Nutrient and Antinutrient Determination of Some Agrowates in Port Harcourt, Rivers State

Agbagwa S. S., Chuku E. C., Nwauzoma A. B. and Nmom F. W.
Department of Plant Science and Biotechnology, Rivers State University.
samuel.agbagwa1@ust.edu.ng

DOI: 10.56201/rjpst.v6.no2.2023.pg39.49

ABSTRACT
Studies on the nutrient and antinutrient compositions of some agrowastes in Port Harcourt were carried out in the Department of Plant Science and Biotechnology, Rivers State University. Agrowastes such as sawdust, wood ash and rice bran were selected for this study. Sawdusts from Xylopia aethiopica and Mitragyna ciliata and Rhizophora racemose wood were obtained from Mile II Timber Market Diobu in Port Harcourt while the wood ash was sourced from burnt Rhizophora racemose wood after cooking. Rice bran was obtained from Dilomat Farms and Services Limited in Rivers State University. All selected agrowastes were brought to the Department for further studies. The atomic absorption spectrophotometer methods described by Association of Official Analytical Chemists (AOAC) were used for the determination of proximate, mineral, vitamin and antinutrient contents of these agrowastes. Proximate evaluation revealed rice bran to possess highest values for moisture (11.63±0.15), lipid (7.50±0.10) and carbohydrate (35.63±0.60). Highest values (9.56±0.03) for protein, 71.50±0.10 for fibre and 15.00±0.50 for ash were recorded for M. ciliata, X. aethiopica and R. racemose wood ash respectively. Mineral and vitamin assessment revealed wood ash to contain highest calcium, iron, magnesium, phosphorus, potassium and sodium while thiamine (0.23±0.01) was only recorded for rice bran. Antinutrient investigation showed the availability of oxalate, tannin, carotenoid, polyphenol, flavonoid and lignant in all tested agrowastes. However, X. aethiopica recorded highest antinutrient composition compared to other assessed agrowastes. Generally, these agrowastes still possess valuable nutrients and antinutrients that could support other production processes.

Keywords: *Nutrient, antinutrient, agrowastes, Rhizophora racemose, Xylopia aethiopica and Mitragyna ciliata*

INTRODUCTION

Rhizophora racemosa commonly referred to as red mangrove is a member of the Rhizophoraceae family. The family is known to be distributed in the African west coast and American coasts as well as within the tropical region (Duke *et al.,* 1998; Maria and Eduardo, 2012).
The plant grows to an average length of 15 to 20m with several stems that are branched. Its leaves are simple and obovate in shape; while flowers are located below the shoot of the apical region (Duke *et al.,* 2002). *R. racemosa* has been profiled by early researchers to be of agricultural benefit as it serves as a soil stabilizer, organic matter, wind break, bee forage and wildlife habitat. More so, its by-products are important as staple food, medicine, timber, fuel wood, dye and craft making

(Duke and Allen, 2006). In addition, the plant is blessed with several phytochemicals and minerals including both macro and micro elements (Udeozo *et al.*, 2018).

Xylopia aethiopica commonly referred to black pepper because of its nature belongs to the Anonaceae family. The plant is native to Ethiopia, DR. Congo, Nigeria, Kenya, Ghana, Senegal, Tanzania, Mosambique and Uganda. Although, *X. aethiopica* still have vast exotic range (Orwa *et al.*, 2009). The biology of the plant reveals it to be an aromatic tall evergreen tree with grey to brown bark. The plant possesses oblong simple leaves that are arranged alternately. Its flowers are bisexual with spices that are branched. The fruits are brown or dark pod shaped and twisted with 5 to 8 black seeds (Burkill, 1985).

X. aethiopica is distributed in the Africa Savannah zones and rainforest but its high population are recorded on South, West and Central Africa. The plant thrives best in drained sandy loam or loamy soil with 1500 to 2500mm and 20-31^{0}C mean annual rainfall and temperature respectively (Tairu *et al.*, 1999). The plant is known for several useful ecosystem services including its use as a source of fuel, timber, essential oil, medicine, cosmetic as well as shade and shelter (Iwu *et al.*, 1999, Erhirhie and Moke, (2014).

Literatures have also shown the availability of several nutrients and antinutrients in *X. aethiopica* (Aguoru *et al.*, 2016; Okwu, 2004). Antinutrient such as alkaloids, saponin, flavonoid, steroid, tannin as well as cardiac glycoside were reported to be present in *X. aethiopica,* (Chinonye *et al.*, 2022). Carbohydrate, protein, ash, fibre, calcium, magnesium, sodium potassium, iron, phosphorus and many more are nutrients that have been recorded in *X. aethiopica* (Abolagi *et al.*, 2007). *Xylopia aethiopica* is an economic plant used for a variety of purposes both in its native and exotic environment (Orwa *et al.*, 2009).

Mitragyna ciliata commonly known as Abura is a tree, plant that belongs to the Rubiaceae family and bears the synonym *M. letermanni.* The genus is distributed within the tropical region including Africa and Asia (Govaerts *et al.*, 2015). The plant is an evergreen tree that can attain 15 to 35m in height. Leaves of *M. ciliate* are simple in nature and obovate with bisexual flowers. The capsule fruit shaped in a spindle manner bear singular winged seeds (Burkill, 1997). The plant has been classified as deciduous hardwood and could be propagated with different means such as stem cuttings, seeds and sucker cuttings (Nyemb, 2011).

Literature has subdivided *Mitragyna* genus into two broad categories (African species and Asian species) with respect to the species distribution and availability. However, *M. ciliata* has been documented to be one of the *Mitragyna* African species (Lemmans *et al.*, 2012). Studies have shown that *Mitragyna* species play vital role in the economic sector as they are utilized for several purposes (Phogphaew, 2003; Keay, 1989; Hawthorne, 1995).

Leaves of the plant are used for the supplementation of feed, serving as a source of quality seed for animals (Phesatcha *et al.*, 2022a). Brown *et al.* (2017) also revealed extensively the ethnomedicinal uses of the *Mitragyna* genus for anti-poison, antimicrobial and have also been used to offer aid to liver, kidney, diabetes, jaundice, pain, inflammation, rheumatism, swelling, drug addiction and others. Phesatcha *et al.* (2022b) further revealed that *Mitragyna* supplement pellet increased animal nutrient digestibility, rumen fermentation and protein synthesis. Researchers have also implicated *Mitragyna* to contain several antinutrients and nutrients (Ahmad *et al.*, 2022; Raphael *et al.*, 2019; Eleminafe *et al.*, 2019).

Rice (*Oryza sativa*) is a unique member of the poaceae family and has over 22 species (Vuaghan, 1994). The plant is widely cultivated around the world as a staple food although its first account of cultivation was recorded in south-east Asia (Murray, 2005). The biology of rice reveals it to a

grass composed of tillers, panicle, stem, leaves and roots. However, the most cherished part of the plant remains its grain fruits which are oblong in shape and consists of the hull, endosperm and the embryo (Moldeuhauer and Gibbons, 2003). The cultivation which terminates at packaging is accompanied by several processes including planting, weeding, harvesting, dehusking and parboiling of the rice grain (Street and Bollich, 2003).
Notwithstanding, Mohammed *et al.* (2019) reported that rice production in Nigeria still faces several challenges including drought, soil salinity, rest and diseases, inadequate supply of fertilizer, unavailability of land as well as poor mechanization. Literature has shown that rice is not just a staple food but also a source of flour and other food products (Valentine and Suleman, 2013). Rice also contains several valuable nutrients including proximate, mineral and vitamins with vital health benefits (Upadhyay and Karn, 2018; Oko *et al.*, 2012; Isaac *et al.*, 2012).

Furthermore, rice also contain several antinutrients (phytochemicals) such as oxalate, tannin, glycosides, saponnin and many more utilized for different beneficial purposes (Fatchiyah *et al.*, 2020; Wordu *et al.*, 2021). Rice bran which is a by-product generated from rice production is obtained from dehusked rice hull. Rice bran is a highly utilized agricultural by-product processed into several other products including animal feeds (Faria *et al.*, 2012). Literature has revealed that rice bran contains several appreciable nutrients and antinutrients just like the endosperm grain. It has quite a number of economic importance as well (Kumari *et al.*, 2017; Chaudhan *et al.*, 2018).

MATERIALS AND METHODS

Sample Collection

Soft wood sawdust from *Xylopia aethiopica* and hard wood sawdust from *Mitragyna ciliata* respectively, as well as woods of *Rhizophora racemosa* were obtained from Timber Market Mile II Diobu, Port Harcourt and identified by Dr. F. Chukwundah, the Head of Department of Forestry and Environment, Rivers State University. Bags were attached directly to the saw machine to collect homogenous portions of the selected wood sawdust. The *Rhizophora* wood was burnt for ash collection. Rice bran were obtained from Dilomat Farms and services limited, Rivers State University.

Determination of nutrient and antinutrient

Samples of the agrowastes obtained were assessed for proximate, mineral, vitamin and antinutrient compositions in accordance to the atomic absorption spectrophotometer technique outlined by AOAC, (2005 & 1990).

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) in a CRD at 5% significance level. Mean separation was by Duncan multiple range test (DMRT) at 5% level of significance

RESULTS AND DISCUSSION

Table 1: Proximate composition of utilized agrowastes (%)

Wastes	Moisture	Ash	Lipid	Fibre	CHO	Protein
HW	8.30±0.05[c]	5.50±0.10[d]	0.21±0.01[c]	70.30±0.10[b]	6.30±0.10[b]	9.56±0.03[a]
SW	9.51±0.09[b]	6.46±0.05[c]	0.38±0.03[b]	71.50±0.10[a]	5.56±0.11[c]	6.67±0.02[b]
RB	11.63±0.15a	7.71±0.07[b]	7.50±0.10[a]	36.13±0.32[c]	35.63±0.60[a]	0.62±0.03[d]
WA	6.45±0.18[d]	15.00±0.50[a]	0.00±0.00[d]	0.33±0.15[d]	0.00±0.00[d]	2.55±0.05[c]

*Means with the same superscripts across the column are not significantly different (p≤0.05)
HW= hard wood, SW= soft wood, RB= rice bran, WA= wood ash, CHO= carbohydrate

Table 2: Mineral and vitamin composition of utilized agrowastes (mg/100g)

Wastes	Thiamine	Ca	Fe	Mg	P	K	Na
HW	0.00±0.00[b]	54.60±0.10[b]	1.70±0.10[c]	17.66±1.52[d]	123.00±1.00[d]	111.00±1.00[c]	0.02±0.01[c]
SW	0.00±0.00[b]	222.66±1.52[b]	0.33±0.05[d]	212.33±2.51[b]	441.00±1.00[b]	120.33±0.57[b]	63.00±1.00[b]
RB	0.23±0.01[a]	12.43±0.40[a]	2.10±0.10[b]	38.56±0.50[c]	287.00±2.64[c]	111.67±2.08[c]	0.30±0.10[c]
WA	0.00±0.00[b]	124.10±1.00[b]	14.20±0.10[a]	351.33±1.52[a]	1201.33±1.52[a]	1404.00±6.08[a]	213.00±1.00[a]

*Means with the same superscripts across the column are not significantly different (p≤0.05)
Ca (calcium), Fe (iron), Mg (magnesium), P (phosphorus), K (potassium) and Na (sodium).
HW= hard wood, SW= soft wood, RB= rice bran,WA= wood ash

Table 3: Antinutrient composition of utilized agrowastes (%)

Waste	Oxalate	Saponin	Tannin	Carotenoi	Polypheno	Flavonoid	Lignant

HW	0.00 ± 0.00^{b}	0.00 ± 0.00^{b}	6.53 ± 0.15^{b}	4.50 ± 0.10^{b}	3.50 ± 0.10^{a}	5.84 ± 0.04^{a}	1.62 ± 0.07^{a}
SW	0.00 ± 0.00^{b}	0.00 ± 0.00^{b}	7.36 ± 0.15^{a}	5.53 ± 0.15^{a}	3.66 ± 0.15^{a}	4.86 ± 0.09^{b}	1.51 ± 0.12^{a}
RB	0.05 ± 0.01^{a}	0.00 ± 0.00^{a}	0.50 ± 0.10^{c}	1.30 ± 0.07^{c}	0.72 ± 0.01^{b}	1.34 ± 0.03^{c}	0.41 ± 0.06^{c}
WA	0.00 ± 0.00^{b}	0.00 ± 0.00^{b}	0.00 ± 0.00^{d}	0.00 ± 0.00^{d}	0.00 ± 0.00^{c}	0.00 ± 0.00^{d}	0.00 ± 0.00^{d}

*Means with the same superscripts across the column are not significantly different ($p\leq0.05$)
HW= hard wood, SW= soft wood, RB= rice bran, WA= wood ash

The result on proximate composition of utilized agrowastes (hard wood, soft wood, rice bran and wood ash) (Table 1) showed that rice bran had highest values of moisture (11.63±0.15%), lipid (7.50±0.10%) and carbohydrate (35.63±0.60%), while highest values of ash (15.00±0.50%), fibre (71.50±0.10%) and protein (9.56±0.03%) were recorded for wood ash, soft wood and hard wood respectively. Although, lowest values of moisture (6.45±0.18%), lipid (0.00±0.00%), fibre (0.33±0.15%) and carbohydrate (0.00±0.00%) were recorded for wood ash. Hard wood and rice bran also recorded lowest values of ash (5.50±0.1%) and protein (0.62±0.03%) respectively.

The result on mineral and vitamin composition of utilized agrowastes (Table 2) revealed highest contents of iron (14.20±0.10mg/100g), phosphorus (1201.33±1.52 mg/100g), magnesium (351.33±1.52 mg/100g), potassium (1404.00±6.08 mg/100g) and sodium (213.00±1.00 mg/100g) in wood ash whereas soft wood recorded highest value for calcium (222.66±1.52 mg/100g). Lowest values of 17.66±1.52 mg/100g, 123.00±1.00 mg/100g, 111.00±0.00 mg/100g and 0.02±0.01 mg/100g were recorded for magnesium, phosphorus, potassium and sodium respectively in hard wood. However, rice bran and soft wood recorded lowest values for calcium (12.43±0.40 mg/100g) and iron (0.33±0.05 mg/100g). Vitamin data of thiamine showed that only rice bran contained 0.23±0.01 mg/100g while other agrowaste materials recorded 0.00±0.00 mg/100g values.

The result on anti-nutrient composition of utilized agrowastes (Table 3) revealed highest values of tannin (7.36±0.15%), carotenoid (5.53±0.15%) and polyphenol (3.66±0.15%) for soft wood. Hard wood recorded highest contents of flavonoid (5.84±0.04%) and lignant (1.62±0.07%). Highest value (0.05±0.01%) of oxalate was seen in rice bran while other agrowastes recorded 0.00±0.00% value. Lowest values of 0.00±0.00% for tannin, carotenoid, polyphenol, flavonoid and lignant were recorded for wood ash. In addition, all tested agrowastes recorded 0.00±0.00% values for saponin.

The current study has revealed that the agrowaste materials employed still possess valuable components that supported the growth, development and cultivation of both species of *Pleurotus*. The evaluation and utilization of different agricultural wastes have been considered by early researches; and studies have further shown the reconversion of these matierials to other useful products such as absorbents, animal feed and manure (Obi *et al.*, 2016; Agbagwa *et al.*, 2020). Evaluation of proximate contents of agrowastes showed that rice bran recorded highest proximate values compared to wood ash of *X. aethiopica* (softwood) and *M. ciliata* (hardwood). This is in line with previous reports that implicated rice to be a good source of nutrient (Oko *et al.*, 2012; Upadhyay and Karn, 2018).

The moisture and carbohydrate values of rice bran recorded in the present study agree with those reported by Faria *et al.* (2012) for whole rice bran. Although they reported lower values for whole rice bran treated in microwave oven and conventional stove. The protein, lipid and fibre result recorded in the present study are lower than those they reported. Kuman *et al.* (2017) reported higher proximate values in full fat rice bran and defatted rice bran with an exception for moisture as against the parameters assessed in this study.

Notwithstanding, Eleminafe *et al.* (2019) reported higher moisture and lower ash values of *M. ciliata* wood compared to those recorded in the present study. The high content of ash in wood ash is in agreement with early report of Saunders (2018) that indicated ashes from burnt wood to be a good source of ash. The high content of fibre in both softwood (71.50±0.10) and hardwood (70.30±0.10) could be as a result of wood anatomy as Stern (1994) showed that fibres are sclerenchyma tissue associated with different part of a plant including the fruit, stem, leaves and root.

Minerals and vitamin assessment revealed rice bran to be the only agrowaste that contain thiamine which agrees with the report of Upadhyay and Karn (2018) and Isaac *et al.* (2012) as they indicated thiamine to be present in rice. Although, wood ash had highest mineral contents compared to other agrowastes tested. The result is in agreement with Udeozo *et al.* (2018) as they indicated that *Rhizophora racemosa* is a good source of macro and micro mineral elements. They also revealed high contents of the minerals elements recorded in the present study. The relationship of wood ash and mineral elements were highlighted by Mandre (2006) as it was revealed that wood ash application play a major role in mineral element assimilation by plants. The high calcium value for softwood concurs to the report of Fategbe *et al.* (2021) as they also reported a calcium value of 236.42±0.96 for *X. aethiopica* plant. Similar report was also presented by Dingtsen *et al.* (2020) as they reported high value of calcium for *X. aethiopica*. On the contrary, lower calcium values of *X. aethipica* were reported by Abolaji *et al.*, (2007) and Osabor *et al.* (2015).

Screening of antinutreints present in all tested agrowastes revealed that soft wood had higher antinutrients than other agrowastes. Literatures have implicated *X. aethiopica* (softwood) to contain high values of antinutrients. Chinonye *et al.*, (2022) reported higher antinutrient values for *X. aethiopica* than those recorded in the current study. Osabor *et al.*, (2015) further revealed high antinutrients values in *X. aethiopica*. The present study has shown zero values of saponin in all tested agrowastes and this disagrees with the findings of Fategbe *et al.* (2021); Raphael *et al.* (2019) and Wordu *et al.* (2021). In addition, oxalate was only recorded in the rice bran samples as other agrowastes recorded zero values. Chinonye *et al.* (2022) and Dingtsen *et al.* (2020) also noted the absence of oxalate in *X. aethiopica.* Notwithstanding, this disagrees with Raphael *et al.* (2019) as they reported the presence of oxalate in *M. ciliata.* Generally, the present study has confined that these materials considered as agricultural wastes still possess valuable nutrients and antinutrients. The availability of the nutrients in agrowastes stand as the attractive joint of concern by different oysters for feed, and manure while the pharmaceutical exploitation could be associated with the occurrence of several antinutrients (phytochemicals) (Correa *et al.*, 2018; Rocha *et al.*, 2012; Baba *et al.*, 2013; Phesatcha *et al.*, 2022a & b; Valentine *et al.*, 2013).

CONCLUSION

Xylopia aethiopica and *Mitragyna ciliata* sawdusts, as well as wood ash of *Rhizophora racemosa* and rice bran are common agricultural and industrial wastes generated in Port Harcourt. The present study has revealed that potentials are still locked in these waste materials as they contained appreciable contents of proximate, mineral and vitamin nutrients. Valuable antinutrients were also recorded in all agrowastes. The reuse of these agrowastes should be encouraged as it will not only release these locked potentials but further curb the challenge of environmental pollution. Therefore, concerns should be targeted towards their reuse for sustainable environment.

REFERENCES

Abolaii, A. O., Adebayo, A. H. and Odesanmi, O. S. (2007). Nutritional qualities of three medicinal plant parts (*Xylopia aethiopica*, *Blifhi sapida* and *Parinan polyandra*) commonly used by pregnant women in the Western part of Nigeria. *Pakistan Journal of Nutrition*, 6(6), 665 – 668.

Agbagwa, S. S., Chuku, E. C. and Worlu, C. W. (2020e). Studies on Chemical Properties of three utilized agrowastes in Nigeria. *Asian Journal of Research in Botany*, 4(4), 76 – 80.

Aguoni, C. U., Pilla, C. and Olasan, J. O. (2016). Phytochemical screening of xylopica aethiopica for medicinal importance. *Journal of Medicinal Plants Research*, 3, 118 – 122.

Ahmad, I., Prabozoo, W. C., Antidlin, M., Fadraersada, J., Indriyanti, N., Herman, H., Purwoko, R. Y., Naina, F., Rahmadi, A., Paramita, S., Kuncoro, H., Mita, N., Narsa, A. C., Prasetya, F., Ibrahim, A., Rijai, L., Alani, G., Munim, A. and Dej-aliwai, S. (2022). *Mitragyna* species as pharmacological agents: from abuse to promising pharmaceutical products. *Life*, 12, 193.

AOAC, (1990). *Official methods of analysis of AOAC international*, 15th edition. Association of official analytical chemists, Washington, D.C., USA.

AOAC, (2005). *Official methods of analysis of AOAC international*, 18th edition. Association of official analytical chemists, Washington, D. C., USA.

Baba, S., Chan, H. T. and Aksornkoae, S. (2013). Useful products from mangrove and other coastal plants. ISME mangrove educational book series no. 3. International Society for Mangrove Ecosystem (ISME), Okinawa, Japan and Int. Tropical Timber Organization (ITTO), Yokohama, Japan. 23.

Brown, P. N., Lund, J. A. and March, S. J. (2017). A botanical phytochemical and ethnomedicinal review of the genus *Mitragyna horm*: implications for products sold as Kradow. *Journal* *of Ethnopharmacology*, 202, 302 – 325.

Burkill, A. M. (1995). *The useful plants of West Africa*. Vol. 3 Caesalpiniodeae, 50 – 177. Royal Botanic Garden, Kew, 857.

Burkin, H. M. (1997). *The useful plants of West Tropical Africa*, 2nd ed. Vol. 4, families M-R, Royal Botanic Gardens, kew, Richmond, United Kingdom, 969.

Chaudhari, P. R., Tamrakar, N., Singh, L., Tandon, A. and Sharma, D. (2018). Rice nutritional and medicinal properties: A review article. *Journal of Pharmacognosy and phytochemistry*, 7(2), 150 – 156.

Chinonye, I. R., Adanna, U. A., Christopher, A., Elah, A. Ifeoma, O., Lynda, U. O. and Chukwudi, A. R. (2022). Chemical and medicinal properties of xylopia aethiopica harvests from the south eastern Nigeria. *Chemical and Pharmeceutical Research,* 4(1), 1 – 9.

Correa, R., Peralta, R. M., Haminuik, C., Maciel, G. M. Bracht, A. and Ferreira, I. (2018). New phytochemicals as potent human anti-aging compounds: Reality, promise and challenges. *Critical Reviews in Food Science and Nutrition,* 58(6), 942 – 957.

Dingtsen, D. J., Bartholomew, O., John, S. S. Esytay, O. E. A. and Ekingwe, O. (2020). Evaluation of the antinutriential and nutritional composition of fine Nigerian spices. *American J. of Quantum Chemistry and Molecular Spectros Copy,* 6(1), 22 – 27.

Duke, N. C. and Allen, J, A. (2006). *Rhizophora mangle, R. samoensis, R. racemosa, R. barrisonii* (Atlantic-east pacific red mangrove). In: Elevitch C. R. (ed). *Species profiles for pacific island agroforestry*. Permanent Agriculture Resources (PAR), Holualoa, Hawai. 54 – 55.

Duke, N. C., Ball, M. C. and Ellison, J. C. (1998). Factor influencing biodiversity and distributional gradients in mangroves. *Global Ecology and Biogeography Letters*, 7, 27-47.

Duke, N. C., Lo, E. Y. Y. and Sun, M. (2002). Global distribution and genetic discontinuities of mangroves-emerging pattern in the evolution of *Rhizophora*. *Tree Structure and Function*, 16, 65-79.

Elehinafe, F. B., Okedere, O. B., Odunlami, O. A., Mamudu, A. O. and Bamidele, S. F. (2019). Proximate analysis of the properties of some south western Nigerian, sawdust of different wood species. *International Journal of Civil Engineering and Technology,* 10(3), 51 – 59.

Erhirhie, E. O. and Moke, G. E. (2014). *Xylopia aethiopica*: A review of its euromedicinal chemical and pharmacolesical properties. *American Journal of Pharmatecla Research*, 4(6), 249 – 387.

Faria, S. A. S. C., Bassinello, P. Z. and Penteado, M. V. C. (2012). Nutritional composition of rice bran submitted to different stabilization procedures. *Brazilian Journal of Pharmaceutical Sciences,* 48(4), 651 – 657.

Fatchiyah, F., Sari, D. R. T., Safitri, A. and Carias J. R. K. (2020). Phytochemical compound and nutritional value in black rice from Java Island, Indonesia. Systematic Reviews in Pharmacy, 11(7), 414 – 421.

Fategbe, M. A., Anoioroko, O. J. and Thukun, E. O. (2021). Comparative biochemical evaluation of the proximate mineral and phytochemical constituents of *Xylopia aethiopica* whole fruit, seed and pericarp *Prev. Nutrition Food Science*, 26(2), 219 – 229.

Govaerts, R., Ruhsam, M., Andersson, I., Robbredet, E., Bridson, D., Davis, A., Schanzer, I. and Sonke, B. (2015). World Checklist of Rubiaceae 6. The Board of Trustees of the Royal Botanic Gardens, Kero, http://www.kew.org/Wesp/rubiaceae/, accessed 27th Feb. 2023.

Hawthorne, W. D. (1995). Ecological profiles of Ghanian forest tress. Tropical forestry papers 29. Oxford Forestry Institute, Department of plant Sciences, University of Oxford, United Kingdom, 345.

Isaac, R. S. R., Nairi, S. A., Varghese, E. and Chavali, M. (2012). Phytochemical antioxidant and nutrient analysis of medicinal rice (*Oryza sativa* L.) varieties found in South India. *Advanced Science Letters,* 5, 1 – 5.

Iwu, M. W., Duncan, A. R. and Okunji, C. O. (1999). New antimicrobial of plant origin. In: J. Janich (ed), Perspectives of New Crops and New Uses. A SHS press, Alexandra, VA, 457 – 462.

Keay, R. W. J. (1989). Trees of Nigeria: A revised version of Nigerian trees (1960, 1964) by Keay, R. W. J., Onochie, C. F. A. and Standfield, D. P., Clarendon Press, Oxford, United Kingdom, 476.

Kumara, N., Vinita, N. K. and Rani, P. (2017). Nutrient composition of full fat and defatted rice bran. *Asian Journal of Diary and Food Research,* DR-1277, 1 – 4.

Lemmans, R. H. M. J., Louppe, D. and Oteng-Amoako, A. A. (2012). Plant resources in tropical Africa: Timber 2, Prota 7(2), Prota foundation, Wageningen, Netherlands.

Mandre, M. (2006). Influence of wood ash on soil chemical composition and biochemical parameters of young scot pine. *Proceedings of the Estonian Academy of Science: Biology and Ecology,* 55(2), 91-107.

Maria, B. B. and Eduardo, B. (2012). First report of *Rhiphora racemosa* Meyer (Rhizophoraceae) in the mangrove forests of the Venezuelan Carribean Coast. *Interciencia*, 37(2), 133-137.

Mohammed, U. A., Ibrahm, S., Hayatu, M. and Mohammed, F. A. (2019). Rice (*Oryza sativa* L.) production in Nigeria, Challenges and prospects. *Dutse J. of pure and Applied Sciences*, 5(2b), 67 – 75.

Moldenhauer, K. A. K. and Gibbons, J. H. (2003). Rice Morphology and development, chapter 2.1. In: CW Smith, RH Dilhay eds. Rice origin history, technology and production solu lively and sons, Inc., Hoboken, New Jersey, 103 – 127.

Murray, S. S. (2005). Searching for the origin of African rice domestication. http:// antiquity. Ac.uk/projlia/murray, access 27th March, 2023.

Nyemb, N. (2011). Mitragyna ledermannii (K. Krause) Riosdale. In: Lemmens, RHMJ, Louppe, D. and Oteng-Amoako, A. A. (ed). PROTA, Wageningan, Netherlands. https:// uses. Plantnet-project.org/en/mitragyna-ledermaunii-(Prota), accessed 27th, Feb. 2023.

Oko, A. O., Ubi, B. E., Efisue, A. A. and Dambaba, N. (2012). Comparative analysis of the chemical nutrient composition of selected local and newly introduced rice varieties grown in Ebonyi State of Nigeria. *International Journal of Agricultural and Forestry*, 2(2), 16 – 23.

Okwu, D. E. (2004). Phytochemicals and mineral content of indigenous species of eastern Nigeria. *Nigerian Journal Sustainable Agriculture and Environment*, 6, 30 – 37.

Orwa, C. Matua, A., Knlt, R. Jamnadass, R. S. and Anthony S. (2009). Agroforestree database: a tree reference and selection guide version 4.0.0htt:www.worldagroforestry.org/sides/treells/treedatabases.asp, referred 27th Feb. 2023.

Osabor, V. N., Bassey, F. I. and Ivara, S. E. (2015). Chemical profiting of African guinea pepper fruit (*Xylopia aethiopica*). *Journal of Medicinal Plant and Herbal Therapy Research*, 3, 10 – 15.

Phonaphaew, P. (2003). The commercial woods of Africa. Liden publishing, Frescio, California, United States, 206.

Phesatcha, K., Phesatcha, B. Wanapat, M. and Cherdthong, A. (2022a). *Mitragyna speciosa* Korth leaves supplementation on feed utilization rumen fermentation efficiency microbial population and methane production in-vitro. *Fermentation*, 8, 8.

Presarcha, B., Phetatcha, K. and Wanupat, M. (2022b). *Mitragyna speciosa* korth leaf peolet supplements on feed intake, nutrient digestability, rumen fermentation, microbial protein synthesis and protozoal population in Thai native beef castle. *Animals*, 12, 32 – 38.

Raphael, B. Rony, M., A., Celestine, N. L., Louis-Clement, O. E., Jacques, L. and Jean-Maurille,

O. (2019). Phytochemical study and antioxidant activities of Terminalia catappa L. and Mitragyna ciliate Aubrev and Pelleger medicinal plants of Gabon. *Journal of Medicinal Plant Studies*, 7(1), 33 – 38.

Rocha, L., Monteiro, M. and Anderson, T. (2012). Anticancer properties of hydroxycinnamic acids – A review. *Cancer Clinical Oncology*, 1, 109 – 121.

Saunders, O. (2018). Giude to using wood ash as an agricultural soil amendment. University of New/Hampshire Cooperative Extension, 4. http://extension.unh.edu.

Stern, K. R. (1994). *Introductory Plant Biology*. W. C. Brown Publishers, 41 – 52.

Street, J. E. and Bollich, P. K. (2003). Rice production, chapter 3.2. In: C. W. Smith, RH Dildary eds. Rice Origin, History, technology and production. John Wiley and sons Inc., Hoboken, New Jersey, 271 – 296.

Tairu, A. O. Hotmann, T. and Schieberle, P. (1999). Identification of the key aroma compounds in dried fruit of xylopia aethiopica. In: J. Janic (ed), perspectives on new crops and new uses. ASHS press, Alacandria, VA, 474 – 478.

Udeozo, I. P., Okafor, G. U., Ike, O. C. and Eze, E. C. (2018). The efficacy of *Rhizophora racemosa* wood: An important study. *Federal University Wukari Trends in Science and Technology Journal*, 3(28), 977-980.

Upadhyay, A. and Kara, S. (2018). Brown rice: Nutritional composition and health benefits. *Journal Food Science Technology Nepal*, 10, 48 – 54.

Valentine, C. M. and Suleman, D. (2013). The Nutritional composition of four rice varieties grown and used in different food preparations in Kassena-Nankana district, Ghana. *International Research in Chemistry and Environment*, 3(1), 308 – 315.

Vaughan, D. A. (1994). The wild relative of rice: genetic hardbonta. *International Research Institute, Manila.*

Wordu, G. O., Orisa, A. C. and China, M. A. H. (2021). Nutrient and antinutrient composition of four rice varieties in Port Harcourt Meropolis. *Asian Food Science Journal*, 20(11): 90 – 100.