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Physico-chemical Properties and Antioxidant Potentials of 6 New Varieties of Ginger (*Zingiber officinale*)

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ABSTRACT
The physico-chemical composition and antioxidant potentials of 6 new varieties of Ginger was evaluated. Analysis of the percentage phenol, oleoresin, lipid, dry matter, crude fibre and ash contents of the ginger varieties using the Association of analytical chemists methods indicated that UGII7GY25 had the highest phenolic content (5.69±0.06) while UGII 7GY5 had the least (4.69±0.16) ($p<0.05$). In terms of ash content, while UGI5GY3 had the highest among the varieties studied (2.6±0.44), UGII5GY6 had the least (0.7±0.02). In addition, the ash contents of UGII5GY6 and UGII 11GY11 were higher than reported values for ginger unlike the values obtained for oleoresin, lipid and crude fibre that were lower than the reported values for ginger. The ginger varieties were also observed to possess strong antioxidant activities as seen from their scavenging activities on 2,2 diphenyl-1-picrylhydrazyl (DPPH) radical and reducing power tests. Correlation analysis carried out revealed that the total phenolic contents of the ginger varieties correlated negatively with their total oleoresin contents suggesting that the oleoresin contents of the ginger varieties may not have come from their phenolic constituents and that the oleoresins present could have little contribution to the antioxidant activities of the ginger varieties. In addition, the ginger varieties were observed to contain high quantities of phenols and this may be responsible for their high antioxidant activities. Finally, UGII5GY6 and UGII 11GY11 contains higher quantities of minerals than reported values for ginger.

Key words: Physico-chemical, antioxidant, ginger, varieties

INTRODUCTION
The medicinal value of plants has attained a more important dimension in the past decade due to the fact that their extracts have been found to contain not only minerals but also a diverse array of secondary metabolites or phytochemicals with antioxidant potentials (Akinmoladun *et al*., 2007; Ahenkora *et al*., 1998). Studies have indicated that these phytochemicals especially polyphenols have high free radical scavenging activity which helps to reduce the risk of chronic diseases such as cardiovascular diseases, cancer, diabetes mellitus, etc. (Ames *et al*., 1993).

Free radicals which have been implicated in these diseases are generated in the human body through numerous sources including normal body metabolism, exposure to toxins, etc and they exist in different forms including superoxide, hydroxyl, hydroperoxyl, peroxyl and alkoxyl radicals.

Ginger (*Zingiber officinale*), a widely used herb and food flavoring agent is considered a major constituent of the diet (Sertie *et al*., 1991). Its medicinal properties against digestive disorders, rheumatism and diabetes have been reported (Afzal *et al*., 2001). The medicinal value of ginger has been linked to its antioxidant characteristics since it can scavenge superoxide anion and hydroxyl radicals (Kar *et al*., 1999). In addition, its neutraceutical properties have long been of interest to the food processing and pharmaceutical industries. The volatile essential oils that contribute to the characteristic flavor of ginger varies from 1.0-3.0% while the oleoresin that is responsible for its pungent flavor ranges from 4.0-7.5% and also possesses substantial antioxidant activity (Balachandran *et al*., 2006).

As the medicinal value of ginger has been linked to its antioxidant potentials arising from the amounts of oleoresin and polyphenols present in it and being that these are new ginger varieties, it would be worthwhile to investigate the amounts of oleoresin and polyphenols present in it. In addition, the knowledge of the chemical composition of a plant together with it antioxidant activity can give a fair estimate of its therapeutic potential (Akinmoladun *et al*., 2007).

This thus led to the study which was designed to investigate the physico-chemical properties and antioxidant potentials of six new varieties of ginger.

MATERIALS AND METHODS

Quercetin(3,3',4',5,7-pentahydroxyflavone), 1,1-Diphenyl-2-picrylhydrazyl (DPPH), sodium dihydrogen orthophosphate (NaH_2PO_4), Disodium hydrogen orthophosphate (Na_2HPO_4), Phenol and Ferric chloride used were products of Sigma Chemical Company (UK). All other chemicals used were purchased from Associated Laboratories, Aba, Abia State, Nigeria and were of analytical grade.

Six varieties of ginger UGII 7GY5, UGI 5GY3, UGII 11GY11, UGII 7GY25, UGII 5GY6 and UGII 9GY3, freshly harvested from the experimental farm of National Root Crops Research Institute, Umudike, Nigeria in 2011 were used for the plant experiments. They were thoroughly washed, peeled, dried in an oven at a temperature of 50°C before being ground into flour using a food processor and analyzed.

Extraction of the sample: One gram of sample was weighed accurately and suspended in 100 mL of solvent. It was shaken for 3 h in an electronic shaker at room temperature, centrifuged at 4000 rpm for 20 min and filtered with Whatman No. 1 filter paper. For all experiments, fresh extracts were used.

Physicochemical properties of ginger: The AOAC (1980) methods was used in the determination of the phenolic, oleoresin, fat, dry matter, crude fibre and ash contents of the six ginger varieties.

Free radical scavenging activity determination: The stable 2,2 diphenyl-1-picryldydrazyl (DPPH) radical was used for the determination of free radical scavenging activities of the extracts. A portion (1 mL) each of the different concentrations (1000, 500, 250, 125, 62.5, 31.25 ug mL^{-1}) of the extracts or standard (Quercetin) in test tubes was added to 1 mL of 0.3 mM DPPH in methanol. The mixtures were vortexed and then incubated in a dark chamber for 30 min after which the absorbances were measured at 517 nm against a DPPH control containing only 1 mL of methanol in place of the extract. The percentage scavenging activity was calculated using the expression:

$$\%\text{Scavenging activity} = \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}} \times 100$$

IC_{50} values denote the concentration of the sample which is required to scavenge 50% DPPH free radicals. Higher IC_{50} values denote lower antioxidant activities.

Reducing power tests: The reducing property of the unripe plantain flour was determined by assessing the ability of the sample extracts to reduce $FeCl_3$ solution as described by Oluwaseun and Ganiyn (2008) and modified by Chinedum *et al.* (2011). The extracts of the ginger varieties were prepared for the assay by dissolving 2 g of the flours in 40 mL of methanol and filtering with Whatman No. 1 filter paper. The resulting solutions were made up to 50 mL with methanol. The absorbance was taken at 700 nm against a reagent blank using a spectrophotometer. Increased absorbance reading indicates increased reducing power.

RESULTS AND DISCUSSION

In recent years, phenolics have attracted the interest of researchers because they show promise of being powerful antioxidants that can protect the human body from free radicals, the formation of which is associated with the normal metabolism of aerobic cells (Oboh and Rocha, 2007). That the phenolic compounds present in plants possess antioxidant activity and may help protect cells against the oxidative damage caused by free radicals has been reported (Kirakosyan *et al.*, 2003).

The high phenolic contents of the six varieties of ginger investigated is the significant finding of this study as it suggests that they may contain high quantities of antioxidants. The phenolic content of UGII7GY25, though not significantly different from that of UGII5GY6 was observed to be the highest (5.69±0.06) among other varieties studied while UGII 7GY5 had the least (4.69±0.16).

Oleoresin is responsible for the pungent flavor of ginger and it also possesses substantial antioxidant activity in addition.Values obtained for the oleoresin contents were below that obtained by Balachandran *et al.* (2006) who reported the oleoresin contents of ginger to range from 4.0 to 7.5%. This explains the mild pungent odor of these ginger varieties.

Fat makes up about 99% of the real fraction of a food. Usually in food analysis, total lipid content is what determined rather than the true fat content. Vadivel and Pugalenthi (2006) reported the percentage lipid contents of ginger to be about 0.9%. The lipid content of UGII7GY25 (0.7±0.00) was significantly higher than other varieties studied while that of UGII 11GY11 was the least (0.25±0.00). Values obtained were slightly higher than the recommended daily allowance for an adult man (Deb, 1999). The low total lipid contents of the ginger varieties as obtained in Table 1 suggests that they can be used in the management of patients with high blood pressure and heart diseases.

Dry matter relates to good cooking qualities. Higher dry matter contents suggests better cooking qualities and extended storage lives. UGII5GY6 had the highest dry matter content (49.85±5.05) while UGII7GY5 had the least (22.7±3.67).

Crude fibre represents that portion of food not used up by the body but mainly made up of cellulose together with a little lignin and is known to increase bulk stool (Selke, 1990). In addition, crude fibre aids digestion, absorbs water and makes stool larger and softer, so preventing constipation (Ayoola and Adeyeye, 2009). Dietary fibre has recently gained much importance as it is said to reduce the incidence of colon cancer, diabetes, heart disease and certain digestive

Table 1: Physico-chemical properties of six new varieties of ginger

Variety	% Phenol	% Oleoresin	% Lipids	% DM	% CF	% Ash
UGII7GY25	5.69±0.06[d]	2.93±0.02[a]	0.7±0.00[e]	23.6±3.03[a]	1.2±0.04[a]	0.9±0.00[ab]
UGII5GY6	5.57±0.11[cd]	3.73±0.06[b]	0.35±0.01[b]	49.85±5.05[d]	1.35±0.03[ab]	0.7±0.02[a]
UGII9GY3	5.24± 0.01[bc]	2.97±0.04[a]	0.35±0.00[b]	28.45±1.06[ab]	1.70±0.7[ab]	1.1±0.09[b]
UGII7GY5	4.69±0.16[a]	3.97±0.15[b]	0.55±0.02[c]	22.7±3.67[a]	1.30±0.0[a]	1.2±0.01[bc]
UGI5GY3	5.20±0.26[b]	3.43±0.61[ab]	0.65±0.1[d]	31.5±4.22[bc]	1.35±0.2[ab]	2.6±0.44[d]
UGII 11GY11	4.88±0.00[ab]	3.07±0.55[a]	0.25±0.0[a]	36.7±2.33[c]	1.9±0.13[b]	1.5±0.03[c]

Each value in the table is the average of triple experiments±standard deviations. Values with the same superscripts down each row are not significantly different from each other

diseases. The crude fibre content of UGII 11GY11 though not statistically different from that of UGII5GY6, UGII9GY3 and UGI5GY3 was the highest among other ginger varieties studied (1.9±0.13) while UGII 7GY25 had the least (1.2±0.04). Values obtained were lower than 2.4% being the reported values as the fibre content of ginger.

Ash is a reflection of the quantity of minerals in a sample. Generally, the ash content of foods is often small (less than 1% of the food). The values obtained for UGI5GY3 (2.6±0.44) (which was significantly higher than all the varieties studied) and UGII 11GY11 (1.5±0.03) (though not significantly different from UGII7GY5) were higher than that obtained by Vadivel and Pugalenthi (2006) (Table 1). However values obtained for UGII7GY25, UGII5GY6 and UGII9GY3 were below the reported values for ginger while values obtained for UGII7GY5 were in agreement with earlier works by Vadivel and Pugalenthi (2006) who reported the ash contents of ginger to be around 1.2%.

DPPH radical scavenging activity: The effect of antioxidants on DPPH is thought to be due to their hydrogen donating ability. The DPPH radical is a free radical stable at room temperature. The antioxidant activities of the extracts and Quercetin were in the order :Quercetin>UGII7GY25>UGII5GY6>UGII9GY3>UGI5GY3>UGII 11GY11>UGII 11GY11. The inhibitory activities of the extracts on DPPH free radical indicates that the extracts have a proton-donating ability and could serve as free radical inhibitors or scavengers, acting possibly as primary antioxidants. The inhibitory actions of the varieties of ginger is attributed to the phenolic content and presence of other phytochemicals in them. Kirakosyan *et al.* (2003) have reported that polyphenols present in plants are responsible for their antioxidant activities leaving us to suggest that the antioxidant activities of these ginger varieties could have come from their phenolic contents. The over production of reactive oxygen species following the ingestion of certain chemicals or drugs (xenobiotics) or when the levels of antioxidants are diminished (such as inactivation of enzymes involved in the disposal of oxygen species) causes a shift from the antioxidants to the pro-oxidants leading to oxidative stress which can lead to tissue damages and necrosis in many instances. Antioxidants function in maintaining a balance between these pro-oxidants and the antioxidant status thus protecting the body from tissue damage arising from these pro-oxidants. Results indicate that these ginger varieties might be useful therapeutic agents for treating radical- related pathological damage (Table 2).

Reducing power is a measure of the ability of the extracts to reduce Fe^{3+} to Fe^{2+}. Substances which have reduction potential react with potassium ferri-cyanide (Fe^{3+}) to form potassium ferro-cyanide (Fe^{2+}) which then reacts with ferric chloride to form ferric ferrous complex that has an absorption maximum at 700 nm. Reducing power has become one of the antioxidant capability indicators of medicinal plants (Duh and Yen, 1997) as it may accord with overall antioxidant activity. This is because antioxidants are strong reducing agents and this is principally because of

Table 2: DPPH radical scavenging activity of six Ginger varieties

Sample	Concentration (μg mL^{-1})	Log concentration	% Scavenging activity	IC_{50} (μg mL^{-1})
UGII7GY25	1000.00	3.00	92.55	28.17
	500.00	2.70	88.00	
	250.00	2.40	75.22	
	125.00	2.10	64.33	
	62.50	1.80	57.22	
	31.25	1.50	55.23	
UGII5GY6	1000.00	3.00	90.80	34.41
	500.00	2.70	84.00	
	250.00	2.40	74.11	
	125.00	2.10	62.33	
	62.50	1.80	56.00	
	31.25	1.50	53.05	
UGII9GY3	1000.00	3.00	88.00	39.84
	500.00	2.70	84.98	
	250.00	2.40	72.00	
	125.00	2.10	65.33	
	62.50	1.80	57.22	
	31.25	1.50	45.25	
UGI5GY3	1000.00	3.00	86.25	57.74
	500.00	2.70	80.00	
	250.00	2.40	77.22	
	125.00	2.10	58.00	
	62.50	1.80	51.44	
	31.25	1.50	42.19	
UGII 11GY11	1000.00	3.00	87.90	90.66
	500.00	2.70	77.66	
	250.00	2.40	61.19	
	125.00	2.10	52.27	
	62.50	1.80	42.19	
	31.25	1.50	38.99	
UGII7GY5	1000.00	3.00	82.00	130.48
	500.00	2.70	78.50	
	250.00	2.40	48.00	
	125.00	2.10	45.64	
	62.50	1.80	37.55	
	31.25	1.50	35.77	
Quercetin	1000.00	3.00	98.00	23.17
	500.00	2.70	96.55	
	250.00	2.40	94.28	
	125.00	2.10	85.09	
	62.50	1.80	55.88	
	31.25	1.50	52.25	

Linear equation: (a) $y = 27.60x+9.985$ (b) $y = 27.09x+9.077$ (c) $y = 28.92x+3.718$ (d) $y = 30.97x-3.835$ (e) $y = 34.27x-17.08$ (f) $y = 33.93x-21.78$ (g) $y = 34.28x+3.209$

the redox properties of their hydroxyl groups and the structural relationships of any parts of their chemical structure (Oboh and Rocha, 2007; Chinedum *et al.*, 2011). Benzie and Strain (1996) also considered antioxidants as any specie that reduces the oxidizing species that would otherwise

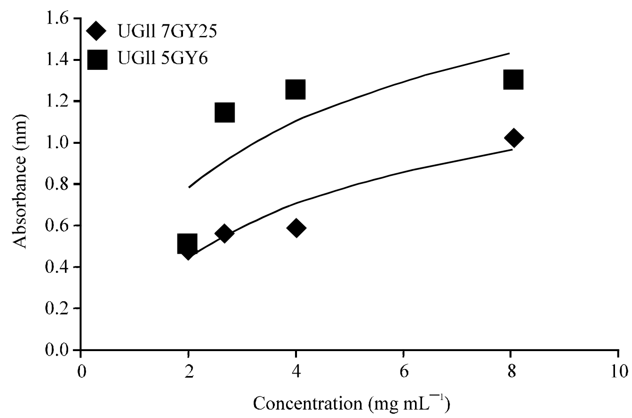

Fig. 1: Reducing power of Ugll 7GY25 and Ugll 5GY6

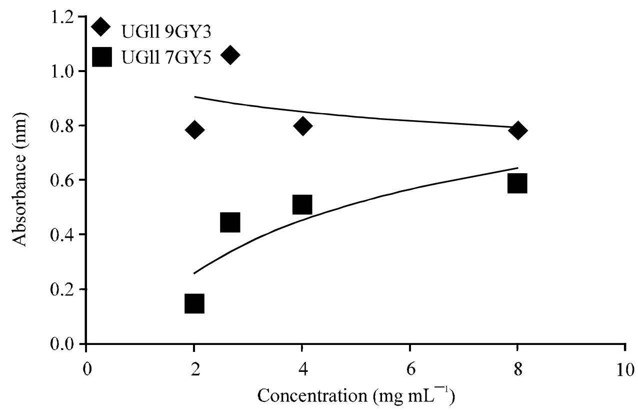

Fig. 2: Reducing power og Ugll 9GY3 and Ugll 7GY5

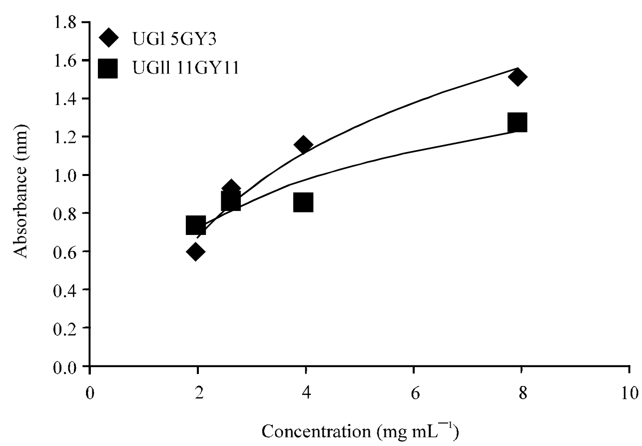

Fig. 3: Reducing power of Ugl 5GY3 and Ugll 11GY11

damage the substrates. Results obtained in Fig. 1-4 suggest that all the flours except UGII 9GY3 have a strong antioxidant activity.

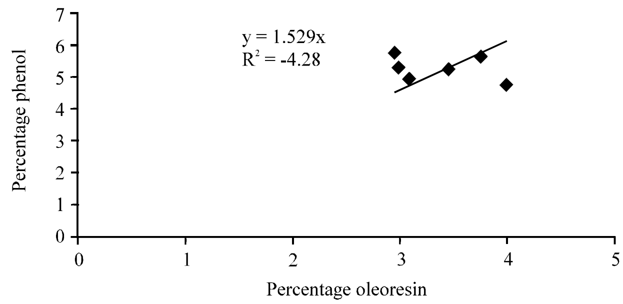

Fig. 4: Correlation between percentage oleoresin and phenol content of 6 ginger varieties

Correlation of the total phenolic content versus the total oleoresin content was negative suggesting that the oleoresin contents of the ginger varieties could not have come from the phenols present in the ginger.

CONCLUSION

The physico-chemical properties and antioxidant potentials UGII 7GY25, UGII5GY6, UGII9GY3, UGII7GY5, UGI5GY3 and UGII 11GY11 have been demonstrated in this study.

The total phenolic contents of the varieties of ginger studied were found to be quite high, suggesting their high antioxidant potentials. In addition, the oleoresin contents of the ginger varieties which were low could not have come from their total phenolic contents, explaining the mild pungent odor of the ginger varieties. The low total lipid contents of the ginger varieties suggest that they can be used in the management of patients with high blood pressure and heart diseases. In addition, the mineral contents of UGI5GY3 and UGII 11GY11 were higher than the reported mineral contents of ginger.

Finally, with the exception of UGII 9GY3, all other varieties of ginger studied were found to possess strong antioxidant activities.

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