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PHYSICOCHEMICAL AND SENSORY ATTRIBUTES OF SOME SELECTED VARIETIES OF WHITE YAM (*DIOSCOREA ROTUNDATA*)

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ABSTRACT

The physicochemical and sensory properties of five varieties of Dioscorea rotundata were investigated for their potential end uses. The water absorption capacity, water binding capacity, swelling power, solubility index, pH, and pasting properties of flour processed from the yam tubers were determined. Also, the sensory attributes of pounded yam produced from the tubers were evaluated. In terms of colour, Gbongi had the highest whiteness value (82.27). Lasinrin had the highest moisture content (39.47 %) and swelling capacity (6.11g/g), Efuru had the highest water absorption capacity (132.50%) and pH (6.75). Gbongi had the highest solubility index (13.82%). Awana had the highest peak viscosity (293.70RVU) holding strength viscosity (279.20RVU) and peak time (7.00min). Lasinrin had the highest breakdown viscosity (140.25RVU) setback viscosity (295.00RVU) and pasting temperature (82.55^{o}C) while Efuru had the highest final viscosity (437.83RVU). All the varieties had good ratings for the pounded yam sensory attributes (stretchability, stickiness, mouldability, smoothness, colour, hardness). All the varieties were acceptable regarding the general acceptability of the pounded yam. The qualities of yam cultivars suggested their appropriateness as an alternative for other flour-based pastes typically consumed by Nigerians.

Keywords: White yam, Physicochemical property, Sensory Property

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INTRODUCTION

Yam (*Dioscorea* spp) is an important multi-species tropical tuber crop that has about 600 known species (Obidiegwu and Akpabio, 2017). The most economically important species grown are white yam (*Dioscorea rotundata*), yellow yam (*Dioscorea cayenensis*), water yam (*Dioscorea alata*), Chinese yam (*Dioscorea esculenta*) aerial yam (*Dioscorea bulbifera*) and trifolate yam (*Dioscorea dumentorum*) (Djeri *et al*., 2015). Of all these important species, the white yam

(*Dioscorea rotundata*) is the most preferred and widely grown specie in West Africa. Nigeria is the largest producer of yam in the world and the country alone accounts for 65.5% of global production (FAO, 2018). Yam is a major and preferred staple food for over 300 million people in West Africa (Alabi *et al*., 2019). Yams are grown for their starchy, energy-dense tubers, which are essentially dietary supplements. Yams contain minerals such as potassium, sodium, phosphorus, sulfur, calcium, magnesium, iron, manganese, zinc, and copper, in addition to protein, lipids, and carbohydrates (Padhan and Panda, 2020). Yam continues to be a highly regarded food crop that is heavily included in West Africans' cultural, economic, religious, and social components in addition to being a part of many communities' diets, notably in the tropics and subtropics (Darkwa *et al*., 2020). Yam tubers can be eaten after being roasted, boiled, or processed into chips, flakes, and flour. Amala and pounded yam are two major traditional cuisines from yam tubers in Nigeria. Particularly, the pounded yam holds a major position, with consumption spanning many ethnic groups (Ufondu *et al*., 2022).

Despite these benefits of yam, its utilization in Nigeria is majorly subsistence with very few value-added products for local and international trade. This may be associated to sparse information on the food quality and industrial prospects of the crop. Using this crop's industrial potential will allow it to transit out of its current subsistence state and encourage the formation of small businesses, which will boost economic growth (Otegbayo *et al*., 2014). The farmers, consumers, and various yam end users are further guided on the utilization of yam food products by the tuber’s physicochemical, functional, and sensory qualities (Ufondu *et al*., 2022). The objective of this study is to investigate the physicochemical and sensory properties of five varieties of white yam in Nigeria.

MATERIAL AND METHODS

Sample collection

Five varieties of *Dioscorea rotundata* (*Efuru, Gbongi, Elentu, Lasirin, and Awana*) were obtained from the farmer’s market in Ogbomoso, Oyo state, Nigeria. Three wholesome tubers were selected for each variety. To prevent variation in composition along the tuber sections (anisotropic effect), 5cm of each of the proximal and distal ends of the tubers were cut off. The middle portions left of all tubers were converted into dry flour for analysis and for preparation of pounded yam for sensory evaluation.

Analyses

Colour Parameters Determination

The colour parameters of the samples were measured using chroma meter (Color Tec PCMTM Color Tec Associates, Konica Minolta Sensing, Inc., Japan). The colour of the tuber flesh was described in L* a* b* notation, where L* is a measure of lightness, a* defines components on the red-green axis and b* defines components on the yellow-blue axis. All determinations were done in triplicates.

Yam Flour Preparation and Moisture Content Determination

Yam tuber of 150g was diced into small cubes and dried in an air convection oven at 60^{o}C for 72h (Baah *et al.*, 2009). The resulting dried chips were weighed milled and then sieved with a 500µm open screen. The fine flour obtained for each variety was packaged separately in zip-lock bags for assessment of physicochemical and pasting properties. Moisture content was determined by oven drying method. Tuber of 2g was weighed in clean, dried moisture can (W_1). The moisture can was placed in an oven at 105^{o}C until a constant weight is obtained. When a constant weight was obtained, the moisture can was placed in the desiccator for 10min to cool. After cooling, the weight was taken (W_2). The percentage moisture content was calculated using the formula in equation

$$\% \text{ moisture} = \frac{W_1 - W_2}{\text{Weight of the sample}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \text{i}$$

Where:

W_1 = Initial weight of moisture can + Sample

W_2 = Final weight of moisture can + Sample

Physicochemical Properties of Flour Produced from Yam Tuber

pH Determination

Flour of 2g was weighed into a beaker, 10ml of distilled water was added after which it was stirred vigorously and filtered. The pH meter was calibrated by inserting the probe in buffer 4 and 7 solutions (standards). The pH of the samples was measured by inserting the probe into the filtrate and the readings were recorded. (Hamlet *et al.*, 2003).

Determination of Water Absorption Capacity

Water absorption capacity was determined by modifying the method of Anderson (1982). Yam flour (1g) was weighed into a centrifuge tube and 10ml of distilled water was added. The mixture was manually stirred, shaken, and allowed to stand for 30min. Then, the mixture was centrifuged at 2000rpm for 30min. The supernatant was decanted and the weight of the water absorbed was recorded. The water absorption capacity was calculated using equation iii.

$$\text{Water absorption capacity} = \frac{\text{Weight of water absorbed}}{\text{Weight of sample}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \text{ii}$$

Determination of Swelling Power and Solubility Index

The swelling power and solubility index were determined as described by Zakpaa *et al.* (2010). A flour of 0.5g was weighed into a pre-weighed centrifuge tube and 10ml of distilled water was added to it and stirred manually. The samples in the centrifuge tubes were heated in a shaking water bath at 85^{o}C for 30min after which the tubes were removed and allowed to cool before centrifuging for 15min at 2200rpm. To obtain the solubility index, the supernatant was decanted into a pre-weighed moisture can and dried at 110^{o}C to a consistent weight. The weight of the residue left in the centrifuge tube was also taken. The swelling power and solubility index were then calculated using the formulae in equations iv and v, respectively.

$$\text{Swelling power (g/g)} = \frac{\text{Weight of sediment}}{\text{Sample weight} - \text{Weight of soluble}} \quad \ldots\ldots\ldots\ldots\ldots \quad \text{iii}$$

$$\text{Solubility index (\%)} = \frac{\text{Weight of soluble}}{\text{Weight of sample}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{iv}$$

Determination of Pasting Properties

The pasting properties of the yam flour were determined with the use of a Rapid Visco Analyzer (RVA). The parameters assessed include pasting temperature, peak time, set back, final viscosity, trough (holding strength), and peak viscosity, which were read using thermocline for Windows software connected to a computer, from the pasting profile (Newport Scientific, 1995).

Sensory evaluation

Preparation of pounded yam: Peeled yam tubers of 600g were cut into small cubes, washed, and cooked (25min) in a mechanical pounder (Model No. sd-900Y National Electronic. Co Ltd. Tokyo). After cooking, the pounder's knob was switched from cooking to pounding. There was no addition of water during pounding (5min) and after pounding, each pounded yam sample (2g) was wrapped in aluminum foil, put in labeled zip-lock bags and it was placed in the warmer until it was ready to be served for evaluation. The yam varieties were cooked separately and labeled accordingly.

Selection and training of panelists: Twenty-five panelists were selected from the students of the Ladoke Akintola University of Technology, Ogbomoso, based on their previous participation in similar sensory studies and familiarity with pounded yam. Twenty out of the twenty-five member trained panel were selected for the sensory evaluation based on their availability and ability to discriminate between levels of the sensory attributes. They were trained using the definition of quality descriptors of pounded yam as described by Otegbayo *et al*. (2005) with little modification. Quality attributes of pounded yam considered include; stretchability, stickiness, mouldability, hardness, smoothness, colour, and general acceptability. The sensory evaluation took place in a sensory evaluation room with partitioned booths to enhance individual assessment without bias. Each sample was assessed for all quality attributes using descriptive phrases that were translated to numerical values.

Data Analysis

All measurements were done in triplicate. The data collected were subjected to statistical analysis to test for variance (ANOVA) using SPSS version 23.0 with Duncan test at $p < 0.05$ level of significance.

RESULTS AND DISCUSSION

The Colour Parameters of Yam Tuber Flesh

Visually, the colour of the flesh of the yam tubers could be described as white to cream. The L* (lightness) value of the flesh varied significantly from 82.27 (*Gbong*i) to 63.77 (*Awana*). Higher

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value indicated lighter (whiter) colour. The a* and b* value ranged from -2.85 to 2.48, 17.92 to 33.37, respectively (Table 1). Colour of food is one of the first parameters of quality assessed by consumers thereby making it a vital factor for food acceptability (Leon *et al.,* 2006).

Physicochemical Properties of Yam Flour

The physicochemical properties of the yam flours are shown in Table (2). The values obtained for the moisture content of the tuber ranged between 33.96to 39.47%. Generally, yam tuber has high moisture and low dry matter content Freshly harvested yam tuber consist about 70% moisture which enhances its deterioration (Maziya-Dixon *et al*., 2017). According to Scalon *et al*. (1999), tubers with high moisture content having dry matter of about 18-20% are more suitable for cooking while tubers with low moisture content of dry matter greater than 20% are more suitable for processing.

The pH value of the flour was 6.03 and 6.75 for *Lasirin* and *Efuru*, respectively. The pH values are in line with the range 5.40 to 6.70 reported by Obadina *et al.* (2014) for yam flours. pH of flour indicates its acidity or alkalinity. According to Falade and Okarfor (2015), flours within the low acid to neutral range (4 to 8) might support the growth and build up of microorganisms, particularly in the slurry form.

The results for water absorption capacity (WAC) ranged from 125.06% to 132.50%. There was no significant difference in the values obtained except for *Elentu* and *Efuru* flour. The ability of flour to absorb water is a crucial functional requirement in food formulation especially those involving formulation of dough. Water absorption capacity is the ability of flour to absorb water and swell for improved consistency in food (Ezeocha *et al*., 2014). The cohesiveness of a product can be influenced by its ability to absorb water, which is necessary for the development of ready-to-eat products (Ogunlakin *et al.,* 2012). The analysed samples had high water absorption capacity which implies that they can be useful in soup thickening and dough formation.

The swelling index of the flour ranged between 3.86% to 6.11%. There was significant difference ($p<0.05$) in the values obtained. The results obtained falls within the values reported by Adedeji (2010). The swelling index of the flour granules, which is connected to the water absorption index of the flour after heating, reveals the strength of the associative forces in the

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granules. The flour sample will be a useful ingredient in bakery products because swelling index is as a quality criterion in several food formulations.

The values obtained for the solubility of the yam flour ranged from 6.11% to 13.82. The solubility index of the flour samples differed significantly ($p < 0.05$). The values obtained are higher than the solubility index of *Dioscorea rotundata* flours (8.52% to 9.32%) reported by Addy *et al*. (2014). However, the values are lower than solubility index of water yam flours which ranged from 6.83% to 20.47% reported by Oke *et al.* (2013). Otegbayo *et al*. (2011) ascribed the high solubility index in starch-based samples to the simple disintegration of the linear fraction (amylose), which is loosely associated with the rest of the macromolecular structure and gets released or leached out during the swelling process.

Pasting Properties of Yam Flour

The peak viscosity of the flour samples ranged from 226.04RVU to 378.45RVU. There was significant difference ($p < 0.05$) in the peak viscosity of the yam flours. Abiodun *et al.* (2014) reported a close value 265RVU to 278RVU for trifoliate yam flour. Peak viscosity is a metric indicating how well starch forms paste. It is starch's capacity to expand without restriction prior to breaking down physically (Adebowale *et al*., 2008). High peak viscosity is an index of high starch content of the sample (Abiodun *et al.*, 2014).

The values obtained for holding strength or trough viscosity ranged from 117.83RVU to 279.20RVU. There was significant ($p < 0.05$) difference in the holding strength of the flour samples however, there was no significant difference in the values obtained for (*Lasinrin* and *Elentu*) and (*Efuru* and *Gbongi*). Holding strength is the minimum viscosity value in the constant temperature phase of the Rapid Visco Analyzer pasting profile (Iwe *et al*., 2016). Holding strength measures the ability of starch to remain undisrupted when yam paste is subjected to a long duration of high and constant temperature (Addy *et al*., 2014). The high holding strength observed in *Awana, Gbongi* and *Efuru* flour is an indication of higher cooked paste stability and greater ability to withstand shear at high temperatures. The values obtained from the result for the breakdown of the yam flour ranged from 9.16RVU to 140.25RVU for *Gbongi* and *Lasirin*. The values obtained differed significantly ($p < 0.05$). The higher the breakdown value, the lower the ability of the flour to withstand heating and shear stress during cooking (Iwe *et al*., 2016).

The low breakdown values obtained from the results of the samples indicate high stability of flour samples in hot condition. Hence, *Gbongi* and *Awana* will be stable under hot conditions.

The values for final viscosity ranged from 259.16RVU to 437RVU. There was significant difference in the values of final viscosity obtained from the flour samples ($p < 0.05$). *Lasirin* and *Efuru* had similar final viscosity values with 'pona' flour reported by Wireko-manu *et al*. (2011). The final viscosity of starch-based samples is a criterion for assessing their capacity to form gel or paste after heating or cooling, as well as their resistance to shear force during stirring (Adebowale *et al*., 2008). The significant high values obtained for the flour analysed may be due to strong bonding between water and starch resulting to progressively higher viscosity during cooling.

The result of setback value of the flour ranged from 37.50RVU to 295.00 RVU. The high setback values obtained from *Efuru*, *Elentu* and *Lasirin* can be compared with the high setback values in *D. rotundata* varieties as observed by other authors (Baah *et al.*, 2009; Wireko-manu *et al*., 2011). The setback value represents the propensity of starch granules to retrograde after chilling. High setback values are linked to syneresis or weeping during freezing or thawing while low setback value of paste indicates greater resistance to retrogradation (Adebowale *et al.*, 2005). The tendency of yam pastes to retrograde limits its use in food industries.

The flour samples showed varying peak time with significant ($p < 0.05$) difference. Flour obtained from Awana cooked longer (7min) than any of the flour samples while *Lasirin* cooked faster (4.73min) than others The pasting temperature of the yam flour samples ranged from 81.9^{o}C to 82.5^{o}C. High pasting temperature leads to scorching before paste is well cooked (Obadina *et al.*, 2014). Therefore, it is important to continuously stir food samples with high pasting temperatures during cooking.

Sensory Evaluation of Pounded Yam

The results obtained for sensory evaluation of pounded yam are shown in table (4). The scores for stretchability of the pounded yam indicated that all the samples are stretchable. According to Otegbayo *et al.* (2011), amongst the textural attributes identified in pounded yam, stretchability of the pounded yam ranked as the most important. From the results obtained, all the pounded yam samples were slightly sticky, soft, without lumps and could be moulded easily. All the samples were white in colour except *Lasirin* which is cream. On the basis of general acceptability, all the pounded yam samples were liked. Starch is a dominant factor in determining the textural characteristics of yam products (Baah *et al*., 2009). The good quality attributes observed in all the pounded yam samples could be due to its starch contents. This is in agreement with Otegbayo (2018) where good textural quality (moderately soft, cohesive, stretchable, smooth and stickiness) of pounded yam was attributed to its starch content.

CONCLUSION

The outcome of this research showed properties of flour produced from varieties of white yam. These research findings are recommended for both domestic and industrial uses of the food material.

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APPENDICES

Table 1: Colour of the tuber flesh

Variety	L*	a*	b*
Efuru	80.03±0.04[b]	-1.86±0.02[d]	22.40±0.01[c]
Elentu	79.86±0.06[c]	-0,67±0.01[b]	19.19±0.01[cd]
Gbongi	82.27±0.01[a]	-1.73±0.03[c]	17.92±0.01[d]
Lasinrin	78.46±0.01[d]	-2.85±0.04[e]	31.90±0.02[b]
Awana	63.77±0.01[e]	2.48±0.04[a]	37.37±0.02[a]

Means followed by the same letters along the column are not significantly different ($p < 0.05$)

Table 2: Physicochemical properties of the flour processed from yam tubers

Variety	MC (%)	WAC (%)	SP (g/g)	SI (%)	pH
Efuru	33.96±0.83[b]	132.50±3.98[b]	3.86±0.32[a]	11.28±3.62[bc]	6.75±0.04[a]
Elentu	34.95±0.27[b]	125.06±2.39[a]	5.50±0.47[bc]	6.60±1.43[a]	6.58±0.17[a]
Gbongi	34.21±o.41[b]	130.43±3.51[ab]	4.04±0.43[a]	13.82±3.57[c]	6.18±0.02[b]
Lasirin	39.47±0.50[a]	128.50±5.01[ab]	6.11±0.70[c]	8.27±1.20[ab]	6.03±0.07[b]
Awana	38.12±0.21[a]	130.61±1.18[ab]	4.42±1.01[ab]	6.11±0.74[a]	6.72±0.10[a]

Means followed by the same letters along the column are not significantly different (*p*<0.05) MC=Moisture Content, WAC=Water Absorption Capacity, SP=Swelling Power, SI=Solubility Index

Table 3: Pasting properties of the flour processed from yam tubers

Variety	Peak viscosity (RVU)	Holding strength (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback value (RVU)	Peak time (min)	Pasting temperature (^oC)
Efuru	278.45 ±2.62[c]	203. ±59.29[b]	74.75±61.91[b]	437.83±64.16[c]	234.15±23.45[b]	5.70±0.63[b]	81.90±0.35[a]
Elentu	226.04±6.79[a]	123.70±5.45a	102.33±1.33[bc]	344.54±1.37[b]	220.83±6.83[b]	5.50±0.10[b]	81.92±0.37[a]
Gbongi	230.75±9.91[a]	221.50±10.33[b]	9.16±0.41[a]	295.16±10.66[a]	37.58±0.33[a]	6.63±0.03[c]	82.25±0.10[ab]
Lasirin	258.70±8.72[b]	117.87±3.29[a]	140.25±12.08[c]	412.87±5.87[c]	295.00±9.16[b]	4.93±0.01[a]	82.55±0.07[b]
Awana	293.70±9.12[d]	279.20±9.45[c]	14.50±0.33[a]	351.75±5.83[b]	72.54±3.62[a]	7.00±0.01[c]	82.37±0.32[b]

Means followed by the same letters along the column are not significantly different (*p*<0.05)

Table 4: Sensory attributes of pounded yam

Variety	Strechability[1]	Stickiness[2]	Mouldability[3]	Hardness[4]	Smoothnesss[5]	Colour[6]	G. acceptability[7]
Efuru	2.91±0.73^{ab}	2.87±0.75^{ab}	1.03±0.17^{a}	3.09±0.46^{a}	1.31±0.47^{b}	1.96±0.73^{c}	1.31±0.47^{ab}
Elentu	2.66±0.65^{a}	2.90±0.77^{ab}	1.00±0.00^{a}	2.81±0.59^{a}	1.56±0.50^{c}	1.68±0.69^{bc}	1.50±0.56^{abc}
Gbongi	3.34±0.78^{c}	3.18±0.82^{bc}	1.18±0.39^{b}	2.97±0.30^{a}	1.59±0.55^{c}	1.28±0.63^{a}	1.59±0.71^{bc}
Lasirin	3.12±0.81bc	3.450.66^{c}	1.00±0.00^{a}	2.81±0.58^{a}	1.06±0.24^{a}	3.93±3.93^{d}	1.18±0.39^{a}
Awana	2.59±0.73a	2.76±0.91^{a}	1.06±0.25^{a}	2.86±0.10^{a}	1.62±0.62^{c}	1.62±0.56^{b}	1.72±0.84^{c}

Means followed by the same letters along the coloumn are not significantly different (P<0.05).
[1]Scoring: 1 = very stretchable; 2 = stretchable; 3 = slightly stretchable; 4 = non stretchable[2]Scoring: 1 = very sticky;
2 = sticky; 3 = slightly sticky;4= non-sticky[3]Scoring: 1 = easy to mould; 2 = difficult to mould;
3 = impossible to mould[4]Scoring: 1 = very hard; 2 = hard; 3=soft; 4=very soft [5]Scoring: 1 = smooth;
2 = small lumps; 3 = big lumps[6]Scoring: 1 = white; 2 = dirty white; 3 = cream; 4=yellow; 5= light brown
[7]Scoring: 1 = like extremely; 2 = like moderately; 3 = neither like nor dislike; 4 =dislike moderately; 5 = dislike extremely