EVALUATION OF PHYTOCHEMICAL AND NUTRITIONAL COMPOSITION OF GINGER RHIZOME POWDER

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Abstract
The phytochemical and nutritional compositions of ginger rhizome powder (GRP) were evaluated. Fresh ginger rhizomes were procured, processed and analyzed in triplicate for their proximate, amino acid, mineral and phytochemical content. Data obtained were subjected to simple descriptive statistics (mean and standard deviation). Phytochemical results revealed that GRP was relatively high in saponin (4.01 g/100g) and cyanogenic glycoside (2.81 mg HCN), but low in phytin (0.28 g/100g), tannin (0.02 mg/100g) and oxalate (0.26 g/100g). Proximate biochemical results revealed the presence of crude fibre (10.36%), ash (6.57%), ether extract (6.48%), nitrogen free extract (64.82%) and crude protein (5.45%). Results also showed that GRP was low in both essential and non essential amino acid groups with the total amino acid value of 25.61 g/100g. The predominant mineral elements were zinc (Zn), manganese (Mn), copper (Cu), calcium (Ca), iron (Fe), sodium (Na), phosphorus (P) and potassium (K). The mineral values follow the order of Na (38.96 µg / g) > K (36.34 µg / g) > Ca (34.55 µg / g) > P (26.70 µg / g) > Mn (18.90 µg / g) > Zn (4.19 µg / g) > Fe (1.59 µg / g) > Cu (0.86 µg / g). The results revealed that ginger rhizome powder contain moderate level of pharmacological active compounds as well as feed nutrients and therefore, can be incorporated into monogastric feeding systems as feed additive.

Keywords: Nutrients, phytochemistry, ginger rhizome

Introduction

There has been growing interest in the use of herbs as feed additive in animal diets to maximize their potential output. In the past, antibiotic growth promoters were used at sub-therapeutic in animal feeds in order to improve the quality of the products (Nettleton, 1991). Other benefits include the control of zoonotic pathogens in the gastrointestinal tract (NOAH, 2001). Although animals raised with these feed additives achieved good performance, their potential side effects became a real public health problem worldwide (Donoghue, 2003) and led to the ban of these products by European Union (Diarra *et al*., 2011). This decision has therefore stimulated a search for natural alternative to antibiotics, such as ginger, garlic, onion among others. The use of feed additives, such as ginger and garlic in livestock feed and human diets are becoming more popular, because of their beneficial health and preservative importance (Manesh, 2012). The addition of natural feed additive is desirable because it ensures greater productivity of livestock, increase palatability, nutrient utilization, stimulates appetite, increases the flow of gastric juice and gives piguancy to tasteless food (Dzizaks, 1989).

Ginger belongs to the family *Zingiberanceae* and also a major crop, grown primarily in China, India and Nigeria and exported worldwide. Ginger leaves are linear and the flowers are yellowish green, oblong and ensheathed in a few scarious bracts. It is a well known herb and is widely used as a spice all over the world (Bartley and Jacobs, 2000) and medical treatment for certain ailments in traditional medicine (Zhang *et al*., 2009). Ginger contains several phytochemical compounds which have biological activities such as antioxidation, antimicrobial and other pharmacological effects (Zhao *et al*., 2011).

The potential pharmacological effects of ginger in monogastric animal production have been documented (Tekeli *et al*., 2011). Akbarian *et al*. (2011) reported the potential feeding value of ginger on growth performance and carcass quality of broiler chickens. The nutritional importance of ginger plant is increasingly acknowledged worldwide (Nwinuka *et al*., 2005); they have established to provide amino acids, oils, vitamins and mineral elements which are lacking inorganic feed additives (Al-Achi, 2007).

Recently, numerous research efforts have been directed at the performance indices and optimal inclusion rate of ginger rhizome in monogastric feeding systems (Tekeli *et al*., 2011). Although ginger may have performed well as a feed additive source, not much has been reported on its nutritional and phytochemical composition. Due to the growing popularity of the use of organic feed additives in feed production as a means of reducing production cost, enhancement of nutrients digestibility and body physiology, there is need to evaluate the nutritional and phytochemical content of ginger; hence the present study was an attempt to assess the nutritional and phytochemical potentials of ginger rhizome powder.

Materials and Methods

Location of the study: The study was conducted at the Teaching and Research Farm of Federal University of Technology, Owerri, Imo State. Imo State falls within latitude $4^0$4' and $6^0$3'N and longitude: 6^o15' and 8^o15'E. The climatic data of Owerri as summarized in Ministry of Lands

and Survey Atlas of Imo State is as follows: mean annual rainfall of 2500 mm in a bimodal rainfall pattern that peaks in July and September with a break of 1 - 2 weeks in August, with daytime temperature of about 27º C and relative humidity range 70 to 80%.

Sample collection and preparation: Fresh ginger rhizomes of the Indian *cultivar Himachel Pradesh* were procured. The fresh ginger rhizomes were washed in water to remove adhering dirts. They were chopped into smaller pieces using kitchen knife and shade dried for 5 days. The dried samples were milled into fine particle sizes using Laboratory mill (Arthur Thomas, USA) and sieved via 2mm test sieve. The ginger rhizome powder so prepared was stored in airtight bag for phytochemical and nutritional analyses.

Chemical analysis: The phytochemical (phytin, tannin, saponin, oxalate and glycoside) and proximate biochemical (CP, CF, EE, NFE and ash) compositions of ginger rhizome powder samples were determined in triplicates using the standard procedures of AOAC (1990). The mineral contents (calcium, phosphorus, sodium, potassium, iron, magnesium, sulphur, manganese, copper and zinc) were determined by wet - ashing the samples with a mixture of hydrochloric acid and nitric acid, followed by flaming in Atomic Absorption Spectrophotometer (Philip Analytica PU 9100X) AAS using different lamps according to AOAC (1990). Calcium (Ca) - phosphorus (P) ratio was determined by dividing the "Ca" value by the "P" value whereas, sodium (Na) - potassium (K) ratio was also determined by dividing the "Na" value by the "K" value. Amino acid value was determined using Automatic Amino Acid Analyzer (Technicon Sequential Multi-Sample Amino Acid Analyser DNA0209, Ireland). The amino acid determined was scored using FAO (1991) reference pattern.

Statistical Analysis

The experiments were done in triplicates and data obtained were expressed as the mean + standard deviation (Mean + SD).

Results and Discussion

The quantitative phytochemical composition (Table 1) indicated that ginger rhizome powder was high in saponins (4.01 mg/100g) and low in tannin (0.02 mg/100g). This finding compared favourably with the report of Adanlawo and Dairo (2007) who reported saponins content of 3.85 mg/100g for ginger rhizome powder.

Determined amino acids in ginger were partitioned using the appropriate formulae:

Total amino acids (TAA) =	∑ (Meth + Isoleuc + Phenyl + Lys + Hist + Val + Arg + Thre + leuc + Cys + Glyc + Glut + Ser + Ala + Asp + Prol + Tyr)
Total essential amino acid (TEAA) =	∑ (Meth + isoleuc + Phenyl + Lys + Hist + Val + Arg + Thre + leuc)
TEAA – (Histidine + Arginine) =	∑(Meth + Isoleuc + Phenyla + Lys + Val + Thre + leuc]
% TEAA – (Histidine + Arginine) =	[(TEAA – (Hist + Arg) / TAA) X 100]
Total non essential AA (TNEAA) =	∑(Cys + Gly + Glut + Ser + Ala + Asp + Prol +Tyr)
%TNEAA =	[(TNEAA / TAA) X 100]
Total aliphatic amino acids (TAAA) =	∑ [Gly + Ala + Val +Leuc + Isoluec]
%TAAA =	[(TAAA / TAA) X 100]
Total neutral amino acid (TNAA) =	∑(Gly + Ala + Val + Leuc + Isoluec + Phenyl + Prol + trypt + Ser + Thre + Meth + Cyst + Aspar + Glut]
%TNAA =	[(TNAA / TAA) X 100)]
Total basic amino acids (TBAA)	TBAA = ∑(Hist + Lys + Arg)
%TBAA =	[(TBAA / TAA) X 100]
Total acidic amino acid (TAcAA) =	∑[Glut + Asp]
%TAcAA =	[(TAcAA / TAA) X 100]
Total sulphur amino acids (TSAA) =	∑(Cys + Meth)
% Methionine in TSAA =	[(TSAA – Meth / TSAA) X 100]
Total polar amino acids (TPAA) =	∑(Asp + Cys + Tyr + Glut + Lys + Hist + Arg + Thre + Ser)
%TPAA =	[(TPAA / TAA) X 100].
Total non polar amino acid (TNPAA) =	∑(Ala + Gly + Isoleuc + Leuc + Meth + Phenyl + Prol + Val)
%TNPAA =	[(TNPAA / TAA) X 100]

AA – Amino acid; Ala – Alanine; Gly – Glycine; Isoleuc – Isoleucine; Meth – Methionine; Phenyl- Phenylalanine; Pro – Proline; Val – Valine; Leu – Leucine; Asp – Aspartate; Tyr – Tyrosine; Lys- Lysine; Hist – Histidine, Arg – Arginine; Thre - Threonine; Ser – Serine; Cys – Cysteine; Glut – Glutamate; Aspar – Asparagine; Trypt - Tryptophan

Interestingly, the observed higher concentration of saponins in ginger rhizome powder corroborated the earlier reports of Johnson *et al*. (1986), that plants with high concentrations of saponins improve the growth of beneficial gastro-intestinal microflora and the permeability of the mucosal cells of the small intestine, thereby facilitating the uptake of nutrients. The trace level of tannins in ginger rhizome is therefore considered to be below toxic level in animals (Ekop *et al*., 2010). The cyanogenic glycoside content recorded by ginger (2.81 mg / 100g) was lower than (7.07 mg / 100 g) recorded for *Congronema latifolia* by Ukorebi (2011). The oxalate value (0.26 mg / 100 g) fell within the acceptable range (NRC, 1996). This result agrees with the studies of Munro and Bassir (1969), which ruled out the possibility of oxalate poisoning from the consumption of local fruits, spices and vegetables.

Table 1: Determined phytochemical composition of ginger (*Zingiber officinale*) rhizome powder

Compound	Concentration (mg / 100 g)
Saponin	4.01 ± 0.07
HCN	0.81±1.05
Phytin	0.28 ± 0.01
Oxalate	0.26 ± 0.002
Tannin	0.02 ± 0.00

HCN = Cyanogenic glycoside; ND = Not detected

The proximate biochemical compositions of ginger rhizome powder are presented in Table 2. Results of proximate analysis are extensively employed in research and industry for quick estimation of nutrient potentials of feedstuffs. The moisture content of the sample was 6.32% which shows that ashing of ginger could be less time consuming. This implies that the shelf life of ginger rhizome powder would be prolonged and that deterioration due to microbial action will be limited. This value is lower than 81.97% and 78.86% reported by Odebunmi *et al.* (2010) respectively and the observed difference may be due to the physical state / processing of the test material. The dry matter content of ginger rhizome powder obtained in this study was high (93.68%), which indicated its richness in organic matter. The crude protein value of 5.45 % recorded in this study is in agreement with the report of Odebunmi *et al*. (2010) that spices have low crude protein content. The low crude protein value of ginger supports its use as additive in monogastric feeding. The ether extract value of 6.48% compared favourably to the value of 5.53% reported by Nwinuka *et al.* (2005) for dry ginger bulb. This indicates that ether extract was fairly high and containing most of the biologically active ingredients that are organic in structure (Weiss, 2002). However, the value for ether extract in the current study was not high enough for ginger to be called an oil plant. The crude fibre value of 10.36% compared favourably with the report of Bhat *et al*. (2010) who reported crude fibre value of 17.6% for pepper. The ash content which is a reflection of mineral elements was 6.57%, which was higher than those reported for ginger powder (1.23 - 2.54%) by Odebunmi *et al.* (2010). It appears that ginger rhizome powder could supply adequate amount of minerals required for proper growth and development.

Table 2: Determined proximate composition of ginger (*Zingiber officinale*) rhizome powder

Nutrients	Composition (%)
Moisture	6.32 ± 0.35
Dry matter	93.68 ± 4.66
Crude protein	5.45 ± 0.46
Ether extract	6.48 ± 0.38
Ash	6.57 ± 0.18
Crude fibre	10.36 ± 0.67
Nitrogen free extracts	64.82 ± 11.33

The mineral elements (µg / g) detected in ginger rhizome powder in the present study are zinc (Zn), manganese (Mn), copper (Cu), calcium (Ca), iron (Fe), sodium (Na), phosphorus (P) and potassium (K) (Table 3). The predominant mineral elements detected in ginger rhizome powder in the current study follow the order of Na > K > Ca > P > Mn > Zn > Fe > Cu. Sodium and potassium were detected in ginger rhizome powder at 38.96 µg / g and 36.36 µg / g levels respectively and confirms the earlier report of Aremu *et al*. (2005) that potassium is one of the most abundant minerals in Nigerian agricultural products. The ratio of sodium to potassium in the feedstuff is of great concern for prevention of high blood pressure. Low sodium / potassium ratio in diet is associated with elevated blood pressure. The high sodium and potassium ratio obtained in this study agrees with the findings of Afzal *et al.* (2001) and explains the roles of ginger rhizome powder in reducing high blood pressure. Calcium and phosphorus value were at moderate levels in ginger rhizome powder and these values were comparable to the values reported by Adanlawo and Dairo (2007) for spices. Calcium constitutes a large proportion of the bone, blood and extracellular fluid and is necessary for normal functioning of cardiac muscles, blood coagulation, milk clotting and regulation of cell permeability. The Ca: P ratio of 1.3: 1 recorded for ginger rhizome powder in this study is lower than the ratio of 2:1 reported by Esonu

(2006). The implication of this finding is that ginger is low in calcium and this could be the possible reasons why it is not used as a mineral source. The moderately lower concentration of manganese, zinc and copper in ginger (NRC, 1996) is a welcome development because these values cannot easily result to manganese, zinc and copper toxicity to animals.

Table 3: Trace and macro mineral compositions of ginger (*Zingiber officinale*) rhizome powder

Minerals	Composition (µg / g)
Zinc	4.19 ± 0.06
Manganese	18.90 ± 1.60
Copper	0.86 ± 0.01
Calcium	34.55 ± 1.39
Phosphorus	26.70 ± 1.59
Calcium : Phosphorus	1.29
Iron	1.59 ± 0.08
Sodium	38.96 ± 3.58
Potassium	36.34 ± 1.93
Sodium : Potassium	1.07

The amino acid analysis revealed that ginger rhizome powder contained both essential and non essential amino acids (Table 4). The present study also revealed that ginger rhizome powder was moderate in arginine (3.90 g / 100 g protein) but relatively low in methionine (0.55 g / 100 g protein). The total amino acid value of 25.61 g / 100 g protein indicates that ginger rhizome powder will not contribute significantly to the supply of amino acids in rations. All the essential amino acids contained in ginger rhizome powder with the exception of leucine were generally inferior and lower than those reported for edible legumes and vegetables by Nwachukwu and Ibrahim (2007). This could be the reason why ginger is usually used as additive in non ruminant feeding. Apart from the fact that ginger does not belong to plants with high amino acid content; the low values might have been influenced by geographical location which has a considerable effect on amino acid value (Bhatty *et al*., 2000). Apart from geographical location and cultural practices, the acid digestion method used in preparation of samples for amino acids analysis could also affect the final results (Wathelet, 2000).

Table 5 showed the classification of amino acids of ginger rhizome powder. Based on the degree of electronegativity, the 17 amino acids determined in ginger rhizome powder were classified into polar and non polar group. The percentage total essential amino acid without histidine and arginine recorded at 56.38 % in the current study is an indication that ginger rhizome contain moderate amount of essential amino acids. Histidine is required for growth and is essential in young mammals (Ihekoronye and Ngoddy, 1985); this amino acid was found to be lower than 1.9 g / 100 g protein set as reference standard set by the Food and Agricultural Organization (FAO, 1991). The result showed that aliphatic amino acids, which constitute the hydrophobic regions of proteins, were not found in abundance in ginger rhizome powder (7.37 g / 100 g protein). However, the total non essential amino acid value recorded for ginger powder in the present study (9.40 g / 100 g protein) was lower than those reported elsewhere for melon seed (53.40 g / 100g protein) and pumpkin seed (38.30 g / 100 g protein) by Aremu *et al*. (2006), which suggests that ginger rhizome powder was low in non essential amino acid groups.

Table 4: Determined amino acid compositions of ginger (*Zingiber officinale*) rhizome powder.

Amino acid	Concentration (g / 100 g protein)
Essential amino acids (EAA)	
Methionine	0.55 ± 0.04
Isoluecine	1.97 ± 0.03
Phenylalanine	2.05 ± 0.001
Lysine	1.84 ± 0.003
Histidine	0.87 ± 0.006
Valine	1.08 ± 0.02
Arginine	3.90 ± 0.15
Threonine	1.92 ± 0.24
Leucine	2.03 ± 0.06
Total EAA	16.21
Non essential amino acids (NEEA)	
Cysteine	0.38 ± 0.001
Glycine	0.55 ± 0.01
Glutamate	0.84 ± 0.15
Serine	1.96 ± 0.04
Alanine	1.74 ± 0.007
Aspartate	1.55 ± 0.06

Proline	0.90 ± 0.28
Tyrosine	1.48 ± 0.004
Total NEEA	9.40
Total amino acids (EAA + NEAA)	25.61

Table 5: Partitioning of amino acids (g / 100 g protein) contained in ginger rhizome powder.

Amino acid classification	Concentration (g / 100 g protein)
Total amino acid (TAA)	25.61
Total non essential amino acids (TNEAA)	9.40
%Total non essential amino acids	36.70
Total essential amino acids (TEAA)	
With histidine and arginine	16.21
Without histidine and arginine	14.44
Total essential amino acids	
%With histidine and arginine	63.30
%Without histidine and arginine	56.38
Total aliphatic amino acids (TAAA)	7.37
%Essential aliphatic amino acid in TAAA	68.93
Total neutral amino acids	15.97
%Total neutral amino acids	62.36
Total basic amino acid	6.61
%Total basic amino acid	25.81
Total acidic amino acid	2.39
% Total acidic amino acid	9.33
Total sulphur amino acids	0.93
% Methionine in total sulphur amino acid	59.14
Total non polar amino acid	10.87
%Total non polar amino acid	42.61
Total polar amino acid	14.74
%Total polar amino acid	57.56

Data on the chemical scores of essential amino acids of ginger rhizome powder compared with the FAO (1991) reference pattern are shown in Table 6. The fact that the ginger rhizome powder met only 27% of the sulphur amino acids requirements as stipulated by FAO (1991) confirms the poor quality of ginger relative to legumes. The FAO (1991) scoring pattern reveals that the first and second limiting amino acids are lysine and leucine. The fact that the ginger rhizome powder meets only 3.77% of leucine and 6.0% of lysine requirements as stipulated by FAO (1991) confirms the poor quality of ginger amino acids relative to the reference values.

Table 6: Chemical scores of amino acid profile of ginger (*Zingiber officinale*) rhizome powder as compared with FAO (1991) reference pattern

Amino acid	FAO Reference pattern (g/100g protein)	Pattern (g / 100g protein)	Amino acid scores
Isoluecine	4.0	1.97	0.49
Leucine	7.0	2.03	0.29
Lysine	5.5	1.84	0.33
Methionine + Cysteine	3.5	0.93	0.27
Phenylalanine + Tyrosine	6.0	3.53	0.59
Threonine	4.0	1.92	0.48
Valine	5.0	1.08	0.22
Total	**36**	**13.3**	**2.67**

Conclusion

In conclusion, it is observed that ginger is a good source of micronutrients and it contains pharmacological active compounds that could be useful in animal production. The presence of micronutrients and pharmacological active compounds in ginger supported its importance in animal nutrition and possible use in ethnoveterinary medicine.

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