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Polyphenolic Content of *Musa Acuminata* and *Musa Paradisiaca* bracts: Chemical Composition, Antioxidant and Antimicrobial Potentials

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Polyphenols are known for their bioactive potentials and have been used as drugs and preservatives for decades. The drive around this research is to estimate the usefulness of bananas and plantain bracts. The bracts of banana (Musa acuminata) and plantain (Musa paradisiaca) were investigated for their chemical composition, antibacterial, and antioxidant capacity. The result of proximate analysis revealed appreciable amount of moisture content (8.45%; 7.83%), crude protein (1.53%; 1.57%), crude fiber (21.2%; 16.5%), fat content (2.01%; 2.25%), ash content (16.60 %; 15.10%), and carbohydrate (52.6%; 56.8%) dry matter (DM) for M. acuminata and M. paradisiaca respectively. The cellulose and lignin content of the bract samples revealed M. acuminata (34.61 ± 1.06%; 9.13 ± 0.31%) and M. paradisiaca (35.68 ± 0.31%; 11.68 ± 0.75%) respectively. The phytochemical analysis showed that the bracts contained (g/100g) tannins (29.01%; 24.21%), flavonoids (8.35%; 6.33%), saponins (26.02%; 25.08%), phenol (0.56%; 0.34%), and alkaloids (3.30 %; 3.74%), respectively for M. acuminata and M. paradisiaca respectively. Antimicrobial activity of the methanolic, ethyl acetate, and n-hexane extracts presented a wide range of inhibition against studied strains. Methanolic and ethyl acetate extracts demonstrated considerable effect against most of the strains. The zones of inhibition ranged from 2 to 10 mm for the extracts. Methanolic extract of M. acuminata bract exhibited the strongest antioxidant activity (IC50 = 2.14±4.17 mg/ml) against DPPH radical. Meanwhile, methanolic extract of the bracts showed iron-chelating ability (2.03±1.48 mg/ml; 2.14±1.46 mg/ml), and FRAP assay (15.36±0.25 mg/ml; 23.09±0.17 mg/ml) for M.acuminata and M. paradisiaca respectively. The presence of polyphenols and essential nutrients present in the bracts showed potential to be exploited as a cradle for feed enhancement, antimicrobial agent, and protective agent against oxidative stress.

Keywords: Antimicrobial; Free Radical Scavenging; Musa acuminata byproduct; Musa paradisiaca byproduct; Polyphenolic content; Proximate analysis.

The herbal chemistry have been observed to exhibit application in the food industries, pharmaceutical, agricultural, cosmetic industries. In the account of all civilizations, the medicinal herbs use for curing disease have been documented[1-4]. Through the commencement of research in medicine, it has been established that plants are made up of active constituents, responsible for the

therapeutic action of the herbal plants[2,4,5]. Amongst higher plant species reported, over 80,000 species are described to possess some pharmaceutical values, while, about 5000 species have definite healing potentials[4,6,7].

Known for their bioactive potentials are plant secondary metabolites used as agents and preservatives for decades[1,8-11]. The production of these metabolites takes place within the plants for several reasons, and some of these metabolites have been reported to play a very significant role in the plant's defense against various types of stress, which includes climatic stress, microbial infestations[4,10]. Phytochemical deals with the chemical structure of these constituents, their biological function, turnover, metabolism, biosynthesis, and natural distribution. The natural products produced by the plant can either be useful or toxic to the body[6,12-14]. These include; alkaloids, saponins, tannins, terpenoids, flavonoid, anthraquinone and glycosides, obtained either from synthesized or metabolism products for defense tenacities[2,4,15,16].

Previous studies carried out on parts of *Musa* spp byproducts of various varieties showed great antibacterial potential[10,17], antioxidants derived from the flowers[18] and fruit peels[10] alongside an antifungal[10]. Any edible part of the plants, be it fruit, flower, or stem, provides energy, vitamins, and minerals. Plantain and banana plants have a lot of medicinal applications. The root extracts have been used as herbal remedies for the treatment of fever, restlessness due to heat (root internal), toothache due to wind (root internal), skin infection (sap internal), and diabetes (flower, fruit, root)[17]. Adepoju et al.[19] conveyed the chemical composition of diverse peels of banana and plantain at stages of maturation. Banana and plantain peels protein content was 8–11%. Presence of phenylalanine, leucine, threonine, and valine were in substantial amounts.

A region referred to as the primary center of diversification of the crop is Southeast Asia and bananas happens to originate from there[19]. *Musa acuminata* is from Malaysia, while, *Musa paradisiaca* originated from Indonesia. The world's largest range of genetic diversity in plantains are from the low land areas of West Africa. Conversely, banana and plantain (*M. acuminata* and *M. paradisiaca* spp) are perennial crops growing healthy in a wide variety of environments in many parts of Africa and serves as a source of energy for the populace in West and East Africa[19]. Banana and plantain bracts are thick purple that covers the cluster of a stalk of both banana and plantain fruit. The bracts begin to fall a day after opening (Figure 1).

Extensive work has been done on the improvement and sustainability of these crops especially in the areas of crop protection and breeding, elucidation of the vitamins, mineral elements, and nutritional components of the edible part of the plant. Little or no research work has been done on the usefulness of the banana and plantain bracts as a potential industrial raw material. The drive of this study is to establish and estimate the usefulness of *M. acuminata* and *M. paradisiaca* bracts as a potential industrial raw material, the phytochemicals, in-vitro antioxidant, and antibacterial potential from *Musa* spp extracts.

MATERIALS AND METHODS

Chemicals and solvents used for this study were of analar grade, and were obtained from British drug House Laboratory, England.

The Banana bracts (*Musa acuminata*) used for the project work were obtained from Aba Oyo, a village near FUTA while plantain bracts (*Musa paradisiaca*) were collected from the University premises located in Akure, Ondo State. The Plantain and banana bracts were properly washed in cleaned water before air drying so as to eradicate sand, dust, and other impurities, followed by drying at room temperature for weeks. The bract samples were later oven-dried at 40! to allow total dryness for grinding. The dried samples were then pulverized into powder using a blender, sieved, and stored in a dried container, and ready for further analysis.

250 ml of methanol was added to 50 g of the pulverized sample in a conical flask, while extraction was carried out as described earlier[4,12,16]. The concoction was agitated and covered. It was allowed to stand for 36 h and sieved using sterile Whatman No 1 filter paper. A light yellow filtrate was obtained. The extracts were then concentrated using a rotatory evaporator to about 50 ml. The procedure was repeated with ethyl acetate,

n-hexane, and distilled water. All the concentrated extracts were cooled and store in the refrigerator for additional analysis.

Proximate analyses were carried out for the banana (*Musa acuminata*) and plantain (*Musa paradisiaca*) bract using standard qualitative tests as described by AOAC[20]. These tests include Moisture content, crude protein content, crude fat, carbohydrate content, crude fiber, and total ash.

The powered bract samples were first extracted with ethanol-benzene mixture 1:2 and dried at 103! in the oven, cool in the desiccator, and weighed. After that, the determination of the lignin content was carried out.

The acid-insoluble part of the lignin is designated Klason lignin was estimated as described in the literature with little modifications[21,22]. 1 gram of ethanol-benzene pre-extracted sample was positioned inside a 100 ml beaker. Fifteen ml of sulphuric acid (72%) was in little increment gradually introduced while stirring, and with a glass rod deliquescing the sample. After sample dispersion, the beaker was concealed with a watch glass and retained in a bath at about 20! for 2 h while stirring to ensure a complete solution. At the end of 2 h, the remainder was diluted to a total volume of 575 ml in a volumetric flask, followed by boiling for 4 hours at a perpetual volume (by the recurrent addition of hot water). The obtained mixture was left overnight to settle. A portion of the filtrate was taken aside for acid-soluble lignin determination. The lignin (Klason lignin) material was filtered, washed using hot water, and kept in the oven to dry to constant weight at 103!. The acid-insoluble lignin was calculated based on the average of three determinations as to the percentage weight of the lignin to the oven-dry weight of the sample (Eq. 1).

$$\text{Lignin (\%)} = ((100Y))/(W) \quad ...(1)$$

Where

Y = weight of lignin (insoluble material)

W = weight of the oven dried test sample

The Kurschner-Hoffer cellulose method was followed[23,24]. One gram of air-dried sample was introduced into a round bottom flask (250 ml) fitted with a condenser, 1.5 ml of concentrated nitric acid (HNO_3) was added. The resultant mixture was heated for precisely 20 min, and 95% cold ethanol (20 ml) was added carefully. The subsequent combination was allow to cool, and filtered over Whatman No. 1 filter paper. The residues were washed successively with hot diethyl ether and benzene solution, and followed by overnight drying to a constant weight, and ashing in a muffle furnace for 5h at about 500!. The weight loss upon ignition was observed as a measure of the cellulose content expressed in percentage. Results were calculated from the mean of three replicates.

The method used for evaluating and documentation of bioactive chemical ingredients present in banana (*Musa acuminata*) and plantain (*Musa paradisiaca*) bract extracts was as described previously[1,4,11,12,16,25,26]. The chemical constituents investigated include: tannin, saponins, flavonoids, cardiac glycoside, phlobatannins, terpenoids, alkaloids, steroids

Alkaloid content was determined following the Harborne method[27]. The test samples were taken into beakers (250 ml) and acetic acid (10%) in ethanol (200 ml) was added. Beakers were covered and allowed to stand for 4 h. This was sifted and filtrate concentrated to quarter of the initial capacity on a water bath. Conc. NH_4OH was dropwisely added to the obtained extract till complete precipitation was achieved. The entire solution was kept to ensure complete separation was attained. The easily collected precipitate from the solution and was washed with dilute NH_4OH and sieved. The obtained residue is the alkaloid, and weighed after total dryness. The percentage yield was calculated, and results expressed as mean of three replicates.

Tannin content was estimated following the Van-Burden and Robinson method[28]. Banana (*Musa acuminata*) and plantain (*Musa paradisiaca*) bract samples (500 mg) were taken into a plastic bottle, 50 ml of distilled water was added. This was followed by power-driven shaking for 1 h, and sifted into volumetric flask (50 ml) made up. The filtrate (5 ml) was pipetted into different test tubes and mixed each with 2 ml of 0.1 M $FeCl_3$ in 0.1 N HCl and $K_4Fe(CN)_6$ (0.008 M). The dissolved tannin alongside the solutions absorption were measured at 120 nm within 10 min. Tannin content was expressed as a percentage. Results were calculated from the mean of three replicates.

Saponins content was determined following the Obadoni and Ochuko method[29]. 20 g of each pulverized sample was introduced into a conical flask (250 ml) and 20% aqueous ethanol (100 cm^3) added. The flasks were made to boil in a water bath for 4 h with continuous agitation at about 55!. The mixture was sieved and the remainder re-extracted with additional 20% ethanol (200 ml). The extracts were pooled together and concentrated to about 40 ml at about 90! over a hot water bath. The concentrate was conveyed into a separatory funnel (250 ml), 20 ml diethyl ether was added, and vigorous quivering was applied. Separated aqueous layer was recuperated while the ether layer was castoff. The process of purification was reoccurred, and n-butanol (60 ml) was added. The pooled n-butanol extracts were washed twice with 5% aqueous sodium chloride (10 ml). The residual solution was heated in a water bath to cause evaporation, remainder of the samples were dried in the oven into a constant weight, and saponins contents calculated as a percentage of the mean of three replicates.

Total phenols were estimated by spectrophotometric method following the Khan and co-workers method[1]. 2 g each of *M. acuminata* and *M. paradisiaca* samples were defatted via diethyl ether (100 ml) in a Soxhlet apparatus for two hours. The fat-free samples were cooked for 15 min with ether (50 ml) for proper extraction of phenolic constituent. Extract (5 ml) was pipetted into a flask (50 ml) and distilled water (10 ml) was added. Then, 2 ml of NH_4OH solution and concentrated amyl alcohol (5 ml) added to the separated solutions. The samples were topped to mark and allowed to interact for 30 min. The developed colour was measured at an absorbance of 505 nm. The amount of total phenol present was expressed as a percentage and the results were calculated from the mean of three replicates.

Flavonoid contents were determined following the Bohm and Kocipai-Abyazan method[30]. 10 g of each banana (*Musa acuminata*) and plantain (*Musa paradisiaca*) bract extracts were extracted with 80% methanol solution (100 ml) recurrently at room temperature. The total solution was sieved via # 42 Whatman filter paper (125 mm). The collected filtrate was transferred later into a crucible, and evaporated into dryness, the weight of the residue material and percentage amount was estimated from the mean of three replicates.

Stock solution for the various extracts was prepared by liquefying 2 g of the bract extracts in 20 ml of ethanol to make a concentration of 1 g/ml. Six concentrations of 0.25, 0.50, 1.00, and 2.00 mg/ml were made ready from the stock solution to provide the working standards. Butylated hydroxytoluene (BHT) and ascorbic acid were utilized as the standard antioxidants.

DPPH scavenging activity of the banana (*Musa acuminata*) and plantain (*Musa paradisiaca*) bract extracts was carried out in line with methods described previously[2,4,16,25]. About 1,l-diphenyl-2-picrylhydrazy (0.3 mM) was prepared in MeOH. For all the different working concentrations, extract (2 ml) was mixed with DPPH solution (1 ml); the blank was obtained by using ethanol (1 ml) instead of DPPH, while for the control, ethanol was used in place of extract. Solutions were prepared in triplicates. The reaction mixtures were kept for 30 min in the dark and the absorbance read at 517 nm. The equation below (Eq. 2) was used to compute the percentage scavenging actions (%RSA) of each extract.

$$\% \text{ DPPH radical Inhibition} = 100 - [(\text{Abs (sample)} - \text{Abs (blank)}) / (\text{Abs (control)}) \times 100\%] \quad ...(2)$$

$Abs_{(sample)}$ = absorbance of the sample, $Abs_{(blank)}$ = blank absorbance, and $Abs_{(control)}$ = control absorbance.

The reducing power assay of the bract extracts was investigated following a described method with slight adjustments[31,32]. 1 ml of the bract extract samples was mixed with phosphate buffer (0.2 M, 2.5 ml) at pH 6.6 and 2.5 m1 (1%) (K_3(Fe(CN}). The blend was hatched for 20 min at 50!, then after 2.5 ml (10%), trichloroacetic acid was introduced. The entire mixture was then centrifuged (650 rpm at room temperature) for 10 mins. The clear supernatant (2.5 ml) was taken into a test tube and 2.5 ml H_2O and (0.1%, 0.5 ml) FeCl were added. Solutions were prepared in triplicates, and allowed to interact for 30 min; the absorbance was collected at 700 nm.

The chelating outcome on ferrous ions of the prepared banana (*Musa acuminata*) and plantain

(*Musa paradisiaca*) bract extracts was assessed by reported methods with slight modifications[31,33,34]. To 0.5 ml of extracts, of deionized water (1.6 ml), and FeCl (2 mM, 0.05 m1) were added. Subsequently in about 30 s, ferrozine (5 mM, 0.1 ml) was introduce. The combination was agitated vigorously and allowed to interact for 10 min at room temperature. Solutions were prepared in triplicates. The absorbance of Fe^{2+}%Ferrozine complex was measured at 562 nm, and chelating power of the extracts for Fe^{2+} calculated as (Eq. 3):

$$\text{Reducing power / Chelating rate (\%)} = (A\_n - A\_t) / (A\_n) \times 100 \quad ...(3)$$

An = absorbance of the blank (in the absence of extract) and At = absorbance in the presence of extract.

Antimicrobial activities of the banana (*Musa acuminata*) and plantain (*Musa paradisiaca*) bract extracts were measured according to previous reports[3,15,16]. The microorganisms of choice used for this investigation are *B. cereus*, *P. syringae*, *E. coli*, *Xanthomonas axonopodis*: *PV. vignicola*, *PV. manihotis*, *C. albicans*, *B. subtilis*, and streptomycin sulphate was utilized as standard. The isolates were collected from the International Institute of Tropical Agriculture (IITA), Ibadan and Department of Microbiology, Federal University of Technology, Akure. The isolates were separately culture over each nutrient agar plate. Sterile cork bores of 8 mm diameter were used to make well on the solidified agar into which 0.5 ml diluted extracts (0.5 mg/ml) were aseptically introduced. The plates were incubated for 24 h at 37!. Zone of inhibition around the wells was measured by the use of a Vernier caliper. Results were quoted as the radii (mm) of the zone of inhibition around the well (subtracting the radius of the negative control well). A negative control plate was also set up using distilled water, standard antibiotics (streptomycin at 0.01 mg/ml) served as the positive control.

Data obtained from the analysis of the *Musa* spp. bract samples were subjected to statistical analysis using SPSS 17 software package, and expressed as mean ± SD for triplicate experiments. One-way analysis of variance (ANOVA) was used for the analysis and means comparison was done using Duncan test to determine the significant differences at 5% probability level of significance ($p < .05$).

RESULTS AND DISCUSSION

The results of the proximate analysis of *M. acuminata* and *M. paradisiaca* bracts presenting the main ash content, moisture content, crude fat, crude protein, crude fiber, and available carbohydrate are itemized in Table 1. Moisture content varies from (8.45±0.43%) for *M. acuminata* bracts which is higher compared to (7.83±0.68%) in *M. paradisiaca* bracts. This is within the described range (0.83 to 90.30%) for green leafy vegetables in Nigeria[14]. The outcomes of the ash content showed that the *M. acuminata* bracts have a higher value (16.60%) than the *M. paradisiaca* bracts. A measure of the mineral content of the food samples is referred to as ash content[19,35]. The results of the crude fiber content showed that the

Fig. 1. Image showing banana bract and plantain bract

bracts of *M. acuminata* revealed a higher value of (21.20±0.70%) compared to *M. paradisiaca* bracts of (16.50±0.72%). This is an indication that the fiber (celluloses) composition of these bracts are high and could stimulate digestion and avert constipation whenever it is consumed[14]. The proximate analysis of the *Musa* spp. varied significantly (P<0.005) among the different bracts and this variations could be ascribed to factors such as soil factors, geographical location, mineral composition, and general environmental conditions.

Satisfactory consumption of dietary fiber can reduce the serum cholesterol level, hypertension, colon, constipation, diabetes, risk of coronary heart disease, and breast cancer[14,19]. The

Table 1. Proximate composition of *M. acuminata* and *M. paradisiaca* bracts

Analysis	*Musa acuminate* (%)	*Musa paradisiaca* (%)
Moisture content	8.45±0.43^{b}	7.83±0.68^{a}
Ash content	16.6±0.56^{b}	15.10±0.70^{a}
Crude fibre	21.2±0.70^{b}	16.5±0.72^{a}
Crude Protein	1.53±0.32^{a}	1.57±0.67^{a}
Fat content	2.01±0.57^{a}	2.25±0.14^{b}
Carbohydrate	52.6±0.04^{a}	56.8±0.04^{b}

Data articulated as mean ± standard deviation of triplicate determination (n = 3, X ± SD). Data with different superscript alphabet along the same row are significantly different (p<0.05). Data with superscript alphabet "a" are significantly lower than data with superscript alphabet "b" at p< 0.05.

Table 2. Cellulose and lignin content of banana and plantain bracts

Samples	Cellulosic Content (%)	Lignin Content (%)
Musa Acuminate	34.61 + 1.06^{a}	9.13 + 0.31^{a}
Musa Paradisiaca	35.68 + 0.31^{b}	11.68 + 0.75^{b}

Data articulated as mean ± standard deviation of triplicate determination (n = 3, X ± SD). Data with different superscript alphabet along the same column are significantly different (p<0.05). Data with superscript alphabet "a" are significantly lower than data with superscript alphabet "b" at p<0.05.

Table 3. Qualitative phytochemical contents of *M. acuminata* and *M. paradisiaca* bracts

Phytochemicals	*Musa acuminata* extract	*Musa paradisiaca* extract
Alkaloids	+	+
Saponins	+	+
Tannins	+	+
Flavonoids	+	+
Steroids	-	-
Terpenes	-	-
Phlobatannin	+	+
Cardiac Glycosides	+	+

+ = present; - = absent

results of the crude protein content revealed that it was higher in *M. paradisiaca* bracts (1.57±0.67%) than that of *M. acuminata* bracts (1.53±0.32%). It has been conveyed that protein (calorie malnutrition deficiencies) is a foremost factor accountable for nutritional pathology. The results of the fat content showed no significant difference in values obtained for *M. paradisiaca* and *M. acuminata* bracts (2.25±0.14 and 2.01±0.57%). This is an indication that the bracts of *M. paradisiaca* and *M. acuminata* had low-fat content. Low-fat foods have been reported to reduce levels of cholesterol and also enhance product storage life by reducing the probabilities of rancidity development[35-37]. The values available for carbohydrate showed that the *M. paradisiaca* bracts have a higher value (56.8±0.04%) than *M. acuminata* bract (52.6±0.04%). The value obtained for carbohydrates is high because most plants store glucose as starch which is a source of energy. The occurrence of these significant nutrients like carbohydrate, low crude fat (2.01±0.57 % 2.25±0.14%) means *M. acuminata* and *M. paradisiaca* bracts attested to the fact that they can be utilized as a nutritionally treasured ingredient to advance poultry health and development performance[14,19]. The ash content and crude fiber content of the samples was reasonably higher than those reported by previous researchers for *M. paradisiaca* bracts[19,36]. Statistical analysis of data showed that these variations amongst the bract samples were significant at $P<0.05$.

The percentage of cellulose and lignin content of *Musa acuminata* and *Musa paradisiaca* bracts as shown in Table 2 revealed that there is no significant difference in the value obtained for the result. Cellulose and lignin have a high value (34.61±1.06 % 35.68±0.31 %) and (9.13±0.31 % 11.68±0.75%) respectively, indicating that *M.*

Table 4. Quantitative phytochemical contents of *M. acuminata* and *M. paradisiaca* bracts

Phytochemicals	*Musa acuminate* (%)	*Musa paradisiaca* (%)
Alkaloids	3.30 +0.15^{a}	3.74 +0.01^{b}
Phenols	0.56±0.03^{b}	0.34±0.04^{a}
Tannin	29.01±0.06^{b}	24.21±0.10^{a}
Flavonoids	8.35+0.14^{b}	6.33 +0.22^{a}
Saponins	26.02+0.23^{b}	25.08+0.30^{a}

Data articulated as mean ± standard deviation of triplicate determination (n = 3, X ± SD). Data with different superscript alphabet along the same row are significantly different ($p<0.05$). Data with superscript alphabet "a" are significantly lower than data with superscript alphabet "b" at $p< 0.05$.

Table 5. Antioxidant activity of *M. acuminata and M. paradisiaca*

Names of plant	Solvent for Extraction	IC_{50} (mg/ml) DPPH	FRAP	Iron chelating
Musa acuminata	Aqueous	3.33±1.81^{c}	25.15±0.16^{c}	2.58±1.25^{c}
	Methanol	2.14±4.17^{b}	15.36±0.25^{b}	2.03±1.48^{b}
Musa paradisiaca	Aqueous	3.71±1.18^{c}	26.87±0.15^{c}	2.74±1.19^{c}
	Methanol	2.52±3.24^{b}	23.09±0.17^{b}	2.14±1.46^{b}
Ascorbic acid	-	0.75±0.01^{a}	-	0.75±0.03^{a}

Data articulated as mean ± standard deviation of triplicate determination (n = 3, X ± SD). Data with different superscript alphabet along the same column are significantly different ($p<0.05$). Data with superscript alphabet "a" are significantly lower than data with superscript alphabet "b" while data with superscript "b" are lower than data with superscript alphabet "c" at $p<0.05$. IC_{50} - Inhibitory concentration, QE = Quercetin equivalent; DPPH = 2,2 Diphenyl 1 picrylhydrazyl; FRAP = Ferric reducing antioxidant power.

acuminata and *M. paradisiaca* bracts are rich in dietary fiber. Cellulose, hemicellulose, and lignin constitute the principal constituent of dietary fiber which is closely associated with the digestibility of a feed; lignin is indigestible even by ruminal microorganism[24].

In contrast, fibers in cell walls are water-insoluble, and include cellulose, lignin, and hemicellulose. This types of fibers escalate fecal bulk and rapidly enhance the passage of food via the digestive tract. One of the profits of a high-fiber diet include but no limited to hemorrhoid, prevention and treatment of constipation, and diverticulosis. In support, certain types of fiber such as crude fiber possess a range of health benefits, this includes decreased risk of type 2 diabetes, reduce inflammation, decrease blood cholesterol levels, improved digestive health, and immune system boost[37,38]. The result of the analysis of variation of cellulose and lignin content for banana and plantain bracts showed no significant difference for cellulose composition.

Table 3 showed the phytochemical screening of different chemical constituents of *M. acuminata and M. paradisiaca* bracts. Qualitative analysis of phytochemicals is very significant in herbal medicine and pharmacological studies[1,4,8,11,37]. This method of phytochemical screening with the bract extracts presented different colour or precipitation look, thus demonstrating the existence of various secondary compound like alkaloids, phenols, flavonoids, tannin, and saponins [2,12,25,39]. Alkaloids, saponins, tannin, flavonoids, phlobatannins and phenol were present in both *M. acuminata and M. paradisiaca* bracts but steroids and terpenoids were found absent. Flavonoids are acknowledged to retain biochemical and pharmacological activities such as anti-inflammatory, antidiuretic, antispasmodic, anti-tumor, anti-allergic, antimicrobial, and antiviral[4,16,37]. The presence of phenolic compounds in extracts could be accountable for the antioxidant activity of plant extracts[3,4,11].

Phytochemicals such as saponins and tannins have allelopathic, anticancer, and anti-inflammatory potentials[1,4,16]. Saponins are reported to exhibit an inhibitory activity on inflammation, and tannins do complex to proline-rich protein, thus interfering with the synthesis of protein[2,25]. According to Sodipo et al.[40], saponins possess the capability to lower the cholesterol level, and can also act as an immune modulation agent, regulation of cell proliferation, and anticarcinogenic agent[37]. The current study concerning the qualitative analysis of the bract extracts agrees with the aforementioned findings from different researchers.

The quantitative assessment of the % crude yields of chemical components of the studied plants indicated that the extracts of the bracts were rich in flavonoids, tannins, alkaloids, and saponins, and displayed in Table 4. Alkaloids were observed in higher quantity in *M. paradisiaca* (3.74±0.01%) than in *M. acuminata* (3.30±0.15%). Tannin and Saponins contents were found to have a higher concentration in *M. acuminata* (29.01±0.06%) and (26.03±0.23%) than in *M.*

Table 6. Antimicrobial capacity of *M. acuminata* and *M. paradisiaca* by agar diffusion method

Extracts	Solvent of Extraction	*B cereus*	*P syringea*	*E Coli*	*PV vignicola*	*PV manihotis*	*C albicans*	*B subtilis*
		Zone of Inhibition (mm)						
M. acuminata	ethyl acetate	7^b	6^a	4.5^b	3^a	3^a	5^a	2.5^b
M. paradisiaca	ethyl acetate	-	-	2^a	-	-	-	-
M. acuminata	methanol	7^b	10^b	5^b	-	6.5^b	6^b	7^b
M. paradisiaca	methanol	6^a	4^a	-	-	-	5.5^a	2^a
M. acuminata	n-hexane	-	-	-	-	-	-	-
M. paradisiaca	n-hexane	-	-	-	-	-	-	-
*Streptomycin Sulphate		14^c	14^c	16^c	13.5^b	15^c	11^c	15^c

* = Standard drug; - = resistant. Data with different superscript alphabet along the same column are significantly different ($p<0.05$). Data with superscript alphabet "a" are significantly lower than data with superscript alphabet "b" while data with superscript "b" are lower than data with superscript alphabet "c" at $p<0.05$

paradisiaca (24.21±0.10%) and (25.08±0.30%), these concentrations are higher than the alkaloids and flavonoids concentrations. Alkaloids and flavonoids values in these bract samples were observed to have low concentration as compared to those of tannin and saponins constituents. The higher quantity of flavonoid was detected in *M. acuminata* (8.35±0.14%) than (6.33±0.22%) in *M. paradisiaca.* The quantitative assessment of the bracts differed significantly (P<0.05).

The percentage yields of phenols obtained for both bracts were low (0.56±0.03 and 0.34±0.04%) for *M. acuminata* and *M. paradisiaca* respectively. One of the prevalent and most pervasive groups of plant metabolites are the phenolic compounds[1,8,9,11]. Motsumi et al.[4] and Ntshanka et al.[16] considered the total phenolic content in certain plant types and confirmed that antioxidant activity is closely associated with phenolic composition referred to as polar secondary metabolites. In the present work, it was detected that the samples exhibited high antioxidant activity concerning phenolic content.

Consequently, it can be recommended that the flavonoids and phenolic constituents significantly contributed to the antiradical activities of the *M. acuminata* and *M. paradisiaca* bracts. The results obtained agrees with the aforementioned findings of other researchers having reported a positive relationship between phenolic constituents and antioxidant potential[4,6,12,13,16]. These compounds possess biochemical properties such as anti-inflammation, anticarcinogenic, anti-atherosclerosis, antiapoptosis, cardiovascular defense, antiaging, endothelial function enhancement, alongside angiogenesis inhibition[4,8,9,16,37]. Hydroxylated phenolic materials produced by plants in answer to microbial contamination are referred to as flavonoids, hence, they institute effective antimicrobial, antioxidant and anticancer activities[1,8,16,39].

The plant extracts also disclosed the existence of tannin and saponins known to cause an inhibitory effects on inflammation. Tannins can bind to proline-rich protein and obstruct the protein preparation[29,37]. Mtunzi et al.[2] have reported the antibacterial activities of tannins and saponins obtained from *Rhus leptodictya* leaves extracts. They reported the correlation between the tannins and saponins contents, and antimicrobial activity. In the present study, higher saponins content for *Musa acuminate* correlated to the higher antimicrobial activity. Saponins possess the precipitating property and red blood cells coagulation. Characteristics of saponins include foams in aqueous solutions formation, bitterness, hemolytic activity, anti-carcinogenic properties, immune modulation activities, and cholesterol-lowering activities[1,37,39,40].

Alkaloids are connected with therapeutic uses for decades and potentials for disease resistance and stress, much of the biological properties include analgesic, antispasmodic, antibacterial, cytotoxicity, antiradical, antifungal, anti-inflammatory properties[1,27,39]. Khan and co-workers[1] in 2011 reported that tannins and alkaloids were not present in *T. officinale* methanolic extract, however, higher amounts of saponins were observed. Nevertheless, saponins were absent in *U. dioca* extract but higher quantities of tannins were present. The results achieved in this research advocate the identified phytochemical constituents, thus, demonstrating to be an increasingly appreciated reservoir of bioactive materials of substantial medicinal merit. Furthermore, the studied samples possess phytochemicals in appreciable amounts indicating they are of health benefits to humans following their antibacterial and anti-oxidative properties, hence, they could be advanced as bactericidal agent acting as a therapeutic agents against microbial infections and anti-stress agents.

The capability of the samples to scavenge DPPH free radicals was evaluated following the standard method with little modifications[2,4,6,12,16,25]. DPPH is an unchanging free radical and receives electron or hydrogen radical to develop into a stable diamagnetic molecule. The degree of discoloration of DPPH radical was contributed by the capability of the samples acting as a hydrogen contributor[2,4,25]. The methanol *M. acuminata* extract was able to scavenge more than 47%, methanol *M. paradisiaca* extract 43%, while aqueous extract scavenged 35% for M. *acuminata* and 32% for *M. paradisiaca* of the DPPH radicals at a level of 2.0 mg/ml. Methanolic extract of the bracts exhibited potent DPPH radical scavenging activity even at the lowest stock solution. Table 5 showed that the methanolic extracts of *M. acuminata* had a higher DPPH scavenging activity (IC_{50} = 2.14±4.17 mg/

ml) than *M. paradisiaca* (IC_{50} = 2.52±3.24 mg/ml), attributable to the polar nature of methanol, and has been used for the extraction of polar bioactive constituents[2,10,12,18]; while aqueous extracts of *M. acuminata* exhibited DPPH scavenging activities (IC_{50} = 3.33±1.81 mg/ml) and *M. paradisiaca* (IC_{50} = 3.71±1.18 mg/ml).

However, the prospective demonstrated by the bract extracts in the current study was low as equated to the standard representatives: ascorbic acid (IC_{50} = 0.75±0.01 mg/ml). The antioxidant action of the DPPH assay is connected with the amount of the phenolic constituents present in the bract fractions[4,25,31]. Roobha et al.[18] conveyed that the bract of *M. acuminata* displayed a notable quantity of cynanidrin rutinoside, a significant antioxidant. The bract extracts are potent DPPH radical scavengers suggesting that they could act as chain-breaking agents. The DPPH scavenging activities (IC_{50}) for the bract samples are low as compared activity of methanolic extract of *M. paradisiaca* cv. Mysore Inflorescences reported by Padam et al.[10]. Methanol, chloroform, ethanol and acetone extracts of *Combretum Molle* and *Acacia Mearnsii* exhibited DPPH scavenging activities (IC_{50}, mg/ml) displayed lower activities as compared to the *M. acuminata* and *M. paradisiaca* bract samples[16]. The antioxidant capabilities of the bract samples differed significantly (P<0.05).

Iron chelation power test was evaluated to judge the chelating ability of the bract extracts, and demonstrated that the methanolic extracts of *M. acuminata* and *M. paradisiaca* possessed notable Fe^{2+} chelation power (IC_{50}) at 2.0 mg/ml (Table 5). A prevalent remedy for the controlling of Fe(II)-connected oxidative anxiety in the brain is the iron chelation procedure. The iron-chelating capability of bracts is an indication of the neuroprotective power of the *M. acuminata* and *M. paradisiaca* plant samples as iron possess a property to catalyze oxidative variations in lipids and other cellular constituents (mechanisms) and is equally intricate in the pathogenesis of Alzheimer's ailment[31,33,34]. The methanolic extracts of the bracts moderately chelated Fe^{2+}at 2.0 mg/ml stock solution. *M. acuminata* had the highest chelating potential of 47% when compared with *M. paradisiaca* 45%. The *M. acuminata* methanol extract (2.03±1.48 mg/ml), and aqueous extracts (2.58±1.25 mg/ml) showed a higher chelating potential than methanolic extracts of *M. paradisiaca* (2.14±1.46 mg/ml), and aqueous extracts of *M. paradisiaca* (2.74±1.19 mg/ml). In addition, the ability of an agent to chelate or deactivate transition metals that are inherently associated with the crucial stages of free radical-induced macromolecular damage has been regarded as the antioxidant mechanism. In this regard, *M. acuminata* and *M. paradisiaca* showed marked metal chelating ability but lower activities as equated to the standard mediators: ascorbic acid (IC_{50} = 0.75±0.03 mg/ml). Metal chelating ability alongside the free-radical quenching potentials of *M. acuminata* and *M. paradisiaca* extracts could be accredited to the occurrence of phytochemical contents such as flavonoids, tannins, polyphenols, and phenones[31]. Iron-chelating capability of *Vitellaria paradoxa*, *Ocimum gratissimum* and *Milletia aboensis* as reported by Nwalo et al.[41] was comparable to the free-radical quenching potentials of *M. acuminata* and *M. paradisiaca* extracts.

The ferric reducing antioxidant power (FRAP) of *M. acuminata* and *M. paradisiaca* as presented in Table 1 revealed that the bract extracts are rich in free electron and readily supplies such electron to Fe^{3+}, thereby reducing ferric tripyridyl triazine (Fe^{3+}%TPTZ) compound to ferrous form (Fe^{2+}%TPTZ) owning an strong dark blue colour which could be checked through the variation in absorption at 700 nm[31,32,34]. FRAP values of bracts methanol and aqueous extracts showed modest decrease of Fe^{3+} to Fe^{2+} with methanolic extract having the highest FRAP value of 15.36±0.25 $mgml^{-1}$ $Fe^{2+}g^{-1}$ extract for *M. acuminata* and 23.09±0.17 $mgml^{-1}$ $Fe^{2+}g^{-1}$ extract for *M. paradisiaca* at concentrations: 0.25 % 2.00 mg/ml solution. Aqueous extracts of the bracts were lower 25.15±0.16 and 26.87±0.15 $mgml^{-1}$ $Fe^{2+}g^{-1}$ for *M. acuminata* and *M. paradisiaca* respectively. Ferric Reducing Antioxidant Power (FRAP) test was utilized to appraise the antioxidant capability of the bract extracts built on its capability to decrease the ferric ion (Fe^{3+}) to ferrous ion (Fe^{2+}), as compared to a known standard Fe^{2+} concentration utilized in the assay investigation. Based on this fact, the greater the decrease of Fe^{3+} ion by a reducing mediator (plant extracts), the enhanced the antiradical ability of that certain extract, and this is often associated with the flavonoids, polyphenols, and phenones present[10,31]. Thus, the bracts of *M. acuminata* and *M. paradisiaca*

exhibited moderate reductive power for the conversion of Fe^{3+} to Fe^{2+} which may be considered as the antioxidant mechanism. The phytochemical compounds present in the samples may have contributed to this antioxidant capacity[10,32].

The antimicrobial potentials of the *M. acuminata* and *M. paradisiaca* methanol, n-hexane, and ethyl acetate extracts were investigated against pathogen strains. Table 5 showed that the antimicrobial activity of *M. acuminata* and *M. paradisiaca* bracts were critically affected by polarity of the solvent. Extracts originating from organic solvents with greater polarity like methanol and ethyl acetate presented a substantial inhibitory action against *B. cereus, P syringe, C. albicans, B. subtilis, PV. vignicola, PV. Manihoti and E. coli.* The methanolic extract of *M. acuminata* bracts indicated good inhibitory activity against *B. cereus* (7 mm), *P. syringe* (10 mm), *E. coli* (5 mm), *PV. manihoti* (6.5 mm), *C. albicans* (6 mm) and *B. subtilis* (7 mm) than *M. paradisiaca* bracts with *B. cereus* (6 mm), *P. syringe* (4 mm), *C. albicans* (5.5 mm) and *B. subtilis* (2 mm). However, no inhibitory activity was observed against *PV. vignicola* for the *M. acuminata* and *M. paradisiaca* bracts, *E. coli* and *PV. manihoti* for *M. paradisiaca* bracts. Earlier reports have established that plant extracts possessing notable antioxidant activity also demonstrate antimicrobial activity following the phenol and flavonoids constituent in the various extracts[4,6,12,13,16,26].

The order of increased inhibitory activity against the strains for the methanolic extract of *M. acuminata* bract were *P. syringe* > *B. cereus* = *B. subtilis* > *PV. manihoti* > *C. albicans* > *E. coli.* Again, the Ethyl acetate extracts of *M. acuminata* bracts showed better antimicrobial activity against *B. cereus* (7 mm) *P. syringe* (6 mm), *E. coli* (4.5 mm), *PV. (vignicola and manihoti)* (3 mm), *C albicans* (5 mm), and *B subtilis* (2.5 mm) than *M. paradisiaca* bracts which only showed activity against *E. coli* (2 mm), no inhibitory activities were observed for *B. cereus, P. syringe, PV. vignicola, PV. manihoti, C. albicans, and B.* subtilis. The order of increase in inhibitory activity for ethyl acetate extracts in *M. acuminata* bract extract was *B. cereus* > *P. syringe* > *C. albicans* > *E. coli* > *PV. manihoti* = *PV vignicola* > *B. subtilis.* The low activities of *M. paradisiaca* bract extract against the surveyed strains could be attributed to the bacterial high resistance and thickness of the cell wall owing to the extra peripheral membrane in their cell wall acting as resistance to the antimicrobial agent[2,4,13,16].

However, n-hexane extracts of both *M. acuminata* and *M. paradisiaca* bracts show no inhibition against any of the studied strains in this study. This result showed that non-polar solvent might not be an excellent solvent for the extraction of bioactive metabolites, owing to the fact that most of the beleaguered metabolites from herbal plants are found at the polar end of the spectrum. The analysis of the two plants experimented against standard streptomycin sulphate showed that *M. acuminata* and *M. paradisiaca* bracts activities were lower as compared to the standard agents, but the antimicrobial potency of *M. acuminata* extracts gave better activities than *M. paradisiaca* extracts. The antimicrobial activity of the extracts amplified as the polarity of the extracting solvent improved. *M. acuminata* and *M. paradisiaca* bracts obtained from polar organic solvents such as methanol and ethyl acetate showed distinct antibacterial activities on selected bacteria.

Methanol possess distinctive physical possessions than other organic solvents, since the molecule consists of a negatively charged hydroxyl ion group attached to a very short hydrocarbon, thus, supporting its better range of extracting capability centered on high polarity, high diffusion constant, and low viscosity[4,8,10]. Padam et al.[10] reported that methanolic extract of the *Musa paradisiacal* cv. Mysore (buds) presented intensely discrete antibacterial potentials with noticeable inhibition ranging from 12.02 to 13.23 mm against gram-positive and gram-negative bacteria, while extracts from the bract had no inhibitory action against gram-negative bacteria (*Vibrio parahaemolyticus* (VP)). Similarly, methanol has been used for the extraction of polar bioactive constituents such as flavonoids, anthocyanins, phlobatannins, tannins, phenones, saponins, polyphenols, and xanthoxyllines exhibiting diverse pharmacological and biochemical activities[2,3,8,10,12,13,16].

CONCLUSION

Management and usage of herbal plants has received a considerable amount of attention in recent years. *Musa acuminata* and *Musa balbsiana* are common fruits consumed in Nigeria, this two

are popular because of their nutritive, energy-giving and medicinal values. The result of this study showed that *M. acuminata* and *M. balbsiana* bracts, one of the agricultural byproducts contain appreciable amounts of nutrient (carbohydrate, fat protein, crude fiber, ash, moisture, and minerals), and this are nutritional necessities for poultries, and exhibits antioxidant and antimicrobial potentials. It was shown that the bracts are rich in fiber; consequently, their ingestion can aid lowering of cholesterol levels in the body. Possibly, the bracts from these plants could be useful as a feed supplements in poultry to advance health and development performance. Since the results of the phytochemical composition have shown that the extract of the bracts contained alkaloids, tannin, saponins, phlobatannins, flavonoid, cardiac glycoside, and phenol. Hence, the plant samples possess potential in the area of pharmacology as a prospective basis of useful medicines. The result of the antioxidant revealed that the scavenging action of methanolic extract owing to phenolic in the bracts could serve as a protective agent against oxidative stress and provides a healthy life. The results of the antimicrobial of the bracts studies also revealed that the plant might be established as bactericidal drugs useful as a therapeutic agent against bacteriological contaminations. The study, thus, has delivered some biochemical source for ethnopharmacological uses of these plants part in the treatment and prevention of various diseases and disorders.

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Conflict of interest

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