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Comparative Study of Phytochemical and Nutrient Contents of Various Parts of *Irvingia gabonensis* (Aubry-Lecomte ex O' Rorke) Baill. and *Irvingia wombolu* Vermoesen

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Abstract: The phytochemical and nutrient constituents of seed, leaf, stem bark and root bark of *Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill. and *I. wombolu* Vermoesen were determined and compared with a view to providing additional taxonomic characters for differentiating between the two species, and to supply useful information that would lead to increased utilization of parts of these species in ethnobotany as food and drug. Significant difference was established at $p<0.05$. The phytochemical analysis of *Irvingia gabonensis* revealed the greatest levels of alkaloid, anthraquinone, flavonoid, saponin and sterol in stem bark at 2.78±0.02%, 3.17±0.01%, 1.17±0.01%, 0.91±0.01% and 0.25±0.00% respectively; hydrogen cyanide and tannin in seed at 4.78±0.03 mg/kg and 1.25±0.00% respectively while terpenoid in the leaf was 0.45±0.00%. Least values of alkaloid, saponin, sterol, tannin and terpenoid were found in the root bark of *I. wombolu* at these values: 0.93±0.01%, 0.56±0.04%, 0.05±0.00%, 0.78±0.02% and 0.13±0.01% respectively. Nutrient determination of *I. gabonensis* and *I. wombolu* had carbohydrate as the highest nutrient with 68.44+0.04% in the root bark and 56.86±0.47% in the stem bark while lowest fat content was present in the root bark of *I. gabonensis* and stem bark of *I. wombolu* at 1.45±0.02% and 1.65±0.00% respectively. It was also observed that the seeds of *Irvingia gabonensis* and *I. wombolu* contained high percentage of crude protein at 17.43±0.03% and 16.61±0.01% respectively. These chemical characters could be applied as additional taxonomic parameters in distinguishing between these two species of *Irvingia*. In addition, the findings have shown that these various parts of both species could be useful in pharmaceutical preparations and ethnobotany as food and drug.

Keywords: Alkaloid, Anthraquinone, Chemical Characters, Fibre, Nutritional Composition, Protein

1. Introduction

Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill. and *I. wombolu* Vermoesen belong to the family Irvingiaceae. The distinction between two forms of *Irvingia gabonensis* was made by Okafor [1]; recognising *I. gabonensis* var. *gabonensis*, which has a sweet edible pulp, and *I. gabonensis* var. *excelsa*, which has a bitter inedible pulp. *I. gabonensis* var. *excelsa* was later raised to species status by Harris [2], naming it *Irvingia wombolu* [3].

The habit of the two species look alike, although they are generally distinguished by the relative small size of the fruit of *I. wombolu*, and the edibility and taste of the fruit mesocarp of *I. gabonensis*. It has been stated that distinction between the herbarium specimens of these two species of *Irvingia* is many times difficult, as a result of their similarity [2]. Proper identification of plants is of utmost importance in phytotherapy. This study therefore, aimed at providing additional taxonomic characters for differentiating between the two species.

In addition, various parts of *I. gabonensis and I. wombolu* have a wide range of economic potentials; but only the seed and pulp are fully utilized, leaving other parts untapped. The seeds are highly valued because of the slimy consistency they

produce, with *I. wombolu* having a greater degree; hence, they are locally used as soup thickening agents in Southeastern and Western parts of Nigeria. The seeds of these two species of *Irvingia* were extensively evaluated for only the nutrient contents [3, 4, 5, 6, 7]. This is probably as a result of the great ethnobotanical usefulness of the seeds as food. It is therefore, needful to study the phytochemical and nutrient compositions of the leaf, root bark and stem bark of *I. gabonensis* and *I. wombolu* as well as the seeds, with the intention of providing useful information that would lead to increased utilization of these parts of the plants in ethnobotany as food and drug.

2. Materials and Methods

2.1. Sample Collection

The plant materials used (leaf, stem bark, root bark and seed) of *I. gabonensis* and *I. wombolu* were obtained from a farm land at Ndiagu village, Mbaukwu, Anambra State, Nigeria in the month of July. The specimens were identified by an authority and the voucher specimens were deposited at the herbarium of the Department of Botany, Nnamdi Azikiwe University, Awka, Nigeria.

2.2. Preparation of Samples for Analyses

The fresh plant samples were dried at room temperature for 4 weeks and then the stem bark, root bark and leaf were ground to powder using an electric blender (Nakai, Japan), while the seeds were ground using pestle and mortar. The dried powdered samples were stored in an air tight container and subsequently used for the various analyses.

2.3. Quantitative Phytochemical Determination

Determinations of alkaloid, flavonoid and saponin contents were done by Alkaline Precipitation Gravimetric, Gravimetric and Double Solvent Extraction Gravimetric methods respectively, as described by [8]. The concentration of phenols was determined using the Folin-Ciocaltean Spectrophotometer [9]. Tannins content was determined by Folin Denis Colormetric method of Kirk and Sawyer [10]. Hydrogen cyanide (HCN) determination was carried out with Alkaline Pikrate Colorimeter method of Trease and Evans [11]. Sterol determination was done using method outlined by Harborne [12]. Total terpenoid content of the two plant species was determined by the method described by Ferguson [13]. Anthraquinone determination was carried out with the method outlined by Ezeabara and Okonkwo [14].

2.4. Nutrient Analysis

Total ash content was determined using the Incineration Gravimetric method [15]. Carbohydrate, crude fibre, crude protein, fat and moisture concentrations were evaluated with difference method {% CHO (nfe) = 100 - % ash + % crude fibre + % crude protein + % fat + % moisture contents}; Weende method; Kjeldahl digestion method (% Crude protein =% N x 6.25); Soxhlet extraction system and Gravimetric method respectively [16].

2.5. Statistical Analysis

Kolmogorov–Smirnov Test and Leven Median Test were used to check all the data for normality and homogeneity respectively. The data were then analyzed at a significant difference of $p<0.05$ with F-Test. The means were separated using Duncan's Multiple Range Test (DMRT). The data were then presented as mean ± standard error of three determinations.

3. Results and Discussion

The results of the phytochemical and nutrient determinations were shown in Tables 1 and 2 respectively. There was variation in alkaloid, tannin, saponin, sterol, flavonoid, terpenoid, phenol, hydrogen cyanide and anthraquinone values found in the various parts of *I. gabonensis* and *I. wombolu*. This is indicative that the degree of accumulation of the secondary metabolites which occurred in different parts of these two plants varied. A report had it that both species of *I. gabonensis* and I. *wombolu* had the same amounts of flavonoids and glycosides, *I. wombolu* possessed relatively higher amounts of alkaloids, saponins and tannins than *I. gabonensis* on wet matter basis [17]. Secondary metabolites occur naturally in plants and serve as natural defense mechanism against herbivory and pathogen attacks. They are also responsible for therapeutic potentials of plants; their presence and level contribute to the medicinal application of both whole and plants' parts.

There was no significant difference ($p>0.05$) between the quantity of alkaloid present in the seeds of *I. gabonensis* and *I. wombolu*. Highest concentrations of alkaloid were present in the stem bark and leaf of *I. gabonensis* at 2.78±0.02% and 2.44±0.01% respectively (Table 1). Theraupeutic applications of bark of *I. gabonensis* have been extensively reported in various studies [3, 18, 19, 20]. The medicinal applications of bark of *I. gabonensis* are presumably as a result of the presence of alkaloid as well as synergistic effect of other bioactive agents that were available. In addition, the potential benefit of *Irvingia gabonensis* for weight loss was reported [21], which could also be as a result of the alkaloid content. Percentage flavonoid was highest in the stem bark of *I. gabonensis* at 1.17±0.01. There was no significant difference ($p>0.05$) between the flavonoid values of seed of *I. gabonensis* and *I. wombolu*. Flavonoids are known to possess anti-inflammatory and antimicrobial potentials. Tannin level was highest in the seed of *I. gabonensis* and lowest in the root bark of *I. wombolu* at 1.25±0.00% and 0.78±0.02% respectively. There was no significant difference ($p>0.05$) between the tannin contents of root bark of *I. gabonensis* and *I. wombolu*. It has been reported that tannin can hasten up healing of wounds in a flamed membrane [22]. This is probably as a result of its antiseptic nature. There was no significant difference between the saponin concentrations of stem bark, leaf and root bark of *I. gabonensis* and *I.*

wombolu. There was also no significant difference between the sterol levels of root bark of the two species. Highest levels of saponin at 0.91±0.01% and sterol at 0.25±0.00% were found in the stem bark of *I. gabonensis*, whereas they were least in the root bark of *I. wombolu*. There was no significant difference ($p>0.05$) between the phenol compositions of all the various parts of *I. gabonensis* and *I. wombolu*. Hydrogen cyanide content of stem bark, leaf, root bark and seed of *I. gabonensis* were greater as compared with *I. wombolu*; suggesting that *I. gabonensis* accumulated greater level of hydrogen cyanide. Besides, the seeds of both species contained high concentration of hydrogen cyanide. The amount of cyanogenic glycosides in plants is usually reported as the level of releasable hydrogen cyanide [23] and is deadly in humans and animals at high dosages. The toxicity effect of hydrogen cyanide is dose, body weight and duration dependent [24]. However, their concentration could be reduced by processing, thereby eliminating the toxic effect. The degree of accumulation of hydrogen cyanide could be used as a delimitating factor in distinquishing between these two species of *Irvingia*. Anthraquinone levels were found in high concentrations in the various parts of both species with the highest quantity in the stem bark of *I. gabonensis* at 3.17±0.01%. There was no significant difference between the anthraquinone contents of stem barks of both species ($p>0.05$). Anthraquinone has been mixed with lanolin and used as a wool spray to protect sheep flocks against kea attacks in New Zealand [25]. It has also been reported that five anthraquinones have been shown to inhibit the formation of Tau aggregates and dissolve paired helical filaments thought to be critical to Alzheimer's disease progression in both mouse models and *in vitro* testing but have not been investigated as a therapeutic agent [26]. The values of terpenoid were highest in the leaf of *I. gabonensis* at 0.45±0.00% and lowest in the root bark of *I. wombolu* at 0.13±0.01%. There was no significant difference ($p>0.05$) between the amount of terpenoid in the root bark of *I. gabonensis* and *I. wombolu*. Terpenoids have a wide range of economic applications, including being used as insecticides and therapeutic agents against diverse diseases. Generally, there were relatively low values of phenol, sterol and terpenoid in parts of *I. gabonensis* and *I. wombolu*.

The two species contained great nutritional values. The levels of carbohydrate, crude fibre, crude protein and fat were relatively high (Table 2). Crude fibre content was highest in the root bark of *I. wombolu* at 17.64±0.16% and least in the seed of *I. gabonensis* at 4.18±0.00%. The seed of *I. gabonensis* contained the highest level of crude protein at 17.43± 0.03%, followed closely by the seed of *I. wombolu* at 16.61±0.10%, while it was least in the stem bark of *I. gabonensis* at 5.28±0.12%. Considerable value of carbohydrate was observed in the stem bark, root bark and seed of *I. gabonensis* and *I. wombolu* while lower level occurred in their leaf. The greatest percentage of fat was found in the seeds of the two species and the seed of *I. gabonensis* contained the higher value at 9.81±0.01%. The quantity of fat was also high in the root bark of *I. wombolu* at 5.78±0.02%. Ash content was highest in the leaf of *I. wombolu* at 10.66±0.04% level and lowest in the seed of *I. gabonensis* at 4.66±0.04%. High values of moisture were detected in the various parts of these two species of *Irvingia*, with the highest level present in the seed of *I. gabonensis* at 11.54±0.13% and lowest in the root bark of *I. wombolu* at 7.85±0.01%. The percentage levels of ash, carbohydrate, crude fibre and crude protein found in the seed of *I. wombolu* at 4.79±0.11, 54.25±0.23, 16.61±0.01 and 4.36±0.00 respectively, were greater than the values reported by Ainge and Brown [3], Ejiofor *et al.* [5] and Ejiofor [6] at 2.46, 26.02, 0.86 and 7.42 respectively; while the fat at 8.45±0.06% and moisture at 10.33±0.08% contents of the seed of *I. wombolu* were lower than the values they stated, which were 51.32% and 11.9% respectively. Stem bark, leaf, root bark and seed of *I. gabonensis* and *I. wombolu* could provide appreciable levels of carbohydrate, fibre, protein and fat for promoting good health and vitality for both human and livestock.

In a previous study, the nutritional values of cormels of *Colocasia esculenta* var. *antiquorum* (L.) (Schott) Hubbard & Rehder and *C. esculenta* var. *esculenta* (L.) (Schott), which are varieties of *Colocasia esculenta* agronomically known as eddoe and dasheen respectively; and also primarily used as local soup thickeners in Southeastern part of Nigeria were reported [27]. The percentage ash, crude fibre and carbohydrate contents of seeds of *I. gabonensis* at 4.66±0.04, 4.18±0.00 and 52.40±0.12 and *I. wombolu* at 4.79±0.11, 4.36±0.00 and 55.38±0.22 respectively were lesser in marked contrast to the values they reported present in cormels of *Colocasia esculenta* var. *antiquorum* at 7.62±0.02, 0.65±0.04 and 70.73±0.04, and *C. esculenta* var. *esculenta* at 7.34±0.06, 0.51±0.02 and 71.59±0.14 respectively, whereas fat and protein levels were higher in *I. gabonensis* at 9.81±0.01% and 17.43±0.03%; and *I. wombolu* at 8.45±0.06% and 16.61±0.01% in comparison with *Colocasia esculenta* var. *antiquorum* at 0.92±0.01% and 8.31±0.01% and *C. esculenta* var. *esculenta* at 0.86±0.03% and 8.32±0.02% respectively, as documented by the same study.

Table 1. *Mean quantitative phytochemical contents of the stem bark, leaf, root bark and seed of Irvingia gabonensis and I. wombolu.*

	Irvingia gabonensis				*I. wombolu*			
Compositions (%)	**Stem bark**	**Leaf**	**Root bark**	**Seed**	**Stem bark**	**Leaf**	**Root bark**	**Seed**
Alkaloid	2.78 ± 0.02^{g}	2.44 ± 0.11^{f}	1.49 ± 0.01^{b}	1.84 ± 0.00^{c}	2.04 ± 0.00^{d}	2.26 ± 0.00^{e}	0.93 ± 0.01^{a}	1.76 ± 0.00^{c}
Flavonoid	1.17 ± 0.01^{f}	1.07 ± 0.02^{e}	0.64 ± 0.02^{c}	0.13 ± 0.00^{a}	1.05 ± 0.01^{e}	0.85 ± 0.00^{d}	0.49 ± 0.01^{b}	0.10 ± 0.01^{a}
Tannin	1.05 ± 0.01^{c}	0.86 ± 0.01^{ab}	0.79 ± 0.01^{a}	1.25 ± 0.00^{d}	0.87 ± 0.04^{b}	1.06 ± 0.01^{c}	0.78 ± 0.02^{a}	1.17 ± 0.02^{d}
Saponin	0.91 ± 0.01^{c}	0.79 ± 0.01^{b}	0.64 ± 0.00^{a}	0.79 ± 0.01^{b}	0.85 ± 0.01^{c}	0.79 ± 0.01^{b}	0.56 ± 0.04^{a}	0.72 ± 0.00^{ab}
Sterol	0.25 ± 0.00^{bc}	0.22 ± 0.20^{bc}	0.08 ± 0.00^{a}	0.17 ± 0.02^{b}	0.19 ± 0.00^{b}	0.16 ± 0.00^{ab}	0.05 ± 0.00^{a}	0.13 ± 0.01^{ab}
Phenol	0.18 ± 0.00^{bc}	0.14 ± 0.00^{b}	0.09 ± 0.00^{ab}	0.06 ± 0.00^{a}	0.15 ± 0.00^{bc}	0.13 ± 0.01^{b}	0.08 ± 0.00^{ab}	0.05 ± 0.01^{a}
Hydrogen cyanide (mg/kg)	1.87 ± 0.03^{c}	3.45 ± 0.00^{e}	1.66 ± 0.04^{b}	4.78 ± 0.03^{f}	1.67 ± 0.03^{b}	2.87 ± 0.04^{d}	1.38 ± 0.03^{a}	3.21 ± 0.05^{e}
Anthraquinone	3.17 ± 0.01^{f}	2.37 ± 0.03^{d}	1.02 ± 0.00^{a}	1.78 ± 0.02^{b}	3.08 ± 0.01^{f}	2.82 ± 0.02^{e}	1.89 ± 0.03^{c}	2.28 ± 0.12^{d}
Terpenoid	0.32 ± 0.02^{bc}	0.45 ± 0.00^{d}	0.17 ± 0.01^{a}	0.25 ± 0.00^{ab}	0.28 ± 0.02^{b}	0.34 ± 0.00^{c}	0.13 ± 0.01^{a}	0.18 ± 0.00^{ab}

Values are mean ± standard error of three determinations. Rows with different superscripts are significantly different at $p<0.05$.

Table 2. *Mean nutrient contents of the stem bark, leaf, root bark and seed of Irvingia gabonensis and I. wombolu.*

	Irvingia gabonensis				*I. wombolu*			
Compositions (%)	**Stem bark**	**Leaf**	**Root bark**	**Seed**	**Stem bark**	**Leaf**	**Root bark**	**Seed**
Moisture content	9.43 ± 0.06^{d}	10.83 ± 0.07^{g}	8.91 ± 0.01^{b}	11.54 ± 0.13^{h}	9.17 ± 0.01^{c}	9.53 ± 0.08^{e}	7.85 ± 0.01^{a}	10.33 ± 0.08^{f}
Dry matter	90.58 ± 0.18^{e}	89.17 ± 0.07^{b}	91.09 ± 0.01^{g}	88.48 ± 0.13^{a}	90.83 ± 0.01^{f}	90.48 ± 0.08^{d}	92.15 ± 0.01^{h}	89.68 ± 0.08^{c}
Ash	7.72 ± 0.09^{d}	9.61 ± 0.09^{g}	6.58 ± 0.13^{c}	4.66 ± 0.04^{a}	8.76 ± 0.00^{f}	10.66 ± 0.04^{h}	8.66 ± 0.04^{e}	4.79 ± 0.11^{b}
Crude fibre	11.38 ± 0.03^{d}	15.34 ± 0.06^{e}	8.69 ± 0.09^{c}	4.18 ± 0.00^{a}	16.27 ± 0.03^{g}	15.88 ± 0.08^{f}	17.64 ± 0.16^{h}	4.36 ± 0.00^{b}
Fat	2.78 ± 0.02^{e}	1.86 ± 0.06^{c}	1.45 ± 0.02^{a}	9.81 ± 0.01^{h}	1.65 ± 0.00^{b}	2.54 ± 0.06^{d}	5.78 ± 0.02^{f}	8.45 ± 0.06^{g}
Crude protein	5.28 ± 0.12^{a}	14.78 ± 0.02^{e}	5.92 ± 0.00^{c}	17.43 ± 0.03^{h}	6.79 ± 0.01^{d}	15.42 ± 0.18^{f}	15.82 ± 0.02^{b}	16.61 ± 0.01^{g}
Carbohydrate	63.43 ± 0.43^{g}	47.58 ± 0.24^{b}	68.44 ± 0.04^{h}	52.40 ± 0.12^{c}	56.86 ± 0.47^{f}	45.98 ± 0.30^{a}	54.25 ± 0.23^{d}	55.38 ± 0.22^{e}

Data are mean ± standard error of triplicate determinations. Rows with same superscripts are not significantly different ($p>0.05$).

4. Conclusion

Different nutrients and phytochemicals were present in the various parts of *I. gabonensis* and *I. wombolu* in varying concentrations. The values of some of them were higher in parts of *I. gabonensis* and vice versa. The chemical characters provided by this study could be useful as additional taxonomic characters for distinction of *I. gabonensis* and *I. wombolu.* In addition, utilization of the leaf, stem and root bark of these two species of *Irvingia* as food and drug sources for both human and livestock is recommended; as a result of their high level of nutrient and phytochemical compositions. The consumption of raw seed of these species of *Irvingia* is highly discouraged due to the high hydrogen cyanide content.

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