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# Phytochemical, Antimicrobial, Antioxidant and Effect of UV Radiation on *Camellia sinensis* (Green Tea), *Curcuma longa* (Turmeric) and *Trigonella foenum-graecum* (Fenugreek)

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**ABSTRACT**
*Phytochemical analysis along with their bio-functional studies have attracted immense interest globally for thousands of years, owing to their immense contribution towards protecting human health. Camellia sinensis commonly known as green tea, Curcuma longa as turmeric and Trigonella foenum-graecum as fenugreek, are tropical plants rich in biological, nutritional and pharmaceutical value in our daily life. They have been found to exert diverse types of functions towards our health through ingestion in a form of infusions or decoctions. Furthermore, bio-molecules such as vitamins and essential metal possess a role of immense importance in neutralizing any adverse physiological or toxic impacts generated from microbial contaminants at human and animal mucous membranes. This study investigates the phytochemical profile and biofunctional properties of Camellia sinensis (green tea), Curcuma longa (turmeric), and Trigonella foenum-graecum (fenugreek), with a specific focus on evaluating the effect of UV radiation on their antioxidant activity. Phytochemical analysis was carried out to identify major bioactive constituents, including phenols and flavonoids. The antioxidant efficiency of UV-treated and untreated extracts was evaluated against selected microbial strains to compare the inherent therapeutic potential of each extract. Stability studies across varying temperature conditions were performed to determine the robustness of the bioactive compounds. Preliminary findings indicate that UV exposure alters the antioxidant performance. Overall, the study highlights the importance of UV modulation on antioxidant potential and provides comprehensive insights into stability and functional value of these widely used medicinal plants.*
***Keywords:*** *Camellia sinensis, Curcuma longa, Trigonella foenum-graecum, Phytochemical profile, Biofunctional properties, Antioxidant Activity, UV Exposure.*

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## INTRODUCTION

It has long been known that medicinal plants are important sources of bioactive substances with a variety of therapeutic uses. Because of their rich phytochemical composition and health-promoting properties, *Camellia sinensis* (green tea), *Curcuma longa* (turmeric), and *Trigonella foenum-graecum* (fenugreek) are used extensively in both traditional and modern medicine. The antioxidant and antibacterial properties of these plants are attributed to a variety of secondary metabolites, such as polyphenols, flavonoids, alkaloids, tannins, saponins, and terpenoids (1-4). Green tea has anti-mutagenic, anti-thyroid, diuretic, and bone health benefits. [8]. Green tea's EGCG inhibits bacteria associated with gum diseases, promoting periodontal healing (9). Oxidative stress, caused by an imbalance between free radicals and antioxidants, is implicated in the development of numerous chronic diseases. Natural antioxidants derived from plant sources play a crucial role in neutralizing free radicals and protecting biological systems from oxidative damage. Green tea, turmeric, and fenugreek have been reported to possess significant antioxidant potential due to their high content of phenolic compounds and other bioactive constituents (1,3,5). However, environmental factors such as ultraviolet (UV) radiation can influence the stability and efficacy of these compounds, thereby affecting their antioxidant capacity.

## MATERIAL AND METHODS

**Preparation of Extracts:** The maceration procedure was used to prepare the extracts of fenugreek, turmeric, and green tea. In an Erlenmeyer flask, around 10g of each powdered sample were combined with 100 ml of ethanol, and the mixture was left to stand for 48 hrs (6). After filtering the mixtures through

Whatman No.1 filter paper, the filtrates were concentrated for one to two hrs at 78$^0$C using a rotary evaporator. For additional analysis, the resulting crude extracts were kept at 4$^0$C.

**Phytochemical Analysis:** The phytochemical analysis of the Ethanolic extracts of green tea, turmeric, and fenugreek has been carried out in accordance with the procedure outlined by Iqbal *et al*., (2015), Shaikh and Patil (2020), and Tiwari *et al*., (2020), (7). It has been carried out using the qualitative tests for the presence of alkaloids, flavonoids, carbohydrates, reducing sugars, tannins, polyphenols, saponins, cardiac glycosides, steroids, and terpenoids.

**Antioxidant Activity**

**a) Before UV Exposure:** An ethanol solution containing 0.1 Mm DPPH was made and shielded from light. Green tea, Turmeric, and Fenugreek extracts in varying concentrations (12.5, 25, 50, 100, and 200 µl) were individually combined with ethanol, and the volume was adjusted to produce a final volume of 1600µl. 2400 µl of DPPH solution was added to each test tube. After covering the reaction mixtures with aluminum foil, they were left at room temperature for half an hour in the dark. A UV-Visible Spectrophotometer was used to measure absorbance at 517nm using ethanol as a blank. Additionally, a control with just ethanol and DPPH solution without any plant extract was made and examined.

**b) After UV Exposure:** In a laminar airflow chamber, green tea, fenugreek, and turmeric extracts were subjected to UV light for half an hour. The DPPH radical scavenging assay was then used to assess the antioxidant activity of the UV-treated extracts.

**Antimicrobial Activity:** The agar well diffusion method was used to assess the antibacterial activity of green tea, turmeric, and fenugreek extracts based on the development of inhibition zones surrounding the wells. Mueller-Hinton agar medium was used for antimicrobial screening against *Bacillus spp, Pseudomonas spp, Staphylococcus spp, Klebsiella spp, Proteus spp,* and *Escherichia coli.* A homogenous bacterial lawn was created using sterile cotton swabs, and a sterile cork borer was utilized to aseptically create wells. A constant volume of each extract was added to the corresponding well, with ethanol acting as the negative control. The extracts were produced in ethanol at concentrations of 0.5, 1.0, and 1.5 mg/ml. Plates were incubated at 37$^0$C for 24 hrs.

**a) Synergistic Effect of Green Tea and Turmeric:** The agar well diffusion method was used to assess the synergistic antibacterial activity of green tea and turmeric extracts. Individual extracts as well as combinations of green tea and turmeric at ratios of 2:1, 1:1, and 1:2 were tested. Standardized bacterial cultures were added to sterile MHA plates, and a sterile well-cutter was used to create wells. The corresponding wells were filled with a set volume of the individual and combined extracts, and they were then incubated for 24 hrs at 37$^0$C. The zones of inhibition were measured in mm to assess the antimicrobial activity.

**Estimation of Phenols:** The Folin-Ciocalteu colorimetric assay established by Siddartha Baliyan *et al* (8) was used to measure the extracts total phenolic content. In short, the calibration standard was gallic acid. Folin-Ciocalteu reagent was combined with extract aliquots, and the mixture was allowed to sit at room temperature for five minutes. The reaction mixture was then incubated foe one hour after the addition of 7.5% sodium carbonate solution. A UV-visible spectrophotometer was used to detect absorbance at 765nm. The gallic acid calibration curve was used to determine the total phenolic content.

**Temperature Stability:** To find out how temperature affects the stability of bioactive substances, the temperature stability of green tea, turmeric, and fenugreek extracts was assessed. The extracts were incubated for 24 hrs and 96 hrs (4days) at 4$^0$C, 25$^0$C, and 37$^0$C. A UV-visible spectrophotometer was used to detect absorbance at 420nm following incubation, using distilled water as the blank. While little variation revealed that the extracts had high heat stability and changes in absorbance suggested potential phytochemical degradation or structural transformation.

## RESULTS AND DISCUSSION

### Preparation of Extracts

Using the maceration process and rotary evaporation, ethanolic extracts of fenugreek, turmeric, and green tea were successfully made. The resulting crude extracts showed up as brownish-yellow viscous liquid for fenugreek, dark yellow to orange viscous liquid for turmeric, and dark brown viscous liquid for green tea.

**Phytochemical Analysis : (Table 1)**

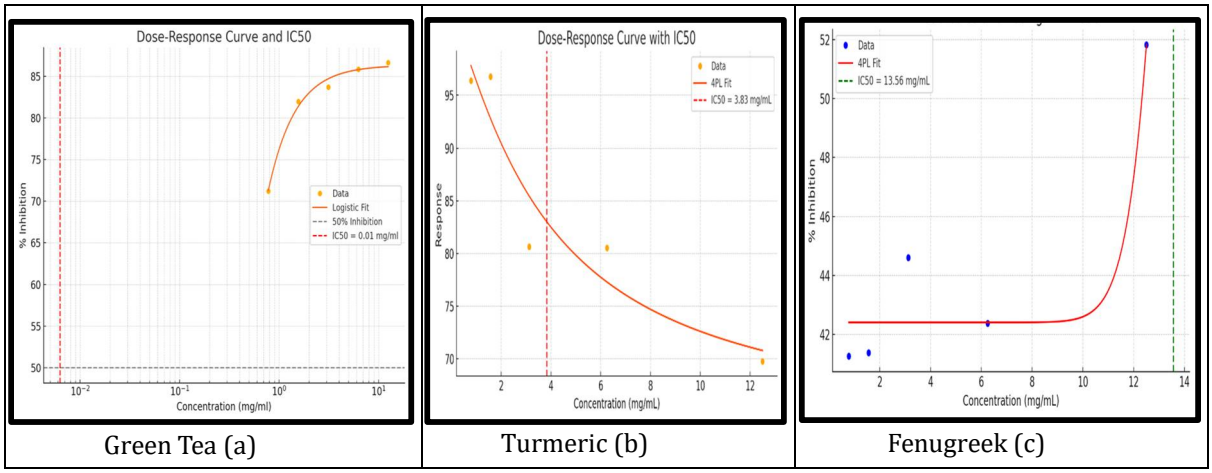
Table 1 Phytochemical analysis of secondary metabolites in Ethanolic extracts of Green tea, Turmeric, and Fenugreek.

| Phytochemicals | Turmeric Extract | Green Tea Extract | Fenugreek Extract |
|---|---|---|---|
| **Alkaloids** | Positive | Positive | Positive |
| **Saponins** | Negative | Positive | Positive |
| **Flavonoids** | Negative | Positive | Positive |
| **Polyphenols** | Negative | Positive | Negative |
| **Carbohydrates** | Negative | Positive | Positive |
| **Reducing Sugars** | Negative | Negative | Negative |
| **Tannins** | Positive | Positive | Positive |
| **Cardiac Glycosides** | Negative | Negative | Positive |
| **Terpenoids** | Positive | Positive | Negative |
| **Steroids** | Negative | Positive | Negative |

**Antioxidant Activity**

**a) Before UV Exposure**

The antioxidant activity of green tea, turmeric, and fenugreek extracts before UV exposure was evaluated using the DPPH radical scavenging assay and analyzed using the 4-parameter logistic (4PL) model. Antioxidant activity increased with concentration in green tea and fenugreek extracts, while turmeric showed variable inhibition at higher concentrations. Among the samples, green tea exhibited the strongest antioxidant activity with the lowest $IC_{50}$ value of 0.01 mg/ml, indicating very high potency. Turmeric showed moderate antioxidant activity with an $IC_{50}$ value of 3.83 mg/ml, whereas fenugreek exhibited weak antioxidant activity with an $IC_{50}$ value of 13.56 mg/ml. Overall, the antioxidant potential followed the order: Green tea > Turmeric > Fenugreek. **(Figure 1)**

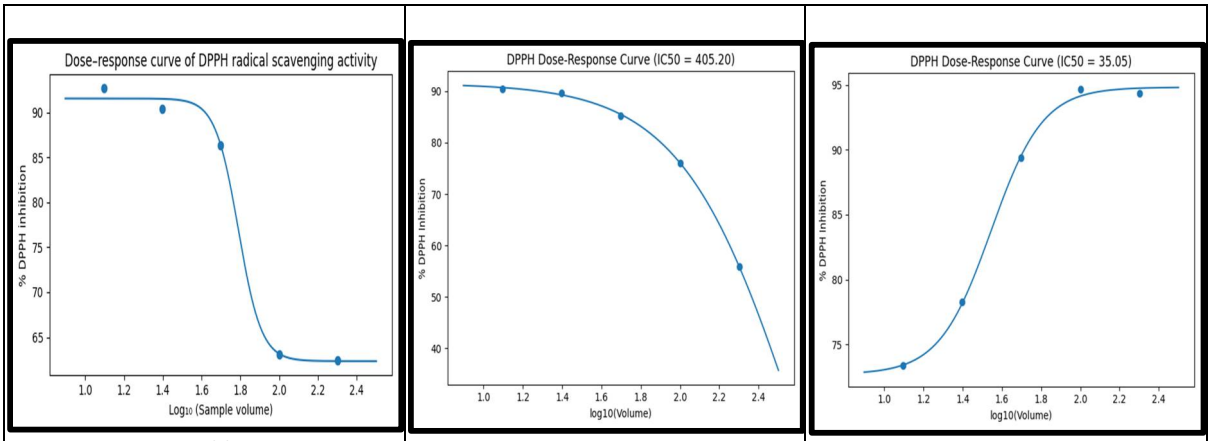



Green Tea (a) Turmeric (b) Fenugreek (c)

Figure 1 Sigmoidal dose response of Green Tea, Turmeric, and Fenugreek with $IC_{50}$ value.

**b) After UV Exposure**

Fenugreek extract exhibited the strongest antioxidant activity with an $IC_{50}$ value of 3.505 mg/ml, followed by green tea with an $IC_{50}$ value of 6.163 mg/ml, while turmeric showed the weakest activity with an $IC_{50}$ value of 40.52 mg/ml. Fenugreek showed a concentration-dependent increase in DPPH inhibition, whereas green tea and turmeric exhibited higher inhibition at lower concentrations. Overall, the antioxidant activity after UV exposure followed the order: Fenugreek > Green Tea > Turmeric. The strong antioxidant potential of fenugreek and green tea may be attributed to the presence of polyphenols, flavonoids, and other bioactive phytochemicals. **(Figure 2)**




Green Tea (a) Turmeric (b) Fenugreek (c)

Figure 2 Sigmoidal dose response curve of Green Tea, Turmeric, and Fenugreek after UV Exposure.

**Antimicrobial Activity**

The antibacterial activity of green tea, turmeric, and fenugreek extracts was evaluated against *Escherichia coli, Pseudomonas spp., Staphylococcus spp., Klebsiella spp., Bacillus spp.,* and *Proteus spp.,* using the agar well diffusion method. Among the tested extracts, green tea exhibited the strongest and broad-spectrum antibacterial activity, showing larger zones of inhibition against most pathogens, likely due to its high polyphenol and catechin content. Turmeric demonstrated selective antibacterial activity, particularly against *Proteus spp.,* and *Staphylococcus spp.,* which may be attributed to curcuminoids such as curcumin. Fenugreek showed moderate antibacterial activity against certain organisms, possibly due to the presence of saponins, flavonoids, and alkaloids. Overall, green tea displayed superior antibacterial efficacy, while turmeric and fenugreek exhibited selective inhibitory effects and may serve as complementary antimicrobial agents. (Figure 3)

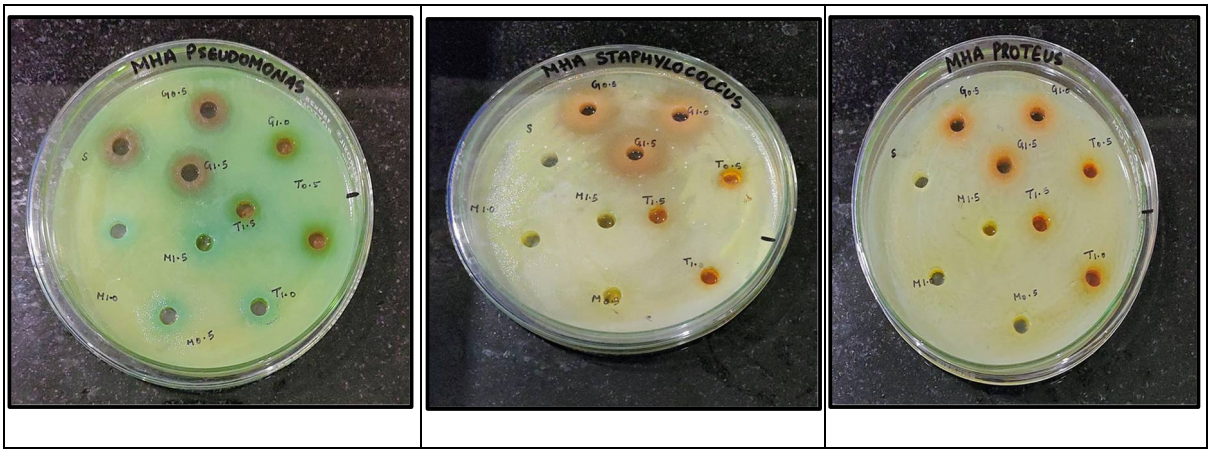



Figure 3 Antimicrobial activity of Ethanolic extracts of Green Tea, Turmeric, and Fenugreek using agar well diffusion method.

**Synergistic Effect of Green Tea and Turmeric**

The synergistic antimicrobial activity of green tea and turmeric extracts showed enhanced inhibition compared to the individual extracts. Among the combinations tested, the 2:1 ratio of green tea to turmeric exhibited the strongest antibacterial activity, particularly against *Staphylococcus* spp. Green tea played a major role in the synergistic effect due its high polyphenol and catechin content, especially EGCG, while turmeric contributed through the antibacterial activity of curcuminoids. The combination demonstrated broad-spectrum antimicrobial potential against *Bacillus, Pseudomonas, Staphylococcus,* and *Proteus spp.* (Figure 4)

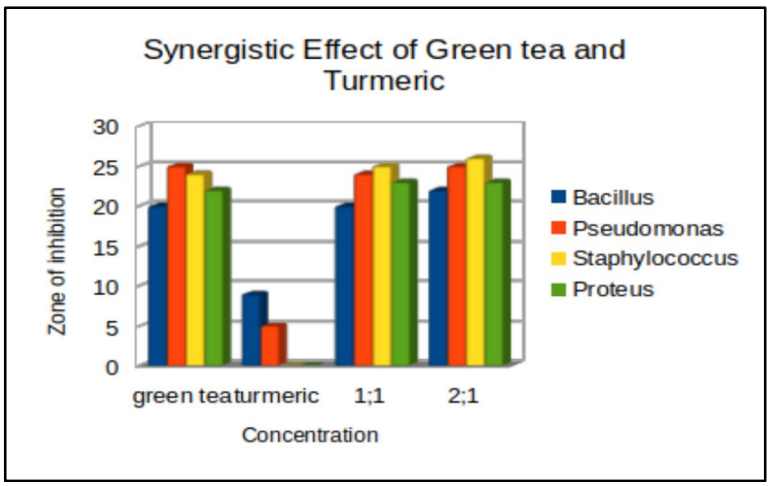



Figure 4 Graphical Representation of Synergistic effect of Green Tea and Turmeric

**Total Phenolic Content**

Total phenolic content (TPC) of green tea, turmeric and fenugreek extracts was estimated using the Folin-Ciocalteu method with gallic acid as the standard. The assay showed a linear increase in absorbance with increasing gallic acid concentration, confirming the reliability of the method. Among the tested samples, green tea exhibited the highest phenolic content (71.5µg/ml), followed closely by turmeric (70µg/ml), while fenugreek showed the lowest phenolic content (34µg/ml). The high phenolic content of green tea is mainly attributed by catechins and other polyphenols, whereas turmeric contains curcuminoids as major phenolic compounds. The comparatively lower phenolic content in fenugreek my be due to the predominance of other phytochemicals such as saponins, alkaloids, and dietary fibers. These findings indicate that green tea and turmeric are rich sources of phenolic antioxidants with significant biological potential. **(Figure 5)**

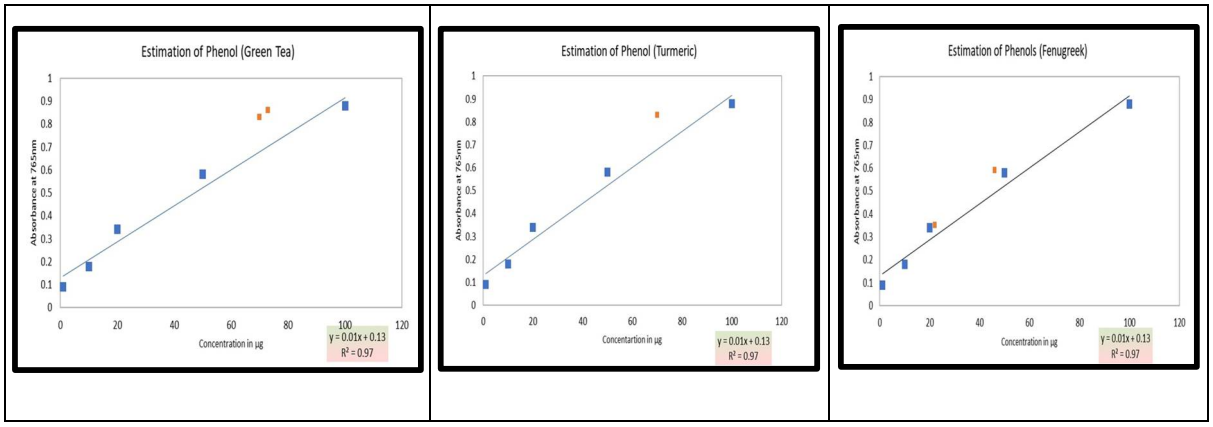



Figure 5 Phenol graph plot of Green tea, Turmeric and Fenugreek

From Standard graphs, shown in fig (5).
m=0.01 , c=0.13
y=absorbance
y= mx+c
x=y-c/m

| | | |
|---|---|---|
| Green tea UK1 = 0.83<br>x= 0.83-0.13/0.01<br>= 70µg/ml<br>Green tea UK2 = 0.86<br>x= 0.86-0.13/0.01<br>= 73µg/ml<br>Concentration = 70+73/2 = 71.5µg/ml or 0.0715 mg/ml. | Turmeric UK1 = 0.83<br>x= 0.83-0.13/0.01<br>= 70µg/ml<br>Turmeric UK2 = 0.83<br>x= 0.83-0.13/0.01<br>= 70µg/ml<br>Concentration = 70+70/2 = 70µg/ml or 0.07 mg/ml | Methi UK1 = 0.35<br>x= 0.35-0.13/0.01<br>= 22µg/ml<br>Methi UK2 = 0.59<br>x= 0.59-0.13/0.01<br>= 46µg/ml<br>Concentration = 22+46/2 = 34µg/ml or 0.034 mg/ml |

**Temperature Stability**

Temperature stability of green tea, turmeric, and fenugreek extracts was evaluated by monitoring changes in UV-Visible absorbance at different temperatures ($4^0$C, $25^0$C, and $37^0$C) over 24 hrs and 4 days. Green tea extract showed the highest thermal stability, with only a slight decrease in absorbance over time , indicating minimal degradation of catechins and polyphenols. Turmeric extract exhibited moderate temperature-dependent instability, with increased absorbance after prolonged incubation, suggesting possible degradation or oxidation of curcuminoids. Fenugreek extract showed the greatest sensitivity to temperature, particularly at $37^0$C, where a marked increase in absorbance was observed after 4 days, indicating significant thermal degradation and oxidative changes. Overall, the stability of the extracts followed the order: Green tea > Turmeric > Fenugreek, suggesting that lower storage temperatures are more suitable for maintaining phytochemical stability. **(Table 2)**

Table 2 Thermal Stability and Time-Dependent Changes in Green Tea, Turmeric and Fenugreek.

| Temperature | 24hr | 4days | 24hr | 4days | 24hr | 4days |
|---|---|---|---|---|---|---|
| $4^0$C | 1.20 | 1.00 | 0.83 | 0.99 | 0.43 | 0.55 |
| $25^0$C | 1.17 | 1.00 | 0.78 | 1.05 | 0.56 | 0.55 |
| $37^0$C | 1.18 | 1.00 | 0.78 | 1.22 | 0.50 | 1.47 |

## CONCLUSION

This study evaluated the effect of UV radiation on the antioxidant activity of green tea, turmeric and fenugreek, along with their phytochemical composition, antibacterial activity, phenolic content, and temperature stability. Phytochemical screening revealed that green tea and fenugreek possessed a broader range of bioactive compounds, including alkaloids, flavonoids, saponins, polyphenols, and carbohydrates, whereas turmeric showed a comparatively limited phytochemical profile. Before UV exposure, green tea exhibited the strongest antioxidant activity with the lowest $IC_{50}$ value, while turmeric and fenugreek showed weaker antioxidant potential. After UV exposure, fenugreek demonstrated the highest antioxidant activity, followed by green tea, whereas turmeric showed the lowest activity. These findings suggest that UV radiation influenced the antioxidant potential of the extracts differently depending on their phytochemical composition. Antibacterial analysis revealed that green tea exhibited the strongest broad-spectrum antibacterial activity against both Gram-positive and Gam-negative bacteria, while turmeric and fenugreek showed selective inhibitory effects against specific pathogens. The synergistic study further demonstrated enhanced antibacterial activity when green tea and turmeric were combined, particularly due to the contribution of catechins such as EGCG present in green tea.

Phenolic estimation confirmed that green tea contained the highest phenolic content, supporting its strong antioxidant and antimicrobial properties. Temperature stability studies showed that green tea possessed the highest thermal stability, whereas fenugreek was the most temperature-sensitive extract, especially at elevated temperatures. Overall, the study highlights the significant antioxidant and antibacterial potential of these medicinal plants and supports their possible application in pharmaceutical, nutraceutical, and functional food formulations.

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**CONFLICT OF INTEREST**

The authors declare that they have no conflict of interest.

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