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Physico-Chemical Evaluation of Herbal Tea(s) Formulated from Spearmint (*Mentha spicata*) and Moringa (*Moringa oleifera*) Leaves and Added Spices

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Authors' contributions

This work was carried out in between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Herbal teas are drawing focus in healthy lifestyles because of its richness in antioxidants, nutrients, and therapeutic agents. However, they have been used by Ayurveda for a long time. These types of tea blends do not have caffeine so they are very good for sleep and detoxification. The objective of this study was to measure the physicochemical properties of herbal teas prepared using mint (*Mentha spicata*) and moringa (*Moringa oleifera)* leaves. Four treatments were constructed of T_1 (only mint leaves), T_2 (mint and moringa leaves), T_3 (mint and moringa leaves, and spices), and T_4

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(moringa leaves and spices). The total soluble solid content, titratable acidity, moisture, sugar content, calorific value and antioxidant activity were measured for each treatment. All treatments showed similar calorific values, between 353 and 354 calories per 100 grams. The highest antioxidant value of 152.51 micromoles TE per gram of dry weight was recorded for T_3. Data of total soluble solids were ranged from 2.50 °Brix to 2.60 °Brix, Titratable acidity range of 0.250% to 0.261%, total sugar range from 4.25% to 4.68%, and energy content ranges from 353.40Kcal to 353.66Kcal which were mostly similar across treatments. In conclusion T_3 (mint and moringa leaves, and spices) was found to be the nutritionally superior among all other treatments, beneficial for the health and consumer friendly.

Keywords: Herbal tea; mint; moringa; physico chemicals.

1. INTRODUCTION

Herbal teas are gaining popularity on a worldwide basis as most consumers search for ayurvedic, herbal, caffeine free beverages. Recent reports of food industries highlight their growing demand because of the increased awareness of plant based food in the industry. These beverages mostly regarded as safe, assessable, and affordable sources of antioxidant and other beneficial physicochemical compounds making herbal tea attractive to health enthusiast consumers and functional beverage sector. Herbal teas have been used in Ayurveda for centuries but now it is gaining widely acknowledged in modern nutrition and nutraceutical research for their role in reducing oxidative stress and supporting metabolic health (Atlaw *et al*., 2024).

With ongoing consumer demand for natural, caffeine-free beverages with the added health rewards, herbal teas are gaining popularity (Dai & Mumper, 2010). Conventional health care systems such as Ayurveda over centuries have understood the benefit of herbal infusions in supporting overall well-being and vitality (Ekor, 2014).

Traditional spices like black pepper, cardamom, and clove have long-standing uses in cultures and in addition to providing typical flavours also contain health benefiting physicochemical compounds. These spices also provide antioxidant and antimicrobial in nature because of tannins and essential oils they contain (Yashin *et al*., 2017). When these are blended together, enhance intricate flavour profiles and also improving health-benefiting actions.

It should be kept in mind, however, that even although the health impacts of single herbal constituents are largely documented; there is proportionally little exploration of their combined effects when consumed in combined blends. Further research into these potential synergies may unlock the creation of teas that are more enjoyable to consume and more useful for maintaining health (Nguyen *et al*., 2020).

Herbal teas have seen unprecedented increase in worldwide popularity not only due to their variety of flavours but also with growing interest in potential benefits to health (Scherer et al., 2023). Spearmint (*Mentha spicata*), for instance, is usually well known for its pungent aroma, mostly contributed by natural chemicals like carvone and menthol. Other than aromatic beauty, spearmint provides phenolic compounds that have antioxidant and antimicrobial activity (Henao-Rojas *et al*., 2022).

Moringa (*Moringa oleifera)* is yet another favourite among herbal tea ingredients. Leaves contain high levels of vitamins A, C, and E and minerals such as calcium and iron. Addition, the bioactive compounds of moringa, i.e., flavonoids and phenolic acids, are linked with antioxidant, anti-inflammatory, and antimicrobial effects. All these activities make it even more beneficial as a functional beverage ingredient (Herman-Lara *et al*., 2024).

There is no systematic study on herbal teas for consumer convenience, for extended shelf life, and for commercial purposes. More importantly, the studies of synergy between mint (*Mentha spicata*) and moringa (*Moringa oleifera)* with or without spices, has hardly been examined in details from a physico chemical and antioxidant activity standpoint.

Hence, the present study was undertaken with the objective of formulating herbal tea from mint (*Mentha spicata*), moringa (*Moringa oleifera)* and some selected spices (black pepper, cardamom, and clove) and to analyze their physicochemical properties (total soluble solids, titratable acidity, sugar profile, moisture, energy content, and antioxidant activity).

Aimed at bridging this knowledge gap and thereby contributing to scientific knowledge of blended herbal tea, the study hopefully will direct attention to development of functional and consumer friendly tea products that integrate nutritional value, sensory quality, and commercial viability.

2. MATERIAL AND METHODS

The current experiment was performed for the standardization of formulations for herbal tea blends preparation and also to find out their physico-chemical properties. The information about the materials used, the methods of preparation, and the procedures for analysis that have been carried out during the study are explained in the following subheadings.

2.1 Details of Experiment

Table 1. Details of experiment

Sl.No	Name of crops	1. Spearmint (*Mentha spicata)* 2. Moringa(*Moringa oleifera)*
1	Experimental Design	Completely Randomized Design (CRD)
2	Name of products	Herbal Tea
3	Total Number of treatments	4
4	Number of Replication	3
5	Year of experiment.	2024-2025
6	Place of research work	Post- Harvest Technology laboratory, Department of Horticulture, SHUATS, Prayagraj, Uttar Pradesh.

Table 2. Treatment combinations for herbal tea

Treatments	Treatment Combination
T_1	Spearmint leaves (100%)
T_2	Spearmint (50%) + Moringa leave (50%)
T_3	Spearmint (50%) + Moringa (37.5%) + Spices (12.5%)
T_4	Moringa (75%) + Spices (25%)

2.2 Preparation of Herbal Tea

Fresh leaves of spearmint and moringa were chosen from the local farms of Prayagraj on the basis of color, freshness, absence of injuries, and the attack of small insect pests. The leaves were washed thoroughly under running potable water. The washed leaves were spread in single layers on food-grade drying trays and shade-dried at room temperature for about 3 days till they reached a constant weight, thus avoiding volatilization of the essential oil and chlorophyll degradation. The dried leaves were ground to an optimal particle size for infusion in the coarsely ground form. The grinding process was done in clean and dry equipment to prevent cross-contamination and to avoid excessive heat generation, which could cause the loss of flavor compounds. The spices clove, cardamom, and black pepper were manually sorted to get rid of any dirt then lightly crushed together. The powders were then put in zip lock bags after that the herbs were weighted in 4 treatments respectively. The tea bags were then soaked in 150 ml of hot water (95^{o} C) per cup for about 5 minutes. The flow diagram for herbal tea preparation as outlined by Yadav *et al*., (2020) is presented below in Fig. 1.

Each treatment examined for physico chemical properties in the department of horticulture, post-harvest technology laboratory, SHUATS, Prayagraj. Total soluble solids were measured by digital hand refractometer (ERMA, Japan). Titratable acidity was recorded using Traditional glass burette (Borosil, India).Antioxidant activity, total sugar, reducing sugar, non-reducing sugar was accessed via a UV-Vis Spectrophotometer (Systronics 2202, India). Moisture was recorded using a Hot air oven (REMI, India). The research formulated in a Completely Randomized Design (CRD) with 3 replication data was evaluated by Analysis of Variation (ANOVA) at 5% level of significance, and mean analyses were made on the basis of critical difference (C.D.) at $p \leq 0.05$.

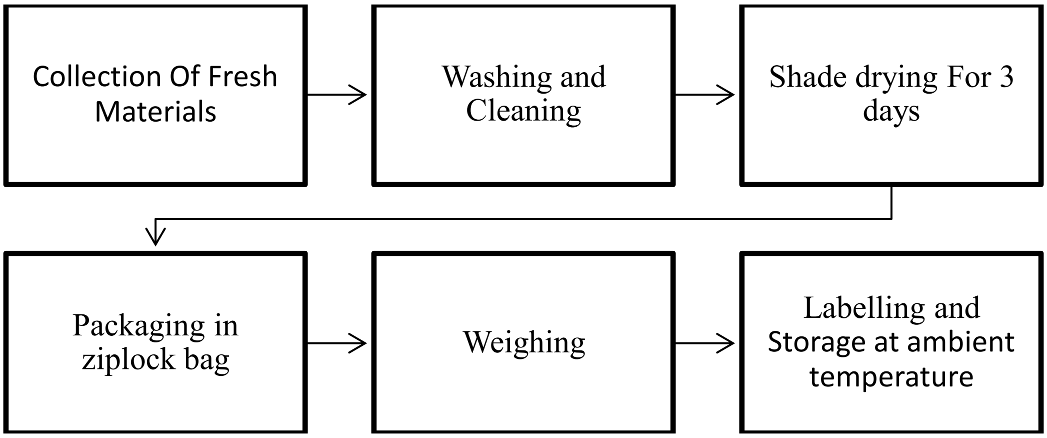

Fig. 1. Flowchart for preparation of Herbal tea

3. RESULTS AND DISCUSSION

Table 3. Physicochemical compositions of herbal tea

Treatment	TSS	Acidity	Antioxidant	T.S	R.S	NRS	Moisture (%)	Energy (Kcal)
T1	2.5	0.250	143.56	4.25	2.38	1.87	5.60	353.46
T2	2.6	0.261	148.32	4.51	2.57	1.94	5.50	353.40
T3	2.6	0.251	152.51	4.68	2.69	1.99	5.41	353.66
T4	2.5	0.253	149.56	4.38	2.81	1.57	5.27	354.42
F-test	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
SE(d)	**0.03**	**0.003**	**0.26**	**0.07**	**0.05**	**0.07**	**0.03**	**0.09**
CV (%)	**0.411**	**1.097**	**0.456**	**0.136**	**1.836**	**1.319**	**0.726**	**0.546**
CD at 5%	**0.072**	**0.006**	**0.712**	**0.158**	**0.09**	**0.13**	**0.067**	**0.202**

3.1 Total Soluble Solids (°Brix)

The total soluble solids in the herbal infusion blends ranged from T_1 (2.50 °Brix) to T_3 (2.60 °Brix) (Table 3, Fig 1). The highest TSS (2.60 °Brix) was achieved in treatment T_3 (mint and moringa), followed by T_4 (2.51 °Brix). The treatments T_1 and T_2 (2.50 °Brix) are statistically the same and have recorded the lowest values. The higher TSS in T_3 could be due to the combination of mint and moringa to which the soluble carbohydrates and free sugars are more easily extracted. Moreover, mint might also be there to help in the maintenance of soluble solids during brewing. There have been similar instances of TSS rising due to the presence of certain botanicals by Patel *et al*. (2023) in fruit–herb infusion beverages.

3.2 Titratable Acidity (%)

The data pertaining to the Herbal Infusion Blends were characterized by a Titratable acidity range of 0.250%-0.261% (Table 3 and in Fig. 1). T_2 (mint and moringa) showed the highest value of 0.261%. Then, with 0.253% was T_4 (moringa and spices) next in line. T3 (mint, moringa and spices) reported 0.251%. While T_1 (mint only) recorded the minimum value of 0.250%. From a statistical sense, the differences in the numbers, though minor, are very significant in terms of flavour development and product stability. The relative differences in titratable acidity for each treatment are most likely dependent on the complex organic acid composition of the ingredients and their brewing solubility. Mentha is full of rosmarinic acid and chlorogenic acid; moringa provides the ascorbic acid, gallic acid, and ferulic acid in small amounts. Acidity in T_2 was more noticeable which could mean that the mint and moringa combination is more efficient in either the retention or the extraction of these acids, and this could be caused by the synergistic effect in the cell wall breakdown during infusion. Similar observations were noted by AOAC (2016), Anesini *et al.*, (2008), and Nguyen *et al.*, (2020).

3.3 Antioxidant Activity (mg TE/ 100 g)

The result of antioxidant activity varies from 143.56 mg TE/ 100 g to 152.51mg TE/ 100 g (Table 3 and in Fig. 1). T_3 (mint, moringa and spices) having the maximum value 152.51. T_4

(moringa and spices) showed a slightly lower antioxidant response of 149.56mg TE/ 100 g. T_2 (mint and moringa) gave a response of 148.32mg TE/ 100 g and the least response 143.56mg TE/ 100 g was found in T_1 (mint only).The superior antioxidant potential in T_3 may be attributed to the synergetic effect among the ingredients in the blend. Mint leaves are an affluent source of phenolic compounds, particularly rosmarinic and chlorogenic acids also flavonoids. Moringa is a reliable source of quercetin, kaempferol, chlorogenic acid and vitamin C, alternatively, inclusion of spices like clove, cardamom and black pepper which are rich in phenolic compounds and strong radical scavengers further enhanced the overall antioxidant response. Similar remarks have been made in the previous reports of Henao-Rojas *et al.*, (2022), Herman-Lara *et al.*, (2024) and Yashin *et al.*, (2017).

3.4 Total Sugar (%)

Considerable variation of total sugar matter in the herbal tea treatments are presented in (Table 4 and in Fig. 1) the average amount of total sugar in herbal tea range from T_1 (4.25%) to T_3 (4.68%). The highest data being (4.68%) which is recorded in T3 (mint, moringa and spices).While it was numerically at par with T_2 (mint and moringa) is 4.51% and T_4 (moringa and spices) is 4.38%, whereas the lowest being (4.25) in the treatment T1 which is consist of mint only. The finding indicate that moringa contributes considerably to extending carbohydrate content and which addition of spices and mint and moringa base (T_3) further increasing soluble sugar which is likely releasing of low molecular weight carbohydrates and other soluble solids during mixing. Similar results were found by AOAC (2016) Method 925.35., Ubbor& Akobundu (2009), and also found in research of Alasalvar*et al.,* (2013).

3.5 Reducing Sugar (%)

The observation in Table 4 and in Fig. 1 recorded that reducing sugar in herbal tea which ranged between (T_1; 2.38%) to (T_4; 2.81%). The maximum value observed 2.81% which belongs to the treatment T_4 (moringa and spices). While it was numerically at par withT_2 (mint and moringa) is 2.57% and T_3 (mint, moringa and spices) is 2.69%. The lowest value was recorded 2.38% is from the treatment T_1 consist of mint leaves only. These results indicate that the addition of spices, especially in moringa based treatments, assist into simple reducing sugars during the brewing process. Additionally, higher reducing sugar substance can be positively regulating flavour by relating an instant sensitivity of sweetness, increasing the aromatic difficulty of the infusion. AOAC (2016) and Ubbor& Akobundu (2009) also reported that combinations with high reducing sugars repeatedly score better in sensory evaluations due to their balanced flavour profile.

3.6 Non- Reducing Sugar (%)

It was revealed from Table 4 the average amount of non-reducing sugar content ranges from 1.57% to 1.99%. A maximum (1.99%) was recorded in treatment T_3 (mint, moringa and spices) combination herbal tea bags. while it was statistically at par with T_2 (mint and moringa) is1.94% and T_1 (mint) is 1.87%which is very similar. Whereas the minimum score (1.57%) is found in T_4 (moringa and spices) combination herbal tea bags.

Moringa lower the non-reducing sugar percentage even tough, having more reducing sugars which indicates that a lot of its sucrose and other complex sugars were reduced in simpler forms. The type of finding was also reported by AOAC (2016), and Alasalvar *et al.* (2013), their research found that spice added herbal blends many times vitalize the lower, most probably due to light acidity and heat during soaking.

3.7 Moisture (%)

The moisture data present in the Table 5 shows moisture percentage varies from 5.27% to 5.60%. The highest observation was 5.60% found in treatment T_1 (mint only), While it was statistically at par with T_2 (mint and moringa) is 5.50% and T_3 (mint, moringa and spices) is 5.41%. Where the lowest data was 5.27% belong to treatment T_4 (moringa and spices).

Blending of moringa and spices hold less moisture then mint which is most likely due to spices rich mixtures dry more faster and attract water from air. Lower moisture percentage is very favourable for storage purpose providing prevention from microorganisms and spoilage also reported by AOAC (2016) and IOS (2011). All the treatments remain inside the safe range for herbal tea (below 6%) so these are safe for storage preserving aroma and flavours.

Table 4: Total sugar, reducing sugar, non- reducing sugar properties of herbal tea bags

Treatment	Total sugar	Reducing Sugar	Non- Reducing Sugar
T1	4.25	2.38	1.87
T2	4.51	2.57	1.94
T3	4.68	2.69	1.99
T4	4.38	2.81	1.57
F-test	**S**	**S**	**S**
SE(d)	**0.07**	**0.05**	**0.07**
CV (%)	**0.136**	**1.836**	**1.319**
CD at 5%	**0.158**	**0.09**	**0.13**

Table 5: Moisture and energy properties of herbal tea bags

Treatment	Moisture (%)	Energy (Kcal)
T_1	5.60	353.46
T_2	5.50	353.40
T_3	5.41	353.66
T_4	5.27	354.42
F-test	**S**	**S**
SE(d)	**0.03**	**0.09**
CV (%)	**0.726**	**0.546**
CD at 5%	**0.067**	**0.202**

3.8 Energy (Kcal)

The data with respect to energy content were mostly alike data that is mentioned in the Table 5 and in Fig. 1 which clearly shows the average amount of energy content ranges from (T_2; 353.40 Kcal) to (T_3;353.66 Kcal). The slightly maximum score was in T_3 (mint, moringa and spice) which is 353.66 Kcal, other data follows T_1 (mint) is 353.46 Kcal and T_4 (moringa and mint) is 354.42 Kcal. Whereas the minimum being T_2 (mint and moringa) having score of 353.40 Kcal.

The observation demonstrates that the treatments having spices gives more energy content probably due to essential oil and bio active compounds found in spices like clove, cardamom, and black pepper that provide more calories Although the energy content isn't the most factor in the merits of herbal tea quality, these small nutritional contributes are a valuable addition when creating functional drinks. The fact that all samples were so consistent shows that changing the herbs did not significantly after the overall energy or micronutrient level of final product. Similar results are reported by Food and Agriculture Organization (2003), Merrill & Watt (1973), and Niranjan & Singh (2015).

4. CONCLUSION

In summary the present investigation based on the obtained results it may be concluded that in respect to herbal tea the blend T_3 (mint, moringa and spices) found to be the nutritionally superior among all other treatments also beneficial for the health. The different components we added had an impact on major chemical compounds like total soluble solids, titratable acidity, antioxidant activity, sugar contents, moisture content, and energy content.

This study highlights that use of mix herbs like mint leaves which is known for its aromatic and cooling properties and moringa leaves which is known for its medicinal values both are better aromatic, healthy and nutritious in an herbal tea bland.

Hence the present finding suggested that the herbal teas are nutritious with appealing taste, good for human health, cost effective and this value addition may help to promote processing industry.

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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