Research Article

Comparative Analysis of Phytochemical, Proximate, and Vitamin Composition of Selected Nigerian Medicinal Leaves

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Abstract

This study provides a comprehensive comparative analysis of seven underutilized Nigerian medicinal leaves that can be explored as preservatives in health-oriented meat products. Medicinal leaves are mostly cherished for their antioxidant and antimicrobial properties in the medical sector; these properties potentially establish medicinal leaves as promising natural preservatives against microbial spoilage and lipid oxidation in meat products. Therefore, this study evaluated the phytochemical, proximate, and vitamin composition of seven Nigerian medicinal leaves harvested in Ejigbo, Osun State, namely: stonebreaker (SBL), guava (GL), scent (SL), moringa (ML), lemongrass (LG), hospital-too-far (HL), and miracle leaves (MIL). The leaves were washed with clean water, shade-dried at room temperature (24 ^{o}C) for 7 days, and ground into a powdery form for analysis. Phytochemical results show that flavonoids were high in SL (72.46 mg), MIL (72.64 mg), and ML (75.03 mg) with no significant ($p > 0.05$) difference. SL (98.55 mg) and MIL (98.78 mg) exhibited the highest phenols with no significant difference. The highest saponin was observed in ML (36.13 mg) and MIL (37.55 mg). Results for proximate analysis show that MIL (22.68%), SL (31.13%), and HL (21.78%) had the highest crude protein with no significant ($p > 0.05$) difference. The highest fat was found in MIL (5.61 mg), while HL had the least content of moisture (4.35%). Vitamin E was highest in SL (52.96 mg) and ML (56.45 mg) with no significant ($p > 0.05$) difference. The highest concentration of vitamin A was found in MIL (22.76 mg), GL exhibited highest vitamin B_1 (1.47 mg), while SBL was significantly ($p < 0.05$) higher in vitamin D (35.08 mg). Phytochemical, proximate, and vitamin contents varied among medicinal leaves. Among the seven leaves, scent, moringa, and miracle consistently showed the highest concentrations of key phytochemicals, proximate, and vitamin contents.

Keywords: Medicinal leaves, Phytochemicals, Proximate, Vitamins

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Introduction

Meat products warrant the use of preservatives to minimize early spoilage caused by lipid oxidation and microbial growth. Over the years, synthetic preservatives have often been employed for these protective roles in the meat industry, however, their residual, toxicological, and carcinogenic effects are of great concern to the health of consumers (Hussain et al., 2019). This has suggested a shift to the use of medicinal leaves, as natural or plant-based preservatives owing to their phytochemical properties. Miranda (2021) defined medicinal leaves as leaves that are directly used as a part of the preparation for medicine to treat a certain condition, and in food as an antibacterial and antioxidant agents. Most of these medicinal plants are outstanding sources of chemical nutrients (such as protein, fat, and carbohydrate), mineral contents (calcium, potassium, iron, and phosphorus), and vitamins (A, B, C, D, and E), which are extremely beneficial to human body (Contini et al*.,* 2014). In addition, medicinal leaves consist of arrays of bioactive compounds known as phytochemicals such as phenols, alkaloids, flavonoids, tannins, and saponins, which possess antioxidant, antimicrobial, anticancer, and antimutagenic properties (Aminzare et al*.,* 2019; Falowo et al., 2014). Interestingly, medicinal leaves have been explored in the treatment of diverse disease conditions by many traditional medical specialists in Nigeria (Aborisade et al., 2017), and in the pharmaceutical industry as part of the preparation of some medical pills due to their phytochemicals (Wu et al*.,* 2011).

Moringa *(Moringa oleifera)*, a member of the Moringaceae family, has been traditionally used to cure wounds, pain, ulcers, liver disease, heart disease, cancer, and inflammation (Gopinath et al., 2017). Scent leaves (*Ocimum gratissimum*), a member of Lamiaceae family, have been used to treat a variety of conditions such as aches, fever, asthma, inflammation, anemia, diarrhea, fungal, and bacterial infections (Shedoeva et al., 2019). *Bryophyllum pinnatum* (miracle leaf), which belongs to the Crassulaceae family, has been used to treat ear infections, ulcer, cancer, cough, dysentery, blennorrhoea, syphilis, jaundice, candidiasis, dysmenorrhoea, external ulcers, burns, and convulsions (Akinpelu 2000). Hospital-too-far leaf (*Jatropha tanjorensis*) belongs to the family Euphorbiaceae, and it is known to show hematological, anti-malarial, antimicrobial, hypoglycemic, hypolipidemic, and antihypertensive activities (Ijoma et al., 2023). Lemongrass leaf (*Cymbopogon citratus*), belongs to the Poaceae family (Kiani et al*.,* 2022) and the "citratus" indicates that it is a rich source of citric and ascorbic acids (Shah et al., 2011); it is often used in weight management and to lower cholesterol. Stonebreaker leaf (*Phyllanthus niruri*), a member of Euphorbiaceae, helps inhibit the formation of kidney stones (Jiraungkoorskul 2022). It is also used in the treatment of liver and kidney diseases, fever, jaundice, prostate issues, menstrual and uterus problems (Origbemisoye et al., 2025). Guava leaf (*Psidium guajava*) which belongs to the *Myrtaceae* family, is utilized in treating diarrhea, diabetes, stomach aches, gastrointestinal, and respiratory issues (Sahal et al., 2025).

The contribution of these medicinal leaves to the health status of humans cannot be over emphasized (Aborisade et al., 2017). While the individual properties of some of these leaves are known, a direct comparative study of their properties as potential meat preservatives is lacking. Therefore, this research evaluated the phytochemical, proximate, and vitamin compositions of selected Nigerian medicinal leaves that can be used as natural preservatives.

Materials and methods

Study Site

This study was carried out at the Faculty Scientific Laboratory, Faculty of Agricultural Production and Management, Department of Animal Science, Osun State University, Nigeria. The experiment was conducted during the rainy season (March – June, 2025) to ensure that fresh leaves were harvested.

Sample collection (Medicinal leaves)

100 g of each medicinal leaf: *Moringa oleifera* (moringa leaves – ML), *Bryophyllum pinnatum* (miracle leaves – MIL), *Phyllanthus niruri* (stonebreaker leaves – SBL), *Cymbopogon citratus* (lemongrass – LG), *Jatropha tanjorensis* (hospital-too-far leaves – HL), *Ocimum gratissimum* (scent leaves – SL), and *Psidium guajava* (guava leaves – GL) were sourced from in and around Ejigbo, Osun State, Nigeria, and the samples were collected on the 17th of March, 2025.

Identification of leaves

Selected leaves were botanically identified and authenticated using www.theplantlist.org and www.worldfloraonline.org. Furthermore, the final verification of the selected leaves was done at the Department of Botany, Faculty of Science, Obafemi Awolowo University. The verified leaves were assigned identification numbers as follows: *B. pinnatum*: IFE – 18424, *C. citrate*: IFE – 18425, *J. tanjorensis*: IFE – 18426, *M. oleifera*: IFE – 18427, *O. gratissimum*: IFE – 18428, *P. niruri*: IFE – 18429, and *P. guajava*: IFE – 18430. The leaves were then deposited at IFE Herbarium, Department of Botany, Obafemi Awolowo University, Osun State, Nigeria.

Sample preparation

The sourced medicinal leaves were thoroughly washed with clean water, shade-dried on a tarpaulin for 7 days at room temperature (24 ^{o}C), with the humidity of the room at 45%, and the medicinal leaves were turned on alternate days to prevent fungal growth. After drying, each leaf was blended with the aid of an electric blender (8000-watt Kenwood multifunction commercial grinder blender, made in Germany). The leaves were kept in clean, dry, air-tight containers, and labelled accordingly. Thereafter, they were stored at room temperature prior to analysis (Adeyemi et al., 2013).

Phytochemical analysis

40 g of each powdered treatment was packaged into an air-tight container to determine the saponins, tannins, flavonoids, alkaloids, and polyphenols content on a dry weight basis, and this was done in triplicates (n = 3).

Determination of polyphenols

This was determined according to the modification of Ayoola et al. (2008). Powdered sample (0.5 g) was dissolved in methanol (1 mg/ml). An aliquot of 0.5 g of each plant sample (1 mg/ml) was mixed with 5 ml of Folin-Ciocalteu reagent, which was previously diluted with distilled water (1:10 v/v). The mixture was slightly shaken and allowed to stand at 22 °C for 5 min. Then, 4 ml (75 g/l) of sodium carbonate (Na_2CO_3) was added, and tubes containing the mixtures were allowed to stand for 30 minutes at 40 °C to develop a colour. Absorbance was then read at 765 nm using a UV spectrophotometer (Shimadzu, Japan). Results were expressed as Gallic acid equivalent in mg of dried sample (10-100 mg/ml). All samples were analyzed in triplicate.

Determination of total flavonoids

The total flavonoid contents were determined using the Aluminum chloride colorimetric method (Ordonez et al., 2006). A volume of 0.5 ml of 2% aluminum trichloride ethanol solution was added to 0.5 g of sample solution. After one hour at room temperature, the absorbance was measured at 420 nm using a UV spectrophotometer (Shimadzu, Japan). The appearance of a yellow colour indicated the presence of flavonoids. Total flavonoid content was calculated as quercetin equivalent (mg).

Determination of total alkaloids

This was done according to the standard method described by Hassan et al. (2020). 200 ml of 10% acetic acid in ethanol was added to 5 g of each plant sample. The mixtures were covered and allowed to stand for 4 hours. The solutions

were decanted and filtered, and the extracts were further concentrated in a water bath until one-quarter of the original volume was obtained. Concentrated ammonium hydroxide was added dropwise to the concentrated mixture until the precipitation was complete. The precipitate was collected and washed with dilute ammonium hydroxide and then filtered. The residue was dried in an oven at 50 ^{o}C, until a constant weight is achieved. Thereafter, the residue was weighed (mg).

Determination of total tannins

50 ml of distilled water was added to 0.5 g of the powdered sample and shaken for 1 hour in a mechanical shaker. The obtained solution was filtered into a 50 ml volumetric flask and made up to the mark. Five mililiters of the filtrate was pipetted into a test tube and mixed with 2 ml of 0.1 M ferric chloride in 0.1 N hydrochloric acid and 0.008 M potassium ferrocyanide. The absorbance was measured at 220 nm within 10 min following the procedures and modifications of Ayoola et al. (2008).

Determination of total saponins

A total of 100 cm^3 of 20% aqueous ethanol was added to 20 g of each plant sample. The samples were heated at 55 °C for 4 hours with continuous stirring. The mixture was filtered and the residue re-extracted with 200 ml %20 ethanol. The combined extracts were reduced to 40 ml over a water bath at about 90 °C. 20 ml of diethyl ether was added to the concentrates and shaken vigorously. The aqueous layer recovered was further purified by adding 60 ml of n-butanol. The combined n-butanol extracts were washed twice with 10 ml of %5 aqueous sodium chloride and heated in a water bath. After evaporation, the samples were dried in the oven to a constant weight and the saponin content was calculated thus:) where: WCS: Weight of crude saponin; WPM: Weight of plant material (Obadoni and Ochuko 2002).

Proximate evaluation

A total of 20 g of each sample was evaluated for crude protein, ash, fat, crude fiber, and moisture content according to AOAC (2015).

Crude protein was determined from total organic nitrogen using the macro-Kjeldhal method. Fat content was determined by extracting 2 g of each sample with petroleum ether for 12 hours. The extract was reduced to half by evaporation and dried at 105 °C until a constant weight was obtained. For the crude fiber, 1 g of the extract of each sample was added to 3 mL of H_2SO_4 followed by addition of 17 mL of hot 1.25% H_2SO_4. The solution was boiled for 30 minutes, allowed to cool, and filtered through filter paper under gravity. Insoluble residue was washed with hot water to remove the acid. A total of 3 mL of 0.313 M NaOH was added to the residue followed by addition of 17 mL of hot 0.313 M NaOH. The mixture was shaken for 30 minutes and passed through filter paper under gravity. The residue was washed with 1% HCl followed by washing with boiling water until no residual acid was present in the final filtrate. The residue was washed with ethanol and ether before drying at 100 °C. Fiber content was calculated by dividing the loss in weight of the sample by the weight of the sample. For the ash, 2 g of the sample was weighed into a porcelain crucible. This was transferred into the muffle furnace set at 550 ^{o}C and left for about 4 hours, until it turned to white ash. The crucible and its content were cooled to about 100 ^{o}C in air, then to room temperature in a desiccator and weighed. Moisture content was determined by drying 2 g of each sample in pre-weighed crucible at 105 °C for 24 hours.

Vitamin determination

A total of 20 g of each sample of medicinal leaf was assessed for vitamin compositions. Vitamin A was done according to the method of Onyesife et al. (2014). Briefly, 1 g of each leaf was macerated with 20 mL of petroleum ether. The solution was

incubated for 2 hours, filtered, and evaporated to dryness, and 0.2 mL of chloroform-acetic anhydride (1:1 v/v) was added to the residue. Thereafter, 2 mL of 30% TCA chloroform was added to the mixture and absorbance was measured at 620 nm using a UV-3000PC spectrophotometer. Retinol standard was prepared in similar fashion. The concentration of vitamin A in the sample was estimated from the standard curve using the equation: $Y = 0.001x + 0.0008$, $R^2 = 0.9969$, and expressed as mg/100 g DW.

Vitamin B_1 was evaluated according to the method highlighted by Okwu and Josiah (2006). A total of 5 g of each sample was homogenized with ethanolic sodium hydroxide (50 ml). It was filtered into a 100 ml flask. 10 ml of the filtrate was pipette and the colour developed by addition of 10 ml of potassium dichromate and read at 360 nm. A blank sample was prepared and the colour was also developed and read at the same wavelength.

Vitamin D was carried in accordance with the procedure of Ayyash et al. (2016). 2.5 IU/gm Ergocalciferol was dissolved in ethanol, and filtered through (0.45µm) Whatman filter paper, then passed through a Millipore Syringe filter 0.22 µm for HPLC analysis. (20 µl, 2.5 IU/gm) standard material of pure vitamin D_2 (Ergocalciferol) was injected and measured at reference conditions to set and fix the real retention time (RT), then 20 µl of extracted plant sample was injected and measured at the same conditions. Separation Conditions were; Acetonitrile: Methanol (25 :75 ml) as an isocratic mobile phase, column C18-ODS (25 cm x 4.6 mm x 5 µm) with 20 µl injection volume, and 1 ml/min flow rate at 30 ºC through 265 nm wave length UV detector spectrophotometer

Vitamin E was estimated using the procedure of Njoku et al. (2015). A known weight, 1 g of each sample was macerated with 20 mL of ethanol. The solution was added to 100 µL of 0.2% ferric chloride in ethanol and 1.0 mL of 0.5% to make the solution up to 5 mL. Absorbance was measured at 520 nm using a UV-3000PC spectrophotometer. The concentrations of the standard solutions ranged from 10 to 100 µg/mL. The concentration of vitamin E in the samples was estimated from the standard curve using the equation: $Y = 0.0086x - 0.0216$, $R^2 = 0.9985$. The vitamin E content in the samples was expressed as mg/100 g DW.

Statistical analysis

A completely randomized design (CRD) was used in this study. All data were subjected to one-way analysis of variance (ANOVA) at the $p < 0.05$ level of significance. Means were compared using Duncan Multiple Range. The SPSS computer software (IBM, SPSS statistics, Chicago, U. S. A.) was used for all statistical analysis.

Results

A total of seven medicinal leaves, namely: stonebreaker leaves (SBL), guava leaves (GL), scent leaves (SL), moringa leaves (ML), lemongrass leaves (LG), Hospital-too-far leaves (HL), and miracle leaves (MIL) were selected for phytochemical analysis. Flavonoids, saponin, alkaloid, steroid, phenols, and tannin were assessed. The result show that SL, ML, and MIL had the highest proportion of flavonoids with no significant ($p > 0.05$) difference. The least proportion of flavonoids was observed in SBL. SL (98.55 mg) and MIL (98.78 mg) exhibited the highest concentration of phenols, followed by GL and ML, with no significant ($p > 0.05$) difference. ML (36.13 mg) and MIL (37.55 mg) revealed the highest values of saponin with no significant ($p > 0.05$) difference, followed by SL, while the least values were recorded in SBL. The highest concentration of steroid was observed in GL (49.06 mg) and SL (52.16 mg) with no significant ($p > 0.05$) difference. SBL (24.13) and ML (28.33) were observed to perform as the second best in concentration, with no significant difference. The highest value for alkaloid was discovered in ML (8.04 mg). The proportion of alkaloids in the selected medicinal

leaves followed this trend: ML > SL > MIL > SBL > GL > HL > LG. GL had the highest amount of tannin, while SBL had the least proportion.

For proximate composition, crude protein, ash, fat, crude fiber, and moisture content of the selected medicinal leaves were evaluated. The highest values for crude protein were obtained in SL (21.13%), HL (21.78 %), and MIL (22.68%) with no significant ($p > 0.05$) difference. The least crude protein was observed in LG (7.33%). The highest amount of ash was noted in HL, and the least value were recorded in SL and ML, with no significant ($p > 0.05$) difference. The least fat content and crude fiber were observed in GL. MIL had the highest fat content, while the least moisture content was observed in HL; however, there is no significant ($p > 0.05$) difference observed between SBL and GL. The result for the vitamin A composition shows that MIL (22.76 mg) is significantly ($p < 0.05$) higher, followed by ML (20.51 mg) while the least was recorded in SBL (14.28 mg). Vitamin B_1 content ranged from 0.38–1.47 mg, with the highest recorded in GL and the lowest in SBL; however, SBL displayed the highest vitamin D, followed by ML and MIL. Vitamin E content ranged from 12.69–56.45 mg, with SL and ML higher, with no significant ($p > 0.05$) differences. SBL and MIL had the second largest proportion of vitamin E, with no significant ($p > 0.05$) differences.

Table 1. Phytochemical, proximate, and vitamin composition of selected Nigerian medicinal leaves.

PARAMETER	SBL	GL	SL	ML	LG	HL	MIL	SEM
Flavonoids (mg)	28.39^{c}	40.12^{b}	72.46^{a}	75.03^{a}	31.39^{c}	36.39^{b}	72.64^{a}	3.78
Polyphenol (mg)	56.77^{d}	79.30^{b}	98.55^{a}	82.12^{b}	62.20^{c}	51.66^{d}	98.78^{a}	3.99
Saponin (mg)	15.16^{e}	20.14^{c}	28.77^{b}	36.13^{a}	17.95^{d}	17.95^{d}	37.55^{a}	1.92
Steroid (mg)	24.13^{b}	49.06^{a}	52.16^{a}	28.33^{b}	16.27^{d}	21.79^{c}	15.07^{d}	3.13
Alkaloid (mg)	6.32^{d}	5.68^{e}	7.75^{b}	8.04^{a}	4.88^{g}	5.37^{f}	7.55^{c}	0.26
Tannin (mg)	9.54^{f}	96.93^{a}	72.36^{b}	42.60^{d}	35.68^{e}	50.09^{c}	72.65^{b}	5.97
CP (%)	15.21^{c}	10.18^{c}	21.13^{a}	18.09^{b}	7.33^{d}	21.78^{a}	22.68^{a}	1.33
Ash (%)	9.02^{b}	4.80^{e}	2.19^{f}	2.64^{f}	6.05^{d}	11.86^{a}	8.42^{c}	0.73
Fat (%)	4.30^{b}	0.89^{e}	3.00^{c}	1.65^{d}	2.99^{c}	3.92^{b}	5.61^{a}	0.34
CF (%)	13.01^{a}	3.83^{f}	8.51^{b}	2.16^{g}	4.45^{e}	8.03^{c}	7.14^{d}	0.75
MC (%)	6.35^{c}	6.37^{c}	6.00^{d}	4.97^{e}	6.94^{b}	4.35^{f}	7.91^{a}	0.25
Vitamin A (mg)	14.28^{f}	16.28^{d}	18.75^{c}	20.51^{b}	12.73^{g}	15.21^{e}	22.76^{a}	0.75
Vitamin B_1 (mg)	0.38^{e}	1.47^{a}	1.29^{b}	0.96^{d}	0.86^{d}	1.09^{c}	1.14^{c}	0.07
Vitamin D (mg)	35.08^{a}	18.71^{e}	21.80^{d}	24.81^{b}	18.17^{e}	15.21^{f}	22.76^{c}	1.34
Vitamin E (mg)	48.65^{b}	34.59^{c}	52.96^{a}	56.45^{a}	12.69^{d}	32.19^{c}	44.21^{b}	4.26

Note: Means with different superscripts (a, b, c, d, e, f) in the same row are significantly different ($p < 0.05$).

Abbreviations: SBL – stonebreaker leaves, GL – Guava leaves, SL – Scent leaves, ML – Moringa leaves, LG – Lemongrass leaves, HL – Hospital too far leaves, MIL – Miracle leaves, SEM – Standard error of means, CP – crude protein, CF – crude fiber, and MC – moisture content.

Discussion

Phytochemicals are non-nutritive plant chemicals that are believed to reduce the risk of several diseases or exert protective actions (Kiani et al., 2022). Phytochemical properties such as tannins, saponins, steroids, polyphenols, and flavonoids were evaluated in this study. The findings revealed that SL, ML, and MIL were significantly higher in flavonoids with no significant ($p > 0.05$) difference. Flavonoids are majorly known for their antioxidant action, and their outstanding presence in SL, ML, and MIL indicates that these leaves have the potential to reduce lipid oxidation in meat products (Lawal et al., 2021). The antioxidative role of flavonoid is exerted by scavenging free radicals, chelating metal ions, or inhibiting enzyme systems that produce free radicals (Pizzino et al., 2017). This indicates that meat products fortified with SL, ML, and MIL are likely to have an extended shelf life by retarding oxidation. Also, the incorporation of these leaves into meat products can preserve and improve the health of consumers by lowering cholesterol, blood pressure, and heart disease (Le Marchand 2002; Daniel et al., 2020). Flavonoids also exhibit antimicrobial effect by disrupting cell membranes and interfering with enzyme systems (Yu et al., 2021). The combined antioxidant and antimicrobial actions of flavonoids present in SL, ML, and MIL make these leaves recommendable as natural preservatives in meat products.

Both flavonoids and phenols have similar antioxidative functions, and they are the most abundant compounds in the medicinal leaves evaluated in this study, which corresponds with the finding of Dreosti (2000). Yu et al. (2021) stated that phenols are recognized as the most important bioactive compounds in plant-based food preservatives. SL and MIL were outstanding sources of phenols with no significant ($p > 0.05$) difference. As a result of their phenolic content, SL and MIL have the potential to trap and eliminates free radical and inhibit cyclooxygenase and lipoxygenase enzymes, which are the main causes of rancidity in meat products (Embuscado 2015). ML and GL ranked as the second-best in phenol content, which signals the antioxidative potential of moringa and guava leaves. Beyond preservative role of phenols in SL, MIL, ML, and GL, they are likely to play a vital role in the colour, flavour, and taste (astringency) of meat products (Swanson 2003). SL is often used as spices because of its distinct flavour, enhancing its culinary usefulness (Edo et al., 2023).

ML and MIL have been proven to be the richest sources of saponin, while SL ranked as the second-best. According to Ali et al. (2011), saponin is a key bioactive compound responsible for the reduction of cholesterol and inhibition of microbial growth. Incorporation of ML, MIL, and SL into meat products has the latent quality of reducing its cholesterol content and microbial load. These leaves can disrupt microbial membranes and inhibit enzymatic actions (Sheriff et al., 2019). Likewise, steroids are also known for their ability to lower cholesterol, although it is often under-discussed, their contribution to functional quality of food cannot be jettisoned (Sultan and Rauf-Raza 2015). This research revealed, GL and SL as outstanding sources of steroids. The presence of phytosterol in plants like GL and SL enabled them to lower cholesterol content in meat products (Marwat et al., 2005).

Tannins are bioactive compounds that enhance antimicrobial and antioxidant activities (Mazid et al., 2011). GL has an excellent amount of tannin, while SL and MIL ranked second in tannin concentration. Daniel et al. (2020), Ayoola et al. (2020), and Okonwu et al. (2020) respectively obtained lower values of 4.98 mg/g, 12.07 mg, and 6.110 mg as tannin content in ML. This could be attributed to differences in developmental stage, geographical location, season of harvest, and method of extraction of bioactive compounds (Gopalakrishnan et al., 2016). Moreover, variation in phytochemical contents is a major concern as there is no standard value for any of the bioactive compounds in medicinal leaves (Yu et al., 2021). Aside from the antioxidant

and antimicrobial activity of tannin in GL, its ability to lower blood pressure is a focal point in health-focused meat products. However, Chung et al. (1998) reported that high tannin in food products can flocculate protein, resulting in lower nutritional value, which may be further validated when GL is incorporated into meat products. Plants that contain alkaloids and their derivatives are gaining attention in health and meat industry. According to Othman et al. (2019), alkaloid is a useful ingredient in meat industry because of its antibacterial activity, and the ability of alkaloids to interact with microbial DNA has been highlighted as a key mechanism for its antimicrobial action. ML is a promising antimicrobial plant due to its high content of alkaloids. Also, SL is likely to offer an effective antimicrobial role because it ranked second in its content of alkaloids.

Antioxidants and antimicrobial actions of these medicinal leaves make them promising candidates in food preservation, especially in meat industry (Teshome et al., 2022). The use of these medicinal leaves, especially SL, ML, MIL, and GL as preservatives represents a viable and suitable domestic approach (Ferreira et al., 2022) for salvaging losses in meat industry, as most of these natural plants are easily found in residential areas. This suggests that, natural preservatives are cheap substitutes to synthetic preservative or lab-created counterpart. Awad et al. (2022) added that the use of natural preservatives is an exploration of green, non-toxic, non-costly, sustainable, economical, eco-friendly, and healthy additives in meat products, which aligns with the current trend of "clean label" in meat industry, that is, meat products that are void of artificial additives (Cegielka 2020).

These medicinal plants could also be a source of protein, and in combination with animal protein such as meat, may result in an increase of nutritional value of the meat products (Ayoola et al., 2020). The highest crude protein was detected in HL, SL, and MIL with no significant ($p > 0.05$) difference. There is a possibility of increased protein content when HL, SL, and MIL are used as natural preservative in meat products. ML ranked second in its content of crude protein, which supports the documentation of Gopalakrishnan et al. (2016) that moringa is a storehouse of macro and micronutrients. The authors obtained 27.1% as protein content in leaf powder, 29.4% in dry leaf, and 6.7% in fresh moringa leaf, which implies that the state of medicinal leaves can affect their nutritional components. According to Contini et al. (2014), most medicinal leaves are outstanding sources of chemical nutrients such as protein, carbohydrate, and fat. Fat content in medicinal leaves determines the quality of oil that they produce, which plays an important role in nutrition (Karaca and Aytac 2007). The highest fat content was observed in MIL followed by SBL and HL with no significant differences. This indicates that MIL, SBL, and HL are likely to produce quality oils, and these oils offer antioxidant and antimicrobial properties (Wang et al., 2017), which are helpful in building arsenal against meat spoilage. Also, when MIL, SBL, and HL are included in meat products, their fat contents is likely to increase palatability by absorbing and retaining flavour (Anita et al., 2006).

Ash content reflects the amount of mineral content present in a leaf (Aborisade et al., 2017), and it can be used to judge the purity and quality of plants. Young leaves tend to have low ash content, while older leaves usually have a higher amount (Liu 2019). The highest ash content was observed in HL, while the least ash contents were detected in ML and SL with no significant difference. The value obtained for ash content in SL aligns with 2.24% obtained by Essen et al. (2025). Previous researchers noted that fiber in medicinal leaves improves the quality characteristics of meat products (Han et al., 2020). Crude fiber peaked in SBL, which signals that incorporation of SBL in meat products will likely increase its quality by improving texture, water holding capacity, and juiciness. Also, inclusion of medicinal leaves that are high in fiber into meat products makes them a source of dietary fibers, which lowers serum cholesterol, heart

disease, hypertension, diabetes, breast cancer, and most importantly constipation (Ishida et al., 2000). SL (8.51%) ranked second in its fiber contents, and the value obtained in this study is highly consistent with 8.51% obtained by Olufayo et al. (2021) and 8.93% reported by Adedoyin et al. (2023). Hence, SL can be said to be hypocholesteremic because of its rich fiber content, which is further supported by its rich content of saponin and steroid, which are also hypocholesteremia in nature.

High moisture content in leaves accelerates microbial proliferation, indicating that the life span of such leaf will be short (Aborisade et al., 2017). The least moisture content was observed in HL, which emphasizes long shelf life and low microbial activity in the leaf, which is an advantage when added into meat formulation. There is no significant ($p > 0.05$) difference observed in the moisture content of GL and SBL. The value obtained in this research aligns with the work of Origbemisoye et al. (2025), who reported 6.03% as moisture content in SBL. SL displayed a moderate amount of moisture content, which is lower than the values of 8.12% and 13.36% obtained by Essen et al. (2025) and Adedoyin et al. (2023). This variation could result from geographical location, climatic conditions, variety of scent leaves used, method of extraction, and developmental phase.

According to Han et al. (2020), natural or medicinal leaves possess excellent antimicrobial and antioxidant function due to organic acids, pigments, and vitamins they contain (Catarino et al., 2017). Vitamins derived from plants are of great interest because their impact on human health cannot be undermined, since vitamins cannot be synthesized in the body (Asensi-Fabado and Munne-Bosch 2010). Plant vitamins contain molecules with a low reduction potential that can donate electrons or hydrogen atoms, thereby preventing the oxidation of other molecules (Alum et al., 2023). Medicinal plants contain arrays of vitamins with strong antioxidant potential, which includes both the water-soluble (B) and fat-soluble (A, E, and D) compounds (Asensi-Fabado and Munne-Bosch 2010). From this study, medicinal leaves are rich sources of vitamin E, as the values obtained ranged from 12.69 - 56.45 mg. The highest vitamin E was observed in SL and ML with no significant ($p > 0.05$) difference. This was also observed by Nwankwo et al. (2014), who reported that SL is a rich source of vitamin E, although, they obtained a lower value of 31.46 mg. Since vitamin E is an antioxidant vitamin, it is likely to synergize with the phytochemical components (flavonoids and phenols) of the leaves to retard rancidity in meat products, especially when SL and ML are used. MIL and SBL had the second largest amounts of vitamin E with no significant ($p > 0.05$) differences. This shows that SL, ML, MIL, and SBL have the capacity to protect meat products from harmful free radicals which are responsible for oxidation (Su and Chen 2020).

It was noted by Moyo et al. (2011) that vitamin E helps to increase the storage of vitamin A in the body. Vitamin A is also an antioxidant vitamin, and its precursor carotenoids can also act as an antioxidant (Asensi-Fabado and Munne-Bosch 2010), which supplies a protective layer against oxidation processes. MIL exhibited the largest concentration of vitamin A, indicating that fortifying meat products with MIL would guard against lipid oxidation. Also, vitamin A helps improve sight (Blaner 2020). It can therefore be deduced that MIL will likely play a dual role when incorporated into meat products; it will preserve the products and probably improve the health of the consumer. ML ranked second in vitamin A concentration, and it was reported by Moyo et al. (2011) that ML is a rich source of vitamin A, especially when it is in powdery form. Koul and Chase (2015) established that, ML contained 10 times the amount of vitamin A in carrot.

GL was identified as an outstanding source of vitamin B_1, while SL performed as the second-best. Addition of medicinal leaves, especially GL and SL into meat products, will probably enhance their vitamin B_1 content (Nwachukwu 2018). For vitamin D, SBL outranked other leaves, while ML had the second largest

concentration, and MIL was the third-best. Intake of vitamin D from these sources (SBL, ML, and MIL) is vital to maintain adequate intake because there are very few foods that naturally contain vitamin D (Mahapatra et al., 2024). Furthermore, vitamin D is responsible for calcium and phosphorus homeostasis in the human body (Mahapatra et al., 2024). Although, further research is needed to evaluate the actual preservative efficacy and to also determine the impacts of medicinal leaves on chemical and sensory properties of meat products.

Conclusion

Medicinal leaves are increasingly becoming the solution to health, nutritional challenges, and losses of meat products due to their phytochemical and chemical components. This study successfully characterized the phytochemical, proximate, and vitamin profiles of seven Nigerian medicinal leaves, identifying scent, moringa, and miracle leaves as the most promising candidates for use as natural meat preservatives. Their high content of bioactive compounds suggests they could be valuable ingredients for the meat industry, although further research is required to validate their actual efficacy, safety, and impact on sensory properties in meat products.

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