COMPARATIVE PROXIMATE AND MINERAL ANALYSES OF *Dioscorea rotundata* AND *Dioscorea bulbifera* GROWN IN MAKURDI, BENUE STATE – NIGERIA

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Abstract: This study compared the nutritional values of *Dioscorearotundata* and *Dioscoreabulbifera* grown in Agboughul village nearby Makurdi, Benue State, Nigeria. Samples of the *Dioscorea*species were collected and analyzed for their proximate and mineral compositions. The results of analyses revealed that*Dioscoreabulbifera*was richer in protein (3.79%), ash content (2.60%), crude fibre (1.75%) and moisture content (60.13%) than *Dioscorearotundata* while the *Dioscorearotundata* was richer in crude fat (1.80 %) and carbohydrate (89.75%) than *Dioscoreabulbifera*. In terms of mineral composition in mg/100g, *Dioscoreabulbifera* was richer than *Dioscorearotundata* in macro minerals such assodium (100.5), potassium (975.0), calcium (103.0), and magnesium (65.0) while the values of micro elements; zinc (1.5), iron (5.0) and manganese (0.6) were all higher in*Dioscorearotundata* but the value of copper was the same (0.2) in both species. The values of metabolizable energy in kJ/100g were 1605.97 and 1646.92 for *Dioscoreabulbifera* and *Dioscorearotundata*, respectively. The adoption of *Dioscoreabulbifera* as staple food is recommended.

Keywords: *Dioscoreabulbifera, Dioscorearotundata,* mineral composition, proximate composition

Introduction

The current food challenges in some parts of the world have raised the desire of many countries, agricultural organizations, institutions and individuals to boost agricultural production. Although scientific efforts are producing improved crop varieties, both in yields and maturity period, efforts towards the determination of nutritional value of some locally available crop varieties are also required in identifying crop species that can complement or even substitute some commonly used ones.

Yam is a member of the flowering plant genus *Dioscorea* (D.)(New World Encyclopedia, 2008).It ismonocot climbing plant with glabrous leaves and twining stems, which coil readily around a stake. There are about 600 species of yam found around the world, mostly in the tropics, and most of them complete their cycle within a year (New world Encyclopedia, 2008;Martin*et al.,* 2010;Salawu*et al.,* 2014). Theyinclude*D. alata, D. bulbifera, D. abyssinia, D. batatas, D. cayenensis, D. esculenta, D. japonica, D. rotundata, D. opposita and D. dumetorum*(Amani*et al.,* 2004). About 10 species are commonly cultivated for food, while a number of others are harvested from the wild in times of food scarcity.Somewild yam species contain toxic or bioactive compounds (Shajeela*et al.,* 2011; Polycarp *et al.,* 2012), and some of these are cultivated for pharmaceutical products (Subhash*et al.,* 2012). Yams are cultivated mainly for their edible tubers, medicinal uses, economicand social cultural values. They are grown on about five million hectares in about 47 countries of the world with Nigeria as the leading world producer (Ogbonna*et al.,* 2011; Polycarp *et al.,* 2012;Ukom*et al.,*2014). Edible yams arevery good source ofcarbohydrates,minerals like phosphorus, calcium and iron as well as vitamins such as riboflavin, thiamine and vitamin B and C in the diet (Okigbo and Ogbonnaya, 2006). Some varieties of yam offer additional economic value since theycan be stored for months without preservatives.

D.rotundata, commonly known as white yam is native to Africa. It is one of the most important cultivated yams (Wikipedia, 2016a). In Africa, it is mostly pounded into a paste to make the dish called 'pounded yam' (Salawu*et al.,* 2014; Wikipedia, 2016a). It is the most widely cultivated and consumed of the Dioscorea species in Nigeria (Adeogun*et al.,* 2014). The Hausas of the Northern Nigeria call it 'doya' The Igbos of Eastern Nigeria call it 'Jiaga' and the Yorubas of Western Nigeria call it 'Isuewura' (Alinnor and Akalezi, 2010). The Tivs and Idomas of Central Nigeria, call it 'iyough' and 'ihinehe', respectively.

D.bulbifera also known as aerial yam or air potato is a yam species that produces tubers under the groundand bulbils that grow at the base of its leaves.The starchy bulbils weigh between 200 g and 2 kg (Libra *et al.,* 2011; Wikipedia, 2016a). Theyare the more important food products of *D. bulbifera*and contain other chemical elements such as protein, fats, fibres and minerals(Libra *et al.,* 2011; Subhash*et al.,* 2012). The plant is known to be a highly invasive plant that will readily overgrow, choke and displace native plant communities via asexual propagation of bulbils that drop from the parent vines to the ground (Afiukwa and Igwe, 2015). It has been reported to have anticancer properties and to be useful in lowering glycemic index, thus providing a more sustained form of energy and better protection against obesity and diabetes (Subhash*et al.,* 2012).Among several other medicinal constituents, the yam species is reported to be rich in diosgenin, a steroid saponnin believed to possess preventive and therapeutic properties against several ailments including arthritis, cancer, diabetes, gastrointestinal disorders, high cholesterol and inflammation (Omoruyi, 2008). Aerial yam is called 'dooya-bisa' among the Hausas; 'adu' among the Igbos; and 'esuru' among the Yorubas (JSTOR, 2005), 'ajie' among the Tivs; 'ikpalo' among the Idomas.

The two yam species are all grown and consumed in Benue State. It is however worrisome to observe that the rate of cultivation and consumption of *D.rotundata* far outweighs that of *D.bulbifera* despite the advantage of early maturation that the latter has on the former. Also, the consumption of*D.bulbifera* which is mostly experienced in rural areas is never done out of preference but mostly at periods of food scarcity.This research work was aimed at determining theproximate and mineral contents of *D.rotundata* and *D. bulbifera*.

Materials and Method

Two yam samples, *D.rotundata* and *D.bulbifera* were obtained from farmers in Agboughul village nearMakurdi, Benue State. The samples were thoroughly washed with de-ionized water and air-dried at 28-33^{o}C for five days. They were peeled, chopped into cubes, oven dried(60^{o}C for 48-72h), milled, sieved (250um) and packed.The flour were

packaged in low density polyethene zip-lock bags and stored in adesiccator until analysis.

Proximate analysis

The crude fibre, ash and moisture contents of *D.rotundata* and *D.bulbifera*samples were determined according Association of Official Analytical Chemists' (AOAC), (1990).

Determination of crude fibre

The defatted flour used for the crude fat determination was transferred into a 750 mL Erlenmeyer flask and approximately 0.5 g of asbestos was added. 200 mL of boiling 1.25% H_2SO_4 was added and the flask was immediately set on a hot plate and condenser connected to the Erlenmeyer flask (cold finger type). The flask and its content were heated for 30 min. The flask was then removed and the contents immediately filtered through linen cloth in funnel and washed with a large volume of boiling water until washings were no longer acidic. This was confirmed using a pH meter. The filtrate and asbestos were washed back into a flask with 200 mL boiling 1.25% NaOH solution. The flask was then connected to the condenser and boiled for exactly 30 min. At the end of 30 min, the contents of the flask were filtered through linen cloth in a funnel and washed with large volumes of boiling water. The residue was transferred into a Gooch crucible with water from a wash bottle and was then washed with 15 mL alcohol. The crucible and its contents were dried for 1 hour at 100^0C, cooled in a desiccator and weighed. The crucible with its content was then ignited in a muffle furnace preheated to 600^0C for 30 min, cooled in a desiccator and reweighed.

$$Percentage\ Crude\ fibre = \frac{(Weight\ of\ dried\ sample - Weight\ of\ ash)}{Weight\ of\ sample} \times 100$$

Determination of ash

2 g of sample was transferred into a porcelain crucible which had previously been ignited, cooled and weighed. The crucible and its contents were then placed in a muffle furnace preheated to 600^0C for 2 h. It was removed with its content, cooled in a desiccator and weighed. The total ash content was calculated and expressed as a percentage.

$$Percentage\ Ash = \frac{(Weight\ of\ crucible + ash) - Weight\ of\ empty\ crucible}{Weight\ of\ sample} \times 100$$

Determination of moisture

About 5 g of chopped fresh yam tuber samples were weighed separately and transferred into previously dried and weighed glass dishes. The dishes with yam samples were placed in a thermostatically controlled oven and heated at 105 ^{0}C for 5 h to a constant weight. They were removed, cooled in a desiccator and re-weighed. The dishes were then dried again for 30 min, cooled down and weighed. This procedure was repeated until constant weight was reached. The moisture content was then determined by difference and expressed as a percentage.

$$Percentage\ Moisture = \frac{(Weight\ of\ dish + fresh\ sample) - (Weight\ of\ empty\ dish + dry\ sample)}{Weight\ of\ freshsample} \times 100$$

Determination of crude protein (Kjeldahl method)

Exactly 2 g of sample, in a Kjeldahlflask was digested by addinghalf of selenium based catalyst tablet, 25 mL of conc. H_2SO_4 followed by gentle heating until the solution became clear.The solution was cooled to room temperature, 100 mL of distilled water added gently with swirling, followed by 100 mL of 50% NaOH solution. The mixture was distilled and the liberated ammonia collected into a 250 mL conical flask containing 25 mL of 2% boric acid. 25 mL of the distillate was titrated against a 0.1 N HCl solution until the pinkcolour end point. The same procedure was followed for the blank(LABCONCO, 2005; Akinniyi and Waziri, 2011).

Percentage Nitrogen content was calculated as follows (LABCONCO, 2005):

$$\frac{(\text{mL standard acid} - \text{mL blank}) \times \text{Normality of acid} \times 1.4007}{\text{Weight of sample in grams}}$$

Where: 1.4007 is themilliequivalent weight of nitrogen x 100.

Percentage Crude Protein was calculated by multiplying % N by 6.25, a factor which depends on the sample matrix (AOAC, 1990).

Determination of crude fat

A previously dried (air oven at 100^0C) and cooled 250 mL round bottom flask was accurately weighed. 2 g of the dried yam flour was then transferred to a 22x80 mm filter paper (thimble). Glass wool was placed into the thimble to prevent loss of flour. 150 mL of petroleum ether was added to the round bottom flask and the apparatus assembled. Thecondenser was connected to the Soxhlet extractor and refluxed for 6 h using a heating mantle. The flask was then removed and evaporated on a steam bath, heated in an oven for 30 min at 105^0C, cooled to room temperature in a desiccator and weighed (Ejembi*et al.*, 2014). The fat content was expressed as percentage by weight. This was calculated as follows:

$$Percentage\ Crude\ fat = \frac{Weight\ of\ extracted\ matter}{Weight\ of\ sample} \times 100$$

Determination of total carbohydrate

Total carbohydrate was calculated as the difference between 100 and the sum of moisture, ash, crude fat, crude protein and crude fibre (Alinnor and Akalezi, 2010;Oko*et al.*, 2012).

Energy value: The energy value (in kJ/g) was calculated from the Atwater general factor system (FAO, 2003; Celestine and David, 2015) based on net metabolizable energy (NME) or heats of combustion of the major energy-yielding substrates (protein, fat, and carbohydrate) using the equation;

Energy (kJ/g) = (carbohydrate x 17) + (crude fat x 37) + (crude protein x 17)

Where: 17, 37, and 17 are heats of combustion of carbohydrate, fats, and protein, respectively.

Mineral analysis

Estimation of Ca, Mg, Zn, Mn, Cu and Fe

1 mL of the digested solution was used to determine the minerals Ca, Mg, Zn, Mn, Cu, and Fe in the sample using Shimadzu Atomic Absorption Spectrophotometer (AAS) (Model AA-6800) with acetylene flame. The AAS was filled with Zn, Mn, Cu, and Fe electrodeless discharge lamps while hollow cathode lamps were used for Mg and Ca at various wavelengths.

Estimation of Na and K

1 mL of the digested solution was used to determine Na and K using a flame photometer(Jenway PFP7, Sheffield, UK) with butanegas.

Results and Discussion

The proximate and mineral compositions of *D.bulbifera* and *D.rotundata*flours are presented in tables 1 and 2, respectively.The result of proximate analysis showed that*D.bulbifera* has protein (3.79%), crude fibre (1.75%) and ash (2.60%) contents which are respectively higher than the values of 3.21%, 1.23% and 2.05% obtained for *D. rotundata*.These were indicative that *D.bulbifera*was a better source of protein, crude fibre and minerals than *D. rotundata*. The protein content of D. *bulbifera*was lower than 5.32 – 7.27 % reported by other researchers (Sanful*et al.*, 2013; Celestine and David, 2015) while the ash content was within 2.33 – 5.57 % range reported by the same authors. The variations in results could be due to different levels of maturity of the

samples that were analysed or the difference in the soil nutrients that were available to the samples during growth. Protein helps in repairing damaged tissues and assisting in building up of the body. Fibre is useful in providing roughage that aids digestion and in reducing the risks of cardiovascular diseases (Alinnor and Akalezi, 2010). Ash indicates total mineral content of samples. The higher moisture content (wet basis) of *D. bulbifera*is an indication that it could beprone to microbial attack more than the*D. rotundata* while the fact that both flours had moisture content (dry basis) of less than 10 % means that they can be stored for long time without deterioration.Conversely, the values of crude fat (1.80 %) and carbohydrate (89.75 %) were respectively higher in *D. rotundata* than (0.90 %) and (88.72 %) in *D. bulbifera*. The values of fat in both species werewithin the reported ranges of 0.53 – 3.29 % (Polycarp *et al.,* 2012; Sanful*et al.,* 2012) for *D. bulbifera*and 0.41 – 2.70 %for *D. rotundata*(Alinnor and Akalezi, 2010; Polycarp *et al.,* 2012).The values of carbohydrate in both specieswere similar to 87.31 % reported for *D. rotundata* by Polycarp *et al.,* 2012). Fat is a high energy nutrient that promotes the absorption fat soluble vitamins in the body (Atasie, *et al.,* 2009). It also serves as energy store in the body.Carbohydrate is useful in the supply of high energy to the body. Both *D. rotundata* and *D. bulbifera* havesimilar amount of metabolizable energy of 1,646.92 kJ/100g and 1,605.97 kJ/100g, respectively. This means that each can produce similar amount of energy in the body.

Table 1: Proximate compositions of *Dioscoreabulbifera* and *Dioscorearotundata* flours

S/No	Nutrients	*D. bulbifera*	*D. rotundata*
1	Crude protein (%)	3.79±0.01	3.21±0.02
2	Crude fat (%)	0.90±0.03	1.80±0.12
3	Crude fibre (%)	1.75±0.02	1.23±0.04
4	Ash content (%)	2.60±0.15	2.05±0.08
5	Moisture (Dry basis) (%)	2.24±0.01	1.96±0.03
6	Moisture (Wet basis) (%)	60.13±0.03	54.18±0.04
7	Carbohydrate (%)	88.72±0.03	89.75±0.2
8	Metabolizable energy kJ/100g	1,605.97±5.72	1,646.92±2.79

Table 2: Mineral compositions of *Dioscoreabulbifera* and *Dioscorearotundata*flours

S/No	Minerals (mg/100g)	Samples	
		D. bulbifera	*D. rotundata*
1	Potassium	975.0±1.14	650.0±1.53
2	Magnesium	65.0±0.83	47.5±0.12
3	Sodium	100.5±1.32	85.5±0.07
4	Calcium	103.0±0.50	91.5±0.45
5	Copper	0.2±0.40	0.2±0.15
6	Zinc	1.4±0.06	1.5±0.10
7	Iron	4.5±0.35	5.0±0.15
8	Manganese	0.5±0.08	0.6±0.02

Minerals are required in diet because of their physiological and metabolic function in the body. The result of the mineral analysis (Table 2) showed that the valuesof all the macro minerals; K, Mg, Na and Ca (in mg/100g)were higher in *D. bulbifera* than in *D. rotundata* while the values of micro minerals; Zn, Fe and Mnwerehigher in *D. rotundata* than in *D. bulbifera* with exception of Cu which was the same for both*Dioscorea* species. All the values were lower than the recommended daily value (mg/day) of K (3500), Mg (400), Na (2400), Ca (1000), Zn (15), Fe (18), Mn (2) and Cu (2) (Wikipedia, 2016b).It implied that more than100 g of the *Dioscorea* species will be required to provide the daily value of the minerals per day. The values of K and Mg for *D. bulbifera*were less than the 1250 – 1475 mg/100 g and 76.5 – 83.5 mg/100g ranges respectively reported by Polycarp *et al.* (2012). The value of K in *D. rotundata*was in between 209.13 mg/100g reported by Alinnor and Akalezi (2010) and 900 mg/100g reported by Polycarp *et al.*(2012). The values of Na and Ca for both *D. bulbifera*and *D. rotundata*were in agreement with those reported by Polycarp *et al.* (2012) for the two species but less than the values reported by Alinnor and Akalezi (2010) for *D. rotundata*.Sodium is an important mineral that assist in the regulation of body fluid and in the maintenance of electric potential in the body tissue.Potassium is associated with protein and carbohydrate metabolism.It is also important in the regulation of heart beat, neurotransmission and water balance of the body.Calcium is an important mineral required for bone formation and neurological function of the body.Magnesium plays essential role in calcium metabolism in bones and also involves in regulating blood pressure and insulin releases (Alinnor and Akalezi, 2010; Iorungwa*et al.,* 2016).

Trace elements such as Cu, Zn, Mn, Fe are essential components of enzyme systems hence, small or conditioned deficiencies of mineral elements have profound effects on metabolism and tissue structure (Soetan, 2012). They are essential for biological processes, but at the same time they are toxic at concentrations beyond those necessary for their biological functions (Suhaila *et al*., 2004). The values of all the micronutrients studied were below the daily values recommended for the nutrients which implied that more than 100 g of each of the *Dioscorea*species will be required to independently provide the amount of the micronutrient required by the body.

Conclusion

The research work has shown that the proximate and mineral compositions of *D. bulbifera*have compared closely with those of *D. rotundata*.This impliedthat although *D. bulbifera* is not highly consumed, it can be utilized as a good alternative or supplement to the popular *D. rotundata.* The yam species was therefore recommended for increased adoption as food produce and for further researchwith a view of its optimalutilization as a food produce.

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