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Proximate Composition, Mineral Content, and Phytochemical Constituents of Four Spices Consumed in Delta State, Nigeria

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Abstract
The growing demand for spices, driven by their health benefits and global interest in natural products, emphasizes the significance of plants used as spices. This research investigated the nutritional composition and phytochemical constituents of four spices commonly used in local dishes by the population in Delta State, Nigeria. Plant samples were screened in powdered form using standard procedures to determine their proximate composition, mineral and phytochemical constituents. Crude protein ranged from 15.31% in *Aframomum sceptrum* to 11.35% in *Piper guineense*. Crude fat varied from 12.82% in *Piper guineense* to 5.20% in *Aframomum sceptrum*. Crude fiber was highest in *Parinari excelsa* at 19.44% and lowest in *Aframomum sceptrum* at 7.29%. *Chrysobalanus icaco* had the highest ash content at 3.80%, while *Piper guineense* had the lowest at 2.44%. *Chrysobalanus icaco* contained the highest levels of potassium (627.80 mg/100 g), and *Piper guineense* had the lowest amounts of potassium (290.20 mg/100 g). *Chrysobalanus icaco* was high in calcium (240.00 mg/100 g), and *Piper guineense* had the lowest amount (115.00 mg/100 g). Phytochemical analysis of the spices revealed the presence of resins, phytosterols, phenolic compounds, saponins, steroids, quinones, cardiac glycosides, flavonoids, alkaloids and coumarins. This study shows that the studied spices are rich in nutritional composition and can be used as food supplements, while their phytochemical constituents indicate their importance in medicinal preparations.

Keywords: nutrition, spices, phytochemical, aromatic substance, Delta State

Introduction

Spices are aromatic substances used to flavour, colour, and preserve food. They are naturally derived from plant seeds, kernels, bulbs, stalks, roots, bark, leaves, pods, or buds and can be used in fresh or dried form (Jiang, 2019). Spices aromatic and pungent properties are attributed to various essential oils (Ndukwu & Ben-Nwadibia, 2005). In addition to enhancing food flavour, spices have been valued for centuries for promoting health and preserving food (Kaefer &Milner, 2011). Although, spices are often consumed in small quantities, their impact on the human diet could be significant if consumed more frequently (AI Dhaheri et al., 2023). From a nutritional standpoint, spices significantly reduce lipid peroxidation during food preparation and processing due to their antioxidant activity (Jessica Elizabeth et al., 2017).

Aframomum sceptrum (Oliv. D. Hanbl.) K. Schum belongs to the family Zingiberaceae, it is a terrestrial rhizomatous plants. They are found in the tropical environments of Africa and Asia and characterized by widely spreading inflorescences at the foot of leafy shoots (Iyeh et al., 2024). *A. sceptrum* is locally called tiako/ataiko by the Urhobos and Itsekiris, and the seeds are used to spice palm fruit (banga) soup by the Ijaw, Urhobo, and Itsekiri people of Delta State. Additionally, the seeds are used in the traditional treatment of measles in children.

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Piper guineense Schumach. & Thonn belonging to the family Piperaceae is native to Ghana, Guinea, Nigeria, and Uganda. It is commonly known as Ashanti pepper, and grown for its pungent and aromatic properties. *P. guineense* thrives at forest edges and in moist environments within closed forests (Kabiru et al., 2016; Ohemu et al., 2024). In South Eastern Nigeria *P. guineense* is used for treating vaginosis, skin rash and oral thrush (Mgbeahuruike et al., 2019). The leaves are often used as leafy vegetables by the Igbo people (Adebayo et al., 2024), while its fruits are utilized as a spice in soups.

Chrysobalanus icaco Linn. belonging to the family Chrysobalanaceae is a shrub found in the tropical and subtropical region of South America, the Caribbean and West Africa (Yakandawala et al., 2010). *Chrysobalanus icaco*, commonly called cocoplum, is locally known as omilo by the Itsekiri people; the seed is used as a spice for making "pepper soup" by the Itsekiri and Urhobo people of Delta State, Nigeria.

Parinari excelsa Sabine of the family Chrysobalanaceae is a woody plant commonly found in forests of Eastern and West Africa. It is traditionally used for treating diarrhea (Ndiaye et al., 2008). *Parinari excelsa* is locally called gbafilo by the Itsekiris and used for making 'pepper soup' by the Itsekiri and Urhobo people of the Niger Delta.

Due to the increased demand and consumption of spices for health reasons and global interest in natural agents (Kumar et al., 2025; FAO, 2023), this research aims to analyze the nutritional composition and phytochemical constituents of *Aframomum sceptrum*, *Piper guineense*, *Chrysobalanus icaco*, and *Parinari excelsa*, which are widely used by the local populations in Delta State, Nigeria as spices in culinary preparations.

Materials and Methods

Collection, Identification and Preparation of Plant Samples

The seeds of the four spices (*Aframomum sceptrum*, *Piper guineense*, *Chrysobalanus icaco*, and *Parinari excelsa*) were bought from Effurun market, located in Uvwie Local Government Area in Delta State. They were identified and authenticated at the Herbarium of the Department of Plant Biology and Biotechnology, University of Benin, Benin City. The seeds were destalked and air dried at room temperature, then ground into fine powder with an electric blender, and stored at -4° C in an airtight glass jar before analysis.

Proximate Analysis

Proximate compositions of the spices were determined using the AOAC (2010) method. Carbohydrate was calculated by subtracting the total of other nutrients from 100. The Atwater factor method was used to calculate the caloric value of each spice (Roberts and Flaherman, 2022).

Caloric value = (% protein ×4) + (% fat × 9) + (% carbohydrates × 4)

Mineral Analysis

Mineral analysis was done after wet digestion of the spices. The method described by Walsh (1971) was used for the digestion of the spices. After digestion, manganese, sodium, zinc, magnesium, calcium, copper, potassium, and iron were analyzed using an atomic absorption spectrophotometer. Phosphorus was analyzed using vanadomolybdate (yellow method) (AOAC, 2010). Percentage transmittance was measured at 400 nm using a Spectronic 20 colorimeter.

Phytochemical Analysis

Fifteen (15 g) grams of each powdered spice was macerated for 24 hours in 45 ml of four different solvents, namely dichloromethane, methanol, n-hexane and water at room temperature in a conical flask and filtered using Whatman No. 1 filter paper. The filtrates were screened for qualitative phytochemical constituents using the methods described by Shaikh and Patil (2020).

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Results

The profiles of the four spices studied are shown in Table 1. The spices belong to three different families: Zingiberaceae, Piperaceae, and Chrysobalanaceae. The habits include herbs, trees, and climbing shrubs.

Table 1: Profile of selected spices studied.

S/N	Scientific Name	Family	Local Name	Part used	Plant Habit
1	*Aframomum sceptrum* (Oliv. D. Hanbl.) K. Schum	Zingiberaceae	Atiako (Its) Tiako (Urh)	Seeds	Herb
2	*Piper guineense* Schumach. & Thonn	Piperaceae	Eshasha (Urh)	Fruits	Climbing shrub
3	*Chrysobalanus icaco* Linn.	Chrysobalanaceae	Omilo (Its)	Seeds	Tree
4	*Parinari excelsa* Sabine.	Chrysobalanaceae	Gbafilo (Its)	Seeds	Tree

Key: (Urh) = Urhobo, (Its) = Itsekiri

Table 2 shows the proximate composition of the spices. *Chrysobalanus icaco* and *Parinari excelsa* had high moisture contents of 22.13% and 17.58%, respectively, while *Aframomum sceptrum* and *Piper guineense* had low moisture contents of 11.38% and 11.46%, respectively. *A. sceptrum* had the highest amount of protein at 15.31%, while *P. guineense* had the lowest amount at 11.35%. Crude fat ranged from 12.82% in *Piper guineense* to 5.20% in *Aframomum sceptrum*. *Parinari excelsa* had crude fibre of 19.44% while *Aframomum sceptrum* had 7.29%. *Chrysobalanus icaco* had the highest ash content of 3.80%, while *Piper guineense* had the lowest of 2.34%.

Table 2: The proximate composition of the spices

	Aframomum sceptrum	*Piper guineense*	*Chrysobalanus icaco*	*Parinari excelsa*
Moisture content (%)	11.38 ± 0.09	11.46 ± 0.03	22.13 ± 1.05	17.58 ± 0.05
Ash (%)	2.44 ± 0.00	2.34 ± 0.01	3.80 ± 0.00	2.54 ± 0.04
Crude fibre (%)	7.29 ± 0.05	10.42 ± 1.07	14.92 ± 0.90	19.44 ± 0.04
Crude fat (%)	5.20 ± 0.42	12.82 ± 0.61	9.65 ± 0.54	11.28 ± 0.03
Crude protein (%)	15.31 ± 1.05	11.35 ± 0.08	12.24 ± 0.07	11.80 ± 0.53
Carbohydrate (%)	58.38 ± 0.80	51.61 ± 0.26	37.26 ± 0.02	37.36 ± 0.06
Calorific value (kcal/100 g)	341.56	367.22	284.85	298.16

Data are presented as mean ± standard deviation. n =3

The mineral constituents of the spices are shown in Table 3. The most abundant minerals in the four spices studied were potassium, phosphorus, magnesium, and calcium. *Chrysobalanus icaco* had the highest amounts of potassium (627.80 mg/100 g), while *Piper guineense* had the lowest amounts of potassium (290.20 mg/100 g). Calcium was high in *Chrysobalanus icaco* (240.00 mg/100 g) and *Parinari excelsa* (232.50 mg/100 g), but low in *Piper guineense* (115.00 mg/100 g) and *Aframomum sceptrum* (132.30 mg/100 g).

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Table 3: Mineral constituents of the spices

Elements (mg/100 g)	*Aframomum sceptrum*	*Piper guineense*	*Chrysobalanus icaco*	*Parinari excelsa*
Macro elements				
Potassium	328.00±1.41	290.20±2.12	627.80±0.71	587.00±1.60
Sodium	120.00±2.23	103.30±1.72	225.00±1.01	218.00±1.84
Calcium	132.30±3.02	115.00±2.83	240.00±1.00	232.50±2.33
Phosphorus	266.50±2.12	170.50±2.66	369.50±3.62	382.00±3.42
Magnesium	149.00±2.00	131.00±2.54	256.65±3.54	250.00±2.83
Microelements				
Iron	11.87±0.10	11.58±0.00	18.21±0.001	19.16±0.02
Manganese	2.24±0.00	1.87±0.00	2.30±0.00	2.54±0.00
Zinc	5.42±0.00	3.92±0.00	5.56±0.01	5.75±0.00

Data are presented as mean ± standard deviation. n =3

Magnesium was high in *C. icaco* (256.65 mg/100 g) and *P. excelsa* (250.00 mg/100 g) but low in *P. guineense* (131.00 mg/100 g) and *A. sceptrum* (149.00 mg/100 g). *Parinari excelsa* contained 19.16 mg/100 g of iron, while *Aframomum sceptrum* and *Piper guineense* had iron contents of 11.87 mg/100 g and 11.58 mg/100 g, respectively. *Parinari excelsa*, *Chrysobalanus icaco*, and *Aframomum sceptrum* had the highest amounts of zinc, while *Piper guineense* had the lowest.

The phytochemical constituent of the spices are shown in Table 4. All the spices screened had phytosterol while resins were absent in all extracts of *Piper guineense*. Flavonoid was present in all extracts of *Chrysobalanus icaco and* saponins were absent in all extracts of *Piper guineense.*

Table 4: Phytochemical constituent of the spices

Constituent	Extract	*Aframomum sceptrum*	*Piper guineense*	*Chrysobalanus icaco*	*Parinari excels*
Alkaloid	Dichloromethane	-	-	+	-
	Methanol	+	+	+	+
	n-Hexane	+	+	+	+
	Aqueous	+	-	-	-
Cardiac glycoside	Dichloromethane	+	+	-	+
	Methanol	+	-	+	+
	n-Hexane	-	+	-	+
	Aqueous	-	-	-	-
Flavonoid	Dichloromethane	+	+	+	+
	Methanol	-	-	+	-
	n-Hexane	-	+	+	-
	Aqueous	+	-	+	-
Tannins	Dichloromethane	-	+	+	+
	Methanol	+	-	+	+
	n-Hexane	+	+	+	+
	Aqueous	-	-	-	-
Saponins	Dichloromethane	-	-	-	-
	Methanol	+	-	+	+

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	n-Hexane	-	-	-	-
	Aqueous	+	-	+	-
Phytosterols	Dichloromethane	+	+	+	+
	Methanol	+	+	+	+
	n-Hexane	+	+	+	+
	Aqueous	+	+	+	+
Steroids	Dichloromethane	+	+	+	+
	Methanol	-	+	+	-
	n-Hexane	-	+	-	-
	Aqueous	-	-	-	+
Quinones	Dichloromethane	+	+	+	+
	Methanol	-	-	-	+
	n-Hexane	-	-	+	+
	Aqueous	+	-	+	-
Resins	Dichloromethane	-	-	-	-
	Methanol	+	-	+	+
	n-Hexane	-	-	-	-
	Aqueous	-	-	-	-
Coumarins	Dichloromethane	+	+	+	+
	Methanol	-	+	-	-
	n-Hexane	+	+	+	+
	Aqueous	+	-	+	+

Key: + = present, - = absent

Discussion

The proximate analysis showed low moisture content in *P. guineense* and *A. sceptrum*, which indicates that *P. guineense* and *A. sceptrum* will have a longer shelf life, while *C. icaco* and *P. excelsa* with high moisture contents may be prone to microbial or fungal growth if not properly dried. Moisture content in any food indicates its water activity and also measures stability and vulnerability to microbial growth (Aruah et al., 2012). Aguda and Gbadamosi (2019) reported a similar low moisture content for *A. sceptrum*, while Ohemu et al. (2024) indicated low moisture content in the seeds of *P. guineense*. The ash content is an indication of the total mineral content in foods (Marshall, 2010), which suggests a high amount of minerals in *Chrysobalanus icaco* with the highest ash content. *A. sceptrum* had the highest amount of protein at 15.31%, exceeding the 9.73% reported by Aguda and Gbadamosi (2019), while *P. guineense* had the lowest amount at 11.35%, which is higher than 5.86% indicated by Ohemu *et al.*, (2024). Aguda and Gbadamosi (2019) reported a higher crude fat of 16.17% for *Aframomum sceptrum*, while Ohemu et al. (2024) reported a lower value of 9.89% for *Piper guineense*. Diets rich in fibre help to prevent digestive issues such as bowel irregularities and constipation. This indicates that *Parinari excelsa* and *Chrysobalanus icaco* having high crude fibre, may help prevent digestive issues such as bowel irregularities and constipation.

Among the spices studied, *Chrysobalanus icaco* and *Parinari excelsa* had the highest mineral composition, making them more beneficial for mineral supplementation and potentially serving as a valuable dietary source for maintaining electrolyte balance and enzyme activation. *Aframomum sceptrum* and *Piper guineense* had lower mineral compositions compared to *Chrysobalanus icaco* and *Parinari excelsa*. Variations observed in the mineral compositions of the studied spices may have resulted from different growing conditions and locations. Zhao et al., (2017) reported that the mineral content of tea leaves was significantly influenced by factors such as geographical location, variety, harvest period, and their interactions. Potassium and sodium are needed for maintaining body fluid balance, regulating muscle and nerve function, stabilizing pH levels, and controlling glucose homeostasis (Barbagallo et al., 2007; Palmer & Clegg, 2016). Calcium is crucial for various physiological functions, including bone and tooth development, blood clotting, muscle contraction, and activating some enzymes essential for biological processes (Aremu et al., 2005). Calcium also plays an important role in activating the transformation of prothrombin to thrombin and activates numerous enzymes, including adenosine triphosphatase, lipase, and succinate dehydrogenase (Soetan et al., 2010). Magnesium catalyzes various enzyme systems and maintains electrical balance

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within nerve cells (Barbagallo et al., 2007; Palmer and Clegg, 2016). Iron is essential for central nervous system function (Riccardi & Brown, 2010) and aids the oxidation of proteins, carbohydrates, and fats (Aremu et al., 2005). Additionally, iron functions as a cofactor for several enzymes involved in neurotransmitter synthesis and proper packaging (Ponka, 2000; Beard, 2001). Zinc is both a cofactor and a component of various enzymes, including lactate dehydrogenase, RNA polymerase, and DNA polymerase (Jurowski et al., 2014; Onilude et al., 2021). Although the spices alone may not meet the recommended daily intake, their inclusion in meals can help improve the nutritional requirements of the individuals consuming them.

Flavonoids were detected in all dichloromethane extracts of all the spices screened. Flavonoids possess diverse bioactive properties, including antioxidants, antimicrobials, anticancer, antiviral, antimalarial, antitumor and neuroprotective effects (Zhao et al., 2019; Ullah et al., 2020). Coumarin was indicated in the dichloromethane and n-hexane extracts of all the spices studied. Coumarin has therapeutic potential in managing mental health conditions such as anxiety and depression (Patil et al., 2013) it is also often used as a fragrance in perfumes, hand soaps, detergents, and lotions at low concentrations (Garrard, 2013). Resin was present in all spices studied except *Piper guineense.* Resins with essential oils are utilized for their healing properties and as fragrant incense (Parimal et al., 2021). This is an indication that the studied spices, except *Piper guineense,* could be useful to the incense industry. Phytosterols promote cardiovascular health by inhibiting cholesterol absorption in the small intestine, thereby lowering overall cholesterol level (Normen et al., 2004). This may be an indication that the consumption of these spices could improve cardiovascular health. Phytochemicals such as alkaloids, phytosterols, cardiac glycosides, flavonoids, and cardiac glycosides in these spices suggests their possible therapeutic applications as antioxidants, antimicrobials, anti-inflammatory and anticancer agents.

Conclusion

This study revealed that the four spices (*Aframomum sceptrum, Piper guineense, Chrysobalanus icaco,* and *Parinari excelsa*) commonly used in Delta State, Nigeria, have different levels of nutritional and phytochemical properties. *Parinari excelsa* and *Chrysobalanus icaco* were remarkable for their high mineral content and therefore, could serve as a dietary source for electrolyte balance and enzyme activation. These spices also contain beneficial phytochemicals such as alkaloids, phytosterols, flavonoids, resins and coumarins, which suggest their possible health benefits and their roles as sources of bioactive compounds, therefore justifying the increased demand for spices in food and cosmetic preparations. The use of these indigenous spices can also help enhance biodiversity and promote food security.

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