Determination of Nutrients, Antinutrients and Antioxidants Concentrations in some edible Forest Vegetables in Ondo and Oyo State, South Western Nigeria

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ABSTRACT

Background: *Native plants are important forest resource commonly explored in traditional cuisines and ethnomedicine in developing countries. Unfortunately, these plants are used routinely with inadequate awareness of their nutrient quality and bioactive components.*

Objective*: This study aimed at investigating the nutritional values, anti-nutrient factors, and antioxidant properties of selected native vegetables that are most commonly consumed in Southwestern Nigeria.*

Method*: The target species were selected based on the preference of 80 respondents from eight different communities using a semi-structured questionnaire. Proximate, antinutrient, vitamins, and Antioxidants constituents were determined using standard methods.*

Results*: The nutritional composition reveals that S. biafrae leaves had the highest moisture (80.21%) and ash contents (3.82%). However, P. guineense leaves contain higher fibre (3.84%), protein (16.39%), and Carbohydrate (13.45%) content. Whereas P. mildbraedii leaves had a significantly high concentration of fat (0.94%). Very low antinutrient content was obtained from the vegetables, with S. biafrae having a significantly low level of phytate (1.24 mg/g), oxalate (0.09 mg/g), tannin (1.38 mg/g), and saponin (7.64 mg/g) compared to others. Antioxidants like phenol (9.75-15.78 mg.g^{-1}), Vitamin C (5.49-23.25 mg.g-1), and Vitamin A (278.25 – 705.64 unit.g-1)obtained from the vegetables have an endless supply of natural and vital nutrients that the body requires for good health*

Conclusion*: Distinctively, the choice vegetables can be reputed as remarkable repositories of essential nutrients, and pharmacologically relevant antioxidant molecules.*

Keyword: *Nutrients, Anti-nutrients, Antioxidants, Forest vegetable*

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INTRODUCTION:

In ancient times, inhabitants of the forest relied on their traditional knowledge to gather and consume various foods and leaves found in their surroundings. But with the advent of scientific research, it has become possible to determine the advantages and hazards of these plant materials

[1]. Importantly, millions of urban and rural populations in developing countries rely on forest foods as a source of income, essential nutrients, and energy requirements [1]. Native vegetables can inherently biosynthesize primary (proteins, lipids, carbohydrates) and secondary metabolites (vitamins, antioxidants nutrients and antinutritional factors). Meanwhile, the specie variations in the bioavailability of these essential nutrients may be attributed to climatic conditions and various biotic and abiotic stressors [2]. Interestingly, these phytochemicals may play vital roles in modulating various pathways of disease initiation and progression. Importantly, certain nutraceuticals are reputed as possessing outstanding antioxidative functions that can help to withstand metabolic crossfires from free radical attack. Forest zones in Nigeria affords an important repository of highly active bioactive compounds that are necessary for maintaining homeostasis [3]. Nevertheless, there is a growing concern that plants may also co-express varying amounts of antinutrients that may potentially perturb important metabolic processes when ingested in large quantity [4].

Despite the abundance of nutrient – rich native vegetal resources, it is worrisome that Africa is still experiencing a wide range of nutrient-related health problems. Regrettably, this may be attributed to poor awareness of the nutritional quality of plant foods, defective conservation techniques, and seasonal variations in the availability of vegetable plants[5][6].In light of the current sky rocketing trends in nutrient based health aberrations in developing nations, the exploration of commonly consumed vegetables and their nutrient composition is inevitable[7].This study aimed at evaluating the nutrient quality of commonly consumed vegetables across two forest zones in South Western Nigeria.

MATERIALS AND METHOD

Plant Source

The vegetables used for the study were procured from four local communities in Oyo (Ijaye, Bodija, Lagbeja and Bamidele) and Ondo (Ilara-Mokin, Odopetu, Ala and Igbara Oke) states, 2 south Western Nigeria. Oyo state has an equatorial climate while Ondo state has a tropical rainforest climate. Both states have predominantly Yoruba populations.

Plant Identification and Storage

The raw samples were identified and authenticated by the Taxonomist in uthe Department of Forestry and Wood Technology, the Federal University of Technology, Akure, Nigeria. Matured leaves of the vegetables were sorted and homogenized to obtain uniform samples. The crude homogenate was kept at ambient temperature (28 °C) until when needed.

Study Participants

A semi-structured questionnaire was developed to obtain information on the forest vegetables that are consumed in selected states (Oyo and Osun State) in Southwestern Nigeria from therespondent which was administered through personal interviews. Four local communities (Oyo (Ijaye, Bodija, Lagbeja and Bamidele) and Ondo (Ilara-Mokin, Odopetu, Ala and Igbara Oke) states) were randomly selected from each state making a total of eight (8) communities. Ten respondents were randomly selected from the eight communities making a total of eighty respondents. The target species for laboratory investigation were selected after obtaining detailed information through ranking of the forest vegetables based on popularity.

Proximate Analysis

Proximate content (moisture, ash, crude fiber, carbohydrate, and crude protein) of the selected vegetable plants was determined according to standard procedures described by the Association of Official Analytical Chemists [8].

Determination of Flavonoid, Phenol and Vitamin Compositions of the Vegetables

The flavonoid content was determined by a colourimeter assay developed by [9]. Using [10] method, phenol was identified by incubating an extract combination with Folinciocalteau's reagent. [11]method was used to calculate the vitamin C content using ascorbic acid as the reference compound. The vitamin A content was determined using the method of [12] while the vitamin B1

(Thiamin) was determined using the method of [13].

Determination of Antinutrient Content of the Vegetables

Tannin was determined using spectrophotometric method as adopted by [14]. The spectrophotometric method of [15]was used for Saponin determination. However, [16] method were adopted in determining oxalate while the phytate component was determining by titrating against iron (iii) chloride solution using [17]method.

Statistical Analyses

Data obtained arepresented as mean and standard deviation computed from triplicate values. The data collected was subjected to analysis of variance (ANOVA) while the significant level was set at $p<0.05$.Data obtained from the questionnaire are presented in form of tables, frequency and percentage. Analyses were performed using SPSS software (version 20.0).

RESULTS

Demographic Characteristics of respondents in the Sampling Area

Table 1 provides a breakdown of the characteristics of the respondents. The gender composition shows that 68.8% of the respondents were female, while 31.3% were male. In terms of age, 13.8% of the respondents were between 19-30 years old, 36.3% were between 31-40 years old, 20% were between 41-50 years old, and 30% were above 50 years old.

Regarding education, 12.5% of the respondents had no formal education, 27.5% had only primary education, 32.5% had secondary education, and 27.5% had tertiary education. Religion-wise, the respondents were predominantly Christians (68.8%), followed by Muslims (28.7%), and traditional worshippers (2.5%). Most of the respondents were married (80%), while 8% were single, 7.5% were widowed, 2.5% were divorced, and 1.3% were separated.

In terms of household size, the majority (68.8%) had a household size of 5-9 people, 28.7% had a household size of 2-4 people, and 2.5% had a household size of above 10 people. The Yoruba and Igbo tribes comprised 60% and 37.5% of the respondents, respectively, while the Hausa tribe accounted for 2.5%.

Occupationally, 40% of the respondents were engaged in trading, 32.5% were farmers, 20% were civil servants, and the remaining 2% had other occupations.

According to the study, only 15% of the respondents have planted the vegetables under investigation, while 85% rely on natural vegetation. The vegetables are obtained from various sources, with 38.8% from the market, 30% from farmland, 20% from the forest and trees outside the forest, and 11% from cocoa farms or cocoa agroforest. Most respondents prefer accessing the vegetables in the morning (66.35%), while a small percentage prefer the afternoon (1.3%) and the evening (32.5%). Additionally, the vegetables are available mostly in the dry season (56.3%) and sometimes in the rainy season (43.8%).

Preference of wild edible vegetables among the respondents

In Table 2, the study results on the preferred edible forest vegetables in the study area are presented. The data reveals that the most favored vegetable among the respondents was the African Rosewood plant (*Pterocarpusmildbraedii*), with a percentage of 21.3%. Following closely as the second most preferred species was African Spinach (*Seneciobiafrae*), with a percentage of 16.5%. The remaining species were ranked based on the frequency and percentage of preference. Notably, Black Plum (*Vitexdoniana*) was the least preferred vegetable among the respondents, with a percentage of 1.2%. The diversity of edible forest vegetables consumed in the study area is highlighted in the table, emphasizing the importance of these plants as a source of food and nutrition.

Proximate Composition

Table 3 presents the nutritional compositions of the leaves of *Pterocarpus mildbraedii*, *Piper guineense*, and *Senecio biafrae*. The moisture contents of the leaves were high and varied significantly among the species (P ≤ 0.05), with *Senecio biafrae* having a higher moisture content than *Pterocarpus mildbraedii* and *Piper guineense*. *Piper guineense* was found to be richer in fibre and protein compared to *Seneciobiafrae*, which had lower fibre and protein content (as shown in Table 4). Among the species investigated, *Seneciobiafrae*had the highest ash content, while *Pterocarpus mildbraedii* had the highest fat content (0.94%), followed by *Senecio biafrae*(0.53%) and *Piper guineense* (0.36%). The soluble carbohydrate content varied significantly between 4.37% and 13.45% in *Senecio biafrae* and *Pterocarpu smildbraedii*, respectively, accounting for the lowest and highest soluble carbohydrate reported. All the nutrients studied showed significant differences in values among the vegetables.

Antioxidant Values and Vitamin Compositions

Table 4 presents the antioxidant contents of the vegetables. The phenolic content ranged from 9.75 mg.g-1 in *Piper guineense* to 15.78 mg.g-1 in *Pterocarpusmildbraedii*, with the highest phenolic content observed in *Pterocarpusmildbraedii*. *Pterocarpusmildbraedii* also had a significantly higher (P ≤ 0.05) flavonoid concentration (1.82 mg.g-1) than *Piper guineense* (0.40 mg.g-1), while *Seneciobiafrae*had the lowest flavonoid concentration (0.11 mg.g-1). *Seneciobiafrae*had higher Vitamin C and Vitamin B1 content compared to the other vegetables investigated. However, *Pterocarpusmildbraedii* had significantly higher (P ≤ 0.05) Vitamin A content (705.64 unit.g-1) than *Seneciobiafrae*(301.26 unit.g-1), while the lowest Vitamin A content was recorded in *Piper guineense* (278.25 unit.g-1).

Antinutrient content

Table 5 shows that the antinutritional factors (saponin, tannin, oxalate, and phytate) varied significantly (P ≤ 0.05) among the vegetables. *P. guineense*had the highest saponin content (24.64 mg.g-1) among the vegetables studied, while *S. biafrae* had the lowest (7.64 mg.g-1). The lowest concentrations of tannin, oxalate, and phytate were also recorded in *S. biafrae*. The oxalate concentration in *P. guineense*and *P. mildbraedii* was very close (ranging from 1.71 to 1.94 mg.g-1). The phytate content varied significantly, with the highest value recorded in *P. mildbraedii* (11.54 mg.g-1) and the lowest in *S. biafrae* (1.24 mg.g-1).

DISCUSSION

In several ethnic groups with similar socioeconomic backgrounds, the consumption of traditional cuisines prepared with green leafy vegetables is a cross-cultural practice. According to the data from the present study, *Pterocarpus mildbraedii* (Oha), *Senecio biafrae*(Worowo), and *Piper guineense* (Uziza) are the most preferred sources of nutrition. *Pterocarpusmildbraedii* was found to be the most preferred, followed by *S. biafrae* and *P. guineense*. The study identified 10 families and 16 species of vegetables, with high ratings based on taste and availability[18]. Female respondents used these vegetables more frequently than male respondents. The respondents were predominantly Yoruba's and Igbos, with the Yoruba tribe showing a higher preference for *S. biafrae* and the Igbo tribe preferring *P. mildbraedii* and *P. guineense*. The majority of respondents did not grow these vegetables themselves but sourced them from the market, farmlands, trees outside forests, and within the forest.

Unfortunately, there is a decline in people's knowledge of wild edible vegetables, limiting information on the medicinal values of these vegetables. Allowing older generations to pass away with their vast knowledge of plants used for health, vitality, and rejuvenation poses a danger [19].

According to [20], vegetables are an essential component of a balanced diet that is widely consumed worldwide. The safety of green leafy vegetables has been extensively researched, and their nutrient content has been studied. [19]reported that *Piper guineense*, a medicinal plant commonly used in Edo and Ghana to treat gonorrhoea, is also added to soups to aid conception. [21]found that *P. guineense*leaves contain valuable compounds that are useful in both the food and pharmaceutical industries. Meanwhile, [19] have identified *S. biafrae* as an inexpensive source of nutrition and medicine that is accessible to people of all income levels, but this species is at risk due to invasive weeds, overharvesting, and herbicidal weed control.

However, food's stability and susceptibility to microbial contamination can be inferred from its moisture content, which is a measure of its water activity[21]. In the present study, the lower moisture content obtained for *P. guineense* was lower than that reported by [19], who found a higher moisture content of 76%. Notably, *P. mildbraedii* and P. guineense, *S. biafrae* had a higher moisture content. This showed that the vegetable should be eaten as soon as possible after harvest except proper storage conditions can be developed.

Moreover, the proximate compositions obtained in the present study is comparable to those of previous investigators. According to [22], *P. mildbraedii* is a useful source of nutrients and is on par with many protein-rich crops; as a result, it has the potential to be used as a protein source for human consumption in places where the cost of obtaining protein from animal products is prohibitive. This finding was substantiated the findings that *P. guineense*had a somewhat greater protein content, whereas *S. biafrae* had the lowest. Contrary to our findings, [19] reported a higher protein content for fresh *S. biafrae* leaves. [22] reported significantly higher crude protein and crude fat content for *P. mildbraedii* than was found in the current study. Crude protein concentration was within the range observed in this study, however values for crude fibre, ash, and fat were found to be greater in a study by [23]. In this study, *P. guineense* had the greatest fibre content of the three vegetables tested. Starch consumption is reduced and digestive health is enhanced when dietary fibre is consumed [18]. For quite some time now, it has been established that green leafy vegetables are an excellent source of dietary fibre [24]. [4] found that the leaves of Morindalucida have an unusually high quantity of carbohydrates, fibre, fat, and ash. Ash and carbohydarate levels in Parkia biglobossa flowers are the highest of any plant in our study, coming in at 6.50% and 79%, respectively [25]. The hypolipidemic activity of vegetable fats and oils has been demonstrated to be helpful in reducing the risk of hyperlipidemia-related diseases like cardiovascular disease, stroke, heart attack, and heart failure [26]. Possible salvation can be found in the low fat content of the investigated vegetables. The remarkable antioxidant content of vegetable plants makes them a well-reputed preventative food, with significant roles in human nutrition as a modulator of various disease pathways [27]. Encouraging the consumption of plants and plant products among locals can improve their diet and health. The vitamin C concentration in *Seneciobiafrae*leaves (23.25 mg.g-1) can help prevent problems associated with the immune system and other illnesses [28]. Flavonoids, found in vegetables, protect against allergies, inflammation, free radicals, platelet aggregation, bacteria, ulcers, hepatotoxins, viruses, and malignancies [3]. The study found that Solanum nigrum seed has a vitamin C content similar to that of *S. biafrae* leaves (23.38 mg/100g)[29], while S. nigrum leaves had a significantly higher vitamin C content. S. nigrum leaves also contained vitamin A (4.660.02 mg/100g) and vitamin B1 (17.140.01 mg/100g). The vitamins A, B1, and C content of *P. guineense* leaves were higher than those found in a 2016 study by [21] *P. mildbraedii* and *P. guineense* did not differ significantly in vitamin content, but *S. biafrae* had a higher vitamin B1 content and a significantly greater vitamin C concentration than the other vegetables listed in this study. Interestingly, native vegetables are remarkable repositories of important plant-based bioactive compounds, including vitamin C, which is a potent modulator of various disease pathways. *P. mildbraedii* has a higher phenol, flavonoid, and vitamin A concentration than *P. guineense*and *S. biafrae*, and its consumption may elicit antioxidant, anticarcinogenic, antibacterial, antiallergic, antimutagenic, and anti-inflammatory activities [30]. In developing nations where pharmaceutical supplements and vitamin A fortified meals are sparse, the consumption of widely available green leafy vegetables like *P. mildbraedii* may be beneficial in avoiding vitamin A deficiency (24).

In the study conducted by [24], it was found that phytotoxic compounds, such as oxalic acid, can be present in vegetable plants in varying amounts and patterns among species. Data obtained from the present study revealed low levels of oxalate and tannins in the samples, which is favorable since high concentrations of tannins in the diet can have negative effects. While [21] found lower levels of antinutrients, such as tannins, phytate, saponin, and oxalate, in *P. guineense*leaves than in this study, *P. mildbraedii* was found to contain significantly higher levels of phytate, tannin, and oxalate than *P. guineense* and *S. biafrae*. Additionally, the phytate content in *P. mildbraedii* and *S. biafrae* leaves was found to be higher than in the leaves, bark, and stems of M. lucida reported by [4]. On the other hand, *P. guineense* contained more saponin than the other vegetables investigated. Overall, the low level of antinutrients found in the vegetables indicates that their consumption may not pose any health challenges related to antinutrients.

CONCLUSION

This study found that traditional green leafy vegetables, including *Pterocarpus mildbraedii* (Oha), *Senecio biafrae* (Worowo), and *Piper guineense* (Uziza), are popular sources of nutrition among Yoruba and Igbo tribes in Nigeria. Additionally, the study found that these vegetables contained valuable nutraceuticals useful in the food and pharmaceutical industries. Unfortunately, threats such as urbanization, bush burning, deforestation, and seasonal changes pose a significant threat to their availability. The study suggests mitigating these threats through conservation, home gardening, domestication, and research into edible wild vegetables. To improve human nutrition and modulate various disease pathways, locals should be encouraged to consume more plants and plant products.

Table 1. Demographic and socio-cultural characteristics

Variables	Categories	F	%
Gender	Male	25	31.3
	Female	55	68.8
Age	19-30 years	11	13.8
	31-40 years	29	36.3
	41-50 years	16	20.0
	Above 50years	24	30.0
Level of Education	No Formal education	10	12.5
	Primary education	22	27.5
	Secondary education	26	32.5
	Tertiary education	22	27.5
Religion	Christianity	55	68.8
	Islam	23	28.7
	Traditional	2	2.5
Marital Status	Single	7	8.8
	Married	64	80.0
	Widowed	6	7.5
	Divorced	2	2.5
	Separated	1	1.3
Household size	2-4	23	28.7
	5-9	55	68.8
	Above 10	2	2.5
Tribe	Yoruba	48	60.0
	Igbo	30	37.5
	Others	2	2.5
Occupation	Civil service	16	20.0
	Farming	26	32.5
	Trading	32	40.0
	Others	6	7.5
Monthly Income	10,000 - 19,999	37	46.3
	20,000 - 29,999	21	26.3
	30,000 - 39,999	10	12.5
	40,000 - 49,999	6	7.5
	Above 50,000	6	7.5

Table 2. Preferred edible forest vegetables in Ondo and Oyo State

Species	Family	Frequency	Percent (%)	Rank
*Pterocarpusmildbraedii*Harms	Fabaceae	35	21.3	1
*Seneciobiafrae*Oliv. & Hiern	Compositae	27	16.5	2
*Piper guineense*Schum. & Thonn.	Piperaceae	15	9.1	3
*Gongronemalatifolium*Benth.	Asclepiadaceae	13	7.9	4
Vernonia amygdalina Del.	Asteraceae	12	7.3	5
Celosia argentea L.	Amaranthaceae	11	6.7	6
*Launaeataraxacifolia*Willd.	Asteraceae	9	5.5	7
Bombax ceiba Thonn.	Malvaceae	7	4.3	8
*Triplochitonscleroxylon*K. Schum.	Malvaceae	6	3.7	9
*Gnetumafricanum*Welw.	Gnetaceae	6	3.7	9
*Crassocephalumcrepidioides*Benth.	Asteraceae	5	3.0	10
Solanum nigrum L.	Solanaceae	5	3.0	10
*Clerodendrumvolubile*P. Beauv.	Lamiaceae	4	2.4	11
*Struchiumsparganophora*Linn.	Composita	3	1.8	12
*Ceibapetandra*L.	Malvaceae	3	1.8	12
*Philenopteracyanescens*Schum. & Thonn.	Fabaceae	3	1.8	12
Vitexdoniana Sweet.	Lamiaceae	2	1.2	13

Table 3: Nutritional composition (wet wt. basis) of the leaves of *Pterocarpusmildbraedii*, *Piper guineense*, and *Seneciobiafrae*

Vegetable Species	Proximate composition					
	Moisture (%)	Fibre (%)	Protein (%)	Ash (%)	Fat (%)	Carbohydrates (%)
P. mildbraedii	70.12^{b}	2.05^{b}	16.06^{b}	2.64^{b}	0.94^{a}	8.18^{b}
P. guineense	64.43^{c}	3.84^{a}	16.39^{a}	1.53^{c}	0.36^{c}	13.45^{a}
S. biafrae	80.21^{a}	1.19^{c}	9.88^{c}	3.82^{a}	0.53^{b}	4.37^{c}

Table 4: Antioxidants composition (wet wt. basis) of the leaves of *Pterocarpusmildbraedii*, *Piper guineense*, and *Seneciobiafrae*

Vegetable Species	Antioxidant				
	Phenol mg/g	Flavonoid mg/g	Vitamin C mg/g	Vitamin A unit/g	Vitamin B1 mg/g
P. mildbraedii	15.78[a]	1.82[a]	5.49[c]	705.64[a]	1.03[b]
P. guineense	9.75[c]	0.40[b]	8.90[b]	278.25[c]	1.02[b]
S. biafrae	12.13[b]	0.11[c]	23.25[a]	301.26[b]	2.46[a]

Table 5: Anti-nutritional composition (wet wt. basis) of the leaves of *Pterocarpusmildbraedii*, *Piper guineense*, and *Seneciobiafrae*

Vegetable Species	Anti-nutrients			
	Saponin mg/g	Tannin mg/g	Oxalate mg/g	Phytate mg/g
P. mildbraedii	17.27[b]	3.14[a]	1.94[a]	11.54[a]
P. guineense	24.64[a]	2.60[b]	1.71[a]	8.65[b]
S. biafrae	7.64[c]	1.38[c]	0.09[b]	1.24[c]

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