The Proximate Composition, Antinutritional Factors and Selected Minerals in Yellow and White Ginger (*Zingiber officinale*) and Local Turmeric (*Curcuma longa*)

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Received: 31 May 2021
Accepted: 10 November 2021

Abstract

In Nigeria, white and yellow gingers (*Zingiber officinale*) and turmeric (*Curcuma longa*) are abundantly available, however, the nutritional composition of turmeric and yellow ginger effects had only been extensively investigated; there is the paucity of information on the nutritional benefits of white ginger. Therefore, this study investigated the nutritional potential of white ginger powder compared to turmeric and yellow ginger powder. Fresh yellow and white ginger and local turmeric were separately procured from the local market within Makurdi town, Benue State, Nigeria. The fresh rhizomes were washed in water to remove adhering soil and chopped into smaller pieces using sharp knives. It was sun-dried on a flat and clean concrete floor to save moisture content. The samples were ground using a hammer mill to obtain a powder of ginger and turmeric. 10 g of the milled samples each were extracted in 20 mL of absolute ethanol for 72 hours at room temperature on a flask shaker and filtered with Whatman No. 1 filter paper. The filtrates obtained were used to screen for the secondary metabolites constituents of the two samples. The result obtained for proximate analysis showed that white ginger powder contained a significantly ($p<0.05$) higher percentage of crude fibre and ash with the least value of nitrogen-free extract compared to yellow ginger and turmeric. Phytochemical properties of the extracts of the powder of yellow and white ginger and turmeric indicate the presence of saponins, tannins, oxalate, flavonoid, alkaloids and phytates with the significant ($p<0.05$) higher values recorded on white ginger though at the minimal level. Significant ($p<0.05$) higher value of calcium and phosphorus recorded for all the materials may qualify their potential source of the desired mineral in poultry diet. It is concluded that yellow and white ginger and local turmeric possesses nutritional qualities that can make them suitable feed additive in the poultry diet.

Keywords: Ginger, Turmeric, proximate, antinutrient, and mineral

Introduction

Ginger and turmeric are herbaceous plants grown annually for their spicy underground rhizomes or stems. The plants have fibrous roots that emerge from the branch rhizomes. It takes about 6 weeks for shoots to emerge after ginger is planted. Vegetative growth is maximized until flowering begins in September – October; flowering marks the beginning of rhizomes maturity and increased fibrous tissue development (Valenzuela *et al.*, 2005).

Nigeria produces an average of 50,000 metric tons of fresh weight ginger per annum (Ezeagu, 2006). About 10 % of the produce is consumed locally as fresh ginger while the remaining 90 % is dried for both local consumption and export. The dried ginger is consumed locally for various uses and 80 % is exported (Ezeagu, 2006). According to the United Nations Food and Agriculture Organization (2014), Nigeria was among the countries that the global production of ginger in 2008 was over 1.4 million metric tons (MT) and the major exporting country to the US in 2007, this implies that ginger is cheaply and/or readily available in Nigeria.

Due to the extremely crowded henhouses and consequently poor hygiene, antibiotics are extensively used to maintain health and activate bird growth (Van Boeckel *et al.*, 2015). This is a significant problem since antimicrobial resistance can be derived from the abusive usage of antibiotics, and thus greater regulatory efforts are needed (Landers *et al.*, 2012). Moreover, in many countries, there are laws and welfare codes protecting farm animals, including poultry, from distress and fear (Bonafos *et al.*, 2010). In line with the above requirements, some plant-derived active compounds, like those present in gingers and turmeric, could be used to reduce antibiotic overuse (Palaniappan and Holley, 2010). The use of ginger and turmeric in poultry production was formerly reviewed by Khan *et al.* (2012).

Ginger and turmeric are well-known plants and are widely used as a spice and treatment for certain ailments (Tapsell *et al*., 2006). Their roots contain several compounds which have biological activities such as antioxidation, antimicrobial and pharmacological effects (Ali *et al.*, 2008).

Ginger contains about 12 antioxidant constituents, the combined actions of which have been regarded as being more powerful than vitamin C (Davies, 2011). The nutrients found in ginger and turmeric include lipids, amino acids, minerals and vitamins especially phosphorus, potassium, riboflavin and vitamin C. Ginger has been shown to have several biological effects, exhibiting anti-inflammatory, anti-oxidant and hypolipidaemic activities Reports exist indicating that it has been used in gastrointestinal and respiratory disorders (Ghosh *et al*., 2011). The antioxidative capacity of ginger and turmeric has been associated with their ability to inhibit carcinogenesis by reducing oxidative stress (Abdullah *et al.*, 2010).

In Nigeria, white and yellow gingers are readily available, however, the nutritional composition of yellow ginger effects had only been extensively investigated; there is a paucity of information on the proximate, mineral and anti-nutritional composition of the white ginger. Therefore, this study investigated the anti-nutritional factors, proximate composition and some selected mineral constituents of yellow and white ginger and turmeric powder.

Materials and Methods

Collection, Processing of Ginger and turmeric

Fresh yellow and white gingers varieties and turmeric considering the skin colour were separately procured from the local market within Makurdi town, Benue State, Nigeria. The fresh rhizomes were washed in water to remove adhering soil and chopped into smaller pieces using sharp knives. It was sun-dried on a flat and clean concrete floor to save moisture content. It was ground using a hammer mill to obtain ginger and turmeric powder. The milled materials (10 g) each were extracted in 20 mL of absolute ethanol for 72 hours at room temperature on a flask shaker and filtered with Whatman No. 1 filter paper (Das *et al.*, 2010). The filtrates obtained were used to screen for the secondary metabolites constituents of the two samples.

Determination of anti-nutritional factors

Qualitative secondary metabolite tests of ginger varieties and turmeric were carried out on the ethanol extracts of ginger varieties and turmeric samples using standard chemical procedures as follows;

Oxalate content

Oxalate content was determined by the method of Ukpabi and Ejidoh (1989). Two g of ginger meal were dissolved in 2 mL of 6M hydrochloric acid. The obtained suspension was homogenized at an ambient temperature (28˚C) for 2 min and then diluted in 30 mL of distilled water contained in a 50 mL conical centrifuge tube. Two (2) drops of caprylic alcohol (5%) were added to the reaction medium and the mixture was heated for 15 min in a boiling water bath. It let cool at an ambient temperature (28˚C) for 2 min and was centrifuged at 5000 rpm for 10 min using a centrifuge (Orto Alresa). Twenty (20) mL of the supernatant was diluted in 5 mL of tungstate phosphoric reagent contained in a conical centrifuge tube. The obtained mixture was allowed to stand on the bench at an ambient temperature (28˚C) for 6 h and then was centrifuged at 5000 rpm for 10 min. The solution obtained was recentrifuged under the same conditions as previously. The pellet, taken up in 10 mL of sulfuric acid (10%, v/v), was homogenized by manual stirring for 2 min at an ambient temperature (28˚C). This solution was heated in a boiling water bath for 2 minutes and then the oxalic acid contained in this reaction medium was titrated with a solution of potassium permanganate (0.02 mM) until pale pink colour persisted for 30 seconds. The oxalate content was calculated by using the volume of potassium permanganate. A blank was carried out in the same conditions. Calibration was performed using an oxalic acid solution (0.2M).

Phytate content

The phytate content was carried out according to the method of Mohammed *et al*. (1986). Five of flour was dissolved in 25 mL of trichloroacetic acid (3%, w/v). Eight mL of this mixture were homogenized for 45 min at an ambient temperature (28˚C) and was then centrifuged at 3000 rpm for 15 min in a centrifuge (Orto Alresa). Five mL aliquots of the obtained supernatant, mixed with 3 mL of iron chloride hexahydrate (1%, v/v) prepared in hydrochloric acid (1N), was heated in a boiling water bath for 45 min. The mixture was cooled at ambient temperature (28˚C) for 5 min and was then centrifuged at 3000 rpm for 10 min. The pellet was dissolved in 1 mL of hydrochloric acid (0.5N) and it let cool at ambient temperature (28˚C) for 2 h. Seven mL of water and 3 mL of sodium hydroxide (1.5N) were added. The obtained mixture was heated in a boiling water bath for 15 min, was let cool and was then centrifuged at 3000 rpm for 10 min. 0.2 mL aliquot of the supernatant was diluted in a solution consisting of 4.6 mL of distilled water and 2 mL of a chromogenic solution. The reaction medium, heated at 95˚C for 30 minutes, was let cool on the bench at ambient temperature (28˚C.). The colouration intensity of the reaction medium was determined at 830 nm against a blank not containing phytate. Calibration was performed by using 0.58 g of phytic acid as the assay. The phytate content of the assay was expressed as mg of phytate per 100 g of dry matter.

Tannin content

The tannin content was performed according to the method of Makkar *et al*. (1993). 0.2 g of flour was dissolved in 20 mL of a solution of diethyl ether containing glacial acetic acid (1%, v /v). The mixture was let cool on the bench at room temperature (28˚C) for 10 minutes and was then centrifuged at 3000 rpm at 15˚C for 10 min in a centrifuge (Orto

Alresa). After centrifugation, the pellet was dried in an oven at 50˚C for 2 h and was then dissolved in 15 ml of acetone (70%, v/v). The mixture in a 50 mL beaker was homogenized at ambient temperature (28˚C) for 2 min. It is closed with cotton wool. This acetone extract was placed in an ice bath and then stirred for 12 minutes. The obtained cloudy solution was centrifuged at 3000 rpm at 4˚C for 10 min. the obtained supernatant was transferred into a 50 mL beaker and held at 4˚C. 1.1g of polyvinyl polypyrrolidone was added to 10 mL of the acetone supernatant. The mixture was homogenized and was stirred at ambient temperature (28˚C.) for 2 minutes. It was allowed to stand at 4˚C for 10 min to precipitate the tannins. The mixture was then centrifuged at 3000 rpm at 40C for 10 min. The result was expressed as mg of tannin per 100 g of dry matter. The pellet, taken up in 10 mL of sulfuric acid (10%, v/v), was homogenized by manual stirring for 2 min at an ambient temperature (28˚C). This solution was heated in a boiling water bath for 2 minutes and then the oxalic acid contained in this reaction medium was titrated with a solution of potassium permanganate (0.02 mM) until pale pink colour persisted for 30 seconds. The oxalate content was calculated by using the volume of potassium permanganate. A blank was carried out in the same conditions. Calibration was performed using an oxalic acid solution (0.2M).

Cyanide content

5g of the sample was dissolved in 50mls of water in a conical flask, corked and allowed to stay overnight. The solution was then filtered with media paper for cyanide determination. 1 ml of the filtered solution was transferred into another conical flask and 4 ml of alkaline picrate solution added and incubated at 50˚C in a water bath for 5 mins. Colour development and absorbance was taken at 190 nm. A blank preparation using 1ml distilled water was made. The cyanide content was extrapolated using a standard curve and reported as a mean of duplicate determination (Olukemi, 2005).

Flavonoids content

Aluminium chloride solution (3 mL of 1%) was added to 5 mL of the ethanolic extracts in each in two test tubes. A yellow colouration was observed indicating the presence of flavonoids. Dilute aqueous ammonia 5mL was added to the two mixtures followed by the addition of concentrated H_2SO_4. The yellow colouration disappeared when left undisturbed indicating a positive test for flavonoids Trease and Evans (1989).

Saponins content

About 5 mL of the ethanolic extract was boiled in 20 mL of distilled water in a water bath and filtered. About 10 mL of filtrate was mixed with 5mL of distilled water and shaken vigorously for a stable and persistent froth. The frothing was mixed with 3 drops of olive oil and shaken vigorously. The formation of emulsion confirms the presence of saponins Sofowora (1993).

Alkaloids content

The extracts (1 mL each) were stirred with 1% aqueous hydrochloric acid (5 mL) on a steam bath and filtered while hot. Distilled water was added to the residue and 1 mL of the filtrate was treated with a few drops of Mayer's reagent (Potassium mercuric iodide- solution). The formation of a cream colour with Mayer's reagent gives a positive test for alkaloids (Harborne, 1973).

Proximate Analysis Procedure of Ginger Varieties and Turmeric

Moisture Content

The crucible was washed, oven-dried and transferred into a desiccator for cooling before

weighing. Two grams (2g) of the sample was weighed and put into the container and dried in the oven at a temperature of 105˚C overnight and then removed and re-weighed. Drying was continued until the weight was obtained. The decrease in weight was expressed as a percentage of the original weight and referred to as percentage moisture content.

Crude Protein

Crude protein was determined using the micro-Kjeldahl procedure. This involved oxidizing a sub-sample (1-2gm) to $(NH_4)SO_4$ by digestion with concentrated H_2SO_4. The digest was made alkaline with NaOH and the NH_3 was distilled into a 4% solution of boric acid. The ammonium borate produced was titrated with standard HCL. The nitrogen obtained was multiplied by a factor of 6.25 to get the crude protein content of the sample

Crude Fibre

Two (2g) of the sample was weighed and placed in a hot 200ml of 1.25% H2SO4 and boiled for 30 minutes. It was filtered through a Buckner funnel covered with muslin cloth and held firm with an elastic band. The hot acid sample solution was filtered and the residue was washed with boiling water to remove acid from it. The residue was returned to 200 ml boiling 1.25% NaOH and boiled for 30 minutes. It was filtered and the residue was washed with boiling water, 1% HCL and boiling water to remove acid from it. The residue was washed twice with alcohol and three times with petroleum ether using small quantities. The residue was then transferred completely into a porcelain crucible and dried in the oven to a constant weight, cooled and receipt. It was incinerated at 600˚C for 2 hrs in a Muffle furnace. The crucible and content were cooled in a desiccator and weighed. The loss weight on incineration is the mass of the crude fibre, and its value was calculated by dividing it from the original weight and multiplying by 100.

Crude Fat (Ether Extract)

A flask was washed and dried in an oven at 100^0C for about 5 minutes. It was allowed to cool in a desiccator and weighed. Three 3gm of the sample was weighed into a thimble or filter paper and carefully wrapped and tied with a thread. The filter paper and content was placed in the Soxhlet extractor column, the flask was connected and the lipid was extracted for about 6 hours. When the solvent was clear in the column, the defatted sample was carefully removed and solvent recovered. The flask and oil were oven-dried until the solvent vaporized. The flask with content was reweighed, and the weight of the extract was determined. The ether extract value was calculated as a percentage of the original weight.

Ash Content

Two grams (2gm) of the feedstuff was accurately weighed and introduced into a silica dish that had been previously heated and cooled. The dish was placed in a Muffle furnace and the temperature of the furnace was increased to 450˚C and maintained at this temperature until whitish-grey ash remained. The dish was then placed in the desiccator and allowed to cool, after which it was weighed. Percentage ash content was calculated by expressing the weight of the ash as a percentage of the original weight.

Mineral Composition Analysis

The mineral composition of the samples was evaluated using spectrophotometric methods. Zinc, iron, and calcium were determined through Atomic Absorption Spectrophotometric while Phosphorus, sodium, potassium, magnesium was evaluated through UV spectrophotometry inductively

coupled plasma (ICP) according to (AOAC, 2000). The wavelengths used were 2483A for the iron, 2133A for zinc and 4227A for calcium. For other minerals, the solutions obtained after mineralization of the samples were diluted with the appropriate reagents. For the determination of magnesium, the solution of EGTA - Acid Ethylene Glycol bis (-aminoethyeteher) - N, N, N ', N' tetraacetic acid, sodium hydroxide and potassium hydroxide was added to the sample and then kept in the dark for 1 hour before reading on a spectrophotometer at 550 nanometers. For the phosphorus content determination, the reagent used is nitrovanadomolybdic and the measurement of the optical density was done at 430 nanometers. Potassium is determined by subjecting the suitably diluted sample solution (with pure potassium chloride dried one hour in 2% hydrochloric acid) in a spectrophotometer set at 760 nanometers while the sodium determination is made by direct submission of the mineralized solution at the spectrophotometer at 590 nanometers.

Results

Proximate Composition

The proximate composition of ginger varieties and turmeric expressed on the dry matter basis is shown in Table 1. The values of crude protein content varied from 12.80 % to 15.20 %. The turmeric meal had a significantly ($p<0.05$) highest crude protein content of 15.20 % compared to the yellow and white ginger meal. However, slight differences were observed between the values recorded for yellow 12.80 % and white ginger meal 12.60 % and were not significant ($p>0.05$) between them**.** The fibre content of the ginger varieties and tumeric meal ranged from 9.20 % to 13. 90 %. A significantly ($P<0.05$) higher value of 13.90 % was recorded for white ginger meal compared to the turmeric meal which recorded the least ($p<0.05$) value of 9.20 %. However, the result obtained indicated that ginger variety showed a significant effect ($p< 0.05$) on fibre content. Thus, there were meaningful differences ($p\leq 0.05$) between the fibre content in ginger varieties and turmeric meals. The values of ether extract obtained varied from 1.32 % to 2.60 %. The result showed that yellow ginger had the highest ($p<0.05$) ether extract content compared to turmeric meal. However, slight differences were also observed between the values recorded for yellow 2.60 % and white ginger meal 1.89 %, and were not significant ($p>0.05$) between them**.** The ash content of the ginger varieties and tumeric meal ranged from 3.50 % to 8.20 %. The lowest ($p<0.05$) ash content of 3.50 % was obtained with yellow ginger meal with the white ginger meal recorded the highest ($P<0.05$) ash content o 8.20 %. The variety main effect appeared to be stronger. Thus, there were significant variations ($p\leq0.05$) between the ash contents of ginger from the two varieties with significant ($p<0.05$) similar value recorded for turmeric meal. The nitrogen-free extract content ranged from 54.41 % to 61.30 %. The white ginger meal had significant ($p<0.05$) lowest total carbohydrate content compared to yellow ginger and turmeric while the significant ($p<0.05$) highest value was obtained with the yellow ginger meal. The dry matter content of ginger varieties and turmeric ranged from 91.80 to 92.90 %). The highest ($p<0.05$) dry matter content was found to be 92.70 % and 92.90 % for both white ginger and turmeric while the lowest ($p<0.05$) dry matter content was obtained with yellow ginger. Slight differences ($p>0.05$) were observed between the dry matter content of white ginger and tumeric, though not differ significantly ($p\leq0.05$).

Table 1. Proximate composition of yellow and white ginger and local turmeric powder

Parameters (% DM)	Nutrients			
	Yellow ginger	White ginger	Turmeric	SEM
Dry matter	91.80[b]	92.70[a]	92.90[a]	0.18[*]
Crude protein	12.80[b]	12.60[b]	15.20[a]	0.43[*]
Crude fibre	10.80[b]	13.90[a]	9.20[c]	0.70[*]
Ether extract	2.60[a]	1.89[ab]	1.32[b]	0.32[*]
Ash	3.50[b]	8.20[a]	7.80[ab]	0.78[*]
Nitrogen free extract	61.30[a]	55.41[c]	58.00[b]	1.04[*]

[abc] Means within each row with different superscripts are significantly different (P< 0.05). ns – not Significantly different (P>0.05); * Significantly different (P<0.05).

Anti-Nutritional Factors

Results on the anti-nutritional factors yellow, white ginger and turmeric meal are presented in Table 2. The saponin content ranged between 1.22 % to 3.24 % with the significant (p<0.05) higher value of 3.24 % recorded on white ginger meal compared to yellow ginger meal and turmeric. Yellow ginger meal showed a slightly higher value of 2.10 % compared to turmeric 1.22 %, though not significantly (p>0.05) differed. Tannins content ranged between 0.08 % to 1.5 %, yellow, white ginger meal and turmeric showed strong significant (p<0.05) differences with the highest tannins content recorded on white ginger meal compared to a yellow ginger meal which was significantly (p>0.05) lower than white ginger and higher than turmeric meal.

Table 2. Antinutritional factors of yellow and white ginger and local turmeric powder

Parameters (%)	Yellow ginger	White ginger	Turmeric	SEM
Saponin	2.10[b]	3.24[a]	1.22[b]	0.32[*]
Tannins	0.24[b]	1.54[a]	0.08[c]	0.23[*]
Oxalate	0.62[b]	0.98[a]	0.62[b]	0.06[*]
Flavanoids	0.60	0.60	0.52	0.02[ns]
Alkaloids	4.62	6.31	5.42	0.45[ns]
Phytate	7.84[b]	9.23[a]	7.21[c]	0.30[*]

[abc]Means within each row with different superscripts are significantly different (P< 0.05).
ns – not Significantly different (P>0.05); * Significantly different (P<0.05).

Content of oxalate was significantly (p<0.05) higher on a white ginger meal (0.98 %) compared to yellow ginger meal and turmeric meal that are significantly equal, it ranged between 0.62 % - 0.98 %. Slight differences were observed in the content of alkaloids with the highest value of 6.31 % recorded on white ginger meal compared to yellow ginger and turmeric meal, though, no significant (p>0.05) differences were recorded. Strong significant (p<0.05) differences were also observed on phytate content across the test materials, the value ranged between 7.21 % - 9.23 %. White ginger meal recorded the highest (p<0.05)

content of phytate (9.23 %) followed by a yellow ginger meal (7.84 %) while the least content (7.21 %) was recorded on turmeric.

Mineral composition of yellow, white ginger and turmeric meal

The mineral composition of the meal of ginger varieties and turmeric expressed in milligram per 100 per cent dry matter were summarised in Table 3. Calcium (Ca), potassium (P), sodium (Na), magnesium (Mg) and phosphorus (P) were the essential minerals evaluated. The values recorded ranged between 26.90 % to 36.18 %, 48.85 % to 60.30 %, 6.20 % to 8.10 %, 19.50 % to 29.62 % and 69.42 % to 86.76 % respectively. Iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) were the non-essential mineral evaluated with the values ranged from 2.69 % - 6.21 %, 0.06 % to 1.02 %, 0.04 % to 0.06 % and 0.42 % to 0.74 % respectively. The significant ($p<0.05$) least value of calcium was recorded on the yellow ginger meal. The value recorded for the meal of white ginger and turmeric were slightly similar but not significantly ($p>0.05$) differed. There were strong significant ($p<0.05$) differences in the values recorded on potassium, the least value observed on the white ginger meal while the highest value was recorded on the yellow ginger meal. The values of potassium content observed on turmeric was significantly ($p<0.05$) higher than white ginger meal but lower compared to the value recorded for the yellow ginger meal. The white ginger meal had a lower ($p<0.05$) value of sodium compared to the yellow ginger meal but significantly ($p<0.05$) equal to the turmeric meal. The white ginger meal had a higher ($p<0.05$) value of magnesium compared to yellow ginger and lower ($p<0.05$) compared to turmeric. The white ginger meal had the highest ($p<0.05$) value of phosphorus compared to the yellow ginger meal that had the least value even compared to turmeric meal.

Table 3. Selected mineral composition of yellow and white ginger and local turmeric

Elements (mg/100g DM)	Samples			
	Yellow ginger	White ginger	Turmeric	SEM
Calcium	26.90^{b}	36.18^{a}	37.90^{a}	1.73^{*}
Potassium	60.30^{a}	48.85^{c}	50.23^{b}	1.81^{*}
Sodium	8.10^{a}	5.24^{b}	6.20^{b}	0.45^{*}
Magnesium	19.50^{c}	26.98^{b}	29.62^{a}	1.53^{*}
Phosphorus	69.42^{c}	86.76^{a}	79.80^{b}	2.52^{*}
Iron	4.60^{b}	2.69^{c}	6.21^{a}	0.56^{*}
Copper	1.02^{a}	0.89^{b}	0.06^{c}	0.15^{*}
Manganese	0.06^{a}	0.04^{a}	0.04^{a}	0.01^{ns}
Zinc	0.42^{b}	0.65^{c}	0.74^{a}	0.10^{*}

^{abc}Means within each row with different superscripts are significantly different ($P< 0.05$). ns – not Significantly different ($P>0.05$); * Significantly different ($P<0.05$).

The least ($p<0.04$) content of iron and zinc were observed on the white ginger meal while the highest was obtained on turmeric meal. White ginger recorded the highest ($p<0.05$) value of copper compared with turmeric but lower compared with yellow ginger. There

were no significant ($p>0.05$) differences in the mean of manganese. White ginger recorded the highest ($p<0.05$) value of copper compared with turmeric but lower compared with yellow ginger. There were no significant ($p>0.05$) differences in the mean of manganese.

Discussion

The proximate composition of powdered yellow and white ginger and turmeric on the dry weight basis studied showed that all samples have significantly different nutritional compositions. The dry matter content which makes them more stable during storage and packaging is within the range values of 89 % to 95 % reported by Edmond *et al.* (2018). The crude protein of the yellow and white ginger ranged from 12.60 % to 12.80 % is higher than 7.70% reported by Nuhu *et al.* (2018) but lower compared to 14.00 % reported by Oshomo *et al.* (2015). The crude protein 15.20% reported for turmeric is higher than 14.00 % reported by Ikpeame *et al*. (2014). The differences observed may probably reflect the varietal difference of the samples. Also, the relatively higher crude protein content of ginger and turmeric may be associated with the presence of active proteinous metabolites such as allicin, ajoene and capsaicin. All samples contain protein below 20 %; this may imply that the relative dietary importance of these spices is to improve the nutritive value of the feed material (Hashemi and Davoodi, 2010). The ether extract is lower than those reported by Nuhu *et al.* (2018); Oshomo *et al.* (2015) and Ikpeama *et al*. (2014) which ranged from 3.30 % to 12.00 %. The relatively high levels of crude fibre obtained from the three samples may pose no threat since they are not usually fed in isolation but as additives with other feedstuff. Hence, their fibre contents may also serve as a boost to the total dietary fibre of the diet. Minerals are important elements of the diet because of their physiological and metabolic function in the body. High ash content recorded for white ginger may imply that it contains more mineral content than yellow ginger and turmeric. These differences observed in ash content may probably reflect the difference in the origin and varieties of the samples. The proximate analysis revealed that both yellow and white ginger (*Zingiber officinale*) and turmeric (*Curcumin longa*) can be ranked as carbohydrate-rich due to their high-calorie content. The samples were found to be a relatively good dietary component of carbohydrates, lipids and protein.

The results of the phytochemical analysis obtained in this study indicate that saponins, tannins, oxalate, flavonoids, alkaloids and phytate were in the extracts of both ginger varieties and turmeric meal. This result confirmed the results of phytochemical analysis obtained by Oshomoh *et al*. (2016) indicated that tannins, alkaloids, saponins, flavonoids and phytic acids were present in the extracts of ginger (*Zingiber officinale*). Tang *et al*. (2008) also stated that turmeric accumulates oxalate, tannins, phenols, flavonoids, alkaloids, saponins and other antinutrients (Imoru *et al.*, 2018; Ikpeama *et al.,* 2014) which at high concentration can have a negative effect on health and thereby underscore the nutritional benefits in turmeric. Antinutrients are chemicals in the feed that prevent the absorption of other nutrients; they are undesirable when consumed in large quantities because they reduce the bioavailability of essential nutrients. The presence of these chemical components in these plants indicates that the plants have some medicinal potential probably due to the fact that each of the components identified has a record of one therapeutic usage or another (Surai, 2006). Antinutrients such as oxalates, tannins and alkaloids interfere with the bioavailability of minerals and vitamins. Oxalate binds with calcium, forming calcium oxalates making Ca bio-unavailable (Ikpeama

et al., 2014). Calcium oxalate has been implicated in kidney stones with about 75% of kidney stones composed of calcium oxalate (Ikpeama *et al.*, 2014; Tang *et al.*, 2008). Oxalate decreases the availability of dietary essential minerals such as Ca. At high concentrations, oxalate causes varieties of pathological disorders including hyperoxaluria, pyridoxine deficiency and calcium oxalate stones and finally death in animals due to its corrosive effects (Kumar, 2010). Tannins can form complexes with metal ions and with macro-molecules such as proteins and polysaccharides (Lou *et al.*, 2019), making metal ion bio-unavailable and macro-molecules indigestible. Elmarie and Johan (2001) observed that plants with tannins have antimicrobial potentials due to their basic character which allows them to react with proteins to form stable water-soluble compounds thereby killing the bacteria by directly damaging its cell membrane. Saponins have been reported to have haemolytic activity against red blood cells (Khalil and El-Adawy, 1994). Surai (2006) also observed that plants rich in saponins are known to be immune boosting and have anti-inflammatory properties. In addition, saponins bind proteins to form a saponin-protein complex reducing protein digestibility (Shimoyamada *et al*., 1998). Among the effects of saponin in poultry are growth inhibitions in reduced palatability of feed and increased excretion of cholesterol concentration (Malinow *et al.,* 1987). Phytate presence is largely blamed for the complexing of dietary essential minerals in legumes and cereals and rendering them poorly available to monogastric animals. Flavonoids have been reported to function as pigments and antioxidants Kumar (2010) and can inhibit enzymes in mammals (Hollman, 1997). Flavonoids are good for keeping animals healthy. Pectin is a kind of carbohydrate gel, a component of plant cell walls. Thus, it has high water absorption properties and can be used for treating diarrhoea and its viscosity has significant health benefits. It was reported that it plays a role in reducing cholesterol because the structure of flavonoids contains numerous OH groups which can supply H atoms to quench free radicals, making it a strong anti-oxidant and anti-tumour activity. The higher concentration of some of the analysed phytochemicals observed with the white ginger meal is lowered compared to those reported by Harbor C. I. (2020) and Ikpeama *et al.* (2014) for the extract of turmeric.

The results of this study revealed the presence of several minerals in the meal of yellow, white ginger and turmeric. These variations could be attributed to intrinsic differences between varieties (Serges, 1996). Calcium is very important in animals for its role in blood clotting, muscle contraction, neurological function, bone and teeth formation/repairs and also as an important factor in enzymatic metabolic processes (Senga *et al*., 2013) and in the preservation of the integrity of the intracellular cement substances (Adjatin *et al*., 2013). Besides, the calcium content change in the samples analysed may be attributed to differences in varieties, climate, soil type, geographical location, and several other factors (Serge, 1996). The calcium content of the samples is lower than the average content of calcium (50mg /100g) reported by Oshomoh *et al.* (2016) for *Zingiber officinale* but higher than the value reported by Ikpeama *et al.* (2014) for turmeric meal. These same authors reported that there is a strong correlation between the calcium content of the soil for cultivation and the *Zingiber officinale*. Thus, the observed difference between our results and those of these authors may likely be due to the difference in calcium content of the soils on which the samples were cultivated. Potassium represented the mineral salt recorded in higher amounts in all the samples. Potassium regulates heart rate and blood pressure, body

water content and neuromuscular excitability. The potassium content of the samples is lower than the average content of calcium (50mg /100g) reported by Oshomoh *et al.* (2016) for *Zingiber officinale* but higher than the value reported by Ikpeama *et al.* (2014) for turmeric meal. A high amount of potassium in the body was reported to increase iron utilization (Nair *et al*., 2013) and beneficial to people taking diuretics to control hypertension (Nair *et al*., 2013; Adjatin *et al*., 2013). Sodium is involved in the control of the osmotic pressure that develops between blood and cells due to unequal ionic concentrations (Paiko *et al*., 2012). It also allows the body to regulate the inflow and outflow of potassium to greatly reduce the risk of deficiency. The potassium content of the samples is lower than the average content of calcium (50mg /100g) reported by Oshomoh *et al.* (2016) for *Zingiber officinale* but higher than the value reported by Ikpeama *et al.* (2014) for turmeric meal. Moreover, the sodium content variation in sweet potato may be attributed to differences in varieties, climate, soil type, geographical location, and several other factors (Serge, 1996). According to Alinnor and Oze (2011), magnesium plays an essential role in calcium metabolism in bones formation and is also involved in the prevention of circulatory diseases. This mineral is known to help in regulating the heartbeat and insulin release. In addition, it has been reported that magnesium intervenes in the prevention of muscle degeneration, growth retardation, immunologic dysfunction, gonadal atrophy, congenital malformations and bleeding disorders (Adjatin *et al*., 2013). All those last functions of the mineral highlighted here could also be more assured by the yellow, white ginger and turmeric meal if their magnesium is well assimilated in the body. Phosphorus, the most abundant mineral in the body, after calcium, plays a vital role in the formation and maintenance of healthy bones and teeth. It participates in the growth and regeneration of tissues and helps maintain the pH of normal blood. Phosphorus is also one of the constituents of cell membranes. Thus, the meal of both yellow, white ginger and turmeric may be considered as undeniable sources of phosphorus. According to Laurie *et al*. (2012), higher phosphorus content in all the samples could be explained by the high phosphorus content of the soil where they are cultivated on one hand, and the high availability of phosphorus for plants due to the high pH of the soil on the second hand. Iron is indispensable for a large number of metabolic reactions. It is involved in the constitution of haemoglobin, myoglobin and many enzymes (Lokombé *et al*., 2004). Iron can also act as an antioxidant and may help prevent cardiomyopathy and stunting (Buss *et al*., 2003). The observed little amounts of iron in ginger and turmeric meal were also noted by Ikpeama *et al.* (2014); Oshomoh *et al.* (2016). Otherwise, the iron content variation in the meal of ginger and turmeric may be attributed to differences in varieties, climate, soil type, geographical location, and several other factors (Serge, 1996). Zinc is one of the most concentrated minerals in the nerves. Also, it is essential to cover zinc requirements in brain growth is particularly important. Zinc is involved in immunity because it reduces the incidence and severity of diarrhoea in birds (Lokombé *et al*., 2004). Its deficiency can lead to a lack of appetite and a weakening of the immune system (Paiko *et al*., 2012). Moreover, the observed variation might be for the same reasons of calcium content that was mentioned above (Endrias *et al*. (2016). Copper, Fe, Mn and Zn function primarily as catalysts in enzyme systems within cells or as parts of enzymes. In particular, Zn is a constituent of thousands of proteins involved in intermediary metabolism, hormone secretion pathways and immune defence (Dieck *et al*., 2003). The observed little amounts of iron in ginger and turmeric meal

were also noted by Ikpeama *et al.* (2014); Oshomoh *et al.* (2016).

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