

## Comparative analysis on physical and chemical characteristics of commercially manufactured/processed green tea in Sri Lanka

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### Abstract

Drinking green tea (GT) is presently becoming popular among consumers due to potential health benefits. Sri Lanka is well-known for its high-quality black tea, local manufacturers have now been entered to the GT market. Thus, it is important to develop and maintain the standards for GT products. The present study was conducted to study the quality of commercially available GT products manufactured in Sri Lanka. Thirteen local GT samples collected from supermarkets in Colombo, Sri Lanka were analyzed for physical and chemical parameters. Colour of the GT samples was brownish and greenish, whereas the infusion color was coppery and golden yellow. Moisture content varied from 4.4% to 8.9%. Water extract of samples varied from 37.6% to 49.7%. Total ash content ranged from 5.5% to 6.5%. Water soluble ash content varied in a wide range. The alkalinity of water-soluble ash% varied from 0.6% to 0.9%. Percentage of acid insoluble ash ranged from 0.1% to 0.5%. Highest crude fibre content was 19.2% (range 12.1% to 19.2%). Total polyphenol content ranged from 16.6% to 20.4% whereas amino acid content varied greatly, and the highest value was 1.0%. The highest value of antioxidant activity observed was 11.0%. Aluminum in the GT samples were not in a risky level. Total ash, water extract, total polyphenol, and acid insoluble ash complied with the ISO standards while the alkalinity of water-soluble ash and water soluble ash were little below than the recommended value. Crude fiber content of some samples exceeded the maximum recommended value.

**Keywords:** green tea, chemical, physical, quality, Sri Lanka

### 1. Introduction

Tea (*Camellia sinensis* L.) is the most consumed non-alcoholic beverage in the world next to water. It exceeds the amount of consumption of coffee, beer, wine, and soft drinks [1, 7]. Sri Lanka, for years, is renowned for the best quality black tea (BT) production and the tea with the symbol "Ceylon Tea" has greater demand and hence a higher price compared to other BT available in the market. But green tea (GT) industry in Sri Lanka is comparatively in a younger stage than the black tea industry. In the recent past, GT industry has been developing gradually in Sri Lanka due to higher demand made by the increasing awareness of the people on beneficial health effects of GT drinking. By 2016, GT is produced by eleven manufacturers on several local estates in the mid-grown and high-grown districts and Ceylon GT looks set to continue growing in success and popularity [8]. According to the ISO standards on GT (Table 1.0), GT should possess quality parameters in acceptable levels from the recommended ISO test methods.

Presently, the high demand for the GT allows noticeable entrance of local GT manufacturers with a range of GT products with different brands especially into the supermarkets. Even the manufacturers apply the same concepts (pan firing or steaming) for the manufacturing process, due to many other reasons; GT products from different countries have different quality characteristics. Even within the same country, GT products from different manufacturers exhibit variations with respect to quality characteristics. These variations of the quality may be due to tea varieties (*i.e.* China, Assam and Cambod), cultivars (genetic make-up), elevation, soil type, environmental effects such as temperature, sunlight, RH, wind and rain fall, harvesting seasons and plucking standards, climate, age, pruning cycles and cultural/ agronomic practices *etc.* and due to processing methods [9]. In addition, fault handling and storage, improper use of pesticides, adulteration and contaminations also play a major role with respect to tea quality and standards. As an emerging beverage with a set of standards, it is necessary to develop and maintain the GT products at least to meet the minimum standards. Consequently, it has emerged the necessity of maintaining unique standard quality parameters for GT in each country [15]. However, ISO standards have been established for both green and black tea to ensure the acceptable quality of the products. Hence, the determination of the physical and chemical quality parameters of GT products is a timely need to identify their acceptable quality as per standards which would be beneficial to both manufacturers and consumers. Hence the purpose of the present study was to determination

**Table 1:** ISO standard parameters for GT

Parameter	Test Method
Water Extract%	ISO 9768
Total ash%	ISO 1575
Water soluble ash%	ISO 1576
Alkalinity of water soluble ash%	ISO 1578
Acid insoluble ash%	ISO 1577
Crude fiber%	ISO 5498
Total Polyphenol%	ISO 14502-1
Total Catechins%	ISO 14502-2

of physical and biochemical parameters of commercially available different GT products and to estimate its compliance with set ISO standards on GT. And, to determine some additional parameters, specifically aluminum content, antioxidant activity, amino acid content and pH which are also in concerns at present day context.

**2. Materials and Methodology**

**2.1 Collection of Samples**

Thirteen (13) locally produced GT samples having approximately similar manufacturing dates were purchased from the Sri Lankan markets. After collection until analyses, GT samples which are stored/ packed in different packages were re-packed in non-moisture absorbing aluminum foil the packets.

**2.2 Estimation of physical quality parameters**

Samples were analyzed for physical quality characters including nature of the particles, color of the sample and color of the infusion visually.

**2.3 Estimation of ISO recommended chemical and other quality parameters**

A fraction of the samples of each GT products were taken for chemical analyses using ISO methods and other standard methods apply for tea (Table 1.0 & 2.0).

**Table 2:** Other Chemical Parameters for GT

Parameter	Method
Dry Matter content and Moisture content	ISO 1573
Total Amino Acid Content	Ninhydrin Method
Total Antioxidant Activity	DPPH Method
Total Aluminum Content	Spectroscopic method
Ph of the Brew	pH meter (2.5 g in 150 ml of boiling distilling water)

**3. Results & Discussion**

**3.1 Physical quality parameters**

Color of the GT samples varied from light green to blackish green and light brown to dark brown. color (Figure 1, 2, 3 & 4).



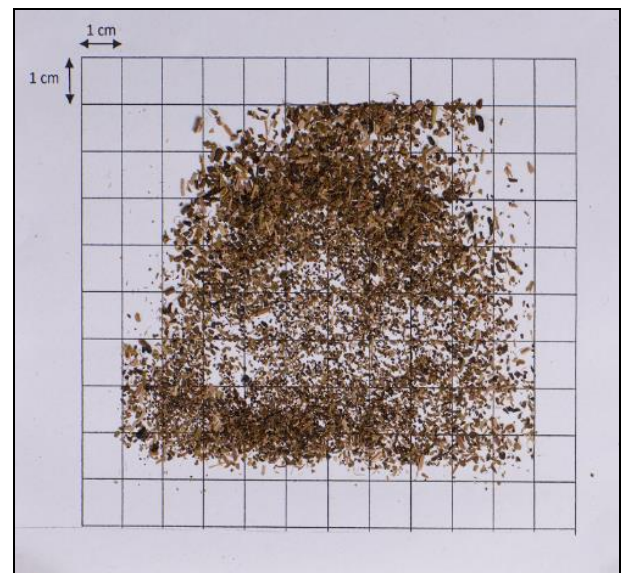
**Fig 1:** Light green colored GT sample



**Fig 2:** Dark green colored GT sample



**Fig 3:** Light brown colored GT sample



**Fig 4:** Dark brown colored GT sample

Infusion color of the GT samples varied from coppery color to golden yellow color (Figure 5).

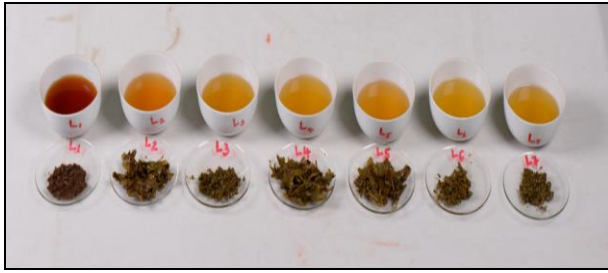


Fig 5: Infusion color of the GT samples

In general, rule of thumb is that GT should have pale green to golden color infusion, if not it resembles the development of more dark color due to the formation of theaflavin and thearubigin, which are responsible for the coppery color development in black tea. Expected color of the GT infusion may not be coming due to cultivar inherent characteristics, sub-optimum manufacturing process or improper storage conditions.

The GT particle size varied from very fine dusty particles to coarse and leafy particles. Since GTs are not graded during

the manufacturing process, there is no such standard particle size for GT (Figure 6 & 7)

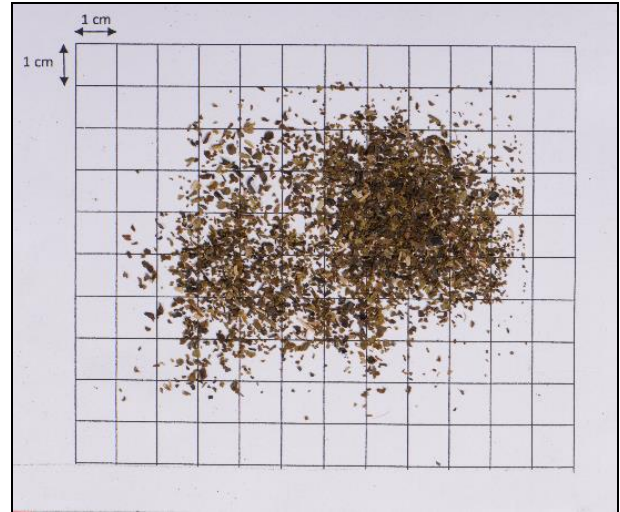


Fig 6: Fine dusty GT particles



Fig 7: Coarse and leafy GT particles

### 3.2 ISO recommended chemical quality parameters for GT

The ISO recommended chemical parameters were determined in all the GT samples (Table 2).

Table 2: ISO standard parameter results for GT

Parameter	Observed Value	ISO requirement
Water Extract%	37.6 - 49.7	>32
Total Ash%	5.5 - 6.5	4% to 8%
Water Soluble Ash%	5.8 - 67.2	>45%
Alkalinity of Water Soluble Ash%	0.6 - 0.9	1% to 3%
Acid Insoluble Ash%	0.1 - 0.5	<1.0%
Crude Fiber%	12.1 - 19.2	<16.5%
Total Polyphenol%	18.0 - 20.4	>11%

According to the results water extract; the soluble matter extracted from the tea samples determines the quality of the tea. These soluble matters include phenolic compounds, alkaloids, amino acids, and many minor soluble substances. The amount of water extract of tea depends on tea and water ratio, temperature of the tea brew, type, and size of made tea particles<sup>16</sup>. Almost all the samples have exceeded the

minimum requirement of ISO standards (32%) and the more extractive substances proves the high quality.

GT is characterized by its high flavonoid content, mainly catechins which are flavan-3-ols and contribute with the bitter taste and astringency of the GT brew. The flavan-3-ols are characterized by epicatechin and its galloylated derivatives, especially in GT, whereas black tea has lower amount of these derivatives due to their oxidative conversion into theaflavins and thearubigins<sup>[3]</sup>. Accordingly, all the analyzed samples contained high polyphenolic content, satisfying the ISO requirement of 11% or more.

Ash content in tea correlates with mineral and the moisture content of the sample. Mineral content measures the, physiological ash, which is derived from the plant tissue itself and non-physiological ash which is the residue of the extraneous matter (e.g. sand and soil) adhering to the plant surface. The higher ash content in tea might be due to less moisture content in tea. The composition of the ash of tea varies somewhat with the age of the leaf because the water-soluble potash and phosphoric acid diminishes as the leaves become mature<sup>13</sup>. Hence, low water-soluble ash content usually indicates an inferior tea which may have been

produced using mature leaves. Total ash% in all GT samples are laid within the ISO standard level of 4-8%. Even though water soluble ash% in GT minimally should be 45% only two samples have exceeded that minimum value while all the other samples are below the recommended ISO value. More than three – fourths of the total potash are lost by infusion, so that the alkalinity of the water-soluble ash is a valuable guide in determining whether a sample of tea has been mixed with previously infused leaves, but as the percentage of potash diminishes as the leaf matures, the conclusion is somewhat fallacious. Alkaline carbonates may occasionally be added to tea, as they have property of increasing the amount of coloring matter extracted on infusion, even after the leaves are separated. None of the sample has reached at least to the minimum recommended ISO value.

Acid insoluble ash content in GT can be used to determine the amount of silica matter present in tea. All the samples complied with the ISO requirements.

As the tea plant matures, it increases in the content of lignin and cellulose, which is consistent with their role in providing structural integrity to growing plant. High crude fiber content was observed in some samples, may be because more mature leaves have been used in the manufacturing process. High fiber content in tea samples may be due to impurities like stems during processing as the roll breaking and stalks removal step is absent during the GT manufacturing process. In addition to this, crushing, tearing, and curling process also destroy the leaf structure that might have effect on fiber content <sup>[6]</sup>. One sample out of 13 exceeded the maximum level of crude fiber content.

### 3.3 Other quality parameters for GT

Other quality parameters were determined in all the GT samples (Table 3.3).

**Table 3:** Other quality parameter results for GT

Parameter	Resulted value
Moisture%	4.4 - 8.9
Amino Acid%	0.3 - 1.0
Antioxidant Activity%	6.6 - 11.0
Aluminium Content%	0.3 - 0.6
pH	5.6 - 5.4

Moisture content of the GT samples were varied from 4.4% to 8.9%. As the high moisture content may negatively influence on the shelf-life, the product moisture percentage should be controlled between 2.5-6.5% for a better-quality product<sup>2</sup>. The high moisture content observed in some GT samples may be due to prolong sifting and grading operations which facilitate the absorption of moisture as well as due to the differences in packing materials and packaging conditions.

At high moisture levels the deterioration of the desirable tea characteristics is faster and is found to lose briskness with time and ends up as flat tea. High moisture content in tea may be an enhancing factor for the growth of microorganisms, especially molds. The moisture content of tea could be kept within the desired limits by proper drying of tea, preventing excessive moisture absorption during packaging and packing tea in proper containers such as plywood tea chests lined with aluminum foil or multiwall paper sacks. Except for 5 samples all the other samples have

moisture content which is higher than the 6.5%.

The main substance responsible for relaxation properties of tea is amino acids, specially Theanine. This is unique amino acid present in tea plant. Amino Acid content in GT samples were varies widely.

Antioxidant activity in GT is an important characteristic which can prevent free radicals, primarily highly reactive oxygen and nitrogen species, from damaging human health. Major antioxidant in tea are Catechins, among them Epigallocatechin-3-gallate is the most power full antioxidant. GT samples showed approximately similar antioxidant activity.

Aluminum is not considered as an essential element for human being. Aluminum content in the GT samples are varied approximately in a small range. According to the WHO recommendation recommended daily intake of Aluminum for children is 2 to 6 mg/day and for teenagers and adults is 6 to 14 mg/day. In the case of Aluminum, even four cups are consumed for adults, it will not exceed the maximum daily intake. As stated by Ananthacumaraswamy and Sivapalan<sup>1</sup>, tea is known as an Aluminum accumulator and it takes up Aluminum throughout its period of growth and stores in the leaf. The Aluminum content in the tea flushes increases progressively from bud to mature leaves<sup>5</sup>.

The pH value (acidity) of a food or drink can be considered as an accurate indicator for the erosive potential of that food or drink. Oxalate and citrate which is associated with the citric acid are mainly responsible for the acidity of the tea infusions. All the samples have very mild acidic condition which indicates the low erosive potential.

### 4. Conclusion

Green Tea (GT) products available in the local supermarket chain consist of a diverse quality. The size of the particles varied from dusty to leafy particles and the color varied from greenish to brown while the brew color varied from golden yellow to dark brown-black color.

With regards to ISO recommended chemical parameters, water extract, total ash, and total polyphenol content and acid insoluble ash of all samples agreed with the ISO Standards while only alkalinity of water soluble ash did not agree with the ISO Standard levels. Some samples of the other parameters such as crude fiber and water-soluble ash agree with the ISO Standards while some does not.

Aluminum content is not in a critical condition for consumption, even at the consumption of four cups per day. Amino acid content in green t varies widely while antioxidant levels vary in approximately similar range. Almost all the GT samples in this study have very mild acidic condition.

Quality of tea is a relative parameter which depends on various factors including cultivar, plucking standards, climatic factors, manufacturing practices, processing conditions, and it could be identified as an interconnection of all the physical, chemical and microbiological characteristics. Hence, the manufacturers should concern about these parameters and should produce GT to meet at least the ISO requirements and SLS standards to ensure quality.

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