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PROXIMATE COMPOSITION, ESSENTIAL OILS AND ENERGY VALUE OF 10 NEW VARIETIES OF GINGER (*Zingiber officinale Roscoe*)

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ABSTRACT

The proximate composition, essential oils and energy value of 10 new varieties of ginger from National Root Crops Research Institute, Umudike, Nigeria were investigated. Results show that all the varieties of ginger analyzed, contained significant quantities of protein, fat and carbohydrates, indicating their nutritive potentials. The significant quantities of crude fibre in all the varieties of ginger investigated, indicate that they could be utilized in the management of diabetes mellitus, colorectal cancers and weight reduction in obesed individuals. The large amounts of ash that were obtained in all the varieties of ginger investigated, make them promising sources of minerals. Correlation analysis carried out revealed that there was a positive correlation between essential oils versus total fat content (0.830) and energy value (0.400), suggesting that the higher the essential oil contents of ginger, the higher could be their fat content and vice versa. There was also a positive correlation between total fat content of the ginger varieties versus energy value (0.439). The high quantities of essential oils in all the varieties of ginger investigated, confer on them very high antioxidant and biological properties. Finally, these varieties of ginger could have wide utility in the food, pharmaceutical and agricultural industries.

Keywords: Spices, Ginger, Oleoresin, Proximate

INTRODUCTION

Spices are vegetable substances that are commonly found in most homes and restaurants all over the world in the seasoning of foods. They have the ability to stimulate appetite and increase the flow of gastric juice, making them food accessories or adjuncts **[1]**. The use to which a spice material is put is dictated primarily by its content of essential oils and oleoresins. Researchers have estimated that every increase in the intake of fruits, vegetables, herbs and spices reduces the risk of cancer by 15%, cardiovascular diseases by 39% and mortality by 20%. This has been confirmed by epidemiological studies **[2]**.

Ginger (*Z. officinale*) is a very important cash crop in Nigeria due to its essential oil and oleoresin contents. Powdered ginger is used in the preservation of meat, soups **[3]** and ginger drinks **[4]**. Among other spices that are being used in Nigeria such as garlic, onion and pepper, it is the one that is majorly grown on a commercial scale for export and it is highly valued in the international market due to its aroma and pungency that arise from its oleoresin (non-volatile) and essential oil (volatile) contents **[5, 6]**. Other constituents that determine the quality of ginger include: fats, proteins, carbohydrates, vitamins (C and B) and minerals. There are reports that ginger functions as an inhibitor of prostaglandin and leukotriene biosynthesis (inflammatory mediators produced from arachidonic acid) to produce its ameliorative effects in arthritis **[7]**. This role it carries out through the inhibition of the production and release of metabolic products from lipid membranes, peptides, proteins and amino acids.

Plants have basic nutritional importance that can be assessed by their content of protein, carbohydrates, fats, oils, minerals, vitamins, in addition to water and which are required for growth and development in man and animals. It has been discovered that regular consumption of fruits, vegetables, herbs and spices has always been associated with health benefits, but their mechanism has become clear only in recent years.

The effect of ginger on the stimulation of bile secretion was studied to identify the basis of its action as a metabolism enhancer. Studies have shown that the acetone extracts of ginger, consisting the essential oils and the pungent principles produce an increase in bile secretion. Bile acids facilitate the absorption of fat, electrolytes and peristalsis of the small intestine.

Thus, an understanding of the overall composition and constituents of the ginger rhizome is required to optimize its potentials as a food adjunct and therapeutic purposes. Studies have also shown that long term dietary intake of ginger has hypoglycaemic and hypolipidaemic effect **[8]**.

In Nigeria, several diseases such as cardiovascular, cancer, diabetes, liver cirrhosis and osteoporosis are among the major causes of mortality and morbidity. In addition, different strains of drug resistant microorganisms keep developing, making this 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 **[9]**.

In 2010, some varieties of ginger 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 varieties 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 mutant lines with high percentage oleoresin contents were selected and analyzed for their Proximates, essential oils, energy values and the results are reported in this paper.

MATERIALS AND METHODS

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 into chips and dried in an oven at a temperature of $70^{o}C$ for 24 hours for the determination of moisture contents.

Determination of Moisture Content

The moisture content was determined by accurately weighing 5g of fresh sample into a previously dried and weighed porcelain crucible. It was then dried in a thermostatically controlled oven at $70^{o}C$ for 24 hours to a constant weight. The porcelain crucible was removed and transferred into a desiccator for cooling after which it was weighed. Moisture content was determined by difference and expressed as a percentage **[10]**. The percentage moisture content was calculated as follows: % Moisture

$$= \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where W_1 = Initial weight of empty crucible

W_2 = Weight of crucible + sample before drying

W_3 = Weight of crucible + sample after drying

Determination of Dry Matter (Total Solid) Content

The dry matter contents of the samples was determined using the formula 100- % moisture content.

Determination of Percentage Lipid

Five grams each of the dried flours from moisture content determination was subjected to fat estimation by refluxing for 3 hours using a Soxhlet extractor and 200ml of petroleum ether as the extracting solvent. A round-bottom flask containing a mixture of fat and petroleum ether solvent was detached from the Soxhlet extractor and petroleum ether solvent was evaporated on a steam bath. The round-bottom flask and its content were heated to 105^{o}C in an oven for 30 minutes and later cooled in a desiccator. The weight of the extracted fat was determined and expressed as percentage lipid **[10]** using the formula:

$$\% \text{ Lipid} = \frac{\text{Weight of lipid}}{\text{Weight of sample}} \times 100$$

Determination of Crude Fiber Content

Two grams each of the samples from crude fat determination was transferred into a 750ml Erlenmeyer flask and about 0.5g of anti-bombing agent was added. To the flask was poured 200ml of boiling1.25% sulphuric acid (H_2SO_4) and the set up was immediately transferred onto a hot plate with a cold finger condenser attached to the flask. The samples were boiled for 30 minutes during which the entire samples were thoroughly wetted while each was prevented from remaining on the side of the flask and out of contact with the solvent. After 30 minutes, the flask was removed, its content filtered into a conical flask through a linen cloth in a funnel and washed with boiling water until the washings were no longer acidic. The content of the linen cloth was washed into another flask with 200ml boiling 1.25% sodium hydroxide (NaOH) solution. The flask was reconnected to the cold finger condenser and boiled for 30minutes. The content was again filtered through linen cloth in a funnel and washed thoroughly with boiling water then with 15ml ethanol. Anti-bombing agents were removed from the residue. The residue was transferred into a previously dried and weighed porcelain crucible dried in an oven at 100^{o}C for 1hour, cooled in a desiccator and weighed. The crucible and its contents were ignited in an electrical furnace at 600^{o}C for 30 minutes, cooled and re-weighed. The loss in weight was reported as percentage crude fiber **[10]**.

Determination of Crude Protein Content

One gram of the sample was weighed into a Kjeldahl flask and 20ml of concentrated sulphuric acid (H2SO4) was added and the setup was swirled under tap water for proper mixing. Three grams of the Kjeldahl catalyst (a mixture of 10g of Na_2SO_4 and 1g of $CuSO_4$) were added to the flask. To the mixture was also added anti-bumping chips and the whole set up was boiled in a fume cupboard until the charred particles disappeared and a clear green solution was obtained. Ten mls of 2% boric acid was measured into a 250ml beaker and 3 drops of methyl orange indicator was added. Ten mls of the digest was placed in a distillation flask and 30ml of 40% NaOH was added to the digest and the mixture was heated for 25minutes. The distillate was then titrated with 0.1N HCl to violet end point. Blank determinations were made, using boric acid and indicator. The values obtained were used to calculate the total nitrogen and the percentage crude protein obtained by multiplying with 6.25 **[10]**.

Determination of Ash Content

Ash content was determined by accurately weighing five grams of finely ground, dried sample into a pre-ignited and previously weighed porcelain crucible, placed in a muffle furnace and ignited for 2 hrs at 600°C. After ashing, the crucible and its contents were cooled to about 105°C in a regulated oven before cooling further to room temperature in a desiccator. The crucible and its contents were re-weighed and the weight was reported as percentage ash content **[10]** using the formula:

$$\% \text{ ash (dry basis)} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where W1 = Weight of empty crucible

W2 = Weight of crucible + sample before ashing

W3 = Weight of crucible + ash

Determination of Total Carbohydrate Content

The total carbohydrate content of the samples was obtained by difference 100- (%moisture + ash + %lipid + crude protein).

Determination of Energy Value

The energy value of the samples was determined by multiplying the protein content by 4, carbohydrate content by 4 and fat content by 9 **[10]**.

Determination of Percentage Essential Oils

The method of Pearson **[11]** was used for the determination of the essential oil constituents of the ginger varieties.

Statistical Analysis

Data was subjected to analysis using the statistical package for social sciences (SPSS), version 15.0. Results are presented as mean ± standard deviations. One way analysis of variance (ANOVA) was used for comparison of the means. Differences between means were considered to be significant at $P < 0.05$ using the Duncan Multiple Range Test.

RESULTS AND DISCUSSION

The moisture contents of all the 10 ginger varieties differed significantly from each other (P < 0.05) and were low in addition, ranging from 9.84 to 11.31% which indicates good shelf life characteristics and minimal deterioration from microbes. UGII 5-48 was observed to have the highest moisture contents (11.20±0.11%) while UGII 5-52 had the least (9.86±0.04 %) **(Table 1)**.

The ash contents of all the 10 ginger varieties (which is an indication of the total inorganic mineral contents), ranged from 5.56 to 7.865 (%) with UGII 5-35 having the highest ash contents (7.85±0.01%) while UGII 5-47 had the least (5.67±0.11 %) **(Table 1)**. Results show that these varieties of ginger could be promising sources of minerals.

The percentage crude protein contents of all the 10 samples investigated differed significantly from each other (P < 0.05) and they ranged from 17.44 to 20.23 with UGI 5-48 having the highest protein content (20.17±0.06 %) while UGII 5-18 had the least (17.46±0.02 %) **(Table 1)**. The Daily Reference Intake (replaces Recommended Daily Allowance) for an infant is 9.1-13.5g/day, children (13-19g/day), adult women (34-46g/day) **[12]** and adult men (45 - 50 g/day) **[13]**. Thus, these 10 varieties of ginger could serve as very rich protein supplements since they are usually combined in human dishes and this is the most significant finding in this present study. In addition, the high protein contents of all the 10 varieties of ginger studied, indicates that their intake can contribute to the formation of hormones which controls a variety of body functions such as growth, repair and maintenance of body. In addition, they could be utilized as a preferred option to animal proteins for diabetics as the later tend to be high in saturated fats.

The large amounts of fats that were extracted in all the 10 varieties of ginger as shown in **Table 1**, were expected since ginger is regarded as an oil seed. Moreover, the Recommended Daily Allowance for fat is 30-35% and results show that the fat contents of all the 10 varieties of ginger that were studied, fell within this range.

Dietary fiber is increasingly being recognized as a useful tool for the control of oxidative processes in food products and as functional food ingredient. In addition, dietary fiber decreases the absorption of cholesterol from the gut in addition to delaying the digestion and conversion of starch to simple sugars, an important factor in the management of diabetes. Dietary fiber also functions in the protection against cardiovascular disease, colorectal cancer and obesity. Thus the high percentage fibre contents of all the 10 varieties of ginger investigated as obtained in **Table 1**, infer that these varieties of ginger could be effectively utilized in the management of diabetes mellitus, colorectal cancers and weight reduction in obesed individuals and this is another important finding in this study. This finding may be the reason behind the hypoglycaemic and hypolipidaemic actions of long term dietary intake of ginger that was reported by **[8]**.

The total carbohydrate contents (%) of all 10 the varieties of ginger investigated as shown in **Table 1** were observed to be high. This was expected as rhizomes are the storage organ for carbohydrates. Results obtained for all the varieties of ginger was higher than that reported for other rhizomes such *Curculigo pilosa* **[14]** and *Curculigo orchiodes* **[15]**. The high amounts of carbohydrates in all the varieties of ginger investigated confer on them, significant roles to human health. This is because, apart from the supply of energy, carbohydrates are also needed in numerous biochemical reactions not directly concerned with energy metabolism. In addition, these carbohydrates may serve as substrates for the production of aromatic amino acids and phenolic compounds through the Shikimic acid pathway and this may confer high phenolic and antioxidant potentials on these varieties of ginger.

The analysis of essential oil contents of all the 10 varieties of ginger investigated as shown in **Table 2**, indicated that they all contained large amounts of essential oils on dry weight basis. The essential oils ranged from 1.67 to 4.74(%) with UGII 5-47 having the highest amounts of essential oils (4.72±0.02 %), while UGII 5-18 had the least (2.03±0.36 %) **(Table 2)**. The essential oils in ginger have been reported to range from 1 to 4% **[16]**. Most of the samples that were investigated, confirmed to this standard except UGII 5-47, UGII 5-52 and UGII 7-24. This variation is attributed to varietal differences while the high amounts of essential oils that were extracted from the flours could be attributed to the method of processing of the flours (oven drying) as oven drying has been reported to yield significant quantities of essential oils. The essential oils in ginger have been credited for many biological properties such as treatment of fracture, rheumatism, bruises, hangovers, cold, flu, catarrh, congestion, cough, sores, sore throat, diarrhea, cramps, fever, anti-diabetic, antibacterial and antifungal properties in addition to very high antioxidant potentials **[17, 18]**. The large amount of essential oils in all the varieties of ginger investigated confers on them very high biological and antioxidant potentials and this is also a significant finding in this present study. Results indicate that these varieties of ginger could have wide utility in the food, pharmaceutical and agricultural industries.

Dry matter content relates to good cooking quality. Higher dry matter contents suggests better cooking qualities and extended storage lives. UGII 7-24 was observed to have the highest dry matter contents among all the varieties of ginger investigated (90.16±0.14%) while UGII 3-04 had the least (89.05±0.12 %). The high dry matter content of the all 10 varieties of ginger analyzed **(Table 2)**, suggests better cooking qualities of the varieties of ginger in addition to their longer storage lives.

Energy value of a food measures its value to the body as a fuel and it measures the inherent chemical energy inherent in the bonds of the organic compounds of foods such as their protein, carbohydrate and fat constituents as well as minor constituents such as organic acids. Energy value is calculated from either bomb calorimeter or from proximate analysis of foods **[6]**. The proximate analysis revealed that all the ginger varieties can be ranked as carbohydrate rich due to their calorie yield.

Correlation analysis carried out revealed that there was a positive correlation between essential oils versus total fat content (0.830) and energy value (0.400). The significant correlation between essential oils and total fat contents of the ginger varieties suggest to us that the higher the fat contents of ginger, the higher will be their essential oil contents and vice versa. The fat contents of all the ginger varieties studied as shown in **Table 1** contributed more to their energy values than either their protein or carbohydrate contents. Since we recorded a high positive correlation between essential oils and total fat contents, it was not surprising that we obtained a positive correlation between essential oils and energy values (0.400), making us to assume that the higher the essential oil contents of ginger, the higher could be their energy value. The contributory role of essential oils to the energy values of ginger as reported in this work is further strengthened by the result that was obtained from the correlation between percentage fat content and the energy values of these ginger varieties (0.439) as seen in **Table 4**. Both essential oils and fat contents of the ginger varieties investigated, correlated positively with their energy values and this makes us to assume that the essential oils in ginger could play very strong roles to the energy values of ginger. This statement is subject to further investigation and confirmation.

Table 1: Proximate Composition of 10 Varieties of Ginger on Dry Weight Basis (%)

Sample	Moisture content	Ash	Crude protein	Fat	Crude fibre	Carbohydrate
UGII 5-47	10.63±0.01^{d}	5.67±0.11^{b}	18.91±0.02^{f}	12.25±0.03^{h}	6.45±0.00^{i}	52.54±0.24^{b}
UGII 11-05	10.96±0.13^{g}	5.69±0.02^{c}	18.33±0.04^{d}	10.17±0.08^{f}	5.16±0.14^{a}	54.85±0.38^{cd}
UGII 5-18	11.17±0.10^{j}	5.97±0.03^{e}	17.46±0.02^{a}	9.25±0.05^{a}	5.73±0.12^{d}	56.15±0.28^{e}
UGII 7-24	10.73±0.02^{e}	6.46±0.14^{h}	19.96±0.12^{i}	13.09±0.07^{i}	6.84±0.07^{j}	49.76±0.49^{a}
UGII 5-52	9.86±0.04^{a}	6.13±0.20^{g}	18.14±0.05^{c}	11.20±0.10^{g}	5.86±0.00^{e}	54.67±0.55^{cd}
UGI 5-24	11.03±0.03^{h}	5.85±0.06^{d}	18.43±0.04^{e}	9.86±0.12^{d}	6.14±0.20^{h}	54.83±0.35^{cd}
UGII 5-31	11.09±0.12^{i}	5.40±0.04^{g}	18.93±0.15^{g}	10.13±0.16^{e}	5.91±0.18^{f}	54.45±0.66^{cd}
UGII 5-48	11.20±0.11^{c}	6.64±0.12^{i}	20.17±0.06^{j}	9.46±0.12^{c}	6.07±0.08^{g}	52.53±0.58^{b}
UGII 5-35	10.79±0.08^{f}	7.85±0.01^{j}	17.86±0.23^{b}	9.87±0.17^{d}	5.71±0.10^{c}	53.63±0.69^{bc}
UGII 3-04	10.14±0.16^{b}	6.12±0.03^{f}	19.13±0.16^{h}	9.41±0.06^{b}	5.29±0.26^{b}	55.20±0.58^{de}

Means With Different Superscripts Along Each Vertical Column are Significantly From Each other (P < 0.05)

Table 2: Essential Oils, Dry Matter and Energy Value of 10 Varieties of Ginger (Dry Weight)

Variety	Essential oil(%)	Dry matter (%)	E. value (Kcal/100g)
UGII 5-24	2.07±0.02a	89.39±0.01g	381.74±0.40cd
UGII 3-04	3.11±1.00abc	89.05±0.12d	382.00±0.66cd
UGII 5-35	3.67±0.40^{bcd}	88.85±0.14^{a}	374.96±0.46^{a}
UGII 11-05	3.77±0.40^{bcd}	89.29±0.13^{f}	379.98±6.33^{bcd}
UGII 7-24	4.51±0.01^{d}	90.16±0.14^{j}	396.17±1.09^{e}
UGII 5-52	4.10±0.13^{cd}	88.99±0.22^{c}	392.04±0.65^{e}
UGII 5-31	3.03±1.00^{abc}	88.93±0.25^{b}	384.69±0.23^{d}
UGII 5-47	4.72±0.02^{d}	89.82±0.13^{h}	396.05±0.47^{e}
UGII 5-48	2.56±0.20^{ab}	89.23±0.18^{e}	375.94±0.45^{ab}
UGII 5-18	2.03±0.36^{a}	89.88±0.11^{i}	377.54±0.59^{abc}

Means with different superscripts along each vertical column are significantly different (P < 0.05) N = 10; E. value = Energy value

Table 3: Correlation Between Essential Oil (%) Versus Total Fat and Energy Value of 10 Varieties of Ginger

	Total fat	Energy value
Essential oil	**0.830	0.400

****Correlation is highly significant at 0.01 level**

Table 4: Correlation Between Total Fat (%) Versus Energy Value of 10 Varieties of Ginger

	Total fat
Energy value	0.439

****Correlation is highly significant at 0.01 level**

CONCLUSION

All the 10 varieties of ginger that were studied, had low moisture contents, indicating good shelf life characteristics and minimal deterioration from microbes. They were observed to have high protein contents indicating that they could serve as very rich protein supplements in addition to contributing to the formation of hormones which controls a variety of body functions such as growth, repair and maintenance of body protein. All the varieties of ginger that were studied were observed to be promising sources of minerals. The large amounts of crude fiber in all the samples investigated infer that these varieties of ginger could effectively be utilized in the management of diabetes mellitus, colorectal cancers and weight reduction in obesed individuals. Finally, the high quantities of essential oils in all the varieties of ginger investigated, confer on them very high biological properties such as: treatment of fracture, rheumatism, bruises, hangovers, cold, flu, catarrh, congestion, cough, sores, sore throat, diarrhea, cramps, fever in addition to very high antioxidant potentials.

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