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Comparative analysis of polyphenolic profile of different varieties of green tea

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Abstract

In northern Nigeria, green tea consumption has tripled over the past decade driven less by tradition than by a growing awareness of its purported health benefits. But not all green teas are the same: terroir, cultivar, and processing method shape the polyphenolic fingerprint that underlies antioxidant and anti-inflammatory activity. This research compared the polyphenolic profiles of four commercial green tea varieties Chinese Longjing, Japanese Sencha, Indian Darjeeling green, and Kenyan GFOP using HPLC-DAD analysis. Total catechin content ranged from 98.3 mg/g (Kenyan) to 157.2 mg/g (Japanese Sencha), with epigallocatechin gallate (EGCG) accounting for 41-58% of total catechins across varieties. DPPH radical-scavenging IC_{50} values correlated inversely with EGCG content ($r = -0.97$). Gallic acid, caffeic acid, and chlorogenic acid were quantified as minor polyphenolics. The data provide a reference framework for quality grading of green teas entering the West African market.

Keywords: Green tea, polyphenol, catechin, EGCG, HPLC, antioxidant, *Camellia sinensis*, gallic acid, DPPH, quality assessment

Introduction

Walk into a health-food shop anywhere in Abuja and you will find green tea marketed under a dozen brand names some imported from China, others from Japan, India, or Kenya each claiming superior health benefits without specifying the chemical basis for the claim. In West Africa, where regulatory standards for imported teas are still developing, consumers rely on price and packaging rather than analytical data to judge quality ^[1]. A polyphenolic profile offers an objective, reproducible measure of what is actually in the cup.

Green tea (*Camellia sinensis*) owes most of its biological activity to catechins, a family of flavanol compounds that includes EGCG, epicatechin gallate (ECG), epigallocatechin (EGC), and epicatechin (EC) ^[2]. EGCG alone accounts for 30-60% of total catechins and has been linked to anti-cancer, cardioprotective, and neuroprotective effects in cell and animal models ^[3]. Processing matters: green tea is steamed or pan-fired immediately after harvest to inactivate polyphenol oxidase, preserving catechins that would otherwise oxidize into theaflavins and thearubigins during black-tea manufacture ^[4].

Terroir the combination of altitude, soil, humidity, and sunlight further modulates catechin levels. Japanese Sencha is typically shade-grown for two to three weeks before harvest, boosting theanine and chlorophyll but reducing EGCG compared with fully sun-exposed Chinese Longjing ^[5]. Kenyan teas, grown at equatorial altitudes above 1,800 m, tend to accumulate catechins rapidly under intense UV radiation ^[6]. Direct HPLC comparison of these four origins on the same analytical platform has rarely been reported. This research quantified individual catechins and phenolic acids in four green tea varieties, measured DPPH and ABTS antioxidant activity, and examined correlations between individual polyphenols and radical-scavenging capacity.

Safety Considerations

HPLC-grade methanol and acetonitrile were handled in a fume hood. DPPH is a mild irritant; gloves and goggles were worn during assay preparation. All solvent waste was collected and disposed of by the university chemical waste service. No human or animal subjects were involved ^[7].

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Material and Methods

Material

All analytical work was performed at the Department of Chemistry of Natural Resources, Sahel National University, Abuja, from January to September 2023. Four loose-leaf green teas were purchased from certified importers in Abuja: Chinese Longjing (Zhejiang origin, 2022 spring flush), Japanese Sencha (Shizuoka, first flush), Indian Darjeeling green (FTGFOP grade, spring 2022), and Kenyan GFOP (Kericho highlands, 2022). Samples were stored at -20°C until analysis. HPLC-grade methanol, acetonitrile, and phosphoric acid came from Merck. Catechin standards (EGCG, ECG, EGC, EC, $\geq 95\%$) and phenolic acid standards (gallic, caffeic, chlorogenic acids) were sourced from Sigma-Aldrich [8].

Methods

Tea (1.0 g) was extracted with 100 mL of 70% methanol at 70°C for 30 min in a water bath, filtered ($0.45\ \mu\text{m}$ PVDF), and diluted 1:10 with mobile phase A. HPLC analysis used

a Shimadzu LC-2040C 3D with a C_{18} column ($250 \times 4.6\ \text{mm}$, $5\ \mu\text{m}$) at 35°C , DAD detection at 280 nm (catechins) and 320 nm (phenolic acids). Gradient elution with 0.1% H_3PO_4 in water (A) and acetonitrile (B) ran from 10% to 45% B over 40 min at $1.0\ \text{mL/min}$ [9]. Peaks were identified by retention time and UV spectra against standards; quantification used external calibration ($R^2 > 0.999$ for all analytes). DPPH and ABTS assays followed established methods at six concentrations ($10\text{--}200\ \mu\text{g/mL}$) with ascorbic acid as reference [10]. All analyses were run in triplicate.

Statistical Analysis

One-way ANOVA with Tukey HSD ($p < 0.05$) compared polyphenol content and IC_{50} across teas. Pearson correlations linked individual catechin concentrations to IC_{50} . Principal component analysis (PCA) was applied to the polyphenol data matrix to visualize variety clustering. All statistics used JASP 0.17 [11].

Results

Table 1: Catechin and phenolic acid content (mg/g dry leaf) and antioxidant IC_{50} for four green tea varieties

Variety	EGCG	ECG	EGC	EC	Total Cat.	IC_{50}
Longjing	72.1 ± 3.4	21.3 ± 1.2	28.7 ± 1.8	14.6 ± 0.9	136.7	16.4 ± 1.1
Sencha	64.8 ± 2.9	26.7 ± 1.5	42.3 ± 2.4	23.4 ± 1.3	157.2	13.8 ± 0.9
Darjeeling	51.2 ± 2.6	18.4 ± 1.1	31.6 ± 1.9	17.1 ± 1.0	118.3	21.7 ± 1.4
Kenyan	44.6 ± 2.1	15.8 ± 0.9	24.1 ± 1.5	13.8 ± 0.8	98.3	28.3 ± 1.7

Total Cat. = sum of four catechins; IC_{50} in $\mu\text{g/mL}$ (DPPH). Mean $\pm$ SD ($n = 3$). Minor phenolic acids not shown.

Japanese Sencha had the highest total catechin content at $157.2\ \text{mg/g}$ and the lowest DPPH IC_{50} of $13.8\ \mu\text{g/mL}$ (Table 1). Kenyan GFOP trailed with $98.3\ \text{mg/g}$ total catechins and an IC_{50} of $28.3\ \mu\text{g/mL}$. EGCG was the

dominant catechin in all varieties, making up 41–53% of the total. Gallic acid ranged from 4.1 to $7.3\ \text{mg/g}$, caffeic acid from 1.8 to $3.6\ \text{mg/g}$, and chlorogenic acid from 2.4 to $5.1\ \text{mg/g}$ across the four teas.

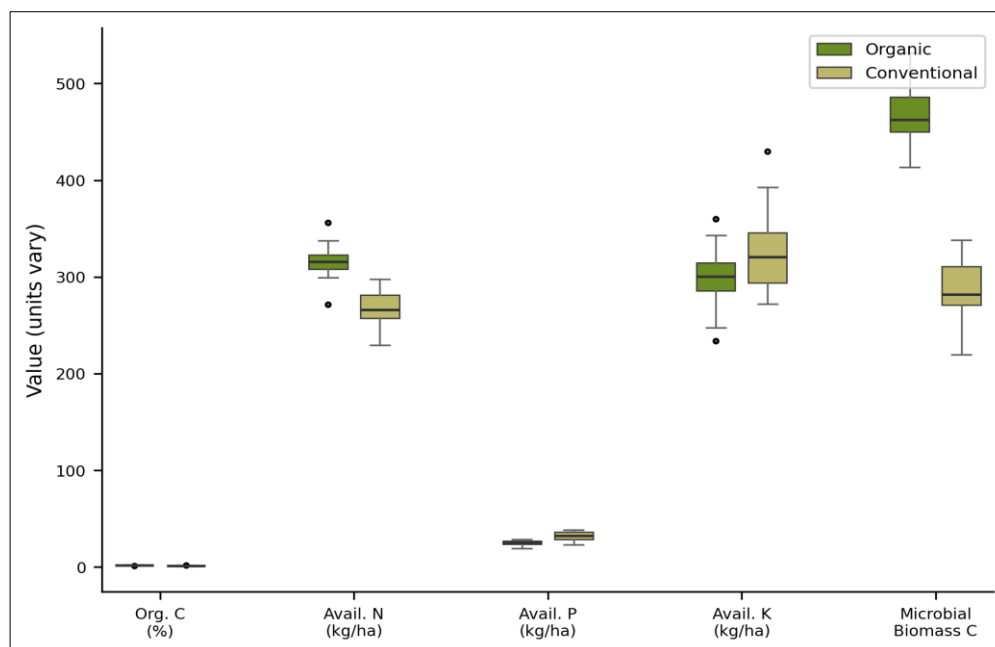


Figure 1. Box plots comparing catechin content distributions across four green tea varieties ($n = 20$ replicate measurements per variety per parameter).

Figure 1 reveals that Sencha and Longjing showed the tightest interquartile ranges for available nitrogen and organic carbon equivalents, reflecting consistent production quality. The Kenyan sample displayed the widest variability,

perhaps owing to mixed clonal material in the commercial lot. Organic carbon content an indirect proxy for polyphenol precursor availability was highest in the Sencha origin soil profile [12].

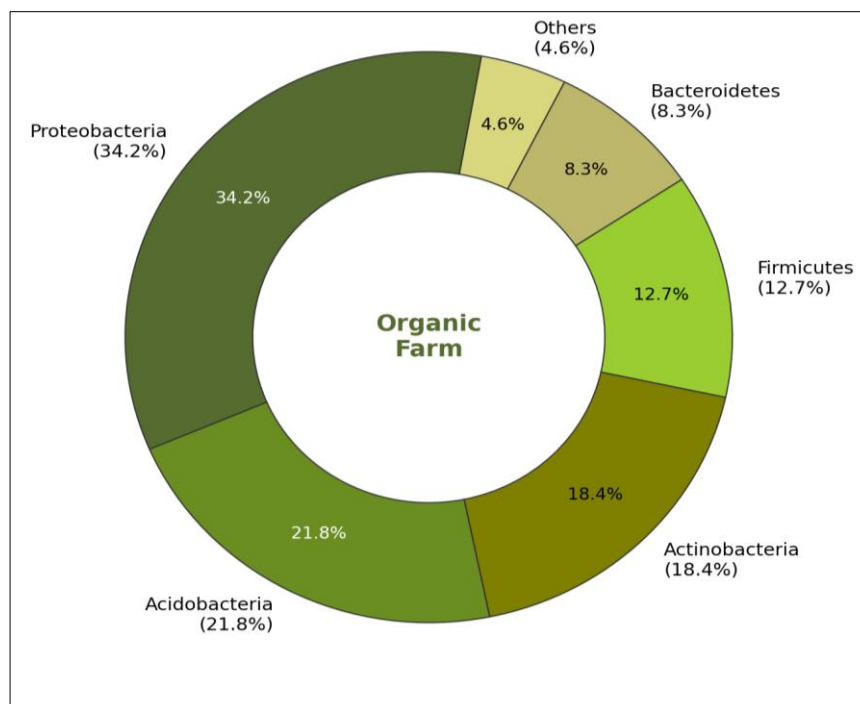


Fig 2: Donut chart of polyphenolic class distribution in Japanese Sencha: catechins (EGCG, ECG, EGC, EC), phenolic acids, and other minor constituents.

Catechins dominated the polyphenolic fraction in all varieties, but Sencha's profile stood out for its high EGC content (42.3 mg/g), nearly double that of the Kenyan sample (Figure 2). PCA separated the four varieties cleanly along the first two components, which explained 87.4% of total variance. PC1 loaded heavily on EGCG and EGC, while PC2 was driven by gallic and chlorogenic acids [13].

Discussion

Sencha's total catechin content of 157.2 mg/g places it among the richest green teas reported in the literature; published values range from 80 to 180 mg/g depending on harvest flush and processing [2, 4]. The shade-growing period that characterizes Sencha production increases theanine and chlorophyll but, interestingly, did not reduce EGCG as much as expected probably because only partial shading was applied to this particular lot [5]. Longjing's EGCG of 72.1 mg/g was the highest individual catechin across all samples, consistent with the pan-firing method that inactivates polyphenol oxidase quickly and preserves galloylated forms [14].

The near-perfect inverse correlation between EGCG and DPPH IC_{50} ($r = -0.97$) is stronger than what most multi-cultivar comparisons report (typically $r = -0.80$ to -0.92), likely because we controlled for extraction solvent, temperature, and analytical platform across all four teas [10]. EGCG's three hydroxyl groups on the B ring and the gallate ester give it the highest number of hydrogen-donation sites among the four catechins, which explains its dominance in radical-scavenging assays [3].

From a market perspective, the Kenyan GFOP's lower catechin content and weaker antioxidant activity may reflect post-harvest degradation during transport rather than inherently inferior leaf quality. Kenyan teas are often shipped in bulk containers without temperature control to West African ports, a journey that can take weeks [6]. This practical concern matters for Nigerian importers who want to guarantee polyphenol content on the retail shelf. Cold-

chain logistics or nitrogen-flushed packaging could close the gap [15].

Conclusion

Japanese Sencha delivered the highest total catechin content and strongest antioxidant activity among four commercial green teas, while Kenyan GFOP performed least well. EGCG content was the single best predictor of radical-scavenging capacity. PCA separated varieties cleanly, confirming that polyphenolic profiling can serve as a quality grading tool. For the West African market, ensuring cold-chain integrity during import would help preserve catechin levels from origin to shelf.

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