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Evaluation of Physicochemical Properties and Mineral Content of some Indigenous Spices Retailed in Ibadan, Nigeria

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Abstract

Spices have been frequently added to foods since ancient times, not only to enhance the taste but also as preservatives and medicinal agents. Their usage may be of concern due to possible contamination during processing and handling. The aim of this study was to investigate the physicochemical properties and heavy metals concentrations in some indigenous spices sold at two main markets namely Bodija and Apata markets in Ibadan, Oyo State, Nigeria. A total of eight commonly consumed spices were purposely analyzed for their proximate and mineral composition, physicochemical properties and anti-nutrients contents. Proximate analyses showed that the spices to contained (fresh matter 'As consumed') moisture content ranging from 11.74g in thyme to 59.36g/100g in scent leaves. Crude protein, fat, fibre, ash and carbohydrate contents ranged between 3.72 – 15.07g, 1.31 – 8.28g, 1.96 – 11.38g, 1.11 – 7.81g, and 17.80 – 50.77g/100g sample, respectively. All the spices contained high levels of potassium (176.3 – 739.6 mg), sodium (60.6 – 317 mg), calcium (78.5 – 423.9 mg), magnesium (82 – 322.1 mg) and iron (5.78 – 20.10 mg), but low levels of heavy metals – copper (0.17 – 0.68 mg), and manganese (0.32 – 1.05 mg)/100g respectively. Flavonoid was the most abundant phytochemical, while terpene was the least phytochemical in all the samples. The samples had very low concentrations of anti-nutrients, and could pose no threat to human health, as their values were within the regulatory standard. The antioxidants and phytochemicals in the spices can help in building up immunity and prevention of non-communicable diseases, hence, their consumption should be encouraged.

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Introduction

Spices are dried parts of plants, which have been used as dietary components often to improve colour, aroma, palatability and acceptability of food, as well as influence digestion and metabolism[1]. They are either used in the form of dried seed, fruit, root, bark, or as vegetables[2]. Spices have been used for centuries by many cultures to enhance flavour and aroma, and as preservative and medicinal agents[3]. In Nigeria, some spices are used in the preparation of certain soups which are delicacies, and also recommended for rapid relief of ailments such as cold, malaria fever, and so on. Therapeutically, spices have been useful in the management of stomach ache, leprosy, cough, loss of appetite, rheumatoid pain, convulsion and inflammation[4].

Spices have been recognized to have some medicinal properties due to their antioxidant and antimicrobial actions[5]. These benefits from spices are as a result of the presence of phytochemicals[6,7], which make each spice to have a unique aroma and flavour. The phytochemicals present in plants are responsible for prevention of disease and promotion of health. The bioactive constituents are steroids, terpenoids, carotenoids, flavonoids, alkaloids, tannins and glycosides[8]. Even though spices have many benefits, they can also contain some toxic chemicals derived from the environment of their production, processing, and storage conditions. Addition of spices that may be contaminated with trace and heavy metals to food as a habit may result in accumulation of these metals in human organs and lead to different health issues both in the middle and long terms[9].

The average amount of metals found in a spice can vary from spice to spice or place of production[1]. Natural food spices such as pepper have been reported to contain significant quantities of some trace metals[10]. The powder of pepper (red), turmeric and coriander spices from the local markets are usually processed by individual sellers, and to attracts customers, some of them add colourants which may contain contaminants in form of some trace metals. Addition of spices that are contaminated with trace and heavy metals above the permissible level can affect human health.

The presence of essential metals such as copper, zinc, nickel and iron in spices are useful for the healthy growth of the body; and they play vital roles as structural and functional components of metalloproteins and enzymes in living cells[11]; though they seem intolerable at very high levels. Due to consumption of significant amount of spices through diets, it is important to know the metal contents in these spices. This study was aimed at investigating the physico-chemical properties and heavy metals concentrations in some indigenous spices sold at Bodija and Apata markets in Ibadan, Oyo State, Nigeria. Fig 1.

Materials and Methods

Sample Collection and Preparation

A total of eight spices were purposively bought from the two markets and these spices were cameroon pepper (*Capsicum chinense Linn*); nutmeg (*Myristica fragrans*); clove (*Syzgium aromaticum*); ginger (*Zingiber officinale*); turmeric (*Curcuma longa Linn*); thyme (*Thymus vulgaris L.*); scent leaves (*Occimum gratisimum*) and garlic (*Allum sativum*) respectively. Samples were oven dried at 80^{0}C for 12 hrs to remove inherent water molecules; the dried materials were pulverized to form powder. Each sample was placed in an airtight container, labeled and kept at room temperature until when needed for further analyses.

Proximate Analyses

Moisture content of the samples was determined by air oven at 105^{0}C (plus 11 Sanyo Gallenkamp PLC UK) for 4 hours. The crude protein of the samples was determined using micro-kjeldahl method[12] and amount of crude protein calculated using the conversion factor of 6.25. Crude lipid was determined by weighing 5 g of dried sample into fat free extraction thimble and plugging lightly with cotton wool. The thimble was placed in the Soxhlet extractor fitted up with reflux condenser. The dried sample was extracted with petroleum ether and the crude lipid estimated as g/100g dry weight of sample and then converted to g/100g fresh sample weight. The ash content was determined by weighing 5g of sample and heated in muffle furnace (Gallenkamp, size 3) at 550^{0}C for 4 hrs and ash calculated as g/100g original sample[12]. Total carbohydrate content was obtained by difference.

Figure 1. Pictures of Spices studied

Mineral Analysis

Potassium and sodium content of the samples were determined by digesting the ash of the samples with perchloric acid and nitric acid, and then taking the readings on the Jenway digital flame photometer/ spectronic20[12]. Phosphorus was determined by vanado-molybdate colorimetric method. Calcium, magnesium, iron, zinc, manganese and copper were determined spectrophotometrically by using Buck 200 atomic absorption spectrophotometer (Bulk Scientific, Norwalk) and absorption values of the samples' minerals were compared with absorption of standards of these minerals[12].

Phytochemical Screening

Flavonoid Determination

The samples were grinded, and 0.50 g of finely ground sample was weighed into a 100 ml beaker and 80 ml of 95% ethanol was added and stirred with a glass rod to prevent lumping. The mixture was filtered through a Whatman No.1 filter into a 100 ml volumetric flask and made up to mark with ethanol, and 1ml of the extract pipetted into 50 ml volumetric flask. Four drops of concentrated HCl were added, after which 0.5 g of magnesium turnings was added to develop a magenta red coloration. Standard flavonoid solutions of range 0-5 ppm were prepared and treated in a similar way with HCl and magnesium turnings like sample. The absorbance of sample and standard solutions was read on a digital Jenway V6300 Spectrophotometer at 520 nm[13]. The percentage flavonoid was calculated using the formula:

$$\%\ Flavonoid = \frac{Absorbance\ of\ sample\ x\ average\ gradient\ factor\ x\ dilution\ factor}{Weight\ of\ sample\ x\ 10{,}000}$$

Glycoside Determination

Ten millilitres of extract was pipette into a 250 ml conical flask, 50 ml of chloroform was added and shaken on a Vortex Mixer for 1 hr. The mixture was filtered, 10 ml pyridine and 2 ml of 2% sodium nitroprusside were added, shaken thoroughly for 10 mins and 3 ml of 20% NaOH added to develop a brownish yellow colour. Standard solutions of glycoside ranging from 0 – 5 mg/ ml were prepared and treated as the sample. The absorbance of the sample and standard solutions was read on a Spectronic21D digital Spectrophotometer at 510 nm[14]. The percentage of the glucoside was calculated using the formula:

$$\%\ Glucoside = \frac{Absorbance\ of\ sample\ x\ average\ gradient\ factor\ x\ dilution\ factor}{Weight\ of\ sample\ x\ 10{,}000}$$

Steroid Determination

About 0.5 g of sample was weighed into 100 ml beaker and 20 ml of chloroform-methanol (2:1) mixture added and shaken for 30 min on a shaker. The mixture was filtered through a Whatman No.1filter paper and resultant residue repeatedly treated with chloroform-methanol mixture until free of steroids. One millilitre (1 ml) of the filtrate was pipetted into a 30 ml test tube and 5 ml of alcoholic KOH added and shaken thoroughly. The mixture was later placed in a water bath set at 37^0C - 40^0C for 90 mins, cooled to room temperature, then 10 ml of petroleum ether added, followed by addition of 5 ml distilled water. The solution was evaporated to dryness on the water bath and 6 ml of Liebermann Burchard reagent was added to the residue in dry bottle and absorbance taken at 620 nm on a Spectronic21D digital Spectrophotometer. Standard steroid solutions of 0–4 mg/ml concentration were prepared and treated like sample[14, 15, 16]. The percentage steroid was calculated using the formula:

$$\%\ Steroid = \frac{Absorbance\ of\ sample\ x\ Gradient\ x\ dilution\ factor}{Weight\ of\ sample\ x\ 10{,}000}$$

Phlobatannin Determination

The method of Analytical methods committee of the Royal Society of Chemistry[14] was employed. About 0.5 g of sample was weighed into 50 ml beaker, 20 ml of 50% methanol was added and covered with parafilm and placed in a water bath set at 77 – 80^0C for 1 hr. The mixture was properly shaken and then filtered through a Whatman No 1 Filter paper into a 50ml volumetric flask using aqueous methanol to rinse and make up to mark with distilled water. To 1 ml of the solution pipetted into a 50 ml volumetric flask, were added 20 ml water, 2.5 ml Folin-Dennis reagent, and 10 ml of 17% sodium carbonate. This mixture was homogenized thoroughly for 20 mins. Standard Phlobatannin solutions of 0-5 mg/ ml concentrations were prepared and treated as the sample above. The absorbance of standard solutions and the sample was read at 550 nm on a Spectronic21D Spectrophotometer. Percent Phlobatannin was calculated

using the formula:

$$\% \, Phlobatannin = \frac{Absorbance\ of\ sample\ x\ gradient\ factor\ x\ dilution\ factor}{Weight\ of\ sample\ x\ 10{,}000}$$

Anthraquinones Determination

About 0.50 g of sample was weighed into 250 ml beaker and 60 ml benzene added and stirred and filtered using Whatman No.1 filter paper. About 10 ml of filtrate was pipetted into another 100 ml volumetric flask and 0.2% Zinc dust was added followed by the addition of 50 ml hot 5% NaOH solution. The mixture was heated just below boiling point for 5 mins and then rapidly filtered and washed once in water. The filtrate was again heated with another 50 ml of 5% NaOH to develop a red colour. Standard anthraquinone solutions of range 0-5 mg/l were prepared and treated with 0.2% Zinc dust and NaOH as the sample. The absorbance of sample as well as that of standard solutions were read on a digital spectrophotometer at 640 nm[14]. The percentage anthraquinone was calculated using the formula:

$$\% \, Anthraquinone = \frac{Absorbance\ of\ sample\ x\ gradient\ factor\ x\ dilution\ factor}{Weight\ of\ sample\ x\ 10{,}000}$$

Terpene Determination

About 0.50g of sample was weighed into a 50 ml conical flask, 20 ml of 2:1 chloroform-methanol mixture was added, thoroughly agitated and allowed to stand for 15 mins. The mixture was later centrifuged for another 15 mins. The supernatant solution obtained was discarded and the precipitate re-washed with another 20 ml chloroform-methanol mixture for re-centrifugation. The resultant precipitate was dissolved in 40 ml of 10% sodium dodecyl sulphate solution, 1 ml of 0.01 M ferric chloride solution added at 30 s interval, shaken well and allowed to stand for 30 mins. Standard terpene solutions of concentrations 0 – 5mg/ml were prepared from stock solution (Sigma-Aldrich chemicals U.S.A). The absorbance of sample as well as the standard solutions of terpenes were read on a digital spectrophotometer at 510 nm[14]. The percentage terpene was calculated using the formula:

$$\% \, Terpene = \frac{Absorbance\ of\ sample\ x\ gradient\ factor\ x\ dilution\ factor}{Weight\ of\ sample\ x\ 10{,}000}$$

Phenol Determination

About 0.20 g of sample was weighed into a 50 ml beaker, 20 ml of acetone added and homogenized for 1hr and filtered through a Whatman No.1 filter paper into a 100 ml volumetric flask using acetone to rinse, and made up to the mark with distilled water. One millilitre of sample extract was pipetted into 50 ml volumetric flask, 20 ml water added, 3 ml of phospho-molybdic acid added, followed by the addition of 5 ml of 23% Na_2CO_3 mixed thoroughly, made up to mark with distilled water and allowed to stand for 10 mins to develop bluish-green colour. Standard solutions of phenol of 0-10 mg/ml was prepared from stock solution (Sigma-Aldrich chemicals U.S.A). The absorbance of sample and the standard solutions of phenol were read on a digital spectrophotometer at 510 nm[14]. The percentage Phenol is calculated using the formula:

$$\% \, Phenol = \frac{Absorbance\ of\ sample\ x\ gradient\ factor\ x\ dilution\ factor}{Weight\ of\ sample\ x\ 10{,}000}$$

Anti-nutrients Determination

Phytate Determination

About 2 g of each sample was weighed into 250 ml conical flask, 100 ml of 2% hydrochloric acid was added, soaked for 3 hrs, filtered through a double layer of hardened filter paper and 50 ml of each filtrate placed in 250 ml conical flask and 107 ml distilled water added. About 10 ml of 0.3% ammonium thiocyanate (NH_4SCN) solution was added to each solution and titrated with 0.00195g/ml iron (III) chloride solution to a slightly brownish-yellow end point which persisted for 5 mins[12]. The percentage phytic acid was calculated using the formula:

$$\% \, Phytic\ Acid = \frac{Titre\ value\ x\ 0.00195\ x\ 1.19\ x\ 100\ x\ 3.55}{Weight\ of\ sample}$$

Saponin Determination

The spectrophotometric method of Brunner[17] was used as adopted by Mujeeb *et al.*, [18]. One gramme of finely ground sample was weighed into a 250 ml beaker and 100 ml of isobutyl alcohol was added. The mixture was shaken on a UDY shaker for 5 hrs, filtered through a Whatman No1 filter paper into a 100 ml beaker and 20 ml of 40% saturated solution of magnesium carbonate was added and filtered through a Whatman No1 filter paper to obtain a clear colorless solution. One millilitre of the colorless solution was pipetted into 50 ml volumetric flask and 2 ml of 5% $FeCl_3$ solution added and made up to mark with distilled

water. It was allowed to stand for 30 mins for blood red colour to develop. Standard saponin solutions of concentration range 0 – 10 ppm were prepared and treated with 2 ml of 5% $FeCl_3$ solution as done for sample above. The absorbance of the sample and standard saponin solutions were read on a Jenway V6300 Spectrophotometer at 380 nm.

$$\% \, Saponin = \frac{Absorbance\ of\ sample\ x\ gradient\ factor\ x\ dilution\ factor}{Weight\ of\ sample\ x\ 10{,}000}$$

Tannin Determination

The total tannin was determined by the Spectrophotometric procedure described by Association of Official Analytical Chemists[12] by measuring 0.20 g of sample into a 50 ml beaker followed by addition of 20ml of 50% methanol, covered with parafilm and placed in a water bath set between 77-80^{0}C for 1 hr and shaken thoroughly. The extract was quantitatively filtered using a double layered Whatman No 41 filter paper into a 100 ml volumetric flask. Twenty millilitres (20 ml) water was added, 2.5 ml Folin-Denis reagent and 10 ml of 17% Na_2CO_3 were added and mixed properly. The mixture was made up to the mark with distilled water and allowed to stand for 20 min for the bluish–green colour to develop. Standard solutions of tannic acid were prepared and treated similarly as the samples. The absorbance of the tannic acid standard solutions as well as samples were read after colour development on a spectronic21D spectrophotometer at 760 nm[12]. Percent tannin was calculated using the formula:

$$\% \, Tannin = \frac{Absorbance\ of\ sample\ x\ average\ gradient\ factor\ x\ dilution\ factor}{Weight\ of\ sample\ x\ 10{,}000}$$

Oxalate Determination

Two grammes (2 g) of sample was boiled in 40 ml of water for 30 mins in a reflux condenser followed by addition of 10 ml of 20% Na_2CO_3 and boiled for another 30 mins. The solution was filtered and washed with hot water until the wash water did not show any alkaline reaction. The combined wash water and filtrate were concentrated together to a small volume and cool. With constant stirring, HCl (1:1) was added dropwise until the final acid concentration after neutralization was about 4%, at which stage a heavy precipitate appears (which is allowed to flocculate). The extract was carefully filtered into a 250 ml flask, made up to mark and kept overnight. The supernatant liquid was filtered through a dry filter paper in a dry beaker. An aliquot of the filtrate was taken into a 400 ml beaker, diluted with water to 200 ml and made just ammoniacal, and then reacidified with lactic acid, and 10 ml of the resultant solution added to cold medium of a 10% calcium chloride solution and stirred well to allow calcium oxalate precipitate to appear, and then allowed to settle overnight. The clean supernatant liquid was carefully decanted off through Whatman No. 42 filter paper, without disturbing the precipitate. The precipitate was dissolved in HCl (1:1) and oxalic acid was re-precipitated by adjusting the pH with ammonium hydroxide solution. Content was allowed to boil and settled overnight, while oxalic acid was determined by titrating against 0.05N $KMnO_4$ solution[19]. Oxalate content was estimated as:

1ml of 0.05N $KMNO_4$=0.00225 M anhydrous Oxalic Acid

= % Oxalic Acid

$$= \frac{\text{Titre value x } 0.00225}{1} \times \frac{100}{2} = \text{Titre value x } 0.1125.$$

Chemical analyses were done in triplicate, and data were presented using means and standard deviation.

Results

Proximate Composition of the Spices

The results of the proximate composition of the spices studied are presented in Table 1. The percentage moisture content varied from 11.74 g in *Thymus vulgaris* to 59.36 g in *Ocimum gratissimum*. *Ocimum gratissimum*, *Capsicum chinense Linn*, *Allium sativum* and *Zingiber officinale* were high in moisture content, constituting about half of the spices on fresh weight basis, while it constituted almost one-third of the constituents of *Curcuma longa Linn*, *Syzgium aromaticum*, and *Myristica fragrans*. *Thymus vulgaris* had the lowest value, being usually used in dry form.

The crude protein content of the spices ranged from 3.72 g in *Allium sativum* to 15.1 g in *Myristica fragrans*. *Allium sativum*, *Capsicum chinense Linn*, *Zingiber officinale* and *Curcuma longa Linn* were low, while *Syzgium aromaticum*, *Ocimum gratissimum*, *Thymus vulgaris* and *Myristica fragrans* were relatively high in crude protein. All the spices were very low in

Table 1. Proximate composition of selected Spices (g/100g, fresh weight basis 'As consumed')

Sample	Moisture	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrate
1	58.3±0.04	5.5±0.02	2.5±0.03	3.3±0.02	0.9±0.03	29.5±0.02
2	28.8±0.03	15.1±0.08	3.0±0.02	11.2±0.02	1.9±0.03	40.0±0.05
3	38.2±0.03	9.3±0.03	2.5±0.02	8.3±0.02	1.2±0.02	40.5±0.03
4	48.9±0.03	5.6±0.02	2.1±0.02	4.1±0.02	1.3±0.02	38.0±0.04
5	35.2±0.04	5.9±0.01	8.3±0.02	2.0±0.02	1.7±0.01	46.9±0.03
6	11.7±0.03	14.9±0.04	3.4±0.02	11.4±0.05	1.8±0.03	56.8±0.07
7	59.4±0.02	10.1±0.04	1.7±0.02	6.8±0.02	1.7±0.03	20.3±0.05
8	55.3±0.02	3.7±0.02	1.3±0.01	2.1±0.02	0.6±0.02	37.0±0.03

1 = Capsicum chinense Linn (Cameroon pepper); 2 = Myristica fragrans (Nutmeg);
3 = Syzgium aromaticum (Clove); 4 = Zingiber officinale (Ginger);
5 = Curcuma longa Linn (Turmeric); 6 = Thymus vulgaris L. (Thyme);
7 = Ocimum gratissimum (Scent leaf); 8 = Allium sativum (Garlic)

crude fat with *Allium sativum* having the lowest value and *Curcuma longa Linn* having the highest value. *Curcuma longa Linn* was lowest in fibre content while *Thymus vulgaris* had the highest value. *Thymus vulgaris* and *Curcuma longa Linn* were high in fibre content, *Syzgium aromaticum*, *Ocimum gratissimum* and *Zingiber officinale* contained appreciable amount, and *Capsicum chinense Linn*, *Allium sativum* and *Curcuma longa Linn* were relatively low in fibre content.

The spices contained substantial amount of ash, *Myristica fragrans* having highest value, followed by *Thymus vulgaris*, *Curcuma longa Linn* and *Ocimum gratissimum*. *Allium sativum* had the lowest ash value. Carbohydrates constituted not less than one-fifth of the constituents of the spices. *Ocimum gratissimum* had the lowest carbohydrate content, followed by *Capsicum chinense Linn*, *Allium sativum* and *Zingiber officinale*, while *Thymus vulgaris* had the highest value of carbohydrates. *Ocimum gratissimum* was highest in moisture, *Myristica fragrans* was highest in protein and ash values, *Curcuma longa Linn* was highest in fat content, while *Thymus vulgaris* was highest in fibre and carbohydrate content.

Mineral Composition of the Spices

The mineral content of the selected spices is presented in Table 2. All the spices were high in sodium, potassium, calcium, magnesium, phosphorus and iron content, except *Allium sativum*, which was low in sodium, calcium, magnesium, and phosphorus content. *Thymus vulgaris* was highest in sodium, calcium, magnesium, iron, zinc, and copper content; while *Myristica fragrans* was highest in potassium, phosphorus, manganese and selenium content. *Allium sativum* had the lowest value for all the minerals studied.

Quantitative Phytochemical Analysis

The phytochemical contents of the extract of the studied spices are presented in Table 3. Flavonoids was found to be the most abundant phytochemical in Cameroon pepper (31.673%) but was present in very minute concentration in the remaining spices. The concentrations of total phenol ranged between 0.003 and 0.276%, glycosides 0.075 and 0.116%, and phlobatanin 0.006 and 0.034%. Steroid content ranged between 0.002% in garlic and 0.041% in clove. Ginger

Table 2. Mineral composition of selected Spices (mg/100g fresh weight basis 'As consumed')

Parameter	1	2	3	4	5	6	7	8
Sodium	114.5±0.20	259.9±0.20	206.8±0.20	169.0±0.16	95.41±0.20	317.0±0.20	146.4±0.30	60.6±0.10
Potassium	408.9±0.50	739.6±0.30	361.5±0.16	553.2±0.30	505.2±0.30	342.1±0.20	845.0±0.12	176.3±0.20
Calcium	111.3±0.20	223.0±0.20	178.8±0.20	153.4±0.40	125.0±0.30	423.9±0.30	223.6±0.28	78.5±0.20
Magnesium	124.6±0.24	260.7±0.20	201.2±0.14	176.4±0.16	136.4±0.28	322.1±0.30	143.6±0.28	82.0±0.20
Phosphorus	172.1±0.20	340.1±0.20	272.7±0.20	230.5±0.20	235.0±0.20	279.5±0.30	223.6±0.28	78.5±0.20
Iron	8.49±0.20	15.68±0.16	13.45±0.34	10.82±0.02	9.11±0.25	20.10±0.21	8.99±0.04	5.78±0.04
Zinc	1.71±0.25	3.46±0.25	2.79±0.29	2.27±0.01	2.26±0.06	4.31±0.21	2.01±0.03	1.41±0.20
Copper	0.29±0.01	0.60±0.02	0.41±0.03	0.30±0.03	0.36±0.02	0.68±0.02	0.35±0.02	0.17±0.02
Manganese	0.34±0.02	0.92±0.05	0.66±0.02	0.49±0.02	0.56±0.03	1.05±0.03	0.52±0.02	0.32±0.02
Selenium (µg/)	2.17±0.02	4.97±0.03	3.01±0.02	2.87±4.24	1.64±0.03	5.09±0.02	2.65±0.03	1.99±0.01

1 = Capsicum chinense Linn (Cameroon pepper); 2 = Myristica fragrans (Nutmeg);

3 = Syzgium aromaticum (Clove); 4 = Zingiber officinale (Ginger);

5 = Curcuma longa Linn (Turmeric); 6 = Thymus vulgaris L. (Thyme);

7 = Ocimum gratissimum (Scent leaf); 8 = Allium sativum (Garlic)

Table 3. Phytochemical composition of selected Spices (% Dry weight basis)

Parameter	1	2	3	4	5	6	7	8
Flavonoids	31.673±4.78	0.008±0.002	0.007±0.000	0.006±0.000	0.005±0.000	0.007±0.000	0.009±0.002	0.003±0.001
Total phenol	0.265±0.002	0.276±0.000	0.251±0.003	0.003±0.000	0.271±0.002	0.261±0.002	0.174±0.002	0.149±0.002
Glycosides	0.105±0.001	0.116±0.002	0.090±0.002	0.094±0.002	0.091±0.002	0.105±0.002	0.114±0.002	0.075±0.002
Phlobatanin	0.023±0.002	0.034±0.001	0.015±0.002	0.013±0.002	0.016±0.001	0.021±0.002	0.026±0.001	0.006±0.000
Steroid	0.028±0.003	0.005±0.000	0.041±0.001	0.008±0.000	0.004±0.000	0.004±0.000	0.005±0.000	0.002±0.000
Anthraqui-nones	0.008±0.000	0.009±0.000	0.006±0.002	0.168±0.002	0.008±0.000	0.008±0.002	0.009±0.000	0.005±0.000
Terpenes	0.005±0.000	0.005±0.000	0.003±0.000	0.003±0.000	0.004±0.002	0.005±0.000	0.006±0.000	0.001±0.000

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had the highest value of anthraquinones while garlic had the lowest concentration. The content of terpenes in the analyzed samples ranged between 0.075 - 0.116%, with *Ocimum gratissimum* having the highest value while *Allium sativum* had the lowest value. In Table 4, all the analyzed spice samples were low in antinutrient content. Ginger had the highest concentration of phytate (0.374%) while its least concentration of 0.059% was found in turmeric.

Discussion

In Table 1, the spices were high in moisture content except *Thymus vulgaris*. The high moisture content of the spices provides for greater activity of water-soluble enzymes and co-enzymes needed for metabolic activity[20]. The moisture values reported here for *Zingiber officinale* and *Ocimum gratissimum* are significantly lower than the value reported in the literature[21, 22], and are different from values reported by other researchers[23]. The observed differences in values could be as a result of seasonal and geographic variations; as these samples were obtained from different geographic locations and years.

The amount of crude protein in the *Ocimum gratissimum* leaf was at variance with those reported in the literature[22, 23]. It has been reported that plant foods that provide more than 12% of their caloric value from protein are of good sources of protein[24], hence, it can be inferred that two of the eight spices investigated (i.e. *Thymus vulgaris* and *Myristica fragrans*) had their values above 12% (12 g /100 g protein) which make them to be termed as good sources of protein. However, the other spices can contribute to protein intake of their consumers if the protein content in them is bio-available. The lowest concentration of crude fat

Table 4. Antinutrient content of selected Spices (% Dry weight basis)

Parameter	Phytate	Oxalate	Tannin	Saponin
1	0.094±0.002	0.056±0.002	0.051±0.002	0.278±0.002
2	0.119±0.002	0.095±0.002	0.252±0.260	0.297±0.004
3	0.094±0.002	0.074±0.002	0.046±0.002	0.268±0.003
4	0.374±0.392	0.057±0.003	0.029±0.002	0.155±0.002
5	0.059±0.002	0.026±0.001	0.028±0.003	0.110±0.002
6	0.105±0.002	0.088±0.002	0.054±0.002	0.279±0.245
7	0.116±0.002	0.097±0.001	0.061±0.003	0.296±0.002
8	0.068±0.001	0.032±0.002	0.015±0.001	0.118±0.001

1 = Capsicum chinense Linn (Cameroon pepper); 2 = Myristica fragrans (Nutmeg);
3 = Syzgium aromaticum (Clove); 4 = Zingiber officinale (Ginger);
5 = Curcuma longa Linn (Turmeric); 6 = Thymus vulgaris L. (Thyme);
7 = Ocimum gratissimum (Scent leaf); 8 = Allium sativum (Garlic)

was recorded in *Allium sativum* while *Curcuma longa* had the highest concentration. These values were fairly similar when compared with values reported in the literature[23], but the spices may not be good sources of fat-soluble vitamins.

The crude fibre content of the spices fell within the range from the reported values of some Nigerian spices and vegetables[25]. Dietary fibre helps to prevent constipation, aid bowel health and weight management[26], hence, consumption of these spices can help in promoting good health and wellness. The spices were relatively high in ash content, indicating that they will be rich in mineral content, especially the macrominerals. The values obtained for the spices in this study are comparable to those reported in the literature[20,27]. The spices can contribute to carbohydrate intake of consumers.

Mineral Content of the Spices

Potassium was the most abundant mineral in all the spices. This finding is in agreement with the report by Shaaban and Moawad[28], that reported potassium as the main macro essential element in the tested spices and herbs analyzed while on the other hand, copper was the least abundant trace element within all the samples. The highest value of sodium was obtained in *Thymus vulgaris*, while *Allium sativum* had the lowest sodium content. The value of sodium reported in this study for *Zingiber officinale* was lower than that of Bamigboye *et al.*,[29]. In comparison to other major elements evaluated in this study, sodium was found in low amounts. The presence of sodium in any food item is responsible for the regulation of plasma volume, acid-base balance, nerve and muscle contraction[30] with potassium and sodium as important intracellular and extracellular cations respectively.

Potassium was the most abundant element in all spices, the highest concentration being found in *Myristica fragrans*. However, the potassium range of values were significantly lower compared with that

of medicinal and aromatic plants used as spices, condiments and herbal teas (357 – 2767mg/100g)[31]. The second abundant element found in all the samples was phosphorus, with the highest value in *Myristica fragrans*. Phosphorus is essential in the body for filtering of waste, repairing of tissue and cells, and the deficiency of phosphorus – calcium balance results in osteoporosis, arthritis, pyorrhea, rickets and tooth decay[27].

All the spices except *Allium sativum* were high in calcium content. The concentrations of calcium in *Allium sativum* and *Curcuma longa* samples were comparable with the results obtained from Canary Island[32] and Ethiopia red pepper[33] but higher than the values reported by some studies[34,35]. Magnesium content was lowest in *Allium sativum* and highest in *Thymus vulgaris*. The results of this study were higher than those reported by Asaolu *et al.*,[27] and much lower than that of Tchiegang and Mbougueng[36]. All the spices contained substantial amount of iron, with the highest value observed in *Thymus vulgaris* and lowest value in *Allium sativum*. The values of iron obtained in this study were higher than those reported by Bamigboye et al.,[29], and Akpanyung[30], but lower than other values reported in the literature[35,38,39,40]. Iron is an important trace element in the human body that plays crucial roles in hemopoiesis, control of infection and cell mediated immunity[27]. Deficiency of iron has been described as the most prevalent nutritional deficiency, and iron deficiency anemia is estimated to affect more than one billion people worldwide[41]. The consequences of iron deficiency include reduced work capacity, impairments in behavior and intellectual performance and decrease resistance to infection[42].

The concentration of zinc in all the samples studied are lower than those reported for spices in Federal Capital Territory, Abuja, Nigeria[43,44]. Zinc is an essential element that enhances growth, and also participate in some enzymes structure or their catalytic and regulatory action[45]. According to World Health Organisation (WHO), permissible limits of zinc is 100mg/kg for spice[43], but the concentrations of zinc (mg/kg) for all the spices studied were well below the permissible limit of WHO, and hence, may be considered tolerable.

All the values obtained for copper in this study were below the regulatory WHO/FAO limit (50mg/kg) for copper in spices and seasonings, hence, its concentrations in all the samples do not pose health risks. Manganese concentration in all the analyzed samples was below the WHO recommended limit, which can be considered tolerable for all the samples. *Zingiber officinale* was high in selenium. Generally, the low level of Se in foods has been ascribed to low selenium in soil content[47]. It has been demonstrated that some plants known as Selenium-accumulator, highly absorb selenium compared to non selenium-accumulator plants. The high selenium content offers dietary selenium sources for the management of several chronic diseases such as cardiovascular diseases, cancers and HIV[48].

The values of flavonoids obtained in this study were significantly different from those in the literature[49, 50]. Flavonoids have antioxidant activities, antimicrobial properties as well as much health promoting effects such as anti-allergic, antispasmodic, anti-cancer, antidiabetic, hypoglycaemic, anti-inflammatory, anti-thrombotic, vaso-protective, tumour inhibitory and anti-viral effects[51, 52]. The values of phenolic content of the spices were lower than those in the literature. Phenolic compounds possess both antioxidant and antimicrobial activities[53, 54,55], while glycosides are useful in lowering blood pressure, treatment of congestive heart failure and cardiac arrhythmia[56]. Steroidal compounds are of importance and interest in pharmacy due to their relationship with compounds such as sex hormones mostly used in the development of female contraceptive pills[54]. This can make these spices useful for pregnant women and breastfeeding mothers to ensure their hormonal balance, as being used in some countries since steroidal compounds could serve as essential starting material in the synthesis of these hormones[50]. Anthraquinones possess laxatives, anti-malaria and anti-carcinogenic effects[47]. The presence of terpenes in food items has been reported to be useful in the treatment of cough, asthma and hay fever[56].

All the spices were low in antinutritional factors. The anti-nutritional activity of phytates can also be beneficial especially in menopause women and most adults, as they tend to have high levels of iron which can be a very strong oxidant and causes biological stress[50]. Oxalates possess certain health benefits

especially when present at low concentration by maintaining the levels of certain minerals in the body. Tannin acts as an antioxidant also has biological property like anti-carcinogen, anti-inflammation, cardiovascular protection and cell proliferation activities[57]. Saponins have potential of inhibiting tumor in animals and also used for traditional medicine preparation[57]. The presence of phytochemicals coupled with low levels of antinutrients which doubles as phytochemical may be the possible reasons why the spices possess health-promoting properties.

Conclusion

The selected spices contained appreciable amounts of crude protein, fibre and carbohydrates. Although, they are not major sources of nutrients but used mainly to add flavor, aroma and taste to food and dishes, they can contribute meaningfully to meeting the recommended dietary allowances of people, especially the essential minerals. The microminerals/heavy metals are present at permissible level of heavy metals as stipulated by World Health Organisation, indicating that their usage in food preparation and consumption on daily basis is safe with no risk of toxicity. The presence of natural antioxidants and phytochemicals in the spices can help in building up immunity and prevention of non-communicable diseases, hence, their inclusion in foods should be encouraged. The study has revealed that these spices have the potential of contributing to the nutritional and health needs of human beings.

Consent and Ethical Approval

It is not applicable.

Competing Interests

Authors have declared that no competing interests exist.

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