Original Research Article

Production and Quality Evaluation of Selected Spices [Ginger (*Zingiber officinale*), Garlic (*Allium Sativum*), Tumeric (*Curcuma longa*) and Clove (*Syzygium aromaticum*)

ABSTRACT

This study investigated the production and quality evaluation of selected spices [Ginger (*Zingiber officinale*), garlic (*Allium sativum*), turmeric (*Curcuma longa*) and clove (*Syzygium aromaticum*)]. The spices were labeled GP (garlic powder), TP (turmeric powder), CP (cloves powder) and GPW (ginger powder). The samples were evaluated for phytochemicals, β-carotene and minerals using standard procedures. The selected phytochemicals ranged as follows: (24.09 – 986.68 mg/g), phenol (150.85 – 2027.00 mg/g), flavonoids (32.55 – 2186.91 mg/g) and alkaloids (4.49 – 6.16 mg/g). The β-carotene content of samples ranged from 0.04 to 3.50 mg/g. For the selected mineral composition of samples, the results indicated; calcium ranged from 81.16 to 120.43 mg/g, potassium ranged from 129.35 to 815.28 mg/g, magnesium ranged from 10.59 to 160.80 mg/g, iron ranged from 1.01 to 14.86 mg/g and phosphorus ranged from 40.26 to 209.99 mg/g. The cloves powder (CP) had the highest level of tannin and phenol while turmeric powder had the highest β-carotene. Mineral content showed that potassium and calcium was more in ginger than other samples while others were high in turmeric powder.

Keywords: spices, quality, evaluation, flavonoids, clove, production, powder.

1. INTRODUCTION

Spices are the dried portions of certain aromatic plants which are effective as flavorants, flavor enhancers, preservatives, colorants, as well as potential therapeutic agents. Spices may be derived from various parts of the plant such as buds, bark, flowers, leaves, fruits, roots, rhizomes, seeds or the whole plant tops. Spices contain many phytochemicals and their main flavor-active components are volatile liquids as well as oleoresins. Volatile essential oils are a concentrated liquid with strong odor obtained by steam distillation and are mainly used as preservatives. In contrast, oleoresins are natural mixtures of essential oils and resin which are responsible for the total flavor profile of spices

and can be extracted from plants by using organic solvents or supercritical fluid extraction (SFE) with CO_2 with or without an auxiliary solvent such as ethanol [1].

Ginger (*Zingiber officinale* Roscoe) is one of the most commonly consumed dietary condiments in the world. The main active phytochemicals present in ginger are gingerols, shogoals and paradols, and they have strong antioxidant and chemo-preventive properties [2]. Ginger extracts have been extensively studied for a broad range of biological activities including antibacterial, anticonvulsant, analgesic, antiulcer, gastric antisecretory, antitumor and other beneficial activities [3]. Garlic or *Allium sativum* is member of family *liliaceae*, it is one of the most considered medicinal plants. Garlic has a higher concentration of sulfur than any other allium species. Garlic has effective results for anti-microbial, cardiovascular and anticancer activity, curative results found for the treatment of hypoglycemia, liver dysfunction, heavy metal poisoning and hyperthyroidism [4].

Turmeric (*Curcuma longa*) is a dietary spice belonging to the family *zingiberaceae*. It is a colouring and flavouring agent in foods, and has been reported to possess antioxidant properties both in in vitro and animal studies. Aqueous extracts of turmeric showed antioxidant and antimicrobial activity due to the presence of curcumin (5%), a polyphenolic compound. It is known that the phenolic character of curcumin is responsible for its anti-oxidant properties [5].

Ginger (*Zingiber officinale*) is a member of *Zingiberaceae* family of plants. The plant is native to Asia but is now cultivated in the West Indies, Africa, India, and other tropical regions. This rhizome can be processed into a powder, syrup, volatile oil, and oleoresin. Its use in culinary applications dates as far back as the 13th century. Among all spices, it exhibits one of the greatest diversity of uses, such as in dietary supplements, beverages (such as ginger ales), and food products (such as in curry powder, confectionaries, soups, jams, and baked goods). The rhizome contains fats, carbohydrates, protein, fiber, water, and volatile oil. The quality and quantity of biologically active constituents of ginger depend on its cultivation practices and postharvest treatment [6]. The study of the nutritional benefits of the selected spices as targeted in this study would help in improving consumers' perception of the selected spices, hence, promoting the utilization of the selected spices.

2. MATERIAL AND METHODS

2.1 Source of materials

Ginger, garlic, clove and turmeric were obtained from Owode market in Offa Local Government Area of Kwara state.

2.2 Preparation of ginger powder

Ginger powder was prepared in accordance to the method of [7], as shown in figure 1. Fresh matured rhizomes of ginger were sorted, thoroughly washed, peeled and sliced (about 2 mm thickness) with sharp knife and oven dried at 55 ^{o}C for 24 h. They would be ground into powder using electric grinder. The powder was sieved with a 0.35 mm mesh.

2.3 Preparation of garlic powder

The method of [8] was used in preparation of the garlic powder, as shown in figure 2. Briefly, the outer cover of the garlic rhizomes were peeled, after which they were washed with clean water, sliced with sharp knife and oven dried at 55 ^{o}C for 24 h. The garlic rhizomes were ground into powder using electric grinder. The powder was sieved with a 0.35 mm mesh.

2.4 Preparation of turmeric powder

The turmeric powder was prepared according to the method of [9], as indicted in figure 3. Turmeric rhizomes were sorted thoroughly to separate the damaged ones from the

good ones and thereafter, they were washed thoroughly in clean water to remove soil particles on them. They were peeled and thinly sliced (about 0.22 mm in diameter). The thinly slice turmeric rhizomes were oven dried at 60 ^{o}C for 24 h. They were ground into powder and stored in airtight container until further usage.

2.5 Preparation of clove powder

Cloves powder was prepared according to the method of [10], as shown in figure 4. Cloves were sorted, cleaned and ground into powder. They were further stored in air-tight container until further usage.

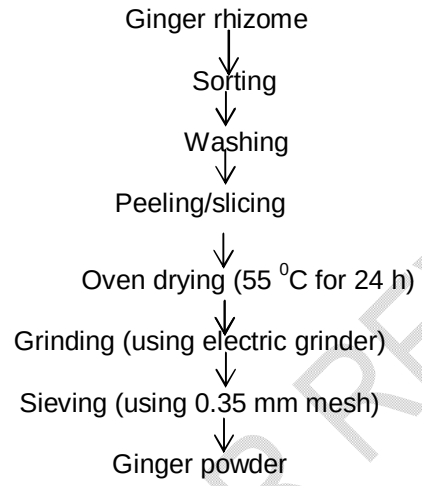

Fig. 1: Flow chart for the preparation of ginger powder

Source: Sukajang *et al.* (2010) [7].

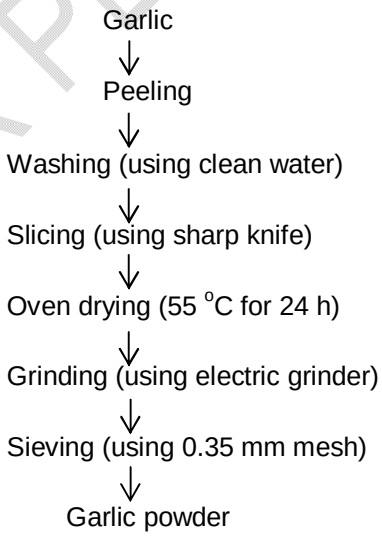

Fig. 2: Flow chart for the preparation of garlic powder
Source: Douglas *et al.* (2005) [8]

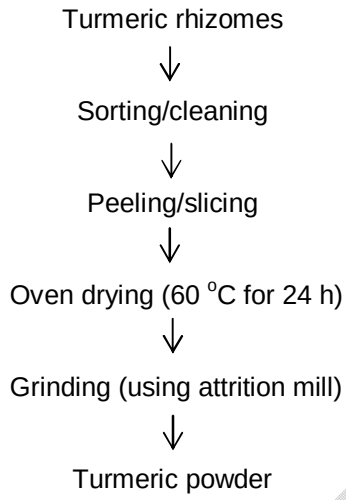

Fig. 3: Flow chart for the preparation of Turmeric powder
Source: Tamuno (2020) [9]

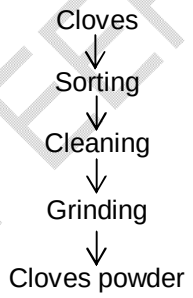

Fig. 4: Flow chart for the preparation of cloves powder
Source: Kumar and Tanwar (2011) [10]

3 ANALYSIS

3.1 Determination of selected phytochemicals of the selected spices samples

3.1.1 Determination of tannins

Tannin was determined according to the method described by [11]. 1 g of sample was weighed into a flask and 10 ml of distilled water was added followed by agitation. It was left to stand for 30 min at room temperature after which it was centrifuged at 2500 rpm to obtain a clear supernatant. 2 ml of the supernatant was taken into a 10ml volumetric flask and 1ml of folin ciocalteu reagent was added followed by addition of 2 ml saturated $NaCO_3$. It was diluted to 10 ml using distilled water and incubated for 30 min at room temperature. Absorbance was read at 725 nm using Spectrum lab 23A UV visible spectrophotometer. The tannin content was obtained by extrapolating the absorbances down the concentration axis of a prepared tannic acid standard or an existing tannic acid standard graph obtained from same procedure.

3.1.2 Determination of phenol

Total phenol content was determined by method of [12]. Phenol was extracted by adding 10 ml of ethanol to 1 g of sample in a conical flask. The flask was cocked and shaken vigorously for 30 min and filtered. The filtrate was used for total phenol assay. 1.00 ml of the ethanolic extract was taken into a tube and 0.5 ml 2 N Folin – Ciocalteu reagent, 1.5 ml 7% sodium carbonate added and made up to 10 ml with water. The mixture was shaken properly and left for 90 min for colour development after which the absorbance was read at 765 nm using a UV visible spectrophotometer. The phenol content was gotten by extrapolating the absorbances obtained down the concentration axis of a tannic acid standard graph obtained from similar procedure or from an existing tannic acid standard graph obtained from similar procedure. The phenol content was reported in mg/kg TAE. (Tannic Acid Equivalent).

3.1.3 Determination of flavonoids

This was estimated by the method of [13]. 1 g of sample was weighed into a conical flask and 50 ml of 80% methanol added. The flask was placed on a hot plate at low temperature for 30 min accompanied with shaking. After 30 min, the mixture was cooled and filtered into a volumetric flask and made up to mark with 80% methanol. 3 ml of the filtrate was taken into a test tube and 0.1ml of 10% aluminium chloride, 0.1 ml sodium potassium tartrate added followed by addition of 3 ml of distilled water. The test tube was shaken and absorbance read at 415 nm with a UV visible spectrophotometer using 80% methanol as blank. The flavonoid content was commuted by extrapolating the absorbances obtained down the concentration axis of a rutin standard obtained from same procedure or from an existing rutin standard graph obtained from same procedure.

3.1.4 Determination of Alkaloids

This was determined by the method of [14]. 5 g of sample (W_0) was weighed into a conical flask and 200ml of 10% acetic acid in ethanol added. The flask was shaken and left to stand for 4hrs. The content was filtered and the filtrate evaporated to about a quarter of its original volume. Few drops of ammonium hydroxide were added to precipitate (ppt) the alkaloid. The ppt was trapped by filtering through a previously weighed filter paper (W_1). The filter paper was dried at 60 degree Celsius and final weight recorded as w_2.

The % alkaloid was calculated as: $(W_2 - W_1) \times \frac{100}{W0}$

3.1.5 Determination of total carotenoids content

The total carotenoids content of samples was determined according to the method of [14]. 1.00 g of sample was weighed into a centrifuge tube and 10 ml of 80% acetone added. This was agitated severally for even extraction of the Carotenoid after which the tubes were place in a centrifuge and centrifuged at a speed of 3000 rpm for 10 min. The supernatant was thereafter decanted and the optical density read using a UV visible spectrophotometer at a wavelength of 480 nm.

The total carotenoid content was calculated as

$$\text{Total Carotenoid content (mg/kg)} = \frac{4 \times OD \times \text{total vol. of sample} \times 1000}{\text{Sample wt.}}$$

3.1.6 Determination of selected mineral composition of the spices powder

Using the Atomic Absorption Spectrophotometer (AAS), corresponding lamp for corresponding mineral was placed in the AAS and the wavelength specific to a particular mineral or heavy metal to be determined was set. The AAS siphoning hose was dipped into the digested sample after running the standards for the selected minerals (calcium, magnesium, potassium, iron, zinc and phosphorus). The concentration of the metal in the solution was displayed on the screen of the AAS machine (Association of Analytical Chemists [15].

3.2 Statistical Analysis

Data obtained from the analysis were subjected to analysis of variance (ANOVA) using the Statistical Package for Social Sciences (SPSS) version 20. All analysis were done in duplicate using Duncan Multiple Range Test (DMRT) for means separation at 5% probability level ($p>0.05$).

4. RESULTS AND DISCUSSION

Table 1 presents the results for the selected phytochemical composition of selected spices samples. Phytochemicals act as natural defense system for the host plants and in addition provide colour, aroma and flavour [16]. The mean score values for the tannin content of samples differed significantly ($p\leq0.05$) with values ranging from 24.09 to 986.68 mg/g. Cloves powder (CP) had the highest value (986.68 mg/g) while the least value (24.09 mg/g) was observed in ginger powder (GPW). These values are higher than the results (2.52 mg/g), (3.54 mg/g) and (4.80 mg/g) reported for tannin content of garlic by [17], [18] and [19] respectively. Variation in values may be attributed to the different variety of garlic used in the respective studies. The presence of tannins might have accounted for the sharp taste of garlic and ability to hasten the healing of wounds and inflamed mucous membranes [20]. Adebisi *et al.* (2021) [21] evaluated the tannin content of clove in their study to be (0.02 mg/g) while [22] also had (0.05 mg/g) which are lower than the values obtained for samples in this study. Higher tannin content of cloves powder in this study (986.68 mg/g) may be attributed to the different varieties, processing methods and periods of harvest. The tannin contents of some Nigerian spices such as ginger (3.42 mg/g), bird pepper (1.62 mg/g), red onion (9.71 mg/g), garlic (0.08 mg/g), cayenne pepper (6.81 mg/g) and nutmeg (0.64 mg/g) reported by [23] are lower than the values reported for samples in this study. Yusuf (2019) [24] and [25] reported (5.46 mg/g) and (0.25 mg/g) for tannin content of ginger powder which are lower than the tannin content of ginger powder (24.09 mg/g) in this current study. Tannins are also known antimicrobial agents. Tannins are water soluble plant polyphenols that precipitate proteins. They have been to inhibit the growth of many fungi, yeasts, bacteria, and viruses. Due to presence of tannins, plants develop astringent taste. Tannins interact and precipitate with proteins which results in bitter taste of plants [21].

The mean results for the phenol content of samples differed significantly ($p\leq0.05$) with values ranging from 150.85 to 2027.00 mg/g. Cloves powder (CP) had the highest value (2027.00 mg/g) while the least value (150.85 mg/g) was observed in garlic powder (GP). These values are higher than the phenol contents of different Nigerian spices reported in the work of [22] for Cameroon pepper (0.27 mg/g), nutmeg (0.28 mg/g), clove (0.25 mg/g), ginger (0.003 mg/g), turmeric (0.27 mg/g), thyme (0.26 mg/g), scent leaf (0.17 mg/g) and garlic (0.15 mg/g) respectively. The reports of [25] on the phenol contents of garlic (0.91 mg/g) and ginger (0.11 mg/g); Adebisi *et al.* (2021) [21] on clove (24.0 mg/g) and turmeric (4.91 mg/g) powder as well as those of fresh (0.53 mg/g), sun-dried (18.94 mg/g), oven-dried (16.08 mg/g) and freeze-dried ginger (20.07 mg/g) by [26] are lower than the phenol content of samples in this current study. Variation in phenol content of the samples in the respective literatures and this current study may be attributed to genetic make-up, climatic factors and processing methods of the various spices evaluated [23]. Phenolic compounds possess both antioxidant and antimicrobial activities [27]; [28]; [29]. Doughari *et al.* (2019) [30] subsequently asserted that phenols are utilized as nutraceuticals probably for their cancer combating role and are also thought to prevent heart ailments as well as possess anti-inflammatory properties.

The flavonoids content of samples differed significantly with values ranging from 32.55 to 2186.91 mg/g. Turmeric powder (TP) had the highest value (2186.91 mg/g) while the least value (32.55) was observed in garlic powder (GPW). Yusuf (2019) [24] and [25] reported (1.34 mg/g) and (1.16 mg/g) respectively for flavonoids contents of ginger which are lower than the values reported for flavonoids content of ginger in this current study. The flavonoids contents of garlic (1.16 mg/g), ginger (5.56 mg/g) and pepper (6.38 mg/g)

reported by [31] are higher than the values obtained for samples in this study. The tannin contents of Cameroon pepper (31.67 mg/g), nutmeg (0.008 mg/g), clove (0.007 mg/g), ginger (0.006 mg/g), turmeric (0.005 mg/g), thyme (0.007 mg/g) and garlic (0.003) reported by [22] are higher than those obtained for samples in this study. Contrarily, [32] reported (238.96 – 458.82 mg/g) for flavonoids content of fresh and processed ginger which are slightly in agreement with the values reported for ginger (1011.13 mg/g) in this study. According to [33], flavonoids are known to shield against allergies, inflammation, platelet aggregation and microbial infection; hence, suggesting that the spice samples in this study will exhibit these properties. The higher flavonoids observed for samples in this study may be attributed to the samples' inherent ability to generate more flavonoids than other spices in the afore-cited literatures [34]. Flavonoids exhibit a range of biological activities, which is their ability to scavenge for biological radicals and superoxide anions radicals and thus has ability to promote health. They also exhibit anti-inflammatory, antiangionic, anti-allergic effects, analgesic and antioxidant properties [35].

The mean score values for alkaloids content of samples significantly differed with values ranging from 4.49 to 6.16 mg/g. Ginger powder (GPW) had the highest value (6.16 mg/g) while the least value (4.49 mg/g) was observed in garlic powder (GP). These results are in slight agreement with the reports (1.22 – 9.40 mg/g) of [36] for different Nigerian spices (*Utazi*, *Uda*, *Ehiri*, *Oghokirigbo* and Garlic) and (4.21 mg/g) for garlic powder by [18]. Contrarily, the findings of [37] on the alkaloids content of ginger (11.21 mg/g) and pepper (13.44 mg/g) are higher than the values reported for samples in this study. The alkaloids content of clove (9.50 mg/g), ginger (11.21 mg/g) and pepper (13.44 mg/g) reported by [21] and [31] are also higher than the values reported for samples in this study. According to [38], alkaloids are one of the most important bioactive components in natural herbs. They constitute potent therapeutic agents.

The results for the β-carotene contents of selected spices samples are presented in table 2. The β-carotene content of the samples differed significantly ($p \leq 0.05$) with values ranging from 0.04 to 5.39 mg/g. turmeric powder (TP) had the highest value (5.39 mg/g) while the least value (0.04 mg/g) was obtained in garlic powder (GP). The β-carotene content (67.92 – 1454.10 mg/g) of ginger-turmeric-pineapple juice mix reported by [39] was higher than the values obtained for samples in this study. They further reported that increase in level of substitution of ginger and turmeric rapidly increased the β-carotene content of the juice mix. Variation in their values may be due to the presence of pineapple, different variety of their ginger and turmeric as well as processing methods employed. Higher values of β-carotene content have been reported by [40] for different Nigerian spices; onions (113.5 mg/g), ginger (109.5 mg/g), garlic (226.8 mg/g), guinea pepper (308.5 mg/g) and clove (98.1 mg/g). The recommended dietary allowance for β-carotene, according to [41], lies at the range (2 – 7 mg/100g); therefore, the β-carotene content of samples in this study may be able to meet up with the recommended dietary allowance for β-carotene. Therefore, obtaining the nutrient from other rich sources of β-carotene such as pumpkin, spinach and cantaloupe are recommended. Beta-carotene is converted to vitamin A in the liver. It protects the eyes in case of infections and contributes to the vision in dim light. Vitamin A combines with the protein opsins to form rhodopsin in the retinal rod cells. When vitamin A levels are inadequate, the lack of rhodopsin makes it difficult to see in dim light [42].

Table 3 presents the results for the selected mineral composition of selected spice samples. The mean score values for the calcium content of selected spice samples differed significantly ($p \leq 0.05$) with values ranging from 81.16 to 120.43 mg/g. Ginger powder (GP) had the highest value (120.43 mg/g) while cloves powder (CP) had the least value (81.16 mg/g). The highest calcium content observed in ginger powder (GP) is an indication that constant feeding on ginger could be important in sustaining strong bones, muscle contraction and relaxation [43]. The high calcium content of samples in this study may be beneficial to patients with soft bone problems to improve bone mineralization and reduction of bone resorption [44]. Osabor *et al.* (2009) [45] and [43] reported (47.60 mg/g) and (0.02

mg/g) respectively for calcium content of ginger which are lower than the values reported for samples in this study. The calcium contents of garlic (26.30 mg/g), ginger (25.76 mg/g) and pepper (23.45 mg/g) reported by [31] are lower than the calcium contents of samples in this study. Contrarily, the calcium contents of samples in this study are higher than the values reported for calcium content of *Aspilla africana* leaves (246 mg/g) in the report of [46]. Normal extracellular calcium concentration is necessary for blood coagulation as explained by [47] and [48].

The mean score values for the potassium contents of samples differed significantly ($p \leq 0.05$) with values ranging from 129.35 mg/g to 815.28 mg/g. The highest level of potassium (815.28 mg/g) was observed in ginger powder (GP) while the cloves powder (CP) had the least value (129.35 mg/g). These values are higher than the reports of [24] and [49] for potassium contents of ginger (0.72 mg/g) and turmeric (9.24 mg/g). The potassium contents of clove (0.39 mg/g) and turmeric (2.49 mg/g) reported by [21] are lower than the values obtained for samples in this study while [43] reported (0.42 mg/g) for potassium content of ginger powder. Contrarily, the findings of [31] on ginger (215.0 mg/g) and pepper (229.0 mg/g) are in agreement with the potassium contents of samples in this investigation. The higher potassium contents of samples indicate that the spices would be effective against prevention of elevated blood pressure [50]. Deficiency of potassium further extends to collecting tubules of the kidney, resulting in the inability to concentrate urine, and also causes alterations of gastric secretions and intestinal motility [34]. Its presence in the body, however, is identified with reduction in blood pressure and it functions in controlling skeletal muscle contraction and nerve impulse transmission. It is vital for the maintenance of osmotic and fluid balance in the body. It is required for chemical reactions in muscles and for skeletal growth [44].

The magnesium contents of the selected spices samples differed significantly ($p \leq 0.05$) with values ranging from 10.59 to 160.80 mg/g. Turmeric powder (TP) had the highest level of magnesium (160.80 mg/g) while ginger powder (GP) had the least value (10.59 mg/g). These values are lower than the reports of [51] for magnesium contents (251.13 – 611.0 mg/g) of different garlic varieties in the previous work. Contrarily, [19] reported (3.9 mg/g) for magnesium contents of garlic which are lower than the values reported for samples in this study. The magnesium contents of different Nigerian spices including Cameroon pepper (124.6 mg/g), nutmeg (260.7 mg/g), clove (201.2 mg/g), ginger (176.4 mg/g), and turmeric (136.4 mg/g) reported by [22] are slightly in agreement with the values obtained for samples in this study. The magnesium contents of African nutmeg (182.99 mg/g) reported by [52] and other Cameroon spice (132 mg/g) by [53] are in agreement with the values observed for samples in this study. The findings of [37] on magnesium content of garlic (4.10 mg/g), ginger (5.00 mg/g) and pepper (4.50 mg/g) are lower than the values obtained for samples in this study. The variations in magnesium content reported in these studies might be linked to the differences in the method of analysis and environmental factors associated with the plant source. Magnesium is required in the plasma and extracellular fluid where it helps maintain osmotic equilibrium. Additionally, magnesium is required in many enzyme-catalyzed reactions and prevents some heart disorders and low blood pressure [52].

The mean score values for the iron content of samples ranged from 1.01 to 14.86 mg/g with turmeric powder (TP) having the highest value (14.86 mg/g) while the least value (1.01 mg/g) was observed in garlic powder (GP). There was no significant difference ($p \geq 0.05$) between cloves powder (CP) and ginger powder (GP) while other samples differed significantly ($p \leq 0.05$) from other samples. The iron contents of samples in this study are lower than the values reported by [52] and [54] for iron contents of African nutmeg (90.00 mg/g) and *Byrsocarpus dinklage* (*efu*) (598.00 mg/g). Ekeanyanwu *et al.* (2010) [55] also reported (21.71 mg/g) for iron contents of African Nutmeg which are higher than the values obtained for samples in this study. Contrarily, [40] reported (0.25 – 1.26 mg/g) for iron content of commonly consumed spices in Nigeria which are lower than the values reported

for samples in this study. The variation in values might be due to the effect of the edaphic factor where nutrients determined are not exclusively those taken up by the plants. Iron is necessary for oxygen transport and plays an important role in human metabolism and it facilitates the oxidation of carbohydrates, proteins and fats to control body metabolic rate, which is a very important factor in diabetes. Iron deficiency leads to anemia and such conditions can present severe complications and adverse consequences for expectant mothers [52].

The mean score values for the phosphorus contents of selected spices samples differed significantly ($p \leq 0.05$) with values ranging between (40.26 – 209.99 mg/g). Ginger powder (GP) had the highest phosphorus content (209.99 mg/g) while the least value (40.26 mg/g) was observed in cloves powder (CP). The phosphorus contents of samples in this study are higher than the phosphorus content of ginger (26.70 mg/g) reported for [50] and (10.19 mg/g) for garlic, ginger (12.56 mg/g) and pepper (9.89 mg/g) by [31]. Phosphorus functions as a structural component of bones and teeth and DNA/RNA and enables the bipolarity of lipid membranes and circulating lipoproteins [56]

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Table 1: Results for phytochemical composition of selected spices samples

Parameters (mg/g)	GP	TP	CP	GPW
Tannin	89.05 ± 0.41^{a}	117.88 ± 0.38^{b}	986.68 ± 0.63^{d}	24.09 ± 1.46^{c}
Phenol	150.85 ± 0.36^{a}	1210.03 ± 0.41^{c}	2027.00 ± 0.16^{d}	1202.28 ± 0.44^{b}
Flavonoids	32.55 ± 0.12^{a}	2186.91 ± 0.28^{d}	1047.59 ± 0.74^{c}	1011.13 ± 0.89^{b}
Alkaloids	4.49 ± 0.05^{d}	4.79 ± 0.03^{a}	5.40 ± 0.04^{b}	6.16 ± 0.02^{c}

Data are means of duplicates ± Standard deviation. Data with different superscripts in the same row are significantly different at $p \leq 0.05$.

Table 2: Results for β-carotene contents of selected spices samples

Samples	β-carotene
GP	0.04 ± 0.01^{a}
TP	5.39 ± 0.02^{d}
CP	0.57 ± 0.01^{b}
GPW	3.50 ± 0.02^{c}

Data are means of duplicates ± Standard deviation. Data with different superscripts in the same column are significantly different at $p \leq 0.05$.

Key:
Garlic powder - GP
Turmeric powder - TP
Cloves powder – CP, Ginger powder – GPW

Table 3: Selected mineral composition of selected spices samples

Parameters (mg/g)	GP	TP	CP	GNP
Calcium	90.45±0.28^{b}	197.06±2.25^{d}	81.16±0.42^{a}	120.34±0.33^{c}
Potassium	319.38±0.89^{b}	410.05±0.74^{c}	129.35±0.57^{a}	815.28±0.66^{d}
Magnesium	10.59±0.78^{a}	160.80±1.20^{d}	26.98±0.18^{b}	30.43±0.14^{c}
Iron	1.01±0.04^{a}	14.86±0.30^{c}	6.28±0.02^{b}	6.29±0.02^{b}
Phosphorus	66.18±0.06^{b}	585.71±0.73^{d}	40.26±0.56^{a}	209.99±0.66^{c}

Data are means of duplicates ± Standard deviation. Data with different superscripts in the same column are significantly different at p≤0.05.

Key:

Sample GP = Garlic powder
Sample TP = Turmeric powder
Sample CV = Cloves powder
Sample GNP = Ginger powder

5. CONCLUSION

This study showed that the evaluated selected spices (garlic, turmeric, cloves and ginger powder) are of commendable level of nutrients. The selected spices contained appreciable amount of phytonutrients including tannin, phenol, flavonoids, alkaloids but are lower in β-carotene; hence, the need to boycott total dependence on the spices for β-carotene content. The mineral compositions of the samples are also of commendable level of acceptability, thus inferring that the spices would perform their respective functions in improving the metabolic activities and physiological functions of the body. Further studies are recommended on the nutritional evaluation of other underutilized Nigerian spices in order to fully exploit their potentials.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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