



Comparative Study on Calcium-enriched Finger Millet Tisane: Optimizing Soaking and Roasting Methods

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study focuses on the development of a calcium-rich herbal tisane using finger millet, a grain known for its high calcium content, aimed at enhancing dietary calcium intake. Two distinct processing methods were employed to optimize the calcium content of the tisane. In Treatment 1, Finger millet was roasted and combined with spice powder, while in Treatment 2, Finger millet underwent soaking, cabinet drying, roasting, and then blending with spice powder. The calcium content and overall quality of both treatments were evaluated, revealing a marginal increase in calcium concentration in Treatment 2, attributed to the additional processing steps. Specifically, Treatment 2 yielded a maximum calcium content of 396 mg compared to 380 mg in Treatment 1, demonstrating the effectiveness of the additional soaking and drying steps in enhancing calcium bioavailability. The final product was further enriched with a blend of spices, including dry ginger, cinnamon, cardamom, Arjuna bark, fennel seeds, and Tulsi leaves, contributing to its healthful properties. Organoleptic evaluations, conducted to assess sensory attributes such as flavor, aroma, and overall acceptability, indicated that both treatments were well-received by consumers. This suggests the product's potential for consumer acceptance and market viability. The findings suggest that calcium-enriched Finger millet tisane could serve as a valuable functional beverage, particularly for populations at risk of calcium deficiency. Its nutrient profile, combined with favorable sensory attributes, positions it as a promising option for improving dietary calcium intake and promoting overall health. Further research on larger sample sizes and bioavailability studies could reinforce its potential as a functional health beverage.

Keywords: *Tisane; calcium; finger millet; herbal tea; infusion; healthful beverage; functional herbs; nutritional enhancement.*

1. INTRODUCTION

Tisane is an infusion beverage composed of a mixture of various ingredients such as leaves, seeds, herbs, legumes, tree bark, fruits, or flowers that are dried, or parts of plants that provide aroma and flavour while also being beneficial for health. Tisanes can offer health benefits such as antioxidant, antimicrobial, antihemolytic, and cytotoxic activities [1].

Tisane, also known as herbal tea, is a beverage made from the infusion or decoction of herbs, spices, flowers, fruits, and other plant materials, excluding the leaves of the tea plant (*Camellia sinensis*). Unlike traditional tea, tisanes are naturally caffeine-free, making them a popular choice for those looking to reduce their caffeine intake [2].

Health-based natural ingredient beverages have become an alternative for health-conscious individuals. The increasing awareness of a healthy lifestyle among the public is reflected in the healthy living patterns adopted in their daily lives. In addition to consuming healthy food daily, beverages that support health are gaining popularity, and one of these is tisane [3].

Tisane has become popular among tea enthusiasts because, besides its pleasant taste

and aroma, it offers health benefits and relaxation. Regular consumption of tisane can be used as a therapeutic treatment to improve heart health, address digestive issues, boost energy and vitality, enhance the immune system, provide essential antioxidants for the body, reduce stress, improve sleep quality, and stimulate the functioning of various organs [4].

Tisanes are a potential source of phytochemicals to reduce disease risk conditions and are used to protect from non-communicable diseases, globally. A few tisanes have gained more popularity than others depending on their chemical composition based on the geographical origin of the used herb. Several Indian tisanes have been claimed to have traits beneficial to people with or at a high risk of type 2 diabetes mellitus [5].

Tisanes have long since been used in many traditional medicinal systems to reduce the burden of diseases. There are several kinds of tisanes (infusions/decoctions), which are consumed for energising and reducing tension and anxiety to curb gastrointestinal problems and boost the body's immunity. Some of these tisanes possess extremely strong medicinal benefits that are used to treat inflammations, bacterial, and viral infections, and even help patients living with HIV and AIDS, so researchers

are exploring and vouching for different tisanes from time to time [6]. I referenced techniques from kombucha preparation to guide the formulation of my calcium-enriched tisane, tailoring the process to suit the unique properties of millet [7].

Hence, this study has been planned to formulate tisane from finger millet with rich calcium to enhance the consumption of finger millet in daily diet as an easiest way.

2. MATERIALS AND METHODS

2.1. Roasting of Finger Millet

The raw Finger millet, sourced from the local market, is carefully selected to ensure it is clean and free from impurities. Before roasting, the Finger millet grains are inspected for any foreign particles, and thoroughly washed and dried to maintain the quality of the final product. The roasting process is carried out in a pre-heated roasting pan, with the temperature maintained consistently between 80-85°C to ensure even cooking. During roasting, the Finger millet grains are continuously stirred to prevent burning and ensure uniform heat distribution across all the grains. The roasting continues until the Finger millet emits its distinct nutty aroma, signaling that the grains are adequately roasted. Once the roasting is complete, the Finger millet is immediately transferred from the pan and spread out to cool naturally at room temperature. This step is crucial to avoid overcooking, which could affect the flavor and nutritional profile of the grains. The cooling process allows the grains to stabilize before further processing. After cooling, the roasted Finger millet is coarsely ground into a powder form using a grinder. This step breaks down the grains into a manageable, fine consistency while preserving the integrity of the nutrients. The coarsely ground powder is then sifted to ensure uniform particle size, ready for use in the subsequent stages of tisane preparation.

2.2 Soaking and Roasting of Finger Millet

The Finger millet, sourced from a local market, undergoes a soaking process as the first step in preparation. The grains are thoroughly rinsed to remove any surface impurities or dirt before being submerged in clean water. The Finger millet is soaked for approximately 24 hours, allowing the grains to absorb water and initiate the enzymatic changes that may enhance nutrient bioavailability; including calcium. After

the 24-hour soaking period, the Finger millet is drained and spread evenly on trays to be dried. The drying process is conducted using a cabinet dryer, with the temperature carefully controlled at 70°C. The Finger millet remains in the dryer for about 30 hours, ensuring the grains are fully dried without damaging their nutritional properties. The slow drying process helps to preserve the integrity of the grain, removing moisture without affecting the delicate balance of nutrients. Once dried, the Finger millet is transferred to a pan for roasting. The pan roasting is done at 80°C, where the grains are continuously stirred to ensure even roasting. The roasting continues until the characteristic nutty aroma of Finger millet develops, indicating that the grains have reached the desired level of roasting. Following roasting, the Finger millet is allowed to cool naturally to ambient temperature. Cooling is essential to stabilize the roasted grains and prevent over-roasting, which could negatively affect the flavor and nutrient content. Once the grains are completely cooled, they are coarsely ground into a powder using a grinder. This powder retains the essential nutrients of the grain and serves as the base for further formulation of the calcium-enriched tisane.

2.3 Preparation of Spice Powder

The whole spices, including cardamom, cinnamon, dry ginger, fennel seeds, and Arjuna bark, are carefully sourced from the local market to ensure freshness and quality. The roasting process is carried out in a heated pan over medium heat. Each spice is added in appropriate quantities, with continuous stirring to ensure uniform roasting. This roasting process enhances the flavor profile of the spices, while also helping to extend their shelf life by reducing moisture content. Roasting also intensifies the flavors, which will enrich the final tisane blend. Once the spices have been evenly roasted, they are allowed to cool at room temperature. After cooling, the roasted spices are finely ground into a powder using a spice grinder. The powdered spice mixture is then combined with dried Tulsi leaves, which are gently crumbled and mixed into the blend. Tulsi leaves are added in their dried form to preserve their natural medicinal properties and flavor, which complement the roasted spice mixture.

2.4 Procedure for Preparation of tea Bag

The ground Finger millet from both treatments is mixed with the finely ground spice powder,

consisting of cardamom, cinnamon, dry ginger, fennel seeds, Arjuna bark, and Tulsi leaves, in a 1:1 ratio. This blend ensures an even distribution of both flavor and nutritional benefits. The mixture is then carefully portioned into empty tea dip bags, which are sealed for convenience and freshness, allowing for easy preparation and optimal infusion when steeped in hot water.

2.5 Procedure for Preparation of Finger millet Tisane

The prepared tea bags are immersed in boiling hot water and steeped for 5 minutes to allow the flavors and nutrients to infuse fully. Once the infusion is ready, it is served with the addition of jaggery for sweetness, lemon juice for a hint of citrus and black salt for enhanced flavor, creating a balanced and refreshing tisane.

Table 1. Details of treatments

S. No	Treatment number	Name of the Treatment
1	Treatment 1(T ₁)	Roasting
2	Treatment 2(T ₂)	Soaking and roasting

2.6 Physical Characteristics

Diffusion is described as the transfer of chemicals from a high concentration area to a low concentration area. There are several molecules within the herbal infusion bags which cannot flow through the bags, but smaller particles comprising essence, color, and taste may diffuse through the membrane of the bags. Heat from boiling water enables the molecules in the infused substance to move significantly quicker than they would at a normal temperature [8].

2.7 Bio- Chemical Characteristics

The bio- chemical characteristics of the Finger millet tisane were evaluated. Some of the chemical characteristics such as moisture [9], protein [10], ash [11], pH [12], ascorbic acid [13] and calcium [12] are discussed. The moisture content is done by hot air oven method, protein content by analysed by the Kjeldahl method and the ash content was done by muffle furnace effectively.

2.8 Organoleptic Characteristics

Sensory evaluation was conducted to evaluate the organoleptic characters of finger millet tisane.

A panel of ten trained judges and evaluated the tea bags at an interval of once in 15 days for a period of 30 days. The organoleptic evaluation sessions were conducted one hour before lunch under adequate conditions of temperature, humidity and illumination. The panellists were asked to score the colour, appearance, flavour, texture, taste and overall acceptability of the above mixes on a scale of 9 to 1 hedonic scale.

3. RESULTS AND DISCUSSION

The results obtained from the present investigation is presented in this chapter. The findings of the experiment are presented in the preceding chapter revealed that the effect of tisane and treatment significantly influenced the physical-chemical characteristics during the storage period of 1 month. In the ensuring pages efforts has been made to establish causes and effects of relationship amongst various parameters, which were found to be influenced significantly.

3.1 Physical Characteristics of Calcium rich Finger millet Tisane

The results of physical characteristics of calcium-rich finger millet tisane with different treatments are discussed. Each tea bag of both the treatments (T₁ and T₂) was soaked for 5 min in 125 mL of preheated (100°C) water before being removed and dried in a hot air oven until no further drying occurred. Each bag was then weighed.

The physical characteristics of calcium-rich finger millet tisane were evaluated by analyzing the solubility index. After soaking each tea bag (T₁ and T₂) in 125 mL of preheated water (100°C) for 5 minutes, the bags were dried in a hot air oven until no further weight change occurred. The solubility index can be inferred from the weight difference, indicating how much of the bioactive components, such as calcium, dissolved into the water. Treatment 2 (T₂), involving soaking, drying, and roasting, is likely to show a higher solubility index compared to Treatment 1 (T₁), due to enhanced structural breakdown during the additional processing steps, leading to better extraction of soluble compounds.

3.2 Bio -Chemical Characteristics of Calcium Rich Finger millet Tisane

The results of bio - chemical characteristics of calcium-rich finger millet tisane with different treatments are discussed.

Table 2. Bio- chemical characteristics of calcium rich finger millet tisane

Nutritional parameters	Treatment 1	Treatment 2	SED	CD (p= 0.05)
Moisture (%)	3.5	4.3	0.08	0.23
Protein (g/100g)	7.4	7.8	0.09	0.24
pH	6.5	6.8	0.07	0.18
Vitamin C (mg/100g)	20	30	0.47	1.30
Calcium (mg/100g)	380	396	0.47	1.30

*Treatment value found significant at p= 0.05

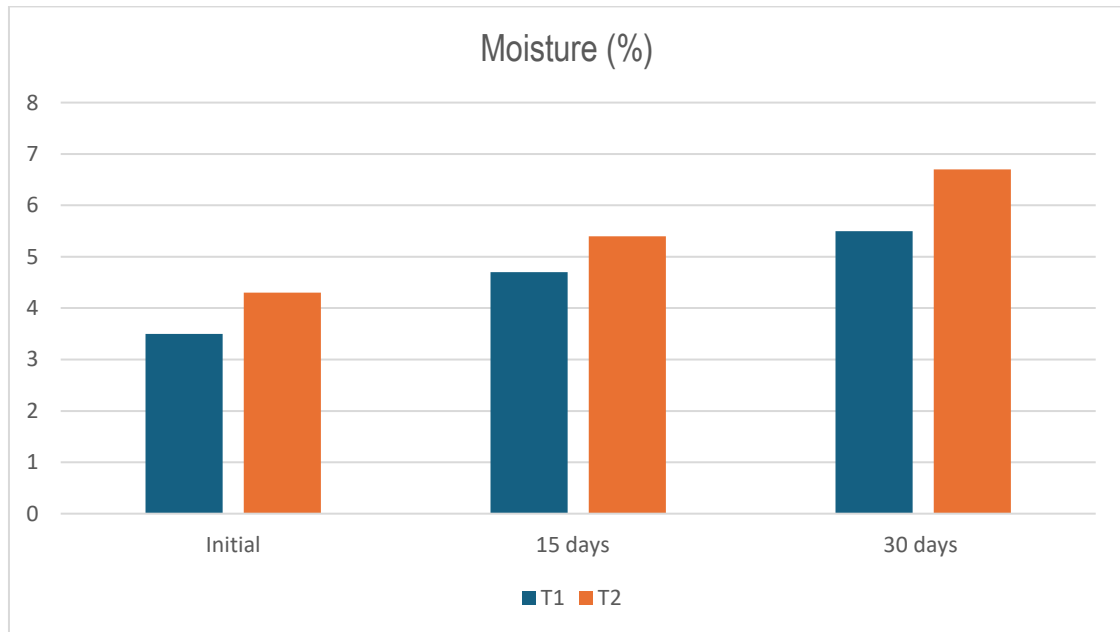


Fig. 1. Effect of treatments on moisture content of Calcium rich Finger millet Tisane

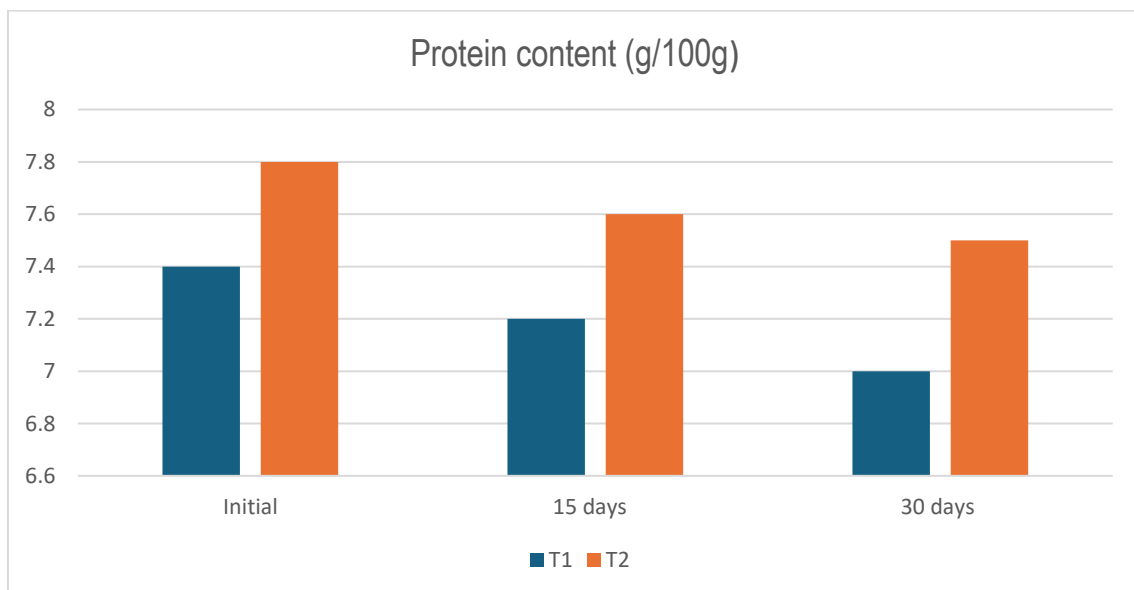


Fig. 2. Effect of treatments on protein content of Calcium rich Finger millet Tisane

The maximum moisture content (4.3%) was observed in T₂, whereas the minimum moisture content (3.5%) was observed in T₁ after 15 days of storage. The increased moisture content in T₂ can be attributed to the additional soaking compared to T₁. This observation aligns with findings by Balkrishna and Visvanathan [14], who noted that increased soaking time leads to a significant rise in the moisture content of finger millet. The moisture content was monitored over a 30-day period as well. After 30 days, the moisture content increased to 4.7% for T₁ and 5.5% for T₂ at 15 days, and further rose to 5.4% for T₁ and 6.7% for T₂ after 30 days. This suggests a continual increase in moisture with extended storage, particularly in T₂ due to the soaking process.

The maximum protein content (7.8 g) was observed in T₂, whereas the minimum protein content (7.4 g) was found in T₁. Shingote et al. [15] examined the effects of various pre-treatments on the nutritional composition of sorghum, green gram, and finger millet, emphasizing that soaking finger millet leads to a notable increase in protein content. This increase is primarily due to the activation of enzymes such as proteases and amylases during the soaking process, which break down storage proteins and enhance the bioavailability of amino acids and other nutrients. These enzymes not only improve the nutritional profile of finger millet but also facilitate its digestibility, making it more beneficial for health. The protein content was monitored over 15 and 30 days of storage. After 15 days, the protein content decreased to 7.2% in T₁ and 7.6% in T₂. After 30 days, the decline continued,

with T₁ showing 7.0% protein and T₂ maintaining 7.5%. This pattern demonstrates how soaking pre-treatment, by activating key enzymes, helps preserve protein content over time, particularly in T₂, where the protein profile remained more stable.

The maximum pH value (6.8) was observed in T₂, whereas the minimum pH value (6.5) was found in T₁. The pH of T₁ decreased to 6.4 after 15 days and 6.3 after 30 days, whereas in T₂, the pH values remained slightly higher, decreasing to 6.7 after 15 days and 6.6 after 30 days.

Additionally, the highest Vitamin C content was observed in T₂ (30 mcg), while the lowest Vitamin C content (20 mcg) was recorded in T₁. Bhagate et al. [16] demonstrated that soaking finger millet significantly increases its vitamin C levels, which can be attributed to the activation of enzymes such as ascorbate, oxidase and peroxidase during the soaking process. These enzymes help enhance the bioavailability of nutrients, particularly ascorbic acid, which contributes to the improved nutritional profile of the grain. The pH and Vitamin C content were also monitored over 15 and 30 days. The Vitamin C content of T₁ decreased to 18 mcg after 15 days and 12 mcg after 30 days, while in T₂, the Vitamin C content remained slightly higher, decreasing to 25 mcg after 15 days and 22 mcg after 30 days. This trend aligns with the increased Vitamin C levels in T₂, where the soaking process helped maintain better nutrient retention, as evidenced by the higher pH stability and Vitamin C content throughout storage.

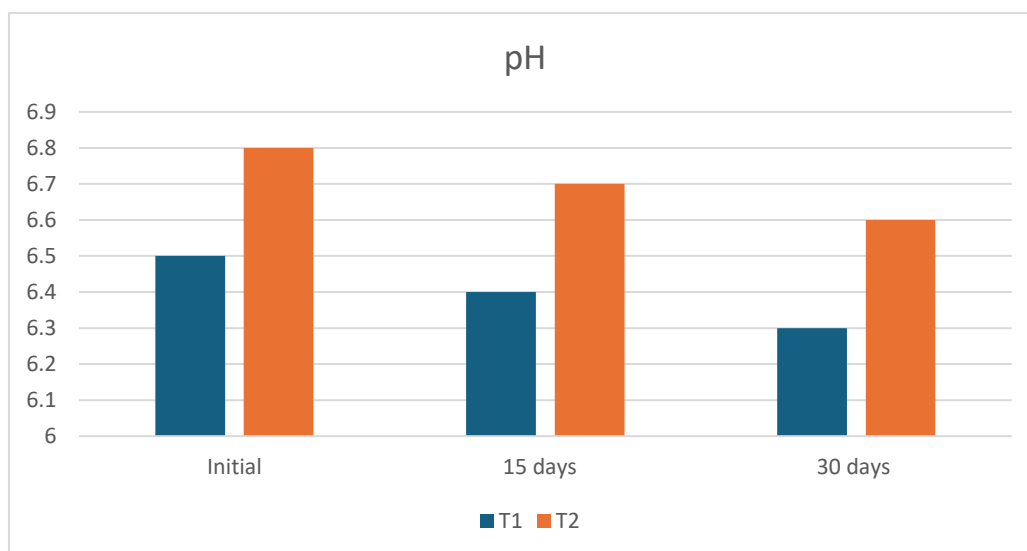


Fig. 3. Effect of treatments on pH of Calcium rich Finger millet Tisane

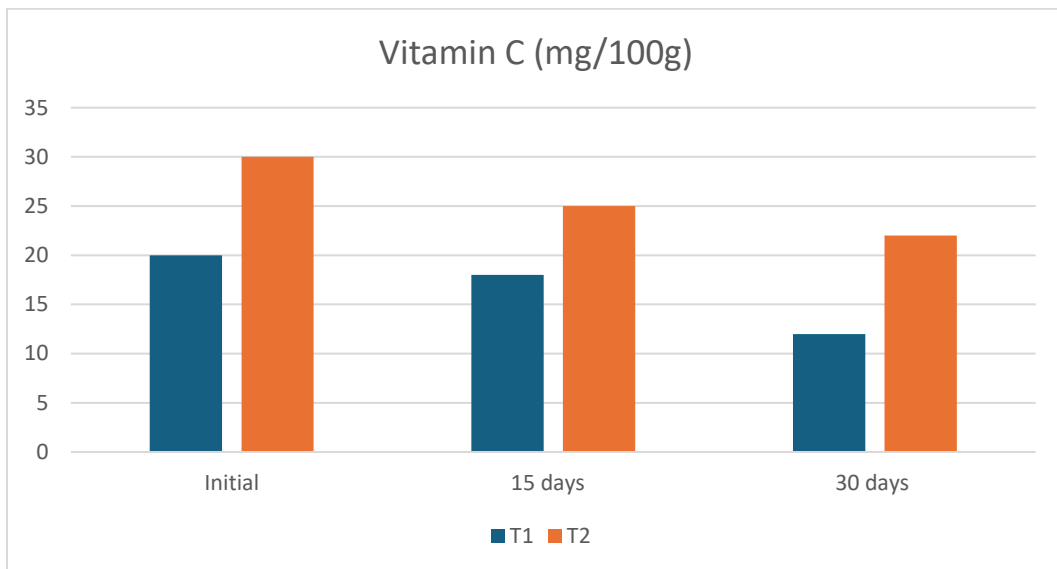


Fig. 4. Effect of treatments on Vitamin C of Calcium rich Finger millet Tisane

The maximum calcium content (396 mg) was observed in T₂, whereas the minimum calcium content (380 mg) was found in T₁. The results indicate that T₂, which combines soaking and roasting, has a higher nutrient content compared to T₁. Anitha et al. [17] conducted a systematic review and meta-analysis on calcium retention from finger millet, specifically examining the effects of soaking on its calcium content. Soaking finger millet is shown to enhance the bioavailability of calcium by reducing anti nutritional factors such as phytic acid, which can inhibit calcium absorption. This reduction of

phytic acid increases the effective calcium content available for absorption in the body. The calcium content was further evaluated over 15 and 30 days of storage. In T₁, the calcium content decreased slightly to 378 mg after 15 days and to 377 mg after 30 days. However, T₂ maintained higher calcium levels, with values of 392 mg after 15 days and 390 mg after 30 days. This data supports the finding that the combination of soaking and roasting in T₂ enhances calcium retention, making it a more nutrient-dense treatment compared to T₁.

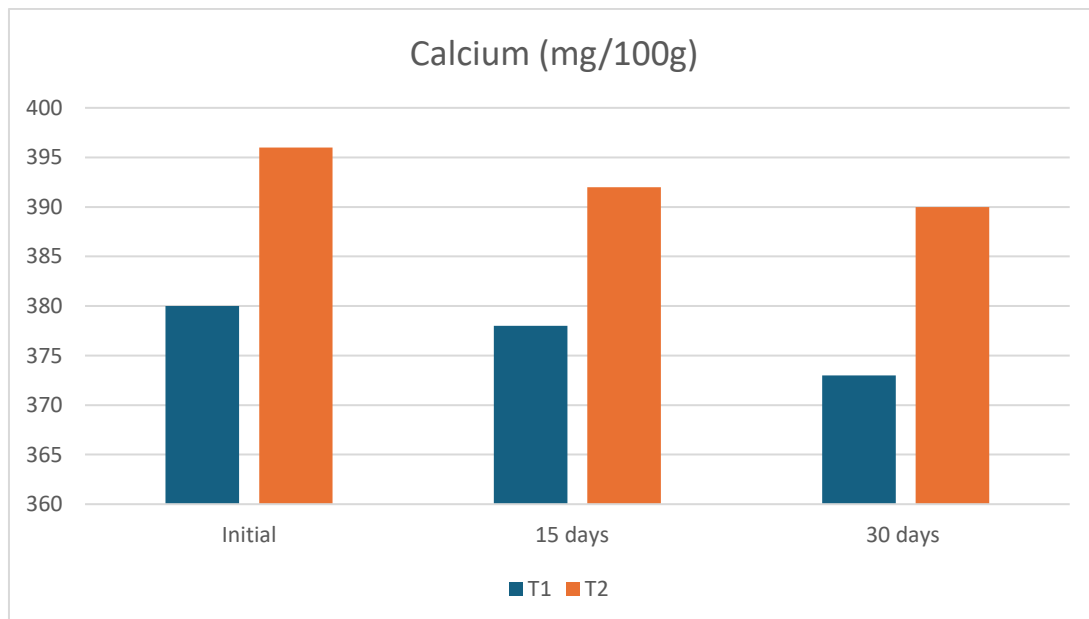


Fig. 5. Effect of treatments on calcium content of calcium rich Finger millet tisane

Table 3. Organoleptic evaluation of calcium rich Finger millet tisane

Sensory Parameters	Treatment 1	Treatment 2	SED	CD (p= 0.05)
Appearance	9.0	8.7	0.05	0.13
Colour	9.0	8.7	0.05	0.13
Flavour	7.8	8.5	0.05	0.13
Taste	8.6	9.0	0.07	0.19
Overall acceptability	8.3	8.9	0.05	0.13

3.3 Organoleptic Evaluation of Calcium Rich Finger Millet Tisane

The results of organoleptic evaluation of calcium-rich finger millet tisane with different treatments are discussed. The maximum score of appearance (9.0) was observed in T₁, whereas minimum score of appearance (8.7) was observed in T₂ on 15 days of storage. The maximum score of colour (9.0) was observed in T₁ whereas minimum score of color (8.7) was observed in T₂. The maximum score of flavour (8.5) was observed in T₂ whereas the minimum score of flavour (7.8) was observed in T₂. The maximum score of taste (9.0) was observed in T₂ whereas the minimum score of taste (8.6) was observed in T₁. The maximum value of overall acceptability (8.9) was observed in T₂ whereas the minimum value of overall acceptability (8.3) was observed in T₁. Based on the organoleptic evaluation the treatments were found to be significant.

4. CONCLUSION

The study successfully demonstrated the potential of Finger millet tisane as a calcium-rich beverage, particularly when employing the more elaborate preparation method outlined in Treatment 2. The enhanced calcium content observed in this treatment underscores the importance of processing methods in optimizing the nutritional value of functional foods. As such, the calcium-rich Finger millet tisane developed through this project holds promise as a valuable addition to the market, catering to consumers seeking healthful and nutrient-dense beverage options. Further exploration into the stability and consumer acceptability of this product is recommended to fully realize its commercial potential.

5. FUTURE SCOPE

This study helps to increase the consumption of our traditional foods in easy form and creates interest to formulate suitability of other millets in tisane development.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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