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Physico-Chemical Composition and Product Behaviour of Flour and Chips from Two Yam Sp. (*Dioscorea rotundata* and *Dioscorea alata*)

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Abstract: The proximate composition, functional properties, starch, amylose and amylopectin content of two major yam sp. (D *alata* and D *rotundata*) were evaluated. Also the fufu, cake and chips making potentials of the two yam sp. were compared. The result showed that the moisture content, ash, fibre, protein, fat, amylose fraction and total sugar were higher in D. *alata* while carbohydrate, starch content and amylopectin fraction were higher in D. *rotundata.* The D. *rotundata* also maintained higher values in most of the functional properties except in whippapability, emulsion capacity and wattability. D. *alata* produced more acceptable yam chips whereas D. *rotundata* gave more acceptable yam fufu and cake.

Key words: Yam, functional properties, proximate composition, cake, fufu, chips

INTRODUCTION

Yam is an important staple in Nigeria and other West African countries. Before the introduction of cereals and grains in West Africa, yam was the major source of carbohydrate[1]. Not only is yam an important stable food, yam is considered a man's crop and has ritual and socio-cultural significance. It is the food of choice of many ceremonies and festivals and an indispensable part of the bride price. Studies conducted in Eastern Nigeria by lageman[2] showed that yams constituted an average of 32% of farmer's gross income derived from arable crops. The two major varieties of yam consumed in Nigeria and other West African countries are D. *rotundata* and D *alata.* D. *rotundata* popularly called white guinea yam, is usually large cylindrical and the flesh is white while D. *alata* or water yam or greater yam, has white or reddish flesh and lose (watery) in texture[3].

It must be emphasized that by far the greater part of the world's yam crop is kept and eventually consumed in the fresh state. Nevertheless, as a result of the combination of a high degree of perishability, bulkiness, distance from production areas to consuming centers and the seasonal nature of production, attention has been focused on the processing of tubers into flour. They depend on some vital functional properties of the yam varieties[4-6].

Earlier study of Rasper and Coursey[7] on some functional properties of yam showed that significant differences exist in viscosities among the yam starches. D. *rotundata* was observed to give the most viscous solutions but exhibits a low swelling power, while D. *rotundata* gave the strongest gel and pasting temperature ranging between 76 and 85°C. Rosenthal *et al.*[8] reported a high swelling power of D. *alata* starches and related these characteristics to the bounding forces in the starch granules. Rasper[9] noted that hot paste viscosities of D. *alata*, sweet potatoes and cassava starches are in the same range.

The results of the chemical analysis of starches of the major West African yam sp. carried out by Rasper and Coursey[7] indicated that the amylose contents of starches extracted from D. *roundata* and D. *alata* were between 21 and 23% and are larger than those of other yam sp.[10].

D. *alata* is often recommended to diabetic patients as tolerable energy sources[11]. Martin and Ruberts[12] working on the preliminary uses of different yam sp. in the production of chips and French fries showed that sp. other than D. *alata* usually do not yield good chips. Osagie[13] recommended the frying temperature of yam chips to be 137.8-148.9°C if the chips colour will not be badly affected.

Knowledge of the physico-chemical and functional properties of yam sp. could be used to predict and interpret their behaviour under actual cooking and cooling conditions Hariprakesh and Bala[14]. This could also enable one seek to modify the starches if necessary to suit product and processing demands Agwunobi[15]. The

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thrust of this study is on the evaluation of the food potentials of the two yam sp. as relates to some of their properties.

MATERIALS AND METHODS

Preparation of yam flours: The two yam sp. chosen for this study, *Discorea alata* and *Discorea rotundata* were purchased from Umuahia main market, Nigeria. 10 kg of each sp. were cut, peeled and immediately immersed in 1.5% sodium metabisulphite separately. The yams were then boiled in water at 80°C for 30 min. The water was drained and cut into thin slices of about 1 mm. The slices were then dried in an oven at about 60° C for 6-10 h until it became dry and crispy. The dried yam chips were finally milled with an electric disc, mill, sieved through a muslin cloth and packed in polyethylene bags.

Yam fufu: Four samples of yam fufu were made using the yam flours and fresh yam from the D. *alata* and D. *rotundata*. In the production of the flour-based fufu, 4 parts of water to 6 parts of flour were used. It was made by first bringing the water to boil, the flour was then gradually introduced while stirring until a thick consistency dough was produced.

On the other hand fufu from the fresh yam sp. were made by cutting and peeling 500 g of each sp.. They were then diced into small cubes and boiled until tender. The boiled yams were finally pounded in a mortar with pestle until a soft dough was produced.

Cake production: Five samples of cake were made from the blends of yam and wheat in the following ratios:

- 100% wheat flour based cake
- 100% D. *alata* flour based cake
- 100% D. *rotundat*a based cake
- 50% wheat/50% D. *alata*
- 50% wheat/50% D. *rotundata*

The following ingredients were used in the recipe for the cake-300 g flour, 150 g sugar, 150 g butter, 1 teaspoon baking powder, 3 eggs, flavour (1 teaspoon) dry fruits 10 g, pinch of salt. In the cake production the creaming method described by O'reilly[16] was used. The sugar and butter were first creamed in a bowl. The eggs were cracked and whisked using egg whisker. The baking powder, pinch of salt, flavouring and dried fruits were added and stirred. The cake mixture were poured into an already greased pan and baked at 210°C for 30 min.

Yam chips production: One tuber each of the D. *alata* and D. *rotundata w*ere cleaned to remove sand and dirt. They were cut and peeled, washed and sliced to 1 mm thick manually with a knife. The slices were seasoned with a pinch of salt and drained in a colander to remove the surface water. The drained yams were then fried in a hot deep frying vegetable oil. The frying chips were occasionally stirred to ensure that the slices were not sticking to each other. The chips were removed when crispy and golden brown in colour, drained and packaged in coded polythene bags.

Chemical analysis of yam samples: The moisture content, crude protein, ash, fat, crude fibre were determined according AOAC[17] methods, while the carbohydrate was evaluated by difference. The estimation of starch in tubers was carried out by the method of Balagopalan *et al.*[18]. Also the fractionating and evaluation of amylose and amylopectin were conducted as enunciated by Balagopalan *et al*[18]. Authrone method of Balagopalan *et al*[18] was employed in the determination of total soluble sugar.

Evaluation of the functional properties: The methods of Narayana and Narasinya-Rao[19] were used in the evaluation of the following functional properties of the yam tuber samples: gelling temperature, water absorption capacity, oil absorption capacity, swelling index, foam stability, whippability, wettability, emulsion capacity and bulk density. The pH was measured by making 10% w/v suspension of each sample in distilled water. Each suspension was mixed thoroughly in a beaker and the pH determined with a pH meter.

Sensory evaluation and data analyses: The yam chips, cakes and fufu were organoleptically assessed by a test panel comprising of 10 judges. Each product was evaluated by the 10-man panel of judges on a 9-point hedonic scale. In this scale 9 represented like extremely while 1 represented dislike extremely. Parameters or attributes evaluated were colour, taste, texture, crispness and overall acceptability. The scores were later subjected to analysis of variance (ANOVA) and the treatment means separated by least significant difference (LSD) according to Snedecor[20]. Other data generated were also subjected to statistical analysis using ANOVA and LSD.

RESULTS AND DISCUSSION

The result of the proximate and starch analyses is shown in Table 1. This result indicates that *Descorie alata* was significantly higher in moisture content, fibre

Table 1: chemical composition of *Discorea rotundata* and *Discorea alata*

Component (%)	*Discorea alata*	*Discorea rotundata*
Moisture content	69.49^a	64.84^b
Ash	2.75^a	2.25^a
Fibre	2.34^a	1.42^b
Protein	7.60^a	4.55^b
Fat	0.54^a	0.50^a
Carbohydrate	20.18^b	26.70^a
Starch content	13.88^b	20.92^a
Amylose fraction	24.77^a	20.03^b
Amylopectin	65.20^b	68.77^a
Total soluble sugar	4.27^a	3.81^b

Mean values on the same row with different superscript are significantly different ($p<0.05$)

Table 2: Functional properties of the yam flour

Functiona property	*Discorea alata*	*Discorea rotundata*
Gelation temperature (°C)	73.00^b	77.67^a
Bulk density (g mL^{-1})	0.79^a	0.82^a
Swelling index	1.77^a	2.15^a
Water absorption (g g^{-1})	21.95	2.43^a
Oil absorption (g g^{-1})	1.15^b	1.35^a
Whippability (%)	40.19^a	27.60^b
Emulsion capacity (g g^{-1})	82.13^a	73.73^b
Wettability (sec)	34.00^a	23.33^b
pH	6.15^a	6.54^a
	Foam stability	
1 (min)	10.00^a	8.40^b
10 (min)	8.90^a	8.20^b
30 (min)	8.04^a	7.80^b
40 (min)	7.40^a	6.79^b
60 (min)	5.11^a	5.99^b

Mean scores on the same row with different superscript are significantly different ($p<0.05$)

Table 3: Sensory evaluation of the yam chips

Sensory parameter	*Discorea alata*	*Discorea rotundata*
Colour	7.9^a	6.7^b
Taste	8.0^a	5.5^b
Flavour	7.5^a	6.3^b
Crispness	7.8^a	3.9^b
Overall acceptability	8.0^a	5.0^b

Mean scores on the same row with different superscript are significantly different ($p<0.05$)

and proteins than *Descorie roundata*. In earlier study carried out by Oyenuga[21], he found the protein content of D. *alata* to be in the range of 7.26-8.10 while that of D. *roundata* to be from 4.42-5.87. This apparently shows D. *alata* to be more nutrious, especially in terms of protein than D. *roundata*. This is why in recent times; rssearch efforts are gearing towards encouraging more diversification and consumption of D. *alata,* which is presently being under utilized.

On the other hand, D. *rotundata* had significantly higher content of total carbohydrate, starch and amylopectin than D. *alata*. This obviously explains why nutritionists recommend the use of more of D. *alata* in dietherapy of diabetic patients than D. *rotundata* as D. *alata* presents itself as a more tolerable energy source Okonkwo[11]. The Amylose/Amylopectin balance of both yam sp. showed why D. *rotundata* has a firmer and more maliable constitution than D. *alata* as it contains significantly higher amylopectin component with the attendant α 1, 6 glycosidic bonded structure.

The results of the functional properties of the yam sp. are given in Table 2. It is apparent from this Table that D. *rotundata* maintained significantly higher functional profile than D. *alata* especially as regards to the gelling temperature 77.69°C, swelling index (2.15) water absorption capacity 2.43 g g^{-1} and oil absorption capacity 1.35 g g^{-1}. D. *alata* however had higher significant values in whippability 40.19% emulsion capacity (82.13 g (g) and wettability (34.00 sec). This trend in the result of the functional properties is expected and can be explained by the fact that D.*rotundata* contained more complex amylopectin fraction of starch molecule than D. *alata.*

The amylopectin confers tighter structure that will present more cohesive effect in D. *rotundata*. Therefore flour of D. *alata* will show looser structure and lesser binding properties. D. *rotundata* will ultimate have higher water absorption property, oil absorption capacity and swelling index than D. *alata*. On the other hand, the loser structure of D. *alata* will be expected to show higher values of whippability, emulsion capacity and wettability.

In terms of utility, the functional properties of the two-yam varieties invariably influenced their ultimate use. D. *alata* significantly performed better than D. *rotundata* when both were used in the production of yam chips. D.*alata* showed a significantly better sensory scores in terms of yam chips' colour, taste, flavour, crispness and overall acceptability Table 3. This better performance of D. *alata* over D. *rotundata* in yam chips production is expected as D. *alata* has higher soluble sugar, lower starch content and looser structure which will invariably show a better oil absorption and better heat penetration effect. All these will affect the final colour, taste, flavour, crispness and overall acceptability.

On the other hand D. *rotundata* performed generally better in yam fufu production than D. *alata,* especially in its fresh form. Infact D. *rotundata* in its fresh form significantly gave a better result in terms of yam fufu colour than the rest and also maintained a leading sensory scores in flavour and overall acceptability Table 4. The better performance of D. *rotundata* over D. *alata* in yam fufu production could be attributed to the higher content of amylopectin which convey on the D. *rotundata* fufu more binding power and strength It can also be pointed out from this Table that all the yam varieties performed better in their fresh form than from the flour in the production of the yam fufu. This trend of result is quite normal as the fresh yam samples

Table 4: Sensory evaluation of fufu produced from *Discorea rotundata* and *Discorea alata*

Yam sample	Colour	Taste	Flavour	Texture	Overall acceptability
Fresh D.*alata* fufu	7.0^{b}	7.4^{a}	7.0^{a}	6.7^{a}	7.4^{ab}
D. *alata* flour fufu	4.5^{c}	5.5^{c}	5.2^{b}	6.3^{a}	5.4^{c}
Fresh D. *rotundata* fufu	8.2^{a}	7.1^{ab}	7.5^{a}	6.7^{a}	7.8^{a}
D. *rotundata* flour fufu	7.2^{b}	6.6^{b}	6.0^{a}	7.1^{a}	7.1^{b}

Mean scores on the same column with different superscript are significantly different (p<0.05)

Table 5: Sensory evaluation of cake produced from composite flour blends of *Discorea rotundata* and *Discorea alata* with wheat flour

Cake sample	Colour	Taste	Texture	Overall acceptability
D. *rotundata* flour cake	7.6^{bc}	6.5^{b}	5.4^{d}	6.4^{b}
D. *alata* flour cake	4.5^{d}	6.1^{b}	6.1^{c}	5.5_{c}
Wheat flour cake	8.3^{a}	8.1^{a}	8.1^{a}	8.2_{a}
alata/wheat flour cake (1:1)	6.4^{c}	7.0^{b}	6.9^{bc}	7.0_{b}
rotundata/wheat flour cake (:1)	7.5^{ab}	6.9^{b}	7.3^{ab}	7.3_{b}

Mean values on the same row with different superscript are significantly different (p<0.05)

retained the original inherent starch molecular structure giving the necessary rigidity and adhesiveness that determine the quality of yam fufu.

Wheat flour based cake performed better than all the yam based cakes, followed by D. *rotundata*/wheat flour blend, then D. *alata*/wheat four blend. The least performance was shown by D. *alata* based flour 100%. This obviously means that D. *rotundata* has a better bakery potential than D. *alata* Table 5.

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