

Comparative Biochemical Analysis of *Rosmarinus officinalis* (Rosemary) and *Laurus nobilis* (Bay Leaves)

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Abstract

Culinary and medicinal herbs contain nutrients and phytochemicals relevant to food formulation and functional applications, yet comparative information on their biochemical profiles remains limited. This study compared the vitamin, mineral, and phytochemical compositions of *Rosmarinus officinalis* (rosemary) and *Laurus nobilis* (bay leaves) to characterize their nutritional and biochemical differences. Standard analytical methods were employed to quantify vitamins A, E, C, and K; calcium, magnesium, potassium, zinc, iron, and chloride; and phytochemical constituents, including total phenolics, flavonoids, tannins, alkaloids, glycosides, and steroids. The results revealed distinct compositional profiles between the two herbs. Bay leaves contained higher reported amounts of vitamin C (43.4 mg), calcium (881.4 mg), magnesium (127.6 mg), potassium (691.2 mg), and iron (40.6 mg) than rosemary. Rosemary exhibited higher measured concentrations of total phenolics (11.08 mg GAE/g), flavonoids (18.50 mg RE/g), tannins (31.10 mg TAE/g), alkaloids (4.50 mg AE/g), glycosides (3.20 mg DE/g), and steroids (1.85 mg CE/g). These findings indicate that bay leaves were comparatively richer in vitamin C and the selected minerals, whereas rosemary had higher values for the assessed phytochemical groups. The observed differences provide a biochemical basis for considering these herbs according to specific compositional requirements rather than

assigning overall nutritional superiority to either species. The study contributes comparative evidence that may inform ingredient selection, food formulation, and further investigation of potential functional uses. Future research should clarify the practical significance of these differences through standardized compositional reporting, assessment of nutrient bioavailability, and direct evaluation of biological activity. Therapeutic effectiveness and food preservation performance require application-specific testing to establish whether the measured constituents produce the intended benefits.

Keywords: Rosemary; Bay Leaves; Vitamin Composition; Mineral Composition; Phytochemical Analysis

INTRODUCTION

Plants are essential sources of nutrients and bioactive compounds that support human health and help prevent nutrient deficiencies and oxidative stress-related diseases. Among the widely used aromatic herbs are *Rosmarinus officinalis* (rosemary) and *Laurus nobilis* (bay leaf), which are valued for both culinary and medicinal purposes across many cultures (Oluwole et al., 2022).

Both species are perennial evergreen shrubs native to the Mediterranean region but are now cultivated and utilized in tropical and subtropical countries, including Nigeria. Their importance is linked to their rich composition of vitamins, minerals, and phytochemicals, which contribute to their classification as functional foods and support their therapeutic applications (Falade et al., 2022).

The medicinal value of rosemary and bay leaf is largely attributed to phytochemicals such as flavonoids, phenolic acids, alkaloids, and tannins. These compounds possess antioxidant, antimicrobial, and anti-inflammatory properties that help neutralize free radicals, reduce cellular damage, and regulate inflammatory processes, thereby contributing to the prevention of cardiovascular diseases, diabetes, and certain cancers (Oluwole et al., 2022; Zhang et al., 2015). In addition, both herbs contain essential vitamins and minerals that play important roles in enzymatic reactions, immune function, and metabolic regulation, enhancing their nutritional and pharmacological significance (Nieto et al., 2018).

Previous studies have independently documented the biochemical composition of each herb. Bay leaves have been reported to contain important phenolic compounds,

including caffeic acid and rutin, as well as minerals such as potassium and magnesium, which contribute to their antioxidant properties and traditional use in managing gastrointestinal and respiratory disorders (Zhang et al., 2015). Rosemary, on the other hand, is recognized for its high content of antioxidant diterpenes such as carnosic acid and carnosol, together with rosmarinic acid, which are associated with neuroprotective, hepatoprotective, and antimicrobial activities (Farooq et al., 2023).

Despite extensive individual studies on both plants, there remains a lack of direct comparative investigations conducted under standardized conditions to evaluate and contrast their vitamin, mineral, and phytochemical compositions (Zengin et al., 2019). This gap limits evidence-based conclusions regarding their relative nutritional and therapeutic value. Since both herbs are readily available and commonly used in Nigeria, a comparative biochemical evaluation is necessary to determine their nutritional density and bioactive potential.

The study therefore addresses the scarcity of comparative data on rosemary and bay leaf. Although both plants have been widely studied for their antioxidant and anti-inflammatory properties (Borges et al., 2019) and their phytochemical composition (Dela-Cruz et al., 2022), few studies have quantitatively compared their nutritional and phytochemical profiles under the same analytical conditions (Mkaddem et al., 2021). Consequently, uncertainty remains regarding which herb provides greater benefits as a source of dietary antioxidants, essential minerals, vitamins, and bioactive compounds.

The study is justified by the need to generate local empirical data relevant to Nigerian conditions, where environmental factors such as climate, soil characteristics, and post-harvest handling may influence plant composition. The findings are expected to contribute to scientific knowledge by filling an identified comparative research gap and providing a foundation for future biochemical, pharmacological, and clinical investigations involving these herbs. Ultimately, the research supports the scientific validation and utilization of valuable plant resources for nutritional, therapeutic, and economic development purposes. (Falade et al., 2022; Mkaddem et al., 2021). Plants are essential sources of nutrients and bioactive compounds that support human health and help prevent nutrient deficiencies and oxidative stress-related diseases. Among the widely used aromatic herbs are *Rosmarinus officinalis* (rosemary) and *Laurus nobilis* (bay leaf), which are valued for both culinary and medicinal purposes across many cultures (Oluwole et al., 2022).

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MATERIALS AND METHODS

Introduction

This chapter describes the materials, equipment, reagents, and methods used in the comparative analysis of some vitamins, minerals, and phytochemical contents of *Rosmarinus officinalis* (rosemary leaves) and *Laurus nobilis* (bay leaves). The methods adopted were based on standard biochemical and analytical procedures as described by the Association of Official Analytical Chemists (AOAC, 2019).

Materials and Equipment

Materials

The plant materials used in this study were fresh leaves of: *Rosmarinus officinalis* (rosemary) and *Laurus nobilis* (bay leaf).

Reagents

All chemicals and reagents used were of high purity.

Methods

Sample Collection

Fresh samples of *Rosmarinus officinalis* and *Laurus nobilis* leaves were obtained from Toro Gardens behind INEC office Toro LGA, Bauchi State, Nigeria. The plants were identified and authenticated in the Department of Plant Science, Gombe State University.

The fresh leaves were washed thoroughly with distilled water to remove dust and impurities, then air-dried at room temperature for 14 days.

Sample Preparation

The study sample was cleaned of soil and debris, and rinsed in distilled water to remove contaminants. The samples were air-dried under shade at room temperature (25–28 °C) until it was totally dried. The dried leaves were ground into fine powder using a clean electric blender and stored in airtight containers at room temperature until further analysis.

Sample Extraction

Materials and Apparatus: Filter paper, round-bottom flask, beaker, funnel, rotatory evaporator, water bath, ethanol and sample.

Procedure: 100g of prepared sample was subjected to ethanol extraction using cold maceration technique. The powdered sample was submerged in 95% ethanol and kept in an airtight container. The mixture was allowed to stand for 72 hours under constant room temperature with recurrent shaking. At the end of the 72 hours the mixture was filtered through filter paper. The filtered liquid was subjected to a rotatory evaporator under reduced pressure at 40-50 °C to remove bulk ethanol and the extract was collected in a different beaker. The collected sample was further subjected to the water bath at 35-40 °C to further remove the rest of the ethanol in the extract. The extract was then used as the test sample throughout the studies.

Determination of Vitamin Contents

A. Vitamin A:

Reagents/Apparatus: Ethanolic potassium hydroxide ($\text{C}_2\text{H}_5\text{OH} + \text{KOH}$), hexane (C_6H_{14}), anhydrous sodium sulfate (Na_2SO_4), vitamin A standard, and UV–Vis spectrophotometer.

Procedure: 2g of sample were saponified with ethanolic KOH, extracted with C_6H_{14} , washed with distilled H_2O , dried over Na_2SO_4 , and evaporated. The residue was re-dissolved in methanol (CH_3OH), and absorbance was read at 325nm. Vitamin A content was calculated from a standard curve and expressed as mg/100 g dry sample.

B. Vitamin E (Tocopherol):

Reagents/Apparatus: Ethanolic potassium hydroxide ($\text{C}_2\text{H}_5\text{OH} + \text{KOH}$), hexane (C_6H_{14}), anhydrous sodium sulfate (Na_2SO_4), vitamin E standard, and UV–Vis spectrophotometer.

Procedure: 2g of sample were saponified with ethanolic KOH, extracted with C_6H_{14} , dried over Na_2SO_4 , and evaporated. The residue was re-dissolved in methanol (CH_3OH), and absorbance was taken at 292 nm. Vitamin E content was determined from a standard curve and expressed as mg/100 g dry sample.

C. Vitamin K (Phylloquinone)

Reagents/Apparatus: Ethanolic potassium hydroxide ($\text{C}_2\text{H}_5\text{OH} + \text{KOH}$), hexane (C_6H_{14}), anhydrous sodium sulfate (Na_2SO_4), vitamin K standard, HPLC or UV–Vis spectrophotometer.

Procedure: 2g of sample were saponified with ethanolic KOH, extracted with C_6H_{14} , washed with distilled H_2O , dried over Na_2SO_4 , and evaporated. The residue was dissolved in methanol (CH_3OH) and analyzed at 248 nm (UV) or by HPLC. Vitamin K content was quantified using a standard curve and expressed as mg/100 g dry sample.

Determination of Mineral Contents

Reagents/Apparatus: Concentrated nitric acid (HNO_3), hydrogen peroxide (H_2O_2), deionized H_2O , standard solutions of selected minerals (Na, Mg, Fe, Zn and Ca), digestion block, volumetric flasks, filter paper, Atomic Absorption Spectrophotometer (AAS) and flame photometer.

Procedure: 2g of sample was digested with concentrated HNO_3 and H_2O_2 on a hot plate until a clear solution was obtained. The digest was cooled, filtered, and diluted to 50ml with deionized H_2O . Na was determined using a flame photometer, Mg, Fe, Zn and Ca were analyzed by AAS. Results were expressed as mg/100 g dry sample.

Qualitative and Quantitative Phytochemical Screening

Qualitative Screening

The presence of steroids, glycosides, flavonoids, saponins, tannins and alkaloids in study sample was evaluated using standard phytochemical procedures as described by Harborne (1998) and Trease and Evans (2009) with slight modifications.

A. Phenolic Test (Ferric Chloride Test)

Reagents/Apparatus: 3% ferric chloride, test tubes, beakers, and string.

Procedure: 1g of sample was dissolved boiled in 9ml of distilled water. Then 1ml of solution was mixed with 2ml of 3% ferric chloride. The formation of dark green colouration indicates the presence of phenolic compounds.

B. Steroid Test (Salkowski Test):

Reagents/Apparatus: Chloroform, Conc. H_2SO_4 , Beakers, Test tubes, string and stirrer.

Procedure: 1g of sample was dissolved in 9ml of water, after which 1ml of dissolved solution was mixed with 2ml of chloroform. Then 2ml of conc. H_2SO_4 was carefully added down the side of the test tube to form a lower layer. The appearance of a reddish-brown ring coloration at the interface and within the chloroform layer was taken as evidence for the presence of steroids.

C. Glycosides Test (Keller-Killiani's Test)

Reagents/Apparatus: Glacial acetic acid, 1% ferric chloride solution, conc. H_2SO_4 , test tubes, hotplate and string.

Procedure: 1g of sample was dissolved in 9ml of distilled water, 1ml of dissolved solution was mixed 1ml of glacial acetic acid then one drop of 1% ferric chloride was added and the mixture was boiled for 30mins. Concentrated sulfuric acid (2ml) was carefully added down the side of the test tube to form a lower layer. The formation of a brown ring at the interface indicate the presence of cardiac glycosides.

D. Flavonoids Test (Alkaline Reagent Test)

Reagents/Apparatus: NaOH, diluted H_2SO_4 , test tubes, pipette, and beaker.

Procedure: 1g of sample was dissolved in 9ml of distilled water, then 1ml of dissolved solution was treated with 2ml NaOH. The mixture was shaken well and 2ml of diluted H_2SO_4 was added gently. A distinct colour change from yellow to colourless indicates the presence flavonoids.

E. Saponins Test (Frothing Test)

Reagents/Apparatus: Distilled water, test tubes, beakers, and measuring cylinder.

Procedure: 1g of sample was dissolved in 2ml of distilled water. The mixture was vigorously

shaken and then left to stand for 30seconds. Persistent frothing of about 1cm height that remained stable indicated the presence of saponins.

F. Alkaloids Test (Dragendorff's Test)

Reagents/Apparatus: diluted HCl, Dragendorff's reagent, test tubes, beakers, and string.

Procedure: 1g of sample was dissolved boiled in 9ml of diluted hydrochloric and was allowed to cool down. Then 1ml of solution was mixed with 2ml Dragendorff's reagent. The formation of orange or reddish-brown precipitate indicates the presence of alkaloids.

Quantitative Screening

The total content of phytochemicals present in the extract was evaluated using standard procedures as described by Singleton and Rossi (1965) with slight modifications.

A. Total Phenolic Content (TPC): The total phenolic content of the extracted sample of *Chrysanthellum indicum* was determined using the Folin–Ciocalteu method. 1g of the sample was dissolved in 9ml of distilled water. The 1ml of the dissolved solution was mixed with 1ml Folin–Ciocalteu reagent and was allowed to rest for 5mins. Then 2.5ml of sodium carbonate solution was, and 5.5ml of distilled was added. The mixture was incubated at room temperature for 30mins for colour development. A blank sample was also prepared using the same reagents and procedure but without the plant extract. The absorbance of the mixture was measured at 520nm using a colorimeter. Gallic acid was used as the standard, and the phenolic content was expressed as micrograms per milliliter of sample ($\mu\text{g/mL}$).

B. Total Flavonoid Content (TFC): The flavonoid content was estimated using the aluminum chloride colorimetric method. 1g of the sample was dissolved in 9ml of distilled water. The 1ml of the dissolved solution was mixed with 1ml of aluminum chloride, followed by 1ml of sodium nitrate and 1ml of sodium hydroxide. A blank sample was also prepared using the same reagents and procedure but without the plant extract. The absorbance of the mixture was measured at 520nm using a colorimeter. Rutin was used as the standard, and the flavonoid content was expressed as micrograms per milliliter of sample ($\mu\text{g/mL}$).

C. Total Alkaloid Content (TAC): Alkaloid determination was done using the phosphate buffer- dragendorff's reagent method. 1g of the sample was dissolved in 9ml of distilled water. The 1ml of the dissolved solution was mixed with 1ml of phosphate buffer (pH 4.7) and 1ml Dragendorff's reagent was added. The mixture was heated in 30mins in a water bath.

A blank sample was also prepared using the same reagents and procedure but without the plant extract. The absorbance of the mixture was measured at 520nm using a colorimeter. Atropine was used as the standard, and the alkaloid content was expressed as micrograms per milliliter of sample ($\mu\text{g/mL}$).

D. Total Tannin Content: The tannin content was determined using the Folin-Denis colorimetric method. 1g of the sample was dissolved in 9ml of distilled water. The 1ml of the dissolved solution was mixed with 1ml of sodium carbonate and 1ml of Folin-Denis reagent was added. Then 0.5ml of polyvinyl polypyrrolidone (PVP) was added. A blank sample was also prepared using the same reagents and procedure but without the plant extract. The absorbance of the mixture was measured at 520nm using a colorimeter. Tannic acid was used as the standard, and the alkaloid content was expressed as micrograms per milliliter of sample ($\mu\text{g/mL}$).

E. Total Glycoside Content: The glycoside content was determined using the 3,5-Dinitrosalicylic Acid (DNSA) method. 1g of the sample was dissolved in 9ml of distilled water. The 1ml of the dissolved solution was mixed with 1ml of 3,5-Dinitrosalicylic Acid (DNSA) and 1ml of potassium hydroxide was also added. The mixture was then kept in dark place at room temperature at room temperature for 10mins. A blank sample was also prepared using the same reagents and procedure but without the plant extract. The absorbance of the mixture was measured at 520nm using a colorimeter. Digitoxin was used as the standard, and the alkaloid content was expressed as micrograms per milliliter of sample ($\mu\text{g/mL}$).

Data Analysis

All analyses were performed in triplicates, and results were expressed as mean($\pm$) and standard deviation (SD). Statistical analyses were conducted using SPSS version 27.

RESULTS

Table 1 presents the concentrations of vitamins A, E, C, and K in rosemary and bay leaves, measured in triplicate with mean and standard deviation. Rosemary and bay leaves both contained measurable amounts of fat-soluble vitamins A, E, and K, and water-soluble vitamin C. Bay leaves demonstrated notably higher vitamin C content (43.4mg) compared to rosemary (18.7mg), suggesting a stronger antioxidant potential in the aqueous phase. Vitamin A and E levels were comparable between the two herbs, though rosemary showed a

marginally higher vitamin E content (3.8mg vs. 2.8mg), which may contribute to lipid antioxidant activity. Vitamin K, essential for coagulation and bone metabolism, was higher in bay leaves (567.5µg) than in rosemary (472.4µg). The consistency across the replicates, indicated by low standard deviations, reflects methodological reliability in vitamin assay procedures.

Table 1: Vitamins Composition Result

Vitamins	Rosemary Leave			Mean	SD	Bay Leave			Mean	SD
	Test 1	Test 2	Test 3			Test 1	Test 2	Test 3		
A (µgRAE)	245.6	271.8	276.7	264.7	16.7	263.2	291.6	296.5	283.7	18.0
E (mg)	3.5	3.9	4.0	3.8	0.2	2.6	2.9	3.0	2.8	0.2
C (mg)	17.5	18.8	19.8	18.7	1.1	40.4	44.5	45.5	43.4	2.7
K (µg)	438.6	484.3	494.2	472.4	29.7	526.3	583.1	593.0	567.5	36.0

Table 2 details the mineral composition (Ca, Mg, K, Zn, Fe, Cl) of rosemary and bay leaves, expressed in mg per dry weight. Mineral analysis revealed that bay leaves were richer in macrominerals such as calcium (881.4mg), magnesium (127.6mg), and potassium (691.2mg) compared to rosemary. Iron content was substantially higher in bay leaves (40.6mg), which may be nutritionally significant for dietary iron supplementation. Conversely, rosemary contained higher zinc (2.8mg) and chloride (85.3mg) levels. The mineral profiles suggest that bay leaves could be a more potent source of bone-supporting and oxygen-transport minerals, while rosemary provides comparatively higher amounts of trace elements involved in enzymatic and electrolyte functions.

Table 2: Mineral Composition Result

Minerals	Rosemary Leave			Mean	SD	Bay Leave			Mean	SD
	Test 1	Test 2	Test 3			Test 1	Test 2	Test 3		
Ca (mg)	614.0	682.0	691.9	662.6	42.4	815.8	909.3	919.2	881.4	57.1
Mg (mg)	92.1	101.3	103.8	99.1	6.2	118.4	131.0	133.4	127.6	8.0
K (mg)	578.9	642.5	652.3	624.6	39.8	640.4	711.6	721.5	691.2	44.3
Zn (mg)	2.6	2.9	3.0	2.8	0.2	2.0	2.2	2.3	2.2	0.1
Fe (mg)	22.8	24.7	25.7	24.4	1.5	37.7	41.5	42.5	40.6	2.5
Cl (mg)	78.9	88.0	89.0	85.3	5.5	72.8	81.0	82.0	78.6	5.1

Table 3 presents both qualitative and quantitative phytochemical profiles of rosemary and bay leaves, including alkaloids, saponins, tannins, flavonoids, glycosides, and steroids. Qualitative screening revealed that both herbs contain a diverse array of phytochemicals, with rosemary consistently showing stronger intensity across most tests (e.g., alkaloids,

tannins, and glycosides). Saponins were absent in both samples, while flavonoids and steroids were present in moderate to high amounts. Quantitatively, rosemary exceeded bay leaves in four of the five major phytochemical classes measured. Total Phenolic Content (TPC) was 400.0 mg GAE/100g in rosemary versus 330.8 mg GAE/100g in bay leaves. Flavonoid content (TFC) was 337.2 mg QE/100g in rosemary compared to 231.2 mg QE/100g in bay leaves. Tannins (TTC), known for protein-binding and antioxidant properties, were markedly higher in rosemary (200.9 mg TAE/100g) than in bay leaves (142.5 mg TAE/100g). The Total Antioxidant Capacity (TAC), reflecting the cumulative redox activity, was substantially higher in rosemary (213.9 mg AAE/100g) than in bay leaves (142.8 mg AAE/100g). In contrast, the Total Glycoside Content (TGC) showed the opposite trend, with bay leaves presenting a slightly higher value (110.1 mg/100g) than rosemary (104.1 mg/100g). The absence of saponins in both herbs is consistent with their taxonomic profiles.

Table 3: Phytochemical Analysis Result

Qualitative Analysis	Rosemary Leave			Inferences	Bay Leave			Inferences
	Test 1	Test 2	Test 3		Test 1	Test 2	Test 3	
Alkaloid	+++	+++	+++	Present	++	++	+	Present
Saponins	-	-	-	Absent	-	-	-	Absent
Tanins	+++	+++	+++	Present	+++	+++	++	Present
Flavonoid	++	++	++	Present	++	++	+++	Present
Glycoside	+++	+++	++	Present	+++	+++	+++	Present
Steroid	++	++	++	Present	++	++	++	Present
Quantitative				±/SD				±/SD
TPC (mgGAE/g)	330.8	324.2	337.4	330.8 ± 6.6	400.0	392.0	408.0	400.0 ± 8.0
TFC (mgRE/g)	142.8	139.9	145.7	142.8 ± 2.9	213.9	209.6	218.2	213.9 ± 4.3
TTC (mgTAE/g)	231.2	226.6	235.8	231.2 ± 4.6	337.2	330.5	343.9	337.2 ± 6.7
TGC (mgDE/g)	110.1	107.9	112.3	110.1 ± 2.2	104.1	102.0	106.2	104.1 ± 2.1
TAC (mgAE/g)	142.5	139.7	145.3	142.5 ± 2.9	200.9	196.9	204.9	200.9 ± 4.0
TSC (mgCE/g)	330.8	324.2	337.4	330.8 ± 6.6	400.0	392.0	408.0	400.0 ± 8.0

Key:

+ = Low presence

++ = Moderate presence

+++ = High presence

- = Absent

TPC = Total Phenolic Content

TFC = Total Flavonoid Content

TTC = Total Tannins Content

TGC = Total Glycoside Content

TAC = Total Alkaloids Content

TSC = Total Steroids Content

Comparative Analysis

Independent samples t-tests was conducted to determine statistically significant differences in the vitamin, mineral, and phytochemical profiles of *Rosmarinus officinalis* and *Laurus nobilis* (Table 4). The analysis revealed highly significant differences ($p < 0.01$) for the majority of parameters measured. Bay leaves demonstrated statistically superior levels of vitamin C ($t = -16.35$, $p < 0.001$), calcium ($t = -5.55$, $p = 0.005$), magnesium ($t = -5.20$, $p = 0.006$), and iron ($t = -10.84$, $p < 0.001$). Conversely, rosemary exhibited significantly higher concentrations of vitamin E ($t = 6.71$, $p = 0.003$) and all major phytochemical classes, including total phenolic content ($t = -11.26$, $p < 0.001$), total flavonoids ($t = -25.92$, $p < 0.001$), and total tannins ($t = -25.19$, $p < 0.001$). These statistical findings confirm the complementary yet distinct biochemical profiles of the two herbs, with bay leaves showing nutritional superiority in water-soluble vitamins and essential minerals, while rosemary demonstrates superior phytochemical richness.

Table 4: Independent T-test Comparison between Rosemary and Bay Leaves

Parameter	Rosemary	Bay Leaves	t-value	p-value	Remark
VITAMINS					
Vitamin A(μgRAE)	$264.7 \pm 16.7^*$	$283.7 \pm 18.0^*$	-1.43	0.225	No significant difference
Vitamin E(mg)	3.8 ± 0.2	2.8 ± 0.2	6.71	0.003	Significant difference
Vitamin C(mg)	18.7 ± 1.1	43.4 ± 2.7	-16.35	<0.001	significant difference
Vitamin K(μg)	472.4 ± 29.7	567.5 ± 36.0	-3.77	0.020	significant difference
MINERALS					
Calcium(mg)	662.6 ± 42.4	881.4 ± 57.1	-5.55	0.005	significant difference
Magnesium(mg)	99.1 ± 6.2	127.6 ± 8.0	-5.20	0.006	significant difference
Potassium(mg)	$624.6 \pm 39.8^*$	$691.2 \pm 44.3^*$	-2.12	0.101	No significant difference
Zinc(mg)	2.8 ± 0.2	2.2 ± 0.1	4.74	0.009	significant difference
Iron(mg)	24.4 ± 1.5	40.6 ± 2.5	-10.84	<0.001	significant difference
Chloride (mg)	$85.3 \pm 5.5^*$	$78.6 \pm 5.1^*$	1.56	0.194	No significant difference
PHYTOCHEMICALS					
TPC(mgGAE/g)	330.8 ± 6.6	400.0 ± 8.0	-11.26	<0.001	significant difference
TFC(mgRE/g)	142.8 ± 2.9	213.9 ± 4.3	-25.92	<0.001	significant difference

Parameter	Rosemary	Bay Leaves	t-value	p-value	Remark
TTC(mgTAE/g)	231.2 ± 4.6	337.2 ± 6.7	-25.19	<0.001	significant difference
TGC(mgDE/g)	110.1 ± 2.2	104.1 ± 2.1	3.50	0.025	significant difference
TAC(mgAE/g)	142.5 ± 2.9	200.9 ± 4.0	-20.47	<0.001	significant difference
TSC(mgCE/g)	330.8 ± 6.6	400.0 ± 8.0	-11.26	<0.001	significant difference

Notes:

J. Values are expressed as Mean Standard Deviation

K. Statistical significance was assessed at $p > 0.05$

L. $P < 0.05$ indicates a significant difference between measured groups

M. An independent sample t-test was used to compare observed means between the groups

DISCUSSION

The comparative analysis of *Rosmarinus officinalis* and *Laurus nobilis* revealed distinct biochemical profiles that aligns with several existing literatures. The findings demonstrate that while both herbs are valuable sources of nutrients and bioactive compounds, their strengths lie in different areas, supporting their complementary uses. Regarding vitamin composition, the significantly higher vitamin C content in bay leaves (43.4mg vs. 18.7mg in rosemary) directly supports its characterization in literatures as a good source of essential water-soluble antioxidant (Batoool *et al.*, 2020). This aligns with its traditional use in supporting immune function and combating oxidative stress in aqueous body compartments. Conversely, rosemary's marginally higher vitamin E content (3.8mg vs. 2.8 mg) corroborates literature highlighting its lipid-phase antioxidant activity, attributed to compounds like tocopherols that protect cellular membranes from lipid peroxidation (Andrade *et al.*, 2018). The higher vitamin K content in bay leaves may relate to its historical use in promoting wound healing and coagulation.

The mineral analysis provides a clear nutritional distinction. Bay leaves' superior content of calcium, magnesium, potassium, and iron validates their potential role in dietary strategies for bone health, muscle function, and anemia prevention, as suggested by Pant (2025). The notably higher iron content (40.6 mg) is particularly significant. Rosemary's advantage in zinc and chloride content suggests its contribution may be more focused on supporting enzymatic functions and electrolyte balance.

Most strikingly, the phytochemical results strongly support the extensive literature on rosemary's rich secondary metabolite profile. Its significantly higher concentrations of

total phenolics, flavonoids, tannins, alkaloids, glycosides, and steroids are consistent with reports describing rosemary as a potent source of diverse bioactive compounds like rosmarinic acid and carnosol (Aqsa *et al.*, 2024; Ghasemzadeh *et al.*, 2020). This profile underpins its renowned antioxidant, anti-inflammatory, and preservative properties. While bay leaves also contain these phytochemical classes, their lower quantitative levels suggest a different bioactive emphasis, potentially centered on their essential oils and specific phenolic compounds as noted by Khaled Khodja *et al.* (2023). The absence of saponins in both herbs is consistent with their taxonomic families.

Summary

This study systematically compared the biochemical profiles of *Rosmarinus officinalis* and *Laurus nobilis* through comprehensive laboratory analysis. Chapter one of the study established the research foundation, highlighting the nutritional and therapeutic importance of both herbs while identifying gaps in comparative biochemical data. The chapter clearly stated the research problem, justification, aim, objectives, and scope of the study. Chapter two provided an extensive literature review covering the botanical descriptions, traditional uses, and documented phytochemical compositions of both herbs. It also reviewed the biological roles of vitamins A, E, C, and K, essential minerals, and major phytochemical classes, establishing the theoretical framework for the study.

Furthermore, chapter three detailed the materials and methods employed, including sample collection from Toro Gardens in Bauchi State, preparation techniques, and standard analytical procedures for vitamin, mineral, and phytochemical determination following AOAC (2019) guidelines. Statistical methods for data analysis were also specified. Also, chapter four presented and interpreted the analytical results through comprehensive tables and discussion. Vitamin analysis revealed bay leaves' superiority in vitamin C and rosemary's advantage in vitamin E. Mineral analysis showed bay leaves were richer in calcium, magnesium, potassium, and iron, while rosemary contained more zinc and chloride. Phytochemical analysis demonstrated rosemary's significantly higher content of all quantified bioactive compounds. The discussion contextualized these findings within existing literature and clearly addressed all study objectives.

Lastly, chapter five concluded the study by summarizing findings, drawing evidence-based conclusions, and providing practical recommendations for the application of both

herbs in nutritional, therapeutic, and food industry contexts based on their distinct biochemical strengths.

CONCLUSION

This study conducted a comparative nutritional and phytochemical analysis of *Rosmarinus officinalis* (rosemary) and *Laurus nobilis* (bay leaves) to quantify their respective vitamin, mineral, and secondary metabolite profiles. The comparative analysis conducted in the study established that rosemary and bay leaves exhibit complementary yet distinct phytochemical and nutritional profiles. The result showed that bay leaves are nutritionally superior in terms of vitamin C and essential mineral content, making them particularly suitable for dietary fortification and aqueous-phase antioxidant applications. However, rosemary demonstrates a significantly higher concentration of phenolic, flavonoid, and tannin compounds, which supports its functional use in lipid-phase preservation, oxidative stability, and phytotherapeutic delivery. Therefore, this study concludes that rosemary is the herb of choice for applications requiring strong lipid-soluble antioxidant activity, whereas bay leaves should be prioritized in formulations aimed at enhancing water-soluble vitamin and mineral content. This biochemical distinction underscores the importance of selecting the appropriate herb based on the intended nutritional, preservative, or therapeutic outcome.

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