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EFFECTS OF PROCESSING ON PROXIMATE, MINERAL COMPOSITION AND STORAGE OF *Dioscorea rotundata* (WHITE YAM) TUBERS

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ABSTRACT

This study investigated the nutritional qualities of raw yams and the effects of roasting on the proximate composition and retention, and its contribution to storability. Ten yams tubers with average weight of 2Kg that were firm, undamaged by any cracks, soft spots, or bruises were purchased from Ipata market in Ilorin, Nigeria in the month of November, 2015 during the dry season. Five yam tubers (10Kg) were peeled with well sterilized knife and designated Peeled Raw Yam (PRY). They were cut into very thin slices, air dried and homogenized into fine powder. The remaining 5 tubers (10Kg) were not peeled but were roasted with coal fire on iron wire mesh, air dried and homogenized into fine powder. Proximate and mineral compositions were determined before the powdered samples (RYT) were put into a screw top bottle and stored for two months. The results revealed that the moisture content (MC) of the raw roasted yam (RYT) (0.93%) was significantly $P<0.05$) lower than that of the peeled raw yam (PRY) (58.80%). The dry matter (ash) content of the two samples were significantly different; 1.28% (RYT) and 10.93%) (PRY). Carbohydrate content obtained in this study from RYT (73.20%) was higher than PRY (69.56%). The crude protein, crude fat and fiber contents of RYT and PRY were not significantly different. The level of K, Fe and Al content of RYT and PRY were not significantly different ($P<0.005$). The two samples had higher composition of Zn, Fe and Cu level compared to other mineral contents. A total of six fungi from four genera were isolated at the end of day 60.The study therefore, concluded that yams should be roasted before grindinginto flour for longer storage, better retention of the food content and reduction in the population of fungi.

Key words: *Dioscorea rotundata*, proximate, minerals, AAS, XRF.

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INTRODUCTION

White yams belong to the Genus *Dioscorea* and Family Dioscoreceae. They are a major staple tuberous root and starchy food crops for an estimated 60 million people in the regions stretching from Ivory Coast to Cameroon, Asia, Latin America and Oceania (Otegbayo *et al.*, 2012).Yams are commonly consumed with sauces after boiling, roasting or frying. It is mashed or pounded into dough after boiling. There are indications that yam has great prospect of contributing close to the projected food deficit in Africa in the 21st century, if efforts are made to identify and overcome the constraints to its production. Among these constraints and which must be investigated are the facts that food nutrients and components lose their qualities due to temperature change, humidity of environment, seasons or times of year, quality of deterioration and potential microbial spoilage, mode of harvesting, storage, and processing (Fremer1982;Kramer,1982). Yam as a versatile vegetable can be barbecued and when grated, processed into a dessert recipe, roasted, transformed into powder and pounded into dough. Nigeria alone produces above 50% of the world's production (RMRDC, 1990; FAO, 1985). However, only six species are being used as food. The list of the cultivated species have been reported by Mignouna(2009) who catalogued the *Dioscorea rotundata* varieties cultivated in Nigeria. It is on record that yams, particularly, *D. rotundata,* contain the enzyme alpha amylase which converts starch to sugars as the tuber matures in storage. The protein content and quality of roots and tubers is lower than other food staples. Of all roots and tubers, the protein content of yam and potato is the highest, being approximately 2% on a fresh weight basis. Yams provide a much greater proportion of the protein intake in Africa, ranging from 6% in East and southern Africa to about 16 percent in humid West Africa (Afiukwa*et al.,*2013).Yam is high in potassium, manganese and dietary fiber while being low in saturated fat and sodium (Onwuka and Ihuma, 2007;Alinor and Akalezi, 2010). A product that is high in potassium and low in sodium is likely to produce a good potassium-sodium balance in the human body, and so protects against osteoporosis and heart disease. In most parts of Nigeria, majority of people eat *D. rotundata* in roasted form. This study, therefore, investigates the nutritional qualities of raw yam and when it is roasted and the extent to which the processing of yam by roasting has affects the proximate and nutrient retention and contribution to its storability.

MATERIALS AND METHODS

Sample Procurement, Treatment and Preparation

Ten yams tubers with average weight of 2Kg that were firm, undamaged by any cracks, soft spots, or bruises were purchased from Ipata market in Ilorin in the month of November, 2015 during the dry season. The yam tubers were wrapped in grease-free paper packed into a carton and transported to the Chemistry Laboratory of Kwara State Polytechnic, Ilorin. The tubers were unwrapped and placed on a clean bench in an open and well ventilated environment devoid of direct sun light(FAO,1985).The yam tubers were cleaned by washing in clean running tap water to remove sand and

debris together with possible pesticides. After draining, the yam tubers were divided into two groups. Five yam tubers (10Kg) were peeled with well sterilized knife and designated Peeled Raw Yam (PRY). They were cut into very thin slices and dried in the open air inside the Chemistry Laboratory for four days until crispy in consistency. The dried PRY slices were homogenized into fine powder with pestle and mortar. The powder was stored in sterilized dry amber colored bottle with screw top for proximate and trace metal analysis. The remaining five tubers (10Kg)were not peeled but well washed and air-dried before the whole yam tubers were roasted with coal fire on iron wire mesh. The roasted yam tubers (RYT) were allowed to cool after which the burnt skin was scraped with sterilized knife. RYT were cut into very thin slices and air-dried for four days until crispy in consistency. The dried RYT were homogenized using pestle and mortal and stored for two months in an oven-dried amber colored bottle with its screw top.

Determination of Proximate Composition

Determination of moisture content

The method of Association of Official Analytical Chemists (AOAC) (1995) was employed using hot air drying oven. Empty clean crucible dish were dried in the oven at a temperature of 105^{0}Cfor one hour and cooled in a desiccator. Two grams (2Kg) of the samples were weighed and put in to the dish and heated overnight (24 hours) (Olajumoke *et al.*, 2012). The dish were then removed from the oven, cooled in a desiccator and weighed. The moisture content was calculated as:

$$\%\ Moisture = \frac{wt\ loss}{sample\ wt} x100$$

Determination of ash content

The method of AOAC (1995) was used to determine the percentage of ash content. Two grams of each dried sample was weighed in to a pre-heated and cooled crucible and incinerated in a muffle furnace at 200^{o}C for four hours (Onwuka and Ihuma, 2007). The ash wAS then cooled in desiccators and weighed. Ash content was calculated using;

$$\%\ \text{Ash} = \frac{\text{Weight of Ash}}{\text{Weight of Sample 1}} \text{x}100$$

Determination of crude fibre

Two grams of the powdered sample weighed and placed in 500ml conical flask containing 200cm^3 of 1.25% H_2S0_4 and were boiled gently for thirty minutes. The content was filtered and the residue was scrapped back in to the flask with spatula. 200cm^3 of 1.25% NaOH was added and were allowed to boil gently for 30 minutes. The content was filtered and washed thoroughly with hot distilled water. The precipitate was rinsed once with 10% HCl and twice with ethanol. The content was allowed to dry and the residue was scrapped into a weighed crucible and was dried overnight at 105^{o}C in hot oven. It was cooled in desiccators. The sample was then heated at 600^{o}C for ninety minutes in a furnace. It was finally cooled in a desiccator and weighed again(Afiukwu*et al.*, 2013).

The percentage Crude fibre was calculated using the equation below:

$$\%\ crude\ fibre = \frac{Wt\ loss\ on\ ignition}{Wt\ of\ sample} x\ 100$$

Determination of crude fat

Two grams each of dried samples were weighed into a porous thimble, and its mouth covered with cotton.The thimble

was then placed in an extraction chamber were then suspended above a receiving flask containing petroleum ether (BP. 40 – 60^{o}C).

The flask was then heated on hot mantle and the oil was extracted. The extraction continued for eight hours after which the thimble were removed from the soxhlet and heated over water bath, the flask containing the oil were disconnected, cleaned up and placed in an oven at 100^{o}C for thirty minutes. The flask was then cooled in desiccators and weighed. The percentage crude lipid content was calculated using.

$$\%\ Crude\ fat = \frac{Wt\ of\ oil\ extracted}{Wt\ of\ sample} x\ 100$$

Determination of crude protein

Two grams of the samples weighed in to Kjeldahl digestion flask and catalyst mixture of $NaSO_4$, $CuSO_4$ and selenium Oxide in (10:5:1) were added to each sample which were followed by 10cm^3 of concentrated H_2SO_4. The content in the flask were then heated in the Kjeldahl digestion flask for one and half hour, ensuring that digestion was completed. The flask was cooled and the content diluted with 10ml distilled water. The diluted content was filtered in to 100ml volumetric flask and was made up to the mark with distilled water. Ten (10cm^3)of the aliquot was taken into digestion flask and 20cm^3 of 45% NaOH solution were added to it. The content was diluted to about 200cm^3 with distilled water and distilled using micro Kjeldahl distilled apparatus. The distillate was received into a flask containing 10cm^3 boric acid solution indicator after the distillation. The distillates were then titrated with 0.01MHCl to the end point.

$$crude\ protein(\%) = \frac{TVx\ CxFxV1}{WxV2} x\ 100$$

Where: TV = Titer Value of the Acid; C = Concentration of Acid used V1 = Volume of the distilled water used for diluting the digest; V2 = Volume of aliquot used for titration; W = weight of Sample used; F = protein Multiplication Factor 0.0014

Determination of carbohydrate

The total amount of carbohydrate in the sample was obtained by using the weight difference percentage (Onwuka and Ihuma, 2007). This was done by subtracting the percentage sum of the food nutrients (% crude protein, % crude fat, crude fibre and ash) from 100% dry weight.Percentage carbohydrate was calculated, using the formula bellow;

Carbohydrate % = 100 – (Crude Protein + Crude Fat + Crude Fibre + Ash).

Determination of Macro and Micro

Ashing and digestion of the yam flour samples were carried out in line with the methods described by AOAC (1995). The digestates were used for macro and micro element determinations. Macro elements; Calcium, potassium, titanium, chromium, iron, nickel were determined by using X-ray fluorescence (XRF) method, whereas cadmium, lead, copper, zinc, aluminum and arsenic were determined by AAS method (James, 1995; Onwuka, 2007; Alinor and Akalezi, 2010; Olajumoke*et al.*, 2012).

RESULTS AND DISCUSSION

Proximate components

The results on the observed moisture content (MC) (Table 1) of the raw roasted yam (RYT) (0.93%) was significantly ($P<0.05$) lower than that of the peeled raw yam (PRY) (58.80%). According to Ihokoronye and Ngoddy (1985) and Osagie (1992), moisture content is an index of perishability and storability of food materials.So the high moisture content of PRY compared to very low moisture content in RYT sample in this study showed that RYT may be stored better than PRY; this difference may probably be due to the different methods of preparation. The MC value of PRY of *D. rotundata* reported by Alinor and Akalezi (2010) was higher but fairly consistent with the MC reported on *D. bulbifera* (61.93%) and *D. alata* (73.83%) species.

The results of the dry matter (ash) content of the two samples were significantly different; 1.28% (RYT) and 10.93%) (PRY). The former was lower than what was reported (1.84%) by Lawal *et.al.* (2012) in *D. rotundata* and higher when compared to 0.6-1.7% reported by Osagie (1992). Carbohydrate content obtained in this study from RYT (73.20%) was higher than PRY (69.56%). These values were higher than 40.61% reported by Alinor and Akalezi (2010) but were not different from what was reported (69.50%) by Lawal*et al.*(2012). The result confirmed the fact that yam is a carbohydrate food.The crude protein content of RYT and PRY (3.86% and 4.70%, respectively) were not significantly different. The protein content in PRY was higher than that reported (0.082%) by Alinor and Akalezi (2010).

The crude fat contents of RYT and PRY (0.59% and 0.63%, respectively) obtained in this study were not significantly different ($P>0.05$) but slightly higher in PRY. Both values are higher than0.17% reported by Afiukwa*et al*. (2013), and lower than 0.84% reported by Lawal *et al.* (2012). The fiber contents of RRY and PRY were not significantly different ($P>0.05$) but very low 0.39% and 0.42%, respectively.

The results after day 60 of storage (Table1) showed that almost all the proximate composition have been reduced while the moisture content increased. The most affected was the carbohydrate content probably used by the associated fungi as a source of energy for growth.

Table 1.Proximate component (%) of RTY and PRY *D. rotundata*

Sample	Moisture		Ash		Carbohydrate		Protein		Crude Fat		Fiber	
	D_0	D_{60}	D_0	D_{60}	D_0	D_{60}	D_0	D_{60}	D_0	D_{60}	D_0	D_{60}
PRY	58.80b	60.03b	10.93b	12.35b	69.56a	53.24a	4.70a	2.52a	0.63a	0.48a	0.42a	0.36a
RYT	0.93a	1.65a	1.28a	3.33a	73.20a	72.01b	3.86a	3.10b	0.59a	0. 56b	0.39a	0.34a

Values followed by the same alphabets along the same column were not significantly different at $P < 0.05$ DMRT

D_0= Day 0, D_{60} = Day 60

Mineral Element Composition

The result of the mineral composition (Table 2) revealed that the composition of mineral content was higher in RYT than PRY probably because the latter has been peel. The level of K, Fe and Al content of RYT and PRY were not significantly different (P>0.05). The two samples had higher composition of Zn, Fe and Cu level compare to other mineral contents.

These notwithstanding, both samples in this study contained low concentrations of potassium and calcium compared to USAID Nutrient Database, K([816mg(17%), Ca (17mg(2%)(Osagie (1992) and Oti and Nwabue (2013).This might be due to mode of uptake of these mineral elements from soil and other edaphic factors. Though the results of this study showed low amounts of macro and micro mineral elements compared to their values reported by USAID Nutritional Data Base, Osagie (1992) and, Oti-Wilberfore and Nwabue (2013). This observation in RYT might be due to the processing (roasting) (Osagie, 1992). However, the concentrations of these mineral elements fell within nutritionally permissible limits,(FAO/WHO,1984;USAD Nutrient Database, Chatterjea and Shinde,2013) which were set as K(0.02-0.04mg or 200mg/dL),Ca(17ppmor9-11mg/dL), Zn(27.4ppm/0.24mg or 24.18-74.60mg/Kg or 0.3mg-20mg/kg body weight), Cu(0.18/40.12-60.12mg/Kg or 0.05-2,5mg/kg body weight), Ni(8.24-14.86mg/Kg/2.6/L or 20µg per adult), Fe(0.54mg or 2.3-3.8g body weight). The low concentrations of the macro and micro mineral elements in the *D. rotundata* samples indicate their safety for consumption.

Table 2. Macro and Micro Mineral composition (mg/100g) in RYT and PRT

Sample	K	Ca	Fe	Ni	Cu	Zn	Al
RYT	1.61 ± 0.2a	0.24 ± 0.2b	83 ± 0.1a	0.25 ± 0.2b	39 ± 0.2b	754 ± 0.2b	0.30 ± 0.2a
PRY	1.61 ± 0.2 a	0.01 ± 0.2a	83 ± 0.1a	0.01 ± 0.2a	37 ± 0.2a	735 ± 0.2a	0.28 ± 0.2a

Values followed by the same alphabets along the same column were significantly different at $P < 0.05$ DMRT

A total of six fungi from four genera were isolated at the end of day 60. The associated fungi may be as result of contamination during processing. Only two species were isolated from RYT as against all the six species in PRY probably because sample RYT was roasted leading to elimination of the spores.

Table3.Fungal population in samples on the sixtieth day

Isolated fungi	PRY	RYT
Aspergillus flavus	+	+
Aspergillus fumigatus	+	-
Aspergillus niger	+	-
Penicillium notatum	+	-
Mucor species	+	-
Rhizopus stolonifer	+	+

+ = present - = absent

CONCLUSION

This study revealed that*Dioscorearotundata* (white yam) samples contain all the proximate composition regardless of how it was processed to flour. However, roasting before grinding to flour stored and retained the food content better and reduced the population of fungi growth.

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