

# A comparative Study on microbial and Sensory Quality of Sri Lankan Green Tea Produced by Different Manufacturing Methods

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## INTRODUCTION

Sri Lanka has become a global leader in tea exports thanks to technological developments and significant trade associations (Achintiya & Ranatunga, n.d.).

However, market trends are shifting from bulk black teas toward value-added tea products such as green tea, organic tea, and tea bags, reducing demand for bulk tea exports (Pilapitiya et al., 2020; Pilapitiya & Silva, 2021). While orthodox black tea remains the primary export, the local tea industry is increasingly focused on the lucrative green tea market.

Despite its global potential, Ceylon green tea accounts for only 1% of Sri Lanka's total tea production, with many teas failing to fulfil microbiological standards. This reduces its competitiveness in key markets such as Asia-Pacific and North America, where green tea demand is increasing (Kumarihami and Song, 2018). The main issue is a drop in microbiological quality, which raises concerns about present manufacturing methods.

Additionally, the manufacturing methods has an impact on the sensory properties of tea, which influence its market value. While black tea has been extensively studied, there is limited study on how different manufacturing methods affect the microbiological and sensory quality of Sri Lankan green teas. Addressing these gaps is crucial to ensure that Ceylon green tea meets international standards and customer expectations.

The major goal of this research is to study the quality of Sri Lankan green tea produced using various manufacturing processes by analyzing microbiological parameters and conducting sensory evaluations. The research intends to establish the microbial diversity of green tea based on the manufacturing method, assess sensory quality, and decide whether the green tea meets the Sri Lanka Tea Board's microbiological requirements.

## MATERIALS AND METHODS

### Sample Collection

Samples were collected from all operating green tea factories (n=15) in Sri Lanka, representing three basic processing methods: steaming, panning, and handcrafted. Two sets of samples (three for microbial testing, three for moisture testing) were taken from each factory, covering the steaming, panning, and handcrafted methods. Each set represented three consecutive batches. Microbiological testing involved three replicates and two duplicates per sample using strict contamination avoidance techniques, categorized by factory elevation, and taken to the Sri Lanka Tea Board's Microbiological Laboratory for optimal preservation. Two sets of samples were collected from each factory: three for microbiological testing and three for moisture testing, which were produced in three successive batches within one month (31.05.2024 to 28.06.2024) to ensure variability. To prevent contamination, the tea was collected in sterilized bags, promptly heat-sealed, and handled with 70% ethanol, allowing for reliable assessment of both microbiological and moisture parameters.

### Moisture Content Analysis

The moisture content of green tea samples was determined using the oven-drying method. Samples for moisture testing were collected alongside microbiological samples, and the analysis involved drying the tea at 105 °C for 6 hours.

### Microbiological Analysis

The Sri Lanka Tea Board's microbiological lab performed microbiological testing in accordance with ISO 11287:2011 standards. Each sample had three replicates and two duplicates, for a total of six tests. The following microbiological parameters were analyzed:

Parameter	Requirement	Test Method Ref.
Total Plate Count	Max. 10,000 cfu/g	ISO 4833-1: 2013
Yeast & Mold Count	Max. 1,000 cfu/g	ISO 21527-2: 2008*
Total Coliform Count	Max. 10 MPN/g	ISO 4831: 2006
E-Coli	Absent / g	ISO 7251: 2005

\*Teas under damp/wet conditions (Water activity,  $A_w > 95\%$ ) are required to use ISO 21527-1: 2008 to evaluate yeast & mold counts.

## Sensory Evaluation

A trained panel of seven expert tea tasters from the Sri Lanka Tea Board using a seven-point hedonic scale conducted sensory evaluation for the green tea samples collected from 15 factories. The 7 expert panelists assessed key sensory attributes of the green tea samples; dry leaf appearance, liquor quality, and infused leaf appearance.

## Statistical Analysis

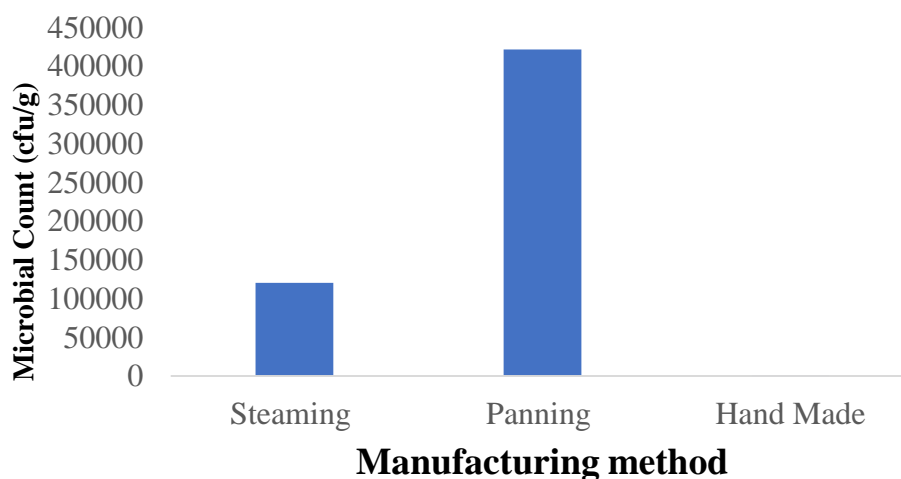
Data was analyzed using SPSS software, with descriptive statistics used to summaries microbiological and sensory quality across three manufacturing processes. Green tea manufacturing processes for the microbial counts and sensory qualities were analyzed using one-way ANOVA, with post-hoc Tukey testing identifying significant differences. Further, the compliance with Sri Lanka Tea Board microbiological standards (circular no:AL/MQS-02/2021) was conducted and samples exceeding the permissible limits were classified as non-compliant.

## RESULTS AND DISCUSSION

### Microbial Quality

The microbiological quality of Sri Lankan green tea samples varied significantly among the three manufacturing methods: steaming, panning, and handcrafted. Handcrafted tea had the lowest microbial contamination, whereas panning had the highest contamination levels across all microbial parameters.

**Yeast and Mold Count:** The yeast and mold contamination was highest in panned green teas, with an average count of  $4.21 \times 10^5$  cfu/g, while handcrafted tea had the lowest, at just  $6.19 \times 10^2$



cfu/g. This highlights the superior microbiological safety of the careful handling practices used in handmade processing

**Total Plate Count (TPC):** TPC showed the highest levels in panning, reaching  $8.15 \times 10^5$  cfu/g. Handcrafted tea, however, had the lowest count, further suggesting better microbial control regarding hygiene and processing conditions.

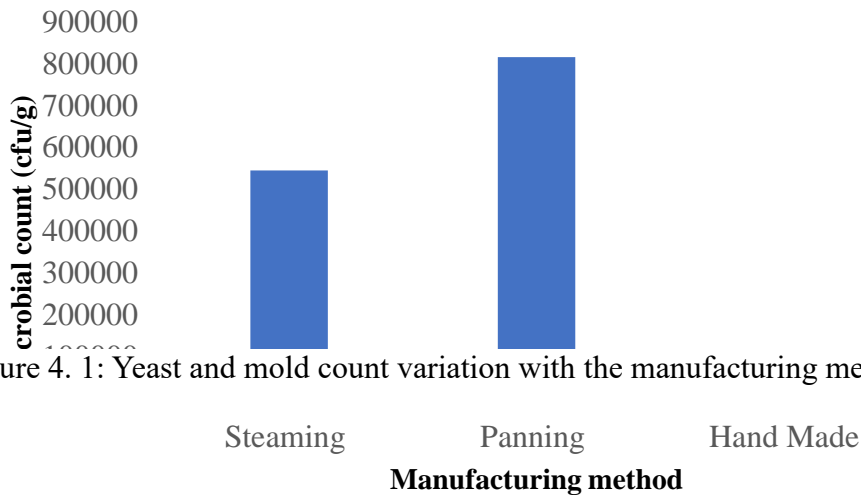


Figure 4. 1: Yeast and mold count variation with the manufacturing methods

Figure 4. 2: Total Plate count variation with the manufacturing methods

**Total Coliform Count:** Steamed green teas recorded the highest coliform levels of  $5.45 \times 10^5$  MPN/g, indicating potential water-borne contamination during processing, while handcrafted tea showed minimal coliform presence showing less contamination with comparative sanitary practices.

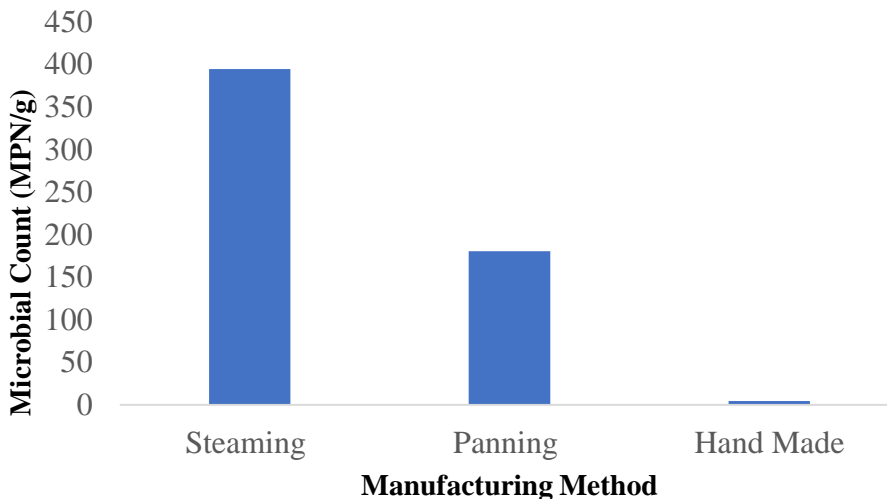


Figure 4. 3: Total Coliform count with the manufacturing methods

## Sensory Quality

Handcrafted tea received the highest sensory test scores for dry leaf appearance, liquor quality, and infused leaf appearance. The handcrafted method regularly outperformed steaming and panning, with the latter producing the lowest results.

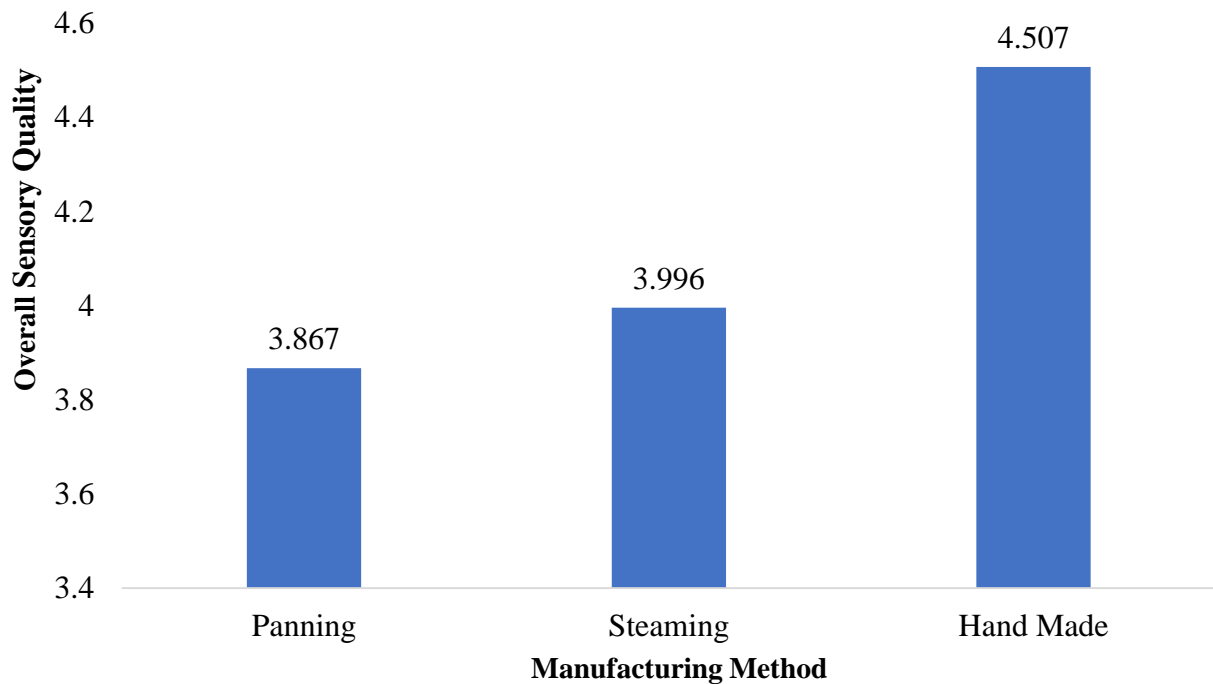


Figure 4. 4: Overall sensory quality based on the processing method

According to the figure 4.4, the overall sensory quality of the handmade method shows higher compared to the steamed and panned green teas. This suggests that the handmade method significantly ( $p$  value=0.002) enhances sensory attributes compared to the other methods, making it the superior choice for improving product quality. However, the steaming method offers moderate improvements over panning, indicating it may balance quality with other considerations like cost or efficiency.

## Compliance with Standards

83% of the whole green tea samples analyzed were not met the microbiological standards of the Sri Lanka Tea Board mentioned in SLTB circular no:AL/MQS-02/2021. Further, following figure 4.4 shows the percentage of yeast and mold, total plate count and total coliform bacteria with their compliance over the Sri Lanka Tea Board microbiological standard. Yeast and mold showed the most non-compliance, with 74.1% of samples exceeding the allowable limits.

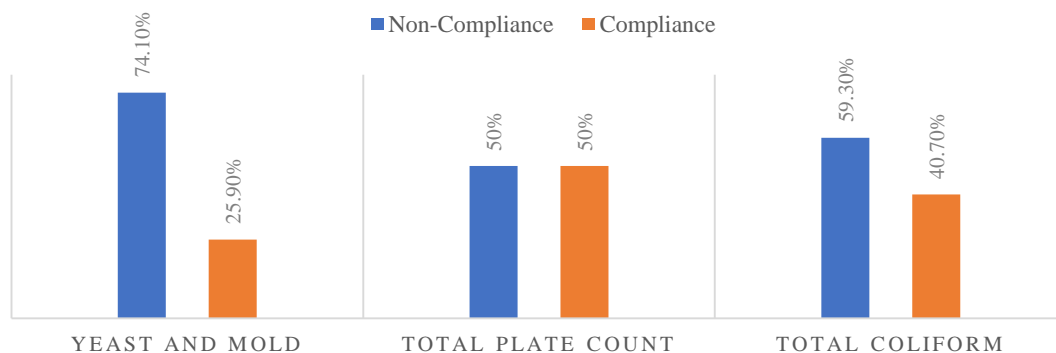


Figure 4. 4: Microbiological Compliance of Green Tea Samples with Sri Lanka Tea Board Standards

However, samples complied with the Tea & Herbal Infusions Europe (THIE) recommended microbiological limits for *Camellia sinensis* with minor deviations observed for yeast and mold

## CONCLUSION

The study reveals notable differences in green tea manufacturing methods in terms of microbiological and sensory properties. The panning and steaming techniques produced higher microbial counts, especially for yeast and mold, TPC and coliforms. In contrast, lower levels of microbial contamination were observed in teas produced under improved sanitary handling. Sensory evaluation further indicated variations in quality, with some methods yielding better appearance, flavor, and infusion characteristics, while panned teas generally exhibited comparatively lower sensory performance. Although all green tea samples were free from *Escherichia coli*, a substantial proportion failed to comply with the stricter microbiological safety limits of Sri Lanka Tea Board Circular ALMQS-02/2021; however, samples complied with the Tea & Herbal Infusions Europe (THIE) recommended microbiological limits for *Camellia sinensis* with minor deviations observed for yeast and mold. These findings highlight the necessity of improving hygiene protocols, particularly during panning and steaming processes, to ensure compliance with microbial safety standards. Further, the moisture analysis

exhibited a weak correlation between moisture content and microbial load, suggesting that other factors like manufacturing environment and handling practices, play a crucial role in microbial proliferation. In conclusion, maintaining rigorous sanitary practices during manufacturing plays a critical role in preserving both microbial quality and sensory attributes of green tea. To enhance the quality of Sri Lankan green tea, adopting stricter sanitation and quality control measures particularly in automated manufacturing processes are essential. These revelations serve as a basis for optimizing manufacturing practices to produce high-quality, internationally competitive Sri Lankan green tea.

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