



Research Article

Evaluation of Phytochemicals, Amino Acids, Mineral and Vitamin Contents in Bee Bread, *Vernonia amygdalina*, *Jatropha tanjorersis*, and *Bryophyllum pinnatum*

Alexander Idoko^{1,2,*}, Ugwudike Patrick², Eyimoga B. Omeche², Ovuta V. Chukwuemeka², Ibezim C. Sylvanus², Egede C. Samuel²

¹Department of Biochemistry, College of Medicine, Federal University of Health Sciences, Otuipo, Nigeria

²Department of Biochemistry, Faculty of Natural Sciences, Caritas University, Amorji-Nike, Nigeria

OPEN ACCESS

*CORRESPONDENCE

Idoko, A.
alexander.idoko@fuhso.edu.ng
+234-803-235-4823

ARTICLE HISTORY

Received: 10/09/2025

Reviewed: 19/09/2026

Revised: 23/04/2026

Accepted: 19/09/2026

Published: 11/09/2026

CITATION

Idoko A., Patrick U., Omeche E.B., Chukwuemeka O.V., Sylvanus I.C. & Samuel E.C. (2025). Evaluation of phytochemicals, amino acids, mineral and vitamin contents in bee bread, *Vernonia amygdalina* *Jatropha tanjorersis* and *Bryophyllum pinnatum*. *Nigerian Journal of Biochemistry and Molecular Biology*. 40(3), 288-298
<https://doi.org/10.4314/njbmb.v40i3.5>

ABSTRACT

A lot of nutrients and bioactive derivatives are available in natural plants and derivable sources, with several benefits. However, knowledge of their composition is paramount to exploit these natural sources. The aim of this study was to evaluate the phytochemicals, amino acids (AA), mineral, and vitamin contents in bee bread, *Vernonia amygdalina* (v. *amygdalina*), *Jatropha tangoresis* (J. *tangoresis*), and *Bryophyllum pinnatum* (B. *pinnatum*). Plant materials were collected, treated and prepared for analysis by high performance liquid chromatography (HPLC) following standard methods and procedures. Quantitative phytochemical results revealed that tannins and flavonoids were significantly ($p < 0.05$) higher in v. *amygdalina* and bee bread respectively than in the other samples, and alkaloids was significantly ($p < 0.05$) higher in both v. *amygdalina* and J. *tangoresis* respectively. Glycosides was significantly ($p < 0.05$) high in all samples. Amino acids analyzed include glutamate, aspartate, proline, phenylalanine, glycine, tyrosine, methionine, leucine, arginine, histidine, lysine, isoleucine, and threonine. The total amino acids analyzed in bee bread were 79.69214 g/100 g, J. *tangoresis* leaf 83.16352 g/100 g, and B. *pinnatum* 82.32374 g/100 g. Total mineral contents of bee bread were (29.79 ppm), J. *tangoresis* (21.32 ppm), and B. *pinnatum* (24.03 ppm). Total vitamins in bee bread (69.50490 mg/100 g), J. *tangoresis* (21.03042 mg/100 g), and B. *pinnatum* (26.59189 mg/100). In conclusion, the phytochemicals, amino acids, minerals and vitamins in bee bread, J. *tangoresis*, V. *amygdalina*, and B. *pinnatum*, reveal their potential benefits as rich sources of functional foods to improve dietary intake, and their bioactive compounds, including flavonoids and saponins, validate traditional uses for managing conditions like diabetes and inflammation.

Keywords: Amino acids; Antioxidants; Minerals; Phytochemicals; Phytomedicine; Vitamins

INTRODUCTION

Phytochemicals are secondary plant metabolites. They are biologically active chemical compounds naturally found in plants that contribute to food value and offer various health benefits. They provide medicinal and health benefits for humans beyond those attributed to common nutrients

(Acidri *et al.*, 2020). Phytochemical biological activities include antioxidant and antilipidemic activities (Idoko *et al.*, 2023), antimicrobial activities, detoxification, anti-obesity and enzyme modulation (Idoko *et al.*, 2025), immune system stimulation, as well as hormone metabolism modulation, anti-inflammatory, and disease-preventive effects (Idoko *et al.*, 2019). Phytochemicals are non-nutritive substances found in plant foods that contribute significantly to the flavour and colour of foods.

Copyright © 2025 Idoko et al. This is an open access article distributed under the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/) CC BY 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

These substances are usually classified as polyphenols, terpenes, sulfur-containing compounds, nitrogen-containing compounds, and others (Idoko *et al.*, 2023). Phytochemicals are not vital nutrients, and they are not needed by the human body to sustain life, but they do have important properties to prevent or combat some common diseases, and in wound healing (Araújo *et al.*, 2023; Acidri *et al.*, 2020).

Amino Acids are the organic compounds that combine to form proteins; hence they are referred to as the building components of proteins (Agnius *et al.*, 2018). These biomolecules are involved in several biological and chemical functions in the human body and are the necessary ingredients for the growth and development of human beings (Dietzen & Willrich, 2023).

Minerals are inorganic substances required by the human body to function correctly (Zoroddu *et al.*, 2019). The human body requires varying amounts of minerals daily in order to build strong bones and muscles. It also helps to maintain various bodily functions. Therefore, we obtain these nutrients from eating foods rich in minerals (Afuape *et al.*, 2022; Carolina *et al.*, 2022). When the body does not receive enough minerals, certain nutritional deficiency disease may arise. Goitre, Osteoporosis, Anaemia, Hypomagnesaemia, and Diarrhoea are a few examples of mineral deficiency diseases (Afuape *et al.*, 2022).

Vitamins are organic molecules (called vitamers) that are essential in small quantities for different biochemical and metabolic functions (Afuape *et al.*, 2022; Carolina *et al.*, 2022). For instance, Vitamin A acts as a regulator of cell and tissue growth and differentiation. Vitamin D provides a hormone-like function, regulating mineral metabolism for bones and other organs, Vitamins C and E function as antioxidants (Afuape *et al.*, 2022). Deficiency and surplus intake of a vitamin can potentially cause clinically significant illness, although excess intake of water-soluble vitamins is less likely to do so (Ali *et al.*, 2021).

Bee pollen, also known as bee bread and ambrosia, is a ball or pellet of field-gathered flower pollen packed by worker honeybees, and used as the primary food source for the hive. It consists of simple sugars, proteins, minerals and vitamins, fatty acids, and a small percentage of other components (Denisow & Denisow-Pietrzyk, 2016). Bee pollen is stored in brood cells, mixed with saliva, and sealed with a drop of honey. Bee pollen is harvested as food for humans and marketed as having various, but yet unproven, health benefits (Ares *et al.*, 2018). Several nutritional benefits are associated with the consumption of bee bread such as improved digestion, rich source of lactic acid bacteria and enzymes such as *Lactobacillus plantarum* and amylase, phosphatase, which enhance its probiotic and enzymatic activities (Sanlier *et al.*, 2026). Similarly, bee bread is reported to have medicinal and pharmacological benefits, including antitumor/anticancer activity, hepatoprotective and antidiabetic abilities, anti-inflammatory and immunomodulatory potentials, and antimicrobial and antifungal activities, due to its antioxidant capacity (Sanlier *et al.*, 2026; Ilie *et al.*, 2024).

Vernonia amygdalina (*V. amygdalina*) is commonly called bitter leaf in English because of its bitter taste. Other African common names include Congo Bololo (D.R. Congo), ebicha (Oromo), grawa (Amharic), ewuro (Yoruba), etidot (Efik), onugbu (Igbo), and Okonu'ache (Idoma). The leaves are a staple vegetable in soups and stews of various cultures throughout equatorial Africa (Degu *et al.*, 2024). The nutritive value of *V. amygdalina* includes; vitamins, minerals, and phytochemicals, as a tributary to food security (Edo *et al.*, 2023). *V. amygdalina* is reported for its medicinal benefits to include; anti-malaria, anti-diabetes, and remedies for gastrointestinal issues (Degu *et al.*, 2024).

Hospital Too Far leaf (*Jatropha tanjorensis*), also known as 'Chaya' and 'Miracle Leaf,' is a leafy vegetable that originates from Mexico but is most typically seen in Nigeria's south-eastern region. Hospital Too Far is high in protein, vitamins, carbohydrates, fiber, calcium, iron, and ascorbic acid, and is rich in antioxidants (Imohiosen, 2023). *Jatropha tanjorensis* nut was reported to reduce hematological parameters (Udokang *et al.*, 2023), protected the liver from aspirin-induced hepatotoxicity, and maintain electrolytes homeostasis in albino Wistar rats' model (Elizabeth *et al.*, 2023).

B. pinnatum commonly known as leaf of life, air plant, cathedral bells, and Goethe plant native to Madagascar which is a popular houseplant and has become naturalized in tropical and subtropical areas (Morais *et al.*, 2021). The plant parts are thick and fleshy which tends to preserve water in dry climates or soil conditions. Imaobong *et al.* (2020) reported that the leaf of *B. pinnatum* contains beneficial medicinal and pharmacological biomolecules such as amino acids, vitamins, quinone, phenol, reducing sugar, coumarin, steroids, terpenoids, glycosides, flavonoids, saponins, tannins, and alkaloids (Imaobong *et al.*, 2020). The plant is prominent for its medicinal properties, including wound healing, anti-inflammatory, antioxidant, antibacterial, antiviral, antimicrobial, antifungal, anti-urolithiatic activity, antihistamine, tocolytic potential (uterine relaxant), and anaphylactic (Imaobong *et al.*, 2020). For instance, *B. pinnatum* leaf extract was reported to effectively prevent urolithiasis (kidney stone formation) in Lithiatic rats induced by 0.75%v/v ethylene glycol (EG) in drinking water (Yadav *et al.*, 2016). The *in vitro* antioxidant and antidiabetic effects of *B. pinnatum* leaf extract was reported by Ogunmoyo;e *et al.* (2025). In a review article, bee bread was generally tagged to have a greater and wider spectrum of bio-compounds compared to individual leafy vegetables (Bakour *et al.*, 2022). This could be because the production of bee bread involves fermentation enhances its digestibility, bioactive compounds addition, and increases its nutritional spectrum than leafy plants (Bakour *et al.*, 2022).

Therefore, based on the available data on nutrients and bioactive derivatives in natural plants, this study has evaluated the phytochemicals, amino acids (AA), mineral, and vitamin contents in bee bread, *v. amygdalina*, *Jatropha tangorensis* (*J. tangorensis*), and *bryophyllum pinnatum* (*B.*

pinnatum), in order to provide additional information of their nutrients and medicinal benefits.

MATERIALS AND METHODS

Collection of samples

Fresh leaf of *Bryophyllum pinnatum* (leaf of life), *Vernonia amygdalina*, and *Jatropha tangoensis* (hospital too far) were collected from a garden in Caritas University, Amorji-Nike, Enugu, Nigeria, on March 25th, 2024. While Bee bread was collected freshly after extraction of honey, from the comb, and removed from the cells of the hive, packed in 5 liters plastic container and stored in refrigerator at 4 °C, until analyses was performed. The bee bread was collected in April 25th, 2024.

Chemical reagents

All the reagents and chemicals used for this study were of analytical grade and products of Sigma Aldrich, USA and were obtained from standard chemical shops.

Preparation of bee bread (BB) concentrate

The bee bread (500 g) was spliced into pieces and dry-blended. The blended bee bread was extracted with one liter methanol: water (50:50 v/v), and filtered. The filtrate was stored in dark glass bottles, at 4°C until needed.

Quantitative phytochemical analysis of bee bread, leaf of life, bitter leaf and hospital too far leaf

Tests for alkaloids, flavonoids, saponins, tannins, terpenoids, glycosides, phenols, and steroids were carried according to the methods of Harborne (1973), Obdoni and Ochuko (2001), Trease and Evans (1989).

Quantitative phytochemical analysis of bee bread, leaf of life, bitter leaf and hospital too far leaf

Determination of tannins

Tannins content of bee bread, leaf of life, bitter leaf and hospital too far leaf extracts was determined by Folin Denis colometric method of Harborne (1973). One gram (1 g) of extract was macerated with 20 ml of distilled water and filtered. The filtrate (5ml) was pipetted into a test tube. To the test tube, 0.3 ml of 0.1N ferric chloride in 0.1N HCl and 0.3 ml of 0.0008 M Potassium ferricyanide were added, with (n=3) number of replicates. The mixture was mixed properly. Absorbance was measured at 720 nm.

$$Tannis = \frac{Absorbance-Blank}{Slope} * \frac{Volume\ of\ solvent}{Weight\ of\ sample}$$

Determination of phenolics

This was done according to the method of Association of Official Analytical Chemists (AOAC, 2005). Briefly, 1 g of bee bread, leaf of life, bitter leaf and hospital too far leaf extract was macerated with 20 ml of 80% ethanol and filtered. This was followed by 0.5 ml addition of folin

ciocalteus reagent to 5 ml of the filtrate and after 30 minutes, 2 ml of 20% sodium carbonate was added, with (n=3) number of replicates. Absorbance was measured at 650 nm.

$$Phenol = \frac{Absorbance-Blank}{Slope} * \frac{Volume\ of\ solvent}{Weight\ of\ sample}$$

Determination of glycosides

This was done according to the method of Association of Official Analytical Chemists (AOAC, 2005). Briefly, 1 g of bee bread, leaf of life, bitter leaf and hospital too far leaf extract was macerated with 20 ml of distilled water and filter. 2.5 ml of 1% lead acetate was added to the filtrate and filtered again. 2.5 ml of chloroform was added to the filtrate and vigorously Shaked. The lower layer was collected and evaporated to dryness. The residue was dissolved with 3ml of glacial acetic acid and 0.1 ml of 5% ferric chloride. 0.25 ml of concentrated sulphuric acid was added and kept in the dark for 2 hours, with (n=3) number of replicates. Absorbance was measured at 539 nm.

$$Glycoside = \frac{Absorbance-Blank}{Slope} * \frac{Volume\ of\ solvent}{Weight\ of\ sample}$$

Determination of flavonoids

The method of Boham and kocipai-Abyazam (1994) was followed for the determination of flavonoid in the samples. Into a 250 ml conical flask was 10 g of sample added followed by 100 ml of 80% aqueous methanol and using an auto-shaker, the mixture was thorough stirred for 3 hours. Into a pre-weighed beaker was the mixture filtered and in a water bath, the mixture was dried by evaporation, then weighed until constant weight was obtained, with (n=3) number of replicates. Flavonoid in sample was calculated as % by the formula:

$$Flavonoids = \frac{W2-W1}{W2} * \frac{100}{1}$$

W1=weight of empty beaker and W2=weight of residue (weight of empty beaker with sample after drying).

High performance liquid chromatography (HPLC) analysis of sample

The HPLC calibration curve was prepared using a series of concentrations which produced linear regression ($y = mx + c$) or ($y = ax + b$). (Where y =Area, x = concentration, m = slope, and c = intercept). This was used to calculate x (concentration of analyte) to y (response of detector), with a coefficient $R^2 > 0.990$ taken for linearity and > 0.995 was set for reliable linear correlation. The quality control standards used for all biomolecules determined were of high purity (>95% or >98%)

HPLC instrumentation for flavonoids analysis

HPLC AGILENT 1260 detector of AGILENT 1200 series was used to analyze the amount and types of flavonoids in all samples. HPLC was performed with a low-pressure gradient and solvent delivery C18 with a high-pressure switching valve, with a Hamilton microliter syringe of 5 micrometers for sample injection with 1.0 ml/min flow rate. The column size is 4.6 x 250 mm, sample injection volume used was 20 µL. The system made use of acetonitrile (solvent A) ran for 13 minutes, and 0.1% phosphoric acid in de-ionized water (solvent B) for 10 minutes, with a maximum Wavelength of 280 nm, column temperature of 40°C.

HPLC flavonoids analysis

Flavonoids was isolated from samples following the modified method of Khuluk et al. (2023). Dried powder samples were made free of water by maintaining constant weight after several oven drying at 105°C for about 1 hour. Then, 1.0g of each sample was weighed into 250 ml conical flask and 100 ml of de-ionized water added, and was allowed to boil for 10 minutes. Into the mixture in the conical flask was 100 ml of the mixture of methanol/water (70:30) ratio added. The resulting mixture was filtered with whatman filter paper 1 after it has macerated for 4 hours. Standards of different concentrations for HPLC calibration and correlation coefficient were prepared for injection into the HPLC system. Prepared samples were injected into the HPLC following the same procedure of standard.

HPLC instrumentation for alkaloids analysis

HPLC AGILENT 1260 detector of AGILENT 1100 series was used to analyze the amount and types of flavonoids in all samples. HPLC was performed with a low-pressure gradient and solvent delivery column shiseido UG 120 C18 with a high-pressure switching valve, with a Hamilton microliter syringe of 5 micrometers for sample injection with 1.0 ml/min flow rate. The column size is 4.6 x 250 mm, sample injection volume used was 20 µL. The system made use of 10 mM ammonium acetate in 0.2% TEA pH 5.0, adjusted by acetic acid (solvent A), and acetonitrile, with gradient elution of 27% CAN for 0-10 minutes, 27-33% CAN for 10-15 minutes, and 33-95% CAN for 15-30 minutes, with a maximum Wavelength of 280 nm, column temperature of 40°C.

HPLC alkaloids analysis

Alkaloids was isolated from samples following the modified method of Kim et al. (2011). Samples extract were kept in cooled temperature of less than 4°C in a refrigerator. Into a borosilicate beaker was about 5g of extract placed and mixed with 10 ml of 70% methanol. Mixture was extracted in an ultrasonic water bath for 20 minutes at 25°C. Then the mixture was centrifuged two times at 10,000 rpm for 10 minutes, and using membrane filter of 0.22 µm, supernatant was filtered. Standards of different concentrations for HPLC calibration and correlation coefficient were prepared for injection into the HPLC system. Prepared samples were

injected into the HPLC following the same procedure of standard.

High performance liquid chromatography (HPLC) condition for amino acids in bee bread, leaf life, and hospital too far samples

HP 6890 powered with HP ChemStation Rev. A09.01 [1206] software, with split injection temperature of 20:1 was used to analyze the amount and types of amino acids in all samples. Hydrogen was the carrier gas used with flow rate of 1.0 ml/minute at inlet temperature of 250°C. Session was performed with hydrogen-pressure of 20 psi, and compressed air of 35 psi using PFPD detector at 320°C detector temperature. The column type is EZ, with dimensions 10 m x 0.25 µm, having an oven program (initial @ 110°C, first: Ramp @ 27°C/minute to 320°C, and second: constant for 5 minutes at 320°C).

Procedure for amino acids HPLC analysis

Amino acids in samples were quantified by the modified method of Themelis et al. (2019). For a period of time, each dried pulverized sample was made free of water by maintaining constant weight. Then, 0.5 g of each sample was weighed into 250 ml conical flask. Defatting was done on the sample by extracting the fat contents with 30 ml petroleum spirit trice using Soxhlet extractor coupled with thimble. Total amino acids recovery was achieved by hydrolyzing each sample trice. The pulverized and defatted sample was soaked with 30 ml of the 1M potassium hydroxide solution and was incubated for 48 hours at 110°C in hermetically closed borosilicate glass container. After the alkaline hydrolysis, the hydrolysate was neutralized to get pH in the range extraction. The amino acids in purified solution were derivatized with ethylchloroformate by the established mechanism.

Optimized chromatography condition for fat and water-soluble vitamins

Water and fat-soluble vitamins were separate simultaneously under the following optimized chromatography conditions combined with valve switching, double injection, envelope-injection, and wavelength switching. Column temperature for both fat and water-soluble vitamins was 25°C, and injection volume: 10 µl. For fat-soluble, Acclaim PA, 3µm, 120A, 3.0 x 150 mm was column used with mobile phase A: CH₃OH-CH₃CN (8:2, v/v), and B: Methyl tert-butyl ether (MTBE). For water-soluble, Acclaim C18, 3µm, 120A, 3.0 x 150 mm was column used with mobile phase A: 25 mM phosphate buffer (dissolve about 3.4 g KH₂PO₃ in 1000 ml water, and pH adjusted to 3.6 with H₃PO₄), and B: CH₃CN (7:3, v/v).

Procedure for HPLC simultaneous analysis of fat- and water-soluble vitamins

Extraction of water-soluble vitamins: Samples were removed from the refrigerator (less than 4°C), and allowed to

acclimatize for about 15 minutes. Using the laboratory mortar and pestle, the sample was ground into powder and 0.1 g weighed into 100 ml of volumetric flask, then mixed with 80 ml of distilled water. Allowing the mixture for ultrasonic extraction for 15 minutes, water was added to the 100 mark of the volumetric flask.

Extraction of fat-soluble Vitamins: The grounded sample (0.125 g) was weighed into 10 ml volumetric flask and 8 ml CH₃OH-CH₂Cl₂ (1:1, v/v) was added to the flask. In 15 minutes of ultrasonic extraction, CH₃OH-CH₂Cl₂ (1:1, v/v) was added to the 100 ml volumetric flask mark. The solution was stored in the dark and diluted when necessary. Using 0.2 µm filter (Millex-GN), the solution was filtered before injection

Statistical analysis

Using one-way analysis of variance (ANOVA) in Statistical Product and Service Solutions (SPSS), version 20, raw laboratory data were examined using the t-test pair-wise comparison of means. The results were provided as mean ± SD. Duncan's new multiple range test was used to identify significant means at the 95% probability level. A mean value of $p < 0.05$ was deemed significant.

RESULTS

The qualitative phytochemical results of beebread, leaf of life, bitter leaf and hospital too far

Flavonoids were observed to be present in high concentration in both beebread and bitter leaf, present in moderate concentration in leaf of life and present in low concentration in hospital too far. Alkaloids were present in low concentration in beebread, and present in high concentration in both leaf of life, bitter leaf and hospital too far. Phenols were observed to be present in high concentration in both beebread, leaf of life and bitter leaf but not detected in hospital too far. Tannins were present in low concentration in beebread, present in low concentration in both leaf of life and hospital too far, and present in high concentration in bitter leaf. Cyanogenic glycosides were present in moderate concentration in both beebread, leaf of life and hospital too far, but present in high concentration in bitter leaf.

High performance liquid chromatography (HPLC) analysis of amino acids in bee bread, leaf of life, and hospital too far samples

Table 2 shows the results of HPLC amino acids analyses in amount (g/100 g) of bee bread, Leaf of life, and Hospital too

far samples. In bee bread, glutamate (11.50199 g/100 g) was found to be the highest followed by proline (8.39635 g/100 g), aspartate (8.12430 g/100 g), with the lowest being cystine (1.12368 g/100 g). The total amino acids analyzed in bee bread sample was 79.69214 g/100 g. In Hospital too far leaf sample, glutamate (13.86938 g/100 g) and aspartate (10.95711 g/100 g) were found to be highest with retention time of 22.605 min and 19.522 min respectively. The total amino acids analyzed in hospital too far leaf sample was 83.16352 g/100 g. While the amino acids profile in Leaf of life sample shows a total amino acid of 82.32374 g/100 g, with glutamate (10.96602 g/100 g) and aspartate (9.85951 g/100 g) higher than others.

High performance liquid chromatography (HPLC) analyses of vitamins in bee bread, leaf of life, and hospital too far samples

Results of vitamins by HPLC analysis in bee bread, Leaf of life, and Hospital too far samples are shown in table 3. The vitamins identified in both samples include; B1, B2, B3, B5, B6, B9, B12, A, C, D, E and K. In bee bread sample, vitamin E had the highest amount (43.10372 mg/100 g), followed by vitamin C (12.99988 mg/100 g), then the B vitamins, vitamin K and then vitamin D. The total vitamins in bee bread sample analyzed is 69.50490 mg/100 g). In hospital too far sample, vitamin C had the highest amount (18.16146 mg/100 g), followed by the B vitamins such as vitamin B3 (9.69552 mg/100 g), vitamin E, D, A and then vitamin K. The total vitamins in hospital too far leaf sample analyzed is 21.03042 mg/100 g). And in leaf of life sample, vitamin C had the highest amount (23.76694 mg/100 g), followed by vitamin B3 (9.04078 mg/100 g), vitamin E, D, K and then vitamin A. The total vitamins in leaf of life sample analyzed is 26.59189 mg/100 g).

Analysis of mineral content in bee bread, hospital too far, and leaf of life samples

Table 4 shows the mineral contents of Bee bread, Hospital too far, and Leaf of life samples. Bee bread contain more iron (18.4521 ppm) than hospital too far (9.6381 ppm), and leaf of life (12.6683 ppm). Zinc in hospital too far (7.5214 ppm) was found to be higher than in leaf of life (6.3186 ppm) and bee bread (4.8532 ppm). Manganese in bee bread (3.8561 ppm) was more than in leaf of life (2.9574 ppm) and in hospital too far (2.4673 ppm). Other minerals analyzed include potassium, sodium, magnesium, calcium, phosphorus, lead, cadmium, copper, selenium, cobalt nickel and iodine.

Table 1: Qualitative Phytochemical Results of Bee Bread, Leaf of Life, Bitter leaf and Hospital too far

	Bee Bread	Leaf of Life	Bitter Leaf	Hospital too Far
Flavonoids	+++	++	+++	+
Alkaloids	+	+++	+++	+++
Phenolics	+++	+++	+++	ND
Tannins	+	++	+++	++
Cyanogenic Glycosides	++	++	+++	++
Cardiac Glycosides	ND	ND	+	ND
Saponins	+	+	+++	++
Steroids	ND	ND	+	ND
Terpenoids	+	ND	++	+
Reducing Sugar	ND	++	ND	ND

Key: +++ = Highly present; ++ = Moderately present; + = Present; ND = Not detectable and (n = 3).

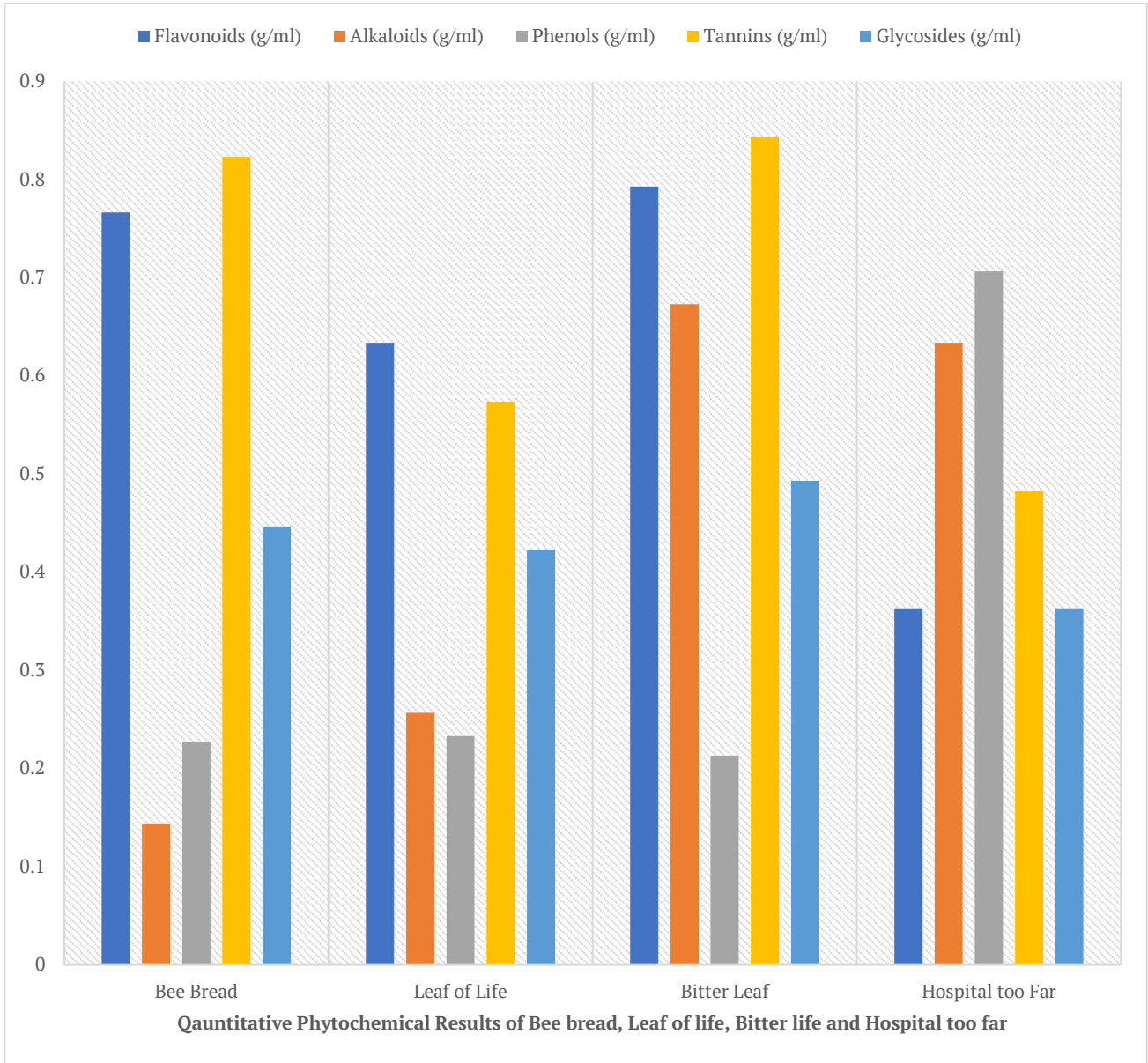


Figure 1: Quantitative Phytochemical Results of Bee bread, Leaf of life, Bitter leaf and Hospital too far.

Results are Mean $\pm$ SD and n = 3. Bars reveal tannins and flavonoids in beebread and bitter leaf to be significantly ($p < 0.05$) higher when compared to leaf of life and hospital too far. Similarly, bars reveal alkaloids in bitter leaf and hospital

too far to be significantly ($p < 0.05$) higher when compared with leaf of life and beebread, and phenols significantly ($p < 0.05$) higher in hospital too far when compared with other samples.

Table 2: Amino acid content in Bee Bread, Leaf of Life, and Hospital too far Samples

Name	Bee Bread		Leaf of Life		Hospital too far	
	Ret Time (min)	Amount g / 100gProt	Ret Time (min)	Amount g / 100gProt	Ret Time (min)	Amount g / 100gProt
GLYCINE	9.343	3.82443	8.903	4.50544	8.903	2.46038
ALANINE	10.850	4.63106	10.362	4.42807	10.362	2.25046
SERINE	12.267	3.91476	12.098	3.22814	12.098	3.87180
PROLINE	13.739	8.39635	13.740	3.41185	13.740	4.67296
VALINE	14.695	4.78337	14.697	5.53307	14.697	4.60241
THREONINE	16.035	3.26443	16.040	3.71309	16.040	3.38062
ISOLEUCINE	18.049	3.79229	18.057	4.57003	18.057	3.70224
LEUCINE	19.019	6.48421	19.027	7.50598	19.027	6.51757
ASPARTATE	19.515	8.12430	19.522	9.85951	19.522	10.95711
LYSINE	20.714	4.53459	20.594	4.50667	20.594	4.24242
METHIONINE	21.675	1.75027	21.674	2.15776	21.674	1.86832
GLUTAMATE	22.596	11.50199	22.605	10.96602	22.605	13.86938
PHENYLALANINE	23.227	4.43380	23.232	4.50404	23.232	5.75606
HISTIDINE	23.963	1.91274	23.968	2.61865	22.968	3.32383
ARGININE	25.108	4.44907	25.109	5.00614	25.109	5.96402
TYROSINE	25.616	2.64708	25.949	2.96264	25.949	3.04939
TRYPTOPHAN	26.227	1.23724e-1	26.416	1.65302	26.416	1.28897
CYSTINE	26.947	1.12368	26.993	1.19363	26.993	1.38558
TOTAL		79.69214		82.32374		83.16352

n=3

Table 3. Vitamin Contents in Bee Bread, Leaf of Life, and Hospital too far Samples

Name	Bee Bread		Hospital too far		Leaf of Life	
	Ret Time (min)	Amount (mg/100g)	Ret Time (min)	Amount (mg/100g)	Ret Time (min)	Amount (mg/100g)
Vitamin B3	11.368	8.05245	11.357	9.69552e-1	11.370	9.04078e-1
Vitamin B6	12.445	7.06303e-1	12.428	1.49610e-1	12.448	1.95953e-1
Vitamin C	12.832	12.99988	12.822	18.16146	12.833	23.76694
Vitamin A	13.834	5.18852e-2	13.612	2.56170e-2	13.833	1.28454e-2
Vitamin B1	14.160	7.08668e-1	14.150	1.55964e-1	14.163	2.11915e-1
Vitamin B2	14.505	8.53880e-1	14.570	2.97105e-1	14.507	3.37338e-1
Vitamin D	14.950	5.52624e-3	15.024	4.05776e-6	14.963	6.34137e-6
Vitamin E	15.389	43.10372	15.382	8.89278e-1	15.392	7.53333e-1
Vitamin B9	16.543	5.33703e-1	16.539	2.16742e-2	16.545	3.10778e-2
Vitamin K	17.696	5.66033e-1	17.361	2.04148e-1	17.696	2.33055e-1
Vitamin B5	18.131	1.92201	18.185	1.55537e-1	18.136	1.44829e-1
Vitamin B12	18.755	8.49883e-4	18.669	4.75125e-4	18.781	5.13671e-4
TOTALS		69.50490		21.03042		26.59189

n = 3

Table 4: Mineral contents in Leaf of life, Bee Bread and Hospital too far Samples

S/N	PARAMETER	LEAF OF LIFE	BEE BREAD	HOSPITAL TOO FAR
1	POTASSIUM (%)	0.0974	0.5413	0.0728
2	SODIUM (%)	0.0083	0.0215	0.0092
3	MAGNESIUM (%)	0.0824	0.0756	0.0641
4	CALCIUM (%)	0.0843	0.4885	0.0584
5	PHOSPHORUS (%)	0.0925	0.5218	0.0642
6	IRON (ppm)	12.6683	18.4521	9.6381
7	ZINC (ppm)	6.3186	4.8532	7.5214
8	LEAD (ppm)	0.0286	0.0213	0.0915
9	CADMIUM (ppm)	0.0148	0.0131	0.0116
10	COPPER (ppm)	1.3074	0.8462	0.9172
11	SELENIUM (ppm)	0.1992	0.0345	0.1826
12	MANGANESE (ppm)	2.9574	3.8561	2.4673
13	COBALT (ppm)	0.0082	0.0035	0.0078
14	NICKEL (ppm)	0.1174	0.0195	0.1327
15	IODINE (ppm)	0.0753	0.0428	0.0812
Total		24.03 ppm	29.79 ppm	21.32 ppm

n = 3

DISCUSSION

The results of Phytochemical screening (qualitative and quantitative) obtained during the experiment are shown in Table 1 and Figure 1. Flavonoid, alkaloid, tannin, phenol, glycoside, steroid, saponin, reducing sugar and steroids were the various phytochemicals found in all samples. Flavonoid, saponin, alkaloid, steroid present in plant extracts can be used as tonics to treat a variety of ailments and maladies, including emesis, nausea, diabetes, anorexia, diarrhea, dysentery and other gastrointestinal tract issues (Yan and Wenhua, 2025; Alexander *et al.*, 2024) which explains why many herbalists and indigenous doctors in Africa recommend that their patients take the aqueous preparations of these leaves against certain health maladies (Yan and Wenhua, 2025). Tannic acid was at another instance also discovered to have inhibitory actions against food-borne bacteria, off-flavor-producing microorganisms and aquatic bacteria (Boham and Kocipai-Abyazam, 1994). This antimicrobial property can be employed in food processing to lengthen the shelf-life of certain foods, like catfish fillets (Kumar *et al.*, 2023). Tannins are found in a wide variety of plant species from all climatic zones and geographical regions (Janine, 2019). Like many other polyphenols, tannins function as antioxidants, assisting in preventing and or repairing cellular damage brought about by the attack of free radicals (Afuape *et al.*, 2022). Saponins have been employed for different applications in the pharmaceutical sector (one such application is the use of saponins by the industry as an initiative precursor for the semi-synthesis of steroidal drugs) (Acidri *et al.*, 2020). Alkaloids have a wide range of physiological effects, including antibacterial, antimitotic, anti-inflammatory, analgesic, local anesthetic, hypnotic, psychotropic, and anticancer activities (Degu *et al.*, 2024). Alkaloids (morphine, quinine, ephedrine) are useful in dietary supplements and medications (Edo *et al.*, 2023). Flavonoids have a variety of beneficial biochemical and antioxidant properties against a number of illnesses, including cancer, Alzheimer's disease (AD), atherosclerosis, Obesity, and Diabetes (Idoko *et al.*, 2023; Idoko *et al.*, 2024).

Results from HPLC analysis of bee bread, *bryophyllum pinnatum*, *vernonoia amygdalina* and *Jatropha tanjorensis* for amino acids, vitamins and minerals are shown in Tables 2 – 4. For amino acids, our results show that glutamate was more in all the samples, which was reportedly supported by Agnius *et al* (2018). Elevated concentrations of glutamate in plants may be due to metabolic processes, and response to stress, revealing resistance to disease. It is crucial in defense mechanisms, metabolism of nitrogen, and signalling pathways. There are about 300 amino acids that occur in nature. Amino acids are the building blocks of proteins and are crucial for various bodily functions (Hou and Wu, 2015). The nutritional value of amino acids in food is determined by their essentiality (whether the body can produce them) and their role in protein synthesis (Hou and Wu, 2015). Dietary sources of essential amino acids, which the body cannot produce, are crucial for maintaining health (Dietzen and

Willrich, 2023). Deficiency or error in metabolism of certain amino acids is associated with several diseases such as homocystinuria, phenylketonuria, and maple syrup urine disease (Hou and Wu, 2015). Thus, essential amino acids from the evaluated sources could serve as rich and healthy alternatives for healthy living (Dietzen and Willrich, 2023).

Our results revealed that vitamins E, C, and B were higher in all the samples analyzed. This is supported by Afuape *et al* (2022), who reported that *H. odoratissimum* have high vitamin A, B1, B2, and C in the stem than the leaf with high vitamin E. The food value of vitamins refers to the amounts of different vitamins found in various foods, as well as their role in supporting the body's needs (Janine, 2019). Different vitamins have different recommended dietary allowances (RDAs) or daily adequate intakes (AIs) (Janine, 2019). Several diseases are linked to vitamin deficiencies, thus the observed high vitamins content in bee bread, *Bryophyllum pinnatum*, *Vernonia amygdalina*, and *Jatropha tanjorensis* could suggest the medicinal and pharmacological potential of these nature's materials as healthy therapeutic alternatives against pernicious anemia, nerve damage, scurvy, osteomalacia/rickets, beriberi, pellagra, and night blindness. Vitamins can be found in a wide variety of foods, both plant and animal-based. Fat-soluble vitamins (A, D, E, K) are stored in the body, while water-soluble vitamins (C, B vitamins) are not and need to be replenished regularly (Afuape *et al.*, 2022).

Our results show that the investigated materials are rich sources of minerals. Thus, mineral deficiencies such as anemia, osteoporosis, goiter, muscle cramps, and weak bones could be managed through supplementation or dietary intervention with these natural therapies (Afuape *et al.*, 2022). In this study, Iron was higher in bee bread than in other samples, as supported by Volkan *et al* (2023) where bee bread was found to be a richer source of iron, zinc, and manganese than legumes, and green leafy vegetables. This could be because the production of bee bread involves fermentation which enhances its digestibility, bioactive compounds addition, and increases its nutritional spectrum than leafy plants (Bakour *et al.*, 2022). Minerals are essential nutrients found in food that play various roles in maintaining bodily functions and health (Zoroddu *et al.*, 2019). They are categorized into two groups: macrominerals (needed in larger amounts) and trace minerals (needed in smaller amounts), found in healthy diet to supply the mineral requirements suitable for growth and development (Afuape *et al.*, 2022).

CONCLUSION

The comprehensive analysis of Bee bread, *Bryophyllum pinnatum* (Leaf of Life), *Vernonia amygdalina* (Bitter Leaf), and *Jatropha tanjorensis* (Hospital Too Far) has revealed significant insights into their phytochemical, amino acid, vitamin and mineral contents as phytonutrient rich sources. The presence of various bioactive compounds, essential amino acids, vitamins, and minerals underscores the substantial nutritional and medicinal potential of these plants. Overall, this research contributes to the growing body

of knowledge on the nutritional and therapeutic benefits of Bee bread, *Bryophyllum pinnatum*, *Vernonia amygdalina*, and *Jatropha tanjorensis*, advocating for their wider application in health promotion and disease prevention. Revealed as rich sources of bioactive compounds, validate their potential as nutritional supplements and therapeutic agents. This study revealed the potentials of the studied materials as natural sources and could serve for antidiabetic pharmaceuticals, antimicrobial treatments, and high-protein livestock feed.

AUTHORS' CONTRIBUTIONS

The following statements should be used "Conceptualization, AI. and EBO.; methodology, AI.; validation, EBO. and OVC.; formal analysis, AI.; investigation, AI and EBO.; resources, AI., EBO. and OVC; data curation, AI. EBO. and OVC; writing—original draft preparation, AI.; writing—review and editing, AI.; supervision, AI.; project administration, AI. EBO. and OVC. All authors have read and agreed to the published version of the manuscript.

FUNDING STATEMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

ACKNOWLEDGEMENT

Not applicable

REFERENCES

- Acidri, R., Sawai, Y., Sugimoto, Y., Handa, T., Sasagawa, D., Masunaga, T., Yamamoto, S., & Nishihara, E. (2020). Phytochemical Profile and Antioxidant Capacity of Coffee Plant Organs Compared to Green and Roasted Coffee Beans. *Antioxidants (Basel)*, 22;9(2):93. doi: 10.3390/antiox9020093.
- Afuape., A. O., Afolayan, A. J., & Buwa-Komoreng, L. V. (2022). Proximate, Vitamins, Minerals and Anti-Nutritive Constituents of the Leaf and Stem of *Helichrysum odoratissimum* (L.) Sweet: A Folk Medicinal Plant in South Africa. *International Journal of Plant Biology*, 13(4), 463-472. <https://doi.org/10.3390/ijpb13040037>.
- Agnius, C., Von Tucher, S., Poppenberger, B., & Rozhon, W. (2018). Quantification of Glutamate and Aspartate by Ultra-High Performance Liquid Chromatography. *Molecules*, 23(6), 1389. <https://doi.org/10.3390/molecules23061389>.
- Alexander, I., Elijah, P. J., Uzoma, N. O., Mbamalu, E. E., Chioma, N. J., & Onubuiwe, N. N. (2024). Hepato-Renal Protection of Methanol Flavonoid-Fraction of Lime Juice in Rats Fed Monosodium Glutamate and Protein-Enriched Diet. *Journal of Biochemical Technology*, 15(4), 35-46. <https://doi.org/10.51847/qf3cf9rUiw>
- Ali, M. Y., Sina, A. A. I., Khandker, S. S., Neesa, L., Tanvir, E. M., Kabir, A., Khalil, M. I., & Gan, S. H. (2021). Nutritional composition and bioactive compounds in tomatoes and their impact on human health and disease: A review. *Foods*, 10(1), 45. <https://doi.org/10.3390/foods10010045>.
- Araújo, E.R.D., Xavier-Santos, J.B., da Silva, V.C., de Lima, J.B.F., Schlamb, J., Fernandes-Pedrosa, M.F., da Silva-Júnior, A.A., de Araújo-Júnior, R.F., Rathinasabapathy, T., Moncada, M., Esposito, D., Guerra, G.C.B., & Zucolotto, S.M. (2023). Gel formulated with *Bryophyllum pinnatum* leaf extract promotes skin wound healing in vivo by increasing VEGF expression: A novel potential active ingredient for pharmaceuticals. *Frontier in Pharmacology*, 12(13):1104705. doi: 10.3389/fphar.2022.1104705.
- Ares, A. M., Valverde, S., Bernal, J. L., Nozal, M. J., & Bernal, J. (2018). Extraction and Determination of Bioactive Compounds from Bee Pollen. *Journal of pharmaceutical and biomedical analysis*. 147:110-124.
- Association of Official Analytical Chemists (AOAC) (2005). Official Methods of Analysis (18th ed). 18th ed. Washington, DC USA.
- Boham, B.A., & Kocipai-Abyazam, R. (1994). Flavonoids and condensed tannins from leaves of Hawaiian *Vaccinium Vaticulatum* and *V. Calycynium*. *Pacific Science*, 48: 458-463.
- Bakour, M., Laaroussi, H., Ousaaïd, D., El Ghouizi, A., Es-Safi, I., Mechchate, H., & Lyoussi, B. (2022). Bee Bread as a Promising Source of Bioactive Molecules and Functional Properties: An Up-To-Date Review. *Antibiotics*, 11(2), 203. <https://doi.org/10.3390/antibiotics11020203>.
- Carolina, C., Graciela, A., Silvia, Q., Eduardo, C., Astrid, L., Josué, V., & Fabio, G. (2022). Analysis of Minerals in Foods: A Three-year Survey from Costa Rican Market Products. *Journal of Food Research*, 12(1):1-27.
- Degu, S., Meresa, A., Animaw, Z., Jegnie, M., Asfaw, A., & Tegegn, G. (2024). *Vernonia amygdalina*: a comprehensive review of the nutritional makeup, traditional medicinal use, and pharmacology of isolated phytochemicals and compounds. *Frontier of Natural Products*, 3:1347855. doi: 10.3389/fntpr.2024.1347855.
- Denisow, B., & Denisow-Pietrzyk, M. (2016). "Biological and therapeutic properties of bee pollen: a review". *Journal of the Science of Food and Agriculture*, 96 (13): 4303-4309.
- Dietzen, D. J., & Willrich, M. A. V. (2023). Amino acids, peptides, and proteins. In: Rifai N, Chiu RWK, Young I, Burnham Carey-Ann D, Wittwer CT, eds. *Tietz Textbook of Laboratory Medicine*. 7th ed. St Louis, MO: Elsevier; 2023: chap 31.
- Edo, G. I., Princess, O. S., Agatha, N. J., Favour, O. O., Laura, I. I., Promise, O., Ajiri, R. O., Joy, E., Victor, O. I., Chinenye, F. O., Eunice, U., Jonathan, O., Miracle, I., Ifechukwude, D. N., Sheyi, R. A., & Joy, E. O. (2023). Biological and bioactive components of bitter leaf (*Vernonia amygdalina* leaf): Insight on health and nutritional benefits. A review. *Food Chemistry Advances*, 3(100488), doi.org/10.1016/j.focha.2023.100488.
- Elizabeth, B., Umoren, I.A., Okon, E.U., Modo, O.E., Etim, P.I., Brown, D.U., Owu, A., & Bassey, I.L. (2023). *Jatropha tanjorensis* Euphorbiaceae ameliorates aspirin-induced hepatotoxicity and maintain electrolytes balance

- in albino Wistar rats, *Phytomedicine Plus*, 3(2):100450, <https://doi.org/10.1016/j.phyplu.2023.100450>.
- Harborne, J. B. (1973). *Phytochemical methods: A guide to modern techniques of plant analysis*. Chapman and Hall Ltd, London. pp. 279-302.
- Hou, Y., & Wu, G. (2015). Nutritionally essential amino acid. *Advances in nutrition*, 240(8): 997-1007.
- Idoko, A., Agu, P. C., Udegbe, U.F., Ezech, M., & Nwali, N. O (2025). Honey and lime juice flavonoids as potential adjunctive remedies against obesity and diabetes mellitus risks via glucagon receptor and glucagon-like peptide-1 receptor binding mechanisms: an in-silico investigation. *Discovery Applied Sciences*, 7(762): 2025. <https://doi.org/10.1007/s42452-025-06556-7>.
- Idoko, A., Parker, J. E., & Njoku, O. U. (2023). Ethylacetate Flavonoid Bio-compounds of Honey with Mitigating Anti-hyperlipidemic and Antioxidant Properties in Carbohydrate and Lipid Enriched Diets – Obese Rats. *Annual Research and Review in Biology*, 38 (9): 1-23.
- Idoko, A., Onyinye, A. N., Blessing, N. O., Ayomide, T. A., Philip, O. C., & Nwali, O. N. (2019). Heating effect on phytochemical and proximate contents of cooked aqueous extract of *Phaseolus vulgaris* (kidney beans). *Universal Journal of Pharmaceutical Research*, 4(6):35-41. DOI:<https://doi.org/10.22270/ujpr.v4i6.334>
- Ilie, C. I., Spoiala, A., Geana, E. I., Chircov, C., Ficai, A., Ditu, L.M., & Oprea, E. (2024). Bee Bread: A Promising Source of Bioactive Compounds with Antioxidant Properties—First Report on Some Antimicrobial Features. *Antioxidants*, 13(3), 353. <https://doi.org/10.3390/antiox13030353>
- Imaobong, E., Daniel, E. I., Akpan., & Edidiong, C. U. (2020). Phytochemical Evaluation, Antioxidant and Antimicrobial Activities of Various Extracts from Leaves and Stems of *Bryophyllum pinnatum*. *Nepal Journal of Biotechnology*, 8(1):17-28.
- Imohiosen, O. (2023). Phytochemical and Biological Screening of Catholic Vegetable (*Jatropha Tanjorensis*) Aqueous Extract in Bali, Taraba State, Nigeria. *American Journal of Chemistry and Pharmacy*, 2(2); 1-4.
- Janine, L. (2019). Codex nutrient reference values. Food and Agriculture Organization of the United Nations and World Health Organization. P 50 – 61.
- Kim, E. K., Jeong, E. K., Han, S. B., & Hong, J. (2011). HPLC Separation of Isoquinoline Alkaloids for Quality Control of *Corydalis* species. *Bulletin of the Korean Chemical Society*, 32(10), 3597–3602. <https://doi.org/10.5012/BKCS.2011.32.10.3597>
- Kumar, A., P. N., Kumar, M., Jose, A., Tomer, V., Oz, E., Proestos, C., Zeng, M., Elobeid, T., K.S., & Oz, F. (2023). Major Phytochemicals: Recent Advances in Health Benefits and Extraction Method. *Molecules*, 16;28(2):887. doi: 10.3390/molecules28020887.
- Khuluk, R. H., Yunita, A., Rohaeti, E., Syafitri, U. D., Linda, R., Lim, L. W., Takeuchi, T., & Rafi, M. (2021). An HPLC-DAD Method to Quantify Flavonoids in *Sonchus arvensis* and Able to Classify the Plant Parts and Their Geographical Area through Principal Component Analysis. *Separations*, 8(2),12. <https://doi.org/10.3390/separations8020012>
- Morais, F. J., Ortiz, S., Padilha, M., Tavares, R., Mandova, T., & Rodrigues, D. (2021). *Bryophyllum pinnatum* markers: CPC isolation, simultaneous quantification by a validated UPLC-DAD method and biological evaluations. *Journal of Pharmacology and Biomedical Analyses*, 193, 113682. doi:10.1016/j.jpba.2020.113682
- Obdoni, B. O., & Ochuko, P. O. (2001). Phytochemical studies and comparative efficacy of the crude extract of some homostatic plants in Edo and Delta state of Nigeria. *Global Journal of Pure Applied Sciences*, 8b:203 – 208. 17.
- Ogunmoyole, T., Odunyemi, P. O., Akeem, Y. A., Johnson, O. D., Adefila, A. O., & Ogundare, A. M. (2025). Antioxidant and Antidiabetic Potential of *Bryophyllum pinnatum* Leaf Extract In Vitro. *European Journal of Applied Sciences*, 13(03). 238-255.
- Sanlier, N., Kaya, E. Y., & Yucel, I. I. (2026). Health Effects of Bee Products: A Comprehensive Review. *Food Science and Nutrition*, 3;14(2):e71165. doi: 10.1002/fsn3.71165.
- Themelis, T., Gotti, R., Orlandini, S., & Gatti, R. (2019). Quantitative amino acids profile of monofloral bee pollens by microwave hydrolysis and fluorimetric high performance liquid chromatography. *Journal of Pharmaceutical and Biomedical Analysis*, 173, 144–153. <https://doi.org/10.1016/j.jpba.2019.05.031>.
- Trease, G. E., & Evans, W. C. (1989). *Pharmacognosy. A physician guide to herbal medicine*, 11th edn. Ballere Tindal, London, United Kingdom 530. <https://doi.org/10.3389/fphar.2013.00177>
- Udokang, N. E., Bassey, G. E., David, J. U., & Wilson, I. I. (2023). *Jatropha tanjorensis* (Barbados Nut) Lowers Hematological Indices in a Dose-Dependent Fashion. *Scholarly Journal of Applied Medical Sciences*, 11(7): 1323-1330.
- Volkan, A., Soraia, I., & Falcão, M. V. (2023). Bee pollen and bee bread nutritional potential: Chemical composition and macronutrient digestibility under in vitro gastrointestinal system. *Food Chemistry*, 413:135597. <https://doi.org/10.1016/j.foodchem.2023.135597>.
- Yadav, M., Gulkari, V. D., & Wanjari, M. M. (2016). *Bryophyllum pinnatum* Leaf Extracts Prevent Formation of Renal Calculi in Lithiatric Rats. *Archive of Science Life*, 36(2):90-97. doi: 10.4103/asl.ASL_90_16.
- Yan, Y., & Wenhua, L. (2025). Health Benefits and Future Research of Phytochemicals: A Literature Review. *The Journal of Nutrition*, 155(1):87-101.
- Zoroddu, M. A., Aaseth, J., Crisponi, G., Medici, S., Peana, M., & Nurchi, V. (2019). "The essential metals for humans: a brief overview". *Journal of Inorganic Biochemistry*, 195: 120-129.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher. The publisher remains neutral with regard to jurisdictional claims.

Submit your next manuscript to NJBMB at
<https://www.nsbmb.org.ng/journals>