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MORPHOLOGY AND PHYTOCHEMICAL PROFILE OF *RHIZOPHORA RACEMOSA* G. MEYER TREE SPECIES FROM THE NIGER DELTA MANGROVE

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ABSTRACT

Rhizophora racemosa is relatively understudied in Nigeria, even though it is a dominant mangrove swamp tree species with distinctive macro-morphological characters occupying the coastal belt of the Niger Delta region. The research work carried out morphological studies, phytochemical and anti-nutrient analyses of dried powdered ethanolic extracts of *R. racemosa* component parts – leaf, stem bark and root bark using standard analytical procedure. Data obtained indicated that the studied plants parts contained similar phytochemical/ secondary metabolites with variation in mean concentration values (mg/100g) %; Saponin (4.09 – 10.29mg/100g), Alkaloid (4.14 – 7.81mg/100g); Phenol (7.64 – 15.67mg/100g); Steroids (2.40 – 5.15mg/100g); Flavonoids (10.90 – 21.30mg/100g); Terpenoids (3.06 – 6.24mg/100g); Tannin (6.32 – 11.56mg/100g); Phytate (0.69 – 1.05mg/100g) and Oxalate (1.35 – 1.96mg/100g). Using the turkey method, these differed significantly (P=0.05) amongst the examined tree parts with tannin, saponin, phenol and flavonoid being relatively abundant. Apart from the terpenoid content found to be high in the leaves sample, all other screened phytochemicals was found to be more abundant in the stem bark. Generally, the flavonoid content was found to be the most abundant and widely distributed phyto-compound in the leaves, stem bark and root bark of *R. racemosa* with the concentration of anti-nutrient compounds appreciably low. Thus, the study revealed the rich phytochemicals present in the component parts of the species and support further pharmacological investigation towards development of novel drug in the treatment/management of human and animal diseases.

Keywords: *R. racemosa*, Macro-morphology, Concentration, Phytochemical, Anti-nutrient

Introduction

Rhizophora L. commonly referred to as "*red mangrove*" or "*true mangrove*" is a pantropical genus of mostly trees belonging to the family Rhizophoraceae, Order Malphigiales; inhabiting tropical and sub-tropical coastlines. The genus was employed as a key taxon in the construction of the phylogenetic history revealing the formation process of the pantropical distribution of mangrove in both the Indo-West Pacific (IWP) and Atlantic-East Pacific (AEP) regions of the world (Takayama *et al*., 2020). The latter bio-geographic region is represented by species found in the tropical and sub-tropical coast of America, the Caribbean Islands and Western Africa. So far, about 7 species viz; *Rhizophora mangle* L.; *R. samoensis* Hochr.; *R. racemosa* G. Meyer; *R. harrisonii* Leech; *R. apiculata Blume; R. mucronata* Lam and *R. stylosa* Griff have been recorded in taxonomic literature and are known to occur along the world tropical coast (Airy-Shaw, 1985; Nyananyo, 2006; Plantlist,

2013). However, 3 of these species, *R. racemosa* G. Meyer, *R. mangle* L and *R. harrisonii* Leechman are primarily found along the West Africa Atlantic Coast of the Niger Delta region of Nigeria (Keay *et al*., 1989; Nyananyo, 2006).

The taxonomy of this occurring congeneric taxa (*R. racemosa, R. harrisonii, R. mangle*) has been problematic due to the morphological similarity of the three *Rhizophora* species and their sympatric nature of distribution (Neyland, 2000; Adenegan and Jayeola, 2015). Ecologically, Keay *et al.* (1989) reported that *R. racemosa* is a pioneer species, occupying the edge of the alluvial salt swamp; *R. harrisonii* inhabits the middle belt of the mangrove forest (intermediate habitat between *R. racemosa* and *R. mangle*). While *R. mangle* preferably thrives at the drier landward edge of the mangrove forest.

However, field observation from some mangrove inundation allotment (habitat) showed that zonation pattern of population of these species are not well defined. Also, *R. harrisonii* have been suggested in literature as a possible hybrid between *R. mangle* and *R. racemosa* based on shared anatomical and palynological features (Jayeola et al., 2001; Adenegan and Jayeola, 2015). Hence, evidences from the external morphology or gross morphology as succinctly explained by Radford (1986) provide the basic language for plant characterization, identification, classification and relationship. Gross morphology is an initial systematic line of investigation, providing diagnostic keys aimed at improving the taxonomic knowledge of plant species. In practical terms, taxonomic knowledge of morphological diagnostic characters in the "Red mangrove" complex proves useful in species identity and avoidance of local taxonomic confusion when the three *Rhizophora* species occur in sympatry; enabling effective mangrove conservation and utilization.

The traditional uses of *R. racemosa* and other members of the group among mangrove community dwellers are well documented. These include: wood for construction of shelters, fishing gear, furniture, dug-out canoe, fish racket, artefacts, basketry, fuel wood, charcoal production, tanning for leather and folk medicine (Albert *et al*., 2012; Vinoth *et al*., 2019; Syawal *et al*., 2020). Several authors has reported on the folk medicinal uses of part of Rhizophora tree species for the treatment/management of diseases such as typhoid fever, diabetics, angina, boils, fungal infection, elephantiasis, leprosy, febrifuge, haematoria, hepatitis, ulcer, malaria, dysentery, diarrhea, nausea and vomiting amongst others (Duke and Allen, 2006; Vinoth *et al*., 2019; Ha and Eduok, 2022).

Recent scientific evaluation have shown the species to possess anti-oxidant, anti-diabetic, anti-inflammatory, anti-fungal and anti-bacterial properties to justify their traditional uses (Hamzah *et al*., 2018; Syawal *et al*., 2020; Ha and Eduok, 2022). Generally, the therapeutic value of medicinal plant used for human and animal health are linked to the bio-accumulation of phytochemicals or secondary metabolites present in its component parts. These plant metabolites which are therapeutic agents, vary from one genetic group to another. Mangroves, in particular, provides distinctive biological habitats characterized by high salinity and other stress factors which contributes to its rich source of bioactive compound with enormous potential for bio-prospecting activities relevant in addressing the numerous human and animal health challenges (Syawal *et al*., 2020; Glubikina *et al*., 2022).

In Nigeria, a search through relevant scientific literature revealed existing dearth of information on the traditional/medicinal uses and phytochemical contents on the component parts in leaves, stem bark and root bark of *R. racemosa* from the Niger Delta region.

Traditionally, the bark have been reported to be used by locals in the treatment of boils and fungal disease, while an infusion of its leaf and bark is used in the treatment of diarrhea, fever, malaria and leprosy (Duke and Allen, 2006; Ha and Eduok, 2022). The leaves were also reported by Angalabiri and Isirimah, (2014) for the treatment of toothache and dysmenorrhea. In animal nutrition, Wekhe *et al*. (2007) reported inclusion of pulverized leaves as additive on broiler performance. However, on the basis of its phytochemistry, little or no comparative phytochemical study has been conducted in the component parts to ascertain variation and amount of phyto-compound present. Thus, this study therefore evaluated qualitatively and quantitatively, the phytochemical and phytonutrient content of the leaf, stem and root samples of *R. racemosa* tree species. Result obtained will provide useful information applicable in phytomedicinal research and contribute to the existing body of knowledge on its phytochemistry.

Materials and Methods

Gross Morphology

Macro-morphological studies were carried out on the fresh and dry specimens of *R. racemosa* tree species. The leaves, flowers and fruits were examined, measured and calculated using meter rule and hand lens (*10). Photographs of both the vegetative and reproductive parts were taken and documented.

Plant material

The freshly collected leaves, bark and root of the species were harvested from the mangrove experimental site of the Forestry Research Institute of Nigeria outstation located at Swamp Forest Research Station, Onne (Lat $4^{o}42'13'$N and Long $7^{o}10'36'$E) of the Greenwich meridian. The specimen were identified by the senior author and further authenticated at the University of Port Harcourt herbarium (UPH) and the Forest Herbarium, Ibadan (FHI) listed in Holmgren (1990) following conventional taxonomic practice. Voucher specimen were deposited authenticated at the University of Port Harcourt herbarium (UPH) with number UPH/P/477.

The sampling method involved selection and collection of plant materials from 10 individual tree species at equidistance of 10 meters apart, along established transect line within population of *R. racemosa* stand in the study area. The composite sample of each plant parts (leaves, stem bark and root bark) were partitioned into three portions (replicates) and prepared further for extraction.

Preparation of the extracts

The collected plant samples of the species were rinsed to remove sand and debris, cut into pieces and air-dried separately for 2 weeks. The plant samples were pulverized and for each sample, 10g was extracted with 100ml of ethanol and allowed to stand for 48 hrs in order to extract a huge amount of the active component in each plant sample. Each sample solutions were filtered, and the filtrates were concentrated in an oven at 40^{o}C which were stored in a sterile bottle and kept in a refrigerator for further use.

Qualitative analysis of the plant extracts

Phytochemical screening were carried out on the leaves, bark and root extracts and were screened for alkaloids, flavonoids, phenols, saponins, tannins, terpenoids using standard procedures as described by Trease and Evans, (2009) while anti-nutrient screening (phytate and oxalate) was done using methods described by (Onwuka, 2018).

Quantitative analysis of the plant extracts

Phytochemicals were determined quantitatively using the standard procedures

according to AOAC, (2005) with modifications by other authors.

Determination of Tannins

Using the Folin-Ciocalteau assay, 1 ml of the extract was measured into a 50 ml beaker, adding 7.5 ml of distilled water, 0.5 ml of the folin-ciocalteau reagent, and 1 ml of 35% sodium carbonate. After giving the mixture a good shake, it is allowed to stand for 30 minutes in order for the colour to appear. The standard solutions consisted of tannic acid dilutions ranging from 0 to 0.5 mg/ml. Using a spectrophotometer, the absorbance of the extracts and standard were evaluated against a blank at 725 nm (Md. Mahadi *et al.*, 2013).

Determination of Alkaloid

About 2.5 ml of the extracts were measured into a conical flask where ammonia was used to wet the sample, and it was left overnight. 50 cc of ethyl acetate was added, the flask was shaken and left for 5-6hrs. After which, it was filtered and the filtrate was then placed in a porcelain-evaporating dish that had been previously dried, weighed, and allowed to evaporate over a hot water bath. It was weighed after being dried in an oven to a constant weight (Md. Mahadi *et al.*, 2013)

$$Total\ alkaloids\ (g/100g) - \frac{weight\ by\ residue}{weight\ of\ sample\ taken} \times 100 \quad \ldots\ldots (1)$$

Determination of Flavonoids

Using the aluminium calorimetry method, 0.1ml of 10% Aluminium chloride and 1M of potassium acetate were mixed with to 0.5ml of the extracts. After which, 1.5ml of 80% methanol and 2.8ml of distilled water were added and mixed further. For 30 minutes, each tube was incubated at room temperature. The same procedure was followed to make a blank, except that 0.5 mL of distilled water was used in place of the extracts, and distilled water was also used in place of the same quantity of aluminium chloride. At 415 nm, the absorbance was measured expressed as mg quercetin (Stankovic, 2011).

Determination of Saponins

25ml of the extract was mixed with 100ml of 50% alcohol and brought to boil for 30 mins. The boiled mixture is filtered and to the filtrate, 2g of charcoal was added, boiled and filtered. The filtrate was then added an equivalent volume of acetone to completely precipitate the saponins. The saponins were then collected by decantation and dissolved in boiling 95% alcohol and filtered. The clear fluid was decanted and suspended in 20ml of alcohol and filtered (Muhammad and Abubakar, 2016). The filter paper was transferred to a desiccator containing anhydrous calcium chloride and left to dry and weighed using;

$$Saponin\ (g/100g) = \frac{weight\ of\ filter - weight\ of\ residue}{weight\ of\ residue} \times 100 \quad \ldots\ldots (2)$$

Determination of Phenols

Using the Folin-Ciocalteu assay method according to Chlopicka *et al.* (2012), 2.25ml of Folin–Ciocalteu phenol reagent was combined with 0.3 mL aliquot of the extract. 2.25mL of 6% NaOH was added after 5 mins and the mixture was let to remain at room temperature for 90 min. The same procedure was used to prepare the standard calibration curve for gallic acid in the range of 0–200 lg/mL, and the findings were represented as mg of gallic acid equivalent (GAE) per gram of extract. The absorbance against the reagent blank was evaluated at 750 nm.

Determination of Total terpenoid content

1ml of each extract was soaked in 9 ml of ethanol for 24 hours. This mixture was then filtered and extracted using 10 ml of petroleum ether in a separating funnel. The ether extract was then dried and transferred into pre-weighed glass vials (Indumathi *et al.*

2014). The ether was then evaporated, and the yield was calculated using the formula;

$$Terpenoid\,(\%) = \frac{final\ weight\ of\ sample - initial\ weight\ of\ sample}{weight\ of\ sample} \times 100 \quad \ldots (3)$$

Anti-nutritive analysis of the plant extracts

Phytate determination -Titrimetric method

2ml of the extracts was mixed in 100ml of 20% concentrated HCl for 3 hours. This was filtered after which 50ml of the filtrate was mixed in 100ml of distilled water and 10ml of 0.3% ammonium thiocyanate solution (indicator). After shaking the mixture, the titration was performed against the standard Iron III Chloride solution, which has 0.00195 iron per ml. The end point produced a five-brownish color lasting for 5 mins (Lucas and Markakas, 1975).

$$Phytate\,(g/100g) = \frac{titre\ value * 0.00195 * 1.19}{weight\ of\ sample} \times 100 \quad \ldots\ldots (4)$$

Oxalate Determination (Titrimetric method)

The titrimetric method consists of the Digestion, Oxalate precipitation and Permanganate titration (AOAC, 2005)

Digestion

In a 250 ml volumetric flask, 2 ml of each sample was suspended in 190 ml of distilled water. After adding 10 ml of 6M HCl, the suspension was allowed to digest for 1 hour at 100^{o}C. Before filtering, the solution was allowed to cool and filled the volumetric flask to the 250 ml mark.

Oxalate precipitation

Four drops of methyl red indicator were adde d to duplicate amounts of the filtrate that were measured into 250 ml beakers. Dropwise additions of ammonium hydroxide solution were made until the test solution turned from pink to a pale yellow color (pH 4.0–4.5). To extract the ferrous ion-containing precipitate, each component of the solution was heated to 90^{o}C, let to cool, and then filtered. Further heating the filtrate to 90°C, 10 ml of a 5% $CaCl_2$ solution was added while stirring continuously. After heating the solution, it was kept at room temperature overnight. It was centrifuged for five minutes at 2500 rpm. The precipitate was fully dissolved in 10 ml of 20% (v/v) H_2SO_4 solution after the supernatant was decanted.

Permanganate titration

The total filtrate resulting from the digestion was made up to 300 ml. A 125 ml filtrate aliquot was heated to almost boiling point before being titrated against a 0.05M standardized $KMnO_4$ solution giving a light pink color.

$$Oxalate\,(g/100g) = \frac{titre\ value * DF}{ME * Mf * 1} \times 100 \quad \ldots\ldots (5)$$

Where, T = Titre value of $KMnO_4$ (ml)
Df = Dilution factor = Vt/A, where Vt is the total volume of the filtrate (300 ml) a123nd A is the aliquot used (250 ml).
ME = Molar equivalent of $KMnO_4$ in oxalate.
Mf = weight of sample

Data Analysis

Analysis of Variance (ANOVA) and mean separation were carried out on three replicates using the turkey method.

Results

Gross Morphology

R. racemosa attains a height of up to 1.8 - 2.5m; with a well-pronounced stilt roots measuring about 5- 15m in length. Leaves are simple, opposite, elliptic to oblanceolate in shape; 13.9 – 15.8cm long, 4.2 -5.9cm broad; narrowly cuneate at base, apex – bluntly pointed. Midrib is prominent with faintly distributed lateral veins; glabrous with an entire leaf margin. Petiole is stout, 1.7 – 2.3cm long; Inflorescence are axiliary,

bifurcated with perfect flowers. The flowers/flower buds are obtuse at apex. Peduncle is 1.2 – 4.0cm broad. Four (4) narrow entire petals; stamens are 9 – 10 short with a 2- pronged style. Fruit is highly distinctive, about 3.2 – 3.6 cm. long, dotted with lenticels and the embedded seed germinating on the tree (viviparous). The germinated stout green root (hypocotyle) may attain up to 28 – 55cm long (Figure 1).



Figure 1: (i) *R. racemosa* tree species (ii) twig with axiliary inflorescence (iii) flowers (iv) fruit

Phytochemical screening

The results obtained for the phytochemical screening of crude extract of *Rhizophora* tree parts as revealed in Table 1 showed the presence of diverse secondary metabolites, such as alkaloids, flavonoids, phenols, saponins, tannins, and terpenoids while anti-nutrient such as oxalates and phytic acids were also detected. Flavonoids, phenols, tannins and saponins showed the highest presence in the different part of the species with flavonoid being the most abundant in all tree parts. However, steroids and terpenoids were least discoverable in the species with a moderate exception in the bark and leaves respectively. On the other hand, anti-nutrient compounds – phytate and oxalate were discovered to be slightly present in the leaves, stem bark and root bark of *R. racemosa* species.

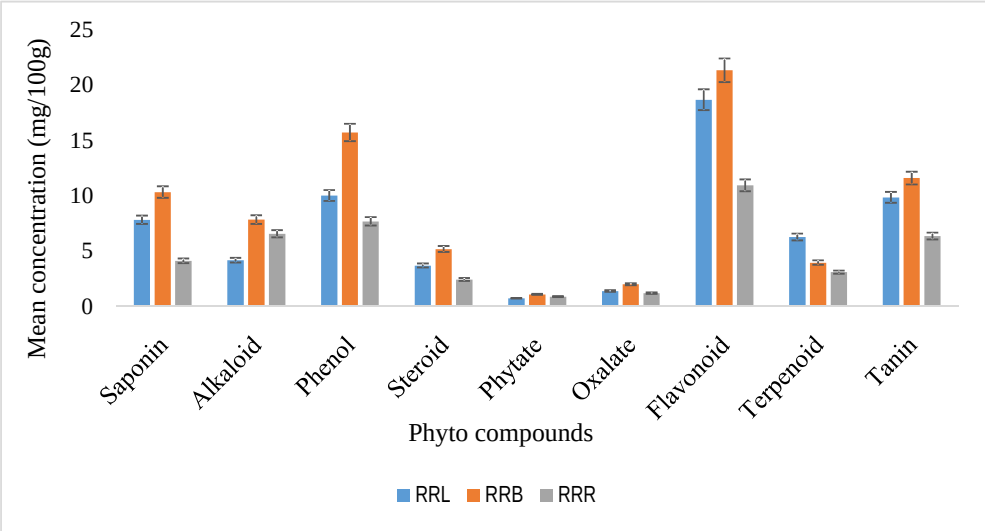
Table 1: Qualitative phytochemical screening of leaves, stem bark and root bark of *R. racemosa*

Phyto - Constituents	Leaves	Stem bark	Root bark
Saponin	++	+++	+
Alkaloids	+	++	++
Phenol	+++	+++	++
Steroids	+	++	+
Flavonoid	+++	+++	+++
Terpenoid	++	+	+
Tannin	++	+++	++
Phytate	+	+	+

Oxalate	+	+	+

***** (-) = Absent; (+) = Slightly present; (++) = Moderately present; (+++) = Highly present**

Quantitative phytochemical analysis of the ethanolic crude extract of *Rhizophora* species is presented in Table 2 and Figure 2. The highest mean concentration value obtained amongst the studied parts was found in the bark of *R. racemosa* with flavonoid having (21.30±0.05 mg/100g), phenol (15.67±0.02 mg/100g), tannin (11.56±0.03 mg/100g) and saponin (10.29±0.06 mg/100g) respectively. While the least content were more evident in the roots having 2.40±0.05 mg/100g of steroids, 3.06±0.03 mg/100g of terpenoids and 4.09±0.04 mg/100g of saponin.



***RRL, RRB and RRR represents *Rhizophora racemosa* leaf, stem bark and root bark respectively.

Figure 2: Graphical representation of the quantitative analysis of *Rhizophora racemosa* species

Results from the anti-nutrients analyses revealed a higher concentration of oxalate (1.96±0.03 mg/100g) in the bark as compared to the lowest value (1.16±0.02 mg/100g) in the roots. Likewise, phytate level was found to be highest (1.05±0.01mg/100g) in the bark but with the least value (0.69±0.01mg/100g) in the leaves. The statistical analysis showed that all the secondary metabolites of *R. racemosa* varied significantly (P = 0.05) amongst the examined tree parts as shown in Table 3.

Table 2: Quantitative phytochemical analysis of leaves, stem bark and root bark of *R. racemosa*

Phyto - Constituents	Leaves	Stem bark	Root bark
Saponin	7.79	10.29	4.09
Alkaloids	4.14	7.81	6.53
Phenol	9.98	15.67	7.64

Steroids	3.67	5.15	2.40
Flavonoid	18.63	21.30	10.90
Terpenoid	6.24	3.92	3.06
Tannin	9.81	11.56	6.32
Phytate	0.69	1.05	0.85
Oxalate	1.35	1.96	1.16

Table 3: Mean separation of phytochemical variation in *Rhizophora* tree parts

Phyto - Constituents	Leaves	Stem bark	Root bark
Saponin	7.79^{b}	10.29^{a}	4.09^{c}
Alkaloids	4.14^{c}	7.81^{a}	6.53^{ab}
Phenol	9.98^{b}	15.67^{a}	7.64^{bc}
Steroids	3.67^{ab}	5.15^{a}	2.40^{c}
Flavonoid	18.63^{b}	21.30^{a}	10.90^{c}
Terpenoid	6.24^{a}	3.92^{b}	3.06^{c}
Tannin	9.81^{b}	11.56^{a}	6.32^{c}
Phytate	0.69^{abc}	1.05^{a}	0.85^{ab}
Oxalate	1.35^{b}	1.96^{a}	1.16^{c}

****Means with same letter are not significantly different (P = 0.05)**

Table 4: ANOVA table for *Rhizophora* phytochemicals

Sources	SS	df	MS	F	P-value
Saponin	58.479	2	29.240	7418.061	6.61E-11
Alkaloids	20.819	2	10.410	9185.029	3.48E-11
Phenol	102.333	2	51.166	45146.735	2.93E-13
Steroids	11.326	2	5.663	2480.069	1.76E-09
Flavonoid	175.092	2	87.546	34786.579	6.41E-13
Terpenoid	16.289	2	8.145	7293.784	6.95E-11
Tannin	42.700	2	21.350	22086.310	2.51E-12
Phytate	0.190	2	0.095	393.207	4.34E-07
Oxalate	1.048	2	0.524	436.750	3.18E-07

Discussion

The therapeutic qualities of medicinal plants rest on phyto-compounds which induce certain physiological effects in the human body and mangrove plants have been reported to be a valuable source of secondary metabolites. These natural resources of complex compounds are often found useful in dietary supplements (Gupta *et al*., 2023). From the study, all the examined secondary metabolites, including flavonoids, alkaloids, saponin, tannin, steroids, terpenoids, and phenols, were present. Qualitative and profiling studies by other authors (Poompozhil and Kumarasamy, 2014; Edu *et al*., 2015; Korfii *et al*., 2022) have shown that *R. racemosa* contains the highest concentrations of flavonoids which is in conformance to this study.

The high presence of flavonoids in the leaves, bark and root of the *R. racemosa* species is an

indication of its anti-inflammatory, analgesic, anti-allergic and anti-oxidant properties (Vaishali and Neeraj, 2018). They also possess UV-rays protective abilities combined with protecting DNA, from oxidative damage. Moreover, it shows improved preservation of cognitive function with aging and protects cardio-metabolic problems (Mazidi *et al.*, 2019). Also, flavonoids are believed to play a vital role in healing process for diabetics by enhancing the activity of antioxidant enzymes and sensitivity of insulin receptors (Kalasuba *et al.*, 2023). The concentration of flavonoids was consistent throughout the species but was below the daily intake of 50 – 400 mg/day (Ahn-Jarvis *et al*., 2019). Generally, Saponins, known for their astringency, is anti-carcinogenic, anti-inflammatory and a fat reducer while boosting immune response. According to Ahn-Jarvis *et al.* (2019), a diet high in saponins can mitigate the symptoms of acute lead poisoning, treat hypercalciuria in people, and reduce dental decay. These findings coincide with Udeozo *et al*., (2018) and Korfii *et al.*, (2022).

The presence of alkaloids in the plant material is an indication that it can relieve stomach pain and act as an anti-mycotic. Alkaloids are known to be physiologically active and have analgesic qualities that treats stress, depression, and fever (Finotti *et al*., 2006). With an ability to regulate gastritis and irritable bowel disorders, and enhancing the antibacterial activity for wound and hemostasis, tannins are a major ingredient in phytomedicine and beverages (Haslam, 1996). The result obtained for alkaloids and tannin were in line with Korfii *et al.,* (2022). The concentrations of both metabolites were within the daily intake rate, however, excessive intake of alkaloids and tannins can be toxic or irritable prompting the maximum intake per day of 10/100g (Calabro *et al.*, 2015) and 560mg/100g (Anonymous, 1973) respectively.

Terpenoids in *R. racemosa* leaves can play a role in anticancer tendencies and aromatherapy functions. Unlike other metabolites, terpenoids was highest in the leaves of the species. According to Shohba *et al*. (2014), many terpenoids showed cancer prevention ability in preclinical animal models, in addition to cytotoxicity against a range of tumor cells. Known to be among the most prevalent, high content of phenol in the bark, leaves and root suggest that it could act as an anticlotting agent, immune enhancer and hormone regulator (Amakoha *et al.*, 2002). Phenols are also employed as a poison to kill parasites and a means of eliminating germs (Khanam *et al.*, 2012). Considering the harmful nature of phenols and the easy metabolism by plants, ingestion should be moderate and with restraint. However, the phenolic content reported was minimal and lesser than the maximum recommended daily intake (EPA, 2000). Steroids act as an active ingredient in anti-cardiovascular and anti-tumor activities. They influence endocrine activities such as reproductive life and exhibit antimicrobial properties that prevent oxidative stress (Fakorede *et al*., 2023). The phenol, steroids and terpenoids obtained in this study were slightly higher than that of Korfii *et al.* (2022) which may have resulted from environmental conditions.

In comparison to stem bark, root bark and leaves, it was observed that the highest concentration of phytochemicals were embedded more in the bark while the least concentration were found in the root of *R. racemosa* species except in terpenoid where it was highest in the leaves. It has been reported that bark of trees grown near the sea shore proximity is characterized by significantly high polyphenol content (Glubikina *et al.*, 2022). Similarly, flavonoids has the highest concentration while steroids show the least concentration overall in the species. These observations were in agreement with findings

by Vittaya *et al*., (2022) for *R. mucronata* and *R. apiculata* and Edu *et al.,* (2015); Korfii *et al.,* (2022) for *R. racemosa.*

The anti-nutrient levels of phytate and oxalate in *R. racemosa* species are significantly low. Phytic acid level in the specie was found to be highest in the bark. Phytate effectively chelate polyvalent metal ions, particularly, iron, calcium and zinc. As a result, when these ions precipitate as insoluble complexes, their bioavailability in the body would be reduced (Gupta *et al.,* 2006). According to Bushway *et al.* (1998), consuming phytate at a toxic level reduces iron absorption by a factor of 4 or 5. The mean concentration in *R. racemosa* species recorded in this study is very little compared to the toxic level of 200mg (Hurell, 2004). Oxalate acids are potent oxidants that trigger attacks by free radicals on cells and organs. High concentration of oxalates causes adsorptive poisoning and form insoluble oxalate salts interfering with their utilization which could cause kidney stones (Sango *et al*., 2016). The content of oxalate in the species is way below the toxic level of 50mg/100g reported by Abdi *et al*. (2022). There was no significant difference in the phytate and oxalate contents of the species stem bark, leaves and the root bark, however, results obtained revealed that their content was highest in the stem bark and lowest in the root bark. The mean concentration reported in this study for phytate and oxalate were in line with Korfii *et al.,* (2022) but in variance with Udeozo *et al.,* (2018). From this study, the quantity of anti-nutrient found are too insignificant to cause a problem based on their level of toxicity.

Conclusion

Investigation into phytochemicals/secondary metabolites in mangrove plants have been relatively under-studied in Nigeria. The study provided useful and informative data on the rich and diverse phytochemical and anti-nutrient compounds such as flavonoid, tannin, phenol, steroid, alkaloid, saponin, terpenoid, phytate and oxalate, present in the leaves, stem bark and root bark of *R. racemosa* tree species.

Conclusively, findings showed that tannin, saponin, phenol and flavonoids are relatively abundant while anti-nutrient (phytate and oxalate concentration) were appreciably low which justify the safe dosage of the plant in traditional medicine. The therapeutic value of these under-explored mangrove bioactive compounds with potential prospect in the food, cosmetic and pharmaceutical industries cannot be over-emphasized. Hence, the reported work supports further collaborative pharmacological research studies on the component parts of the tree species inclusive of the flowers and fruits to harness its great medicinal properties. In addition, concerted effort should be geared towards the conservation of mangrove ecosystem in view of its enormous genepool and untapped biological compound useful in human/animal nutrition and medicine.

References

Abdi F., Gemede H., Keyata E. (2022). Nutritional composition, Anti-nutrient contents, and Polyphenol compounds of selected underutilized and some commonly consumed Vegetables in East Wollega, West Ethiopia, *Journal of Food Quality*, vol. 2022, https://doi.org/10.1155/2022/6942039

Adenegan T. and Jayeola A. (2015). Leaf and petiole anatomical studies of the genus *Rhizophora* Linn in Nigeria. *International Journal of Current Science.* 18:125 – 135.

Ahn-Jarvis J., Parihar A., and Doseff A. (2019). Dietary flavonoids for Immuno-regulation and Cancer: Food design for targeting disease. *Antioxidants.* 8(7); 202 https://doi.org/10.3390/antiox8070202

Airy-Shaw H. K. (1985). A dictionary of the flowering plants and ferns. 8th edition.

Cambridge University Press, Cambridge 1245pp.

Albert C., Nwisuator D. and Gangan B. (2012). Socio-economical importance of Red Mangrove (*Rhizophora racemosa*) to rural dwellers in Southern Nigeria. *Journal of Natural Sciences Research.* Vol. 2(8); 182-185.

Amakoha R., Ubwa S., Otokpa T. and Shenge G. (2002). Phytochemical composition and biological activities of *Uvaria chamae. Urology*. 54(6), 1001-1201.

Angalabiri O. and Isirimah J. (2014). Evaluation of the lethal dose of the methanol extract of *Rhizophora racemosa* leaf using karber's method. *African Journal of Cellular Pathology.* 2: 65-68.

Anonymous (1973). Tannic acid gain. *Food Cosmetology Toxicology*. In: Toxicants naturally occurring in foods. National Academy of Sciences. Third Edition. pp 112.

AOAC (2005): Official method of analysis, 5th edition, Sidney Williams (ed.), Association of Official Analytical Chemists Inc, Arlington

Bushway R. J. Burean J. I. and Gann D. F. (1998). Phytate and Cyanide contents of edible mushrooms. *Journal of Food Science*, 48(2), 84 - 86.

Calabrò S., Cutrignelli M., Lo Presti V., Tudisco R., Chiofalo V., Grossi M., Infascelli F. and Chiofalo B. (2015). Characterization and effect of year of harvest on the nutritional properties of three varieties of white lupine (*Lupinus albus* L.) *Journal of Science of Food and Agriculture*; 95: 3127–3136. doi: 10.1002/jsfa.7049

Chlopicka J., Pasko P., Gorinstein S., Jedryas A., and Zagrodzki P. (2012) Total phenolic and totalflavonoid content, antioxidant activity and sensory evaluation of pseudocereal breads. *LWT –Food Science Technology*. 46 pp 548–555

Duke C. and Allen J. (2006) *Rhizophora mangle, R. samoensis, R. racemosa, R. harrisonii* (Atlantic-East Pacific Red mangrove). Species Profiles for Pacific Island. *Agroforestry*, 10: 1-18.

Edu E., Edwin-Wosu B., and Udensi O. (2015). Evaluation of Bioactive Compounds in Mangroves: A Panacea towards Exploiting and Optimizing Mangrove Resources. *Journal of Natural Sciences Research*. 5(23):1-9

EPA (2000) Environmental Protection Agency,. Toxicological review of Phenol; Information on the Integrated Risk Information System (IRIS) summary; Federal Register CAS No. 108-95-2

Fakorede, C., Odega, C. and Anguruwa, G. (2023). Phytochemical evaluation of *Terminalia catappa* linn. for biomedicinal and nutritive purposes. *Renewable;* 3(1): 89-100

Finotti E., Bertone A. and Vivanti V. (2006). Balance between nutrients and anti-nutrients in nine Italian potato cultivars. *Food Chemistry*. 99. 698–701. 10.1016/j.foodchem.2005.08.046

Glubikina N., Ulyana P., Vladimir L., Helene L., Sargey S., Zarena A., Visita M., Tatin N., Natalia B. and Lidia L. (2022). Evaluation of factors affecting tree shrubs bark and antioxidant status. *Plants:* 11(19); 2609. https://doi.org/10.3390/plantsn192609

Gupta, S., Lakshmi, A. and Prakash J. (2006). In-vitro bioavailability of calcium and iron from selected green leafy vegetables. *Journal of the Science of Food and Agriculture*. 86(13): 2147–52.

Gupta K., Masne T. and Umekar M. (2023). Marine plants: Extraction and their medicinal importance. *International Journal of Pharmaceutical Chemistry and Analysis.* 10. 185-193. 10.18231/j.ijpca.2023.031.

Ha B. and Eduok S. (2022). In vitro antioxidant and antifungal activities of *Rhizophora racemosa* GFW. May. Stem bark extracts. *Scientific African;* 15: 2268-

2276. https://doi.org/10.1016/j.sciaf.2021.e01091

Hamzah T., Lee S., Hidayat A., Terhem R., Hanum I. and Mohamed R. (2018). Diversity and Characterization of Endophytic Fungi Isolated from the Tropical Mangrove Species, *Rhizophora mucronata*, and Identification of potential antagonists against the soil-borne fungus, *Fusarium solani*. *Frontier in Microbiology.* https://doi.org/10.3389/fmicb.2018.01707

Haslam, E. (1996). Natural Polyphenols (Vegetable Tannins) as Drugs: Possible Modes of Action. *Journal of Natural Products*, 59, 205-215. https://doi.org/10.1021/np960040

Holmgren P., Holmgren N. and Barnett L. (eds.) (1990). Index Herbariorum - Part I: The Herbaria of the World (Regnum Veg. Vol. 120). New York Botanical Garden, New York

Hurell R. (2004). Phytic acid degradation as a means of improving iron absorption. *International Journal for Vitamin and Nutrition Research*, vol. 74(6): 445– 452.

Indumathi, C., Durgadevi, G., Nithyavani, S., and Gayathri, P. (2014). Estimation of terpenoid content and its microbial property in Enicostemma Litorrale. *Recent Trends in Biotechnology and Chemical Engineering* 6(9): 4264 – 4267.

Jayeola A., Thorpe J. and Adenegan T. (2001). Macro-morphological and micro-morphological studies of the West African *Rhizophora* Linn. *Feddes Repertorium* 1: 349-356.

Kalasuba K., Miranti M., Rahayuningsih S., Safriansyah W., Syamsuri R., Farabi K., Oktavia D., Alhasnawi A. and Doni F. (2023) Red Mangrove (*Rhizophora stylosa* Griff.)—A Review of Its Botany, Phytochemistry, Pharmacological Activities, and Prospects. *Plants*. 12(11): 2196. https://doi.org/10.3390/plants12112196

Keay R., Onochie C. and Stanfield D.P. (1989). Nigeria Trees. Revised edition. Lagos: Nigerian National Press, Vol. 1, pp 167-168

Khanam *U*., Oba S., Yanase E., and Murakami Y. (2012). Phenolic acids, flavonoids and total antioxidant capacity of selected leafy vegetables. *Journal of Functional Foods.* 4(4): 979-987. Doi: 10.1016/j.jff.2012.07.006

Korfii U., Boisa N., and Tubonimi I. (2022). Phytochemical profiling of red mangrove plant (*Rhizophora racemosa*) bark: A factor to its applications. *Journal of Research in Chemistry*. **3** (1): 10–14.

Lucas, G.M. and P. Markakas, (1975). Phytic acid and other phosphorus compound of bean (*Phaseolus vugaris*), *Journal of Agricultural and Food Chemistry*, 23: 13-15

Mazidi M., Katsiki N., Banach M. (2019). A higher flavonoid intake is associated with less likelihood of nonalcoholic fatty liver disease: Results from a multiethnic study. *Journal of Nutritional Biochemistry*; 65:66–71. doi: 10.1016/j.jnutbio.2018.10.001.

Md. Mahadi H., Nizam U., Md. Rakib H., Mahmudul A., Md. Monir H., Akib Bin R., Md. Sazzad H., Ishtiaque A., Md. Sohel R. (2013). Analgesic and Anti-Inflammatory Activities of Leaf Extract of *Mallotus repandus* (Willd.) Muell. Arg., *BioMedical Research International*, vol. 2, https://doi.org/10.1155/2014/539807

Muhammad S. and Abubakar S. (2016). Qualitative and Quantitative Determination of Phytochemicals in Aqueous Extract of Chrysophyllumalbidum Seed Kernel. *Biosciences, Biotechnology Research* Asia. 13. 1201-1206. 10.13005/bbra/2153.

Neyland R. (2000). Large Ribosoma subunit 26s rRNA gene sequence suggest that *Rhizophora harrisonii, R.mangle and R. racemosa (Rhizophoraceae*) are distinct

species. The proceedings of the Louisiana Academy of Science. ISSN 0096-9192, USA

Nyananyo B.L. (2006). Plants from the Niger Delta, Onyoma Research Publication, Port Harcourt, Nigeria 403pp.

Onwuka G.I. (2018) Food Analysis and Instrumentation: Theory and Practice (2nd Ed.). Lagos, Nigeria: Naphtali Prints. 35-40

Plantlist, (2013) Available on:
http://www.theplantlist.org/1.1/browse/A/Rhizophoraceae/Rhizophora/

Poompozhil S. and Kumarasamy D. (2014). Studies on phytochemical constituents of some selected mangroves. *Journal of Academia and Industrial Research*. 2(10): 590-592.

Radford A. (1986). Fundamentals of Plant Systematics. New York, Herper and Row publishers.

Sango, C., Marufu, L. and Zimudzi, C. (2016). Phytochemical, Anti-nutrients and Toxicity evaluation of *Cleome gynandra* and *Solanum nigrum*: Common indigenous vegetables in Zimbabwe. *British Biotechnology Journal*. 13(3): 1-11

Shobha R., Rajeshwari C., Andallu B. (2014). Oxidative Stress and Antioxidant Herbs and Spices in Cancer Prevention, *Cancer*, Pg 91-100. Doi: 10.1016/B978-0-12-405205-5.00009

Stankovic M.S. (2011) Total phenolic content, flavonoid concentration and antioxidant activity of *Marrubium peregrinum* L. extracts. *Kragujevac Journal of Science,* 33 pp 63–72

Syawal H., Hakim L. and Effendi I. (2020). Phytochemical analysis of Rhizophora apiculata leaf extract and its inhibitory action against *staphylococous aureus, Aeromonas hydophita* and *Pseudomonas aeruginosa* AACL Bioflux 13(4): 2242 – 2249

Takayama, K., Tateishi, Y. and Kajita, T. (2021). Global phylogeography of a pantropical mangrove genus *Rhizophora*. *Sci Rep* **11**, 7228. https://doi.org/10.1038/s41598-021-85844-9

Trease and Evans (2009). 16th edition. *Pharmacognosy*; pp. 376–480.

Udeozo I., Okafor O. and Eze E. (2018). The efficacy of *Rhizophora racemosa* wood: An important study. *Trends in Science and Technology Journal*. 3(2): 977 – 980.

Vaishali P. and Neeraj M. (2018). Anticancer Potential of Flavonoids: Chemistry, Biological Activities, and Future Perspectives. *Studies in Natural Products Chemistry*, Vol 59, 401-430.

Vinoth R., Kumaravel S. and Ranganathau R. (2019). Therapeustic and traditional uses of mangrove plants. *Journal of Drug Delivery and Therapeutics* 9(4): 849-854.

Vittaya L., Charoendat U., Janyong S., Ui-eng J. and Leesakul N. (2022) Comparative analyses of saponin, phenolic, and flavonoid contents in various parts of *Rhizophora mucronata* and *Rhizophora apiculata* and their growth inhibition of aquatic pathogenic bacteria. *Journal of Applied Pharmaceutical Science;* 12(11):111–121.

Wekhe S., Ogbamgba K. and Oboh C. (2007). Preliminary Investigation of the effect of Rhizophora racemosa (mangrove) feetd additive on broiler performance. *African Journal of Biotechnology* vol 6(16): 1963-1965.