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Chemical composition, proximate and phytochemical analysis of *Irvingia gabonensis* and *Irvingia wombolu* peels, seed coat, leaves and seeds

Nkoli Marynnn MGBEMENA*,[1] Ifenna ILECHUKWU,[2] Felicia Uchechukwu OKWUNODOLU,[1] Joe-Vera Ogugua CHUKWURAH,[2] and Isioma Blessing LUCKY[2]

[1]*Department of Chemistry, Michael Okpara University of Agriculture Umudike, Abia State Nigeria*
[2]*Department of Industrial Chemistry, Madonna University Nigeria*

Abstract. The study focused on the proximate, minerals and phytochemical analysis of the leaves, seeds, seed coats and peels of *Irvingia gabonensis* and *Irvingia wombolu* from Uli in Anambra State Nigeria. The minerals concentrations (Ca, Zn, Fe, Mg) were determined with atomic absorption spectrometer (AAS) while sodium was determined with flame photometer. The trend in mineral concentration was Mg > Na > Ca > Zn > Fe. Phytochemical analysis revealed the presence of alkaloids, flavonoids and saponins in both species. The proximate analysis showed that the carbohydrates contents in the leaves and seeds of *I. wombolu* were 51.7±1.3% and 57.6±0.31% respectively, while the moisture content of the peels was 34.0±0.20%. The results of this study showed that the leaves, seeds, seed coats and peels of the two *Irvingia* species are potential sources of food nutrients and phytochemicals, and therefore should be maximally utilized.

Keywords: *Irvingia* species; proximate analysis; mineral analysis; phytochemical analysis.

1. Introduction

Irvingia species are economically important trees that grow in the wild forests of most West and Central African countries [1]. There are about seven species of *Irvingia* in Africa, i.e. *Irvingia excels* and *Irvingia grandiofolia* (Central Africa), *Irvingia gabonensis*, *Irvingia robur* and *Irvingia smithii* (West and Central Africa), *Irvingia wombolu* (West Africa) and *Irvingia malayana* (Southeast Africa). Of these species, two are predominantly found in Nigeria (*Irvingia gabonensis* and *Irvingia wombolu*). *Irvingia* spp. is commonly called African/bush/wild mango because of their mango like fruits [2, 3]. The fruits are ellipsoidal, 4 - 7cm long, with a fleshy mesocarp, green when unripe and yellow or light orange when ripe [4]. The pulp, kernel and fruit are edible both by man and animals, although bitter and acrid, with turpentine flavor [5]. The fruits are rich in oil and can be used in making bread, chocolate, cheese, butter, soap and feed cake. The kernels of the fruits are considered to be the most valuable component for various reasons. They are rich source of fat, oil and protein and are used widely as condiments in thickening of sauce [2]. *Irvingia gabonensis* and *Irvinga wombolu* are similar and are often difficult to differentiate from herbarium specimens alone [1]. However, the two may be distinguished by edibility of the fruit mesocarp. Harris [1] also mentioned the density of fibers in the mesocarp, the amount of mucilage in the cotyledons, the size of the endosperm, the height of first branching, the disc shape in unfertilized flowers and the shape of the tree as diagnostic characters. *Irvingia gabonensis* fruit can be eaten as fruit. The sweet pulp can be juiced or used for making smoothie, jelly, jam and wine. The seeds can be pressed for vegetable oil or margarine. The dried dika nut seeds can be ground and used for preparing "*ogbono*" soup, stew, chocolate and dika bread. Ngodi *et al.* [3] opined that *ogbono* seed is capable of reducing fasting blood glucose levels in obese beings. Furthermore, a study evaluated the anti-diabetic properties of *Irvingia gabonensis* leaf and bark extracts on alloxan induced diabetic rats [6]. The study showed that the aqueous extracts of leaf and bark of *Irvingia gabonensis* had more anti-diabetic activity than ethanolic extracts. Okoro [7, 8] screened the water and ethanol extracts of the powdered stem bark to ascertain the analgesic effects of this fruit. The results were further compared with standard analgesic drugs. The study suggests that the water extract has analgesic effects similar to a narcotic analgesic. Dika nut contains sticky wax (mucilage) that has useful excipient properties for making medicinal tablets. The wax acts as a binding agent during tablets production. Studies reveal that tablets manufactured with bush mango have increased bitterness and reduced tensile strength when compared to gelatin tablets [3]. The study validates that obese patients given *Irvingia gabonensis* had a significant decrease in low density lipoprotein (LDL) cholesterol, triglycerides, and total cholesterol with an increase in high density lipoprotein (HDL) cholesterol. This suggests that *Irvingia gabonensis* is suitable for regulating the serum cholesterol levels.

Ekpe *et al.* [9] support that bacterial and fungal infections can be treated with the methanolic extract of *Irvingia gabonensis*. The decocted bark can be used in the treatment of diarrhea and dysentery. The bark can also be mixed with palm oil for treating diarrhea. Dika nut fruit can be eaten to improve bowel functioning and for preventing constipation because it is rich in dietary fiber. The powdered kernels can be used as an astringent to soothe burns and reduce bleeding from minor

*Corresponding author. *E-mail address:* nkolimgbemena@gmail.com (Nkoli Marynnn Mgbemena)

abrasions [10]. The stem of the tree also serves as chewing sticks for cleaning teeth [11]. The plant though being highly explored still lacks sufficient evidences to ascertain the best variety and parts possessing the highest degree of medicinal, nutritive and mineral values. The study therefore aimed at evaluation of the leaves, peels, seeds and seed coats of *I. wombolu* and *I. gabonensis* to ascertain which of these parts has more of the mineral nutrients and phytochemicals.

2. Experimental

2.1. Collection and preparation of samples

Twenty fresh fruits and 100 g of leaves of each of *Irvingia spp*. were plucked from the trees in March, at Uli in Anambra State, Nigeria and carried to the laboratory for analysis using polythene bags. Both the fruits and leaves were washed thoroughly to remove sand particles and debris. The two species were identified by a botanist in the Department of Pharmacognosy, Faculty of Pharmacy, Madonna University Nigeria. The seed coats and peels were separated from the fleshy pulp with knife and air dried under a shade for three days. This was done to exclude direct sunlight in other to prevent the active constituents from being degraded. The dried leaves, peels, seeds and seed coats were milled separately with blender and stored in airtight containers at 4 ^{o}C until required for analysis.

2.2. Proximate analysis

Samples were analyzed for percentage moisture, ash, crude lipid, crude protein, carbohydrates and crude fiber using AOAC 2016 methods [12]. Moisture was determined by drying to constant weight while protein was determined using Kjeldahl method. Ash content was determined with Loss-on-Ignition method.

2.3. Mineral analysis

1 g of each sample was digested with 10 % HNO_3 after ashing. The sample was filtered after digestion and the filtrate made up to 100 mL with distilled deionized water. Atomic Absorption Spectrometer (Buck Scientific East Norwalk, USA) was used to determine the concentration of Fe, Mg, Zn, and Ca, while Flame Photometry (Jenway Ltd, Dunmow Essex UK) was used for the determination of Na.

2.4. Phytochemical analysis

Phytochemical analysis was done on two extracts (methanolic and aqueous extracts) of the powdered samples. 10 g of each powdered samples were transferred into a conical flask and the extracting solvent (90 % methanol) was added. The mixture was shaken vigorously to ensure proper mixing between the samples and the solvent. It was then kept for 24 hours after which it was sieved, and the filtrate stored in the refrigerator prior to analysis. Aqueous extraction followed the same procedure with distilled water as the extracting solvent. Qualitative phytochemical analysis of the extracts was carried out using the methods of Harbone [13] and Abdulrahman *et al.* [14]. Wagner's reagent and Meyer's reagent were used to test for alkaloids, while ferric chloride was used to test for flavonoids. Salkowski test was used to determine steroids while Frothing test was used for the saponins and the terpenoids were determined with sulfuric acid and chloroform while glycosides were determined using Keller-Killian test [15].

3. Results and discussion

Table 1 shows the proximate composition of *Irvingia gabonensis* and *Irvingia wombolu* leaves, peels, seeds and seed coats samples. The moisture contents in seeds, leaves, peels and seed coats of *Irvingia gabonensis* were 1.4±0.41%, 22.2±0.11%, 38.7±0.01%, and 57.6±0.90% respectively. In *Irvingia wombolu*, the moisture contents were 6.5±0.41%, 9.4±0.02% 9.8±0.14% and 13.24±0.13% in seeds, leaves, seed coats and peels respectively. *Irvingia gabonensis* had higher moisture content than *Irvingia wombolu*. High moisture content in fruits is an index of its water activity, measure of stability and susceptibility to microbial contamination [15]. *I. wombolu* is less susceptible to microbial contamination given the less moisture content. The ash contents in peels and seed coats of *I. gabonensis* were 0.75±0.11% and 6.8±0.12% respectively. The leaves and seed coats had the same ash contents of 2.4±0.12%. The ash content in *I. wombolu* were 6.3±0.20%, 14.5±0.11%, 22.9±0.04%, and 34.00±0.20% in seeds, seed coats, leaves and peels respectively. Ash content in this work was higher than that of Ekundayo *et al.* [16] where ash ranged from 3.30% to 2.43% and that of Adeyeye [17] with ash content of 2.4% and 2.5% in *I. gabonensis* and also related to the work of Efosa *et al.* [18]. Ash content in food is the inorganic residue left after the removal of moisture and organic matter. It provides the measure of the total amount of minerals within a food. The result of this work showed high ash contents in the peels and leaves of *I. wombolu* and low ash contents in the peels and seed coats of *I. gabonensis*. Therefore, the peels and leaves of *I. wombolu* should not be discarded or allowed to waste away. *I. wombolu* showed higher value of crude fat. Dietary fat is the major source of energy. The daily recommended value of not more than 30 calories should not be exceeded to avoid obesity, diabetes and heart diseases. Crude fiber contains indigestible cellulose which helps to absorb water, provide roughage and better functioning of the alimentary system. Protein contents contribute positively to the requirement for biomolecules needed for repair and maintenance of the body tissues as well as synthesis of vital hormones for the body [19, 20]. The seed of *I. gabonensis* had the highest carbohydrates content. So by eating the seed of *I. gabonensis* a lot of energy is acquired.

Table 1. The proximate composition of *Irvingia gabonensis* and *Irvingia wombolu*

	I. gabonensis				***I. wombolu***			
Percentage (%)	Leaves	Peels	Seed	Seed coat	Leaves	Peels	Seed	Seed coat
Moisture	22.2±0.11	38.7±0.01	1.4±0.11	57.6±0.10	9.4±0.02	13.24±0.13	6.5±0.41	9.8±0.14
Ash	2.4±0.12	0.75±0.11	6.8±0.12	2.4±0.12	22.9±0.04	34±0.20	6.3±0.20	4.5±0.11

	I. gabonensis				***I. wombolu***			
Crude lipid	2.1±0.01	1.6±0.12	7.9±0.01	1.59±0.12	3.1±0.20	1.2±0.10	37.9±0.95	2.2±0.01
Crude fibre	11.8±0.02	19±0.21	21.6±0.45	16.7±0.12	18.1±0.21	22.5±0.18	20±0.18	25.4±0.11
Crude protein	98±0.11	7.7±0.12	5.6±0.20	6.65±0.11	7.7±0.01	6.3±0.01	8.4±0.20	9.45±0.01

Table 2. Mineral composition of *Irvingia gabonensis* and *Irvingia wombolu*

	I. gabonensis				***I. wombolu***			
Metal (mg/kg):	Leaves	Peels	Seed	Seed coat	Leaves	Peels	Seed	Seed coat
Iron	0.280±0.02	0.237±0.01	0.040±0.02	0.395±0.00	0.474±0.00	0.462±0.01	0.304±0.02	0.565±0.01
Magnesium	41.138±0.00	4.911±0.01	27.944±0.02	4.176±0.01	20.528±0.01	24.750±0.00	11.717±0.02	7.501±0.01
Zinc	3.829±0.02	2.984±0.01	2.937±0.02	3.466±0.01	2.985±0.01	4.298±0.02	1.937±0.02	3.188±0.01
Sodium	8.977±0.02	5.263±0.01	7.297±0.02	5.372±0.02	6.373±0.02	10.372±0.01	4.992±0.02	9.466±0.02
Calcium	4.222±0.02	3.928±0.01	3.278±0.01	4.992±0.01	5.229±0.01	5.786±0.002	6.373±0.00	3.772±0.02

Table 2 shows the mineral contents of *I. gabonensis* and *I. wombolu* leaves, peels, seeds and seed coats. The highest concentration of Fe in *I. gabonensis* was found in seed coats (0.395±0.00 mg/kg) while the lowest was found in the seeds (0.040±0.00 mg/kg). The same trend was observed in *I. wombolu* seed coats (0.565±0.01 mg/kg) and seeds (0.304±0.00 m/kg). *I. wombolu* had a higher concentration of iron than *I. gabonensis*. The level of iron in this study did not agree with the work of Ujowundu *et al.* [21] that found low Fe in the seeds of *Dacryodes eldulus* but agreed with the work of Ibrahim *et al.* [22]. The seed is therefore recommended for eating due to its high iron content. *I. wombolu* contained higher concentration of sodium than *I. gabonensis*. The trend in the level of concentration of sodium in *I. wombolu* was peels > seed coats > leaves > seeds.

For calcium, the level of concentration was higher in the seed coats (4.912±0.01 mg/kg) and lower in the seeds (3.278±0.01 mg/kg) in *I. gabonensis*, while in *I. wombolu* the highest concentration was in the seeds (6.373±0.01 mg/kg) and the lowest concentration was in the seed coats (3.772±0.02 mg/kg). The level of calcium in the study agreed with the work of Ujowund u *et al.* [21]. For most of the minerals determined, *I. wombolu* had the highest concentrations than *I. gabonensis*. The result of the mineral concentration in this study was lower than the work of Adeyeye [17] which had sodium (26.2 mg/kg), calcium (35.1mg/kg) and zinc (6.20 mg/kg).

Mineral content in food is a measure of the amount of specific inorganic components present within the food. Minerals act as co-factors for enzyme reactions. Sodium, calcium and magnesium are required in major quantities. Sodium acts as charge carriers and is a major factor in extra cellular fluid. It also participates in the functioning of muscle nerve [23].

Table 3. Results for phytochemical screening of *Irvingia gabonensis* aqueous extract (AE) and methanolic extract (ME)

		Leaves		**Seeds**		**Peels**		**Seed coats**	
Phyto-chemicals	**Tests**	**AE**	**ME**	**AE**	**ME**	**AE**	**ME**	**AE**	**ME**
Alkaloids	Wagner's test	++	+	+	+	-	+	-	+
	Meyer's test	+	+	++	+	+	++	+	++
Flavonoids	Ferric chloride test	++	+	++	+	+	+	++	++
	10% Lead acetate test	+	++	-	-	+	++	++	+
Tannins	5% Lead acetate test	+	+	-	-	+	+	+	+
	HCl test	++	+	-	-	-	-	+	+
Cardiac glycosides	Keller Killiani	+	-	+	+	-	++	+	++
Terpenoids	Salkowski	+	++	+	+	-	+	+	++
Saponins	Water	+	+	+	+	+	++	Slightly +	+
	Olive oil	+	+	+	+	+	++	+	+
Steroids	Salkowski	+	-			++	-	++	++

(+): presence (moderate amount); (++): presence (high concentration); (-): absence.

Table 4. Results for phytochemical screening of *Irvingia wombolu* aqueous extract (AE) and methanolic extract (ME)

		Leaves		**Seeds**		**Peels**		**Seed coats**	
Phyto-chemicals	**Tests**	**AE**	**ME**	**AE**	**ME**	**AE**	**ME**	**AE**	**ME**
Alkaloids	Wagner's test	+	+	+	+	+	+	+	+
	Meyer's test	++	+	+	+	+	+	+	+
Flavonoids	Ferric chloride test	++	+	+	+	+	+	+	+
	10% Lead acetate test	+	+	+	-	++	+	Slightly +	Slightly +
Tannins	5% Lead acetate test	+	+	+	-	+	+	-	-
	HCl test	+	+	-	-	-	+	-	-
Cardiac glycosides	Keller Killiani	++	-	-	+	+	+	Slightly +	++
Terpenoids	Salkowski	+	Slightly +	+	+	+	-	Slightly +	+
Saponins	Water	+	-	+	Slightly +	++	++	++	+

		Leaves		Seeds		Peels		Seed coats	
Phyto-chemicals	**Tests**	**AE**	**ME**	**AE**	**ME**	**AE**	**ME**	**AE**	**ME**
	Olive oil	+	+	+	+	++	++	++	+
Steroids	Salkowski					++	-	+	+

Table 3 shows the phytochemical screening results of *I. gabonensis* while Table 4 shows that of *I. wombolu* leaves, seeds, peels and seed coats. The results revealed the presence of alkaloids, tannins, flavonoids, terpenoids, steroids, saponins and glycosides in both species of *Irvingia* in varying quantities. These compounds are known to be biologically active and therefore aid in the antimicrobial activities [24].

Phytochemicals like alkaloids, flavonoids, terpenoids, steroids, saponins are present in both extracts (aqueous and methanolic) of the *Irvingia* species studied. There are flavonoid units with several degrees of condensation [25]. The flavonoid pigments are water soluble. Flavonoid protects plants against damaging effect caused by UV-radiation and anti-microbial infection [26]. It possesses antioxidant and hormonal activity imitating human ostrogen and helps to reduce menopausal symptoms and osteoporosis, increased blood flow and oxygenation of the cells and tissue [27, 28]. Flavonoids provide beneficial effects on capillaries and absorb oxygen radicals that cause skin oxidation through their antioxidant properties. Flavonoids in general help to reverse age related declines in cognitive function by increasing the number of connections among neurons which could help prevent and treat a variety of neurogenerative disorder [29]. The peels of both species of *Irvingia* had high levels of saponin. The nutritional significance of saponins stems largely from their hypo cholesterolemic action, leading to the belief that they may prove useful in the control of human cardiovascular diseases [17]. Terpenoids are used traditionally for medicinal purposes and currently being explored as anti-cancer agents in clinical trials. It exhibits cyto-toxicity against a variety of tumor cells as well as anticancer efficacy in preclinical animal models [30].

4. Conclusions

Proximate composition of *Irvingia gabonensis* and *Irvingia wombolu* species revealed the presence of carbohydrate, crude protein, crude fiber, crude lipid and moisture in varying amount in the various parts investigated. *Irvingia* species are therefore considered important due to their various food components. Minerals like magnesium, sodium, calcium and zinc were available in the various parts of these two species and iron had the least concentration. The leaves of *I. gabonensis* contained the highest concentration of minerals among the parts studied while the peels of *I. wombolu* had the higher concentration of minerals. Phytochemical analysis revealed the presence of alkaloids, flavonoids, tannins, glycosides, terpenoids, saponins and steroids in both species. The presence of these phytochemicals, minerals and other food components renders the *Irvingia* species very valuable as food nutrients and in reduction of various disease states. The *Irvingia* species are therefore recommended for their nutrient value. The various parts of these species especially the leaves and peels are very valuable and should be highly recommended.

Conflict of interest

No conflict of interest declared.

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