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Proximate and Elemental Analysis of Local Spices Used in Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author ISE designed the study, wrote the protocol and corrected the drafts of the manuscript. Author LMO performed the sampling, the laboratory work, did the statistical analysis and wrote the first draft of the manuscript. Author RS Managed the literature searches and proof read the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Comparative study of the proximate and mineral components of five local spices (*Denniettia tripetala, Monodora myristica, Piper guineense, Syzygium aromaticum, Xylopia aethiopica and*) were investigated. The proximate composition revealed that the spices had considerable carbohydrate ranging from 26.2 – 53.4%, crude fibre 13.6 – 23.7%, crude protein 5.67 – 10.9%, but low ash 2.41 – 5.56%, moisture 8.61 – 17.7% and fat 2.34 – 24.3%; except *D.tripetala* and *M. myristica* with high moisture content of 17.7% and crude fat content of 24.3%, respectively. The EDXRF analysis shows the presence of mineral elements in the order of K > Ca > Fe > Zn > Sr > Se > Mo > Cu > Mn > Br > Rb. Statistical analysis indicates that there is no significant difference (α = 0.01, 0.05) in the mean contribution of the various sample. However, there is a relationship between the constituents *of P.guineense and S. aromaticum, X. aethopica, D. tripetala* and the elements (Mn, Br) and (Se, Zn). Generally, the findings indicate that the five spices are good sources of nutrients and mineral elements which could be exploited as great potentials for drugs and/or nutritional supplements.

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1. INTRODUCTION

The various parts of plants provide food for animals and human beings because it contains mineral, vitamins and certain hormone precursors in addition to protein and energy [1]. In herbal medicine, any part of plant that contributes aromatic as well as adding distinctive flavour to food and drink is considered as a spice. Spices have traditionally been used for their medicinal qualities before the development of synthetic drugs in the nineteenth century [2,3]. The overwhelming flavour and aroma spices give to food is due to the fusion of volatile chemicals concentrated within the plants. The major chemical families from which these aroma compounds are derived are the terpenes and the phenolics [4]. In the last decade many researchers has worked on series of spices to ascertain its nutritional composition and its value. Okwu and Okpara [5] worked on the elemental composition (Ca, P, K, Mg, Fe, Cu, Zn and Mn) of *D. tripetala* using atomic absorption spectrophotometer (AAS). Adedayo et al. [6] also investigated elemental composition of *D. tripetala* and *M. myristica* using atomic absorption spectrophotometer (AAS). Similarly, other researchers like Ekeanyanwu et al. [7], Alqareer et al. [8], Farhin et al. [9] and Rania et al. [10] had all investigated various spices using AAS.

However, in the AAS techniques the sample needs to be digested and some analyte may be lost in the process. Therefore, there is a need to use X-ray fluorescence (XRF) that eliminates the digestion process and the rough samples was analysed in pellet form. Specifically, the study seek to determine the elemental analysis of five different most common spices (*M. myristica, P. guineense, S. aromaticum X. aethiopica and D. tripetala)* used in Nigeria using EDXRF techniques and also to compare their results statistically.

2. MATERIALS AND METHODS

Sample Collection and Preparation: *D. tripetala* (Pepper fruits) was bought from the Open-market in Aba, Abia State of Nigeria. While *M. Myristica* (African nutmeg), *P. guineense (*African black pepper*), S. aromaticum (*Clove*)* and *X. aethiopica* (African pepper) were bought from the Open-market in Nasarawa-Toto in Nasarawa State in their dried form. The samples were thoroughly screened to remove stones, washed with distil de-ionized water and subsequently stored at room temperature. The samples (fruit seed, flower and bark) were then pulverized using electric mill in the laboratory, stored in an air tight container and kept in refrigerator at 4 ^{0}C until needed for analysis.

Proximate analysis: All the parameters investigated (moisture content, ash content, crude protein, crude fibre and carbohydrate) were carried out by standard method without any modification [11].

Elemental analysis: Mineral elements were determined by Energy Dispersive X-ray Fluorescence (EDXRF) method using AMPTEK$^{(R)}$ available at the Centre for Energy and Research Development (CERD) Obafemi Awolowo University Ile-Ife, Osun State.

Sample preparation: The samples were pulverized into fine powder using an agate mortar. The powdered samples were later transformed in to pellets using a CARVER model manual pelletizing machine at a pressure of 6 torr. The pelletized sample were inserted into the sample holder of the XRF system and was bombarded by X-ray fluorescence spectrometer with a Ag anode at a voltage of 25 kV and current of 50 µA for 1000 counts or approximately 18 minutes in an external chamber setup. Characteristic x-ray of the samples was detected by the solid state Si-Li detector system and spectrum acquisition was done using ADMCA^R software. The spectrum analysis was done using the ADMCA plus Fundamental Parameter (FP-CROSS) Software which translates the peak areas into concentration values or percentages.

Statistical Analysis: Software for Statistical Programme for Social Sciences (SPSS) version 16.0 was used to obtain the mean concentration of elemental components along with their respective standard deviations. Values of treated groups were compared statistically with control by Independent Sample Two-way ANOVA and Pearson correlation coefficient. Inferences were made from findings at 95 and 99% confidence level.

3. RESULTS AND DISCUSSION

The proximate composition of the five local spices (%) (Moisture content, Ash content, Crude protein, Fat, Fibre and Carbohydrate) are presented in Table 1, while the XRF mineral analysis of the spices are presented in Table 2.

3.1 Proximate Analysis

Moisture content: The values ranges from 8.61 – 17.7%, *D. tripetala* has the highest value while the *S. aromaticum* have the lowest value. These values were in agreements with previous studies reported by Tairu et al. [4], Abdel et al. [12], Burubai et al. [13] and Ihemeje et al. [14]. However, high moisture content in the range of 36.9 – 84.7% has been reported by Uhegbu et al. [15] for some spices. The low moisture content of the *S. aromaticum* would hinder the growth of micro organisms and shelve life could be higher while high moisture content of *D. tripetala* indicate lower shelf life, therefore long storage would lead to spoilage and high susceptibility to microbial attack.

Ash Content: The ash content ranges from 2.41 – 5.56%, as *P. guineense* has the highest value while *M. myristica* has the lowest value. The values are in line with the once reported by Ekeanyanwu et al. [7] but higher than 0.33 and 1.37% as reported by Alqareer et al. [8] and Nwinuka et al. [16]. The high ash content of *P. guineense* shows that it is rich in mineral element.

Crude Protein: The relatively high content of crude protein in the sample indicates that it can contribute to the daily value of 45 g of protein recommended by USDA. The protein ranges between 5.67 – 10.9% with *P. guineense* having the highest value while *D. tripetala* has the lowest value. This value agrees with that reported by Burubai et al. [13] and Tiaga et al. [17]. However, it was higher than 5.57% reported for *P. guineense* by Uhegbu et al. [15] and less than 12.50 reported for *P. guineense* by Nwinuka et al. [16]. This indicates that *P. guineense* seed is a good source of dietary protein supplement to meet the recommended daily requirements for human.

Crude Fibre: The fibre content falls between 13.6 – 23.7% with *M. myristica* having the highest value while *X. aethiopica* has the lowest value. The values obtained were within the range of literature values [14]. This quality of *M. myristica* is highly desirable because adequate intake of dietary fibre can lower serum cholesterol level, risk of coronary heart disease and breast cancer [7].

Crude Fat: The crude fat content ranges from 2.34- 24.2%, with *M. myristica* having the highest amount while *P. guineense* has the lowest amount. The values obtained were within the range of literature values [12,18,19]. This indicates that *M. myristica* can be sources of energy and it also promotes fat soluble vitamins absorption but should be consumed with caution so as to avoid obesity and other related disease.

Carbohydrate: Carbohydrate content of these spices range between 26.2 – 53.4% with *P.guineense* having the highest value while *M.myristica* has the lowest value. This values are in line with the value reported by Adeolu et al. [18] and Enwereuzoh et al. [20] but higher than 8.96 and 21.2% reported by Ekeanyanwu et al. [7] and less than 61.2 and 63.7% reported by Alqareer et al. [8] and Tairu et al. [4], respectively. Therefore, *P. guineense* having the highest value is an indication of good source of energy.

3.2 Elemental Analysis

Potassium (K): The most abundant mineral in all the samples with values ranging from 302 ± 5mg/g in *S.aromaticum* to 499± 7mg/g in *P. guineense*. Similarly, all the samples contained relatively high amount of Calcium (Ca) with values between 426± 7mg/g in *S. aromaticum* to 325± 1 mg/g in *M. myristica.* These values are higher than Ca (416.01±1.42 mg/g); K (869.64±4.03 mg/g) as reported by Ekeanyanwu et al. [7] using Atomic absorption spectrophotometric method; Since K and Ca are alkaline – and alkaline earth – metals, respectively, Low calcium diet (< 200 mg Ca per day) increases the risk of calcium oxalate stone formation while high calcium diet (>1200 mg Ca per day) decreases it. Ca is also useful in blood clotting, muscle contraction, maintenance of the electrical potential in nerve cells, and in many enzymes activation in the metabolic process. Considering the importance of calcium for the growth and maintenance of the body this value could be said to be adequate to contribute to the Recommended Daily Allowance (RDA 1200 mg) values of calcium for an adult man. Potassium in the body is also of great important for prevention of high blood pressure.

Copper (Cu) was detected in all the five samples with values between 0.862 ± 0.03 mg/g in *P.guineense* to 0.095 ± 0.01 mg/g in *D. tripetala.* Ekeanyanwu et al. [7] reported a low value of

Table 1.The proximate analysis of the nutrients in five local spices

Parameters (%)	*M.myristica*	*P.guineense*	*S.aromaticum*	*X.aethiopica*	*D.tripetala*
Moisture	12.6	10.9	8.61	9.54	17.7
Ash	2.41	5.56	4.82	4.12	5.37
Crude fat	24.2	2.34	10.7	9.35	5.65
Crude fibre	23.7	16.7	16.8	13.6	14.3
Crude protein	10.6	10.9	6.13	10.7	5.67
Carbohydrate	26.2	53.4	52.9	52.5	51.2

Table 2. Summary of the minerals present in all the samples (mg/g)

Sample	Ca	K	Cu	Fe	Mn	Mo	Se	Sr	Zn	Rb	Br
M. myristica	325±11	464±11	0.296±0.01	56.8±2.0	0.059±0.01	0.372±0.03	2.83±0.03	1.55±0.2	17.7±0.7	Not Detected	Not Detected
P. guineense	385±7.6	499±6.9	0.862±0.03	40.2±0.9	0.069±0.004	1.49±0.2	1.19±0.1	1.76±0.1	5.84±0.3	0.031±0.01	0.139±0.01
S. aromaticum	426±7.0	302±5.1	0.816±0.03	24.0±0.7	0.084±0.01	1.14±0.2	0.953±0.1	1.48±0.1	4.94±0.2	Not Detected	Not Detected
X. aethiopica	358±8.6	499±8.2	0.488±0.04	30.4±0.9	32.3±1.1	0.216±0.03	0.770±0.1	1.27±0.1	7.04±0.3	Not Detected	0.589±0.01
D. tripetala	376±10	463±9.0	0.0950±0.01	39.1±1.2	0.0490±0.01	0.172±0.02	2.35±0.2	1.98±0.2	13.6±0.5	Not Detected	0.0210±0.004

0.19+0.02mg/g for *P.guineense* using AAS. Similarly, Farhin et al. [9] investigating *M. myristica* reported Cu content to be between 2.30 – 19.69 ppm. The high value Cu we reported could be as a result of the method employed for the analysis. Although, Cu and Zn are essential metals but have potential for toxicity at high level. The shows that this spices could serve as source of Cu human diets since the RDA value of copper is 1.5-3.0 mg for a male adult was recommended by the United State Department of Agriculture [21].

Iron (Fe) was detected in all the samples with concentrations ranging from 56.8 ± 2.0 mg/g in *M. myristica* to 24.0 ± 0.7 mg/g in *S. aromaticum* which is higher than that reported value by Ekeanyanwu et al [7]. The methods of analysis and nature of soils where those spices were grown could attribute to the high values in our results. The importance of iron as a trace element in the body can be seen in its role in haemoglobin formation, normal functioning of the central nervous system and oxidation of carbohydrates, proteins and fats. This value for iron suggests that *M. myristica* seeds can contribute in boosting the blood level in anaemic conditions [21].

Manganese (Mn) levels in the five samples ranged between 32.3 ± 1.1 mg/g in *X. aethiopica* to 0.0490 ± 0.01 mg/g in *D. tripetala.* The Mn content in *X. aethiopica* is higher than the values reported for *P. guineense* (1.05±0.35 mg/g) by Ekeanyanwu et al.[7]. The range of Mn level in *M. myristica* (28.73 – 562.6ppm) reported by Farhin et al. [9] accommodate our value for *X. aethiopica* only. The RDA for manganese is 12 mg for a male adult and *X. aethiopica* can contribute about 32.3 ± 1.1 mg/g of Mn to the RDA and could be said to be a fairly good source of Mn [21].

Molybdenum (Mo) levels in the five samples ranged between 1.49 ± 0.2 mg/g in *P. guineense* to 0.172 ± 0.02 mg/g in *D. tripetala.* Molybdenum plays a role by inhibiting pulmonary and liver fibrosis which is thickening and scarring of tissue and helps prevent liver and heart damage and the activation of enzymes that are involved in breaking down food to produce energy. The richest molybdenum food sources are plants but the nutrient content varies with the amount of it in the soil. The RDA is 75µg per day and hence *P. guineense* could serve as a good source of molybdenum.

Selenium (Se) was detected in all the samples with concentrations ranging from 2.83 ± 0.03 mg/g in *M. myristica* to 0.77 ± 0.1 mg/g in *X. aethiopica.* The values disagree with that reported by Farhin et al. [9] from Negligible to 2.26 ppm. Selenium is an essential trace mineral important for cognitive function, a healthy immune system and fertility for both men and women. Selenium is involved in the production of prostaglandins in the body, which regulate inflammation and may reduce inflammation related to Rheumatoid arthritis. The RDA for selenium is 55 µg per day for adults and hence *M. myristica* can contribute to this health benefit.

Strontium (Sr) levels in the five samples ranged between 1.98 ± 0.2 mg/g in *D. tripetala* and 1.27 ± 0.1 mg/g in *X. aethiopica. D. tripetala* is a good source of strontium. Strontium is a trace mineral in the diet whose metabolism is closely tied to that of calcium. Both metals compounds are having great role in providing strength to the skeletal system of human being. An average daily intake is approximately 1 to 5 mg [22].

Zinc (Zn) was detected in all the samples with concentrations ranging from 17.7 ± 0.7 mg/g in *M. myristica* to 4.94 ± 0.2 mg/g in *S. aromaticum.* The value disagree with the low value of 1.52 ± 0.11mg/g that was reported for *M. myristica* by Ekeanyanwu et al. *[7]*. Zinc plays a vital role in protein synthesis and helps regulate the cell production in the immune system of the human body. Zinc is mostly found in the strongest muscles of the body and is found in high concentrations in the white and red blood cells, eye retina, skin, liver, kidneys, bones and pancreas. The *M. myristica* value could be used as nutritional supplement since the RDA for zinc is 15 mg for adults [21].

Rubidium (Rb) was detected only in one of the spices with concentration of 0.031 ± 0.01 mg/g in *P. guineense* and the RDA is 0.68g as an average. Rubidium has a close physiochemical relationship to potassium and may have the ability to act as a nutritional substitute for it. Rb plays an essential role in the synthesis of enzymes that create essential for the proper absorption of glucose and hence decreases chances of getting diabetes. It also help in maintains hormonal balance [23]. Therefore, *P. Guineense* could also be used for Rb supplement.

Br was also detected in three samples with concentrations between 0.589 ± 0.01 mg/g in *X.*

aethiopica and 0.021 ± 0.004 mg/g in *D. tripetala.* Bromide ion, in human either as NaBr or KBr has anti-seizure properties and it is an effective trace mineral in the treatment of hyperthyroid conditions. The recommended dietary allowance/intake is 2 – 5 mg per day [24].

Table 3. Two-way ANOVA, of parameters present in all the samples

Source	**DF**	**SS**	**MS**	**F**	**P**
Treatment	5	6044.64	1208.93	24.39	0.000
Group	4	0.01	0.00	0.00	1.000
Error	20	991.39	49.57		
Total	29	7036.04			

S = 7.041 R-Sq = 85.91% R-Sq(adj) = 79.57%

Table 4. Two-way ANOVA, for elements present in all the samples

Source	DF	SS	MS	F	P
Treatment	10	13498.8	1349.88	169.01	0.000
Group	4	18.1	4.52	0.57	0.688
Error	40	319.5	7.99		
Total	54	13836.4			

S = 2.826 R-Sq = 97.69% R-Sq(adj) = 96.88%

Table 5. Correlation analysis between sample spices

Spices		*M. myristica*	*P. guineense*	*S. aromaticum*	*X. aethiopica*	*D. tripetala*
M. myristica	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	6				
P. guineense	Pearson Correlation	.513	1			
	Sig. (2-tailed)	.298				
	N	6	6			
S. aromaticum	Pearson Correlation	.649	.971**	1		
	Sig. (2-tailed)	.163	.001			
	N	6	6	6		
X. aethiopica	Pearson Correlation	.596	.982**	.990**	1	
	Sig. (2-tailed)	.212	.000	.000		
	N	6	6	6	6	
D. tripetala	Pearson Correlation	.534	.973**	.964**	.965**	1
	Sig. (2-tailed)	.275	.001	.002	.002	
	N	6	6	6	6	6

***. Correlation is significant at the 0.01 level (2-tailed)*

Table 6. Correlation analysis between elements in each sample

Parameter		Ca	K	Cu	Fe	Mn	Mo	Se	Sr	Zn	Rb	Br
Ca	Pearson Correlation	1										
	Sig. (2-tailed)											
	N	5										
K	Pearson Correlation	-.701	1									
	Sig. (2-tailed)	.187										
	N	5	5									
Cu	Pearson Correlation	.615	-.345	1								
	Sig. (2-tailed)	.270	.570									
	N	5	5	5								
Fe	Pearson Correlation	-.815	.512	-.479	1							
	Sig. (2-tailed)	.093	.378	.414								
	N	5	5	5	5							
Mn	Pearson Correlation	-.243	.365	-.039	-.349	1						
	Sig. (2-tailed)	.693	.546	.951	.565							
	N	5	5	5	5	5						
Mo	Pearson Correlation	.620	-.315	.901*	-.252	-.430	1					
	Sig. (2-tailed)	.265	.606	.037	.682	.469						
	N	5	5	5	5	5	5					
Se	Pearson Correlation	-.619	.207	-.744	.848	-.519	-.458	1				
	Sig. (2-tailed)	.266	.739	.150	.069	.370	.438					
	N	5	5	5	5	5	5	5				
Sr	Pearson Correlation	.103	.155	-.335	.299	-.696	.077	.511	1			
	Sig. (2-tailed)	.869	.804	.582	.626	.192	.902	.379				
	N	5	5	5	5	5	5	5	5			
Zn	Pearson Correlation	-.770	.300	-.829	.846	-.280	-.640	.964**	.316	1		
	Sig. (2-tailed)	.128	.623	.083	.071	.648	.245	.008	.605			
	N	5	5	5	5	5	5	5	5	5		
Rb	Pearson Correlation	.178	.366	.594	.094	-.250	.758	-.262	.313	-.400	1	
	Sig. (2-tailed)	.775	.545	.291	.881	.685	.138	.670	.609	.504		
	N	5	5	5	5	5	5	5	5	5	5	
Br	Pearson Correlation	-.210	.476	.079	-.339	.973**	-.281	-.589	-.620	-.377	-.024	1
	Sig. (2-tailed)	.735	.417	.900	.577	.005	.647	.296	.264	.532	.970	
	N	5	5	5	5	5	5	5	5	5	5	5

**. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed)*

Statistical Analysis: The two-way ANOVA analysis of the different spices and elements present in all the samples were presented in Tables 3 and 4, respectively. Since P-value (= 0.000) < α (=0.05) for the treatment we conclude that there is significant difference in the mean constituents across each group. Secondly, Since P-value (=1.000) > α (=0.05) for the group therefore we conclude that there is no significant difference in the mean contribution of the various samples (groups).

Table 5 shows the correlation for the constituents at significant level of 0.01. It was observed that there is no relationship between *M. myristica* and *P. guineense, S. aromaticum, X. aethiopica, D. tripetala* since their p- values were all greater than p(> 0.01). However, there is a relationship between *P. guineense* and *S.aromaticum, X. aethiopica, D. tripetala* and also between *S.aromaticum* and *X. aethiopica, D. tripetala* then *X*. aethiopica and *D. tripetala* since their p-values were less than 0.01 and hence significantly different. The ANOVA for elements present in all the samples are shown in Table 4. Since P-value (=0.000) < α (=0.05) for the treatment, we conclude that there is significant difference in elements across all samples Secondly, Since P-value (=0.688) > α (=0.05) for the group, we therefore we conclude that there is no significant difference in the mean contribution of the various samples. From Table 6, it was observed that relationship only exist between (Mn, Br) and (Se, Zn), for other elements the relationship was not significant therefore no relationship exists.

4. CONCLUSION

The five spices are good sources of carbohydrate, thus contributes to the energy generation for metabolic reactions of the cells (cellular activities). The high fibre content of the spices will have far reaching effects on lowering of gastric cholesterol and increase in digestion. The presence of high ash content is an indication of higher mineral content. Potassium (K) Calcium (Ca) and Iron (Fe) were the most abundant mineral in all the samples they are useful in blood clotting, muscle contraction, bone formation, maintenance of the electrical potential in nerve cells, and in many enzymes activation in the metabolic process. The overall pattern of mineral composition was as follows in descending order: K > Ca > Fe > Zn > Sr > Se > Mo > Cu > Mn > Br > Rb. Therefore consumption of the spices should be encouraged since the body uses minerals for many metabolic activities.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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