

Green Tea: Its Health Benefits and the Key Role of Clonal Genetic Architecture on the Quality of Green Tea

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ABSTRACT

Green tea, a non-alcoholic beverage, is getting popularity in recent years because of the health benefits associated with its two major components: EGCG and theanine. Although, there is a scarcity of literature on clinical evidence on green tea consumption, the research findings on experimental animal system are sufficient enough to confirm its health benefits and that there is no adverse effect even after consuming a high amount of green tea. Several factors determine the quality of green tea, however, biochemical characteristics of the clone, particularly ratio of polyphenol to theanine, plays the crucial role in quality of green tea.

Keywords: Polyphenol; EGCG; Theanine; Genotyping; Nano-fluidic technology

INTRODUCTION

Green tea (*Camellia sinensis* var. *sinensis*) originated in China where it has been used as a beverage and medicine since 2,700 BC. Japan and China are the major green tea producers in the world. Because of the perceived health benefit of green tea, the demand of the green tea is continuously increasing globally. According to FAO, global output of green tea is foreseen to increase at rate of 7.5 percent annually to reach 3.6 million tons in 2027, largely driven by China, where the production of green tea is expected to more than double from 1.5 million tons in 2016-2017 to 3.3 million tons in 2027.

Green tea is processed with fresh leaves; the process starts with roasting or steaming to disable polyphenol oxidase activity to prevent oxidation. The leaves are withered and processed immediately so that no fermentation occurs. Green tea leaves often remain green with a subtle flavor after the process. The green teas produced in China are mainly manufactured by roasting method (eg. Longjing tea), whereas the steaming method is followed to manufacture green tea in Japan (eg. Sencha tea). However exceptions are there: Kamairi-cha is a popular Japanese tea and manufactured by roasting method. In contrast, black, oolong and Pu erh tea are made from fermented leaves, which results in the EGCG being converted into other compounds that impart the typical colors of fermented teas.

HEALTH BENEFITS OF CONSUMING GREEN TEA

The health beneficial effects of green tea are recently reviewed by several literatures [1-3] and green tea is established as a functional food, satisfactorily demonstrated to affect beneficially one or more functions of the human body. A large numbers of research findings establish the health benefit effects of consuming green tea and notable among them are: prevention of various types of cancer and cardiovascular diseases, anti-inflammatory, anti-arthritis, anti-mutagenic, protection from ultraviolet rays, neutralize various bacterial toxin, improvement of bone mineral density, improving cognitive function, anti-depression, prevention dental caries, antibacterial, antiangiogenic, antioxidative, antiviral, neuroprotective, prevention of hyper-tension related diseases, cholesterol-lowering effects and reducing the risk of stroke and coronary heart disease. Green tea polyphenol, with its capacity to scavenge the Reactive Oxygen Species (ROS) can prevent the acceleration of senescence process associated with ageing.

Obesity becomes a serious health issue globally and animal studies established that laboratory mice when fed with diet with 2% green tea could reduce fat accumulation by 60% in comparison to mice fed with diet without tea polyphenol. Green tea suppresses fat accumulation in the body by inhibiting adipocyte proliferation and differentiation, promoting lipolysis

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and improvement of lipid metabolism in liver [4]. Tea catechins, especially EGCG, appear to have antobesity and antidiabetic effects [5].

Recent studies suggested that Green Tea Polyphenol (GTP)s might protect against Parkinson's and Alzheimer's diseases and other neurodegenerative diseases [6]. In Alzheimer disease, beta secretase is abnormally activated in the brain protein metabolism and the amyloid beta protein is accumulated. EGCG in green tea prevents dementia by inhibiting the accumulation of amyloid-beta protein through the activation of alpha -secretase which function normally in cerebral protein metabolism [7].

Regular drinking of green tea may have a positive effect on developing resistance against attack of COVID 19 viruses. In a recent report [8] the role of green tea in preventing replication of coronavirus was investigated. Coronavirus 3 CL-protease is a promising drug target for coronavirus diseases and EGCG, the major component of green tea, inhibits 3 CL-protease. Low pathogenic human coronavirus HCoV-229E, and HCoV-OC43 were used in the investigation and decreased viral RNA and viral protein production was observed in the EGCG enriched media, indicated EGCG interfered with coronavirus replication.

Theanine (L- γ -glutamylethylamid or 5-N-ethyl-glutamine) is a specific amide found abundantly in tea and is an important determinant of quality of green tea along with its health benefit effect. Theanine can reduce the mental stress by reducing release of Glutamate-the principal excitatory neurotransmitter in brain. [9], According to the literatures L-theanine might be neuroprotective and cognitive enhancing agent [10,11] and also reduce psychological and physiological stress [12].

The prominent physiological and pharmacological functions of theanine include-prevent development of cancerous tumor (mainly by enhancing the effect of anticancer drugs), reduces anxiety, attenuates blood pressure, alleviates physical fatigue by raising the concentrations of dopamine (DA) and hepatic glycogen, antidepressant, protect cardiovascular system by lowering the serum cholesterol, decrease alcohol induced liver injury by increasing activities of aldehyde dehydrogenase and alcohol dehydrogenase and can improve immunity in old person when administered orally before vaccination, particularly in persons with low haemoglobin [13]. Experimental rats when administered with theanine dose as high as 4.0 g/kg of body weight expressed no adverse effect, indicating the potentiality of theanine in developing drugs to combat health problems in human [14].

THE ADVERSE EFFECT OF GREEN TEA CONSUMPTION

The adverse effect of green tea component was also reported in many findings [15,16]. In contrast, [17] from their investigation confirmed that drinking even a very high dietary amount of green tea would be unlikely to cause any adverse effects in humans. The results from epidemiological and clinical studies of the relationship between green tea consumption and human health are many times contradictory. This is because the health benefit effects is dependent on the type of green tea, its source

and more importantly, the socio economic and other health aspects of the target population. Human clinical evidence on green tea consumption is still limited. There are clinical trials under way for a standardized green tea polyphenol preparation called Polyphenon E or sinacatechin, which is used as medicine for genital warts and has been approved by United State Food and Drug Administration [2].

COMPOSITION OF GREEN TEA

The composition of green tea varies depending on the clone or variety used, place of origin and on season. On an average the biochemical composition of green tea is presented in Table 1 [1].

Compound	Green Tea (%)
Protein	15
Amino acids (mainly theanine)	4
Fiber	26
Others carbohydrates	7
Lipids	7
Pigments	2
Minerals	5
Phenolic compounds (Mainly EGCG)	30
Oxidized phenolic compounds	0

Table 1: Composition of green tea.

Many of the aforementioned beneficial effects of green tea were attributed to its most abundant catechin, (-)-epigallocatechin-3-gallate (EGCG) which constitutes up to 63% of total catechins [17]. A cup of green tea typically provides 60 to 125 mg catechins, including EGCG and EGCG has been shown to be 25 to 100 times more potent than vitamins C and E in terms of antioxidant activity [18]. Caffeine in green tea is at levels around a third of those in coffee and is also very bitter which adds to green tea's sharpness. Theanine, ranging from 1307.86 to 3029.98 $\mu\text{g/g}$ in green tea leaves, has a sweet and brothy taste which counteracts the astringency and bitterness of the catechins and caffeine. The concentrations and interactions of these different constituents in the tea will determine how intense the tea flavours are [19]. In addition green tea is also a source of macro-element like Na, K, Mg and Ca and trace element like Mn and Cr. Although, the amount cannot fulfil the need even in high consuming countries like China (11.4 g/day), the green tea may be an important source of Mn and dietary chromium [20].

Key determinants of quality of green tea

Various green teas are available to consumers that represent different processing methods, harvest times, clonal

characteristics and growing regions, all of which may contribute to different aroma characteristics in each tea [21]. In addition, clonal characteristics, country of origin, agronomy, withering time, drying technology and climatic condition also play significant role in determining the quality of green tea. The operative steps, significance, operative parameter and advantages of each of the steps for manufacturing roasted green tea are presented in Figure 1.

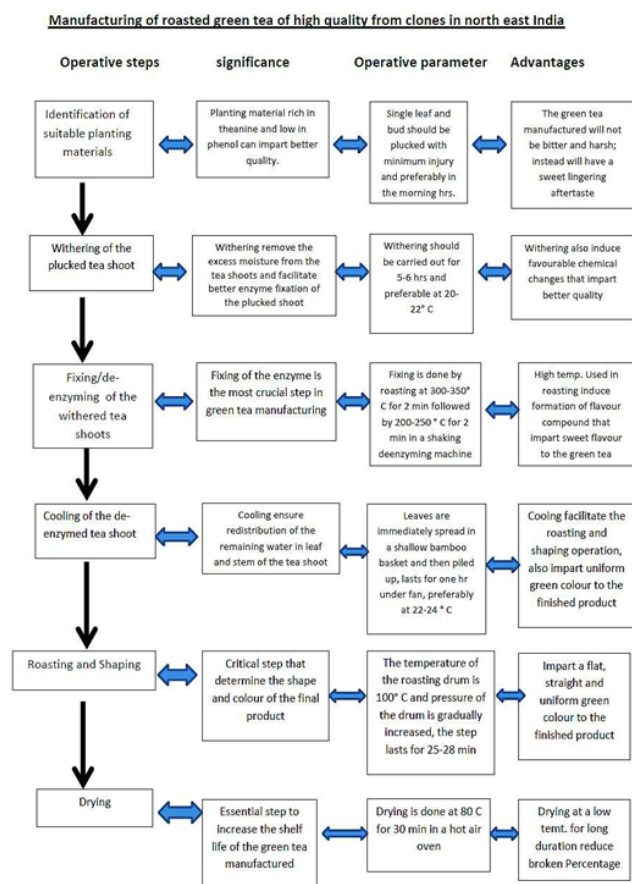


Figure 1: Steps and significance in manufacturing roasted green tea with clones available in NE India.

Clonal characteristics: Green tea is mainly produced from *Camellia sinensis* var. *sinensis*. With small leaves as this variety has low amount of polyphenol 12%-15%. The Assam type (*Camellia sinensis* var. *assamica*) with broad leaves has high content of polyphenol 25%-30% and is suitable for manufacturing black tea and other fermented teas. Green tea made from this type of varieties will tastes excessively bitter because of high polyphenol content. Polyphenol-amino acid ratio is a good indicator of tea taste. The high ratio of polyphenol to amino acid causes a strong and bitter taste. The green tea with low phenol- amino acid ratios has a good taste. Thus, identification of the clones having favorable ratio of polyphenol to amino acids is vital for obtaining green tea with high quality [22]. In this investigation genotyping was performed on a nanofluidic 96.96 Dynamic Array™ IFC (Integrated Fluidic Circuit; Fluidigm Corp. South San Francisco, CA, USA) and the principal component analysis (PCoA) revealed that all the clones suitable for manufacturing green tea were grouped

together, indicating the importance of clonal characteristics in green tea quality.

Country of origin: [23] reported that, although there was no strong relationship between aroma profile and country of origin, green teas from Southeast Asia and the Indian subcontinent generally had nonanal. Green teas from Northeast Asia typically had nonanal and a few other compounds, such as benzene ethanol and jasmine, not found in teas from other regions. Linalool and hexanal were detected from almost all the green tea samples regardless of origin.

Tea agronomy: Amino acids, especially theanine, an important determinant of green tea quality is produced in root and transported to the shoot with the growth of the shoot. As such, sustaining adequate levels of soil nitrogen, especially ammonium, during shoot growth is more important for developing good flavor in tea processed as green tea [24].

Withering of tea leaves: Duration of withering, the first step in processing of green tea, is an important factor determining the aroma of the finished product. [25] from their investigation reported that green tea leaves when withered at 25 °C with R/H 67%-72%, the highest number of volatile compounds were found in leaves withered for four-hours. 4 hrs, instead of prolonged withering, imparted a pleasant aroma to the final product.

Drying technology: During the manufacture of green tea, the drying process is a critical step for physical and chemical changes which affect the final tea quality. [26] studied four different methods viz. hot-air drying (AD), vacuum drying (VD), microwave drying (MD), and microwave vacuum drying (MVD) on the effect of green tea quality. Results indicated that using microwave drying not only retained more nutrients but also produced green teas with less astringent taste with the lowest phenol-amino acid ratio among four different drying methods. The structure of cells was uniform and better maintained by microwave drying with/without vacuum. In contrast, inconsistency of tea quality and low process efficiency are common problems in the traditional drying process [27].

Climatic and growth condition: The metabolic pathway and expression pattern of different genes in biosynthetic pathway are strongly influenced by the stage of growth [28] and growing seasons [29] and thus influenced the quality of the tea manufactured. [30] used a solid-phase micro-extraction (SPME) method and found that volatile compounds were lower in teas grown in lower temperatures than ones picked from the same fields a year later when temperatures were warmer.

CONCLUSION

There are certain health beneficial effects of consumption of green tea. Although, sufficient clinical evidence on green tea consumption is still limited, a significant volume of scientific literature confirms the beneficial effects of two key components of green tea: EGCG and theanine. The quality of green tea is dependent on many factors of which clonal characteristic is the key factor and tea variety with perfect balance of polyphenol and theanine is required to process green tea of high quality.

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