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Watermelon Rinds and Sage (*Salvia officinalis* L.): Ingredients as Novel Nutraceutical Beverage.

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ABSTRACT

Among the numerous approaches, the transformation of fruit and vegetable by-products into functional ingredients is recognized as a promising avenue for innovation and sustainable development. Concurrently, the global market for herbal beverages has been expanding significantly, driven by their distinctive attributes and the health-promoting benefits they offer to consumers. This study introduces an innovative formulation for preparing a health-promoting herbal tea by leveraging the synergistic combination of watermelon rinds (WMRs) and Salvia officinalis L. leaves (known as Maryam Goli). WMRs and dried S. offinalis were combined in different percentages, and commercial tea and 100% WMR were used for comparison. The research aims to evaluate the physicochemical attributes and sensory characteristics of herbal teas derived from these components, specifically using finely ground powders. A comprehensive analysis was conducted to determine the mineral content, trace element, and heavy metal levels, as well as other physicochemical parameters, in accordance with internationally recognized analytical standards. The findings of current investigation revealed that Optimal Formula (60/40 w/w) possess a robust nutritional profile. Specifically, they contain protein (8.13 g/100g), fat (0.71 g/100g), ash (15.8 g/100g), fiber (31 g/100g), sodium (42.41 mg/100g), potassium (2324 mg/100g), calcium (564 mg/100g), copper (3.15 mg/100g), iron (32.08 mg/100g), magnesium (198.44 mg/100g), zinc (3.14 mg/100g), and phosphorus (98.8 mg/100g), selenium (0.008±0.001 µg/g). Additionally, Heavy metals such as cadmium and lead (0.001, 0.002 µg/g respectively), were detected in minute concentrations. The sensory evaluation results indicated that the chosen formula was the top choice among panelists due to its appealing taste and aroma, while still retaining beneficial antioxidant and nutritional qualities and emerge as a promising candidate for creating S. officinalis & WMRs herbal tea that blends enhanced sensory appeal with maintained functional benefits.

Keywords: *Herbal Tea, by-product, watermelon rinds, functional ingredients, Salvia officinalis L., Beverage.*

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1. Introduction

The conversion of agricultural waste into valuable products or its utilization as raw material across various industries has gained considerable attention due to its environmental and economic implications (Sawicka et al., 2022; Ziarati et al., 2023). Considering the widespread societal acceptance of tea infused with herbal extracts, coupled with growing concerns over environmental pollution, elevated levels of nitrates, lead, and other contaminants in food, as well as the rising incidence of cancer, it is plausible to propose the introduction of a tea that not only incorporates herbal ingredients but also possesses significant antioxidant properties and reduced caffeine content. Furthermore, it is important to note that tea holds a prominent position as one of the staple beverages in Iran and many other countries.

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Watermelon is recognized for containing moderate yet noteworthy amounts of phenolic compounds (Maheshwari et al., 2022). In several countries, watermelon rind is utilized in the production of jams, pickles, or juices to mask any unwanted flavors underscored an innovative method of repurposing watermelon waste for bacterial cellulose production, highlighting its sustainable nature and potential for cost efficiency(Nasharudin et al.,2024; Acun et al.,2025). The peel of watermelon constitutes a substantial fraction of byproducts generated in abundance by restaurants, fruit processing establishments, and food-related industries throughout Iran. As one of the leading producers of watermelon worldwide, Iran cultivates numerous varieties, with prominent production centers located in regions such as Chabahar, Shiraz, Dezfoul, Jiroft, and Boushehr (Dekamin et al., 2025). The country's watermelon sector is distinguished by robust export practices, incorporating advanced packaging solutions and precise temperature control to maintain product freshness during international transport (Feizy et al., 2020; Nasharudin et al. 2024). Iran currently ranks as the second-largest producer of watermelons globally. Popular export varieties include B32, Mikado, and Ion Gene, each possessing distinct characteristics designed to cater to a wide range of consumer preferences (Nabavi-Pelesaraei et al., 2016). Despite the industry's scale, a significant proportion of watermelon byproducts, particularly peels, are disposed of indiscriminately, contributing to environmental pollution. Globally, the market for new herbal beverages is experiencing rapid growth, driven primarily by their distinctive qualities and reported health benefits. In light of the escalating prevalence of cardiovascular diseases and various forms of cancer, there is an increasing demand for plant-based products rich in phenolic compounds, widely recognized for their antioxidant properties and capacity to neutralize free radicals (Manikishore et al., 2025). Additionally, the rind is especially rich in citrulline, a compound known for its strong antioxidant properties that help shield the body against damage caused by free radicals. Once metabolized, citrulline is converted into arginine, an essential amino acid vital for maintaining cardiovascular, circulatory, and immune system health. Arginine also facilitates the relaxation of blood vessels, which supports the prevention and management of cardiovascular diseases, as highlighted by Rimando and Perkins-Veazie in 2005(Dobrynina et al., 2023).

To enhance the antioxidant properties and other health benefits, such as bioactive compounds, in herbal tea, Salvia has been chosen as the secondary component in the present study on herbal tea formulation. Salvia officinalis L., also known as Maryam Goli, is one of the native plants used to Persian medicinal herbs (Kazemivash & Ziarati, 2025). S. officinalis, commonly known as sage, belongs to the Lamiaceae (formerly Labiatae) family. The genus Salvia (with 900 species) is one of the numerous members of the Lamiaceae family. Within the scope of Flora Iranica, this genus is represented by fifty-eight distinct species (Moradi et al., 2023). These plants are economically valuable and used in production of essential oils and extracts. Several Salvia species have been extensively cultivated across the world due to their significance in traditional medicine and their applications in culinary practices. In traditional medicine, S. officinalis has been employed in the treatment of numerous ailments, including seizures, ulcers, gout, rheumatism, inflammation, dizziness, tremors, paralysis, diarrhea, and hyperglycemia. It can be used to reduce the frequency of menopausal hot flashes (Dadfar & Bamdad, 2019; Moradi et al., 2023; Zeidabadi et al., 2020). The Salvia name comes from the Latin word for healing (or to heal) and so use of the essential oils and extracts of these plants has been considered in traditional medicine. Also, Salvia flavoring properties has been in a wide way used in the preparation of many foods. The genus Salvia contains the widespread of secondary metabolites, such as flavonoids, tannins, and terpenoids. Investigation of the terpenoid (mono-di-, tri-, sesqui- and tetraterpenoids) has shown antioxidant analgesic, anti-inflammatory, hemostatic, antioxidant, antimicrobial and antitumoral activity in this genus (Gohari et al., 2010). Some species, including Salvia officinale L. (a cultivated plant in Iran) contains 50% salviol and is used as a stomach tonic (warming and regulating), diuretic, antiseptic, blood sugar lowering, and aphrodisiac. Also, other studies show that the active ingredients of Salvia have been used for the treatment or control of rheumatism, asthma, inflammatory bowel diseases in new medicine. The results of another studies show that extract of S. officinale are effective in enhancing memory which could be due to the presence of monoterpenes and cholinesterase activity (Hadipour et al.,2024' Brinza et al., 2025). S. officinale has been shown to have cholinergic binding properties and cognitive function in humans, regulating mood and thus being considered as a novel treatment for Alzheimer's disease (Ertas et al., 2023). Salvia encompasses significant chemical constituents that are categorized into terpenoids, flavonoids, phenolic acids, steroids, caffeoyl derivatives, and essential oils. The distribution of these compounds varies across different plant parts: the aerial sections predominantly contain flavonoids, triterpenoids, monoterpenoids, and sesquiterpenoids, whereas the roots primarily accumulate diterpenoids and phenolic acids (Askari et al., 2021).
The primary objective of the present study is to develop a beverage that can be safely consumed by healthy individuals without causing any adverse side effects. Additionally, the drink should retain its effervescence and flavor profile. The aim is to formulate an herbal beverage endowed with robust antioxidant properties, making it suitable for incorporation into the diet of healthy individuals. This would contribute to enhancing the body's defenses against free radicals, which arise due to the presence of toxic substances within the nutritional system. This study introduces a novel formulation of nutraceutical beverage consist of watermelon rinds and Salvia officinalis L. leaves. The research aims to assess the physicochemical characteristics, nutrient content analysis, and sensory attributes of herbal teas developed from finely ground powders of these components.

2. Materials and Methods

2.1-WMRs& Salvia sampling

Watermelon fruits (Citrullus lanatus) utilized in this investigation were sourced from farmlands in Fars Province, Iran. The study specifically used organic watermelon rinds (WMRs) obtained from fresh, naturally cultivated watermelons, deliberately avoiding greenhouse-grown samples to eliminate the risk of chemical residues from cultivation processes being present in the rinds. A total of 85 watermelons, primarily round in shape and weighing between 6 to 10 kilograms, were procured from farms located in Marvdasht and Shiraz. The sampling period commenced in mid-May and concluded at the end of September 2024. The watermelons were processed by removing the red pulp and retaining the white rinds, which were then chopped and immersed in four volumes of distilled water for 10 minutes with gentle agitation. The cleaned rinds were cut into small pieces measuring 2.0–0.5 centimeters using a sanitized cutter. These pieces were then spread on trays to allow any residual water to drain before being dried in an air oven at 50°C for 24 hours. Once dried, the rinds were ground using a clean electric mixer, and the resulting material was sieved through a 250 µm mesh (Retsch GmbH & CoKG, Germany) to isolate fine particles. The prepared WMR samples were stored in desiccators at 0% humidity until further use.

Figure 1- watermelon Rind

Salvia officinalis L. Leaves were purchased from Vazir Nazam

herbal market in Bazar Bozrg (Tehran) in summer 2024.

Figure2- *Salvia officinalis* L. leaves powder

2.2-Formulation

Samples of each medicinal plant, including sage and white watermelon rind, were first stored under standard shaded conditions for seven days before being further dried. Extracts were then obtained from the dried powder using the steam extraction method. The resulting extracts were filtered, and their scent and taste were subsequently evaluated. The aim at that time was to eliminate any unpleasant herbal taste and smell from the extract, ensuring it became as odorless and tasteless as possible. To achieve this, the vacuum odor removal technique was employed. For optimizing the flavor, various ratios of the two base components used in the tea were tested and adjusted accordingly (Su et al., 2021).

WMRs and dried S. *Offinalis* were combined in a percentage of: 90:5 (A), 90:10 (B), 85:15 (C), 80:20 (D), 75:25 (F), 70:30 (G), 65:35 (H), 60:40 (I), 55:45 (J), 50:50 (K), respectively, and commercial tea and 100% WMR were used for comparison.

In the subsequent stage, the extract was evaluated for its compatibility with the drink's base, along with its taste and color, to determine the optimal combination. During this process, a trained panel of 30 professional sensory testers assessed the flavor and mouthfeel produced, with the ISO 8586:2012 guidelines for sensory analysis (Iso 8586, 2012). Additionally, the physicochemical stability of the drink was analyzed, with various parameters being measured and quantified. The approved formulas C, D, E, H and I have been officially recorded. In the subsequent process, extracts with varying concentrations were evaluated for their compatibility in terms of taste and color when paired with the beverage base, and the optimal combination was determined. For the test, 100 ml of water at 96 degrees Celsius was added to 10 grams of the mixture prepared using white watermelon rind and sage. The samples were subjected to steaming under a cover for duration of 10 minutes. Following this process, the mixture was filtered using Whatman filter paper (grade 1) to isolate the aqueous extract. Subsequently, the extracted solution underwent the necessary physicochemical analyses to evaluate its properties.

2.3-Physicochemical characteristics

The AOAC-recommended analytical methods were employed to determine the contents of ash (942.05), crude protein (920.152), crude fat (948.22), and fiber (2009.01) as outlined in the AOAC guidelines (2016). Ash content was measured by incinerating a 5 g sample in a muffle furnace at 550°C for five hours. Crude protein (% total nitrogen × 6.25) was determined using the Kjeldahl method with 2 g of the sample, following the procedure described by Morais et al. (2017). Crude fat was assessed by thoroughly extracting 2 g of each sample in a Soxhlet apparatus with petroleum ether as the solvent, having a boiling range of 40-60°C (AOAC, 2016).

2.4-Zinc, Manganese, Copper, and Potassium Determination

All stock solutions and working standards were stored at 4°C to ensure accuracy and were adjusted to room temperature (25°C) before use. For the measurement of Zinc, Manganese, Copper, and Selenium levels in final chosen formula of herbal tea samples, powdered seeds were oven-dried for 48 hours at a temperature of 85°C. After drying, the samples were finely ground and sifted through a sieve with a mesh size of 0.5 mm. These powdered samples then underwent acid digestion with concentrated nitric acid (65%, Merck), sulfuric acid (96.5%, Merck), and perchloric acid (70%, Sigma). Additionally, analar-grade hydrogen peroxide (approximately 30%) was employed during the digestion process (Seify et al., 2025). The use of concentrated nitric acid combined with 30% hydrogen peroxide (Merck) ensured complete mineralization of the samples following the Environmental Protection Agency Method 3052 (EPA, 2014). For the digestion, two grams of each air-dried formula (I) sample were carefully weighed, and 30.0 mL of a digestion mixture consisting of two parts nitric acid, one part sulfuric acid, and four parts perchloric acid by weight was added. This mixture underwent gradual heating in an oven, with temperatures being increased incrementally throughout the process. After digestion, the remaining inorganic residues were dissolved in 30.0 mL of concentrated nitric acid, forming a solution ready for trace and essential mineral element analysis. To maintain consistency, blanks and sample runs were processed alongside the test samples. All chemicals used were analytical grade (AR) and adhered to internationally recognized protocols for material preparation and heavy metal analysis. The evaluation was performed using a Flame Emission Spectrophotometer Model AA-6200 (Shimadzu, Japan). The equipment parameters included an air-acetylene flame maintained at a temperature of 2800°C, with acetylene pressure between 0.9 and 1.0 bar and air pressure stabilized between 4.5 and 5 bars. The reading duration ranged from 1 to 10 seconds, extending to a maximum of 60 seconds if needed, while the flow time varied from 3–4 seconds, reaching up to a maximum of 10 seconds. A minimum of five standard solutions per element were utilized to determine potassium content according to FDA guidelines for elemental analysis (ORA Laboratory Manual FDA, 2004; Lahiji et al., 2016). Regular testing of standard solutions ensured instrument reliability and data consistency. The accuracy of these procedures was verified through quality control assessments involving fungal samples and their substrates, which demonstrated close alignment with standard values, showing discrepancies below 5%.

2.5-Iron Determination

An aliquot was subjected to analysis utilizing an atomic absorption spectrophotometer to quantify its iron concentration. Calibration standards were formulated using a stock solution with a concentration of 10 mg/L, prepared from ferrous ammonium sulfate as described by Jame-Bozorgi and Ziarati (2025). Volumes ranging from 3 to 60 mL of this stock solution were transferred into 100 mL volumetric flasks. Subsequently, 2 mL of hydrochloric acid (Merck) was added to each flask, and the solutions were meticulously diluted to the mark with distilled water. The iron concentration in the aliquot was determined in units of mg per 100 g through atomic absorption spectroscopy, and the entire procedural sequence was conducted in triplicate to ensure reliability.

2.6-Calcium, Sodium and Magnesium Determination

For the quantification of calcium, sodium, and magnesium, a 5 ml aliquot was precisely transferred into a titration flask using a calibrated pipette and subsequently diluted to a final volume of 100 ml with distilled water. Following this, 15 ml of buffer solution, ten drops of Eriochrome Black T indicator, and 2 ml of triethanolamine were added to the flask. The prepared solution was then titrated with an Ethylene-Diamine-Tetra-Acetate (EDTA) solution until the endpoint was reached, characterized by a distinct color transition from red to clear blue(Jame-bozorgi & Ziarati, 2025). This analytical procedure adheres to the EDTA Titrimetric Method as described under the standard guidelines (Method 3500-Ca B) by the National Environmental Methods Index (NEMI).

2.7-Selenium Determination

For the determination of selenium, stock standard solutions with a concentration of 1000 g/mL were prepared. All reagents and standards utilized were of analytical grade and procured from Merck, Germany. The palladium matrix modifier solution was prepared by diluting Pd(NO3)2 to achieve a concentration of 10 g/L. Additionally, an iridium atomic absorption (AA) standard solution at a concentration of 1000 g/mL was prepared using 20% hydrochloric acid, complemented with 0.1% V/V nitric acid, obtained from trace-grade 65% nitric acid, diluted and mixed with 0.1% Triton X-100. Throughout the entire procedure, doubly distilled water was used to ensure high purity and consistency in all experimental steps. The analysis of samples was conducted employing the Shimadzu Flame Emission Spectrophotometer (Model AA-6200), adhering strictly to guidelines established by the Analytical Method ATSRD (Yarahmadi et al., 2024; ATSRD, 2013).

2.8-Cadmium, Lead, and Cobalt Determination

Internationally accepted protocols were adhered to for the preparation of materials and the analysis of heavy metal content. The flasks were initially heated gradually, followed by vigorous heating until a white residue was obtained, as described by Gholizadeh and Ziarati (2016). This residue was dissolved and adjusted to a final volume of 10 ml using 0.1 N HNO3 in a volumetric flask. The analysis of heavy metals in fruit samples was carried out utilizing Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) from PerkinElmer, USA, with six standard solutions prepared for each metal. Stringent precautions were implemented to prevent any sample contamination, in accordance with AOAC guidelines (AOAC, 2000; Ziarati et al., 2023).

2.9-Arsenic Determination

The glassware and plastic containers employed in this study underwent rigorous cleaning procedures to ensure the elimination of potential contaminants. The cleaning involved washing with liquid soap, followed by with water. Subsequently, the materials were immersed in 10% v/v nitric acid for a period of 24 hours, rinsed comprehensively with distilled water, and dried. Calibration curves and reference solutions were prepared using certified standard solutions containing arsenic at a concentration of 1000 mg/L (ICP Standard, Merck, Darmstadt, Germany). All solutions utilized in this study were prepared using distilled-deionized water to maintain purity. The residual acidity of the digested samples was assessed through acid-base titration, employing sodium hydroxide solution standardized with potassium hydrogen phthalate. For hydride generation analysis, a 2 mol/L hydrochloric acid solution (Merck, analytical grade, 37%) and sodium borohydride (NaBH4 tablets, purity >97%) prepared as a 1.5% solution in 0.2% NaOH (Sigma Aldrich, Extra Pure) were used. Concentrated acids, including HNO3, HCl, and H3PO4 (all analytical grade from Merck), were diluted with ultrapure water to produce solutions for analytical purposes. In addition, reference material from the National Institute of Standards and Technology (NIST RM 8704) was utilized for selected tests to ensure analytical reliability. Fruit samples were subjected to digestion using a methodology recommended by the United States Environmental Protection Agency (USEPA) for metal detection via Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) (EPA, 2014; Ziarati et al., 2023). The digestion process encompassed a two-stage heating protocol: an initial heating phase up to 140 °C with a duration of five minutes, followed by a second phase reaching 180 °C for ten minutes. A subsequent 40-minute ventilation stage facilitated sample cooling to ambient temperatures (20–25 °C). Throughout the process, meticulous monitoring was conducted to ensure adherence to procedural standards (Amaral et al., 2016; Prasad et al., 2020). The resultant extracts were analyzed using an inductively coupled plasma optical emission spectrometer (ICP-OES), specifically the Optima DV 7000 model from Perkin Elmer Instruments (Shelton, USA), equipped with a hydride generation unit. This advanced analytical instrument was utilized for its dual-viewing technology, which provides a broad analytical range along with optimal sensitivity. These features ensured enhanced accuracy by allowing low detection limits and the capacity to accommodate higher analyte concentrations within a unified system.

2.10-Sensory Evaluation

The sensory assessment was conducted with a panel of 30 participants, consisting of 21 women and 9 men, aged between 18 and 45 years. All individuals firstly took part in a screening session where their ability to distinguish primary tastes was evaluated using the triangular test. They were asked to assess taste intensity through the ranking test. Following the methodology for sensory evaluation of tea and the established vocabulary for sensory analysis, the study selected five key indicators: appearance (including rope, evenness, neatness, brightness, and leaf color); infusion characteristics (such as infusion color and transparency); infused leaves (evaluating texture and openness); taste (assessing sweetness and lubrication); and aroma (noting the cleanliness of the aroma). The sensory evaluation of the herbal tea samples was conducted at room temperature, with a randomized sequence of samples assigned to each assessor. For testing, one gram of tea leaves was steeped in 100 mL of freshly boiled tap water for five minutes. After preparation, assessors smelled the aroma, assessed the infusion color immediately, and evaluated taste only after the tea had cooled sufficiently. Finally, the infused leaves were arranged on plates for further examination.

2.11-Statistical techniques

All analyses were performed in triplicate, and the data were statistically evaluated using a one-way analysis of variance (ANOVA) (IBM Corporation, Armonk, NY, USA). The values reported for chemical composition in this study represent an average of five measurements. Each sample result reflects the mean of five subsamples.

3. Results and discussion

Table 1 highlights the chemical composition analysis of Formula I, as the final approved and chosen by pentalist by highest score of sensory tests (60% WMR + 40% Sage (w/w) by the highest scores on the sensory evaluation results as : sodium (42.41 mg/100g), potassium (2324 mg/100g), calcium (564 mg/100g), copper (3.15 mg/100g), iron (32.08 mg/100g), magnesium (198.44 mg/100g), zinc (3.14 mg/100g), and phosphorus (98.8 mg/100g), selenium (0.004±0.001 μg/g).

Table 1- Nutrient composition of final formula of Herbal Tea [60% WMR + 40% Sage (w/w)]

Mineral & Trace Elements in Herbal Tea Formula [60% WMR + 40% Sage (w/w)]	(DW±SE)
Fe	32.08 ± 0.012 mg/100g
Zn	3.14 ±0.06mg/100g
Mg	198.44±0.06 mg/100g
Mn	198.44±0.04 mg/100g
K	2324.1 ±8.1 mg/100g
Cu	3.15±0.06 mg/100g
Na	42.41 ±0.02 mg/100g
Se	0.004±0.001 μg/g
Li	0.08±0.03 μg/g

DW=Dry weight
SE= Standard Error

Table 2-Proximate analysis results of Final Formula of Herbal Tea [60% WMR + 40% Sage (w/w)]

Characters	(g/100g)
Protein	8.13
Fiber	31
Ash	15.8
Fat	0.71

To evaluate the percentage of elemental analysis across various components and formulations, a criterion variance analysis was employed. This analysis was performed using different formulations, each comprising five samples. For each sample, three measurements were recorded over three consecutive days. The results, characterized by a coefficient of variation (CV) of less than 2%, were obtained through this process.

Table3- Heavy metals contents in Final product Tea [60% WMR + 40% Sage (w/w)]

Toxic & Heavy Metals	(μg/g DW±SE)
Arsenic	ND*
Cadmium	0.001±0.000
Lead	0.002±0.000

ND= Not detected
DW=Dry weight
SE= Standard Error

The findings of current study in determining the components have confirmed the important role played by the amount of bioactive compounds in the final formulation of the nutraceutical beverage watermelon and sage ingredients. The 2024 study conducted by Rigi and Shahnavazi highlighted the potential of S. officinalis tea as an effective intervention for enhancing students' sleep quality. However, the research is limited by the absence of comparable studies specifically examining the impact of S. officinalis tea on sleep quality. Furthermore, the study does not account for various confounding variables, including pre-existing health conditions, psychological stress, environmental noise, dietary habits, and exposure to light. Additionally, the investigation did not assess the participants' histories of sleep disorders or the types of food consumed prior to sleep, which could have influenced the outcomes. This underscores the need for comprehensive studies that address these limitations to validate and elaborate on the findings (Rigi & Shahnavazi, 2024).

Sage teas and tinctures have long been utilized within traditional herbal medicine practices. The plant S. officinalis L., commonly known as sage, has been suggested as a potentially effective remedy for a range of health conditions, including cardiovascular diseases, neurological and nervous system disorders, various infections such as throat infections, dental abscesses, and mouth ulcers, and digestive issues. Its health-promoting properties are attributed primarily to the presence of polyphenolic compounds, such as phenolic acids, polyphenols, flavonoids, and phenolic terpenes, which are known to confer significant antioxidative potential. However, research has also highlighted potential adverse effects linked to the presence of two bioactive terpenoid compounds in sage: thujone and camphor. These compounds may pose certain health risks that warrant careful consideration in the use of sage-based products (Walch et al., 2012).

Conclusion

The objective of this research was to conduct a comprehensive investigation encompassing the nutritional, phytochemical, and sensory analysis of a herbal formulation composed of watermelon peels and Salvia, with the goal of evaluating its phytochemical contents and potential application in the development of herbal tea. Phytochemical analysis was carried out for individual herbal samples to quantify total phenolics, total flavonoids, crude alkaloids, minerals, trace elements, and to identify specific phytoconstituents such as terpenoids, anthraquinones, and phlobatannins. Additionally, nutritional analysis included assessments of moisture content, ash content, and mineral composition within the herbal formulation blend. Inductively Coupled Plasma (ICP) screening was employed to detect the presence of mineral and trace elements, as well as detecting probably presence of heavy metals, which underscored the formulation's potential classification under the category of nutraceuticals. This study further involved the preparation of a herbal tea using the selected blend, followed by sensory evaluation to assess key parameters such as aroma, color, astringency, flavor, and overall acceptability as a viable herbal tea product. The findings from both nutritional and phytochemical analyses demonstrated that the herbal mixture is an exceptional source of nutraceuticals with significant therapeutic properties. Enriched with diverse phytochemical constituents of high utility, this polyherbal formulation shows remarkable promise as a beverage that contributes positively to both physical and psychological health.

Conflict of interest

The authors had no relevant financial interests to disclose.

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