GSC Advanced Research and Reviews
eISSN: 2582-4597 CODEN (USA): GARRC2
Cross Ref DOI: 10.30574/gscarr
Journal homepage: https://gsconlinepress.com/journals/gscarr/

(Research Article)

Check for updates

Effect of processing methods on functional, pasting properties of flours and sensory evaluation of "Amala" made from different yam cultivars

Babalola John Olarenwaju [1,*], Olakunle Esther Jesufemi [1], Elutilo Oluwashola Oyedunni [1], Adeoti Olatunde Micheal [2] and Adesina David Ademola [2]

[1]Department of Food Science and Technology, The Oke-Ogun Polytechnic Saki, Oyo State Nigeria.
[2] Department of Science Laboratory and Technology, The Oke-Ogun Polytechnic Saki, Oyo State Nigeria.

GSC Advanced Research and Reviews, 2021, 07(01), 123–132

Publication history: Received on 06February 2020; revised on 28 March 2021; accepted on 01 April 2021

Article DOI: https://doi.org/10.30574/gscarr.2021.7.1.0006

Abstract

The effect of processing methods on the functional, pasting properties of flours and sensory evaluation of "amala" made from three different cultivars of yam were determined using standard analytical methods. The three cultivars of yam namely; *Dioscorea caynensis* "Amula and Lasinrin) and *Dioscorea alata* (Cote divoire) were processed using three different methods as following; (a) parboiling with steep water (omi-ogi) in aluminium pot and local clay pot (b) parboiling with clean water in aluminium pot and local clay pot (c) heating steep water omi -ogi and clean water separately at 60°C and blanching sliced yam with it in plastic bucket. The functional and sensory properties of the yam flour obtained from the three processing methods were determined using standard analytical method. Data collected were analyzed statistically to determine the Analysis of Variance (ANOVA) and the means. There were significant differences (P<0.05) in the result obtained. The bulk density, water absorption capacity, wettability, oil absorption capacity and swelling index of the yam flour ranged from 0.33±0.01 to 0.49±0.03g/ml, 7.50±0.44 to 0.50±0.44g/ml, 36.67±11.55 to 178.33±2.89secs, 1.47±0.23 to 7.40±1.06g/ml and 1.10±0.01 to 1.82±0.03g/g respectively. The peak viscosity, trough, breakdown, final viscosity, setback, peak time and pasting temperature of yam flour ranged from 1783.00±7.07 to 3682.00±2.83 cP, 1691.00±4.24 to 3533.50±3.54cP, 27.50±2.12 to 195.00±7.07cP, 2351.00±1.41 to 4332.50±3.54cP, 420.00±7.07 to 799.00±1.41cP, 7.03±0.04 to 5.10±0.14cP, 81.35±0.92 to 89.10±0.14cP respectively. The appearance, colour, taste, texture and overall acceptability of the "amala" ranged from 3.70±1.08 to 8.65±0.75, 3.70±1.03 to 8.60±0.82, 3.50±1.19 to 8.20±1.01, 3.35±1.04 to 8.50±0.95 and 3.35±0.75 to 8.60±0.75 respectively. The LLPSW (cultivar "Lasinrin" processed with local clay pot and steep water "omi-ogi") had the highest water absorption capacity, LAPOW (cultivar "Amula" processed with aluminium pot and clean water) had the best overall acceptability. Water absorption capacity measures the extent of water retention in yam flour. It can be concluded that yam flour processed with LCPSW was the best flour from the above results on water absorption capacity.

Keywords: "Lasinrin"; "Amula"; "Omi-ogi"; "Cote divoire"; Functional properties, Sensory evaluation

1. Introduction

Yam belongs to the family *Dioscorea spp.* It is a semi-perishable class of food due to its relatively high moisture content (1). It is a tuber crop that is grown widely in many part of the world. It is majorly grown in sub-saharan Africa, with the production of more than 95% of the global yam cultivation. It is the second most important root/tuber crop in Africa after cassava (2, 3). The traditional storage structures used for yam storage include leaving the tubers in the ground until required, the yam barn and underground structures (3). In the absence of good storage facilities, yam tubers are prone to gradual physiological deterioration after harvesting (1). Yam is a source of carbohydrate and has a lower

*Corresponding author: Babalola JO
Department of Food Science and Technology, The Oke-Ogun Polytechnic Saki, Oyo State Nigeria.

glycemic index which makes it a sustainable source of energy and gives better protection against obesity and diabetes (4). Fresh yams are difficult to store and are subject to post-harvest losses during storage (5,6). These losses serve as an impetus for processing this staple food into a product of longer shelf-life.

Elubo is processed by peeling, slicing, blanching in hot water (at 40-50^{o}C for 1-3hrs), steeping for a day and drying to brittleness at 60^{o}C. The resulting dried sliced tuber is referred to as “gbodo” in Nigeria (7, 8, 9). When “gbodo” is milled into flour, it is referred to as “elubo” which when stirred in boiling water will form a thick brown paste known as “amala”. The processing of yam traditionally depends on the species, for instance white yam (*Dioscorea rotundata*) are always preferred for production of gbodo and pounded yam (10) due to better textural quality of the final product. Water yam (*Dioscorea alata*) is always preferred for use in preparing porridge such as “ikokore” mainly eaten by Ijebu people of South West Nigeria and “Ojojo” (grated and fried water yam) with no appreciable economic secondary food product (11).

In Nigeria, particularly the South Western region, root and tuber crops such as; yam and cassava are usually processed into flour known as “elubo” using traditional methods of parboiling in water or soaking followed by drying. This is to overcome the high perishability of fresh forms of the seasonal nature of their production. Little or no work has been done on the effect of processing methods of producing yam flour “elubo” using different yam cultivars.

This study aims at producing yam flour by different processing methods using three yam cultivars and to determine the functional properties of the resultant flour and sensory properties of prepared “amala”.

2. Material and methods

2.1. Sources of raw materials

Two cultivars of *Dioscorea cayenensis* (“Amula” and “Lasinrin”) and one cultivar of *Dioscorea alata* (“Cote devoire”) were purchased from Sango market, Saki, Oyo state, Nigeria. The processing of yam into yam flour (elubo) was done at the Food Science and Technology Laboratory of the Oke-Ogun Polytechnic, Saki (TOPS).

2.2. Production of yam flour

Four kilogrammes each of the yam cultivars were separately washed, weighed, peeled, sliced and washed in water containing 0.1ppm sodium metabisulphite. The sliced cultivar was parboiled using 4L of steep water (“omi ogi”) in local clay pot and aluminium pot separately at 50^{o}C for 30 min. The parboiled yam slices was steeped for 24 hrs, drained, sundried for 4 days and milled into flour as shown in Figure 1.‘

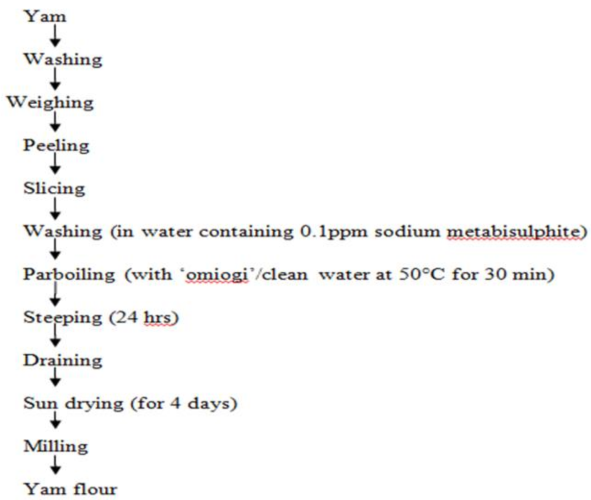

Figure 1 Flow chart for production of yam flour using steep water (“omi-ogi”)/clean water, local clay pot and aluminium pot and plastic bucket respectively

2.3. Determination of functional properties of the flour

Bulk density and water absorption capacity were determined using the methods of (12,13) respectively. Oil absorption properties of the flour were determined following method of (14). A quantity of oil in a Moulinex blender (Model DEPC 3, Frence) at high speed for 30 sec. The sample was allowed to stand at 30^{0}C for 30 mins and then centrifuged at 10,000rpm for 30 min the volume of supernatant in a graduated cylinder was noted.

Swelling index was determined using the method described by (15).

2.4. Pasting Properties

Pasting characteristics was determined with a Rapid Visco Analyzer (RVA), (Model RVA3D+), Network Scientific and Australia. First, flour sample (2.5g) was weighed into a dried empty canister; then 25ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA as recommended. The slurry was heated at 59^{o}C to 95^{o}C with a holding time. The rate of heating and cooling was at a constant rate of 11.25^{o}C per minute. Peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile with the aid of thermo cline for windows software connected to a computer (16).

2.5. Sensory Evaluation of 'Amala' samples produced from flour of different yam cutivars

Fifty grammes each of the Yam flour was stirred in 150ml boiling water to make paste (Amala) that was used for sensory evaluation. Scoring difference test and hedonic scale test was used in measuring the intensity and acceptability of the paste, colour, taste, mould-ability, texture and aroma of the prepared amala. A semi-trained fifty member panel was used and scores were allocated by the panelists based on 6-point hedonic scale, ranging from 1(extremely black) to 6 (cream) and a 9-point henodic scale was used to determine the overall acceptability of yam paste ranging from 1(dislike extremely) to 9 (like extremely) as described by (17). The data collected were subjected to statistical analysis to determined possible differences among samples.

2.6. Statistical Analysis

All data were subjected to Analysis of Variance (ANOVA) using SPSS Version 16.00 and means were separated using Duncan Multiple Range Test (DMRT).

3. Results and discussion

Functional properties are the intrinsic physiochemical properties that reflect the complex interaction between the composition, structure, confirmation and physiochemical properties of protein and other food components and the nature of the environment in which these are associated and measured (18). The functional properties of yam flour produced from different yam cultivars are shown in Table 1.

The bulk density of the yam flour varied significantly ($P<0.05$). The bulk density of the yam flour ranged from 0.33g/ml to 0.49g/ml. CLPSW has the highest bulk density (0.49g/ml), while ALPOW has the lowest bulk density value (0.33g/ml). The result obtained from this study is similar to the one obtained by (19) on effect of processing on cocoyam which ranged from 0.588g/ml to 0.714g/ml. Bulk density is dependent upon the particle size of the sample. It is important for determining packaging requirements, material handling and application is wet processing in the food industry (20). Flour with low bulk density will be an advantage in the bulk storage and transportation of the flour (21).

Water absorption capacity (WAO) measures the extent of water retention in yam flour. This affects the ability of the yam flour to form paste. There was significant difference in the water absorption capacity of the yam flour produce. Water absorption capacity of the yam flour produced ranged from 3.40g/ml to 7.53g/ml. APBOW has the lowest water absorption index (2.40g/ml) while LAPOW has the highest water absorption index (7.53g/ml). The result obtained conforms with the result recorded by (22) on quality evaluation of wheat – cocoyam – soybean cookies which ranges from 2.43 to 8.00g/g). Water absorption capacity can be used to determine carbohydrate physicochemical properties in various food product like soup, dough and baked product (23). Low water absorption capacity is attributed to compactness of the molecular structure while high value indicates loose structure of the starch polymers (24). High water absorption capacity is an indication of its use in composite flour for bread making (25).

Table 1 Functional properties of yam flour made from different yam cultivars using different processing methods.

SAMPLES	BULK DENSITY (G/ML)	WATER ABSORPTION CAPACITY (G/ML)	WETTABILITY (SECS)	OIL ABSORPTION CAPACITY (G/ML)	SWELLING INDEX (G/ML)
APBSW	$0.41±0.02^{c}$	$2.67±0.31^{ef}$	$178.33±2.89^{a}$	$1.87±0.12^{a}$	$1.35±0.27^{cd}$
ALPSW	$0.38±0.00^{c}$	$2.53±0.23^{ef}$	$120.00±0.00^{de}$	$1.60±0.35^{a}$	$1.10±0.01^{ged}$
AAPSW	$0.35±0.01^{eff}$	$2.80±0.20^{def}$	$148.00±44.81^{c}$	$5.13±2.32^{b}$	$1.61±0.02^{fg}$
APBOW	$0.37±0.02^{d}$	$2.40±0.53^{f}$	$120.00±0.00^{de}$	$7.40±1.06^{a}$	$1.28±0.01^{cde}$
ALPOW	$0.33±0.01^{f}$	$3.07±0.31^{def}$	$156.00±5.77^{abc}$	$1.80±0.20^{a}$	$1.15±0.04^{efg}$
AAPOW	$0.36±0.03^{ef}$	$3.35±1.01^{cde}$	$173.00±25.17^{ab}$	$2.33±0.76^{cd}$	$1.43±0.00^{efg}$
CPBSW	$0.35±0.03^{f}$	$3.83±0.29^{bcd}$	$88.33±2.89^{fg}$	$5.20±1.73^{b}$	$1.32±0.00^{cd}$
CLPSW	$0.49±0.03^{a}$	$4.63±0.11^{b}$	$86.67±11.55^{g}$	$3.57±0.75^{c}$	$1.12±0.00^{ab}$
CAPSW	$0.45±0.01^{b}$	$4.27±0.11^{bc}$	$36.67±11.55^{h}$	$2.80±0.00^{cd}$	$1.16±0.00^{ab}$
CPBOW	$0.36±0.03^{ef}$	$4.40±0.20^{bc}$	$100.00±0.00^{efg}$	$3.53±0.12^{c}$	$1.15±0.00^{c}$
CLPOW	$0.40±0.02^{c}$	$3.77±0.21^{bcd}$	$120.00±0.00^{cd}$	$3.00±0.00^{cd}$	$1.11±0.10^{bd}$
CAPOW	$0.46±0.00^{a}$	$3.53±0.46^{cde}$	$86.67±2.89^{g}$	$2.77±0.25^{cd}$	$1.10±0.11^{ab}$
LPBSW	$0.45±0.03^{b}$	$2.33±0.23^{f}$	$138.33±2.89^{cd}$	$1.47±0.23^{a}$	$1.26±0.01^{def}$
LLPSW	$0.40±0.02^{c}$	$7.50±0.44^{a}$	$93.33±5.77^{fg}$	$1.90±0.26^{a}$	$1.32±0.03^{cd}$
LAPSW	$0.33±0.02^{g}$	$3.13±0.23^{def}$	$150.00±0.00^{bc}$	$1.60±0.35^{a}$	$1.15±0.01^{efg}$
LPBOW	$0.41±0.02^{c}$	$2.60±0.00^{ef}$	$93.33±5.77^{fg}$	$1.67±0.12^{a}$	$1.73±0.39^{fg}$
LLPOW	$0.34±0.01^{fg}$	$2.87±0.12^{def}$	$110.00±10.00^{efg}$	$1.80±0.20^{a}$	$1.29±0.18^{cd}$

Values are mean ± standard deviation (SD) of triplicate sample; means with different superscripts in the same row were significantly different (P<0.05)

APBSW, ALPSW, AAPSW, APBOW, ALPOW, AAPOW=Cultivar “Amula” processed with: plastic and steep water, local clay pot and steep water, aluminium pot and steep water, plastic bucket and clean water, local clay pot and clean water, and aluminium pot and clean water respectively.

CPBSW, CLPSW, CAPSW, CPBOW, CLPOW, CAPOW=Cultivar “Cotedivoire” processed with: plastic bucket and steep water, local clay pot and steep water, aluminium pot and steep water, plastic bucket and clean water, local clay pot and clean water, and aluminium pot and clean water respectively.

LPBSW, LLPSW, LAPSW, LPBOW, LLPOW, LAPOW=Cultivar “Lasinrin” processed with: plastic bucket and steep water, local clay pot and steep water, aluminium pot and steep water, plastic bucket and clean water, clay pot and clean water, and aluminium pot and clean water respectively.

The wettability of the yam flour ranges from 36.67secs to 178.83secs. APBSW has the highest wettability value (178.83secs) while the lowest wettability (36.67secs) was recorded for CAPSW. There were significant difference (P<0.05) in the result obtained for the yam flour. The result obtained differs from the result obtained by (22) which ranges from 106.33 to 136.67secs. The non-conformity may be as a result of the yam cultivar used and the processing methods adopted wettability is a function of the ease of dispersion/displacement of water by any sample. The sample with the lowest time of wettability will dissolve in water faster and would perform better in texture and comminuted meats and baked products (25).

Oil Absorption Capacity of yam flour ranges from 1.47g/ml to 7.40g/ml. LAPOW has the lowest oil absorption capacity while LPBSW has the highest value. The results obtained does not vary significantly (P<0.05) except in AAPSW, AAPOW, CPBSW, CLPSW, CAPSW, CPBOW, CLPOW and CAPOW where the 5.13g/ml, 2.33g/ml, 5.20g/ml, 3.57g/ml, 2.80g/ml, 3.53g/ml, 3.60g/ml and 2.77g/ml respectively. The results obtained from this study conform with the result recorded by (26) on quality evaluation of wheat – cocoyam – soybeans cookies which ranges from 1.92g/ml to 3.84g/ml and the one recorded by on Sorghum – African yam bean flour which ranged from 6.48 – 8.86g/ml. Flours with excellent oil absorption capacity will be useful in the preparation of pastries and pie crust mixes.

The pasting characteristics of yam flour made from different yam cultivar using different processing methods are shown in Table 3. When heat is applied to starch based foods in the presence of water, a series of changes occur known as gelatinization and pasting which influences the quality and aesthetic considerations in food industry, as it affects the texture, digestibility of starchy food (27). Peak viscosity of yam flour ranged from 1783.00cP to 3682.00cP. CPBOW had the lowest peak viscosity (1783.00cP) while LAPSW had the highest peak viscosity (3682.00cP) there was significant difference (P<0.05) in the peak viscosity of yam flour except in APBOW, LPBSW, LLPSW, LPBOW and LLPOW which are 3257.00, 3257.00, 3269.50, 3272.00 and 3281.00cP respectively. The result obtained is not similar to the one reported by (28) on chemical and sensory properties of water yam – cassava flour and paste which ranged from 212.00 to 362.07cP. The variation might be as a result of the method of processing or equipment used for analysis. High peak viscosity is an indication of high starch content which also relate to water binding capacity of starch (29). Peak viscosity is often correlated with the final product quality. It also provides an indication of the viscous load likely to be encountered during mixing (31). High swelling index is indicative of high peak viscosity while higher solubility as a result of starch degradation or dextrinization results in reduced paste viscosity (32).

The maximum viscosity of constant temperature phase of the cP profile and the ability of paste to withstand breakdown during cooling is referred to as the trough (33). The trough of the yam flour ranged from 1691.00cP to 3533.50cP. CPBOW has the lowest trough (1691.00cP) while LAPSW had the highest trough value (3533.50cP). There was significant difference (P<0.05) in the result obtained except in CLPSW, CAPSW, CLPOW and CAPOW which were 2006.50cP, 2020.00cP, 2005.00cP and 2041.00cP respectively. The result obtained differs from the one recorded by (34) on effect of processing methods on pasting and functional properties of Aerial yam (Dioscorea bulbifera) flour which ranged from 16.67cP to 239.17cP. The different might be as a result of the yam cultivar used in this study or the processing method. Trough is an indication of breakdown or stability of the starch gel during cooking (35, 36).

The final viscosity of the yam flour ranged from 2464.00 – 4332.50cP. CAPSW had the lowest final viscosity (2464.00cP) while LPBOW had the highest peak viscosity (4332.50cP). The result varied significantly (P<0.05) except in AAPSW and APBOW which were 3868.50 and 3862.5cP respectively. The result obtained is not similar to the result recorded by (9) on effect of yam varieties on pasting properties of traditional dry yam which ranged from 55.5cP to 378.0cP. The difference might be as a result of the yam cultivar used or equipment used for analysis. The peak and final viscosities are considered to be the most important paste viscosity especially with regard to product properties (37). (38) have reported the use of starches with high viscosity value in pharmaceutical companies especially as tablet binders.

The values obtained for setback of the yam flour varied significantly (P<0.05). The value ranged from 340.50cP to 799.00cP. CLPSW had the lowest setback value (340.50cP) while APBOW had the highest setback value (799.00cP). The obtained from this study differs from the result recorded by (39) which ranged from 118.75 to 168.96cP. Higher setback value means reduced dough digestibility (32) while lower setback during cooling of paste indicates lower tendency for retrogradation (35, 40).

The peak time is a measure of the cooking time (27). The peak time of the yam flour varied significantly. The peak time value ranged from 5.10mins to 7.03mins. CPBOW had the lowest peak time (5.10mins) while APBSW had the highest peak time (7.03mins). The values obtained are similar to the values obtained by (34) on Aerial yam flour and (41) on pasting and sensory properties of poundo yam which ranged from 4.07mins to 5.66mins and 7.0mins respectively.

The pasting temperature of the flour ranged from 81.35˚C to 89.10°C. The lowest value (81.35°C) was recorded for LPBOW while the highest value (89.10°C) was recorded for CLPOW. The result obtained is similar to that recorded by (34) on Aerial yam flour which ranged from 82.45°C to 88.25°C. There was no significant difference (P<0.05) in the pasting temperature except in CPBSW, CLPSW, CAPSW and CPBOW which are 88.13°C, 88.30°C, 87.05°C and 88.35°C respectively. The pasting temperature gives an indication of the gelatinization time during processing. It is the temperature at which the first detectable increase in viscosity is measured and is an index characterized by the initial change due to the swelling (42).

Table 2 Pasting properties of yam flour made from different yam cultivars using different processing methods.

SAMPELS	PEAK VISCOSITY (cP)	TROUGH (cP)	BREAKDOWN (cP)	FINAL VISCOSITY (cP)	SETBACK (cP)	PEAKTIME (MINS)	PASTING TEMPERATURE (°C)
APBSW	3497.00±69.30^{c}	3259.00±1.41^{b}	195.00±7.07^{b}	3941.00±1.41^{d}	686.50±3.54^{c}	7.03±0.04^{a}	83.15±0.07^{bc}
ALPSW	3475.00±21.21^{c}	3432.00±2.83^{a}	27.50±2.12^{l}	3889.50±17.68^{c}	445.50±3.54^{i}	6.54±0.01^{b}	82.23±0.04^{bc}
AAPSW	3466.50±4.95^{c}	3271.50±207.18^{b}	39.00±1.41^{k}	3868.50±3.54^{f}	662.00±2.83^{f}	6.47±0.05^{bc}	82.29±0.05^{bc}
APBOW	3267.00±63.64^{d}	3068.00±2.83^{d}	157.50±2.12^{d}	3862.50±3.54^{f}	799.00±1.41^{a}	6.32±0.26^{bcd}	81.54±0.06^{bc}
ALPOW	2789.00±1.41^{e}	2741.00±2.83^{e}	48.50±0.71^{ij}	3352.50±3.54^{j}	612.00±5.66^{h}	6.23±0.04^{bcde}	82.28±0.04^{bc}
AAPOW	2735.00±7.07^{f}	2694.50±6.36^{e}	178.00±2.83^{c}	3731.50±2.12^{i}	629.50±12.02^{g}	6.15±0.07^{cde}	83.39±0.05^{bc}
CPBSW	1886.50±4.95^{i}	1784.00±5.66^{g}	45.00±7.07^{jk}	2531.00±1.41^{l}	437.00±7.07^{i}	6.56±0.03^{b}	88.13±0.04^{a}
CLPSW	2017.00±1.41^{h}	2006.50±4.95^{f}	27.50±3.54^{l}	2556.50±3.54^{k}	340.50±6.36^{m}	6.48±0.07^{bc}	88.30±0.03^{a}
CAPSW	2034.00±1.41^{h}	2020.00±7.07^{f}	40.05±1.48^{k}	2464.00±4.24^{m}	362.00±1.41^{l}	5.34±0.03^{f}	87.05±0.07^{a}
CPBOW	1783.00±7.07^{j}	1691.00±4.24^{g}	29.00±1.41^{l}	2.35.50±3.54^{l}	442.50±3.54^{i}	5.10±0.14^{f}	88.35±0.07^{b}
CLPOW	2044.50±14.85^{h}	2005.00±7.07^{f}	117.50±3.54^{g}	2447.00±2.83^{n}	420.00±7.07^{j}	6.05±0.07^{de}	89.10±0.14^{a}
CAPOW	2136.50±4.95^{g}	2041.00±2.83^{f}	67.00±1.41^{h}	2338.00±2.83^{o}	378.50±2.12^{k}	5.15±0.21^{f}	83.90±3.25^{b}
LPBSW	2257.00±4.24^{d}	3126.00±1.41^{cd}	128.50±2.12^{f}	3806.00±1.41^{g}	685.00±7.07^{e}	6.17±0.24^{cde}	82.23±1.31^{bc}
LLPSW	3269.50±7.78^{d}	3051.00±2.83^{d}	210.00±1.41^{a}	3772.00±2.83^{h}	719.50±0.71^{d}	6.38±0.45^{bcd}	82.25±1.06^{bc}
LAPSW	3682.00±2.83^{a}	3533.50±3.54^{a}	154.00±1.41^{d}	4288.00±11.31^{b}	762.50±3.54^{b}	5.93±0.00^{e}	82.57±1.79^{bc}
LPBOW	3272.00±2.83^{d}	3187.50±2.12^{bc}	143.50±4.95^{e}	4332.50±3.54^{a}	743.50±2.12^{c}	6.08±0.02d^{e}	81.35±0.92^{c}
LLPOW	3281.00±1.41^{d}	3224.50±4.95^{bc}	53.50±0.71^{i}	3940.00±1.41^{d}	710.00±4.24^{d}	6.20±0.00^{bcde}	82.13±0.18^{bc}
LAPOW	3571.00±1.41^{b}	3441.00±1.41^{a}	127.50±3.45^{f}	4099.50±0.71^{c}	655.00±4.24^{f}	6.48±0.08^{bc}	83.91±0.06^{b}

Values are mean ± standard deviation (SD) of triplicate sample; means with different superscripts in the same row were significantly different (P<0.05

Table 2 Sensory evaluation of yam flour made from different yam cultivar using different processing methods.

SAMPLES	APPEARANCE	TASTE	COLOUR	TEXTURE	OVERALL ACCEPTABILITY
APBSW	8.05±0.89^{abc}	7.75±1.07^{bc}	8.00±0.92^{a}	7.70±1.03^{b}	7.90±1.07^{bcd}
ALPSW	7.70±0.92^{bc}	7.45±1.15^{bc}	7.55±1.19^{b}	7.45±1.19^{b}	7.95±0.99^{abcd}
AAPSW	7.85±1.23^{bc}	7.20±1.47^{c}	7.95±1.32^{ab}	7.45±1.23^{b}	7.80±0.95^{bcd}
APBOW	7.60±0.88^{c}	7.30±1.47^{c}	7.45±1.15^{b}	7.45±1.05^{b}	7.40±0.94^{d}
ALPOW	7.70±0.98^{bc}	7.35±1.04c	7.55±1.05^{b}	7.25±1.07^{b}	7.60±0.75^{cd}
AAPOW	8.05±0.83^{abc}	7.95±0.83^{abc}	7.85±0.75^{ab}	7.50±0.89^{b}	7.80±0.77^{bcd}
CPBSW	5.05±1.23^{d}	4.10±1.21^{d}	4.45±1.47^{cd}	4.10±1.33^{c}	4.10±1.37^{e}
CLPSW	4.55±1.19^{de}	3.80±1.06^{d}	5.00±4.15^{c}	3.95±0.94^{c}	3.90±1.17^{ef}
CAPSW	4.15±1.31^{ef}	3.65±1.04^{d}	4.00±0.92^{d}	3.65±1.04^{c}	3.85±1.27^{ef}
CPBOW	3.70±1.08^{f}	3.70±1.08^{d}	3.70±1.03^{d}	3.40±0.99^{c}	3.60±0.94^{ef}
CLPOW	3.75±1.25^{f}	3.55±1.05^{d}	3.70±1.08^{d}	3.35±1.04^{c}	3.35±0.75^{f}
CAPOW	3.95±1.32^{ef}	3.50±1.19^{d}	3.08±1.20^{d}	3.45±1.09^{c}	3.80±0.95^{ef}
LPBSW	7.45±1.32^{c}	7.55±0.89^{bc}	7.65±1.09^{ab}	7.35±1.39^{b}	7.60±0.99^{cd}
LLPSW	8.00±1.12^{abc}	7.40±1.05^{bc}	7.10±1.17^{b}	7.20±1.28^{b}	7.40±0.94^{d}
LAPSW	7.90±1.07^{abc}	7.75±1.02^{bc}	7.45±0.99^{b}	7.75±1.12^{ab}	8.00±0.73^{abcd}
LPBOW	8.40±0.88^{ab}	7.95±1.50^{abc}	8.15±0.88^{ab}	7.90±1.48^{ab}	8.40±0.60^{ab}
LLPOW	8.40±0.82^{ab}	8.20±1.01^{ab}	8.15±1.09^{ab}	8.00±1.34^{ab}	8.25±0.91^{abc}
LAPOW	8.65±0.75^{a}	6.38±2.21^{a}	8.60±0.82^{a}	8.50±0.95^{a}	8.60±0.75^{a}

Values are mean ± standard deviation (SD) of triplicate sample; means with different superscripts in the same row were significantly different (P<0.05).

The swelling index of yam flour from different yam cultivars varied significantly (P<0.05). The results obtained ranged from 1.10 to 1.82ml/ml. ALPSW and CAPOW had the lowest swelling index (1.10ml/ml) while the highest swelling index was recorded for LAPOW. This result is similar to the result obtained by (19) on effect of processing on cocoyam which ranges from 1.26ml/ml to 2.00ml/ml. The swelling index of flour granules is an indication of the extent of associative forces within the granules (43). Swelling power is an indication of presence of amylase which influences the quantity of amylase and amylopectin present in the yam flour. Therefore, the higher the swelling power, the higher the associate forces (44).

The mean score of sensory evaluation of the yam flour made from different yam cultivars is presented in Table 2. There were significant difference (P<0.05) in the panelist score for all sensory attributes. Appearance ranged from 3.70 to 8.65, colour ranged from 3.70 to 8.60, taste ranged from 3.50 to 8.20, texture ranged from 3.35 to 8.50 and overall acceptability ranged from 3.35 to 8.60. It was observed that majority of the panelist preferred LAPOW (Cultivar Cotedivoire processed with aluminium pot and clean water) in terms of appearance, colour, texture and overall acceptability.

CAPSW (Cultivar Cotedivoire processed with aluminium pot and steep water) had the lowest scoring test (3.65) in terms of taste and CPBOW (Cultivar Cotedivoire processed with plastic bucket and clean water) had the lowest scoring test in terms of colour. The two samples had bitter taste and dark colour. The yam developed bitter taste and dark colour presumably due to the yam flour content and rate of browning that occurred during processing (45).

4. Conclusion

LLPSW (cultivar "Lasinrin" processed with local clay pot and steep water "omi ogi") had the highest water absorption capacity; LAPOW (Cultivar "Amula" processed with aluminium pot and clean water) had the best overall acceptability. Water absorption capacity measures the extent of water retention in yam flour. This affects the ability of the yam flour to form paste.

Compliance with ethical standards

Acknowledgments

We appreciate the local farmers within The Oke-Ogun Polytechnic, Saki. (TOPS) who gave us the local names of the Yam cultivars used in the research work.

Disclosure of conflict of interest

All the authors hereby declared that there are no conflicts of interest before, during and after the conduct of this research.

References

[1] Jimoh KO, Olatidoye OP. Evaluation of physic-chemical and Rheological characteristics of soya beans fortified with yam flour. Journal of applied bioscience. 2009; 13:703-706.

[2] FAO. Food production yearbook. Food and Agricultural Organization, Rome vol.50. FAO (1997). Food production yearbook. Food and Agricultural Organization, Rome. 1996; 51.

[3] FAO. Food and Agricultural Organization: Food Production Yearbook. 1997; 50:160-168.

[4] Brand-miller J, Burani J, Foster-Powell K. The New Glucose Revolution Pocket Guide to the Top 100GI Foods. ISBN 1-56924-500-2. 2003.

[5] Otusanya MO, Jeger MJ. Effect of Aspergillus niger on shoot emergence and virus development in full sown yam (Dioscorea spp) and root development under long term storage condition. Int. Biodegrade. 1996; 38:89-100.

[6] Afoaka EA, Dedeh SKS. Biochemical and Textural Changes in Triofoliate Yam (Dioscoreadumentorum) Tuber after harvest. 2001.

[7] Onayemi O, Potter NN. Studies on local techniques of yam flour production. Journal of food technology. 1974; 16:303-311.

[8] Ige MT, Akintunde FO. Preparation and storage properties of drum dried water yam. Journal of Food Chemistry. 1981; 1:141-149.

[9] Babajide JM, Henshaw FO, Oyewole OB. Effect of yam variety on the pasting properties and sensory attribute of traditional dry-yam and its product. Journal of Food Quality. 2008; 295-305.

[10] Ajibola OO, Babatunde OO, Ige MT. A modified process for low cost Palm Oil Extraction. Journal of food science and Technology. Cabdirect.org. 1988.

[11] Ukpabi UJ, Omodamiro RM, Ikeorgu JG, Asiedu R. Sensory evaluation of amala from improved water yam (Dioscorea alata) genotype in Nigeria. African journal of biotechnology. 2008; 7(8): 1134-1138.

[12] Mbofung CM, Abubakar YN, Njintang A, Abdu-Boubak BF. Physico-chemical and functional properties of six varieties of Taro (Colocasiaesculenta I.schott) flour. J. Food Technol. 2006; 4: 135-142.

[13] Wang YD, Kinsella JE. Functional properties of novel protein. J. Food Sci. 1976; 41: 286-294.

[14] Sathe SK, Pont LG, Rangnekar PD, Salunkhe DK. Effect of addition of great northern bean flour and protein concentrates on the rheological properties of dough and baking quality of bread. Cereal Chem. 1981; 58:97-100.

[15] Tharise N, Juliana F, Nurminah M. Evaluation of physic-chemical and functional properties of composite flour from cassava, rice, potato, soybean santhan gum as alternative of wheat flour. Int. Food Research. 2014; 21: 141-1649.

[16] IITA. International Institute of Tropical Agriculture: Operation manual for the 3 rapid visco analyzer using thermocline for windows. Newport scientific property Ltd. Standard Univ. press. Stanford, CA,USA. 2001; 315.

[17] Ihekoronye AI, Ngoddy PO. Integrated food science and technology for the tropics. Macmillan Pub.ltd., London. 1985 pp115-375.

[18] Kinssella JE. Functional ppts of protein in food – A survey. Crit Rev Food Sci. Nutr. 1976; 5: 219 – 225.

[19] Ukomi AN, Richard CP, Abasiekong SK. Effect of processing on the Proximate, Functional and Anti-nutritional properties of cocoyam (Xanthosoma matata) (Schott) flour. Official J. of Nig. Inv. of Food Sci. and Tech. 2017; 32(2):9-17.

[20] Ocloo FCK, Bansa D, Boatin R, Adom T, Agbemavor WS. Physiochemical, functional and pasting characteristics of flour produced from Jack fruits (Artocarpushetorophyllus) seeds. Agriculture and Biology journal of North America. 2010. ISSN print: 2151-7517.

[21] Oluwalana IB, Oluwamukomi MO, Fagbemi TN, Oluwatemi GI. Effect of Temperature and period of blanching on the pasting and functional properties of plantain (Musa Parasidiaca) flour. Journal of stored product and post – harvest Research. 2011; 2(8): 164 – 169.

[22] Ojinnaka MC, Nnorom CC. Quality Evaluation of wheat – cocoyam – soybean cookies. Nigerian Journal of Agriculture Food and Environment. 2015; 11(3): 123-129.

[23] Adeyeye EI, Aye PAC. (1998). The effects of sample preparation on the proximate composition and the functional properties of the African yam bean flours. Note 1La Rivista Haliana Della sostanzecrasceLXXV-Maggio. 1998; 253-261.

[24] Saani LO, Adebowale AA, Tafa SO. Proximate functional, pasting and sensory qualities of instant yam flour. A paper presented as the 15th LSTRC symposium, central Tuber Crops Research institute Trivandrum, Kerala State, India. 2006.

[25] Akinyede AI, Amoo IA, Eleyinmi AF. Chemical and functional properties of full fat and defatted Diocleare flaxa seed flours. J. Food. Agricul. Environ. 2005; 3(2):112-115.

[26] Okoye JI, Ene GI, Ojobor CC. Chemical component and functional properties of sorghum – Africa yam bean flour blend. Sky Journal of Food Science. 2017; 6(2): 021-026.

[27] Adebowale AA, Sanni LO, Awonorin SO. Effect of texture modifiers on the physiochemical and sensory properties of dried fufu. Food Science and Technology International Journal. 2005; 11(5):373-382.

[28] Babajide JM, Olowe S. Chemical functional and sensory properties of water yam – cassava flour and its paste. International Food Research Journal. 2013; 20(2):902-909.

[29] Olkku J, Rha C. Gelatinization of starch and wheat flour – a review. Journal of Food Chemistry. 1978; 3:293-317.

[30] Osungbaro TO. Effect of differences in varieties and dry milling of maize on the textural characteristics of Ogi (Fermented maize meal). Journal of Science and Food Agriculture. 1990; 52:1-12.

[31] Maziya – Dixon B, Dixon AGO, Adebowale AA. Targeting different end uses of cassava: genotypic variations for cyanogenic potentials and pasting properties. A paper presented at ISTRC-AB symposium, 31 October – 5 November 2004, whitesands Hotel, Mombasa, Kenya. 2004.

[32] Shittu TA, Lasekan OO, Sanni LO, Oladosu MO. (2001). The effect of drying methods on the functional and sensory characteristics of pupuru – a fermented cassava product. ASSET Int. J. 2001; 1:9-16.

[33] Newport Scientific,. Applications Manual for the Rapid Viscotm Analyzer using Thermocline forWindows. Newport Scientific Pvt. Ltd., Australia, 1998: 2-26.

[34] Prince will – Ogbonna IL, Ezembaukwu NC. Effect of various processing methods on the pasting and functional properties of Aerial yam (Dioscorea bulbifera) flour. British Journal of Applied Science and Tech. 2015; 9(5):517-526.

[35] Ragaee S, Abdel – Aal EM. Pasting properties of starch and protein in selected cereals and quality of their food products. J. Food Chem. 2016; 9-18.

[36] Zaidhul ISM, Hiroaki Y, Sunju K, Naoto H, Takahiro N. RVA study of mixture of wheat flour and potato starches with different phosphorus contents. Food Chemistry. 2006;06:056.

[37] Akissoe NH, Hounhouigan JD, Mestres C, Nago M. How blanching and drying affects the colour and functional and functional characteristics of yam (D. cayenensis-rotundata) flours. Food chemistry. 2003; 82:257-264.

[38] Brooks MA, Schitzsaci U. Food Science and technology, Abstracts Int'l. Food into serves (IFIS). 1999; 4(70):67.

[39] Babajide JM, Olowe S. Chemical functional and sensory properties of water yam – cassava flour and its paste. International Food Research Journal. 2013; 20(2):902-909.

[40] Sandhu K.S,Singh N, Malhi N.S.Some properties of Corn grains and their flours. Physiochemical, functional and Chapti-marking properties of flours. Journal food chem. 2007.101:938-946.

[41] Oluwamukomi MO, Adeyemi AO. Physicochemical, Pasting and Sensory properties of "Poundo-yam" enriched with defetted soy flour. J. Applied Tropical Agriculture. 2015; 20(1):89-95.

[42] Emiola L, Delarosa LC. Physicochemical characteristics of yam starchs. Journal of Food Biochemistry. 1918; 5:115-130.

[43] Moorthy SN, Rarnanujan T. (1986). Variation in properties of starch in cassava varieties in relation to age of the crop. Starch/Starke. 1986; 38(2):58-61.

[44] Ruales J, Nair BM. The content of fat, vitamin and mineral in quinoa (Chenopodium quinoa) Wild seeds. Food chemistry Elesevier. 1993.

[45] Samir AM, Abdelgaleil FH, Muneiro N. Antifungal activity of limonoids from KhayaIvorensis. Past Management Science. 2005; 61(2):186-190.