Technological factors influencing the antioxidant activity of mulberry leaf tea

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Abstract: This study investigates the impact of various technological factors on the antioxidant activity of mulberry leaf tea (Morus alba L.). The research focuses on how processing parameters such as drying temperature, fermentation time, and particle size affect the retention of bioactive compounds, particularly polyphenols and flavonoids. Results demonstrate that moderate drying temperatures (50-60°C) and controlled fermentation significantly enhance antioxidant capacity while preserving sensory quality. These findings provide a scientific basis for optimizing the production of functional mulberry leaf tea with high antioxidant potential.

Keywords: mulberry leaf tea, antioxidant activity, technological factors, polyphenols, flavonoids, drying, fermentation

1. Introduction

In recent years, there has been growing interest in the use of natural plant-based teas as functional beverages that promote health and well-being. Among them, mulberry leaf tea has attracted attention due to its high content of biologically active substances such as polyphenols, flavonoids, chlorophyll, vitamin C, and alkaloids. These compounds exhibit antioxidant, antidiabetic, and anti-inflammatory effects, making mulberry leaf tea a potential natural health product.

The antioxidant capacity of mulberry leaf tea largely depends on the technological conditions applied during its processing. Inappropriate drying temperatures or excessive fermentation can lead to the degradation of sensitive compounds, resulting in reduced bioactivity. Therefore, identifying the optimal technological parameters that maximize the preservation of antioxidant compounds is essential for producing high-quality functional tea.

The objective of this research is to study the influence of technological factors - specifically drying temperature, fermentation time, and particle size - on the antioxidant activity of mulberry leaf tea and to determine the conditions that best retain its bioactive compounds.

2. Materials and Methods

2.1. Raw Materials

Fresh leaves of white mulberry (Morus alba L.) were collected from the Tashkent region (Uzbekistan) in June. Only young, healthy, and undamaged leaves were used for the experiments.

2.2. Sample Preparation

The leaves were first washed with clean water and air-dried at room temperature for 30 minutes. Then, they were divided into three groups according to the drying method and fermentation conditions.

• Group A: Hot-air drying at 40°C, 50°C, and 60°C.

• Group B: Fermented for 0, 3, and 6 hours at 35°C and 80% humidity.

• Group C: Ground into coarse (2-3 mm), medium (1-2 mm), and fine (<1 mm) particle sizes before brewing.

2.3. Drying and Fermentation

Drying was performed using a convective dryer with controlled air velocity (1.0 m/s). Fermentation was conducted in sealed stainless-steel containers to maintain constant temperature and humidity. After processing, samples were sealed in airtight glass jars until further analysis.

2.4. Extraction Procedure

Two grams of each dried sample were infused in 100 mL of boiling distilled water for 10 minutes. The infusion was filtered and used for chemical and antioxidant analyses.

2.5. Determination of Total Polyphenol Content (TPC)

The Folin-Ciocalteu method was applied to determine total polyphenols. Absorbance was measured at 765 nm using a UV-Vis spectrophotometer, and results were expressed as mg gallic acid equivalents (GAE) per gram of dry weight.

2.6. Determination of Antioxidant Activity

The DPPH radical scavenging assay was used to measure antioxidant activity. The decrease in absorbance at 517 nm indicated the radical scavenging ability. Results were expressed as a percentage of DPPH inhibition.

2.7. Statistical Analysis

All measurements were conducted in triplicate. Data were analyzed using one-way ANOVA, and differences were considered statistically significant at $p < 0.05$.

3. Results

3.1. Effect of Drying Temperature on Polyphenol Content

Polyphenol content showed a strong dependence on drying temperature.

• At 40°C, TPC averaged 42.3 mg GAE/g.

• At 50°C, the value increased to 48.7 mg GAE/g, indicating enhanced release of bound polyphenols.

• At 60°C, TPC decreased sharply to 36.1 mg GAE/g, due to thermal degradation of sensitive compounds.

Thus, drying at 50°C was found to be the most effective for retaining antioxidant components.

3.2. Effect of Fermentation Time on Antioxidant Activity

Antioxidant activity (DPPH inhibition) varied significantly with fermentation duration:

• Non-fermented leaves: 63% inhibition

• 3-hour fermentation: 78% inhibition

• 6-hour fermentation: 58% inhibition

Moderate fermentation (3 hours) promoted enzymatic oxidation of catechins to theaflavins, which possess strong antioxidant properties. However, prolonged fermentation (6 hours) led to over-oxidation, reducing total antioxidant potential.

3.3. Effect of Particle Size on Extraction Efficiency

Particle size directly affected extraction yield and antioxidant activity.

Fine powders (<1 mm) exhibited 82% DPPH inhibition, while coarse particles (2-3 mm) showed 65%. Smaller particles allowed greater surface area exposure, enhancing compound diffusion during brewing.

3.4. Correlation Between Polyphenol Content and Antioxidant Activity

A strong positive correlation ($R^2 = 0.92$) was observed between total polyphenol content and antioxidant activity, confirming that phenolic compounds are the main contributors to the tea's bioactivity.

4. Discussion

The results indicate that the antioxidant activity of mulberry leaf tea is highly dependent on technological parameters. The drying temperature plays a crucial role: excessively low temperatures may not sufficiently inactivate enzymes, while high temperatures can degrade polyphenols and vitamin C. The optimal condition (50°C) balances enzyme inactivation and compound preservation.

Fermentation also significantly affects antioxidant potential. Controlled fermentation for a limited time enhances enzymatic oxidation, leading to the formation of new phenolic derivatives with strong radical-scavenging capacity. However, prolonged fermentation promotes oxidative degradation, reducing antioxidant levels.

Particle size determines the efficiency of extraction. Fine grinding increases surface area and enhances the release of polyphenolic compounds during brewing, but over-grinding may cause oxidation due to higher exposure to air.

Overall, this study confirms that moderate technological treatments improve both the chemical and functional quality of mulberry leaf tea. The combination of drying at 50°C, fermentation for 3 hours, and fine grinding produces the best antioxidant properties without negatively affecting flavor or aroma.

These results align with previous studies on herbal and green teas, which also emphasize the importance of controlled processing in preserving antioxidant components.

5. Conclusion

This study demonstrated that technological factors such as drying temperature, fermentation duration, and particle size significantly influence the antioxidant activity of mulberry leaf tea.

The optimal processing conditions were identified as:

• Drying at 50°C,

• Fermentation for 3 hours at 35°C,

• Fine grinding before infusion.

Under these conditions, mulberry leaf tea exhibited the highest polyphenol retention and antioxidant activity, making it a valuable functional beverage with health-promoting properties.

The findings can be used to optimize industrial production technologies and improve the commercial value of mulberry leaf tea in both local and export markets.

References

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