

Full Length Research Paper

Comparative analysis of the chemical composition of three spices – *Allium sativum* L. *Zingiber officinale* Rosc. and *Capsicum frutescens* L. commonly consumed in Nigeria

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The beneficial health effects of spices against common chronic systemic diseases have been well documented. Comparative study of the proximate, mineral and phytochemical components of three spices namely garlic (*Allium sativum* L.), ginger (*Zingiber officinale* Rosc.) and pepper (*Capsicum frutescens* L.) were investigated. Analysis of the proximate composition revealed that the spices had considerable carbohydrate and crude protein content, but low ash, fibre, moisture and fat except pepper which has high crude fat content. The spices were also characterized by the presence of mineral elements such as calcium, iron, potassium, phosphorus, sodium, magnesium, copper and zinc which are very important to human nutrition. Phytochemical screening indicated that these spices are also rich in phytonutrients including alkaloid, tannin, carotenoids, saponin and flavonoids. The spices had low concentrations of steroids and cardenolides. Overall, the findings indicate that the spices are good sources of nutrients, mineral elements and phytochemicals which could be exploited as great potentials for drugs and/or nutritional supplements.

Key words: Comparative, nutritional, supplements, spices.

INTRODUCTION

Spices are any of several vegetable substances used to season or flavor food. They are usually dried for use and have distinct flavor and/or aroma. Common examples include cloves, cinnamon, nutmeg, pepper, garlic, onion, curry, ginger and thyme. They stimulate appetite by increasing the flow of gastric juice and are used in most homes and restaurants all over the world (Nwinuka et al., 2005). Spices are used either whole, ground, or in the form of extracts (oils and oleoresins).

The beneficial health effects of spices have been well documented (Mensah et al., 2009; Bhattacharjee and Sengupta, 2009; Soetan and Aiyelaagbe, 2009). Many spices have been reported to have antimicrobial properties,

cholesterol lowering effects, anti-diabetic and anti-inflammatory properties (Suekawa et al., 1984; Kwada and Tella, 2009). The consumption of garlic has the potential to reduce arterial plaque and possess antioxidant properties on skin cancer (Koscienly et al., 1999; Das and Saha, 2008). According to Thomson et al. (2002), the consumption of ginger led to reduction in blood cholesterol and also served as a potential anti-inflammatory and antithrombotic agent. Nwose (2009) reported the importance of pepper as antioxidant nutrition therapy used to treat cardiovascular diseases, diabetes, erectile dysfunction and respiratory diseases.

In Nigeria, cardiovascular diseases, cancer, diabetes, liver cirrhosis and osteoporosis are some of the common chronic systemic diseases that are the major causes of morbidity. In addition, drug-resistant micro organisms are a serious public health concern because they are difficult to treat (Schmidt, 2003). Therefore, the need for new

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Table 1. Proximate composition of garlic, ginger and pepper.

Parameters	Composition (%)		
	Garlic	Ginger	Pepper
Moisture	4.55 ± 0.11 ^c	6.37 ± 0.01 ^a	5.70 ± 0.15 ^b
Ash	4.08 ± 0.10 ^b	6.30 ± 0.13 ^a	4.35 ± 0.10 ^b
Crude protein	15.33 ± 0.01 ^a	8.58 ± 0.01 ^c	11.70 ± 0.13 ^b
Crude fat	0.72 ± 0.01 ^c	5.35 ± 0.13 ^b	12.70 ± 0.10 ^a
Crude fibre	2.10 ± 0.01 ^b	3.25 ± 0.13 ^a	2.61 ± 0.01 ^b
Carbohydrate	73.22 ± 0.01 ^a	68.15 ± 0.01 ^b	62.94 ± 0.01 ^c

Values are mean ± SD of 3 replicates. ^{a-c} Test values along the same row carrying different superscripts for each parameter are significantly different ($p < 0.05$).

therapeutic agents is pertinent and spices are considered as one of the most promising agents (Rios and Reccio, 2005).

Before the commencement of this work, there was no information in scientific literature on the comparative analysis of the chemical composition of these three spices namely; *Allium sativum*, *Zingiber officinale* and *Capsicum frutescens* commonly consumed in Nigeria. Therefore, the present study was designed to compare the chemical properties of these spices which are usually combined when used. The findings from this study may justify the usage of these spices for their medicinal purposes as well as nutritional supplements.

MATERIALS AND METHODS

Sample collection and preparation

Garlic, ginger and pepper were bought at the local Ipata Market in Ilorin, Nigeria. The plant materials were authenticated by Mr. Adebayo of the Department of Botany, University of Ilorin and the voucher specimens were deposited at the University of Ilorin Herbarium (UIH), Nigeria. The spices were washed, thinly sliced, oven dried at 60°C for 72 h and milled. The powder obtained was stored in airtight plastic containers under refrigeration until needed for use.

Proximate and mineral analyses

The methods described in AOAC, (2002) were used to analyze the proximate composition of the spices for protein, fat, fibre, ash and moisture while carbohydrate was calculated by subtracting the sum of the values of the other nutrients from 100. The mineral analysis was carried out as described by Okalebo et al. (2002) using Atomic Absorption Spectrophotometer (Pye Unicam Sp9, Cambridge, UK.). The minerals determined were sodium (Na), calcium (Ca), magnesium (Mg), potassium (K), phosphorus (P), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), cobalt (Co), cadmium (Cd) and lead (Pb).

Phytochemical analysis

The phytochemical contents of the three spices including alkaloids, tannins, saponins, flavonoids, carotenoids, steroids and cardenolides

were quantitatively and qualitatively investigated (Harbone, 1973; Odebiyi and Sofowora, 1979 and Edeoga et al., 2005).

Statistical analysis

All data were expressed as mean ± S.D and were statistically analyzed using one way analysis of variance (ANOVA). Means were separated by the Duncan multiple test using SAS (2002). Values were considered significant at $p < 0.05$.

RESULTS

The proximate composition indicates that the three spices contained appreciable amount of carbohydrates suggesting that they can be ranked as carbohydrate rich spices (Table 1). Carbohydrate content was significantly high in garlic, followed by ginger and lowest in pepper. There was a significant difference in the protein content in all the spices, with garlic having the highest value followed by pepper, while ginger had the lowest value. Pepper had a significantly high crude fat content compared to garlic which had only a trace and ginger with low content as indicated in Table 1. The three spices had low moisture contents which were significantly different from each other, with ginger having the highest value and garlic the lowest. The ash and fibre contents were significantly higher ($p < 0.05$) in ginger when compared with garlic and pepper.

The mineral analysis of the three spices indicated their richness in sodium, calcium, potassium, iron, zinc, copper, manganese, phosphorous and magnesium (Table 2). The level of Ca and Fe in garlic was markedly higher than that of ginger and pepper, while the values for Na and P were significantly higher for ginger. Pepper had a higher K content when compared with garlic and ginger. However, there was no significant difference in Zn, Cu and Mn values among the three spices, while Pb, Ca and Co was not detectable.

The phytochemical analysis indicated that the spices are rich in phytonutrients (Table 3). Pepper has a significantly high content of carotenoids, flavonoids and saponins when compared with garlic and ginger. The

Table 2. Mineral composition of garlic, ginger and pepper.

Mineral	Composition (mg/100 g)		
	Garlic	Ginger	Pepper
Sodium	4.10 ± 0.14 ^b	5.00 ± 0.35 ^a	4.50 ± 0.00 ^b
Calcium	26.30 ± 0.14 ^a	25.76 ± 0.28 ^b	23.45 ± 0.00 ^c
Iron	5.29 ± 0.08 ^a	3.46 ± 0.28 ^b	3.39 ± 0.15 ^b
Phosphorous	10.19 ± 0.26 ^b	12.56 ± 0.21 ^a	9.89 ± 0.08 ^b
Potassium	54.00 ± 1.40 ^c	215.00 ± 1.06 ^b	229.00 ± 0.71 ^a
Zinc	0.34 ± 0.17 ^a	0.04 ± 0.00 ^b	0.02 ± 0.00 ^b
Copper	0.001 ± 0.00 ^a	0.001 ± 0.00 ^a	0.001 ± 0.00 ^a
Manganese	0.001 ± 0.00 ^a	0.002 ± 0.00 ^a	0.002 ± 0.00 ^a
Magnesium	4.10 ± 0.14 ^b	5.00 ± 0.35 ^a	4.50 ± 0.00 ^b

Values are mean ± SD of 3 replicates. ^{a-c} Test values along the same row carrying different superscripts for each parameter are significantly different ($p < 0.05$).

Table 3. Percentage composition of phytochemicals in the spices.

Phytochemicals	Composition (%)		
	Garlic	Ginger	Pepper
Alkaloids	2.54 ± 0.00 ^c	11.21 ± 0.00 ^b	13.44 ± 0.02 ^a
Tannins	0.07 ± 0.00 ^c	3.54 ± 0.00 ^a	1.77 ± 0.02 ^b
Carotenoids (µg/100 g)	0.00 ± 0.00 ^c	0.64 ± 0.00 ^b	648.00 ± 2.86 ^a
Saponin	4.60 ± 0.03 ^b	0.80 ± 0.41 ^c	7.40 ± 2.86 ^a
Flavonoids	1.16 ± 0.01 ^c	5.56 ± 0.00 ^b	6.38 ± 0.01 ^a
Steroids	0.04 ± 0.00 ^a	0.04 ± 0.37 ^a	0.33 ± 0.02 ^a
Cardenolides	0.20 ± 0.00 ^a	0.02 ± 0.00 ^a	0.55 ± 0.00 ^a

Values are mean ± SD of 3 replicates. ^{a-c} Test values along the same row carrying different superscripts for each parameter are significantly different ($p < 0.05$).

tannin content in ginger was high compared to garlic and pepper. Saponin was present in trace amount in ginger, while pepper and garlic had an appreciable amount of the compound. Both pepper and ginger had significantly high contents of alkaloid, unlike garlic which had quite a low content. Steroids and cardenolides were present in trace amounts in all the three spices, while flavonoids were significantly low in garlic when compared with ginger and pepper.

DISCUSSION

The proximate analysis revealed that the three spices can be ranked as carbohydrate rich due to their high calorie content. Though high in crude fat content, pepper may not be rated as an oil seed, however, the oil could be extracted for use as essence or essential oil (Okwu and Nnamdi, 2008). The high crude protein content of garlic and pepper may be due to the presence of active proteinous metabolites such as allicin, ajoene and capsaicin. According to Dashak et al. (2001), the normal

daily protein requirement for a normal adult is 45 - 50 g; therefore, these spices could serve as supplements since they are usually combined in human main dishes. Low ash is usually an indication of low inorganic mineral content (Oloyede, 2005); however, the nutritionally important ones such as Ca, Mg, K and Fe were found in relatively high amount in the three spices. The reduced levels of crude fibre obtained for the three spices posed no threat since they are not usually consumed in isolation but as adjuncts or additives to other foods. Hence, their low fibre contents serves as a boost to the total dietary fibre of the dishes in which they are used. The reduced moisture content in the spices is an indication that their shelf life would be prolonged and that deterioration due to microbial contamination would be limited (Dashak et al., 2001). The data obtained for the proximate analysis of the spices agree with earlier reports and indicates that they contribute nutrients to the diet (Dashak and Nwanegbo, 2000; Nwinuka et al., 2005; Edeoga et al. 2006).

The mineral elements contained in these spices are very important in human nutrition. Sodium, potassium, calcium and magnesium play a central role in the normal

regulation of blood pressure (Karppanen, 1994). In particular, these elements have important interrelationships in the control of arterial resistance (Altura and Altura, 1999). They also regulate the fluid balance of the body and hence, influence the cardiac output. It is increasingly being realized that a lower than normal dietary intake of Mg can be a strong risk factor for hypertension, cardiac arrhythmias, ischemic heart disease, atherogenesis and sudden cardiac death (Altura and Altura, 1999). Zinc and chromium are well known trace elements in diabetes as cofactors for insulin (Kimura, 1996) while calcium, magnesium and phosphorus are also essential for bone and teeth formation (Okwu, 2005). The importance of these elements cannot be overemphasized because they are required by many enzymes as co-factors (Ozcan, 2004). The non-detection of Pb, Cd and Co is of great advantage to consumers of these spices as these elements have been reported to be highly toxic even at low concentrations (Asaolu et al, 1997; Oloyede, 2005).

Phytochemicals are bioactive, non-nutrient, naturally occurring plant compounds found in vegetables, fruits and spices (Okarter et al., 2009). Purified alkaloids as well as their synthetic derivatives are used as medicinal agents as analgesic, antimalarial, antiseptic and bactericidal (Evans, 2002). In this study, the observed high alkaloid content in pepper and ginger could be responsible for their much acclaimed medicinal values though the exact mode of action is poorly understood. Saponins are produced by plants as a defence mechanism to stop attacks by foreign pathogens, which makes them natural antibiotics (Okwu and Emenike, 2006). They have also been demonstrated to have cholesterol lowering effects and the ability to kill or inhibit cancer cells (Okwu, 2005; Nwinuka et al., 2005; Okwu and Emenike, 2006, Okwu and Nnamdi, 2008). Therefore, the appreciable amount of saponin in garlic and pepper could be responsible for their antimicrobial properties. The presence of tannins might have accounted for the sharp taste of both ginger and pepper and have been reported to hasten the healing of wounds and inflamed mucous membranes (Okwu and Emenike, 2006). Cardenolides contribute to the medicinal values of plants in which they occur and have been known for the treatment of congestive heart failure (Oloyede, 2005). Flavonoids are known to protect against allergies, inflammation, platelet aggregation and microbial infection (Okwu and Omodimiro, 2005). This suggests that pepper and ginger with high flavonoids contents will exhibit these properties. The high carotenoid content of pepper compared to virtually none in garlic and ginger is not surprising as carotenoids are largely responsible for the red colour of peppers (Tripathi and Mishra, 2009).

In general, the presence of these phytochemicals could account for the much touted medicinal properties of these spices in various disease conditions such as atherosclerosis, arthritis, nausea, asthma, worm expeller, bacterial infections and cancer (Das and Saha, 2008; Kaur and Arora, 2009).

Conclusion

The present study has provided some comparative biochemical information on the proximate, mineral element and phytochemistry of garlic, ginger and pepper species found in some Nigerian markets. There are indications that all three spices are good sources of nutrients, mineral elements and phytochemicals. Therefore, their use as nutritional supplements is highly promising.

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