

Full Length Research Paper

Biochemical qualities of 10 elite accessions of ginger (*Zingiber officinale Roscoe*)

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The extractable sugars and nutritive quality of 10 elite accessions of ginger (*Zingiber officinale Roscoe*) from National Root Crops Research Institute, Umudike and Nigeria were investigated. The percentage reducing sugar (RS) contents of the ginger accessions were observed to be low and they ranged from 0.28 to 0.65 (%) with UG II 7-24 having the highest amounts of reducing sugar ($0.64 \pm 0.00\%$) while UGII 3-04 had the least ($0.43 \pm 0.06\%$). In addition, UGII 5-18 had the highest amounts of total soluble carbohydrates/sugars (TSC) ($53.00 \pm 1.41\%$) while UGII 5-35 had the least ($33.80 \pm 0.42\%$). All the accessions of ginger contained significant quantities of minerals, nitrogen and oleoresin. Correlation analysis that was carried out, showed that oleoresin correlated positively with RS ($r = 0.110$), TC ($r = 0.359$), magnesium ($r = 0.22$), phosphorous ($r = 0.58$), sodium ($r = 0.45$) and potassium ($r = 0.72$), negatively with nitrogen ($r = -0.08$) and insignificant with calcium ($r = 0.02$). Results show that these accessions of ginger could possess considerable economic, nutritive and medicinal potentials. Finally, the oleoresins in ginger could contribute to the potassium contents of ginger

Keywords: Sugars, accessions, ginger, oleoresin, nutrition.

INTRODUCTION

Spices are substances usually of vegetable origin that are used to season or add flavor to foods. They are used either whole, ground, or in the form of extracts (oils and oleoresins) (Nwinuka *et al.*, 2005). The significant roles spices play with regards to human health have been reported by several authors (Mensah *et al.*, 2009; Bhattacharjee and Sengupta, 2009; Soetan and Aiyelaagbe, 2009).

The health effects of various plant extracts in the management of diseases have been attributed to the bioactive compounds in them that often exhibit a wide range of biological and pharmacological activities such as anti-inflammatory, anti-diabetic, antimicrobial, anti-atherosclerotic, anti-carcinogenic and anti-thrombotic properties (Girish *et al.*, 2008). These bioactive compounds are naturally occurring minerals, phytochemicals and vitamins that are responsible for the color and flavor of plants.

There has been an upsurge in the past decade in the use of medicinal plants in the treatment of a wide array of diseases. Medicinal plants are used as primary health care aid among 80% of the world's population in the form of plant extracts or their active components (WHO, 2008).

Recent studies have focused on a new group of bioactive components in some foods which have protective effects against cell oxidation. These food groups otherwise known as functional foods play significant roles to human health (Klein *et al.*, 2000) such as prevention or delay of the onset of chronic diseases as well as provision of the basic nutritional requirements (Medoua *et al.*, 2009). In Nigeria, several diseases such as cardiovascular, cancer, diabetes, liver cirrhosis and osteoporosis are some of the major causes of mortality. More so, different strains of drug resistant microorganisms keep developing and this has become a serious public health issue. Therefore, the need for new therapeutic agents cannot be overemphasized and spices are considered as one of the most promising agents (Rios and Reccio, 2005).

Ginger (*Zingiber officinale Roscoe*), a widely used herb and food spice is considered a major constituent of

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most Nigerian diets. The medicinal value of ginger has been linked to its antioxidant potentials that could arise from the oleoresins that are present in it (Balachandran *et al.*, 2006). The oleoresins in ginger have also been credited for various pharmacological effects such as: anti-nauseant, antimicrobial, anti-inflammatory (Verma *et al.*, 1994), antioxidant (Shobana *et al.*, 2000., Eleazu and Eleazu., 2012), anticoagulant, anti-hypercholesterolemic, anti-hypertensive, anti-hyperglycemic, antispasmodic (Bradley, 1992) and vasodilatory properties.

In most Nigerian homes, the ginger rhizome is mainly used as a spice for flavoring a variety of dishes and drinks such as stews, rice, 'kunu', 'zobo', 'burukutu", etc. A greater percentage of the Nigerian populace is unaware of its medicinal purposes, thus making it under-utilized.

In 2009, some ginger accessions were subjected to Genetic breeding in the Breeding Unit of the National Root Crops Research Institute, Umudike, Nigeria with an aim of developing ginger varieties with high oleoresin contents. Preliminary screening of those accessions in early 2011 indicated that they had lower percentage oleoresin contents than reported values for ginger. The breeding for the selection of ginger varieties with high oleoresin contents was concluded in January 2012 and the ginger varieties were further subjected to analysis. Those accessions with high percentage oleoresin contents were selected and analyzed for reducing sugar, total soluble carbohydrates and mineral contents and the results are reported in this paper.

MATERIALS AND METHODS

Dinitrosalicylic acid reagent, phenol and glucose standards used were obtained from Sigma and Aldrich Chemical Company, Germany and were of analytical grade. Other chemicals that were used for the experiment were bought locally from Hos Lab, Umuahia, Abia State, Nigeria and were of analytical grade.

Preparation of plant extracts

Ginger rhizomes, freshly harvested from the experimental farm of National Root Crops Research Institute, Umudike in 2012, were properly washed, sliced to a thickness of about 2mm and dried in an oven at a temperature of 65°C for 24 hours. A measured quantity (0.1g) each of the dried samples was processed to flour and soaked in 100ml of distilled water. The mixture was centrifuged at 3000 x g for 10 minutes and filtered. The filtrate was analyzed for total soluble carbohydrates.

Oleoresin determination

The percolation method (AOAC, 1975) was used with modifications.

Ten grams of each of each accession of the fresh ginger rhizomes was washed properly with distilled water, sliced into chips of approximately 0.5cm in diameter and dried in an oven at a temperature of 70°C for 8 hours to a constant weight. Five grams of the dried samples (W_1) were mashed with 100mls of acetone and the mixture was left overnight. It was later filtered (Whatman No. 1 filter paper) into a pre-weighed empty beaker (W_2) and the acetone evaporated on a water bath at 65°C, cooled and the whole setup was re-weighed (W_3). The percentage oleoresin contents of the samples was determined by weight difference as:

$$\text{Percentage oleoresin (dry weight)} = \frac{W_3 - W_2 \times 100}{W_1}$$

W_3 = Weight of beaker + oleoresin

W_2 = Weight of empty beaker

W_1 = Weight of sample taken

Determination of total soluble carbohydrates/sugars

The phenol-sulfuric acid method (Dubois *et al.*, 1956) as modified by Eric (2001) was used in the determination of the total soluble carbohydrate contents of the flours. Five μ l of the aqueous extract + 500 μ l phenol (4% in water) + 2.5mls sulphuric acid (96% in water) were mixed thoroughly. The resulting solution was further re-diluted with 4mls of water and the absorbance was read at 490nm against a reagent blank that contained 500 μ l (4%) phenol and 2.5ml (96%) sulphuric acid. The resulting solution was further re-diluted in 2mls of water and the absorbance was read with a spectrophotometer (Genesys 10 VIS Thermo Electron Corporation) at 490nm against a reagent blank which contained 500 μ l (4%) of phenol and 2.5ml (96%) of sulfuric acid. The same procedure was followed for the glucose standard (0.1g in 100mls water) which was serially diluted to varying concentrations of 0.005, 0.01, 0.02, 0.03, 0.04 and 0.05mg/ml and results were expressed in mg/ml. The amount of soluble carbohydrates in the samples was obtained from the equation: $Y = 15.97x - 0.042$ ($R^2 = 0.879$) where Y = Unknown concentration of the sample; 15.97 = slope of the graph; x = absorbance reading of the sample; 0.042 = intercept and R^2 = correlation coefficient.

Analysis of reducing sugars

The dinitrosalicylic acid reagent method (Miller, 1972) was used with modifications. A weighed amount of the sample (0.1g) was mixed with 5mls of 80% ethanol in a test tube. The mixture was filtered using Whatman No.1 filter paper and centrifuged at 300 x g for 10 minutes. The supernatant was collected in a test tube and evaporated in a water bath at 80°C for 5minutes. Ten mls of water was added to the residue and two mls of the extracts collected and added in a test tube. Three mls of distilled water and 3mls of dinitrosalicylic acid reagent

Table 1. Percentage sugar composition of 10 elite accessions of ginger (dry basis)

Accessions	Reducing sugars	Total soluble carbohydrates
UGI 5-24	0.4±0.04 ^{ab}	46.24±0.23 ^{cd}
UGII 3-04	0.34±0.06 ^a	35.70±0.00 ^a
UGII 5-18	0.46±0.10 ^{ab}	53.00±1.41 ^d
UGII 5-31	0.48±0.03 ^{abc}	38.90±3.54 ^{abc}
UGII 5-35	0.50±0.07 ^{abc}	33.80±0.42 ^a
UGII 5-47	0.42±0.15 ^{ab}	38.40±2.26 ^{abc}
UGII 5-48	0.57±0.02 ^{bc}	35.04±0.00 ^a
UGII 5-52	0.39±0.08 ^{ab}	45.06±0.00 ^{bc}
UGII 7-24	0.64±0.01 ^c	37.50±6.65 ^{ab}
UGII 11-05	0.42±0.02 ^{ab}	39.30±6.93 ^{abc}

Means with the same superscripts in each vertical column are not significantly different from each other ($P > 0.05$). $N = 10$

were added to all the test tubes. The whole set up was heated in a boiling water for 5 minutes. It was later cooled and 1ml of 40% Rochelle salt (Potassium sodium tartrate) solution was added and the intensity of dark red color formed was read spectrophotometrically at 510nm against the reagent blank after re-diluting the resulting solutions with 5mls of distilled water. The same procedure was followed for the glucose standard (0.1g in 5mls of ethanol) which was serially diluted to give the concentrations of 1.11, 2.22, 3.33, 4.45 and 5.56mg/ml and results were expressed in mg/ml. The reducing sugar contents of the samples were extrapolated from the standard graph using the equation $Y = 0.133x + 0.043 * D$ ($R^2 = 0.937$) where Y = Unknown concentration of the sample; 0.133 = slope of the standard graph; x = absorbance reading of the sample; 0.043 = intercept; D = Dilution factor and R^2 = Correlation coefficient.

Nutrient analysis

An atomic absorption spectrophotometer (Analyst 200, Perkin Elmer, Waltham, MA, USA) was used in the analysis of magnesium and calcium, the flame photometric method was used for analysis of sodium and potassium (AOAC, 1984) the molybdate method (Onwuka, 2005) was used for the analysis of phosphorous while the Kjeldahl method (AOAC, 1984) was used for determination of the nitrogen contents of the ginger accessions.

Statistical analysis

Results are reported as the means \pm standard deviations of triplicate experiments. Data was subjected to analysis of variance. Differences between means were separated using the Duncan Multiple Range Test and results were considered significant at $P < 0.05$. Correlation analysis was carried out using Pearson correlation.

RESULTS AND DISCUSSION

Ginger is recommended to diabetics for its anti-diabetic actions (AL-Amin *et al.*, 2006) which could arise from its low sugar contents and this justified the need for the assay of the total carbohydrate and reducing sugar contents of the ginger varieties.

Oligosaccharides are hydrolyzed by concentrated sulfuric acid during the phenol-sulfuric assay for analysis of total soluble sugars/carbohydrates and form monomers, namely glucose, fructose and galactose which are reducing sugars. Enhanced oxidative stress and changes in antioxidant capacity are considered to play an important role in the pathogenesis of chronic diabetes mellitus. Although the mechanisms underlying the alterations associated with diabetes mellitus are presently not well understood, hyperglycemic levels lead patients to an increased oxidative stress because the production of several reducing sugars (through glycolysis and polyol pathways) is enhanced. These reducing sugars can easily react with lipids and proteins (non-enzymatic glycation reaction), thus increasing the production of reactive oxygen species. The Shikimic acid pathway that participates in the production of most of the phenolic compounds in plants require soluble carbohydrates as their basic compounds to carry out such task (Ali *et al.*, 2012). The significant quantities of soluble carbohydrates in all the accessions of ginger that were studied as shown in Table 1 indicate that they may contain significant quantities of phenolics. In addition, there were no significant differences ($P > 0.05$) in the soluble carbohydrate contents of all the ginger accessions investigated. The lower amounts of carbohydrates we observed in these accessions of ginger compared with our previous reports on these accessions of ginger (Eleazu *et al.*, 2012) is attributed to the fact that in this study, we investigated the soluble carbohydrates while in our previous report, we investigated their total carbohydrate contents.

The low amounts of reducing sugar in all the ginger accessions investigated as shown in Table 1, underscore the need for them to be included in the list of plants that

Table 2. Mineral composition of 10 accessions of ginger (%)

Accessions	Ca	Mg	P	N	K	Na
UGII 5-47	1.2±0.00 ^a	0.24±0.01 ^a	0.77±0.01 ^a	3.02±0.33 ^a	0.80±0.00 ^e	0.45±0.00 ^f
UGII 5-24	1.0±0.00 ^b	0.37±0.01 ^b	1.07±0.23 ^b	2.93±0.17 ^a	0.80±0.03 ^d	0.45±0.00 ^f
UGII 5-31	1.2±0.03 ^b	0.37±0.01 ^b	1.26±0.15 ^b	2.79±0.87 ^a	1.50±0.02 ^g	0.60±0.12 ^g
UGII 7-24	1.0±0.00 ^c	0.49±0.00 ^c	0.78±0.01 ^c	3.19±0.62 ^a	0.70±0.00 ^c	0.23±0.00 ^b
UGII 5-18	1.0±0.00 ^c	0.49±0.01 ^c	1.24±0.02 ^c	2.90±0.42 ^a	1.30±0.12 ^h	0.40±0.05 ^e
UGII 3-04	1.2±0.08 ^d	0.61±0.03 ^d	1.44±0.02 ^d	2.95±1.42 ^a	0.65±0.00 ^b	0.30±0.01 ^d
UGII 5-35	1.0±0.03 ^b	0.37±0.02 ^b	0.96±0.04 ^b	3.03±0.92 ^a	0.85±0.02 ^f	0.45±0.12 ^f
UGII 5-52	1.2±0.12 ^a	0.24±0.00 ^a	1.14±0.00 ^a	3.23±1.02 ^a	0.60±0.12 ^a	0.13±0.00 ^a
UGII 5-48	1.2±0.12 ^b	0.37±0.02 ^b	1.38±0.02 ^b	2.86±0.85 ^a	0.65±0.18 ^b	0.25±0.06 ^c
UGII 11-05	1.2±0.15 ^a	0.24±0.01 ^a	1.28±0.02 ^a	3.06±0.00 ^a	0.70±0.21 ^c	0.30±0.08 ^d

Means in the same column with the same superscripts are not significantly different from each other ($P > 0.05$). N = 10.

are used in the dietary management of diabetes in Nigeria.

Food security and food quality are of concern to governments of developing countries. One factor contributing to overall food quality is the amount and availability of essential minerals. Minerals are inorganic elements that serve a variety of functions such as co-factors in enzyme catalyzed reactions, regulation of acid-base balance and structural elements of the body. Some of the most important minerals are calcium, phosphorous, sodium, potassium and iron. The low mineral bioavailability in some tuber crops is an important factor militating against their increased consumption.

Calcium and phosphorous play critical roles in bone formation and neuromuscular function. Calcium is also necessary for blood clotting and functioning of certain enzymes while phosphorus helps to control acid-alkaline reaction of the blood (Norman and Joseph, 1996). Thus, a deficiency of calcium and phosphorous could lead to rickets in children and osteomalacia in adults resulting from the softening of bones due to insufficient mineralization. Values obtained for calcium and phosphorous in all the accessions of ginger that were studied as shown in Table 2 were higher than that reported by previous authors (Shirin and Prakash, 2010., Gloria *et al.*, 2010).

Magnesium is important in muscle relaxation while sodium and potassium are necessary for maintenance of the electrolyte balance in body fluids. Magnesium, sodium and potassium play central roles in the regulation of blood pressure (Karppanen, 1994), control of arterial resistance (Altura and Altura, 1999), regulation of the fluid balance of the body and thus, 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). The importance of these elements cannot be overemphasized because they are also

required by many enzymes as co-factors (Ozcan,2004). In addition, the risk of stroke related death is inversely proportional to potassium intake. A diet low in sodium but high in potassium is associated with the lowest blood pressure levels and lower disposition to stroke. Thus the higher amounts of potassium/sodium ratio in all the ginger accessions analyzed is of comparative advantage. Values obtained for all the accessions of ginger analyzed as shown in Table 2, were higher than that reported by previous researchers (Shirin and Prakash, 2010; Gloria *et al.*, 2010).

The assay of nitrogen in the ginger accessions was of importance because the nutritional value of dietary proteins in humans is based on their ability to meet the nitrogen and amino acid requirements for growth and maintenance. Nitrogen is a macro nutrient that plays an important role in the digestion of food and growth of fetus. Catabolism of amino acids leads to a net loss of nitrogen from the body corresponding to approximately 30 to 55g of protein each day in healthy adults (Pamela and Richard, 1994). This loss must be compensated by diet in order to maintain a constant amount of body protein. Results obtained in Table 2 indicate that these ginger accessions could be promising sources of plant proteins with UGII 5-52 having the highest percentage nitrogen (3.23±1.02%) while UGII 5-31 had the least (2.79±0.87%). In addition, since ginger is used mostly in Nigeria as a spice or natural additive, the large amount of nitrogen that was observed in all the ginger accessions analyzed as observed in Table 2, indicate that usage of these ginger accessions as food additives (in foods that have low protein contents) may reduce the amount of dietary supplement of proteins from animal sources to meet the recommended daily allowance of proteins in humans. This is approached from a Biochemical point of view and is the major significant finding in this present study. In comparison with other spices.

Ginger is grown on a commercial scale for export and its highly valued in the international market due

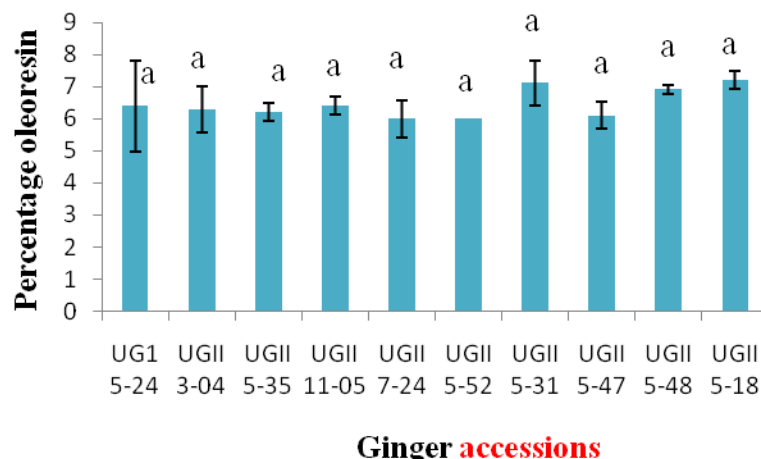


Figure 1. Percentage oleoresin contents of 10 **accessions** of ginger
Values with the same superscripts for each parameter are not significantly different ($P > 0.05$)

Table 3. Pearson correlation between percentage oleoresin versus sugar and mineral composition of ginger accessions

Parameter	TSC	RS	Ca	Mg	P	N	Na	K
Oleoresin	0.359	0.110	0.020	0.220	0.580	-0.080	0.45	0.712*

*Correlation is significant at 0.05 level. TC = Total soluble carbohydrates; RS = Reducing sugar.

to its aroma, pungency and high oleoresin content (Fameruwa *et al.*, 2011). Results shown in Figure 1 indicate that the percentage oleoresin contents of the ginger accessions ranged from 6.0 to 7.48 with UGII 5-18 having the highest ($7.2 \pm 0.28\%$) while UGII 5-52 had the least ($6.00 \pm 0.00\%$). There were no significant differences in the oleoresin contents of the ginger accessions analyzed ($P > 0.05$). Values obtained for the oleoresin contents of all the accessions of ginger analyzed, fell within the reported range of 4.0 to 7.5% for ginger (Balachandran *et al.*, 2006) and this indicates the possible economic and therapeutic potentials of these ginger accessions.

There was a positive correlation between the oleoresin contents of the ginger accessions versus total soluble carbohydrates (0.359), reducing sugars (0.110), magnesium (0.22), phosphorous (0.58), sodium (0.45), potassium (0.712) but insignificant correlation between oleoresin versus calcium (0.020 and Nitrogen (0.08) (Table 3). The significant correlation between oleoresin versus potassium as observed in Table 3, suggest to us that the oleoresins in ginger could contribute to the potassium contents of ginger. This is subject to further investigation and confirmation.

CONCLUSION

All the accessions of ginger that were investigated were

observed to contain high quantities of oleoresin, indicating their possible therapeutic and economic potentials. The significant quantities of minerals and nitrogen in all the accessions of ginger investigated indicate their nutritive potentials. Finally, the low quantities of reducing sugars in all the accessions investigated, indicate that they could serve as very useful food adjuncts in the dietary management of diabetes in Nigeria.

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