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Comparative Assessment of the Physicochemical Parameters of White Tea Leaves Collected in Khelvachauri Municipality (Makho Village) under Different Processing Conditions

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ABSTRACT

This study presents an assessment of the quality and physicochemical characteristics of white tea (*Camellia sinensis*) leaves collected in Makho village, Khelvachauri Municipality, under different processing conditions: thermal drying at 50°C for 2 hours, and freezing at −5°C for 24 hours followed by thermal drying at 70°C.

The experimental results demonstrated that the white tea sample processed at 50°C retained superior organoleptic properties, significantly higher contents of catechins, tannins, and vitamin C, as well as a higher pH value. In contrast, the combined processing regime involving freezing and subsequent thermal drying at **70°C** resulted in partial oxidation of polyphenols, a reduction in catechin and tannin contents, and an increase in extract acidity. However, this treatment enhanced the extraction of certain mineral elements, including potassium (K), iron (Fe), and nickel (Ni).

The study established that mild thermal drying (50°C) is more effective for preserving the bioactive compounds of white tea, whereas the combined processing technology (−5°C for 24 h followed by thermal drying at 70°C) promotes the release of the mineral fraction to a greater extent.

KEYWORDS: white tea; processing method; organoleptic properties; physicochemical parameters; quality

Relevance of the Research. White tea is a minimally processed type of tea whose quality and functional value are highly dependent on the technological conditions used during raw material processing. Studying the effects of different processing regimes on the quality characteristics of tea is particularly important, as modern food science increasingly focuses on the preservation of bioactive compounds and the development of functional foods. Evaluating white tea processed by different methods makes it possible to determine the optimal conditions for obtaining high-quality products characterized by strong antioxidant activity, as well as significant functional and pharmacological value.

Aim of the Study. The aim of the study was to investigate the quality characteristics of white tea leaves collected in Makho village, Khelvachauri Municipality, under different processing conditions: thermal drying at **50°C for 2 hours**, and freezing at **–5°C for 24 hours** followed by drying at **70°C for 4 hours**.

Research Object. The research object consisted of white tea (*Camellia sinensis*) leaves collected from a household plot in Makho village, Khelvachauri Municipality, Georgia.

Methods Used in the Study. The following analytical methods were employed: Gravimetric method [8]; Titrimetric method [9, 12]; Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) [15]; Comparative assessment method.

Material and Technical Base. The experimental work was carried out at the Institute of Agrarian and Membrane Technologies, Batumi Shota Rustaveli State University (BSU).

I. HISTORY OF WHITE TEA AND REGIONAL CHARACTERISTICS

White tea is a minimally processed type of tea derived from the plant *Camellia sinensis*. Its unique chemical composition is largely determined by the low degree of oxidation during processing, which contributes to the preservation of high concentrations of polyphenolic compounds. White tea is characterized by minimal processing of leaves and buds, as particularly gentle methods are employed during raw material preparation, resulting in the omission of certain technological processing stages [1, 3]. The province of Fujian in China is considered the birthplace of white tea; however, today it is also produced in Yunnan Province, India, Laos, and Sri Lanka. The name “white tea” is associated not only with the appearance of the leaves but also with a long-standing tradition, as the raw material consists of young leaves from the upper branches of the tea plant and tender buds (tips) covered with fine silvery-white hairs. These hairs are the origin of the tea’s name [13, 14]. Several varieties of white tea are recognized, including Bai Hao Yin Zhen (Silver Needle), Bai Mu Dan (White Peony), Shou Mei (Longevity Eyebrows), and Gong Mei (Tribute Eyebrows) [4, 5]. White tea production in Georgia is currently at an early stage of development. Small-scale farmers and boutique tea producers, such as Gurieli Tea, Georgian Tea, Renegade Tea Estate, and Tea House Guria, are actively working to produce organic and premium-quality teas. These producers are distinguished by hand-picking only the first buds and tender leaves, using low-temperature drying techniques, avoiding chemical additives, and producing small batches of high-quality tea products. The regions of Guria and Adjara are particularly notable for the implementation of experimental processing technologies and the development of premium white tea production.

II. NUTRITIONAL VALUE, THERAPEUTIC POTENTIAL, AND PROCESSING TECHNOLOGY OF WHITE TEA

White tea leaves contain vitamins (B, C, and E), amino acids, macro – and microelements, and antioxidants, including polyphenols and catechins. White tea is known to support the immune system, help combat free radicals, slow the aging processes of the skin and the body, improve metabolism, promote the elimination of toxins, and exert a calming effect [2, 6]. White tea infusion is beneficial for the cardiovascular system, contributes to the normalization of cholesterol levels, and may reduce the risk of hypertension and cardiovascular diseases. Due to its minimal processing, white tea undergoes limited enzymatic transformation and retains a more complete phytochemical profile. White tea also contains less caffeine than many other tea types; therefore, it has a milder stimulating effect and a comparatively greater calming influence on the body [7, 10, 11]. To obtain the maximum benefits and preserve the valuable properties of white tea, proper brewing is essential. The recommended water temperature is 75–80°C. Approximately 2–3 g of tea leaves should be infused in 200 mL of water for 3–5 minutes. The use of a porcelain or glass teapot is recommended to achieve the best sensory and quality characteristics of the infusion.

III. COMPARATIVE ASSESSMENT OF THE QUALITY CHARACTERISTICS OF WHITE TEA LEAVES

III.1. Organoleptic Characteristics of White Tea Leaves Processed by Different Methods

The white tea sample dried at **50°C** was characterized by a greenish color and the preservation of white buds, indicating minimal damage to the raw material. In contrast, the second sample, which underwent freezing followed by drying at **70°C,** exhibited a brown coloration of the leaves, likely resulting from damage to the cellular structure and oxidation of polyphenolic compounds (Table 1). The infusion prepared from the first sample displayed a light yellow, straw-like color, reflecting the relatively mild processing conditions. The infusion of the second sample showed an amber color tending toward light brown, suggesting partial oxidation of polyphenols, transformation of pigments, and a more intensive transfer of extractive substances into the infusion. The tea dried at **50°C** was characterized by a delicate and distinctive flavor. The mild processing regime contributed to the preservation of aromatic compounds and amino acids. In contrast, the sample processed by freezing and subsequent drying at **70°C** exhibited a slightly astringent taste, which may be associated with the oxidation of catechins and tannins. In the first sample, the leaves retained their green coloration and natural shape, whereas the brown coloration observed in the second sample indicates more pronounced oxidative and thermal changes in the leaf tissue.

Table 1. Organoleptic Characteristics

Parameter	White Tea Obtained by Thermal Drying (50°C)	White Tea Obtained by Freezing (-5°C) Followed by Thermal Drying (70°C)
Appearance	Greenish-colored leaves with white buds (one bud and two leaves)	Brown-colored leaves (one bud and two leaves)
Infusion Color	Light yellow (straw-colored)	Amber-colored (tending toward light brown)

Aroma and Taste	Pleasant aroma and a very delicate characteristic taste	Pleasant aroma with a slightly astringent aftertaste
Color of Brewed Leaves	Leaves developed a green coloration and retained the natural shape of one bud and two leaves	Brown coloration of the leaves remained unchanged

III.2. QUALITY CHARACTERISTICS OF WHITE TEA LEAVES PROCESSED BY DIFFERENT METHODS

The content of extractive substances was higher in the first sample, which may be attributed to the lower degree of structural degradation under mild drying conditions. As a result, soluble organic compounds were better preserved (Table 2). The contents of tannins and catechins were also higher in the first sample. This can be explained by the partial degradation and oxidation of these compounds under the higher temperature and oxidative conditions applied to the second sample. The increased total ash content observed in the second sample indicates a relatively higher concentration of mineral substances. This phenomenon is likely associated with cellular disruption during freezing, followed by intensive dehydration during drying at **70°C**.

The infusion prepared from the first sample was less acidic, whereas the acidity of the second sample was higher. The combination of freezing and subsequent high-temperature drying promotes more intensive oxidation of polyphenolic compounds and the release of greater amounts of organic acids. The vitamin C content was significantly higher in the first sample. Vitamin C (ascorbic acid) is a thermolabile compound that is readily degraded through oxidation under the influence of oxygen and elevated temperatures. Therefore, the **70°C drying regime** accelerates the decomposition of ascorbic acid, resulting in lower concentrations in the second sample.

Table 2. Quality Characteristics of White Tea Samples

Processing Method	Extractive Substances (%)	Tannins (%)	Catechins (%)	Total Ash (%)	Vitamin C (mg/100 g)	pH
Thermal drying (50°C)	19.75	20.37	6.25	0.39	48.2	5.6
Freezing (-5°C) + Thermal drying (70°C)	18.25	14.55	4.00	0.42	32.6	4.9

III.3. MULTI-ELEMENT ANALYSIS OF WHITE TEA LEAVES PROCESSED BY DIFFERENT METHODS

The white tea sample processed by **freezing** contained a higher concentration of **potassium (9360 mg/L)** compared with the sample obtained by **thermal drying (8460 mg/L).** In contrast, no significant differences were observed between the samples in terms of **calcium** and **magnesium** contents (Tables 3 and 4). The **sodium** content in the first sample was approximately **2.4 times higher** than that of the second sample. This may be associated with the greater concentration effect of dry matter during thermal processing. The **phosphorus** content was also higher in the first sample, which may be attributed to more efficient extraction or preservation of phosphorus from phosphorus-containing organic compounds. Among the **microelements,** the dominant elements were **Mn, Si, and Al** (Table 4). **Cobalt** and **nickel** were detected only at **trace levels.**

The toxic elements **As, Cd, Pb, Hg, Sb, Ti, Li, Ba, Be, V** were **not detected** in either sample, indicating the safety of the analyzed tea leaves with respect to toxic element contamination.

Table 3. Concentrations of Macroelements (mg/L)

Processing Regime	K	Ca	Mg	Na	P
Thermal drying (50°C)	8460	1510	1350	734	4110
Freezing (-5°C) + Thermal drying (70°C)	9360	1530	1300	301	3480

Table 4. Concentrations of Microelements (mg/L)

Sample No.	Fe	Si	B	Al	Co	Cu	Mn	Ni	Zn
No. 1 (Thermal drying, 50°C)	53.2	84.2	7.78	339	0.622	18.7	51.4	3.04	24.8
No. 2 (Freezing, −5°C + Thermal drying, 70°C)	27.8	86.5	10.1	365	0.152	19.2	63.9	6.94	19.1

IV. INTEGRATED COMPARISON OF THE QUALITY PARAMETERS OF WHITE TEA PROCESSED UNDER DIFFERENT CONDITIONS

The comparative study of white tea samples processed under different technological regimes demonstrated that the sample dried at **50°C** is characterized by higher quality parameters. It retains the natural greenish coloration typical of white tea, a delicate aroma, and a mild taste, indicating relatively gentle processing conditions. Mild thermal treatment ensures the stability of biologically active polyphenolic compounds. The sample dried at 50°C also better preserves vitamin C. In contrast, the sample obtained by **freezing (−5°C) followed by drying at +70°C** exhibited more pronounced physicochemical changes, including brown coloration of the leaves, a darker infusion color, and a slightly astringent taste, along with reduced levels of catechins and tannins. Both samples were found to be environmentally safe.

Table 5. Comparative Integrated Characteristics of White Tea Processed by Different Methods

Parameter	White Tea Obtained by Thermal Drying at 50°C	White Tea Obtained by Freezing (-5°C) + Drying at 70°C	Assessment
Appearance	Greenish coloration, good preservation of white buds	Brown coloration	50°C regime better preserves natural structure and chlorophyll
Infusion color	Light yellow, straw-colored	Amber, light brown	High temperature enhances oxidation of polyphenols
Aroma and taste	Delicate, soft, and characteristic taste	Pleasant aroma but astringent taste	50°C better preserves aromatic compounds
Brewed leaf color	Green coloration and natural shape	Brown leaves	Freezing + 70°C causes stronger oxidative changes
Extractive substances (%)	19.75	18.25	Mild drying ensures chemical stability
Tannins (%)	20.37	14.55	High temperature reduces tannin content
Catechins (%)	6.25	4.00	50°C better preserves antioxidant compounds

Total ash (%)	0.39	0.42	Freezing + 70°C increases mineral fraction concentration
pH	Higher pH, lower acidity	Lower pH, higher acidity	Intensive processing increases organic acid release
Vitamin C	Higher content	Reduced content	High temperature leads to vitamin C degradation
Potassium (K, mg/L)	8460	9360	Freezing increases mineral extraction
Calcium (Ca, mg/L)	1510	1530	Difference is negligible
Magnesium (Mg, mg/L)	1350	1300	Difference is negligible
Sodium (Na, mg/L)	734	301	Thermal drying causes concentration effects
Phosphorus (P, mg/L)	4110	3480	Thermal regime enhances phosphorus release
Dominant elements	Mn, Al, Si	Mn, Al, Si	Same dominant elements in both samples
Fe (mg/L)	7.78	10.1	Freezing increases Fe extraction
Zn (mg/L)	24.8	19.1	Zn is more sensitive to intensive processing
Trace elements	Co, Ni	Co, Ni	Present in trace amounts in both samples
Toxic elements	Not detected	Not detected	Both are ecologically safe

CONCLUSION

Thermal drying at 50°C is a more effective technological regime for preserving the high quality, organoleptic properties, and bioactive compounds of white tea. In contrast, the combined method of freezing and high-temperature drying contributes to a greater extraction of mineral elements; however, it simultaneously leads to the partial degradation and loss of important bioactive substances.

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