - ❖ **Antioxidant and Anticancer activity:** Chemical compounds including flavonoids, glabridin, liquiritin, isoliquiritin, glycyrrhizin, glycyrrhizic acid, and carbenoxolone which gives anticancer activity by antioxidant activity, DNA-protective activity, suppressive action, cyclooxygenase inhibition, and phytoestrogenic and progesterone antagonist activity [43].
 - ❖ **Antiulcer, mucoprotective action:** Inhibition of 15-hydroxyprostaglandin dehydrogenase, delta 13- PG reductase, which promotes mucosa secretion, cell proliferation, and healing activity.
 - ❖ **Useful in hypotension:** Licorice helps to increase blood pressure and in hypoadrenalism (one of the main root causes of low blood pressure) which increase time span of cortisol in the bloodstream, meaning that if you have low cortisol levels.
 - ❖ **Protection of Liver:** 18β-glycyrrhetic acid, inhibiting both free radical generation and lipid peroxidation.
 - ❖ **Anti-spasmodic Effects:** Help to relieve heart palpitations by limiting the damage from LDL cholesterol due to presence of isoflavones, smooth digestive properties, and ensure proper muscle function
 - ❖ **Hair Care:** Helps for re-growth hair and stop hair loss
 - ❖ **Detoxification of body:** Triterpenes (18β-GC, 18α-GC and 18β-glycyrrhetic acid,18β-GA)), Flavonoids (licochalcone A, licochalcone B, licochalcone C, licochalcone D, licochalcone E, isoliquiritigenin, echinatin, glabridin, isoangustone A, licoricidin, licorisoflavan A, dehydroglyasperin C) stimulating the digestive system and can also clear out phlegm from the throat and lungs as a result of its expectorant capabilities.
 - ❖ **Remedy for Cold and Boosts immune system:** Mainly effective remedy for cold and cough due to its antiviral (Glycyrrhizic acid, Glycyrrhizin, Licochalcone, Licochalcone, Glycyrrhetic acid, Glabridin, Liquiritigenin) and expectorant property (Carbenoxolone which stimulates tracheal /gastric mucus secretion). Improve immunity by enhancing levels of interferon, Glycyrrhizin affect release step while infectious HCV particles inhibits the proliferation of AIDS virus and show demulcent action; Glycyrrhetic acid reduce the levels of viral proteins VP2, VP6 and NSP2 and finally virus entry into the cell; Glycyrrhizic acid inactivates herpes simplex virus, reduce virus replication; Licochalcone A shows antimalarial activity; [44].
 - ❖ **Anti-inflammatory and useful in Arthritis:** Beta-glycyrrhetic acid act as a vital inhibitor of inflammatory immune system. Glycyrrhetic acid has shown anti-inflammatory and anti-arthritic activity by prostaglandin E 2 inhibitory Glycyrrhizin act as a anti-inflammatory agent due to selective inhibition of thrombin (a clotting factor), which results in the removal of blood congestion also mediated by cortisol, an hormone with anti-inflammatory action. Glycyrrhetic acid suppress the expression of inflammatory mediator like nitric oxide, LPS induced interleukin12, CD80,CD86, major histocompatibility complex class I, II and T helper cell immune responses also reduced. [Herbs and Natural Supplements,

Volume 2: An Evidence-Based Guide, Volume 2, Lesley Braun, Marc Cohen J Flavonoids (licochalcone A, licochalcone B, licochalcone C, licochalcone D, licochalcone E, isoliquiritigenin, echinatin, glabridin, isoangustone A, licoricidin, licorisoflavan A, dehydroglyasperin C) and triterpenes (18 β -GC, 18 α -GC and 18 β -glycyrrhetic acid (18 β -GA)) show anti-inflammatory action. Also Carbenoxolone, glycyrrhetic acid have vital role in metabolism of prostaglandin which enhance prostaglandin level leads to ulcer healing activity [45].

- ❖ **Estrogenic activity and hormonal imbalance:** The isoflavone / formononetin, has estrogenic acting as protection against stronger estrogenic action from estradiol and protecting against cancers that are estrogen receptor positive. It can be used in regulating and stimulating hormones for pre-menopause and menopause.

High Dose side effect: Hormonal problems, headaches, fatigue, high blood pressure, water retention, heart attacks, arm /leg numbness, digitalis toxicity. Licorice show drug interaction with corticosteroid medications, antidepressants, oral contraceptives, hormonal imbalance

Roasted Chicory Root: Botanical name is *Cichorium intybus* but commonly known as called Inulin, coffee weed. It's been used on numerous continents as a liver tonic, to relieve upset stomachs, reproductive enhancer, detoxify, calm the nerves, regulate the heartbeat, and treat osteoarthritis, gout, and diabetes. Chicory is blessed with vitamin B6;C, Selenium, Manganese, Oligosaccharide, chlorogenic acids, and flavonoids (anthocyanins, flavonols, flavanone, and flavan-3-ols),

- ❖ **Help lower fat, sugar, and calories in foods**
- ❖ **Support absorption of the mineral calcium:** Inulin also has the capability for enhancement of calcium absorption.
- ❖ **Lower blood glucose and support for delaying in Diabetes:** Vitamin B6 (pyridoxine) maintains normal blood sugar levels and nerves. Inulin content is not digestible and the lack of glucose can help promote optimal blood sugar levels also affects lipid metabolism, fatty acid breakdown.
- ❖ **Immunity booster and digestive support role:** Selenium, manganese present in Chicory root helps regulate thyroid hormones, immune system; and supports the formation of healthy bones, tissues, and sex hormones. Vitamin C help for fights various infection. Inulin, reduce acidity, increase bile secretion (Prevent acid reflux, indigestion); act as a prebiotic vital to the immune system that nourishes the growth and activity of probiotics, which in turn improve digestive health by preventing digestive flora imbalances to encourage healthy elimination by increasing stool bulk and consistency to help eliminate toxins efficiently. Anthocyanin has been reported to reduce the risk of coronary heart disease in animals by exhibiting arterial protection, inhibition of platelet aggregation, and protection of endothelial tissues.
- ❖ **Antioxidant Activity:** Chicory is a rich source of polyphenols which to help combat inflammation.
- ❖ **Anti-stress activity:** It helps to lower epinephrine and cortisol levels which help for reduction of stress.
- ❖ **Antimalarial Activity:** Due to presence lactucin, lactucopicrin, guaianolide sesquiterpenes.
- ❖ **Analgesic action:** Lactucin, lactucopicrin, and 11 β , 13-dihydroxylactucin exhibited analgesic action

Cinnamon: Botanical name is *Cinnamomum cassia*, Cinnamon helps stop menstrual cramps, indigestion, diarrhea, and genital and urinary infections. It increases sweating, and creates heat when used in a liniment. Emotional Attribute due to smell of cinnamon helps for relieve tension, steadies nerves and invigorates the senses. In very small amounts cinnamon can be an aphrodisiac. Cinnamon contains mainly

vanillic, caffeic, gallic, protocatechuic, p-coumaric, ferulic acids, cinnamaldehyde, eugenol, (E)-cinnamyl acetate, linalool and caryophyllene.

- ❖ **Anti-inflammatory activities:** Due to presence of gossypin, gnaphalin, hesperidin, hibifolin, hypolaetin, oroxindin, and quercetin which show an inhibitory effect on the production of nitric oxide by inhibiting the activation of the nuclear factor kappa-light-chain-enhancer of activated B cells (NF- κ B).
- ❖ **Support for health of Cardiovascular:** 2-methoxycinnamaldehyde (2-MCA) decreases the expression of vascular cell adhesion molecule-1 (VCAM-1) in TNF α -activated endothelial cells, suggesting that ischemia/reperfusion (I/R) injury is ameliorated due to the induction of hemeoxygenase- (HO-) 1. Cinnamophilin have thromboxane A2 (TXA2) receptor blocking activity and acts as potential thromboxane synthase inhibitors which help in the prevention of vascular diseases and atherosclerosis. Cinnamaldehyde also help for cardiovascular health.
- ❖ **Cholesterol, lipid lowering effects:** It helps for reduction in high density lipoprotein (HDL) cholesterol levels, plasma triglycerides.
- ❖ **Antioxidant Activity:** Epicatechin, catechin, and procyanidin B2, showed potentially inhibitory activities on the formation of Advanced Glycation End Products (AGE's) which is attributed to antioxidant activities and antidiabetic activity.
- ❖ **Anticancer activity:** Procyanidins slow down vascular endothelial growth factor subtype 2 (VEGFR2) kinase activity, thereby inhibiting the angiogenesis which is involved in cancer. CB403, a chemical that can be synthesized from 2'-hydroxycinnamaldehyde derived from cinnamaldehyde which show inhibitory effect on tumor. Cinnamic aldehyde inhibits the activity of NF- κ B, production of tumor necrosis factor alpha (TNF α -) induced interleukin-8 (IL-8) which reflects as a potential anticancer agent.
- ❖ **Antimicrobial activity:** Cinnamon oils have potential action against various bacteria (*Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Escherichia coli*) and yeast (*Torulopsis utilis*, *Schizosaccharomyces pombe*, *Candida albicans*, and *Saccharomyces cerevisiae*).
- ❖ **Stimulant and aphrodisiac action:** Cinnamophilin is a novel thromboxane A2 receptor antagonist which may provide protection against ischemic damage of brain.
- ❖ **Improve digestion and improve Sensitivity to Insulin hormone:** Cinnamon is effective in relieving abdominal discomfort, improving glucose metabolism and stimulating the production of natural insulin, lowers blood cholesterol to appropriate levels (helps in Type II diabetes). It reduces nausea and vomiting.
- ❖ It reduces cholesterol levels and the risk of suffering from cardiovascular disease and powerful natural anticoagulant.

Ginger:

Green tea with ginger has become important elements in preventive health care. Ginger is recognized by the U.S. Food and Drug Administration (FDA) as a food additive. Ginger (*Zingiber officinale*) is a natural anticoagulant, increases blood circulation, reduces blood sugar, aphrodisiac effect on the body, use in treatment of colds /coughs by reducing fever, soothes sore throats, and helps clear up phlegm. It also relieves heartburn, indigestion, diarrhea, vomiting, headaches, fatigue, muscle pain, menstrual cramps, gout, asthma, hypersensitivity, dementia and soreness. The major constituents in ginger rhizomes are carbohydrates (50-70%), lipids (3-8%), terpenes, and phenolic compounds. Terpene components of ginger include zingiberene, β -bisabolene, α -farnesene, β -sesquiphellandrene, and α -curcumene, (phenolic compounds) gingerol, paradols, shogaol, zingiberene and bisabolene (pungent compound) which exerts immuno-modulatory, anti-apoptotic, anti-tumourigenic, anti-inflammatory, anti-hyperglycaemic, anti-hyperlipidaemic, antioxidant and anti-emetic activities. Other 6-paradol, 1-dehydrogingerdione, 6- gingerdione and

10-gingerdione, 4- gingerdiol, 6-gingerdiol, 8-gingerdiol, and 10-gingerdiol, and diarylheptanoids present in ginger rizoid.

❖ **Anticancer and anti-oxidative activity:** It can be show as a anticancer activity for skin, ovarian, colon, breast, cervical, oral, renal, prostate, gastric, pancreatic, liver, and brain cancer. 6-gingerol induces TNF-related (ligand- (TRAIL-) induced apoptosis) apoptosis of cancerous cells by increasing caspase- 3/7 activation. 6-gingerol inhibits cancer cell growth through cell cycle arrest at G1 phase and independent of p53 status; by decreased both cyclin A and cyclindependent kinase (Cdk) expression followed by reduction in retinoblastoma (Rb) phosphorylation and blocking of S phase entry. Also regulates tight junction-related proteins and suppresses invasion (were mediated by decreased activity of MMP-9, urokinase-type plasminogen activator (uPA) and increased expression of tissue inhibitor metalloproteinase protein- (TIMP-) 1), metastasis in cancer cell by NF-B/Snail inhibition (inhibition of the extracellular signal-regulated kinases (ERK) pathway). 6-Shogaol has exhibited the most potent antioxidant and anti-inflammatory properties in ginger, which can be attributed to the presence of alpha, beta-unsaturated ketone moiety.

❖ **Anti-inflammatory activity:** Inhibits prostaglandin and leukotriene biosynthesis through suppression of 5-lipoxygenase or prostaglandin synthetase; also inhibition of pro-inflammatory cytokines such as IL-1, TNF- α , and IL-8, cyclooxygenase-1 and cyclooxygenase-2 (by inhibiting 5-lipoxygenase).

❖ **Antimicrobial Action:** 6-gingerol, 8-gingerol and 10- gingerol that exhibited antimicrobial activity.

❖ **Prevention of Gallstone:** Gingerol decrease secretion of prostaglandin, also mucin in bile, and stop the combining of mucin and calcium, bilirubin.

❖ **Improve blood circulation:** Stimulatory effect on the heart muscle and by diluting blood, increase the cellular metabolic activity, reduced the formation of proinflammatory prostaglandins and thromboxane thus lowering the clotting ability of the blood. It helps in nourishment of skin, support for removal of toxins from body and cleans bowels and kidney.

❖ **Antinausea Agent:** Gingesulfonic acid, gingerol ,shogaol show potent antiulcer activity. Gingerol inhibiting the central or peripheral increase of 5-hydroxytryptamine, dopamine, and substance P.

High Dose side effect: High dose in pregnancy may leads to mutation, abortion. It can cause depression of central nervous system, cardiac arrhythmias, inhibition of platelet aggregation.

Tulsi: The scientific name of tulsi is *Ocimum tenuiflorum/ Ocimum sanctum*. It relieves stress, balance hormones, prevents infections, and boosts energy. It has strong antibacterial, antiviral, anti-stress, energizing, healing, and immunity boosting properties [46].

❖ **Anti-oxidative activity:** Enhance the amount of glutathione and enhancing the activity of anti-oxidant enzymes such as superoxide dismutase and catalase, which protect cellular organelles and membranes by mopping up damaging free radicals caused by lack of oxygen. Also cytochrome increases the activity of P450 enzymes, which deactivates toxic chemicals and show anti-cancer activity [47].

❖ **Anti-inflammatory and Antiulcer Activity:** Fixed oil (composed of palmitic, stearic, linolenic, linoleic and oleic acids) significantly possessed antiulcer activity due to its lipoxygenase inhibitory, histamine antagonistic and antisecretory effects. Fix oil show dual inhibition of arachidonate metabolism supplemented by antihistaminic activity.[48] It is rich in antioxidants which help in extenuating stress [49].

Flavoring agents: One of the most appreciated and astonishing characteristics of tea is its ability to easily preserve any aroma, which can be advantageously used to prepare scented or flavored teas. Flavoring and scenting which utilized for enhancing the tea's taste/ , applicable for both commercial. Flavoring agents used in green teas may be Natural like inclusions/ extracts or artificial origin which are chemically produced in a lab/ lack of nutritional benefit. Total limits 0.5% and 5% of the weight of the tea being flavored .Following are some examples of flavoring agents:

- ❖ Lemon grass
- ❖ Guduchi
- ❖ Bramhi
- ❖ Kali mirch
- ❖ Cardamom
- ❖ Orange peel
- ❖ Hibiscus flowers
- ❖ Lemon peel
- ❖ Mint leaves
- ❖ Tulsi
- ❖ Jasmine flower extract
- ❖ Ginger

Diverse preparation methods for green tea: [50-53]

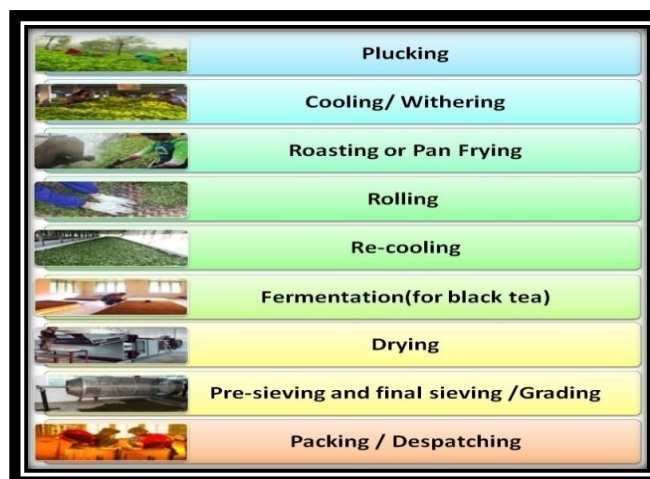


Fig. 3: Diverse preparation methods for green tea [51, 52, 54, 55]

1. Picking:

Picking done commonly by hand, usually stems with a shoot and two or three opened leaves are plucked by extremely expert tea pickers, early in the morning, when the cell content of the leaf is at its mellowest, before the harsh upland sun sets in motion the chemical processes in the leaf. The plucking takes place in season of the year when temperatures is lowest. After plucking yellow leaves and other debris are removed.

2. Cooling / Wintering, Steaming:

The freshly picked raw tea leaves they immediately begin to ferment and heat up. To prevent loss of quality, collected leaves are fanned / humidified with damp air to help maintain their moisture. The leaf is weighed and dispatched to the lofts from where it is sent through a barrel shaped steamer, in which steam at high pressure softens the leaf and coats it with its own cell fluids. The extended steaming time can easily breaks down cellular membrane during this can leads to cloudiness in the tea's color. However, longer-steamed leaves have a brighter luster while astringency and fragrance is reduced and quality aspects like flavor, aroma, color is maintained. The steaming helps to conserve natural oils and important natural antioxidants. Conditioned air is circulated between the leaves which help to remove any surface moisture. The cooling process carried out for 10 hours to 14 hours immediately after steaming for the physical and chemical changes to take place. Treated leaf became soft, rubbery condition suitable for the next stage of manufacture.

3. Pre-drying:

The processed steamed leaf briefly traverses through the pre-drier which arrest chemical action in the leaf cells and preparing the leaf for drying in the troughs.

4. Pan Frying/Roasting:

After pre-drying the collected leaves are used for Roasting, with the help of Roasting machine for 20 minutes and then these leaves are pressed.

5. Rolling:

First rolling mechanism is used on soften the leaves and lower the internal moisture content, hot, dry air is blown over the leaves while applying pressure and suitable friction and compression. This process also compensates for any lack of pressing during the first rolling process and moisture content is made uniform.

6. Drying:

The moisture content of leaf around 10-13% after rolling, and this is reduced to 5% with hot-air drying. Which will support for long-term storage /enhance shelf life, further draws out their distinctive aroma/ flavor. Final drying, shaping and styling done by using the ball tea machine.

7. Grading:

After drying the dried material used for sifting and grading depending on shape and size. In this process produced leaf are long, narrow, uniform shape or broken fine leaf and coarse tea leaf. The main grades are Leaf and Broken grades with the former consisting of larger and longer particles, yielding a light infusion, whilst the smaller particles produce darker and stronger infusions. The orthodox production method provides teas of all leaf grades: leaf, broken, Fanning and Dust. Leaf grades only refer to the leaf size, however: they are not necessarily an indication of the quality of the tea.



Fig. 4: Picking of green tea leaves with the help of tea picking machine

Table No. 1: Steaming and tea characteristics of green tea leaf

Method	Light steaming	Normal steaming	Deep steaming	Special steaming	Extra deep steaming
Time for steaming (seconds)	20-30	30-40	40-60	90-120	140-160
Flavor obtained	Clean Astringent	Slightly rich taste	Rich taste	Deep full boiled taste (smoothness)	Less Astringent taste
Aroma obtained	Strong	Slightly less as Light steaming	Slightly as normal steaming	Weak	Light aroma
Leaf shape	Long, narrow, uniform shape	Slightly broken as compare with Light steaming	Slightly broken as compare normal steaming	Broken shape	Coarse tea leaf
Tea Color	Clear, Light green color	Slightly dark as Light steaming	Slightly dark as normal steaming	Darkish green color	Deep green color



Fig. 5: Pre-drying Process



Fig. 6: Pan Frying/Roasting process



Fig. 7: Rolling machine



Fig. 8: Drying machine

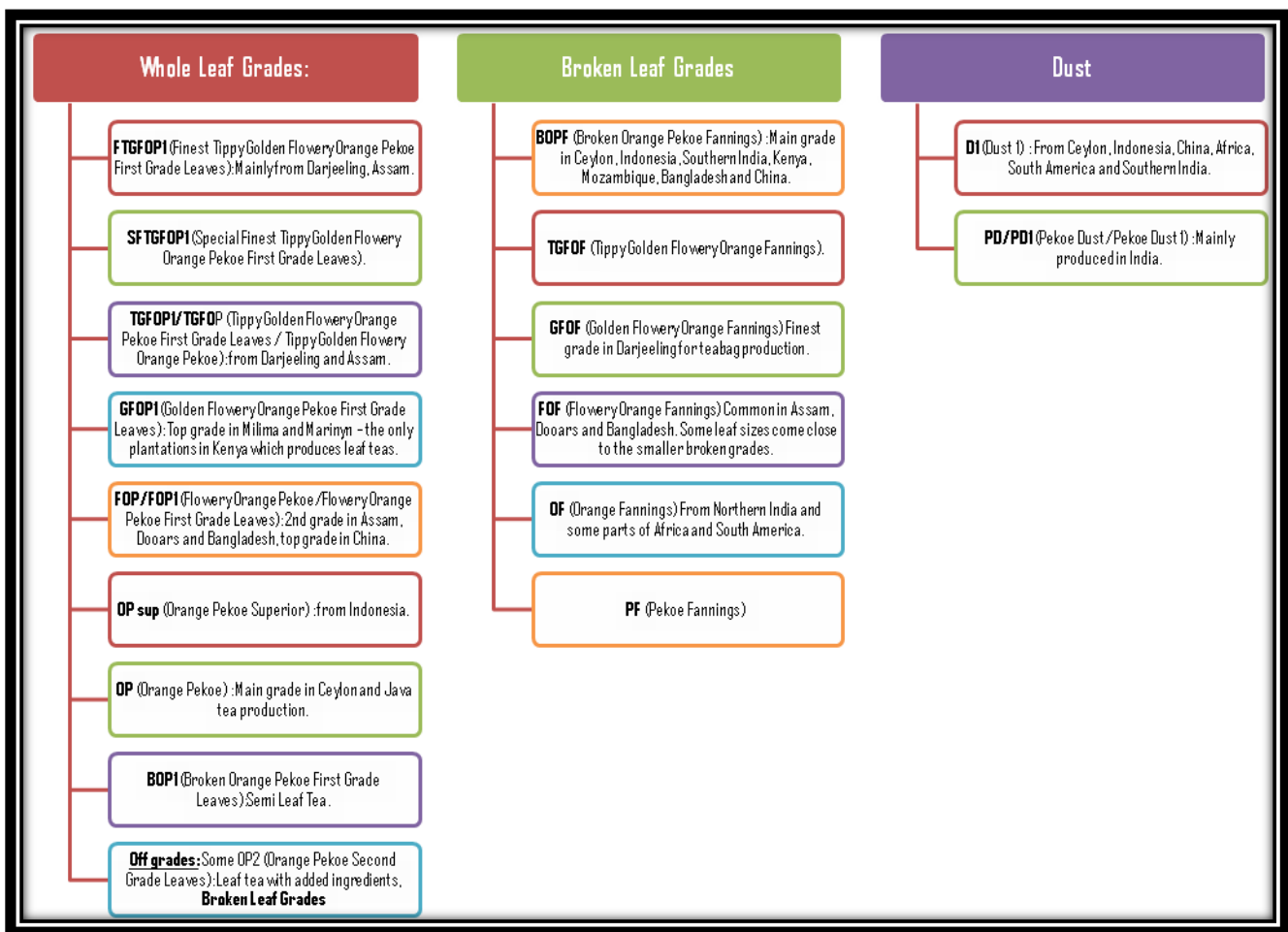


Fig. 9: Classification of Green Tea with help of Grading

Table No. 2: Various components of green tea and its pharmacological activity

S. No.	Component	Effect
1	<p>Catechins:</p> <ul style="list-style-type: none"> • Polyphenol/ astringency component, present as orange/ red colour • Around 12-15% present in tea, high content in young leaf as compare to mature leaf. • Theanine (Present in roots) → migrates to the leaves 	<ul style="list-style-type: none"> • Decreases blood cholesterol • Body fat reduction • Cancer prevention effect • Antioxidant • Tooth decay prevention • Antibacterial effect


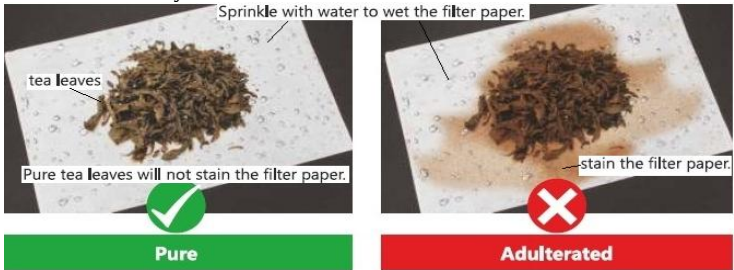
	<p>broken down in ethylamino → convert in catechin.</p> <ul style="list-style-type: none"> Types : Epicatechin, Epigallocatechin, Epicatechin gallate, Epigallocatechin gallate These types of Catechin undergo chemical reaction and formation of following products like <ul style="list-style-type: none"> Epicatechin → Catechin Epigallocatechin → Gallocatechin Epicatechin gallate → Catechin gallate Epigallocatechin gallate → Gallocatechin gallate 	<ul style="list-style-type: none"> Anti-influenza effect Inhibits high blood pressure Anti-hyperglycemic effect Bad breath prevention (deodorizing effect)
2	<p>Caffeine</p> <ul style="list-style-type: none"> Approximately: 0.01-0.02%. High content in young leaf as compare to mature leaf. Caffeine is sublimated due to heat treatment Used for enhance the metabolism of alcohol which relief hangover 	<ul style="list-style-type: none"> Increases alertness/ Stimulant Increases stamina Mild diuretic
3	<p>Amino Acid:</p> <ul style="list-style-type: none"> Theanine (Upto 60%), glutamine, asparagine, arginine, serine. Theanine limit the stimulant effect of caffeine 	<ul style="list-style-type: none"> Neuronal cell protection Relaxation effect Lowering of blood pressure
4	<p>Vitamins</p> <ul style="list-style-type: none"> Present along with saccharides, lipids, proteins, minerals 	<p>1.Vitamin C</p> <ul style="list-style-type: none"> Maintenance of healthy skin and mucus membrane Antioxidant <p>2.Vitamin B₂</p> <ul style="list-style-type: none"> Maintenance of healthy skin and mucus membrane <p>3.Folic acid</p> <ul style="list-style-type: none"> Prevention of fetal neural tube defects (NTD) Prevention of arterial sclerosis Prevention of colon cancer, dementia ,Alzheimer's Disease <p>4. β-carotene</p> <ul style="list-style-type: none"> Maintenance of nighttime vision Act as a precursor for synthesis of Vit A Maintenance of night vision <p>5. Vitamin E</p> <ul style="list-style-type: none"> Antioxidant
5	Saponins	<ul style="list-style-type: none"> Lowering of blood pressure Anti-influenza effect Anti-fungal, anti-inflammatory, and anti-allergy Prevent obesity and influenza
6	Fluorine	<ul style="list-style-type: none"> Prevention of tooth decay by formation of acid resistant layer on tooth surface
7	γ-aminobutyric acid (GABA)	<ul style="list-style-type: none"> Lowering of blood pressure
8	Minerals (Potassium, calcium, phosphorus, manganese, etc.)	<ul style="list-style-type: none"> Biological regulators
9	Chlorophyll	<ul style="list-style-type: none"> Deodorizing effect

Table No. 3: Prospective difference between Green tea and White Tea

Green Tea	White Tea
Harvested leaves are Younger Leaves are Partially fermented Taste of Green tea is stronger, slightly bitter	Harvested leaves are mature Steamed and then leaves dried therefore leaves are not oxidized/ rolled. Taste of White tea is Milder, slightly sweet
Processing steps are more	Processing steps are less, Only collected leaves are steamed rapidly and then dried. While green tea is partially fermented
Antioxidants are retained (But content is less as compare to white tea)	Higher amount of same type of Antioxidants are retained. health promoting properties including boosting cardiovascular health, helping to lower cholesterol, reducing the risk of cancer and enhancing weight loss. (High amount of Polyphenol, catechin and less amount of Theaflavins, Thearubigins)
The caffeine component of green tea help to weight loss – so choosing green over white in this instance maybe more beneficial as green tea contains slightly more caffeine. Green tea contains around 8-30mg per cup of caffeine, compared to white that has around 15g.	White tea contains around 6-20mg per cup of caffeine
Vitamine Content IN MG: Vit. B1 : 0.007 Vit. B2 : 0.06 Vit.B3 : 0.03 Vit.B6 :0.005 Vit.C : 0.3 Vit.A : 0.0 Vit. PP : 0.0	Vitamine Content IN MG: Vit. B1 : 0.07 Vit. B2 : 0.04 Vit.B3 : 0 Vit.B6 :0 Vit.C : 0 Vit.A : 0.08 Vit. PP : 11.3
Mineral content in mg: Iron :0.02 Magnesium: 1	Mineral content in mg: Iron :- Magnesium: 18

Manganase:0.18 Potassium: 8 Sodium:1 Phosphorous:- Calcium: -	Manganase:- Potassium:1.2 Sodium:35.2 Phosphorous : 17.4 Calcium: 20
Green tea may help stop the growth of cancer cells in breast, esophageal, prostate and stomach cancer. It shown positive results in preventing atherosclerosis, high cholesterol, reduce risk of esophageal cancer in women, prevent obesity by inhibiting growth of fat cell and dental diseases. It also may promote thermogenesis, a fat-burning / fat oxidation mechanism that contributes to successful weight loss.	It show more beneficial effects than that of Green tea, because of white tea's higher content of some polyphenols. It also show UV protection of skin, Boost mental performance, High in Antioxidants, Improves Oral Health, Amps Up Fat Burning, May Kill Cancer Cells,Improves Reproductive Health, Protects Brain Health, Reduces Cholesterol Levels. Also prevent colon cancer protection
Caffeine concentration 35 to 70 mg or 1.67-3.90 % for green tea per cup	Caffeine concentration is 30 to 55 milligrams per cup or 3.35-5.74% of dried leaves
EGCG is the most plentiful catechin which show antioxidant activity including promoting properties including boosting cardiovascular health, helping to lower cholesterol, reducing the risk of cancer, enhancing weight loss. EGCG content is 21.38 to 228.20 mg/g or 42.4 mg/100ml brewed	EGCG content is 70.2 mg/100ml brewed
Types: <ul style="list-style-type: none"> Japanese green tea Chinese green tea 	Types: <ul style="list-style-type: none"> Silver Needle (Yin Zhen) White Peony (Bai Mu Dan) Gongmei (Tribute Eyebrow) Fujian New Craft (DaBai Cha) Shou Mei (Noble, Long Life Eyebrow)

Table No.04: Common adulterants and tests to identify the adulterants [56]

Sr.No	Name of Adulterant	Method of identification
1	Added color	Spread leaves on wet filter paper, added colors can be identified (by imparting colour on paper)
2	Iron flakes	Iron flakes if present can be identified by spreading magnet over a sample of tea powder 
3	Leather flakes	An odour of burnt leather will be emitted if a sample is spread over burning paper ball
4	Coal tar dye	On a moistened white blotting paper scatter a little amount of the sample. Remove the sample and examine the paper after 5min. Colored spots indicate the use of the coal tar dye 

Factors affecting the quality of tea:

- The polyphenol and the enzyme content
- Higher elevations of 900-2100 m, humidity of 70-90%.and temperature range 13°C-32°C for cultivation.
- High quality is generally produced from leaves that have been hand plucked.
- Soil quality.
- Processing techniques used.
- Type of bush

International Standards for Tea:

- 1970's - Tea Committee became ISO Working Group 8 - ISO Technical Committee 34 Sub-committee 8 - Tea

- 1977 - ISO 3720 Black tea standard 8 testing methods to measure basic tea parameters
- 1980 - ISO
- 1839 Sampling tea
- 1980 - ISO 3103 Preparation of liquor for sensory analysis
- 1982 - Glossary of terms
- 1990 - Instant tea standard 4 supporting test methods I

Quality Control of Green Tea:

In India following are the various regulatory bodies to maintain quality of both the raw and finished products.

- Food Safety and Standards Authority of India (FSSAI)
- Bureau of Indian Standards (BIS)

- AGMARK (Agricultural Marketing)
- Export Inspection Council of India (EICI)
- Tea Board of India's Acts and Regulations (Distribution and Export Control Order, 2005, Tea Marketing Control Order, 2005).
For quality of green tea Good Manufacturing Processes (GMP) and HACCP systems are followed by manufacturer.

Tea Board of India:

The Tea Board of India's is headed by a Chairman and consists of 30 Members appointed by the Government of India representing different sections of the Tea industry. The Board's Head Office is situated in Kolkata and there are two Zonal offices-one each in North Eastern Region at Jorhat in Assam and in Southern Region at Coonoor in Tamil Nadu. 18 regional offices spread over in all the major tea growing states and four metros; 71 subregional offices.

Functions of Tea Board in India:

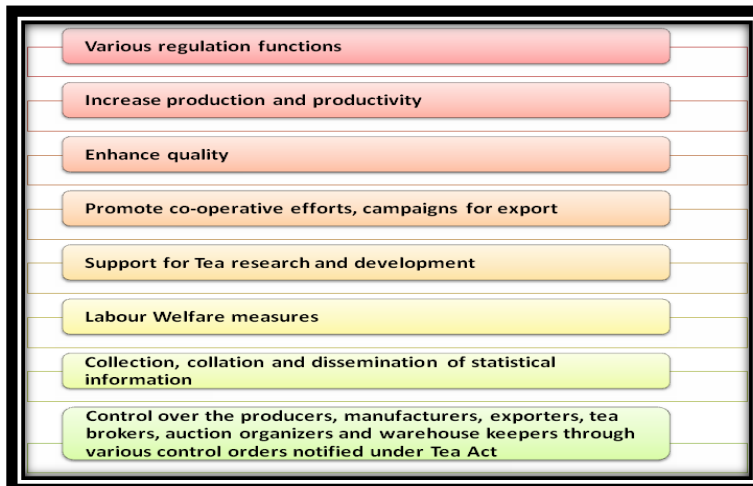


Fig. 10: Functions of Tea Board in India

Administrative parameters of Tea board in India [53].

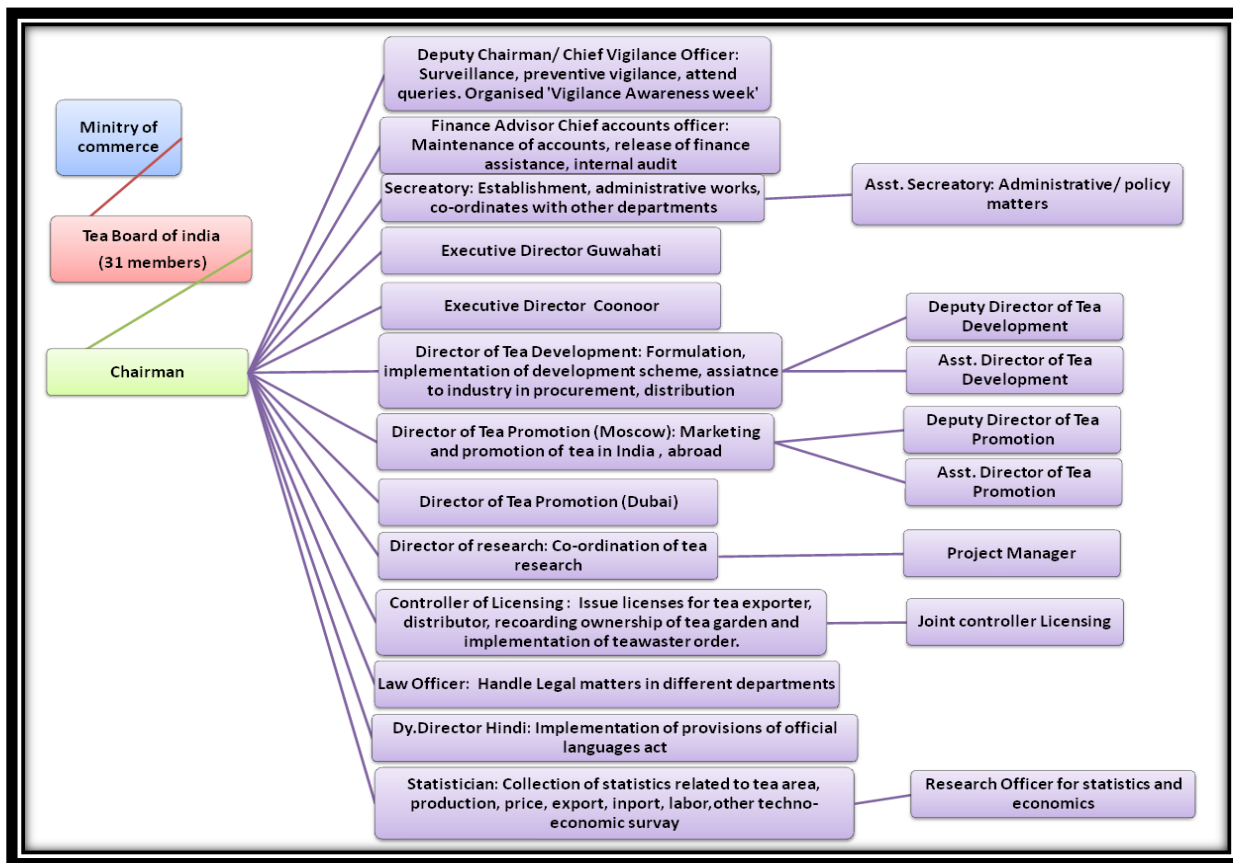


Fig. 11: Administrative parameters of Tea board in India and respective functions

The natural quality of the leaf, including color and aroma, must then be preserved during the manufacturing process by controlling the temperature 34-36° C during rolling, drying, and storage. And also chemical analysis to determine tannin, caffeine, vitamin, and mineral contents [54].

1. Sensory Quality Test: [58]

This procedure involves the appearance (observing the shape and color of the leaves) and the inner quality (aroma, color and taste of the liquid) accordingly ISO 4149 2005-03.

- Appearance: Approximately 150 g of tea are set on trays and placed on a table. The feeling of touch is an important fact to evaluate the well twisting condition.
- Particle Size: The size of tea particles can vary from very small powdery particles to delicately rolled full sized leaves.
- Color: to estimate the time of harvest and the condition of production.
- Smell: fresh and flowery.
- The bud and debris quantities: observed by spreading the leaves.
- Inner quality: For each sample of tea, 2 testing cups are used. A representative sample of 3 g (2.5 - 4 g for refined tea) is put into a testing cup. Hot water is poured into the cups stirring the leaves. After about 1 minute, tasters raise leaves by the strainer from one cup and check the aroma. In the other cup, after 5 minutes (2~3 min for refined tea), the leaves are removed, and then the color of liquid is observed before cooling down.
- Taste: liquid by a spoon and check the taste by spreading it all over the tongue. To estimate the quality of tea accurately, the amounts

of samples, water temperature and time of soaking must be uniform in all tests.

2. Instrumental Evaluation:

The quality is quantified by the amount of irradiation of infra-red rays wave-lengths of tea leaves. This apparatus is able to determine the amounts of total nitrogen, moisture, catechins, vitamin C and fiber of crude tea and fresh tea leaves.

Analytical Methods

- Moisture (water content)
- Total nitrogen (Kjeldahl method)
- Caffeine: Near Infrared Spectroscopy (NIRS)
- Water extract
- Tannin
- Descriptive Analysis with Spider Charts
- Comparative Analysis – Degree of Difference
- Chemical Hazard Analysis
- Pesticide / Herbicide Hazard Analysis
- Microbial Hazard Analysis
- Titratable Acidity
- Caffeine Analysis
- Ochratoxin Testing
- Chlorogenic Acid Testing
- Nutritional Analysis
- Radioactivity analysis

Table No. 5: ISO recommended chemical parameters for green tea and its methods [59,60,61,62]

Parameter	Test Method	Requirement for Green Tea	Technique
Water extract %	ISO 9768	32 %	Extraction/Gravimetry $\text{Aqueous extract (\% (on dry wt.))} = \frac{(W_2 - W_1) \times 250 \times 100 \times 100}{W \times 50 \times (100 - M)}$ W= Weight of sample. W1 = Weight of empty aluminium dish. W2 = Weight of empty aluminium dish + dried extract. M = Moisture %.
Total ash%	ISO 1575	4-8%	Gravimetry, Muffle furnace and ash at a temperature of 550 ±10 °C $\text{Total ash (\% on dry weight)} = \frac{(W_2 - W) \times 100 \times 100}{(W_1 - W) \times (100 - M)}$ W1 = Weight in gms of Silica dish. + sample W2 = Weight in gms of Silica dish + ash W = Weight in gms of empty Silica dish. M = Moisture % of the sample.
Water soluble ash	ISO 1576	45%	Water in-soluble ash on dry wt basis (%) = $\frac{(W_2 - W) \times 100 \times 100}{(W_1 - W) \times (100 - M)}$ W2 = Weight in gms of Silica dish + water insoluble ash. W = weight in gm of empty dish W1 = weight in gm of dish with material M = Percentage of moisture
Alkalinity of total ashT	ISO 1578	1-3%	Alkalinity of soluble ash % per gm of sample (on dry wt.) = $\frac{\text{Titre value} \times \text{Normality of HCl}}{\text{Wt. of sample} (W_1 - W) \times (100 - M)}$ W = weight of empty dish W1 = weight of dish + sample, M = % Moisture of the sample
Acid insoluble ash	ISO 1577	1.0 %	Grinded sample of treatment with boiling sulfuric acid solution +sodium hydroxide solution produce residue which separated by filtration, washed, dried, weighed and then ash. % Fiber = $\frac{(W_2 - W_3)}{W_1} \times 100$ W1 = sample weight (1g) W2 = crucible weight with fiber and ashes, after drying in an oven at 103 °C for 2 h W3 = crucible weight with ashes, after muffle at 550 °C for three hours
Crude fibre %	ISO 5498	16.5 max.	GRAVIMETRY
Total Polyphenol %	ISO 14502-1	11 %	Spectrophotometry
Total Catechins %	ISO 14502-2	7 %	HPLC
Ratio of TC/TP%	ISO (BS) 14502-1: 2005(E)	0.5 %	HPLC

Pesticide Residue Limits			Gas Chromatograph with flame ionization detector (FID) coupled with head space, nitrogen phosphorus detector (NPD) and electron capture detector (ECD) with auto sampler & mass spectrum (MS) detector and High Performance Liquid Chromatograph equipped with diode array detector (DAD), UV detector and fluorescence detector (FLD) are used for the quantification of pesticide residues.
1. Dicofol, mg / kg, Max	IS 14629	5	
2. Ethion, mg / kg, Max	IS 11773	5	
3. Quinolphos, mg / kg, Max	IS 14437	0.01	
Other test			
Total antioxidant activity	-	10.97-11.61%	DPPH assay
Total amino acid content	-	0.45-1.2%	Ninhydrin method
Total fluoride content	-	0.1-0.20 mg/120 ml	Fluoride ion selective method (2.5 g in 150 ml of boil-ing distilling water)
Total aluminum content	-	0.1-0.25 mg/120 ml	Spectrophotometric method
Dry matter and moisture content	ISO 1572 (ISO 7513 FOR INSTA NT TEA)	4.4-11.1%.	Gravimetric
pH of the tea brew			pH meter (2.5 g in 150 ml of boiling distilling water) (Other standard methods DIN 10776-1 2016-07; ASU L 46.02-31987-11 ; DIN 10776-2 2016-07; ASU L 46.03-4 1999-11)
Microbiological parameters			
Total aerobic plate count	Sri Lanka Standard 516		
Yeast and mould count	SLS 516 part 1; 1991		
Total coliform content	SLS 516, part 2; 1991		
Total E. coli content	SLS 516, part 3; 1982		

Tea Manufacturers in India:

- Bombay Burmah
- Mcleod Russel
- Goodricke Group
- Rossell India
- Jay Shree Tea
- Dhunseri Petrochem & Tea Limited
- Assam Company India Limited
- James Warren Tea Ltd.
- Warren Tea Limited
- Harrisons Malayalam Limited
- Lykis
- B & A Limited
- Terai Tea Company Limited
- Kanco Tea & Industries Limited
- Diana Tea Company Limited
- Asian Tea & Exports Ltd.

Over 2016/2017, the number of tea houses in India increased, particularly in second-tier cities. Latent demand (in millions of U.S. dollars), or potential industry earnings (P.I.E.) estimates are given across over 1,600 cities in India. In 2012, the International Institute for Sustainable Development (IISD) reported that 12% of globally produced tea was certified. In 2015, experts estimated this share at roughly 17%, predicting that it would grow even further and in India it up to 18% in 2012 [63]. In India production of tea about 1267 Million Kg and around 9 % share in global market in 2016.

Various Certifications for tea:

- *India Organic*: for organically farmed food products manufactured in India for organic food product conforms to the National Standards for Organic Products established in 2000.

- *Rainforest Alliance*: non-governmental organization (NGO) working to conserve biodiversity and ensure sustainable livelihoods by transforming land-use practices, business practices and consumer behavior.
- *Demeter*: International Demeter Production and Processing Standards, as well as applicable organic regulations in the various countries
- *European Union*: quality and production methods provided for food in European Union
- *USDA Organic*: Certification that allows exporting organic food items to USA.
- *JAS Control union certifications*: quality and production methods provided for foods, beverages and forestry products in Japanese market
- *Control Union Certifications*: accredited by the Dutch Accreditation Council RvA
- *Biologique Canada*: Organic certification required for exporting products to Canada.
- *Naturland*: Organic certification required for exporting products to Germany
- *British Retail Consortium Global Standards*: food safety, quality and operational criteria required to be in place within a food manufacturing organization to fulfill obligations with regard to legal compliance and protection of the consumer.
- *ISO 22000:2005 certificate*: Food Safety Management System & the quality of the food and it is obtained through Royal Cert – Germany
- *UTZ*: for sustainable farming and better opportunities for farmers
- *Kosher*: legislation concerning permitted and forbidden food according to the Jewish law.
- *Ceylon Quality Certificate*: for process quality and product quality in tea manufacturing industry.

- ESR (Equitable, Solidaire, Responsible) standard, applies to organic & fair trade products
- *Fairtrade International*: non-profit organization working towards developing and reviewing fair trade standards, assisting producers in gaining and maintaining fair trade certification and capitalizing on market opportunities.

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