Journal of Food Science and Technology (Iran)

Homepage:www.fsct.modares.ir

Scientific Research

Proximate, Mineral, and Vitamin Composition of Bay (*Laurus nobilis*) and Mint (*Mentha spicata*) Leaves Harvested in Nigeria

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ARTICLE INFO

Article History:

Received: 2025/10/14
Accepted: 2026/01/16

Keywords:

Laurus nobilis,
Mentha spicata,
proximate composition,
minerals,
vitamin,
calories

DOI:10.48311/fsct.2026.117030.82888

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ABSTRACT

Bay (*Laurus nobilis* L.) and mint (*Mentha spicata* L.) leaves are widely used aromatic herbs with culinary and medicinal relevance, yet comparative nutritional data generated under identical ecological conditions remain limited. This study evaluated and compared the proximate composition, vitamin content, mineral profile, and energy value of bay and mint leaves harvested in Nigeria using standard analytical methods. Proximate analysis showed significantly higher wet moisture (93.98%) and dry moisture (25.31%) contents in mint leaves compared with bay leaves (4.21%), indicating differences in shelf stability and storage requirements. Ash content was also higher in mint leaves (15.75%) than in bay leaves (3.69%). In contrast, bay leaves contained a substantially higher carbohydrate level (65.43%) relative to mint leaves (31.87%), resulting in a significantly greater energy value (412.5 kcal/100 g). Protein (17–19%) and fat (7–15%) contents were moderate and comparable between both species, while crude fibre was negligible. Vitamin analysis revealed species-specific accumulation patterns, with bay leaves being notably richer in vitamin A (1418.5 µg/100 g) as well as higher levels of vitamins B and E. Mint leaves, however, exhibited a higher vitamin C content (4.49 mg/100 g). Mineral assessment indicated that mint leaves contained more concentrations of essential minerals, particularly calcium, whereas sodium levels were comparable in both plants. Overall, the findings demonstrate distinct and complementary nutritional attributes between *L. nobilis* and *M. spicata*. Bay leaves provide superior energy and fat-soluble vitamin density, while mint leaves contribute more vitamin C content, supporting their combined dietary, functional food, and nutraceutical applications.

1. INTRODUCTION

Plant-derived herbs and spices have been integral to human culture due to their nutritional value, phytochemical diversity, and functional properties, contributing to dietary quality, food preservation, and therapeutic applications [1]. These botanicals are rich in bioactive compounds which are associated with antimicrobial, antioxidant, anti-inflammatory, antidiabetic, anticancer, antiulcer, hepatoprotective and cardioprotective effects [2]. Among these, bay (Laurus nobilis L.) and mint (Mentha spicata L.) are two popular leafy plants that are widely grown and used for food, medicinal, and industrial purposes [3-5]. The two plants belong to important botanical families—Laurus nobilis of the Lauraceae and Mentha spicata of the Lamiaceae—but they have similar biological and nutritional characteristics that merit comparative research. Bay leaf is an evergreen plant native to the Mediterranean basin that has been historically valued for its distinctive flavor and numerous biological properties [3, 6]. Its leaves are leathery, elliptical, and high in essential oils, specifically monoterpenes, phenylpropanoids, and sesquiterpenes [7,8]. These phytochemicals contribute to its distinctive flavor, while also exhibiting antioxidant, antimicrobial, and anti-inflammatory activities [9,10]. The leaf is commonly used in soups, stews, and sauces to enhance taste, and its essential oils are employed in the cosmetic and pharmaceutical industries because of their aromatic and preservative qualities [6,11]. Nutritionally, bay leaf contains considerable amounts of proteins, carbohydrates, fats, vitamins, and minerals that make it a useful dietary additive [10,12]. Mint (*Mentha spicata* L.) is an aromatic perennial herb belonging to the Lamiaceae family and is recognized for its characteristic fragrance, refreshing flavor, and medicinal benefits [13,14]. It grows well in tropical and temperate regions and contains a variety of volatile oils, including menthol, menthone, and carvone, that impart its cooling sensation and flavor [15]. The chemical composition of mint leaves varies with environmental conditions and processing methods, but the plant is consistently rich in polyphenols, carotenoids, vitamins, and essential minerals [5,16]. Mint has a long history of therapeutic use, being employed in the management of digestive and respiratory disorders, nausea, and infections [17]. Its essential oil and extracts are widely used in food, beverages, and pharmaceuticals, while its bioactive compounds have been linked to antioxidant, antimicrobial, and anticancer activities [18,19]. The presence of vitamins A, C, and E, along with minerals such as calcium, iron, and phosphorus, enhances its nutritional significance [20,21]. Mint is also incorporated into various food products like yogurt, drinks, and confectionery, improving sensory attributes and extending shelf life [22,23].

Although both bay and mint possess established nutritional and pharmacological importance, there is limited scientific information comparing their proximate, mineral, and vitamin composition under the same ecological conditions. Environmental factors such as soil fertility, humidity, and temperature influence the synthesis of nutrients and secondary metabolites, resulting in variations across geographical regions [7,24]. Studies on bay leaves have focused mainly on their phytochemical and pharmacological activities in the Mediterranean and Asian regions [6,12], while most research on mint emphasizes essential oil yield and antioxidant characteristics from temperate climates [14,25]. Nigeria provides favorable agroecological conditions for the cultivation of both plants, yet their comparative nutrient

profiles remain poorly documented. Evaluating their proximate composition, mineral elements, and vitamin content within the same local environment will offer scientific evidence for potential dietary and industrial utilization. Proximate analysis provides an overview of nutritional quality, including moisture, protein, fat, fiber, and carbohydrate contents, while mineral and vitamin determinations reveal essential micronutrients that contribute to human metabolic and physiological functions [20,26].

The increasing demand for diets rich in plants and organic food additives emphasizes the need of investigating indigenous herbs that have both nutritional and functional benefits. Understanding the nutritional composition of bay and mint leaves will lay foundations for their use into functional foods, nutraceutical formulations, and herbal supplements. Furthermore, encouraging indigenous herb use promotes sustainable agriculture, strengthens local economic value chains, and adds to food and nutritional security. Therefore, this study aims to determine and compare the proximate, mineral, and vitamin composition of bay (*Laurus nobilis*) and mint (*Mentha spicata*) leaves harvested in Nigeria.

2-METHODS

Plant collection and preparation

Bay and mint leaves were freshly harvested from a farmhouse in Abak LGA, Akwa Ibom State, Nigeria, and immediately transported to the laboratory for examination to avoid moisture loss. In the laboratory, a sample of fresh leaves was used for estimating the wet moisture content. The remaining portions of the leaves was processed for chemical analysis, by washing with distilled water to remove all impurities and air-dried at room temperature for days to eliminate residual moisture, subsequently oven-dried at 60 °C for 30 minutes. Once they were completely dried and brittle, the leaves were ground into powder using a milling machine. The powdered samples were stored in air-tight containers and identified alphabetically. The powdered samples were used to test for dry moisture content, protein, fat, ash content (minerals) and vitamins.

Proximate Compositions

The proximate composition of the samples, comprising moisture, ash, crude protein, crude fat, crude fibre, and carbohydrate, was determined by employing the Association of Official Analytical Chemists' standard techniques as well as modified protocols [27,28].

Crude fibre determination

Crude fibre was analysed by the Weende procedure. A 5.0 g portion of sample was boiled in 200 mL of 1.25% H_2SO_4 for 30 minutes and subsequently rinsed with hot distilled water. The insoluble residue was transferred to a boiling flask containing 200 mL of 1.25% NaOH and boiled for a further 30 minutes. After filtration and washing, the residue was dried, transferred to a pre-weighed porcelain crucible, and oven-dried at 105°C for 1 hour. The crucible was cooled in a desiccator and weighed (W2). The dried residue was then ignited in a muffle furnace, cooled in a desiccator and reweighed (W3). Crude fibre content was calculated by difference and expressed as a percentage of the original sample weight [27,28].

Moisture and ash determination

Moisture and ash contents were obtained gravimetrically (27,28). For moisture, 10.0 g of each sample were placed in a moisture dish and oven-dried at 105°C for 3 hours, cooled in a desiccator and reweighed. Drying, cooling and weighing were repeated at hourly intervals until constant weight was achieved. Moisture content was reported as the percentage weight loss relative to initial

sample mass. For ash determination, samples were incinerated in a muffle furnace at 600°C until grey ash remained; precautions were taken to prevent loss of ash. The recovered ash was retained for subsequent acid extraction and mineral analysis.

Crude fat determination

Crude fat was analysed by Soxhlet extraction (27,28). Approximately 5.0 g of sample were wrapped in a pre-weighed filter paper and placed in the extraction thimble. The apparatus was fitted with 200 mL of solvent and operated under reflux such that solvent vapor condensed and percolated through the sample, dissolving lipid constituents. The cycle was continued for ~4 hours. After extraction, the defatted residue was dried at 100°C for 30 minutes and reweighed. Fat content was calculated from the mass loss attributable to extraction and expressed as a percentage of sample mass.

Crude protein determination

Crude protein was estimated by the Kjeldahl method and AOAC [28]. A 0.50 g aliquot of each sample was digested under a fume hood, mix 10 mL of concentrated H_2SO_4 with a selenium catalyst until a clear digest is formed. The digest was diluted to 100 mL with distilled water. A 10 mL sample of the digest was made alkaline with an equal volume of 40% NaOH and subjected to steam distillation.; the liberated ammonia was trapped in 10 mL of 4% boric acid containing mixed indicators (methyl red and bromocresol green). Total nitrogen was quantified and crude protein calculated using a conversion factor of 6.25.

Vitamins and Minerals

Vitamin A (Retinol)

A specific amount of each sample, equivalent to one gram, was weighed and then macerated with 20 millilitres of n-hexane in a test tube. The entire procedure was allowed to run for ten minutes. Following that, 3mL of the higher hexane extract was transferred in triplicate to a dry test tube and evaporated until completely dry. Then, 0.2 mL of acetic anhydride-chloroform reagent (1:1 v/v) was added, followed by 2 mL of 50% trichloroacetic acid in chloroform (1:1 v/v). The absorbances were measured at 15 and 30 second intervals. The content of vitamin A in the sample was calculated using the standard curve [29].

Vitamin B: The sample was weighed and ground in a mortar. 0.2 g was transferred to a 250 mL flask, added to 3 mL of 1M NaOH and stirred until dissolved. Then, three milliliters(3ml)of ethanoic acid were addedand the volume adjusted to mark with distilled water. A 25 mL aliquot was diluted to 100 mL, then undiluted and serially diluted again. A 100-ppm vitamin B standard solution and working standards were prepared using 1% glacial ethanoic acid as the solvent. Absorbance was measured within the wavelength range of 240–550 nm, and the wavelength corresponding to the maximum absorbance was selected. The concentration of vitamin B was subsequently determined from the calibration curve, taking into account the appropriate dilution factors. The final results were expressed as mg/100 g of sample [30].

Vitamin C (ascorbic acid) determination

A 0.5 g portion of the sample was macerated with 10 mL of 0.4% oxalic acid and left to stand for 10 minutes. The mixture was then centrifuged for 5 minutes and subsequently filtered. From the filtrate, a 1 mL aliquot was transferred into a clean test tube, and this step was repeated twice. Each aliquot was treated with 9 mL of 2,6-dichlorophenolindophenol (DCPIP), and absorbance measurements were recorded at 520 nm after 15 and 30 seconds. Standardization was performed using a DCPIP solution (295 mg/L) prepared in 100 mg/L sodium bicarbonate. The vitamin

C concentration was quantified and expressed as mg/100 g of dry weight [31].

Vitamin E determination

One gram (1g) of the sample was extracted with 20 mL of ethanol and the resulting mixture was filtered. An aliquot of 1 mL from the filtrate was combined with 1 mL of 0.2% ferric chloride solution in ethanol and 1 mL of 0.5% α,α-dipyridine solution. The reaction mixture was then diluted to a total volume of 5 mL using distilled water, after which absorbance was recorded at 520 nm. Standard solutions were prepared following the same procedure, and the concentration of vitamin E in the sample was determined by reference to the standard calibration curve [32].

Mineral analysis

Mineral elements were quantified using the AOAC methods. Sodium (Na) and potassium (K) were measured with a Sherwood Flame Photometer (Model 420), while phosphorus (P) was analysed using a Labtech Advance Microprocessor Single Beam UV-VIS Spectrophotometer (Model 295). The remaining trace and heavy metals were determined with a REYLEIGH Atomic Absorption Spectrophotometer (Model WFX320) following wet digestion with a mixture of 70% perchloric acid and nitric acid in a 1:3 ratio [34].

STATISTICAL ANALYSIS

Data were presented as mean ± SEM. The proximate composition values were presented in percentages, mineral contents in mg/g, and vitamin concentrations in mg/100 g of sample. One-way ANOVA was used to compare the two plant species at a level of significance of p = 0.05.

3-RESULTS

Proximate compositions

The proximate compositions in bay and mint leaves are represented in Figure 1. There was a significant difference in wet and dry moisture while no difference in the ash content was found.

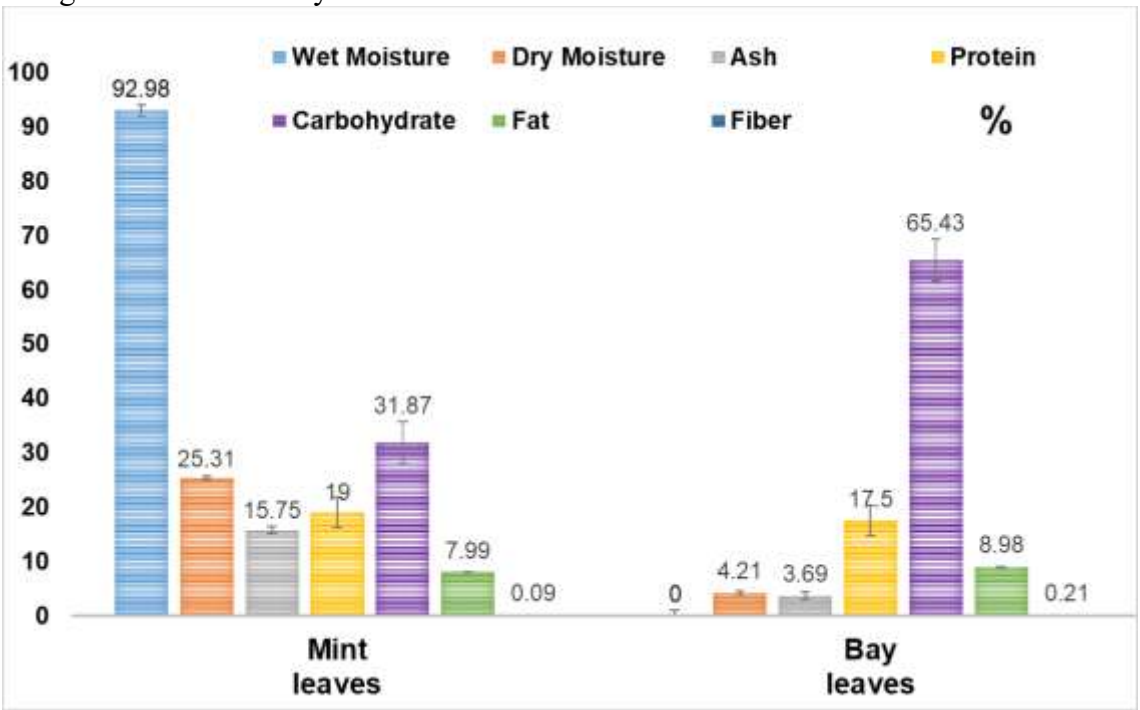

Figure 1: Proximate compositions *Laurus nobilis* and *Menta spicata*

The proximate composition in leaves of the two plants is shown in Figure 1. The dry moisture and ash contents in Mint leaves were 5 times higher than Bay leaves. Dry moisture represents the water content after drying, reflecting the inherent moisture of the sample. Bay leaves had a lower dry moisture content (4.21 ± 0.22%) compared to Mint leaves (25.31 ± 0.37%). This could influence their textural properties and shelf life when dried. Mint leaves had a significantly higher wet moisture (93.98 ± 0.36%). The much high-water content in the leaves may affect their freshness and perishability, and therefore require different storage conditions compared to Bay leaves. The result indicates protein content of 17.50%) bay leaves

The total fat content of 15.25% observed in this study for mint is significantly higher compared to that n bay leaf (8.93%) .No significant differences were seen in protein and fat contents amongst samples, 17-19% and 7-8 %, respectively. The amount of fiber was almost negligible in the two plants. The ash content in mint leaves was 15.75%, whereas bay leaves had an ash content of 3.69%. The amount of fiber present in bay leaf of this result (0.21%) was significantly lower. The carbohydrate content in bay leaves approximately doubles that of mint leaves. Carbohydrate content was observed to be higher in bay leaves (65.43%) compared to mint leaves (31.87%).

Vitamins and Minerals

The vitamins stored in these plant leaves was the lowest, below one gram (Figure 2). Bay leaves also contain small amounts of many vitamins and minerals. Bay leaf is a good source of vitamin A, vitamin C, vitamin B6, calcium, iron, and manganese. Mint leaves, while containing lower amounts of most vitamins, had a slightly higher content of vitamin C. These compositional differences are likely attributable to species-specific physiological traits and post-harvest processing conditions. Overall, both bay and mint leaves offer important micronutrients in the diet. Bay leaves are richer in fat-soluble vitamins, while mint stands out for its higher vitamin C content.

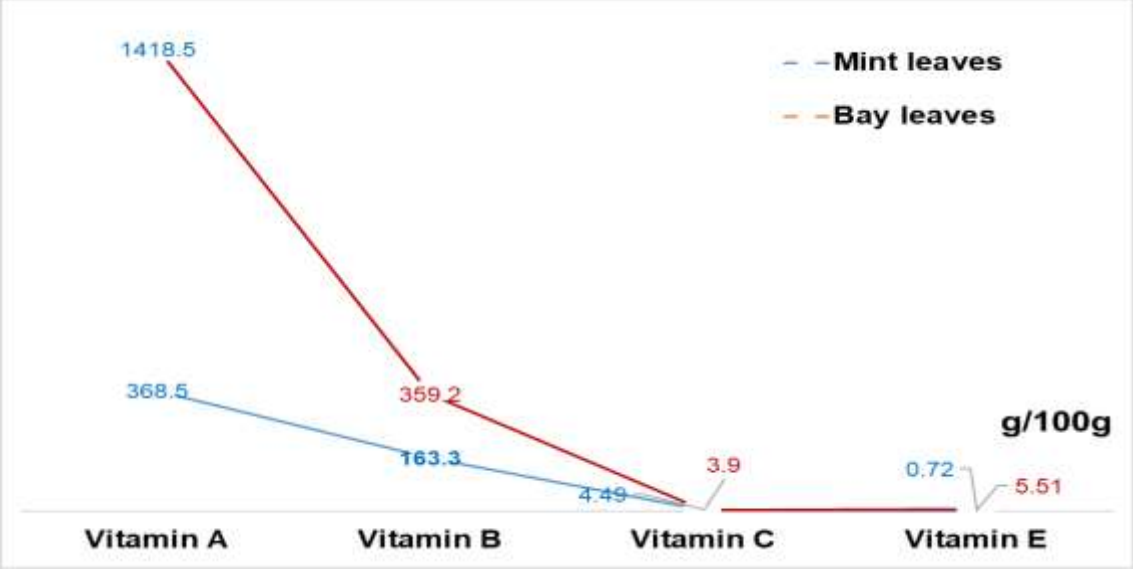

Figure 2: Vitamin composition of *Laurus nobilis* and *Mentha spicata*

Figure 3 presents the comparative mineral composition of bay and mint leaves, highlighting their essential mineral content. Bay leaves showed higher concentrations of calcium, copper, iron, magnesium, and manganese. Mint leaves also contained

significant amounts of these minerals but exhibited variability influenced by moisture and drying conditions. Notably, mint had higher levels of certain elements such as potassium and zinc.

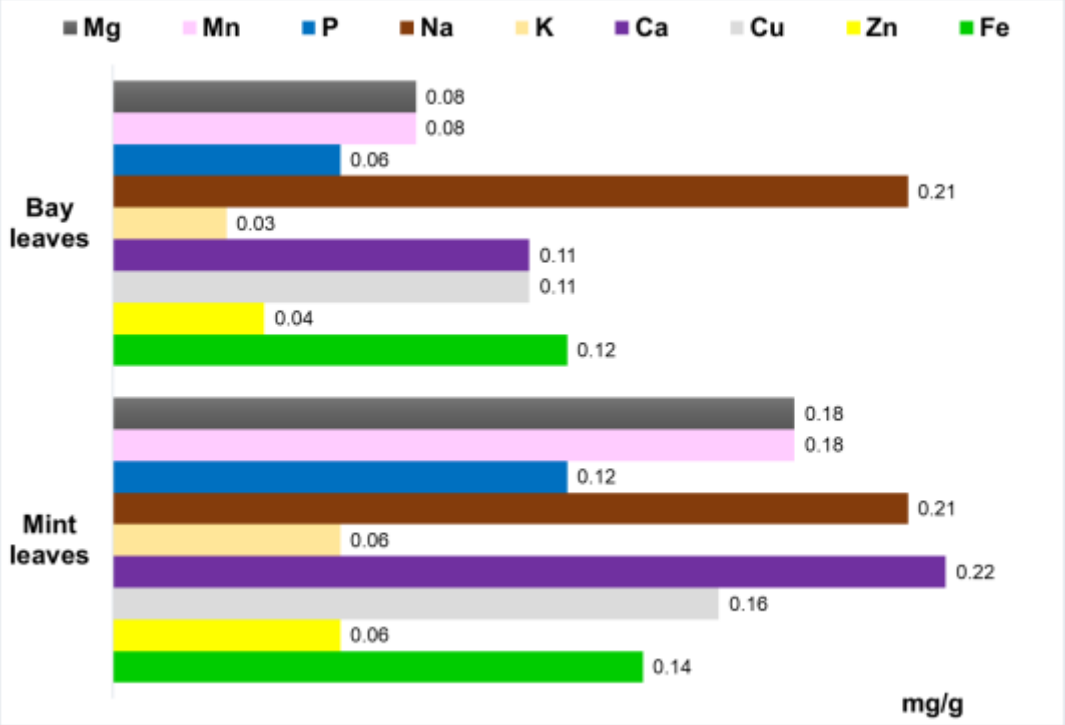

Figure 3: Mineral compositions of *Laurus nobilis* and *Mentha spicata*

4-DISCUSSION

The comparative investigation of bay (Laurus nobilis L.) and mint (Mentha spicata L.) leaves indicates significant differences in their proximate, mineral, and vitamin compositions, which both confirm based on previous study results. For example, this study revealed that mint leaves had much higher wet and dry moisture contents than bay leaves, with 93.98% wet moisture and 25.31% dry moisture. The findings is consistent with a previous study by [33], which stated that fresh mint leaves have a high moisture content (82.60%), and that drying considerably increases nutrient concentration. The current study revealed that bay leaves had a moisture content of 4.21 ± 0.22%, which is similar with a previous result of 4.95% [34]. These moisture differences affect the shelf life, storage conditions, and overall utility of the leaves in various applications. For instance, mint's higher perishability necessitates careful drying to preserve its nutritional integrity. The result supports previous claims that appropriate drying methods like shade drying enhance the nutritional value of mint leaves by preserving delicate phytochemicals [33]. With regard to protein and fat contents, the findings in this study present both expected and unexpected results when compared with past studies. The protein content of bay leaves in this study was 17.50%, which is higher than the 12.91% reported by [35] and much greater than the 7.62% previously observed by [34]. This discrepancy could arise from geographical variation, growing conditions, or sample preparation. Meanwhile, mint leaves exhibited a protein content of 13.90% when shade-dried,

according to Salve et al. [33], aligning with the trend seen in this study where mint also demonstrated a high protein level. Regarding fat content, bay leaves in this study contained 8.93% fat, comparable to [36] who reported 5.05%. This supports [34] observation that bay leaves contain a notable amount of oil, contributing to their use in culinary and medicinal contexts. In contrast, the fat content reported for mint by Salve et al.[33] also rose after drying, highlighting the role of processing in enhancing nutrient density. These variations suggest that while intrinsic nutritional values remain relatively stable, extrinsic factors such as drying methods and environmental exposure can cause significant shifts in content.

Carbohydrate and fiber compositions showed distinctive differences that are important for both dietary planning and therapeutic uses. The carbohydrate content in bay leaves recorded in this study (65.43%) was slightly lower than the 71.8% previously reported by [36], but still indicated bay leaves as a high-carbohydrate plant compared to mint. This aligns with [36] conclusion that most leafy vegetables are not rich in carbohydrates, with few exceptions like bay leaves. Mint leaves, following drying, experienced a carbohydrate increase from 8.95% in fresh leaves to 53.88% in cabinet oven-dried leaves [33], supporting the observation that drying intensifies nutritional density. On fiber content, this study recorded a negligible amount (0.21%) in bay leaves, which starkly contrasts with the 24.40% crude fiber reported by [34]. This inconsistency may stem from differences in analytical methods or sample conditions. The importance of dietary fiber in digestive health and disease prevention underscores the need for accurate quantification. Meanwhile, mint leaves' fiber content increased post-drying, showing how processing enhances their functional properties [33]. The data collectively indicate that while both herbs possess valuable nutrients, their efficacy can be greatly influenced by post-harvest treatment.

The present investigation examined the ash and mineral contents, which provided useful insights into the inorganic nutritional profiles of bay and mint leaves. According to [34], bay leaves contain crucial minerals such as calcium (377 mg/100g), iron (45 mg/100g), and magnesium (550 mg/100g), all of which play important roles in metabolic and structural activities. Similarly, the much lower mineral content in this study than in prior publications could be attributed to variations in soil composition, plant growing conditions, and sample processing procedures. Al-Hashimi and Mahmood [34] reported that heavy metal presence and urban pollution influence mineral uptake in bay leaves. Additionally, Salve et al. [33] reported that drying methods significantly influence nutrient retention in herbs. These variations suggest that the reduced mineral values in this study may reflect methodological and environmental factors rather than actual plant deficiencies. [33] noted significant increases in calcium, potassium, and magnesium, with shade drying preserving higher levels of zinc (13.10 mg/100g), which supports immune function and wound healing.

In terms of vitamins, bay leaves demonstrated a noteworthy profile, with substantial amounts of vitamin A, C, and riboflavin. This study noted 2000–3000 IU of vitamin A and 14–15 mg of vitamin C in bay leaves, consistent with the earlier data from [34], who highlighted bay leaves as a rich source of these vitamins. Riboflavin (45.33 mg/g) plays a pivotal role in oxidation-reduction reactions and energy production [37] while vitamin C acts as a powerful antioxidant [38]. Mint leaves are high in β-carotene, a precursor of vitamin A. They also include phytochemicals including alkaloids and flavonoids, which contribute to their antioxidant qualities [33]. These bioactive

compounds, particularly in shade-dried mint may enhance its medicinal value and nutritional potency. Previous findings indicates that *Mentha spicata* and related Lamiaceae species contain diverse bioactive phytochemicals, including high levels of phenolics which exhibit substantial antioxidant and antimicrobial potential, supporting their functional food and nutraceutical relevance [39]. Furthermore, the energy composition of bay and mint leaves provides insight into their potential as functional food. In this study, bay leaves had higher energy levels (398.6 kcal), validating their traditional use as culinary enhancers and energy-boosting substances. This is consistent with prior investigations by Akinola et al., [36], who revealed that bay leaves may provide a high caloric value mostly obtained from carbohydrates. Mint leaves, though less emphasized in energy value in this study, gain nutritional potency after drying, particularly in carbohydrate and fat content, which together contribute to increased caloric density [33]. Thus, the combination of caloric contribution and bioactive components in both leaves supports their roles as nutraceutical agents with holistic health benefits.

5-CONCLUSION

This study provides a comparative nutritional evaluation of bay (*Laurus nobilis* L.) and mint (*Mentha spicata* L.) leaves cultivated under Nigerian agroecological conditions, highlighting clear interspecific differences in proximate composition, vitamins, minerals, and energy value. Bay leaves demonstrated superior carbohydrate content and caloric density, alongside higher levels of fat-soluble vitamins, underscoring their potential as energy-enhancing and antioxidant-rich dietary additives. In contrast, mint leaves exhibited markedly higher moisture and ash contents, reflecting enhanced mineral availability and freshness, although with implications for reduced shelf stability. The relatively comparable protein and fat contents between both species further support their nutritional relevance, despite negligible fibre levels. Observed variations in mineral and vitamin composition emphasize the influence of species-specific physiology and environmental factors on nutrient accumulation. Collectively, the findings confirm that bay and mint leaves possess complementary nutritional attributes, supporting their combined utilization in functional foods, nutraceutical formulations, and dietary diversification strategies.

Conflict of Interest Disclosure

The authors declare no conflict of interest.

Acknowledgment

This work was self-funded by the research group

6-REFERENCES

[1] Shahidi, F., & Ambigaipalan, P. (2015). Phenolics and polyphenolics in foods, beverages and spices: Antioxidant activity and health effects – A review. *Journal of Functional Foods, 18*, 820–897. https://doi.org/10.1016/j.jff.2015.06.018

[2] Harish, K., Sivasankaran, S. M., & Manoharan, S. (2024). Indian Medicinal Plants with Multiple Pharmacological Efficacies: A Comprehensive Review. *Journal of Drug Delivery and Therapeutics*, *14*(1), 143-154. https://doi.org/10.22270/jddt.v14i1.6347

[3] Parthasarathy, V. A., Chempakam, B., & Zachariah, T. J. (2008). *Chemistry of spices*. CABI

[4] Batool, S., Khera, R. A., Hanif, M. A., & Ayub, M. A. (2020). Bay leaf. In M. A. Hanif, M. M. Khan, H. Nawaz, & H. J. Byrne (Eds.), *Medicinal plants of South Asia* (pp. 63–74). Elsevier

[5] Michel, J., Abd Rani, N. Z., & Husain, K. (2020). A review on the potential use of

medicinal plants from Asteraceae and Lamiaceae plant family in cardiovascular diseases. *Frontiers in Pharmacology, 11*, 852

[6] Patrakar, R., Mansuriya, M., & Patil, P. (2012). Phytochemical and pharmacological review on *Laurus nobilis*. *International Journal of Pharmaceutical and Chemical Sciences, 1*, 595–602.

[7] Biondi, D., Cianci, P., Geraci, C., Ruberto, G., & Piattelli, M. (1993). Antimicrobial activity and chemical composition of essential oils from Sicilian aromatic plants. *Flavour and Fragrance Journal, 8*, 331–337.

[8] Caputo, L., Nazzaro, F., Souza, L. F., Aliberti, L., De Martino, L., Fratianni, F., Coppola, R., & De Feo, V. (2017). Laurus nobilis: Composition of essential oil and its biological activities. *Molecules, 22*(6), 930.

[9] Sayyah, M., Valizadeh, J., & Kamalinejad, M. (2002). Anticonvulsant activity of the leaf essential oil of *Laurus nobilis* against pentylenetetrazole- and maximal electroshock-induced seizures. *Phytomedicine, 9*, 212–216.

[10] Fang, F., Sang, S., Chen, K. Y., Gosslau, A., Ho, C.-T., & Rosen, R. T. (2005). Isolation and identification of cytotoxic compounds from bay leaf (*Laurus nobilis*). *Food Chemistry, 93*, 497–501.

[11] El, S. N., Karagozlu, N., Karakaya, S., & Sahin, S. (2014). Antioxidant and antimicrobial activities of essential oils extracted from *Laurus nobilis* L. leaves by using solvent-free microwave and hydrodistillation. *Food and Nutrition Sciences, 5*(2), 97–106.

[12] Elmastaş, M., Gülçin, İ., Işığlu, M., Ibaoğlu, O., Küfrevioğlu, K., & Aboul-Enein, H. (2006). Radical scavenging activity and antioxidant capacity of bay leaf extracts. *Journal of the Iranian Chemical Society, 3*, 258–266.

[13] Naidu, J. R., Ismail, R. B., Yeng, C., Sasidharan, S., & Kumar, P. (2012). Chemical composition and antioxidant activity of the crude methanolic extracts of *Mentha spicata*. *Phytology, 4*(1), 13–18.

[14] Brahmi, F., Khodir, M., Mohamed, C., & Pierre, D. (2017). Chemical composition and biological activities of Mentha species. *Aromatic and Medicinal Plants—Back to Nature, 10*(1), 47–79.

[15] Tsai, M. L., Wu, C. T., Lin, T. F., Lin, W. C., Huang, Y. C., & Yang, C. H. (2013). Chemical composition and biological properties of essential oils of two mint species. *Tropical Journal of Pharmaceutical Research, 12*(4), 577-582.

[16] Abuajah, C. I., Ogbonna, A. C., & Osuji, C. M. (2015). Functional components and medicinal properties of food: A review. *Journal of Food Science and Technology, 52*(5), 2522–2529.

[17] Yassin, M. T., Mostafa, A. A., & Al-Askar, A. A. (2020). Anticandidal and anti-carcinogenic activities of Mentha longifolia (Wild Mint) extracts in vitro. *Journal of King Saud University-Science, 32*(3), 2046-2052.

[18] Berdowska, I., Zieliński, B., Fecka, I., Kulbacka, J., Saczko, J., & Gamian, A. (2013). Cytotoxic impact of phenolics from Lamiaceae species on human breast cancer cells. *Food Chemistry, 141*(2), 13–21.

[19] Tafrihi, M., Imran, M., Tufail, T., Gondal, T. A., Caruso, G., Sharma, S., Sharma, R., Atanassova, M., Atanassov, L., Valere Tsouh Fokou, P., et al. (2021). The wonderful activities of the genus *Mentha*: Not only antioxidant properties. *Molecules, 26*(4), 1118.

[20] Hsu, C. Y., Chao, P. Y., Hu, S. P., & Yang, C. M. (2013). The antioxidant and free radical scavenging activities of chlorophylls and pheophytins. *Food and Nutrition Sciences, 4*(1), 1–8

[21] Soleimani, M., Arzani, A., Arzani, V., & Roberts, T. H. (2022). Phenolic compounds and antimicrobial properties of mint and thyme. *Journal of Herbal Medicine, 36*, 100604.

[22] Karousou, R., Balta, M., Hanlidou, E., & Kokkini, S. (2007). ―Mints‖, smells and traditional uses in Thessaloniki (Greece) and other Mediterranean countries. *Journal of Ethnopharmacology, 109*(2), 248-257.

[23] Deyab, M. H., Awady, B. E., & Bakir, N. G. (2018). Is immersion in mint oil or apple vinegar solution a valid antifungal approach for acrylic soft liners? *Future Dental Journal, 4*(2), 302-307.

[24] Xalxo, R., Yadu, B., Chandra, J., Chandrakar, V., & Keshavkant, S. (2020). Alteration in carbohydrate metabolism modulates thermotolerance of plant under heat stress. In S. H. Wani & V. Kumar (Eds.), *Heat Stress Tolerance in Plants: Physiological, Molecular and Genetic Perspectives* (pp. 77–115).

[25] Kaur, G., Singla, N., & Singh, A. (2019). Effect of vacuum drying on nutrient retention of some commonly consumed herbs. *Studies on Ethno-Medicine, 13*(1), 62–70.

[26] Young, A. J., & Lowe, G. L. (2018). Carotenoids—Antioxidant properties. *Antioxidants, 7*(2), 28.
[27] Association of Official Analytical Chemists - AOAC. *Official Methods of Analysis of AOAC International* (17th ed.). AOAC International. 2000
[28] AOAC International methods committee guidelines for validation of qualitative and quantitative food microbiological official methods of analysis, J. AOAC Int. 2002; 85 (5):1187–1200
[29] Achikanu, C. E., Eze-Steven, P. E., Ude, C. M. and Ugwuokolie, O. C. Determination of the vitamin and mineral composition of common leafy vegetables in southeastern Nigeria. *Int. J. Curr. Microbiol. App. Sci,* 2013; 2(11**)**:347-353.
[30] Sabah, S., Tahere, K., Sami, S., Ali, D., Moayed, A., Ali, M. A Novel and Sensitive Method for the Determination of Vitamin B (Riboflavin) in Urine and Pharmaceutical Samples Using an: Aqueous Two-Phase Extraction. *Journal of Chemistry*, 2013; **1**, 1-5.
[31] Sahlin E, G.P. Savage and C.E Lister. Investigation of the antioxidant properties of tomatoes after processing. J. Food Comp. Analy. 2004;17: 635-647
[32] Igiri, I. I. Compendium manual of food chemistry practical, Judaeson press. Calabar, 2019; **21**, 23-28.
[33] Salve, R. V., Syed, H. M., More, S. G., & Shinde, E. M. (2020). Effect of different drying treatment on composition, nutritional and phytochemical content of mint leaves. *The Pharma Innovation Journal, 9*(7), 568-573.
[34] Al-Hashimi, A., & Mahmood, S. (2016). The nutritional value and antioxidant activity of bay leaves (Laurusn obilis L.). *Basrah Journal of Veterinary Research, 15*(4), 10–23.
[35] Aparna, K., Sahoo, M., Sowmya, M., Devi, M., Dasgupta, M., & Mulinti, S. (2020). Nutrient, antioxidant and anti nutrient composition of value added products made with underutilized forest produce bay leaf (Cinnamomum tamala). *Agricultural Engineering International : The CIGR e-journal, 22*, 226-234.
[36] Akinola, V, Salami, A., Durodola, O., Olasoju, A . Ogunsina, B. Proximate and Some Phytochemical Constituents of Three West CoRReg African Vegetable Spices. *Eurasian Journal of Food Science and Technology*, 2021; 5(1):59-66.
[37] McCormick, D. (1999). Riboflavin. In O. J. Shils M, Shike M, Ross AC (Ed.), *Modern Nutrition in Health and Disease* (9 ed., pp. 391–399). Baltimore: Williams & Wilkins.
[38] Alberts, A., Moldoveanu, E.-T., Niculescu, A.-G., & Grumezescu, A. M. (2025). Vitamin C: A comprehensive review of its role in health, disease prevention, and therapeutic potential. *Molecules, 30*(748).
[39] Silva, B. N., Cadavez, V., Caleja, C., Pereira, E., Calhelha, R. C., Añibarro-Ortega, M., Finimundy, T., Kostić, M., Soković, M., Teixeira, J. A., Barros, L., & Gonzales-Barron, U. (2023). Phytochemical composition and bioactive potential of *Melissa officinalis* L., *Salvia officinalis* L., and *Mentha spicata* L. extracts. *Foods, 12*(5), 947. https://doi.org/10.3390/foods12050947