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ASSESSMENT OF SENSORY, FUNCTIONAL AND PASTING PROPERTIES OF DIFFERENT YAM CULTIVAR FLOURS SUBJECTED TO THE SAME PROCESSING CONDITION

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Abstract

Yam cultivars (*Dioscorea spp*) were used to produce a popular food consumed by both adults and children using the same processing conditions. The functional and pasting properties as well as sensory qualities were evaluated using standard procedures. The results obtained from the flour samples showed that there were significant ($p \leq 0.05$) differences in the functional properties evaluated. Bulk density ranged from 0.63 to 833g/ml, water absorption capacity ranged from 119.08 to 253.65, pH varied between 3.55 to 4.35, foaming capacity varied from 3.92 to 15.15%, foam stability ranged from 91.50 to 97.17%, wettability ranged from 62.5 to79.0 seconds, sedimentation varied from 4.10 to 6.15% while the swelling capacity ranged from 11.50 to 14.50%. The pasting properties which included peak viscosity trough, breakdown, final viscosity, set back, peak time and pasting temperature were all significantly ($p \leq 0.05$) different from each other. The *amala* paste prepared from white yam flour was the most preferred in terms of colour, taste, mould-ability aroma and overall acceptability.

Key words: Yam cultivars, functional properties, pasting properties, sensory qualities, yam flours

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Introduction

Yam is the first most valuable food and agricultural commodity in Nigeria for the year 2012 (FAO STAT, 2014), it is also an integral to the socio-cultural life in this sub region. Yams are annual or perennial tuber-bearing and climbing plants with over 600 species in which only few are cultivated for food and medicine (IITA, 2006). The tubers of various species of *Dioscorea spp* constitute one of the stable carbohydrate foods for the people in many tropical countries (Akissoe, Hounhouigan, Mestres & Nago, 2003). Yam is an excellent source of starch, which provides calorific energy (Coursey, 1973). It also provides protein three times more superior than the one of cassava and sweet potato (Bourret-Cartedelleas, 1973).

Yam flour is powdered starch widely used in food preparation. Typically white, the flour is commonly used in African dishes such as “amala”. It may be used in many other recipes if desired as well. It is prepared by grinding dried yam until they reach a powdered consistency. Dehydrated flour from yams may also be produced from sun drying (Arthur, 2012).

To overcome the problem of perish ability due to their high moisture content and seasonal nature of their production, yam tubers are processed into dry-yam tubers/slices or flour in West African countries such as Nigeria, Ghana and Republic of Benin (Bricas Vernier, Ategbo, Hounhouigan, Miitchikpe, N’Kpenu & Orkwor, 1997; Akissoe, Hounhouigan, Bricas, Vernier, Nago & Olorunda, 2001; Mestres, Dorthe, Akissoe & Hounhouigan, 2004; Babajide and Olowe, 2013). Dry yam slices are processed by peeling, slicing, blanching in hot water (at 40-50^{o}C for 1-3h), steeping for a day and drying to brittleness at 60^{o}C. The resulting dried tuber/slice is referred to as “gbodo” in Nigeria (Onayemi and Potter, 1974; Ige and Akintunde, 1981; Babajide, Henshaw, & Oyewole, 2008; Babajide and Olowe, 2013).When gbodo is milled into flour; it is referred to as “elubo” which when stirred in boiling water will form a thick paste known as “amala”.

Babajide and Olowe (2013) and Ajibola, Aboniyi & Onayemi. (1988) reported that processing of yam traditionally depends on the species, for instance, white yam (*Discorea rotundata* or *D. esculenta*) are always preferred for production of gbodo and pounded yam due to better textural quality of the final product. Water yam (*Discorea alata*) is always preferred for use in preparing porridges such as “ikokore” mainly eaten by the Ijebu people of South-Western Nigeria and “ojojo” (grated and fried water yam balls) with no appreciable economic secondary food product (Ukpabi, Omadamiro, Ikeorgu & Asiedu, 1992).

Functional properties are the fundamental physico-chemical properties that reflect the complex interaction between the composition, structure, molecular conformation and physico-chemical properties of few components together with the nature of environment in which they are associated and measured (Kaur and Singh, 2006; Siddiq, Nassir, Ravi, Dolan & Butt, 2009),

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while pasting properties indicates what physical changes may be expected during the processing of starchy foods.

An earlier study report on some functional properties of yam showed that significant differences exist in viscosities among yam starches studied. *Discorea rotundata* gave the strongest gel and pasting temperature ranging between 76 and 85°C. A high swelling power of *D. alata* starches was also reported and its characteristics were related to the bonding forces in the starch granules (Onwka and Ihuma, 2007). Hariprakesh and Bala (1996), also reported that the knowledge of the physico-chemical and functional properties of the yam *spp* could be used to predict and interpret their behavior under actual cooking and cooling temperature conditions. The processed form in which yam tubers are consumed or preserved is mostly flour (Iwuoha, 2004). Yam flour, specifically white yam has found increasing use in bakery (Courtesy and Ferber, 1979; IITA, 1988; Iwuoha, 2004). Oke, Awonorin & Workneh. (2013) also reported that the pasting characteristics of the flour and starch from different varieties of water yam varied significantly and that the pasting and physico-chemical properties indicate that flour and starch have useful technological properties for many applications. However, there is little information on functional, pasting properties as well as sensory qualities of different yam flours subjected to the same processing condition. The aim of this study was to access the functional, pasting properties and sensory qualities of different yam flour cultivars subjected to the same processing conditions.

Materials and Methods

Matured diseased free fresh yams were randomly harvested from the school farm of Federal Polytechnic, (Botanical Garden) Ilaro, Ogun State, Nigeria. Four yam cultivars were used, which are white yam (*D. rotundata*), Bitter white yam (*D. dumetorum*), Bitter yellow yam (*D. cayenensis*) and water yam (*D. alata*). The yams were transferred to the laboratories of the Department of Food Technology, The Federal Polytechnic, Ilaro for further processing and analyses.

Methods

Production of yam flour

Yam flour was produced as described by Nwosu (2013). Matured yam tubers of different cultivars were selected washed properly with portable water in order to get rid of sands, adhering soil and other extraneous materials. The washed yam tubers were then peeled, sliced to desired thickness of 2-3cm, blanched at 70°C for 5 minutes after which they were removed from hot water, drained and cooled. The blanched yam slices were dried in a cabinet dryer (Model, RCD-

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5, Zhejiang, China) at 50^{o}C for 2 days. The dried yam slices were milled into flour to pass through a 100µm mesh sieve using a laboratory hammer mill. The different milled yam cultivars were packaged in cellophane bags, sealed to avoid moisture absorption and stored at ambient temperature prior to further analyses.

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Selection of yam
↓
Washing
↓
Peeling
↓
Slicing 2-3 thickness
↓
Blanching at 70^{o}C for 5 minutes
↓
Drying at 50^{o}C for 24 hour
↓
Milling
↓
Sieving
↓
Packaging

Fig 1: Flowchart for the production of yam flour

Functional properties of yam flour

Bulk density

The method reported by Onwuka (2005) was used. An empty 10 ml capacity graduated measuring cylinder was weighed. The cylinder was gently filled with the sample, and then the bottom of the cylinder was gently tapped on the laboratory bench several times until there is no further diminution of the sample level after filling to the 10ml mark. The bulk density was calculated as weight of sample (g) per volume of the sample (ml)

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

W_1 = the already weighed measuring cylinder

W_2 = the weight of the sample and weight of the cylinder

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Water absorption capacity

Water absorption capacity was determined by using the method described by Awoyale, Maziya-Dixon, Sanni and Shittu. (2011). Ten milliliters of distilled water was mixed with 1g of flour each and blended for 30 seconds. The samples were allowed to stand for 30 minutes and centrifuged at 1300 rpm for another 30 min at room temperature (27+2ºC). The supernatant was decanted. The weight of water absorbed by the flour was calculated and expressed as percentage water absorption capacity.

Wettability Index

Wettability index was determined using the method reposted by NIRO () but with slight modification. 10ml of distilled water at 25˚C was poured into 400ml beaker (70mm diameter). A glass funnel (height 100mm, lower diameter 40mm, upper diameter 90mm) was placed and maintained on the upper edge of the beaker. A test tube was placed within the funnel to block the lower opening of the funnels. Three grams flour was placed around the test tube, while the time is started, the tube was simultaneously elevated. Finally the time was recorded when the flour was completely wet (visually assessed that all powder particles have diffused into the water). The measurement was performed at least twice for each flour sample until the relative difference between two results does not exceed 70%.

pH

Ten grams of the flour samples was weighed and dissolved in a beaker containing 25ml distilled water to form slurry. It was allowed to stand for 10 minutes with constant stirring. The pH was then directly determined with the aid of pH meter (Model PHS-25CW Microprocessor pH/mv meter)

Sedimentation Index (SI).

Sedimentation index was determined according to method described by Naega (2008), with slight modification. 1.3g of yam flour was transferred into a 25ml graduated cylinder. 20ml of distilled water was added, the mixture stirred for 5 minutes using vortex shaker with an interval of 30 seconds. After agitation, the cylinder was immediately held vertically and the sedimentation volume was recorded (ml) every 10 minutes during one hour except for the first 5 minute

Swelling Capacity

The method of Okaka and Potter (2000) was used in determining the swelling capacity. 100ml graduated cylinder was filled with flour sample to 10ml mark. Them, distilled water was added

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to give a solid volume of 50ml. the top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 minutes and left to stand for further 5 minutes and the volume occupied by the sample was recorded after the 8th minute.

Foam Capacity (Fc) and Foam Stability (Fs)

Foam capacity (FC) was determined by the method of Sze-Tao and Sathe (2000). A weighed sample (250mg) was mixed with 250ml distilled water, and the pH adjusted to 2, 4, 6, 8 and 10. The solution was whipped for 3 minutes in a stainless GS Blender (model 38 BL45, Dynamic Corporation, Auburn Hills, USA). The whipped solution was then poured into a 100ml graduated cylinder. The total sample volume was taken at 0 minutes for foam capacity and at 10 minutes intervals, up to 60 minutes for foam stability.

Foam capacity and foam stability were then calculated thus:

$$\textbf{\textit{Foam Capacity (FC) \%}} = \frac{\text{(volume after whipping-volume before whipping) ml x 100}}{\text{(Volume before whipping) ml}}$$

$$\textbf{\textit{Foam stability (FS) \%}} = \frac{\text{(volume after standing-volume before whipping) ml x 100}}{\text{(Volume before whipping) ml}}$$

Pasting Characteristic

The pasting characteristics were determined by using rapid visco-analyzer (RVA) (Model 3DRVA, Newport scientific PVT-Ltd, Narrabeen, Australia). A suspension of 4g (14% wet basis) sample in 25 ml was made of distilled water the RVA canister and inserted into the tower, which was lowered into the system. The suspension was heated from 50^{o}C – 90^{o}C and then cooled back to 50^{o}C within 12 minutes, rotating the canister at a speed of 160rpm with continuous stirring of the contents with a plastic paddle. Parameters determined were peak viscosity, trough viscosity, breakdown viscosity, setback viscosity, final viscosity, peak time and pasting temperature.

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Sensory Evaluation

The sensory evaluation for the flour stiff paste (amala) of each sample was carried out in a well-lit sensory evaluation laboratory. A 40 member panelists consisted of male or female adults who are familiar with the product were used. Each panelist conducted an independent assessment in separate sensory boots on the coded samples with respect to colour, taste, mouldability, aroma and overall acceptability. The panelists were provided with water to rinse their mouths before and after tasting each sample. The samples were evaluated for their degree of likeness using a 9-point Hedonic scale (9= like extremely and 1= dislike extremely) ranking.

Statistical analysis

Data generated were subjected to one-way analysis of variance (ANOVA). Means obtained from triplicate determination were separated with the Fisher Least Significance Difference (LSD) at 0.05 significant level using the Statistical Package for Social Sciences (SPSS version 21) for windows.

Result and Discussion

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Table 1: Functional properties of yam flour subjected to the same processing condition.

Sample	Bulk Density (g/ml)	Water Absorption Capacity (%)	pH	Foaming Capacity (%)	Foaming Stability (%)	Wettability (Sec)	Sedimentation (%)	Swelling Capacity (%)
A	0.77^{a}±0.01	119.08^{d}±5.86	3.55^{b}±0.03	15.15^{a}±2.50	91.50^{b}±1.50	79.00^{a}±4.00	4.25^{b}±0.25	13.25^{a}±0.25
B	0.69^{a}±0.01	253.65^{a}±27.12	4.23^{a}±0.01	7.84^{b}±0.00	93.64^{b}±0.91	76.50^{b}±4.50	6.15^{a}±0.35	14.50^{a}±0.50
C	0.63^{b}±0.05	174.93^{b}±9.62	4.35^{a}±0.02	3.92^{c}±0.00	97.12^{a}±0.94	67.50^{c}±2.50	6.10^{a}±0.10	11.50^{b}±0.50
D	0.83^{c}±0.01	134.46^{c}±10.43	4.14^{a}±0.04	3.92^{c}±0.00	96.23^{a}±1.89	62.50^{d}±2.50	4.10^{b}±0.10	12.50^{b}±0.50

Means within the same column not followed by the same superscript are significantly (P< 0.05) different. A= white yam, B= Bitter white yam, C= Bitter yellow yam, D= water yam

Table 2: Pasting properties of yam flour subjected to the same processing condition.

Sample	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak Time (Min)	Pasting Temperature (°C)
A	149.67^{c}±0.03	131.50^{c}±0.22	18.17^{b}±0.05	188.75^{c}±0.15	57.25±0.05	7.00 ^{a}±0.05	84.00^{a}±0.12
B	61.50^{a}±0.07	31.25^{a}±0.12	30.25^{c}±0.12	69.75^{a}±0.11	38.50^{a}±0.05	5.13^{a}±0.03	89.80^{c}±0.11
C	108.50^{b}±0.05	46.67^{b}±0.11	61.83^{d}±0.14	89.83^{b}±0.12	43.17^{b}±0.04	4.87^{a}±0.02	88.10^{b}±0.15
D	182.42^{d}±0.02	177.42^{d}±0.13	5.00^{a}±0.02	216.92^{d}±0.15	39.50^{a}±0.02	7.00^{b}±0.02	84.85^{ab}±0.14

Means within the same column not followed by the same superscript are significantly (P< 0.05) different. A= white yam, B= Bitter white yam, C= Bitter yellow yam, D= water yam

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Table 3: Sensory score of yam flour stiff paste subjected to the same processing condition.

Samples	Colour	Taste	Aroma	Mouldability	Overall Acceptability
A	7.52^{a}±0.02	8.10^{a}±0.07	8.22^{a}±0.12	7.66^{a}±0.03	8.43^{a}±0.04
B	6.32^{b}±0.05	7.31^{b}±0.07	7.65^{b}±0.15	6.96^{b}±0.02	7.12^{b}±0.05
C	5.89^{c}±0.01	6.45^{c}±0.04	6.98^{c}±0.14	6.05^{c}±0.05	6.14^{c}±0.04
D	5.02^{d}±0.03	4.99^{d}±0.03	6.10^{d}±0.12	5.11^{d}±0.05	5.68^{d}±0.03

Means within the same column not followed by the same superscript are significantly (P< 0.05) different. A= white yam, B= Bitter white yam, C= Bitter yellow yam, D= water yam
.

Functional properties of yam flour samples.

The mean scores of the functional properties obtained for different yam cultivars flours subjected to the same processing condition are shown in Table 1. There are significant (p<0.05) differences in the functional properties of the yam flours as shown in Table 1. Bulk densities of 0.773g/ml, 0.693g/ml, 0.631g/ml and 0.833g/ml were obtained for white yam, bitter white yam, bitter yellow yam and water yam flours respectively. Bulk density depends on the particle size and initial moisture content of flours, however, high bulk density of flours reveals their suitability for use in food preparation where increasing food bulkiness is desirable. On the contrast, low bulk density would be an advantage in the formulation of complementary foods (Akpata and Akubo, 2000). There are significant differences (p<0.05) in the water absorption capacity of the four yam flour samples. The bitter yam flour had the highest water absorption capacity value of 253.65 while flour from white yam had the least value of 119.08. Water absorption capacity represent the ability of a product to associate with water under conditions which is limited (Singh, 2001). Also, the carbohydrate (starch) content and fibre of yam cultivar plays a significant role in its ability to absorb water. The pH values for the yam flour samples ranged from 3.55- 4.35 suggesting a slightly acidic samples.

Foamability is related to the decrease in the surface tension of the air-water interface caused by absorption of protein molecules (Mempha, Luayt & Niraojigoh, 2007). Foam capacity (FC) ranged from 3.92 to-15.15% while foam stability (FS) varied from 91.50 to 97.17% for all these samples respectively. There were significant differences (p<0.05) in all the flour samples: Highest foam stability (97.17%) was observed for bitter yellow yam flour and lowest for white yam flour (91.50%). Highest foam capacity revealed by flour obtained from white yam (15.15%) may be due to the protein content in the dispersion which may cause a lowering of the surface

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tension as the water air interphase forming a cohesive film around the air bubbles in the foam (Kaushal, Kurma & Sharma, 2012). Also, the foam capacity (FC) and foam stability (FS) have been related to the decreased surface tension of air-water interface caused by absorption of protein molecules (Mempha *et al*., 2007). The values obtained for wettability showed significant differences ($p<0.05$) among the flour samples as it ranged from 62.5 to 79.00 seconds. However, during temperature process, some of the starch in the flour may be gelatinized and in the process absorb moisture and swell up and consequently the flour obtained from these blanched slices possesses a reduced hydrophilic ability leading to reduced hydration capacity of flour, thereby increasing the value for wettability. The sedimentation indices obtained for the flours were 4.25 (white yam flour), 6.15 (bitter yam flour), 6.10 (bitter yellow flour) and 4.1 (water yam) respectively. The values are significantly different ($p<0.05$) from each other. Sedimentation property is a very important flour property as it reflects the suspension stability and particle properties in terms of hydrodynamic interaction between particles and surrounding medium. (Lerche, 2002; Concha, 2009). Swelling capacity is the volume of expansion of molecules in response to water uptake, which it possessed until a colloidal suspension is achieved or until further expansion and uptake are prevented by intermolecular forces in the swollen particles (Houssou Ayernor, 2002). Values obtained for swelling capacity ranged from 11.50-14.50, suggesting significant differences ($p<0.05$) among flour samples. These values are higher than those reported in a previous work for maize-distillers spent grain (Awoyale *et al*., 2011) and maize-pigeon pea (Adegunwa, Adeniji, Adebowale & Bakare, 2015).

Pasting properties of yam flours.

The pasting characteristics of yam flours are shown in Table 2. The pasting property is an essential factor in predicting the cooking and baking qualities of flour. When heat is applied to starch based foods in the presence of water, a series of changes occur known as gelatinization and pasting which influence the quality and aesthetic considerations in food industry, as it affects the texture, digestibility and starchy foods (Adebowale, Adeyemi, & Oshodi, 2005). Usually, starch when heated increases in viscosity as a result of the swelling of the starch granules and the quantity of absorbed moisture depend on the duration of cooking and starch content (Yadav, Anand, Kaur & Singh, 2012). The pasting temperature of yam flours ranged between 84.00^oC and 89.90^oC. Pasting temperature has been described as the temperature above the gelatinization temperature when starch granules begin to swell and it is characterized by an increase in viscosity on shearing (Adebowale *et al*., 2005). The present values are in agreement with a previous work of 85.89^oC and 79.88^oC for *D.alata* and *D. rotundata* flours by Wireko-Manu, Ellis, Oduro, Asiedu & Dixon. (2011). Furthermore, pasting temperature provides an indication of the minimum temperature required to cook the flour and this has an implication for its suitability in other foods. Peak viscosity of the flour samples ranged between 738.0 to 2189.0 RVU (Rapid Viscosity Unit), where water yam flour had the highest and bitter white yam flour had the least value. The peak viscosity is the highest viscosity attained during the gelatinization (i.e. heating cycle). It is often correlated with the final product quality and also provides an

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indication of the viscous load likely to be encountered during mixing (Maziya-Dixon, Dixon & Adebowale, 2007). The minimum viscosity at constant temperature phase of the RVA profile and the ability of paste to withstand breakdown during cooling is referred to as the trough viscosity. The trough or holding strength revealed that there was a significant difference ($p < 0.05$) in all the flour samples. The trough viscosity ranged from 375.00 RVU for bitter white yam flour to 2129.00 RVU for water yam flour. The ability of a paste to withstand the heating and shear stress in an important factor for most food processing operations and is also a factor for describing the quality of starch gel. High paste stability is a requirement for industrial users of starch (Oduro, Ellis, Argeetacy, Aherikara & Otoo, 2000). This is because drastic changes in paste during and after processing could lead to undesirable textural changes. *D alata* flour had higher trough, which indicates greater ability to withstand shear at higher temperature and higher cooked paste stability. The breakdown viscosity is an index of the stability of starch (Fernandez de tonella and Berry, 1989). It is also the difference in the peak viscosity and trough, which is an indication of the rate of gelling stability, which is dependent on the nature of the product. There were significant difference ($P<0.05$) in the breakdown viscosity obtained for all the yam flour samples. The breakdown viscosity, also referred to as shear thinning is an indication of the ease with which the swollen granules can be disintegrated (Yadav et al., 2012). As reported by Sanni, Adebowale & Onitilo. (2008), the rate of starch breakdown depends on the nature of the material, the temperature and the degree of mixing and shear applied to the mixture. The ability of the mixture to withstand heating and the shear stress that is usually encountered during processing is an important factor for many processes, especially those requiring stable paste and low retrogradation or syneresis (Sanni *et al.*, 2008). There are significant difference ($p<0.05$) in the values of final viscosity. It ranged from 837.00 - 2603 RVU. The final viscosity (indicates the ability of the material to form a viscous paste) has been reported in a previous work as the most commonly used parameters to determine the ability of the starch-based material to from a viscous paste or gel after cooking and cooling, as well as the resistance of the paste to shear force during stirring (Adebowale *et al.*, 2005, Maziya-Dixon *et al*., 2007). The setback viscosity has been the correlated with the texture of various flour samples. High setback value is also associated with syneresis or weeping during freeze\thaw cycles (Adebowale *et al*., 2005); white low setback value during the cooling of paste from starch or starch based food indicates greater resistance to retrogradation (Sanni, Christiana & Silifat, 2004). As observed from table 2, the lowest setback value of flour from *D. dumentorum* (bitter white yam flour) indicates it lower tendency to retrograde. Adebowale and Lawal (2003) requested that smaller tendencies to retrograde are advantaegeous in food products such as soup and sauce, which undergoes loss of viscosity and precipitation as a result of retrogradation. The peak time ranged between 4.87 and 6.87 minutes, suggesting significant ($p<0.05$) differences. The peak time gives an indication of ease of cooking. More so, the shorter the peak time, the better the ease of cooking (Adegunwa *et al*., 2015).

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Sensory evaluation of yam flour

The results obtained for sensory evaluation of yam flour samples is presented in table 3. There were significant ($p<0.05$) differences between colour, taste, mouldability, aroma and overall acceptability of the flour samples. Sample A (white yam flour) had the highest value of 7.52 like very much" for colour, followed by bitter white yam flour (6.32) while water yam flour had the lowest value of 5.02. "dislike extremely". The same trends were exhibited in all the remaining attributes evaluated i.e. taste, mouldability, aroma and overall acceptability.

Conclusion

This study has revealed that functional and pasting properties as well as sensory qualities of yam flour are affected by yam cultivars, even after subjecting them to the same processing conditions. All the cultivars studied gave the potentials for the manufacture of value-added products. However, the wide variation observed in both the functional and pasting characteristics of the yam flour can serve as a database for the selection and the improvement of the yam cultivars for specific food application to stimulate their industrial processing and utilization.

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