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Review Article

GREEN TEA (ANTIOXIDANT): A NOVEL INFUSION

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ABSTRACT

Green tea is an evergreen plant named *Camellia sinensis*, which is an angiosperm of dicot plant. After water, tea is the most consuming beverages in the world. However it is made up of unfermented leaves with minimal processing with low cost, and is herbal aromatic drink. Green tea is quickly preserved and heated to prevent oxidation which contains high concentration of polyphenols. An antioxidant is a compound capable of inhibiting the oxidation of other compounds. It removes and prevents radical intermediate, detoxifies, has antibacterial, antiviral, antinflammatory and anti-ageing effect and prevents tooth decay. Green tea has special component *i.e.* catechins which may be epigallo catechin gallate (EGCG), epicatechin gallate (ECG), epigallocatechin (EGC) and epicatechin (EC). It is a chemical antioxidant which removes free radical species and chelate transition metals, induction of oxidative stress, induction of apoptosis in tumor cells by leakage of ROS (reactive oxygen species) by mitochondria of the cell. Green tea shows infusion with respect to water, temperature and time, which gives special type of fragrance and flavor. The tea leaves are placed in the hot water and left it to infuse for certain time and after that filtered out. Hereby, different color of tea is produced depending upon the oxidation of the leaves like unoxidized leaves show white color and fully oxidized show black color and semioxidized are green tea. Infusion of tea leaves at different temperatures show different aroma and extract contents. Green tea is an effective super antioxidant and show many health benefits.

Keywords: Polyphenol, Antioxidant, Infusion, Catechin, Oxidation

1. INTRODUCTION

Green tea is an evergreen plant named *Camellia sinensis* (Fig. 1) which is an angiosperm dicot plant. It is next to water as the most consuming beverages in the world. However, it is made from unfermented leaves with minimal processing, low cost, herbal and aromatic drink [1]. It reportedly contains the highest concentration of antioxidants called polyphenols. Antioxidants (Catechins, vitamins, polyphenols) are the substances that fight and reduce free radical intermediate which are detoxicants, antibacterial, antiviral, antiinflammatory, anti-ageing, prevent tooth decay etc. Green tea is most popular drink in Japan and China and it is gaining popularity in India and other countries due to its many health benefits and unique taste. Green tea is among the least oxidized of all teas. It is quickly preserved and heated to prevent oxidation, the same process that the change in color of an apple after you cut it, because it is exposed to oxygen.

2. ANTIOXIDANTS

An antioxidant is a compound capable of inhibiting the oxidation of other compound. Oxidation is a chemical reaction that transfers electrons from the substance to an oxidizing agent. Oxidation reactions can produce free radicals. A molecule with one or more unpaired electron in its outer shell is called a free radical. Free radicals are formed from molecules through breakage of chemical bonds such that each fragment keeps one electron, by cleavage of a radical to give another radical and, also via redox reactions. Antioxidants play a significant role in our health. They are the compounds that protects cell against the damaging effect of reactive oxygen species (ROS). Green tea is scavanger of reactive oxygen species (ROS) by more stable phenolic radicals [2].

The active constituent present in green tea are powerful antioxidants called polyphenols. It is reported that green tea contains nearly 4000 bioactive compounds of which one third is contributed by polyphenols. The basic phenolic compounds in green tea are the Flavonoids which are responsible for antioxidant activities such as neutralization of free radicals that are formed in the process of metabolism. These flavonoids carry a substance called catechin. Moderate doses of tea polyphenol induces finite amount of lower level of ROS

which may also activate nuclear factor erythroid-2-related factors (Nrf2) to activate antioxidants & detoxifying enzymes, while excessive amount cripes probably induce a pro- oxidant effect, resulting in induced toxicity effect [3].

3. FORMATION OF FREE RADICALS

Oxygen is an element indispensable for life. Free radical oxygen species is generated by mitochondria that lead to cell apoptosis. Radicals are less stable than non-radical species, so reactivity of radical is generally stronger. ROS (reactive oxygen species) are present in the surrounding as pollutant and can be generated by-

- By UV light, X-rays and gamma rays,
- During metal catalyzed reactions,
- By neutrophils, eosinophils and macrophages during inflammatory cell activation,
- By oxygen free radicals in the atmosphere considered as pollutants.
- In mitochondria, (ETC reaction) electron transport chain reactions which produce highly reactive oxygen free radicals.
- By the metabolism of arachidonic acid, platelets, macrophages and smooth muscle cells.
- During cooking, forest fires, volcanic activities, Industrial effluents, excess chemicals, alcoholic intake, certain drugs, asbestos, certain pesticides and herbicides, some of metal ions, fungal toxins and xenobiotics.
- By cytochrome P_{450} metabolism and the enzyme xanthine oxidase which catalyzes the reaction of hypoxanthine to xanthine and xanthine to uric acid. [4, 5].

ROS includes radicals such as superoxide (O_2•−), hydroxyl (OH•), hydro-peroxyl (HO_2•), alkoxyl (RO•), peroxyl (ROO•), nitric oxide (NO•), nitrogen dioxide (NO_2•) and Non radicals which are hydrogen peroxide (H_2O_2), hypochlorous acid (HOCl), ozone (O_3), peroxy-nitrate (ONOO−), nitrous acid (HNO_2), dinitrogen trioxide (N_2O_3), lipid peroxide (LOOH)[4].

Free radicals cause damage to different levels in the cell: Attack lipids and proteins in the cell membrane so the cell cannot perform its vital functions (transport of nutrients, waste disposal, cell division, etc.).

3.1. Mechanism of free radical reaction

***Initiation Step*:** Formation of radicals.

***Propagation Step*:** Free radical is regenerated repeatedly as a result of chain reaction, which would take the reaction to completion.

Termination Step: Destruction of radicals. Oxidation is a chemical reaction that transfers electrons from the substance to an oxidizing agent [4].

Oxidation reaction can produce free radicals. In turn, these radicals form chain reactions. Antioxidants remove free radical intermediates, and inhibit other oxidation reactions. An anti-oxidant is capable of slowing or preventing the oxidation of other molecules. The term "anti-oxidant" also refers to any molecule capable of stabilizing or deactivating free radicals before they attack cells. Antioxidants act as free radical scavenger, hydrogen donor, electron donor, peroxide decomposer, etc.

4. INFUSION

Infusion of tea leaves when placed in a teapot, hot water is added to the tea leaves and left to infuse for a certain amount of time. During tea preparation, the type of water used, water temperature, time the tea is left to infuse and the amount of tea leaves used are some of the certain factors determining aroma of the tea [6].

5. RELATION BETWEEN TEMPERATURE AND AROMA

Green tea infusions were prepared at 75°C, 85°C, and 95°C with brewing time of 1, 2, 3, 5, 10, 20, 30, & 45 minutes. Brewing at 85°C for 3 minutes was found to be the optimal condition, where EGCG content was at maximum of 50.69mg/100ml with the highest sensory scores. It was observed that the yield of epigallocatechine increased rapidly for the first 3-5 minutes of brewing time reisolated in decreasing in the yield of epigallocatechines. Sensory scores for the infusion color, taste, aroma and overall acceptability were highest at 3-5 min brewing time at all temperatures. Sensory score was very low for 30 & 45 minutes brewing at 85°C & 95°C due to the bitter taste and dark color. Chemically, catechins are water soluble colorless compounds and impart astringency to tea infusions. However, as infusion time is prolonged, the catechin may undergo chemical changes and the epi-form of the catechins can be converted in to non-epi forms. Green tea has a particle size of approximately 3mm and moisture 4.56gm/100 gm [6-8].

Table 1: Mean chemical composition of green tea leaves in compare with black tea leaves and its infusion for 3 minutes [9, 10]

Compounds	Green tea	Black tea	Infusion
Proteins	15	15	Trace
Amino acid	4	4	3.5
Fibre	26	26	0
Carbohydrates	7	7	4
Lipids	7	7	Trace
Pigments	2	2	Trace
Minerals	5	5	4.5
Phenolics	30	5	4.5
Oxidised phenolic compounds	0	25	4.5

In terms of Infusion, there two types are:-

- Cold tea infusions were prepared by adding 20 ml of water at room temperature (20-25°C) to 0.5 g of tea and leaving the infusions to stand at room temperature for 15, 30, 60, or 120 min, agitating manually every 10 min.
- Hot tea infusions were prepared by placing 0.5 g of tea in 20 ml of mineral water thermostated at 70°C or 90°C in a water bath for 7 min. Both hot and cold infusions were then filtered through Whatman paper filters (43-38 micrometer) [11].

Table 2: Composition (%) of Catechins

Type of Catechin	% Content in Green tea
EGCG	59%
EGC	19%
ECG	13.6%
EC	6.4%

It was proved that higher temperature (100°C) prolonged extraction time for 2 hours leads to degradation of bioactive molecules of tea due to the partial epimerization of EGCG and ECG into Gallo catechin-gallate (GCG) & Catechin gallate (CG).

Wu & Wei indicated that a cup of green tea (2.5gm of green tea leaves/200 ml of water) may contain maximum EGCG (90 mg) (Table-2) [10, 12, 13]; Amino acids, such as threonine or 5-N-ethylglutamine, glutamic acid, tryptophan, glycine, serine, aspartic acid, tyrosine, valine, leucine, threonine, arginine, lysine; Carbohydrates such as cellulose, pectin, glucose, fructose, sucrose; lipids as linoleic and α- linolenic acids; sterols as stigmasterol; Vitamins (B, C, E) xanthic bases such as caffeine as chlorophyll pigment and carotenoids volatile compounds as aldehydes, alcohols, esters, hydrocarbons; Minerals and trace elements such as Ca, Mg, Cr, Mn, Fe, Cu, Zn, Mo, Se, Na, P, Co, Sr, Ni, K, F and Al. Flavonoids are phenol derivatives synthesized in substantial amounts and variety (more than 4000 identified), and widely distributed among plants [14,15].

6. INGREDIENTS

6.1. Catechin

Green tea gives astringent flavour. Higher the content of polyphenols bitter will be the tea. It has both antioxidant and antibacterial properties, and also acts as detoxificant. Green tea canned and bottled not only contain epicatechins which are epigallocatechin gallate (EGCG), epicatechin gallate (ECG), epigallocatechin (EGC), and epicatechin (EC) (Fig. 2), but also contain four GTE epimers, which are gallocatechin gallate (GCG), catechin gallate (CG), gallocatechin (GC), and catechin (C). So, It was examined for antioxidant activity and bioavailability of tea epicatechins with their corresponding precursors. The results showed that CG and ECG had the same antioxidants potency with their difference in antioxidant property in all assays. In addition, EGCG and GCG had the same antioxidant activity in LDL (low density lipid) oxidation and DPPH free radical. Generally, GTE and epimers have small differences and low bioavailability in both activity and bioavailability of antioxidant of total tea polyphenols.

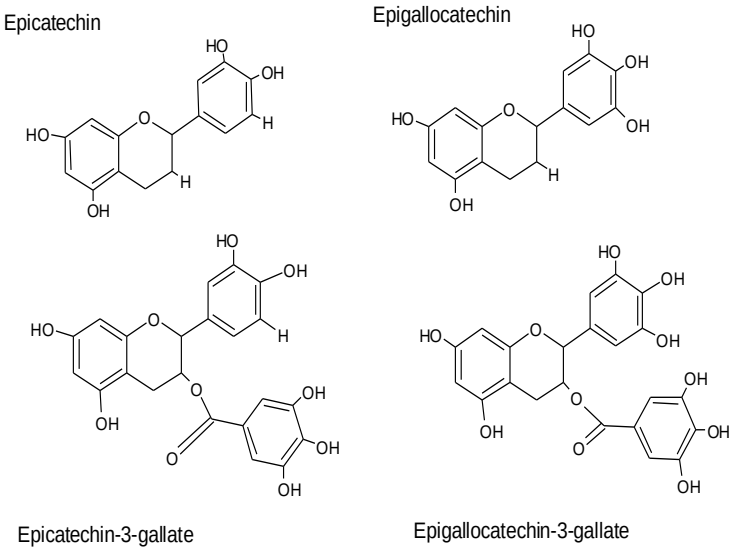

Fig. 1: Chemical structure of catechins (a) Epicatechin (b)Epigallocatechin (c) Epicatechin-3-gallate (d) Epicatechin-3-gallate.

Kim et al. experimented to measure the levels of green tea catechins in plasma and tissue of mice after chronic consumption of green tea polyphenols. Experiment was planned for 28 days; both sexes of mice were given different concentrations (0.2%, 0.4%, and 0.6%) of green tea polyphenols in their drinking water. They reported large bioavailability of epicatechin gallate (EGC) and epicatechin (EC) in the mice's esophagus, large intestine, kidney, bladder, lung, and prostate. However, low concentrations of EGC and EC were found in mice's liver, spleen, heart, and thyroid. Because of the poor absorption, EGCG level were less in some organs but were higher in esophagus and large intestine [16].

6.2. Caffeine

It is a bitter ingredient. While a stimulant, the caffeine in green tea also a stress reliever, it is also used for weight loss and type 2 diabetes treatment. If anyone consumes caffeine and does a moderate amount of physical exercises, before the muscles' internal energy sources (glucose or glycogen) is utilized, there is a process in which fat is used as an energy source, which helps to enhance stamina. Around 11 mg of Caffeine is found in 100mg of leaves of green tea. Caffeine acts as an excellent stimulant. However the caffeine content also depends on how the tea is brewed. Caffeine is mainly a tri-methyl derivative of purine 2,6-diol and is produced from leaves of green tea plant [17]. Green tea contains about 50 to 70 mg of caffeine per 6 to 8 ounce. This is normal and average 100 mg caffeine contained in a cup of coffee. But green tea is generally consumed in greater amounts for weight loss and this increases the consumption of caffeine. And if more than five cups of green tea per day are used, it will raise caffeine in blood, and may increase risk for insomnia, restlessness, tremors, and upset stomach [18, 19].

6.3. Vitamins

Green Tea has a lot of vitamins:

Vitamin A: Content in green tea helps in the safeguarding from eye problems such as night vision.

Vitamin B: Green tea contains Vitamins B1, B2, niacin and pantothenic acid. B vitamins aid carbohydrate metabolism. They also promote secretion of digestive fluids and protect the mucous membranes. Vitamin B2 tone up and keep up healthy skin. Folic acid is a form of water-soluble B vitamin which aids in red blood cells formation. It also helps you stay away from colon cancer, Kidney disease, Alzheimer's disease and several other diseases. Green tea like Matcha and Sencha has five times extra folic acid than the sum found in spinach [18].

Vitamin C: Green tea contains huge amounts of vitamin C, which is heat resistant. Two to three cups of green tea a day fulfill all the requirement of vitamin C. It also prevents the formation of melanin, inhibits oxidation, and increases the body's resistance to disease which helps in the growth and repair of tissues in all parts of your body.

Vitamin E: Green tea contains chemical compounds called tocopherols, which are thought to have anti-aging properties.

Vitamin K: Assists in the blood clot after wound or tissue break.

6.4. Saponin

Saponin is a special ingredient in green tea that has a strong bitterness, anti-inflammatory properties, astringency anti-fungal, antiallergy, lower blood pressure, prevents obesity and influenza. Saponins are found in all teas, and result in the frothing seen in teas like Matcha. Tea leaves contain 0.1% saponins, which give it strong bitterness and astringency. Saponins have anti-fungal, anti-inflammatory, and anti-allergic properties and have been shown to lower blood pressure and prevent obesity and influenza (according to studies by the ITO EN Central Research Center) [20].

6.5. Fluoride

The fluorine found in green tea is around 0.3 to 0.4 milligrams which helps to reduce cavity problems. According to Christine Wu, professor of Periodontics at the University of Illinois, studies in Japan exposed cavity-fighting advantages of green tea.

7. CONCLUSION

After water, tea is the most consuming beverages in the world. It is a low cost, herbal, aromatic drink shows the property of antioxidant which fights and reduces free radical intermediate, antiageing, anti-bacterial, antiviral, detoxicants and also prevent tooth decay. Generally, speaking green tea possessed the high antioxidant capacity and total phenolic content which was also a richer source of polyphenols especially catechin. The ingredients and chemical compounds found in green tea are effective super antioxidant and exhibit many health benefits.

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