Evaluation of the Mineral composition, Phytochemical and Proximate Constituents of three Culinary Spices in Nigeria: A Comparative Study

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Abstract

A comparative assessment of the quantitative mineral composition, phytochemical and proximate constituents of *Xylopia aethiopica* (fruits), *Piper guineense* (seeds) and *Rhaphiostylis beninensis* (roots) was done using standard protocols. Mineral analysis of the culinary spices revealed significant differences ($p < 0.05$) in the Magnesium, Zinc, Iron, Selenium, Copper, Calcium, Manganese, Molybdenum, Potassium and Sodium contents of the spices. The respective concentrations of Iron and Selenium (16.03 ± 0.01, 0.25 ± 0.01 mg/L) in *R. beninensis* were the highest and lowest of all mineral elements evaluated in the three spices. Similarly, the carbohydrate and moisture contents (81.24 ± 0.25%, 0.71 ± 0.01%) of *R. beninensis* were the highest and lowest among all proximate parameters evaluated in the three spices. However, the Fibre contents of *R. beninensis* and *P. guineense* and the ash contents of *P. guineense* and *X. aethiopica* respectively, showed no significant differences ($p > 0.05$). Moreover, flavonoid and oxalate concentrations (4.04 ± 0.09%, 0.25 ± 0.04%) in *X. aethiopica* were the highest and lowest of phytochemicals in the three spices respectively. Nevertheless, there were no significant differences ($p > 0.05$) in the tannin content of *P. guineense* and *X. aethiopica* spices respectively. Similar trends were observed between the oxalate contents of *R. beninensis* and *X. aethiopica*, the phytate contents of *R. beninensis* and *P. guineense* and the saponin contents of the three spices respectively. These results indicate that the spices are notable sources of essential nutrients and phytochemicals. Therefore, they are possible candidates in the search for natural ingredients to formulate drugs and nutraceuticals by pharmaceutical industries.

1. Introduction

Plants are known sources of a great category of bioactive chemical substances that function as biochemical and physiological agents in the body. Spices represent a class of plants with such effects. They are rich in aromatic compounds and have found wide applications in traditional medicine, industries, food preservation and in improvement of sensory characteristics. Moreover, several ethnic cuisines are exceptionally certified owing to their spice constituents. Few examples are; the Italian cuisine(turmeric), Thai cuisine (lemon grass, ginger and chili peppers) and the African/Nigerian “Pepper soup” (bastered melegueta, clove, alligator pepper, ginger, black pepper, garlic, Ethiopian pepper, chili peppers and other spices) [1] .

A remarkable attribute of spices is their phytochemical constitution. The extraordinary benefits of phytochemicals have led researchers to continually unveil additional usefulness of spices. Moreover, in recent times, there is increase in the research of dietary minerals as a result of their importance in disease prevention coupled with the notable developments in the field of mineral research. *Xylopia aethiopica, Piper guineense* and *Rhaphiostylis beninensis* are notable spices of culinary and ethnomedicinal importance in Nigeria.

Xylopia aethiopica, a deciduous tree that belongs to the plant family, *Annonaceae* is predominant in West Africa and commonly referred to as *pepper tree*, *African guinea pepper, Ethiopian pepper* or Senegal

pepper [2]. In Nigeria, *X. aethiopica* has many vernacular names: *eeru* (Yoruba), *Kimba* (Hausa), *uda* (Igbo) and *urherien* (Urhobo). The medical importance of *X. aethiopica* have been reported [3]. *Raphiostylis beninensis* is a medicinal plant and a seasoning agent. The plant is called *atapata* (Yoruba), *osumadin* (Benin), *kpolokoto* (Igbo), *umeni* (Urhobo) and *kumeni* (Itsekiri) [4]. Some biological and pharmacological reports have also been made on the root bark extracts of *R. beninensis* [5, 6]. *Piper guineense* is a West African spice plant commonly called Ashanti pepper. In Nigeria, it is known as *uziza* in Igbo and *Iyere* in Yoruba. It has other common names such as *Guinea pepper, Benin pepper, and False cubeb* [7]. *Piper guineense* is utilized in different forms for a variety of purposes; culinary, medicinal, cosmetic and insecticidal uses [8]. In light of the general usefulness and importance of *Xylopia aethiopica, Piper guineense* and *Rhaphiostylis beninensis*, the mineral composition, phytochemical and proximate constituents of the culinary spices were evaluated for a broader application in foods and other relevant areas.

2. Results

2.1 Mineral composition of the spices

The mineral composition of *X. aethiopica* (fruits), *P.guineense* (seeds) and *R. beninensis* (roots) are shown in table I. The sodium (Na), potassium (K), magnesium (Mg) and manganese (Mn) concentrations in *X. aethiopica* were significantly higher ($p < 0.05$) than those of *P. guineense* and *R. beninensis* spices. Moreover, *P.guineense* had significantly higher ($p < 0.05$) concentrations of Calcium (Ca), Molybdenum (Mb) and Selenium (Se) mineral elements compared to the other two spices. Similarly, the concentrations of iron (Fe), zinc (Zn) and copper (Cu) in *R. beninensis* were significantly higher ($p < 0.05$) than those of *P.guineense* and *X. aethiopica* spices. Generally, the highest and lowest concentrations of mineral elements in the three spices were found in iron and selenium respectively.

Table I: Mineral composition of selected spices

Mineral Elements	*X. aethiopica*	*P. guineense*	*R. beninensis*
Zn (mg/L)	4.09 ± 0.04^{e}	1.11 ± 0.01^{c}	7.33 ± 0.01^{k}
Ca (mg/L)	8.62 ± 0.02^{p}	10.77 ± 0.01^{j}	9.03 ± 0.01^{m}
Fe (mg/L)	14.07 ± 0.02^{z}	11.16 ± 0.01^{r}	16.03 ± 0.01^{f}
Se (mg/L)	0.45 ± 0.01^{g}	0.64 ± 0.02^{b}	0.25 ± 0.01^{q}
Na (mg/L)	6.08 ± 0.01^{d}	4.98 ± 0.01^{m}	3.72 ± 0.01^{c}
Mo (mg/L)	1.09 ± 0.01^{x}	3.07 ± 0.01^{v}	2.33 ± 0.01^{t}
Mg (mg/L)	7.54 ± 0.01^{s}	4.38 ± 0.04^{k}	5.95 ± 0.02^{y}
Cu (mg/L)	3.95 ± 0.01^{j}	5.58 ± 0.01^{a}	6.82 ± 0.02^{z}
Mn (mg/L)	5.47 ± 0.01^{u}	4.75 ± 0.01^{f}	2.43 ± 0.01^{h}
K (mg/L)	11.31 ± 0.02^{c}	8.81 ± 0.01^{s}	6.55 ± 0.01^{j}

Values are expressed as mean ± standard error of mean (X ± S.E.M*)* in triplicate. *Values with different letter along the same row are significantly different ($p < 0.05$).*

2.2. Phytochemical Constituents of the Spices

Table II below reveals the quantitative phytochemical constituents of *R. beninensis P. guineense* and *X. aethiopica* spices. The flavonoid, alkaloid and phenol contents of *X. aethiopica* were significantly higher ($p < 0.05$) than those of *P. guineense* and *R. beninensis* spices respectively. The tannin content of *R. beninensis* was significantly higher ($p < 0.05$) than those of *P. guineense* and *X. aethiopica* spices. However, there were no significant differences ($p > 0.05$) in the tannin content of *P. guineense* and *X. aethiopica* spices respectively. A similar trend was observed in the Oxalate contents of *R. beninensis* and *X. aethiopica* spices and the Phytate contents of *R. beninensis* and *P. guineense* spices respectively. In the same vein, no significant differences ($p > 0.05$) were observed in the saponin contents of the three spices.

Table II: Phytochemical constituents of selected spices

Phytochemicals	*R. beninensis*	*P. guineense*	*X. aethiopica*
Flavonoids (%)	¶3.72 ± 0.13[a]	2.73 ± 0.08[b]	4.04 ± 0.09[c]
Tannins (%)	¶0.78 ± 0.04[a]	0.22 ± 0.02[b]	0.17 ± 0.02[b]
Alkaloids (%)	¶1.74 ± 0.07[b]	1.57 ± 0.03[b]	2.23 ± 0.05[c]
Phenols (%)	¶2.03 ± 0.07[a]	0.33 ± 0.02[b]	2.92 ± 0.16[c]
Saponins (%)	¶0.23 ± 0.01[b]	0.36 ± 0.06[b]	0.28 ± 0.01[b]
Phytate (%)	0.57 ± 0.02[a]	0.66 ± 0.02[a]	0.42 ± 0.02[b]
Oxalate (%)	0.31 ± 0.02[b]	0.05 ± 0.01[a]	0.25 ± 0.04[b]

Values are expressed as mean ± standard error of mean (X ± S.E.M*)* in triplicate. *Values with different letter along the same row are significantly different (p < 0.05)*.

¶*Values derived from our previous published work* [6].

2.3. Proximate Composition of the Spices

Proximate composition of dried fruits of *X. aethiopica*, dried seeds of *P. guineense* and dried roots of *R. beninensis* are shown in Table III.

Table III: Proximate composition of R. beninensis, P. guineense **and** X. aethiopica **spices**

Parameters	*R. beninensis*	*P. guineense*	*X. aethiopica*
Moisture content (%)	0.71 ± 0.01[a]	0.82 ± 0.01[b]	1.13 ± 0.02[c]
Crude Protein (%)	3.82 ± 0.08[a]	4.83 ± 0.09[b]	3.14 ± 0.05[c]
Lipid (%)	0.39 ± 0.01[a]	1.84 ± 0.01[b]	13.82 ± 0.04[c]
Ash (%)	7.43 ± 0.07[a]	6.22 ± 0.08[b]	6.47 ± 0.08[b]
Crude Fibre (%)	6.42 ± 0.01[b]	6.35 ± 0.04[b]	5.36 ± 0.05[a]
Carbohydrate (%)	81.24 ± 0.25[b]	79.93 ± 0.11[b]	70.08 ± 0.30[a]

Values are expressed as mean ± standard error of mean (X ± S.E.M*)* in triplicate. *Values with different letters along the same row are significantly different (p < 0.05)*

The moisture, protein and lipid contents of the 3 spices were significantly different ($p < 0.05$) from each other respectively. Moreover, *X. aethiopica* had the highest moisture and lipid contents while *P. guineense* and *R. beninensis* had the highest protein and carbohydrate contents respectively. However, there were no

significant differences ($p > 0.05$) in the Fibre and carbohydrate contents of *R. beninensis* and *P. guineense* spices respectively. A similar trend was also observed in the ash contents for *P. guineense* and *X. aethiopica* spices respectively.

3. Discussion

3.1. Mineral composition of the spices

Spices are proven sources of vital nutrients necessary for growth and sustenance of various physiological processes of the body hence, lack of an adequate quantity of these nutrients may lead to a host of diseased conditions. In the present study, Iron which is an essential trace element for the synthesis of haemoglobin, normal functioning of the central nervous system, had the highest nutritional composition of all the three spices evaluated. It ranged from 11.16 mg/L to 16.03 mg/L with *Rhaphiostylis beninensis* having the highest amount and *Piper guineense* having the lowest amount. Moreover, the considerable amount of copper (6.82 mg/L) present in *Rhaphiostylis beninensis* could have actuated the release of iron in the formation of haemoglobin. Hence, consumption of foods or supplements prepared with *Rhaphiostylis beninensis* roots may supply more iron to the body necessary for oxygen transport in the haemoglobin of erythrocytes. Thus, the haematinic attribute of this spice makes it a good candidate for the treatment of anaemic conditions. This could also be the rationale behind application of the spice as tonic for Children within the ages of two to three years and for the treatment a diseased condition that makes the whole skin turn white (*afun)* in the South-Western region of Nigeria [9]. Similarly, in *X. aethiopica and P. guineense* spices, the relative high proportions of Iron have given a better understanding of their applications in preparation of the renowned “pepper soup” for women immediately after delivery in several parts of Nigeria [10]. Manganese which is a known activator of several enzymes and also necessary for the formation of haemoglobin, predominates in *X.aethiopica*. This outcome may have contributed to the spice’s haematinic property.

Zinc has been reported to exhibit catalytic and modulatory activities on over 300 enzymes. It also aids in the maintenance of a healthy immune system and enhances sperm development, ovulation and fertilization. The significantly higher ($p < 0.05$) concentration of Zinc observed in *Rhaphiostylis beninensis* than the other two spices could be traceable to its reported pro-sexual attributes [11]. Zinc acts as a vital component in male and female reproductive prospects. It cannot be stored in the human body. Consequently, consumption of Zinc in diets is the only means of sustaining the body’s physiological activities particularly in males and females who have attained the age of reproduction. Therefore, diets supplemented with *Rhaphiostylis beninensis* may serve a better chance in enhancing the reproductive potentials of Men and Women undergoing treatment on infertility than those with *X. aethiopica and P. guineense* spices.

Sodium and potassium present in relatively high concentrations in *X. aethiopica* are major cations present in extracellular and intra-cellular fluids respectively. They assist in sustaining electrolyte balance in body fluids. The higher significant concentration ($p < 0.05$) of sodium is an indication that the spice will

possess the capacity to assist in osmotic balance regulation and maintenance of the body's internal environment in comparison with the other two spices. In the same vein, the higher significant level ($p < 0.05$) of potassium in the said spice shows that; it will act in synergy with sodium to enhance the above functions. Previous similar report [12] has also revealed relative higher concentrations of Potassium in *X. aethiopica* compared to other elements evaluated in course of this study. Consequently, consumption of food substances containing *X. aethiopica* may aid in the prevention of diseased conditions linked with sodium and potassium deficiencies.

Magnesium is essential in glucose and insulin metabolism chiefly by enhancing tyrosine kinase activity of the insulin receptor. The activity of phosphorylase b kinase is also activated by Magnesium thereby bringing about the release of glucose-1-phosphate from glycogen. Thus, it could be deduced that *Xylopia aethiopica* may be a better candidate for the formulation of chemotherapeutic agents for diabetic conditions associated with dysfunctional insulin than *P. guineense* and *R. beninensis*.

Piper guineense contains the highest concentration of Calcium (10.77 mg/L) in the three spices. A previous similar study [13] had also reported highest concentrations of Calcium than other minerals in this spice. This indicates that the seeds of the spice may play vital roles in good teeth and bone development coupled with its essential role as a cofactor in various enzyme-catalyzed reactions such as blood clotting and several other physiological processes. Plausibly, *Piper guineense* seeds may be employed in the management of bone-related disorders associated with calcium deficiency such as osteoporosis in post-menopausal women.

The relative concentrations of Molybdenum and Selenium in the spices were low compared with those of other elements. Though, present in meagre portion of the spices, they contribute to the total well-being of the human body. Molybdenum assists in the inhibition of pulmonary and liver fibrosis. Furthermore, enzymes involved in energy metabolism are also activated by Molybdenum. Selenium on the other hand, is vital for a robust immune system, production of "good" prostaglandins and fertility.

It is worthy to note that; this is the first time information is made available in the Literature on the mineral composition of root of *R. beninensis.* However, data obtained for the levels of Iron, Sodium, Copper, Zinc and Manganese minerals for *X.aethiopica* and *P.guineense* were higher than those of previous similar studies [10, 13]. The discrepancies observed in values could be attributed to differences in methods employed during analysis, stage of maturity of the fruits/seeds before harvesting them, nature of the soil and climatic factors of the geographical region where the spices were harvested. Contrarily, values of 8.81 mg/L and 10.77 mg/L obtained for potassium and Calcium levels in *P. guineense* in this study are comparable to 8.87 ppm and 11.20 ppm obtained by (Imo *et al*2018) [10].

3.2. Phytochemical constituents of the spices

Phytochemical evaluation of the dried roots of *Rhaphiostylis beninensis*, dried seeds of *Piper guineense* and dried fruits of *Xylopia aethiopica* revealed the presence of flavonoids, alkaloids, phenols, saponins, Phytate, Oxalate and tannins in varying concentrations (Table II). The presence of the above

phytochemicals in *Xylopia aethiopica* is in consonance with earlier reports [14, 15]. However, the relative compositions of alkaloids (2.23 ± 0.05), flavonoids (4.04 ± 0.09) and saponins (0.28 ± 0.01) in the fruit extracts of *X. aethiopica* were higher than those of Uhegbu *et al.*, (2011) [16]: alkaloids (1.49 ± 0.03), flavonoids (0.22 ± 0.02) and saponins (0.18 ± 0.03). The observed differences may be due to method of analysis, harvesting time, climatic conditions of growing area and variation in solvent for extraction.

The phytochemical results obtained for the root of *R. beninensis* is in agreement with previous studies by Ofeimum and Mbionwu (2014) [17] in which the methanol root extract of the plant gave a higher concentration of flavonoids compared to its alkaloid and tannin contents respectively. Similarly, findings on the phytochemical components of *P. guineense* are in line with the reports of previous authors [18, 19]. Echo *et al.*, (2012) [18] also reported that the phytochemical composition of alkaloid in *P. guineense* was 1.67 ± 0.29% which was comparable to 1.57 ± 0.03% obtained in this study. This study also observed that the percentage composition of tannins is 0.22% in seeds of *P. guineense* which was also comparable to 0.30% reported by Omodamiro and Ekeleme (2013) [19].

Okwu (2001) [20] reported that the mean percentage alkaloid and saponin contents of *P. guineense* seeds were 1.20 ± 0.22% and 0.45 ± 0.10% respectively which were comparable to 1.57 ± 0.03% and 0.36 ± 0.06% respectively obtained for *P. guineense* seeds in this study. Qiu *et al.*, 2014 [21] have shown that alkaloids have a wide range of pharmacological activities. Hence, the presence of alkaloids in *X. aethiopica, R. beninensis and P. guineense* spices could account for their use as antimicrobial agents.

A growing interest exists in the Flavonoids and phenol contents of plants owing to their roles against pathogenic organisms and in the scavenging of free radicals. Flavonoids were found to be the most abundant phytochemical in all the spices; *X. aethiopica* (4.04%), *Piper guineense* (3.72%), and *R. beninensis* (2.73%). Flavonoids and phenols are known antioxidants in plants and humans. Hence, *X. aethiopica* may have a greater antioxidant potential in comparison with the other two spices owing to its higher constituent of flavonoids and phenols.

Tannins are aromatic compounds containing phenolic groups. They are one of the principal active ingredients found in plant based medicines possessing antiviral, antibacterial, and antitumor activities. Tannins significantly predominate ($p < 0.05$) in *R. beninensis.* Consequently, *R. beninensis* may serve a better potential as major active ingredients in drug production compared to the other two spices.

Oxalates and phytates possess potent binding affinities to vital minerals such as calcium, iron and zinc at high concentrations. Thus, they may be regarded as anti-nutritional factors. The phytate and Oxalate compositions of the samples analyzed ranged from 0.42–0.57% and 0.03–0.31% respectively. Plausibly, the above amounts may not pose any health hazard.

Roa *et al.*, (1995) [22] have shown that saponins possess antioxidant, antitumor, and anti-mutagenic activities and may also reduce the incidence of human cancers by inhibiting the growth of cancer cells. Saponin content of the spices ranged from 0.23 ± 0.01 to 0.28 ± 0.01%. Interestingly, toxicological studies of saponin using relevant experimental models have established that even at a higher concentration of

3.5%, saponin was safe and did not cause any systemic side effects (Qin *et al*, 2009) [23]. Thus, it can be deduced from the above that the levels of saponin in the three spices are safe for human consumption.

3.3. Proximate composition of the spices

Findings on nutritional components of the three spices, *Rhaphiostylis beninensis*, *Piper guineense* and *Xylopia aethiopica* are highlighted in Table III. *X. aethiopica* and *R. beninensis* had the highest and lowest percentage moisture contents respectively of the three spices. The proximate data obtained for the moisture contents of *Piper guineense* and *Xylopia aethiopica* spices reported in this work does not agree with those of Borquaye *et al.*,(2017) [13] who reported higher moisture content values for the spices. The observed difference in values may be due differences in the nature of soil and climatic conditions at the areas of cultivation, genetic variations and differences in analytical procedures.

The values obtained for the percentage moisture contents of the three spices ranges from 0.71–1.13%. These values indicate that the spices are relatively dry owing to their low moisture contents. Moreover, moisture was the lowest amount among all proximate parameters evaluated in the three spices. Low moisture content prevents quick deterioration of food materials and deters the activities of food spoilage microorganisms. Consequently, the three spices in this study can be stored for a longer period of time.

The ash content obtained for the three spices under this study ranged from 6.22% – 7.43%. *Raphiostylis beninensis* had the highest value while *P. guineense* had the lowest value. Results obtained for the ash content of *P. guineense*, 6.22 ± 0.08% is in line with the reports of Negbenebor *et al.*, (1999) [24] whose value obtained was 6.33 ± 0.02%. Ash content connotes mineral composition of the spices. These minerals are essential for proper functioning of the human immune system. There were no significant differences ($p > 0.05$) in the ash contents of *P. guineense* and *X. aethiopica* spices. Therefore, both spices may have similar and lower composition of vital mineral elements compared to *R. beninensis* spice.

The crude protein content of the spices are in the range of 3.14–3.82% with *P. guineense* seeds having the highest and *X. aethiopica* having the lowest protein contents respectively. The percentage mean crude protein content, 4.83 ± 0.09% obtained in this study is comparable to 5.86 ± 0.04% and 5.57 ± 0.04% obtained by Negbenebor *et al.*, (1999) and Uhegbu *et al.*, (2011) [24,16] respectively for *P. guineense* seeds. However, the percentage mean crude protein content obtained for *X. aethiopica*, 3.14 ± 0.05 in this study was lower than 7.73 ± 0.98 and 11.90 ± 0.06 obtained by Borquaye *et al.*,(2017) and Uhegbu *et al.*, (2011) [13,16] respectively in a similar study.

The observed differences in crude protein content obtained for *X. aethiopica* fruits could be as a result of variations in the solvents for extraction or analytical procedure. Notwithstanding, the proteins present in the three spices could impact on the proteins required by humans for certain biochemical activities or processes such as replacement and repair worn-out tissues, growth, provision of hormones, and amino acids. Hence, crude protein values obtained for spices in this study makes them good sources of plant protein.

Fibre content was highest in *R. beninensis* (6.42%), followed by *P.guineense* (6.35%) and subsequently, *X. aethiopica* (5.36%). There were no significant differences ($p > 0.05$) between the fibre contents of *R. beninensis* and *P.guineense* spices. Thus, both spices could serve a good source of fibre in diet compared with *X. aethiopica*. Moreover, adequate intake of dietary fibre could aid absorption of water from the body, bulky stool, digestion and prevention of constipation.

Painstaking survey of literatures revealed no data for the proximate composition of *R. beninensis* spice. However, values obtained for the fibre content of *P.guineense* seeds is comparable to that of a similar study conducted by Negbenebor *et al.*, (1999) [24]. In that work, the mean percentage crude fibre content of *P.guineense* seeds was estimated as 8.79 ± 0.01% while that of this study is 6.35 ± 0.04. In the same vein, the values obtained by Okwu, (2001) [20] and Okwu and Josiah (2006) [25] for *P.guineense* seeds (4.31 ± 0.01) and *X. aethiopica* fruits (6.44 ± 0.03) were also comparable to the 6.35 ± 0.04 and 5.366.35 ± 0.05 obtained respectively for the said spices.

Lipid content of the spices is in the range of 0.39–13.82% with *R. beninensis* and *X. aethiopica* having the lowest and highest amounts respectively. Lipids are excellent sources of energy. They also aid in the transport of fat-soluble vitamins. The low amount of lipid obtained for *R. beninensis* (0.39%) and *P. guineense* (1.84%) spices respectively, implies that they can be recommended as part of a weight loss regimen. However, *X. aethiopica* may support the production of hormones of lipid origin owing to its higher amount of lipids.

The percentage lipid content obtained for *P. guineense* seeds in this study (1.84%) is comparable to that of the leaves (1.74%) of the same spice investigated by Dibulo *et al.*, (2017) [26]. In the same vein, Uhegbu *et al.*, (2011) [16] obtained 10.64% as the percentage lipid content for *X. aethiopica* fruits. This value is comparable to the13.82% obtained in this study. However, a value of 6.73% obtained by Imo *et al.*,(2018) [10] for *X. aethiopica* fruits does not agree with the 13.82% obtained in this study. This may be as a result of differences in solvent used for extraction or environmental factors.

Carbohydrate content had the highest nutritional composition of all the spices evaluated in this study. It ranged from 70.08–81.24% with *X. aethiopica* having the lowest amount and *R. beninensis* having the highest amount. Carbohydrates such as glucose provide energy to cells in the body, especially the brain, which solely depends on glucose for energy. Therefore, the high carbohydrate contents observed for the three spices indicate that they are good sources of fuel and energy for the body's daily activities. Effiong *et al.*, (2009) [27] obtained 69.46 ± 0.48% as mean percentage content of carbohydrate in *X. aethiopica*. The value obtained by the said authors is in consonance with 70.08 ± 0.30% obtained in this study. However, a lower value of 26.08 ± 1.41% recorded by Imo *et al.*, (2018) [10] was not in line with the value obtained in this study. For *P. guineense*, results from earlier studies [13, 20] estimated the percentage carbohydrate content of the spice as 48.77% and 40.29% respectively. The values reported do not agree with the 79.93% obtained in this study. This disparity in results could be as a consequence of variations in environmental conditions during cultivation of the spices or methods of analysis.

In conclusion, the mineral elements, phytochemical and proximate constituents of the spices have rendered them prospective sources of ingredients for the formulation of drugs and nutraceuticals and have given relevance to their applications in cuisines and folklore medicines in Nigeria. However, further studies involving isolation of their bioactive components are encouraged.

4. Materials And Methods

4.1 Chemicals

All chemicals used in the present study were of analytical grade purchased from Pyrex- IG Scientific Company, Benin City, Nigeria.

4.2 Collection, identification and pulverization of plant samples

The spices, *Xylopia aethiopica* (Fruits), *Piper guineense* (seeds) *and Raphiostylis beninensis* (roots) were purchased from a local market in Oghara, Delta State, Nigeria, identified and authenticated at the Herbarium Section of the Department of Plant Biology and Biotechnology, University of Benin, Edo State, Nigeria by Dr. H.A. Akinnibosun. Specimens with voucher numbers, UBHx0348, UBHa0328 and UBHp0262 respectively were deposited in his herbarium. A large quantity of the spices were subjected to room temperature drying at 27.0 ± 2.0 C for two weeks. Thereafter, the spices were subjected to homogenization by means of a warring mechanical blender to obtain dried, pulverized plant materials respectively. The pulverized plant materials were then stored in an air-tight containers at $4^{o}C$ until required for use.

4.3 Mineral analyses of the spices

The relative concentrations of Magnesium, Zinc, Iron, Selenium, Copper, Calcium, Manganese, Molybdenum, Potassium and Sodium in the spice samples were ascertained by using the Atomic Absorption spectrophotometer (SP9, Pychicham, UK) according to the method described by the Association of Official Analytical Chemists (AOAC, 1990) [28].

4.4 Phytochemical analysis of the spices

Tannin content of the samples was determined by Folin Denis colometric method [29]. Alkaloids were quantitatively determined according to the method of Harborne (1973) [30]. Flavonoids were determined using the method described by Harbone (1975) [31]. Quantitative determination of Oxalate was carried out using the method reported by Ejikeme et *al*., (2014) [32]. Phytates were determined through phytic acid determination using the procedure described by Akaneme *et al*.,(2014) [33]. The determination of saponins was done following the method of Obadoni and Ochuko (2001) [34] and total phenol in the plant extracts were determined according to the method of Association of Official and Analytical Chemists *(AOAC, 1990)* [28].

4.5 Proximate Nutrient Analysis of the Spices

The crude fibre, crude protein, fat, moisture, and total ash contents of samples were analyzed using standard protocols [28, 35–37]. The total carbohydrate was determined by difference; the sum of the percentage moisture, ash, crude lipid, crude protein and crude fibre was subtracted from 100 [38].

4.6 Data Analysis

Data obtained from this study were subjected to analysis of variance (ANOVA) using the statistical package (SPSS 21.0). Results were expressed as Mean ± SD of three replicate determinations. Mean values of various groups were significantly compared by Tukey's Multiple Range Test and a probability of $p < 0.05$ was considered significant.

Declarations

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