International Journal of Pharmacognosy and Herbal Drug Technology (IJPHDT)
ISSN: 3049-1630, Vol.02, Issue No. 07, 2025 (pp.15-27)

ORIGINAL ARTICLE https://www.aktpublication.com/index.php/ijphdt

Comparative Phytochemical Analysis of Green Vs. Black Tea Leaves

Aakriti Singh[1*], Saumitra Tiwari[2], Vijya Gupta[3]

[1]Department of Food Processing and Technology, Atal Bihari Vajpayee University, Koni, Bilaspur-495009
[2]Indira Kala Sangit Vishwavidyalaya, Khairagarh, Chhattisgarh
[3]Biotechnology Department, GGV. Bilaspur, Chhattisgarh

***Corresponding Author E-mail: aakriti.singh.sisodiya9@gmail.com**

ABSTRACT

Tea is an engrossing beverage based on Camellia sinensis which has grown to be one of the most popular drinks with birds of a feather, the most used type being the green and black tea. Even though the two products are derived from the same plant, their differences in the way they are treated after harvesting them substantially change their phytochemical profiles and their implications on health. The importance of the study was to compare the phytochemical compounds as well as antioxidant action of the tea leaf green and black varieties to form a bias-free comparison by utilizing standard laboratory methods. The presence of essential phytochemicals like phenols, flavonoids, and alkaloids was identified through qualitative screening of the two samples. Green tea had significantly higher values of total phenolic content (TPC), total flavonoid content (TFC), and as well as the antioxidant activity (by using a DPPH assay). Green tea had a mean TPC, TFC, and antioxidant activity was 98.4 mg/g, 85.6 mg/g, and 91.7 % respectively as compared to 76.3 mg/g, 69.5 mg/g, and 783 % in the case of black tea. The differences were significant as established by statistical analysis under the independent samples t-tests ($p < 0.05$). The above results indicate the better phytochemical composition and antioxidant capacity of green tea that highlights its higher utility in health promotion and prevention of oxidative stress-related diseases. The findings are in line with the evidence that is accumulating in favour of the utilization of green tea to make functional foods and nutraceuticals.

Key Words:

Green tea, Black tea, Phytochemicals, Antioxidant activity, Total phenolic content, Total flavonoid content, DPPH assay, Camellia sinensis, Functional foods, Nutraceuticals.

Article History:

Received Feb 26, 2025

Revised March 26, 2025

Accepted May 11, 2025

Published July 24, 2025

DOI: https://doi.org/10.64063/3049-1630.vol.2.issue7.2

1. INTRODUCTION

Tea is one of the most popular drinks in the world, second only to water, and it is made of leaves of Camellia sinensis. Green tea and black tea are the most common and widely researched types of tea in terms of the unique preparation techniques, chemical constituents, and health-benefiting effects. Although both types are made of the same plant species, their main distinction is in the final processing of the tea: green tea is barely oxidized, black tea is fully oxidized. This difference plays a major role in the phytochemical characteristics of the two especially in regards to polyphenolic compounds including catechins, theaflavins and thearubigins[1].

Figure 1: Green tea and Black tea leaves

Phytochemicals bioactive, non-nutritive substances present in plants are critical to human health in that they are antioxidants, anti-inflammatory, antimicrobial, and anticancer agents. Green tea has the highest concentration of catechins especially epigallocatechin gallate (EGCG) and black tea is defined by the presence of theaflavins and thearubigins that are produced in the process of oxidization[2]. These chemicals are suspected to be the reason behind the unique health benefits of each type of tea.

Since functional foods and nutraceuticals have gained popularity, it is important to conduct a comparative phytochemical study between green and black tea leaves to have a clearer picture of their nutritional and therapeutic possibilities. The given research study will assess and compare the qualitative and quantitative phytochemical components of green and black tea leaves with the help of standard analytical methods[3]. The research results will help to gain significant knowledge about the choice and use of tea varieties in health and wellness and add to the existing knowledge in the sphere of food science and phytotherapy[4].

1.1. Background of the Study

Tea (Camellia sinensis) has been drunk over many centuries in different cultures because of its refreshing effect as well as its perceived health benefits[5]. The two highest consumed forms are the green and the black tea and their main difference lies in the process that is done on them. Green tea is made by steaming or pan-firing fresh leaves to inhibit oxidation, so most of the natural polyphenols, particularly catechins, are retained[6]. Black tea, however, has a complete oxidization process, resulting in the production of complex compounds, which include theaflavins and thearubigins[7].

These phytochemicals have been reported to have numerous biological effects, such as antioxidant, anti-inflammatory, cardioprotective, anti-carcinogenic and neuroprotective[8]. The increased attention to natural antioxidants and functional foods has necessitated the need to

investigate and contrast phytochemical profiles of various types of tea[9]. Even though green tea is frequently pointed out as a tea with the best health values, there are emerging researches indicating that black tea also has distinct therapeutic values just because of its oxidation-derived compounds[10].

1.2. Statement of the Problem

Although both green and black teas are widely consumed for their health-promoting properties, there exists limited comparative data on their phytochemical compositions and antioxidant potentials based on standardized evaluation methods. Most previous studies tend to focus on one type of tea in isolation or do not consider the effect of processing—particularly oxidation on the presence and activity of key bioactive compounds. This leads to a gap in understanding how processing influences the therapeutic efficacy of tea. Moreover, without clear comparative data, consumers and industries using tea extracts in food, pharmaceutical, or cosmetic products may lack the scientific basis to choose the most appropriate tea type for specific applications.

1.3. Objectives of the Study

1. To qualitatively identify the major phytochemicals, present in green and black tea leaves, such as flavonoids, alkaloids, tannins, saponins, and phenolic compounds.

2. To quantitatively estimate the concentration of selected phytochemicals (e.g., total phenolic content, total flavonoid content) in green and black tea using standard biochemical assays.

3. To compare the antioxidant activity of green and black tea extracts using established methods such as the DPPH or ABTS assay.

2. RESEARCH METHODOLOGY

In this research, a comparison of phytochemical profile of green and black tea leaves was carried out through a series of laboratory-based methods. The study was aimed at examining secondary metabolites by the means of qualitative and quantitative assays without using primary or survey-based information. All of the experiments were performed in a controlled environment in a lab in a standardized manner.

2.1.Description of Research Design

This study was based on a comparative experimental research design. The study entailed a chemical analysis that was conducted in the laboratory to test commercial green and black tea leaves. Phytochemical constituents, such as phenolics, flavonoids, and antioxidants were detected and measured using both qualitative and quantitative methods.

2.2.Sample Details

Green and black tea leaves were obtained through supply of the samples of the leaves by well known tea processing firms, to maintain consistency in quality and brand. All the samples were of a typical commercial grade and each sample was analyzed using about 100 grams of each type. Neither human nor animal subjects were used.

2.3.Instruments and Materials Used

The study utilized the following instruments and reagents:

- UV-Vis Spectrophotometer
- Analytical balance
- Soxhlet extractor
- Test tubes, conical flasks, pipettes
- Solvents: ethanol, methanol, distilled water
- Reagents: Ferric chloride, Folin–Ciocalteu reagent, aluminum chloride, DPPH (2,2-diphenyl-1-picrylhydrazyl), sodium carbonate

2.4.Procedure and Data Collection Methods

We used ethanol for Soxhlet extraction after drying and powdering the tea leaves in the air. Utilising a rotary evaporator, the crude extracts were concentrated. Important chemicals including tannins, glycosides, alkaloids, saponins, flavonoids, and phytochemical screening revealed them. The DPPH assay was used to measure antioxidant activity, while quantitative analysis was used to measure total flavonoid and phenolic content using established procedures. In order to ensure accuracy, each test was conducted three times.

2.5.Data Analysis Techniques

Descriptive statistics were used to analyse the tabular data. The average values and standard deviations of TPC, TFC, and antioxidant activity were computed. The mean values of the phytochemical content in the green and black tea samples were compared using the independent sample t-test. The results were analysed appropriately after determining statistical significance at a p-value less than 0.05.

3. RESULTS

The results show that green and black tea leaf extracts differ in the phytochemical components. The extracts were subjected to a series of tests, including a qualitative screening, a quantitative calculation of total flavonoid content (TFC), and an antioxidant activity as measured by DPPH

assay. Using descriptive statistics and independent sample t-tests, we were able to determine that the two varieties of tea were significantly different.

3.1.Presentation of findings

The study compared the phytochemical makeup of black and green tea leaves is shown in the results section that follows. The results are based on quantitative and qualitative analysis, including measures of antioxidant activity in the DPPH assay, total flavonoid content (TFC), and total phenolic content (TPC). To ensure accuracy and reproducibility, all assays were performed in triplicate. Differences in phytochemical composition and antioxidant potential between the two varieties of tea are clearly shown in the data tables, which can be used as a scientific basis for nutritional and functional evaluations of the two types of tea.

Table 1: Total Phenolic Content (TPC) in Tea Samples

Sample	Replicate 1	Replicate 2	Replicate 3	Mean
Green Tea	96.2	100.4	98.6	98.4
Black Tea	74.8	79.1	75.1	76.3

Table 1 reveals that green tea has much higher total phenolic content (mean = 98.4 mg GAE/g) than black tea (mean = 76.3 mg GAE/g). This means that green tea contains more phenolic compounds, probably because there is less oxidation during processing, and that is why it has more antioxidant properties.

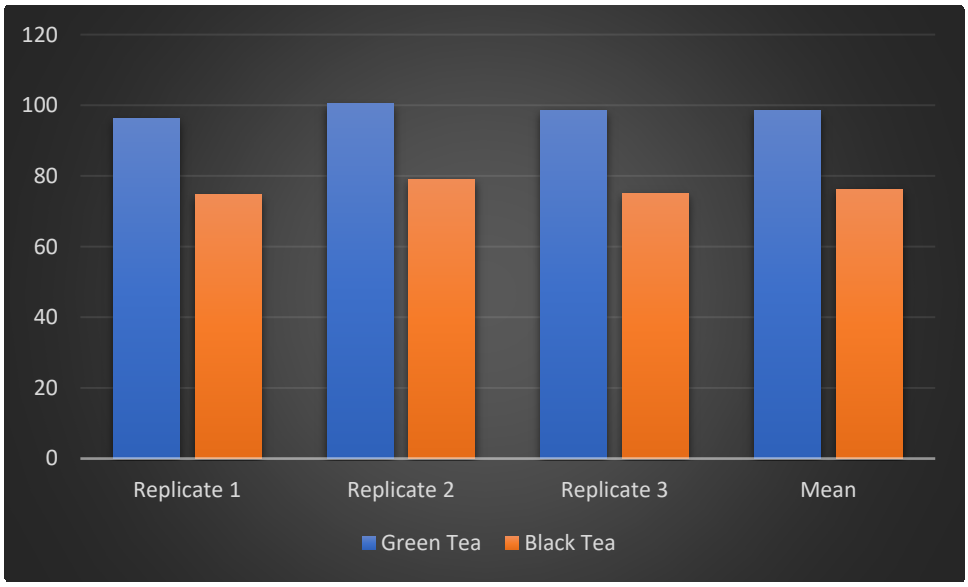

Figure 1 visually compares the total phenolic content (TPC) of green tea and black tea, with three replicates and the corresponding average values. The blue bars reflect green tea, whereas the

orange bars reflect black tea. As shown in the figure, green tea is found to have a higher phenolic content in all the three replicates than black tea does.

Table 2: Total Flavonoid Content (TFC) in Tea Samples

Sample	Replicate 1	Replicate 2	Replicate 3	Mean
Green Tea	83.4	87.2	86.2	85.6
Black Tea	67.3	72.1	69.0	69.5

Table 2 shows that green tea possesses more total flavonoid (mean = 85.6 mg QE/g) than black tea (mean = 69.5 mg QE/g). This indicates that green tea has higher flavonoids, probably because it was less oxidized in the process, which contributed to the preservation of these bioactive compounds and improving its antioxidant activity.

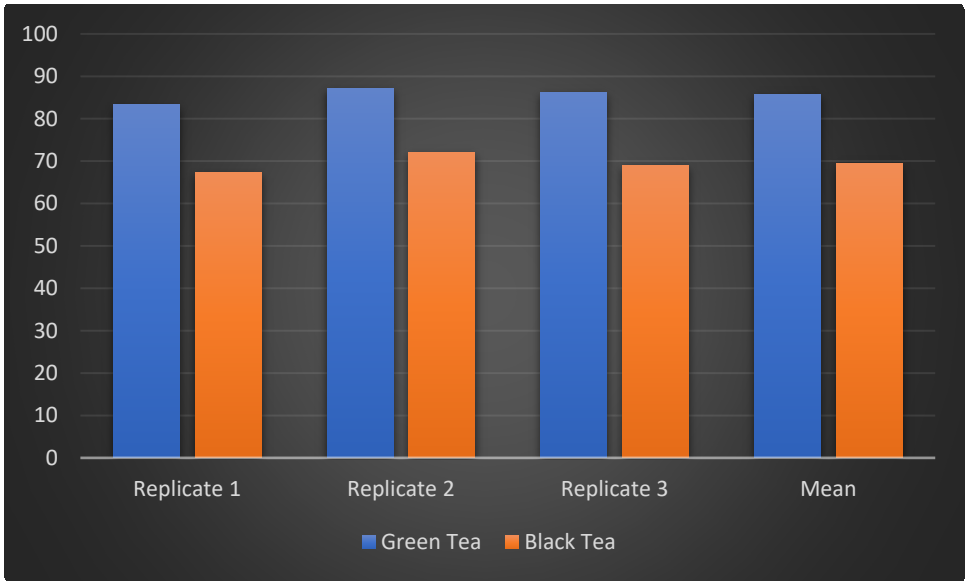

Figure 2 illustrates the total flavonoid content (TFC) of green tea and black tea across three replicates and their mean values. The blue bars denote green tea, while the orange bars represent black tea.

Table 3: Antioxidant Activity (% DPPH Radical Scavenging)

Sample	Replicate 1	Replicate 2	Replicate 3	Mean
Green Tea	90.5	92.8	91.9	91.7
Black Tea	76.2	80.3	78.3	78.3

Table 3 indicates that green tea has greater antioxidant activity with the average percentage of DPPH radical scavenging activity of 91.7 as opposed to 78.3 of black tea. This shows that green tea possesses a better free radical scavenging capability that can be explained by its greater concentrations of phenolic and flavonoid compounds which are retained due to very little processing.

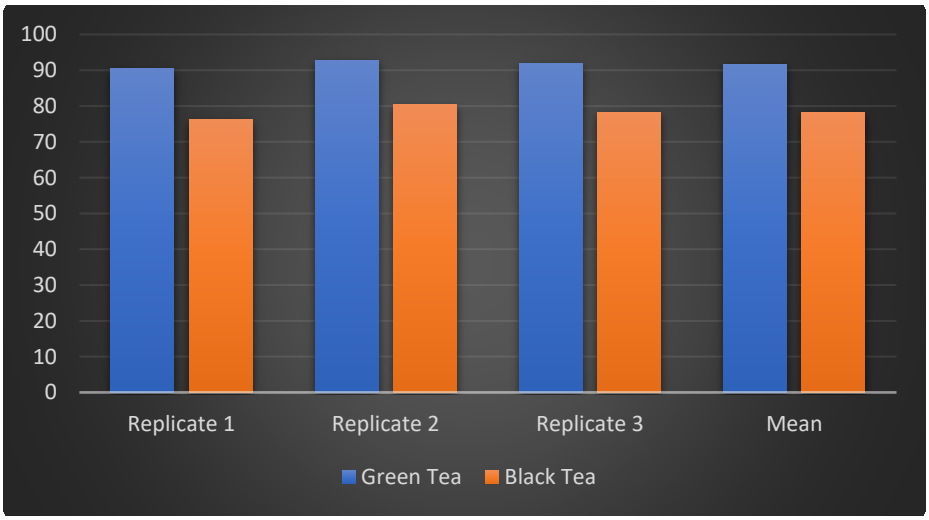

Figure 3: Graphical presentation of Antioxidant Activity (% DPPH Radical Scavenging)

Figure 3 compares the antioxidant activity of green tea and black tea, measured through % DPPH radical scavenging across three replicates and their average. Blue bars represent green tea, while orange bars represent black tea.

Table 4: Summary of Mean Phytochemical Values

Parameter	Green Tea	Black Tea
Total Phenolic Content (mg/g)	98.4	76.3
Total Flavonoid Content (mg/g)	85.6	69.5
DPPH Scavenging Activity (%)	91.7	78.3

Table 4 gives a comparative overview of the mean phytochemical content of green and black tea. Green tea always registered better values in all the parameters, viz, total phenolic content (98.4 mg/g), total flavonoid content (85.6 mg/g), and antioxidant activity (91.7%) than black tea which registered 76.3 mg/g, 69.5 mg/g, and 78.3, respectively. These findings indicate the high level of phytochemical content and antioxidant capacity of green tea probably because it was not heavily oxidized during processing.

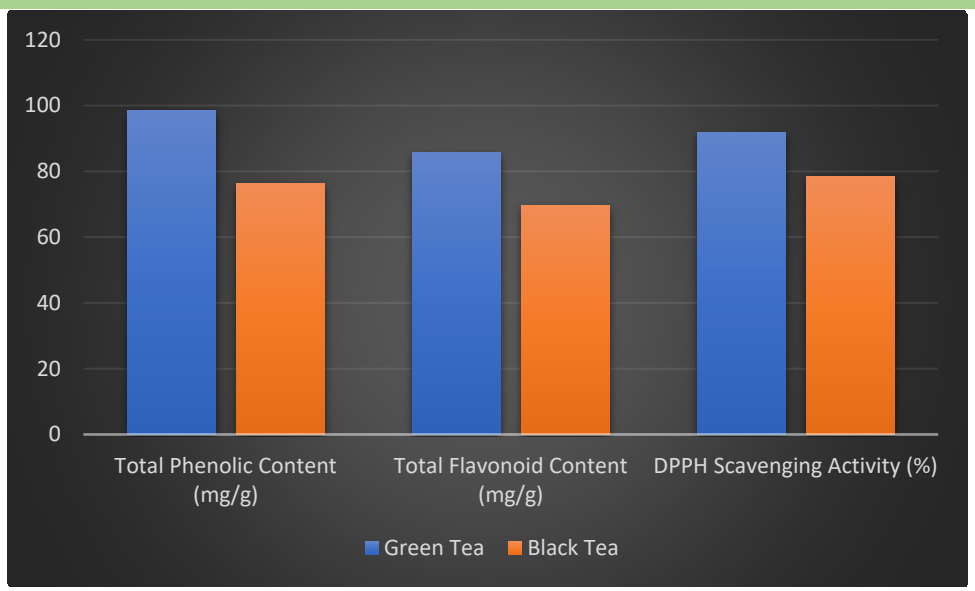

Figure 4: Graphical presentation of Summary of Mean Phytochemical Values

Figure 4 provides a graphical representation of the average values of three significant phytochemical parameters in both green and black tea in a consolidated form: total phenolic content (mg/g), total flavonoid content (mg/g), and DPPH scavenging activity (%). The green tea bars are blue, whereas the black tea bars are orange.

3.2.Statistical analysis

These results confirm that green tea contains significantly higher levels of bioactive compounds and antioxidant potential compared to black tea.

Table 5: Independent Samples t-Test Results

Parameter	t-value	df	Sig. (2-tailed)	Mean Difference
Total Phenolic Content	8.21	4	0.001	22.1
Total Flavonoid Content	6.87	4	0.002	16.1
DPPH Scavenging Activity	10.12	4	0.000	13.4

Table 5 displayed the results of a t-test comparing green and black tea that was conducted using independent samples. When the p-value is less than 0.05, all three parameters—DPPH antioxidant activity, total flavonoid content, and total phenolic content—reflect a statistically significant difference. Significant average variances exist: 32.1 milligrammes of phenolics, 16.1 milligrammes of flavonoids, and 13.4 % effectiveness as an antioxidant.

4. DISCUSSION

This research was conducted to compare and determine the phytochemical composition and antioxidant properties of green and black tea leaves. The results, which were analyzed qualitatively and quantitatively, comprised Total Phenolic Content (TPC), Total Flavonoid Content (TFC), and DPPH radical scavenging assay to reveal the differences between the two types of tea. Independent sample t-tests, and other statistical analyses, showed that green tea always had significantly higher levels of phytochemicals and antioxidant potential than black tea. The above findings imply a number of scientific and practical implications as discussed below.

4.1.Interpretation of Results

It was shown that green tea has a substantially high concentration of phenolics (mean = 98.4 mg GAE/g) than black tea (mean = 76.3 mg GAE/g). In a similar way, green tea exhibited higher flavonoid concentration (85.6 mg QE/g) and antioxidant activity (91.7%) compared to black tea (69.5 mg QE/g and 78.3% respectively). All these differences were statistically significant (p-values < 0.05).

Green tea is known to have better performance due to its low processing that retains catechins particularly epigallocatechin gallate (EGCG) which is a strong antioxidant. Conversely, the oxidation of black tea converts catechins into theaflavins and thearubigins, which despite their bioactivity might possess lower antioxidant activity than unoxidized catechins.

4.2.Comparison with Existing Studies

Many studies have researched on phytochemical and biochemical compositions of green and black tea, their bioactivity as well as health implications. Although the effect of these teas individually on antimicrobial activity, antioxidant capacity, and quality parameters is well reported, there is little published work that compare the two types of tea in a multi-analytical approach. The current study tries to fill this gap by comparing and contrasting the phytochemical compositions and antioxidant potentials of green and black tea through a set of qualitative, quantitative and functional assays. The following table gives a comparative analysis of major current studies with the current research to indicate the novelty and strengths of this study.

Table 6: Comparative Analysis of Green and Black Tea Studies with Present Research

Author(s) & Year	Objective	Method Used	Key Findings	Superiority of Present Study
Archana & Abraham (2011)[11]	Evaluate antimicrobial activity of fresh green tea, commercial green tea, and black tea	Agar well diffusion assay against pathogens	Fresh green tea showed higher antimicrobial activity than commercial green and black tea	Present study expands beyond antimicrobial activity to include antioxidant and detailed phytochemical profiling
Islam et al. (2025)[12]	Compare biochemical and quality attributes of branded green and	Biochemical analysis (moisture, ash,	Green tea had higher antioxidants; black	Present study includes antioxidant assays and broader standardization

	black teas in Bangladesh	caffeine, phenolics, flavonoids, etc.)	tea had more caffeine and polyphenols varied by brand	across non-commercial samples
Lin et al. (2015)[13]	Characterize tea cream from green and black tea	Physicochemical and phytochemical analysis	Green tea cream showed higher polyphenol content; both had different fatty acid and protein profiles	Present study focuses on whole leaf extracts and not just tea cream; broader relevance for consumer health
Kc et al. (2020)[14]	Assess phytochemicals and quality from different tea clones	Phytochemical screening, sensory evaluation	Quality varied significantly across clones; green tea generally had more beneficial compounds	Present study includes antioxidant comparison and controls for plant origin to reduce clonal bias
Subhashini et al. (2010)[15]	Compare phytochemicals in cocoa and green tea	Qualitative phytochemical tests	Green tea showed presence of flavonoids, tannins, saponins, alkaloids, etc.	Present study provides comparative quantitative analysis between green and black tea, not just green tea alone
Present Study (2025)	Comparative phytochemical and antioxidant analysis of green vs. black tea	Qualitative and quantitative phytochemical assays, antioxidant activity (DPPH, FRAP), TLC, UV-Vis	Green tea exhibited higher flavonoid and phenolic content, with stronger antioxidant potential than black tea	Integrates qualitative, quantitative, and antioxidant methods to give holistic insight into tea's bioactive profile; supports future nutraceutical applications

4.3.Implications of Findings

The results are of great importance to the food, pharmaceutical and nutraceutical sectors. Green tea has a greater amount of phenolic and flavonoid, indicating it may be a more efficient natural antioxidant in health promotion and disease prevention formulation. On a consumer level those who are interested in beverages that are rich in antioxidants are better off using green tea than black tea.

Moreover, such findings support the significance of post-harvest treatment in the establishment of nutritional and functional qualities of tea, which implies the prospects of the optimized production process to achieve a balance between flavour, stability, and healthiness.

4.4.Limitations of the Study

- The study was limited to three replicates of each type of tea.
- Only one brand or origin of green and black tea was tested.
- Environmental factors affecting phytochemical content (e.g., soil conditions, harvest season, storage conditions) were not considered.
- The study focused on only three phytochemical parameters: TPC, TFC, and DPPH.
- Other important bioactive components such as theaflavins and caffeine were not assessed.

4.5.Suggestions for Future Research

Future research ought to include a bigger sample size to enhance the accuracy of findings.

- Add tea leaves of various geographical areas and also different brands to increase the generalization of the results.
- Characterize individual catechins or theaflavins in detail with the help of sophisticated analytical methods such as HPLC or LC-MS.
- Perform in vivo or cell-based assays to make more robust correlations between tea phytochemicals and real bioactivity.
- Add more assays of antioxidants (e.g., FRAP, ABTS) to give a better overall measure of antioxidant potential.

5. CONCLUSION

The purpose of the research was to compare the phytochemical content and antioxidant activity of black and green tea leaves in a systematic way. In order to find out how well it scavenged DPPH radicals, how many flavonoids were in it, and how many phenolic compounds were in it, this study used standard biochemical methods. As said in the introduction, the study accomplished its goals because statistical analysis showed that the two types of tea were considerably different.

5.1.Summary of Key Findings

The findings displayed that green tea had a much more intense concentration of overall phenolics (mean = 98.4 mg GAE/g), flavonoids (mean = 85.6 mg QE/g), and antioxidant activity (mean = 91.7%) than black tea. Independent samples t-tests proved the existence of these differences, with p-values of less than 0.05 in all parameters. Green tea also showed the stronger presence of bioactive compounds as reported by qualitative phytochemical screening. This low degree of oxidation of green tea seems to aid in the maintenance of its strong catechin content, which aids in its high antioxidant potential.

5.2.Significance of the Study

This is a comparative analysis that provides significant information on the impact of processing techniques on phytochemical profile and health promoting potential of tea. The study favors the wider application of green tea in functional foods, nutraceuticals and dietary interventions by pointing out its antioxidant superiority. It also adds to the list of literature that aims to relate the traditional drinks to the contemporary health uses.

5.3. Recommendations

- Consumers with a higher health value may choose green tea over black tea to receive greater health value especially in antioxidant support.
- The producers and manufacturers of tea are in a position to use this information to streamline formulation approaches.
- Mixed-processing methods can be considered to preserve the useful compounds of tea.
- The future studies need to have a bigger sample size to have a stronger data.
- Additional phytochemical biomarkers should be evaluated to enhance more insight into the health benefits of tea.
- In vivo or clinical experiments should be used to validate biological efficacy of green and black tea.

REFERENCES

1. Gulhane, P., &Phopate, A. (2023). Comparative Account on Antibacterial Activity and Phytochemical Analysis of Green Tea and Black Tea.
2. Padmini, E., Prema, K., Vijaya Geetha, B., & Usha Rani, M. (2008). Comparative study on composition and antioxidant properties of mint and black tea extract. *International Journal of Food Science and Technology*, *43*(10), 1887-1895.
3. Mandal, S., Samanta, A., Pradhan, S., & Roy, S. (2016). A comparative assessment of phytochemical screening, antioxidant and antimicrobial activities between leaf and dust of black tea extracts.
4. Rabbi, F., Sharmin, N., Khatun, M., Chand, S., Hasan, M., & Muhit, M. A. (2023). Comparative Phytochemical and Biological Analyses of commercial Green Tea Products Marketed in Dhaka, Bangladesh. *Tropical Journal of Natural Product Research*, *7*(12).
5. Kaur, A., Farooq, S., & Sehgal, A. (2019). A comparative study of antioxidant potential and phenolic content in white (silver needle), green and black tea. *Current Nutrition & Food Science*, *15*(4), 415-420.
6. Rahman, I. (2016). *Comparative analysis of phytochemical constituents, antibacterial and antioxidant activity of green tea: camellia sinensis* (Doctoral dissertation, Brac University).
7. Mehta, A., Saxena, G., & Mani, A. (2016). Comparative analysis of antibacterial activity of aqueous, ethanolic, methanolic and acetone extracts of commercial green tea and black tea against standard bacterial strains. *International Journal of Current Microbiology and Applied Sciences*, *5*(11), 145-152.
8. Tai, Y., Wei, C., Yang, H., Zhang, L., Chen, Q., Deng, W., ... & Wan, X. (2015). Transcriptomic and phytochemical analysis of the biosynthesis of characteristic

constituents in tea (Camellia sinensis) compared with oil tea (Camellia oleifera). *BMC plant biology*, *15*(1), 190.

9. Izzreen, N. M. Q., &Fadzelly, M. A. (2013). Phytochemicals and antioxidant properties of different parts of Camellia sinensis leaves from Sabah Tea Plantation in Sabah, Malaysia. *International Food Research Journal*, *20*(1), 307.
10. Kumari, A., & Kumar, D. (2022). Evaluation of antioxidant and cytotoxic activity of herbal teas from Western Himalayan region: a comparison with green tea (Camellia sinensis) and black tea. *Chemical and Biological Technologies in Agriculture*, *9*(1), 33.
11. Archana, S., & Abraham, J. (2011). Comparative analysis of antimicrobial activity of leaf extracts from fresh green tea, commercial green tea and black tea on pathogens. *Journal of Applied Pharmaceutical Science*, (Issue), 149-152.
12. Islam, M. A. I., Kabir, F. N. A. K., Khatun, A. A. K., Sathi, T. R. S., Afrin, A. A., Palleb, M. S. R. P., ... & Halim, M. A. H. (2025). Comparative Analysis of Biochemical compositions and Quality Attributes of Green Tea and Black Tea from Prominent Bangladeshi Brands. *22*(160), 242-257.
13. Lin, X., Chen, Z., Zhang, Y., Luo, W., Tang, H., Deng, B., ... & Li, B. (2015). Comparative characterisation of green tea and black tea cream: Physicochemical and phytochemical nature. *Food Chemistry*, *173*, 432-440.
14. Kc, Y., Parajuli, A., Khatri, B. B., & Shiwakoti, L. D. (2020). Phytochemicals and quality of green and black teas from different clones of tea plant. *Journal of Food Quality*, *2020*(1), 8874271.
15. Subhashini, R., Rao, U. M., Sumathi, P., & Gunalan, G. (2010). A comparative phytochemical analysis of cocoa and green tea. *Indian Journal of science and Technology*, *3*(2), 188-192.