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Evaluation of the physico-chemical properties of twelve *D. rotundata* land races grown in south-east agro-ecology

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ABSTRACT

This study was aimed at characterizing twelve land races of D. rotundata tubers (namely: Ameh, Ekpe, Okpani, Jiaga, Adaka, Nwokpoko, Miyango, Gwari, Aloshi, Hembakwase, Giwa and Dan Jaling) in terms of their physico-chemical properties and textural quality of pounded yams made from them. The yam samples were analysed for their physico-chemical properties such as dry matter, starch, amylose, amylopectin contents, water and oil absorption capacity, swelling index, bulk density and gelatinization temperature which were determined using standard analytical methods. Pounded yam produced from the yam varieties were assessed by a panel of 20 judges for colour, smoothness, elasticity, mouldability and general acceptability. The results showed that there were significant differences in the physico-chemical properties of the different varieties. Ameh had the highest dry matter content of 42%, starch yield ranged from 16.40% for Jiaga to 26.34% for Ekpe. The amylose content ranged from 14.56% for Hembakwase to 32.72% for Okpani. The yam flours had high bulk densities ranging from 0.706 for Giwa to 1.05g/cm^3 for Jiaga. Hembakwase had the highest swelling index (2.44). Pounded yam produced from Hembakwase was the most preferred of the twelve landraces investigated. Most D. rotundata landraces have very good functional properties which can be explored for different food formulations.

Key words: Land races, functional properties, sensory evaluation, amylose content.

INTRODUCTION

The yams are members of the genus Dioscorea in the section, *Enantiophyllum*. Yams (*Dioscorea*) are a vital component of the agricultural sector of West Africa, in terms of food, social, and cultural values. Yam is grown and cultivated for its energy-rich tuber. White yam (*Dioscorea rotundata* Poir), is the most favoured yam species in West Africa because it possesses a highly viscous starch. Boiled yam, pounded yam and *amala* are yam products most consumed in West Africa [1]. Yam is an excellent source of starch, which provides caloric energy [2]. Starch is an important functional food biopolymer that contributes to the quality of the final food product [3]. Yam starch accounts for about 60-80% of the dry matter of yam tuber (on dry weight basis). Functionality of a food is the property of a food ingredient apart from its nutritional value that has great impact on its utilization [4]. Sensory properties such as texture, appearance and taste are the main acceptability factors used by consumers to assess the quality of yam [5]. These sensory factors are influenced by the physico-chemical and pasting properties of the starch. Sustainable production and utilization of yam are important steps in enhancing food security and alleviating poverty, especially in West Africa where it is estimated to provide more than 200 dietary calories each day for over 60 million people [6-7]. This study was aimed at:

1) Characterizing different land races of *D. rotundata* tubers in terms of their physico-chemical properties.
2) Evaluating the quality of pounded yam made from these land races.
3) Establish a relationship between physico-chemical properties of the landraces and the products they will be best used for.

This information will be useful in increasing the use of yam flour in the production of value-added products and in selection during breeding for improved food qualities.

MATERIALS AND METHODS

Twelve varieties of *Dioscorea rotundata* namely: *Ameh, Ekpe, Okpani, Jiaga, Adaka, Nwokpoko, Miyango, Gwari, Aloshi, Hembakwase, Giwa* and *Dan Jaling*; obtained from the yam programme of National Root Crops Research Institute, Umudike were used for the experiment.

Determination of moisture content

Two grammes of each of the fresh yam pulps were weighed into dried weighed crucibles. The samples were placed in a moisture extraction oven at 105°C and heated for 3hrs. The dried samples were put into desiccators, allowed to cool and reweighed. This process was repeated until constant weights were obtained. The percentage moisture was calculated as follows:

$$\text{Percentage moisture} = \frac{(W_2 - W_3)100}{W_2 - W_1}$$

Where
W_1 = weight of empty dish
W_2 = weight of dish + wet sample
W_3 = weight of dish + dried sample.

Determination of amylose:

Amylose content was determined with the method of Williams *et al.*, [8]. Hundred micrograms of the yam flour was weighed and transferred to 100ml volumetric flasks. One microliter of 95% ethanol and 9ml of 1N sodium hydroxide (NaOH) were added carefully. The sample was heated for 10mins. in a boiling water bath to gelatinize and then cooled and made up to volume with water. A 5ml portion of the starch solution was pipetted into a 100ml volumetric flask, and 1ml of 1N acetic acid, then 2ml of iodine solution were added and then made up to 100ml with distilled water. The solution was shaken and the absorbance was determined with Jenway 6320D spectrophotometer at 620nm after 20 minutes. Amylose content was estimated thus:

$$\text{Amylose content (\%)} = (3.06)(A)(20) = 61.20(A)$$

$$\text{Amylopectin} = 100 - \text{Amylose content}$$

Determination of bulk density

This was carried out using the method of Okezie and Bello, [9]. A specified quantity of the flour sample was transferred into an already weighed measuring cylinder (W_1). The flour sample was gently tapped to eliminate spaces between the flour and the level was noted to be the volume of the sample and then weighed (W_2).

$$\text{Bulk density (g/cm}^3) = \frac{W_2 - W_1}{\text{Volume of sample}}$$

Determination of water and oil absorption capacity

Water absorption capacity was determined using the method of Sathe and Salunkhe, [10] as modified by Adebowale *et al.*, [11]. Ten millilitres of distilled water was added to 1.0 g of the sample in a beaker. The suspension was stirred for 5 minutes. The suspension obtained was then centrifuged (with Celtech 80-2B centrifuge) at 3555 rpm for 30 minutes and the supernatant measured in a 10 mL graduated cylinder. Water absorbed was calculated as the difference between the initial volume of water added to the sample and the volume of the supernatant. The same procedure was repeated for oil absorption except that oil was used instead of water.

Determination of swelling index:

The swelling capacities of the samples were determined using the method of Lin *et al.*, [12], with slight modification by Adebowale *et al.*, [11]. One gram (1 g) of the flour sample was dispersed in 10 ml of cold distilled water in a graduated centrifuge tube. The suspension was left at room temperature for 5 minutes to absorb water. After 5 minutes the mixture was centrifuged (with Celtech 80-2B centrifuge) at 2000 rpm for 30 minutes and the volume of the sediment recorded as initial volume. Another 1 g of the sample was dispersed in a centrifuge tube of known weight and the suspensions heated in boiling water for 30 minutes. The suspension was cooled to room temperature under the tap water and then centrifuged at 2000 rpm for 30 minutes using a stirrer. The volume of the heated sediment was recorded as final volume:

$$\text{Swelling index} = \frac{\text{Final vol. after heating}}{\text{Initial Vol. before heating}}$$

Sensory evaluation

Pounded yam was prepared from the different yam varieties using the method described by Otegbayo *et al*., [13]. A taste panel evaluation of the pounded yam samples was conducted using a panel of 20 judges who were regular consumers of pounded yam. The judges were asked to score for colour, smoothness, elasticity, mouldability and general acceptability using a 9-point hedonic scale, where 1 and 9 represent dislike extremely and like extremely respectively.

Statistical analysis

Data generated from the physico-chemical and sensory analysis were subjected to Analysis of variance (ANOVA) using the SAS statistical package version 9.0. Means were separated using Fischer's LSD at 5% level of probability.

RESULTS AND DISCUSSION

The moisture content of the *D. rotundata* varieties ranged between 58.00% for *Ameh* and 76.65% for *Okpani* as shown in table 1. The higher the moisture content the higher the rate of spoilage. There were significant ($p<0.05$) differences in moisture content among the different varieties. Dry matter is an important chemical index of food quality in root and tuber crops and relates positively with good eating qualities and good textural properties [14]. *Ameh, Giwa* and *Jiaga* had the highest dry matter content of 42, 41.11 and 39.05% respectively. High dry matter content is desired because the dry matter is composed of starch, fibre, protein etc.

Starch yield ranged between 16.40% for *Jiaga* and 26.34% for *Ekpe*, *Okpani* and *Jiaga* had the lowest starch yield while *Ekpe*, *Miyango*, *Hembakwase*, *Nwokpoko*, *Adaka*, *Ame* and *Dan Jaling* have high starch yield as shown in table 1. Starch is an important factor in determining the physicochemical, rheological and textural characteristics of yam food products. There were significant differences ($p<0.05$) in the starch yield of the different land races, this supports the report [15] that differences in starch content and properties may occur among the cultivars of the same species even under identical environmental conditions.

The amylose content and amylose properties of starch dictate most of its uses and determine the properties of starch. The amylose content of the *D. rotundata* landraces ranged from 14.56 (for *Hembakwase*) to 32.72% (for *Okpani*). This is similar to the range of 27.45 to 32.803% reported [16] and 27.47 to 41.90% reported [17] for *D. rotundata*. There were significant differences ($p<0.05$) in amylose content amongst the twelve varieties of *D. rotundata*. The amylose portion of starch affects its swelling and hot paste viscosities [17]. High amylose contents are desired in starches that are to be used for the manufacture of extrudates [18]. Amylopectin content of the landraces ranged between 67.28% for *Okpani* and 85.45% for *Hembakwase*. Amylose/amylopectin ratio gives specific characteristics and functionality to starches by determining the texture and nature of their products [19-20].

Table 1: Chemical composition of some *D. rotundata* land races

Sample	Moisture Content (%)	Dry Matter (%)	Starch Yield (%)	Amylose (%)	Amylopectin (%)
Aloshi	61.60^{de}	38.40^{bc}	19.68^{ab}	15.20^{d}	84.80^{b}
Nwokpoko	63.50^{cd}	36.50^{cde}	22.68^{ab}	26.47^{b}	73.54^{d}
Hembakwase	63.66^{cd}	36.34^{cde}	23.09^{ab}	14.56^{e}	85.45^{a}
Okpani	76.65^{a}	23.35^{g}	16.87^{b}	32.72^{a}	67.28^{e}
Miyango	63.05^{cd}	36.95^{cde}	23.86^{ab}	17.23^{cd}	82.77^{bc}
Dan jaling	64.83^{c}	35.17^{de}	20.91^{ab}	28.34^{b}	71.67^{d}
Ekpe	62.55^{cd}	37.45^{cd}	26.34^{a}	30.02^{a}	69.98^{e}
Ameh	58.00^{f}	42.00^{a}	20.83^{ab}	26.71^{b}	73.29^{d}
Giwa	58.89^{ef}	41.11^{ab}	19.22^{ab}	16.87^{cd}	83.14^{bc}
Jiaga	60.95^{def}	39.05^{abc}	16.40^{c}	15.49^{d}	84.52^{b}
Adaka	65.60^{bc}	33.85^{ef}	21.58^{ab}	26.35^{b}	73.65^{d}
Gwari	68.08^{b}	31.92^{f}	19.22^{ab}	19.34^{c}	80.66^{c}
LSD	3.126	3.150	7.134	3.677	3.677

Means with same superscripts in the same column are not significantly different at 5% level of significance.

The functional properties of the *D. rotundata* landraces are shown in Table 2. The bulk density of the flours of the landraces ranged from 0.706 for *Giwa* to 1.050g/cm^3 for *Jiaga*. The bulk density is influenced by particle size and the density of the flour and is important in determining the packaging requirement and material handling [21]. The high bulk density of the flours suggests that they can be used as thickeners in food products and should not be used in formulations where low bulk density is required such as in baby foods. Water absorption capacity is the ability of flour to absorb water and swell for improved consistency in food. It is desirable in food systems to improve yield and consistency and give body to the food [22]. The water absorption capacity of the landraces ranged from 2.60 to 4.50ml/g. A high water absorption capacity is required for flours used in dough products and soup thickening.

[23] reported that the swelling power of flour granules is an indication of the extent of associative forces within the granule. Swelling power is also related to the water absorption index of the starch-based flour during heating [24]. Therefore, the higher the swelling power, the higher the associate forces [25]. The variation in the swelling power indicates the degree of exposure of the internal structure of the starch present in the flour to the action of water. Moderate and high swelling power enhance the functionality of flours in such food systems like breakfast cereals, baby foods and *fufu* [26]. These results obtained indicated that flour and starch derived from *Hembakwase* and *Aloshi* could be useful in breakfast cereals, baby foods and other food formulations where high swelling capacity is required.

The gelatinization temperature ranged from 74.5^o in *Giwa* to 89.5^o in *Nwokpoko*. This suggests that these flours should not be added to a formula where gelling is required below 70^{o}C. This also implies that more heat energy may be required for the full gelatinization of these starches in comparison with conventional starch.

Table 2: Functional properties of the *D. rotundata* land races

Sample	WAC (ml/g)	OAC(ml/g)	BD (g/cm^{3})	SI	GT (^{o}C)
Aloshi	2.95^{d}	2.45^{cd}	0.78^{bcd}	2.40^{b}	76.50^{b}
Nwokpoko	4.05^{b}	2.65^{c}	0.77^{bcd}	1.39^{f}	89.50^{a}
Hembakwase	3.05^{d}	2.35^{cde}	0.81^{bcd}	2.44^{a}	77.50^{b}
Okpani	3.85^{b}	3.70^{a}	0.85^{bc}	1.20^{k}	82.50^{ab}
Miyango	2.95^{d}	2.25^{de}	0.90^{b}	1.35^{h}	79.50^{ab}
Dan Jaling	3.85^{b}	2.05^{e}	0.75^{b}	1.36^{g}	79.00^{ab}
Ekpe	3.75^{bc}	1.60^{f}	0.75^{cd}	1.32^{j}	81.50^{ab}
Ameh	4.50^{a}	3.05^{b}	0.83^{bcd}	1.47^{d}	75.00^{b}
Giwa	2.60^{e}	3.25^{b}	0.71^{d}	1.33^{i}	74.50^{b}
Jiaga	4.05^{b}	2.55^{cd}	1.05^{a}	1.57^{c}	76.00^{b}
Adaka	3.45^{c}	0.83^{bc}	0.83^{bcd}	1.57^{c}	80.00^{ab}
Gwari	3.95^{b}	3.65^{a}	0.77^{bcd}	1.45^{e}	82.50^{ab}
LSD	0.327	0.348	0.145	0.008	10.748

Means with same superscripts in the same column are not significantly different at 5% level of significance.
Where: WAC = water absorption capacity, OAC = oil absorption capacity, BD = bulk density, SI = swelling index, GT = gelatinization temperature.

The mean value of sensory evaluation scores for pounded yam produced from the twelve land races are shown in table 3. There were significant differences (p<0.05) in the panellists' rating of the samples for all the parameters investigated. Pounded yam produced from most of the land races were liked by the panellists except *Okpani*, *Dan Jaling* and *Giwa*. *Hembakwase* had the highest rating for all the parameters. *Dan Jaling* ranked the lowest in smoothness while *Okpani* was rated the lowest in elasticity, mouldability and general acceptability.

Table 3: Sensory evaluation on pounded yam samples from the *D. rotundata* land-races

Sample	Colour	Smoothness	Elasticity	Mouldability	General Acceptability
Ameh	6.75^{bcd}	6.19^{cde}	6.75^{ab}	7.00^{ab}	7.19^{ab}
Ekpe	6.69^{bcde}	7.06^{abc}	6.81^{ab}	6.38^{bc}	6.44^{bc}
Adaka	6.25^{cde}	7.56^{ab}	6.69^{ab}	6.88^{ab}	6.50^{bc}
Jiaga	6.88^{abc}	6.94^{abcd}	6.00^{bc}	6.94^{ab}	6.88^{bc}
Okpani	5.56^{ef}	4.50^{fg}	3.56^{e}	3.06^{e}	4.31^{e}
Hembakwase	7.94^{a}	7.75^{a}	7.63^{a}	7.94^{a}	8.06^{a}
Giwa	5.00^{f}	5.19^{ef}	4.38^{de}	5.31^{cd}	5.06^{de}
Gwari	7.56^{ab}	6.81^{abcd}	5.94^{bc}	6.63^{abc}	7.31^{ab}
Miyango	7.56^{ab}	5.81^{de}	5.25^{cd}	5.88^{bcd}	5.81^{cd}
Nwokpoko	6.69^{bcde}	6.19^{cde}	5.88^{bc}	6.00^{bc}	6.19^{bcd}
Dan Jaling	5.69^{def}	3.75^{g}	3.94^{e}	4.69^{d}	4.56^{e}
Aloshi	7.19^{abc}	6.38^{bcde}	7.00^{ab}	6.63^{b}	6.56^{bc}
LSD	1.176	1.204	1.306	1.295	1.169

Means with same superscripts in the same column are not significantly different at 5% level of significance.

CONCLUSION

The results obtained from this study showed that *D. rotundata* landraces have very good functional properties which could be harnessed in the formulation of various food forms. *Hembakwase, Aloshi, Jiaga, Giwa* and *Miyango* would be recommended for formulations where expansion is needed like in bread and pudding making while *Okpani, Ekpe* and *Dan Jaling* would be recommended for formulations where crispness is needed such as extrudates and biscuits. All the land races were good for pounded yam except *Okpani* and *Dan Jaling*.

REFERENCES

[1] Akissoe HN, Houhouigan DJ, Bricas N, Vernier P, Nago CM, Olorunda OA, *Trop. Sci*. **2001**, 41, 151-155.
[2] Coursey DG, Cassava as Food: Toxicity and Technology. In: B. Nestel, R. MacIntyre, (Eds.), Chronic Cassava Toxicity, Ottawa, Canada, IDRC, IDRC, **1973**, 10, 27-36.
[3] Brunnschweller J, Denise L, Handschin S, Farah Z, Escher F, Conde-Petit B, *Starch/Starke* **2005**, 57, 107-117.
[4] Mahajan A, Dua S, *Cereal Chem*. **2002** 79, 834–837.
[5] Bourne MC, Basic principles of food texture measurement. In: Dough and baked product texture. Faridi H, Faubion JM, (edns). Van Nostrand Reinhold **1990**, 331-341.
[6] Nweke FC, Ugwu BO, Asadu CL, "Production cost in yam based cropping system in South western Nigeria", Research monograph, IITA Ibadan, Nigeria, **1991**, 6, 4-12.
[7] FAO Food and Agricultural Organization. FAOSTATDATA. FAO. Rome, Italy, **2002**.
[8] Williams PC, Kuzina FD, Hlynka IA, *Cereal Chem*. **1970**, 47, 411-420.
[9] Okezie BO, Bello AB, *J. Food Sci*. **1988**, 53, 450-454.
[10] Sathe SK, Salunkhe DK, *J. Food Sci*. **1981**, 46, 71-75.
[11] Adebowale YA, Adeyemi IA, Oshodi AA, *African Journal of Biotechnology*, **2005**, 4,12,1461-1468.
[12] Lin MJY, Humbert ES, Sosulski F, *J. Food Sci*. **1974**, 39, 368.
[13] Otegbayo B, Aina J, Sakyi-Dawson E, Bokanga M, Asiedu R, *J. Texture Studies* **2005**, 36, 476-488.
[14] Izutsu T, Wani K, *J. Texture Studies*, **1985**, 16, 1, 1-28.
[15] Ratnayake WS, Hoover R, Sahidi T, Perera C, Jane J,. *Food Chem*. **2002**, 44, 189-200.
[16] Otegbayo JA, Akingbola TS, Akinyemi JO, Adedapo KS, Odaibo GN, Aken Óva YA, Olaleye DO, Adewole IF, Murphy R, Kanki P, *World J. AIDS*, **2011**, 1, 31-36.
[17] Oke MO, Awonorin SO, Workneh TS, *African journal of Biotechnology*, **2013**, 12, 11, 1250 - 1256.
[18] Oluwole OB, Effect of thermo extrusion cooking on physicochemical, textural and sensory qualities of yam (*Dioscorea rotundata*) and bambara groundnut (*Voandezeia subterranean L. Thou*) blends. Unpublished Ph.D thesis, UNAAB, Abeokuta, Nigeria. **2008**, 117-213.
[19] Moorthy SN, Tuber crop starches. Technical Bulletin, Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India. **1994**, 18.
[20] Scott H, Understanding starch functionality; relating structure and function. In: Food Product design. January edn. Scott, H. weekly publishing co. North brook, IL. **1996**, 1-7.
[21] Karuna D, Noel G, Dilip K, Food and Nutrition Bulletin, United Nation University, **1996**, 17, 2.
[22] Osundahunsi OF, Fagbemi TN, Kesselman E, Shimoni E, *J. Agric. Food Chem*., **2003**, 51, 2232-2236.
[23] Moorthy SN, Ramanujam T, *Starch/Starke*, **1986**, 38, 2, 58 - 61.
[24] Loss PJ, Hood LF, Graham AJ, *Cereal Chem*., **1981**, 58, 282-286.
[25] Ruales J, Valencia S, Nair B, *Starch*, **1993**, 46, 1, 13-19.
[26] Okoli EC, Effect of Gammar irradiation on Biochemical, Malting and keeping Quality of sorghum grain. Ph.D. Thesis, Obafemi Awolowo University, Ile-Ife, **1998**, 37.