



## **COMPARATIVE ANALYSIS OF NUTRITIONAL, FUNCTIONAL AND ANTIOXIDANT PROPERTIES OF SELECTED TROPICAL TUBER CROPS**

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### **Abstract**

Tubers are important staple food in many tropical countries because of their nutritional, economical and health functionality values. Four different tubers *Dioscorea rotundata* (DR), *Dioscorea alata* (DA), *Dioscorea dumetrum* (DD), *Colocasia esculentum* (CE)) were selected in this study with the aim of evaluating their nutritional, functional and antioxidant properties. Nutritional properties were assessed by proximate and minerals assays, functional properties by titratable acidity, bulk density and water absorption capacity while antioxidant was assessed by total phenolics, total flavonoids, total antioxidant capacity, 1,1-diphenyl-2-picrylhydrazyl (DPPH) and reducing power. All assays were done using standard methods. CE has significantly ( $p < 0.05$ ) higher carbohydrate content and bulk density, DD has the highest crude fat content, DR has the highest moisture content while DA has the highest ash content. On the mineral contents CE has the highest content of magnesium; DR has the highest content of potassium while DD possessed the highest content of calcium and sodium. DA has the highest antioxidant ability of all the tubers investigated which is significantly ( $p < 0.05$ ) higher than the other tubers. From this study, it can be concluded that these tubers possessed appreciable nutritional, functional and antioxidant qualities. Therefore they could be used in prevention, management and treatment of oxidant-related diseases.

**Keywords:** Antioxidant; Proximate; Mineral; Tuber crops; Functional

### **Introduction**

Root and tuber crops are second only in importance to cereals as a global source of carbohydrates (Chandrasedkara and Joseph 2016). They also provide some minerals and essential vitamins in the diet. The quantity and quality of the protein in these starchy foods are variable and relatively low on a fresh weight basis but compare favourably with some cereals on a dry weight basis. Despite the importance of

yams to people, the attention to its production and utilization is still questionable (Verter and Bečvařova, 2014). Yams (*Dioscorea* species) are annual root tuber bearing plants with more than 600 species out of which six are socially and economically important in terms of food, cash and medicine (IITA, 2009). Some of the yam species are water yam (*Dioscorea alata*), white yam (*Dioscorea rotundata*), yellow yam (*Dioscorea cayanaensis*), Chinese yam

(*Dioscorea esculant*) and three-leaf yams ( Zaknayiba and Tanko, 2013).

*Dioscorea dumetorum* Pax (family Dioscoreaceae) is commonly known as bitter yam or cluster yam. It originated wildly throughout Africa, predominantly in the tropics (Nimenibo–Uadia, 2003) and occurs in both wild and cultivated forms. It serves as food of choice for the diabetic patients and as herb for the treatment of various ailments (Egbonuet *al.*, 2014). In the south-western Nigeria, bitter yam is utilized in the treatment of malaria (Dike *et al.*, 2012). Cocoyam (*Colocasia esculenta* L. Schott) is a root crop belonging to the family of the Araceae, after yam and cassava, it is the third most important tuber crop in West Africa (Nwanekezi *et al.* 2010). Amongst the root crops, taro is perhaps the most widely prepared or processed into more consumable products such as flour, paste, canned products, cereal bars, beverage powders, and chips (FAO, 2008). *Dioscorea rotundata* also known as white yam is a tropical species requiring a temperature of 25–30 °C and very popular in Ivory Coast and Nigeria (Lim, 2016). It is the choice species for production of many yam products; fried yam, roasted yam, yam flour, yam pottage, cakes, instant yam flakes and chips. *Dioscorea alata* L. also known as water yam is the most commonly grown specie in the Caribbean and Central America (Onyeka *et al.*, 2006). Water yam is not only important for local consumption but is also the preferred food for emigrants from these regions now residing in Europe and North America, which results in export trade of great value for the economy of the producing countries (Marcos *et al.* 2011). It is noted for its bulkiness, high moisture, and starch content, although underutilized compared to the popular variety of *Dioscorea rotundata* (Tortoe *et al.*, 2019). Despite that

they are tuber crops with different importance and uniqueness as economic and functional foods; they have been neglected. Assessing the food and health qualities of this type of neglected tubers can lead to increased food security while improving the human health of the populations. Therefore, this study is aimed at comparative analysis of nutritional, antioxidant and functional properties of the selected tuber crops.

## **Materials and Methods**

### **Chemicals and reagents**

Quercetin, Gallic acid, Ascorbic acid, 1, 1-diphenyl-2-picrylhydrazyl (DPPH), Trichloroacetic acid (TCA), and Sodium carbonate were purchased from Sigma-Aldrich, USA. Folin– Ciocalteu reagent, Aluminum chloride, Sodium hydroxide, Ferric chloride and other reagents were purchased from Loba chemie, India. All chemicals were of analytical grade.

### **Plant Materials**

The tuber samples used in this work were gotten from a farm along Owo express road in Ifon, Ose Local Government, Ondo State. They were identified at the Department of Biological Sciences, Olusegun Agagu University of science and Technology (OAUSTECH). The yam tubers were at fresh, full commercial maturity stage and without infection. The samples were washed under a slow running tap water in the laboratory to remove dirt and sand.

### **Sample Preparation**

The cleansed samples were peeled and in cut into small sizes (0.2-0.3 cm) to enhance drying. The chopped samples were shade dried. After the samples had been perfectly air-dried, the sample were crushed into smaller pieces with the aid of mortar and pestle, before the small chips were grinder to powdered form via mechanical method using a blender. The blended samples were then sieved to remove particles of higher diameter.

The powdered samples were packed into an air tight container and kept in the refrigerator before analysis.

### **Extraction of Sample**

The extraction of samples was done by the method described earlier (Karigidi *et al.*, 2019). Ten grams (10 g) of powdered tuber samples were extracted with 100 ml distilled water at room temperature on orbital shaker (800 rpm for 1 hr). The resulting slurry was centrifuged at 3000 rpm for 10 mins. The supernatants obtained were decanted and used for chemical analyses immediately.

### **Total Phenolic Determination**

The total phenolic content (TP) of tuber samples was determined using the Folin Ciocalteu phenol reagent method (Kim *et al.*, 2003) as modified by (Karigidi *et al.*, 2018). Briefly, 1 ml of the sample was mixed with 1ml (1:10) of Folin-Ciocalteu phenol reagent. After 5 mins, 5 ml of 7 % Na<sub>2</sub>CO<sub>3</sub> was added followed immediately with by addition of 5 ml of distilled water and shaken thoroughly. The mixture was kept in the dark for 90 min at room temperature. The absorbance was measured at 750 nm and the TPC was evaluated from gallic acid calibration curve and expressed as gallic acid equivalent.

### **Total Flavonoid Determination**

The total flavonoid content (TF) of the tuber samples was determined using the method of Park *et al.*, (2008). Briefly, 0.3 ml of the sample was mixed with 3.4 ml (30%) of methanol, 0.15 ml (0.5M) of NaNO<sub>2</sub> and 0.15 ml (0.3M) of AlCl<sub>3</sub>·6H<sub>2</sub>O consecutively. After 5 mins, 1 ml (1M) NaOH was added and mixed well. The absorbance was measured at 506nm and the flavonoid content was evaluated from quercetin calibration curve and expressed as quercetin equivalent.

### **Diphenyl-2-Picrylhydrazyl Scavenging Activity Determination**

The 1, 1-diphenyl-2-picrylhydrazyl (DPPH)

radical scavenging activity of tuber samples was determined using the method of Gyamfi *et al.*, (1999) with minor modification. Briefly, 1 ml (100-400 µg/ml) of sample was added to 4ml (instead of 3.9 ml) of DPPH solution (30 mg/l) prepared in methanol. The samples were shaken and allowed to stand in the dark for 30 minutes. The absorbance was measured at 520 nm. The inhibition percentage was calculated as

Inhibition percentage of DPPH =  $\{(Abs\ control - Abs\ Sample) / (Abs\ Control)\} \times 100$

DPPH solution without sample served as control.

### **Total Antioxidant Capacity Determination**

The total antioxidant capacity (TAC) of the tuber samples was determined using the Phosphomolybdate method of Prieto *et al.*, (1999). Sample (0.4 ml) and 4.0 ml of reagent (0.6 M sulfuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate) was thoroughly mixed together. The mixture was capped and incubated in a boiling water bath at 95 °C for 90 minutes. The mixture was cooled to room temperature and the absorbance of the samples was measured at 695 nm against and the total antioxidant capacity was calculated from ascorbic acid calibration curve and expressed as ascorbic acid equivalent (mg AAE/g).

### **Reducing Power Determination**

The reducing power (RP) of tuber samples was determined using the method of Oyiazu *et al.*, (1986). Briefly, 1 ml of the sample was added to 1 ml phosphate buffer (0.2 M, pH 6.6) followed by 1 ml (1 %) of potassium ferricyanide and incubated for 20 min at 50 °C. The reaction was terminated by 1 ml (10 %) trichloroacetic acid. Thereafter 1 ml of the upper portion was taken, mixed with 1 ml of distilled water and followed by 1 ml (0.1 %) of ferric chloride. The reaction mixture was thoroughly mixed and the absorbance was read at 700nm.

**Proximate composition**

Proximate analysis for crude protein, moisture content, ash, crude fat and crude fibre were determined by the method (AOAC, 2010). Carbohydrate content was calculated by difference. Mineral analysis was determined by the method of (AOAC, 2010) after digestion with mixed acids (Nitric and hydrochloric acids) using atomic absorption spectrophotometer.

**Titrateable Acidity Determination**

Titrateable acidity was determined by the method of AOAC (2014). Five (5) mL aliquot of the sample solution was pipetted into a conical flask and two drops of phenolphthalein indicator was added. Titration was done with 0.1 M NaOH until the endpoint was reached. The used factor for calculating citric acid was 0.007005 %. Total acidity was calculated as citric acid percentage (% citric acid).

**Bulk Density Determination**

Bulk density was determined according to the method described by Wang and Kinsella (1976) with some modifications. Briefly, 2 g of sample was put into a 100 mL graduated cylinder. The cylinder was tapped forty (40) times and the bulk density was calculated as weight per unit volume ( $\text{g}/\text{cm}^3$ ).

**Water Absorption Capacity Determination**

Water absorption capacity was determined according to the method of Sosulski *et al.* (1976) as modified by Chandra *et al.* 2015. The sample (2 g) was transferred into a weighed centrifuge tube to which 30 mL of distilled water was added. The bottle was tarred and agitated in a shaker for one hour. It was then centrifuged at 500 rpm for 10 min. The supernatant was decanted immediately and allowed to drain for 10 minutes

**Statistical Analysis**

The result were expressed as mean  $\pm$  SD

(Standard deviation) of experiments performed in triplicate and were statistically analyzed using Microsoft Excel and Graph prism pad 5.0

**Results and Discussion**

The result of the functional and physiological properties of the samples is presented in Table 1; Bulk density was significantly higher in CE than the other tubers. Bulk density is one of the structural properties of food materials and it is significant in the characterization and prediction of the quality of processed products (Boukouvalas *et al.*, 2006). It determines the choice of the container size and strength of the reconstituted food, if prepared from a given volume (Peleg 1983). The value obtained for CE which is the highest in the study is lower when compared with the value reported by Falade and Okafor (2014) for cocoyam. DA has the highest water-binding capacity and DD has the highest titrateable acidity. The water-binding capacity is defined as the ability of food sample to absorb water and to hold it even after treatment with external forces (Laufenberg and Schulze 2009). The values obtained in this study were lower than the ones reported for some food samples by Chandra *et al.*, (2015). Total titrateable acidity is a measure of organic acid present in food and it directly reflects the amount of organic acids in food which determines the flavour of the foods. The titrateable acidity of the tuber samples in this study were higher when compared with the ones reported for some tuber samples by Kasaye *et al.*, (2018).

The results of polyphenols (total phenolics and total flavonoid) and other antioxidant assays are presented in Figure 1. In the total phenolics, DA possessed significantly ( $p < 0.05$ ) higher content than the other selected tubers which was distantly followed by CE, DD and DR. The same trend was also followed in flavonoid. However, the highest phenolics

content in selected tubers (DA) is lower than the value obtained in the study of Tamaroh *et al.*, (2018). These phytochemicals have been widely reported to possess antioxidative capacity thereby making these selected tuber crops ample source of antioxidants (Adetuyi *et al.*, 2018, Karigidi *et al.*, 2018). Antioxidants are substances that scavenge or slow down the activities of reactive oxygen species (ROS) and reactive nitrogen species (RNS) which inhibit oxidative mechanisms that lead to chronic and degenerative diseases (Olaiya *et al.*, 2016). Antioxidant ability of the selected tuber crops were evaluated using three antioxidant assays: DPPH, TAC and RP. The trend of the result of antioxidant assay was the same and corresponding to the phytochemicals in the selected tuber crops. The observed correlation between phytochemicals and antioxidant assays is in agreement with numerous studies that phenolics and flavonoids are strong determinant of antioxidant capacity of food (Soetan *et al.*, 2018). The results of proximate and mineral compositions are presented in Table 2 and 3 respectively. Proximate composition is an important criterion to determine the nutritional values and quality of food (Qayyum *et al.* 2012). The protein content of the selected tubers varies slightly, the protein contents of CE, DA and DD were not significantly ( $p < 0.05$ ) different from each other but higher and significant ( $p < 0.05$ ) different from DR. Dietary proteins plays an important role in synthesis and maintenance of body tissues, enzymes, and hormones as well as other substances required for healthy functioning (Hayat *et al.* 2014; Ogunyinka *et al.*, 2016). The crude protein obtained in this study is lower than the ones reported by Ezeocha and Ojmelukwe 2012, but higher than those reported by Omohimi *et al.* 2018 for

different Nigeria yam flours. The crude fat and fibre contents of DD are significantly higher than the other selected tuber samples. Dietary fats are not just a source of energy; they function as structural building blocks of the body, carry fat-soluble vitamins and also, are involved in vital physiological processes in the body. The value obtained in this study is lower than what was reported by Omohimi *et al.* 2018 for different Nigeria yam flours. The carbohydrate content also varies; CE has the highest value closely followed by DR which is not significantly ( $p < 0.05$ ) different from each other, followed by DA and DD. The carbohydrate content reported in this work is lower than what was reported by Ezeocha and Ojmelukwe (2012) and Omohimi *et al.*, (2018) for different yam varieties. The moisture content of DD is the highest and CE has the lowest moisture content. Moisture content has always been used as a determinant of microbial growth in food. Low moisture content is always desirable in food because high moisture content encourages the growth of bacteria and mold, which could reduce stability and shelf storage capability (Ogunyinka *et al.*, 2016). The moisture contents obtained in this study were higher when compared with the work of Omohimi *et al.* 2018 but lower than what was reported by Adegunwa *et al.*, 2011. The mineral composition of the selected yam tuber is reported in ppm. The mineral elements evaluated include sodium, potassium, calcium and magnesium. DD has significant ( $p < 0.05$ ) higher sodium and calcium content while DR has the highest in potassium and CE has the highest in magnesium. Mineral elements are essential for the proper functioning of every living being on earth, it is one of the essential components of food (Soetan *et al.* 2010; Quintaesl and Diez-Garcia 2015). Generally, DA has the lowest mineral element concentrations among the selected

tubers while DD has the highest. The mineral elements in the selected ranked well with the minerals in other tuber crops (Soetan *et al.*, 2010). The values of the

mineral elements obtained in this study were higher than the values reported by Omohimi *et al.*, (2018) for different yam flours.

**Results**

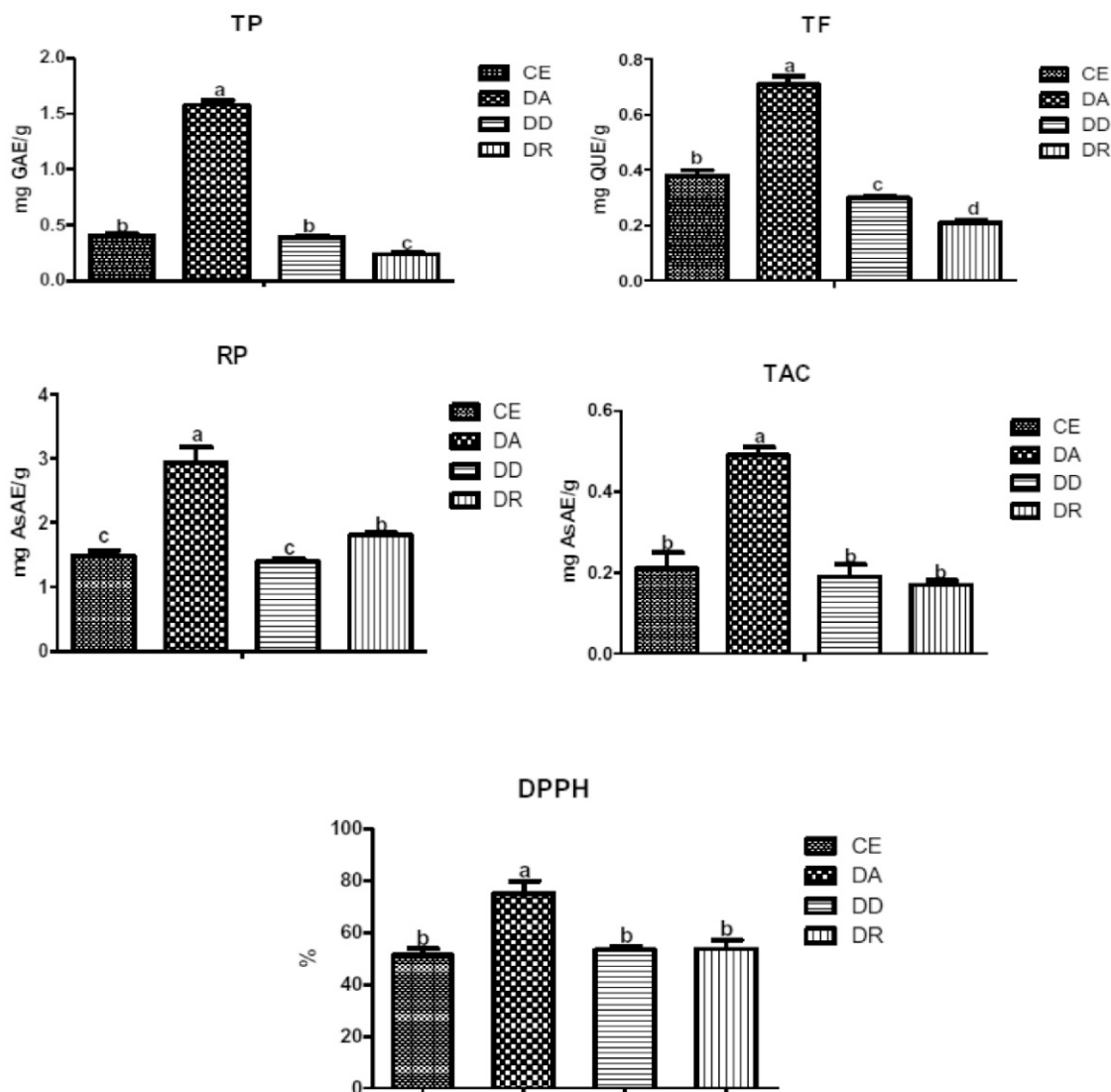


Figure 1: Antioxidant properties of selected yam tuber. Bars with different letter are significantly (P < 0.05) different. CE= *Colocasia esculenta*; DA= *Dioscorea alata*; DD=*Dioscorea dumetrum*; DR=*Dioscorea rotundata* TP; Total phenolic, TF: Total flavonoid, TAC: Total antioxidant capacity, RP: Reducing power, DPPH; 1,1-diphenyl-2-picrylhydrazyl scavenging activity

**Table 1: Bulk density, water binding capacity and titratable acidity of tuber samples**

	CE	DA	DD	DR
<b>Bulk density (g/cm<sup>3</sup>)</b>	0.78 ± 0.01 <sup>a</sup>	0.66 ± 0.24 <sup>b</sup>	0.48 ± 0.23 <sup>c</sup>	0.68 ± 0.21 <sup>b</sup>
<b>Water binding capacity (%)</b>	61.0 ± 1.05 <sup>b</sup>	64.5 ± 0.58 <sup>a</sup>	60.67 ± 0.47 <sup>b</sup>	48.67 ± 0.47 <sup>c</sup>
<b>Titratable acidity (10<sup>-3</sup>LA)</b>	1.46 ± 0.05 <sup>b</sup>	1.94 ± 1.93 <sup>a</sup>	2.07 ± 0.01 <sup>a</sup>	0.12 ± 0.02 <sup>c</sup>

Values represent Mean ± Standard deviation of triplicate. Values with different letter across the same row are significantly (P < 0.05) different. CE= *Colocasia esculenta*; DA= *Dioscoreaalata*; DD=*Dioscoreadumetrum*; DR=*Dioscorea rotundata*; LA=Lactic acid

**Table 2: Proximate composition of the selected yam samples in %**

	CE	DA	DD	DR
<b>Crude Protein</b>	9.44 ± 0.86 <sup>a</sup>	9.62 ± 0.86 <sup>a</sup>	9.48 ± 1.01 <sup>a</sup>	8.10 ± 0.01 <sup>b</sup>
<b>Crude Fat</b>	0.50 ± 0.01 <sup>a</sup>	0.45 ± 0.07 <sup>b</sup>	1.10 ± 0.40 <sup>c</sup>	0.31 ± 0.06 <sup>b</sup>
<b>Crude Fibre</b>	4.79 ± 1.01 <sup>a</sup>	6.96 ± 2.60 <sup>b</sup>	7.40 ± 1.83 <sup>b</sup>	6.80 ± 1.12 <sup>b</sup>
<b>Ash Content</b>	2.48 ± 0.01 <sup>a</sup>	4.30 ± 0.85 <sup>b</sup>	1.84 ± 0.89 <sup>c</sup>	0.40 ± 0.06 <sup>d</sup>
<b>Moisture Content</b>	10.59 ± 0.05 <sup>a</sup>	12.79 ± 0.03 <sup>b</sup>	15.56 ± 0.01 <sup>c</sup>	13.49 ± 0.07 <sup>b</sup>
<b>Carbohydrate</b>	72.20 ± 0.30 <sup>a</sup>	65.88 ± 1.41 <sup>b</sup>	64.62 ± 0.05 <sup>b</sup>	70.90 ± 1.03 <sup>a</sup>
<b>Dry matter</b>	89.41 ± 0.11 <sup>a</sup>	87.21 ± 0.08 <sup>a</sup>	84.44 ± 0.09 <sup>a</sup>	86.51 ± 0.13 <sup>a</sup>

Values represent Mean ± Standard deviation of triplicate. Values with different letter across the same row are significantly (P < 0.05) different. CE= *Colocasia esculenta*; DA= *Dioscoreaalata*; DD=*Dioscoreadumetrum*; DR=*Dioscorea rotundata*

**Table 3: Mineral contents of the selected tuber samples in ppm**

	CE	DA	DD	DR
<b>Sodium</b>	231.52 ± 11.50 <sup>c</sup>	27.23 ± 3.50 <sup>d</sup>	418.21 ± 14.60 <sup>a</sup>	267.00 ± 9.80 <sup>b</sup>
<b>Potassium</b>	121.23 ± 4.80 <sup>b</sup>	13.71 ± 1.90 <sup>d</sup>	23.04 ± 1.30 <sup>c</sup>	321.22 ± 16.80 <sup>a</sup>
<b>Calcium</b>	320.05 ± 15.80 <sup>b</sup>	44.50 ± 4.20 <sup>d</sup>	381.01 ± 10.5 <sup>a</sup>	65.32 ± 4.50 <sup>c</sup>
<b>Magnesium</b>	63.15 ± 4.40 <sup>a</sup>	51.12 ± 3.22 <sup>b</sup>	55.32 ± 3.80 <sup>b</sup>	31.54 ± 1.10 <sup>c</sup>

Values represent Mean ± Standard deviation of triplicate. Values with different letter across the same row are significantly (P < 0.05) different. CE= *Colocasia esculenta*; DA= *Dioscorea alata*; DD=*Dioscorea dumetrum*; DR=*Dioscorea rotundata*

## CONCLUSION

It can be concluded that these selected yam tubers can serve as ample source of nutrients and phytochemical compositions which are very essential for the body and prevention of many diseases. Based on this, their regular usage can help to mitigate food security and improve the human health. Therefore, their consumption should be encouraged.

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