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Chemical, functional and sensory properties of water yam – cassava flour and its paste

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Abstract

Elubo flour is usually produced from traditionally steeped and dried yam (*Dioscorea rotundata*) slices/tubers while lafun flour is a fermented cassava product. During the off season of yam, the elubo retailers tend to mix water yam elubo (*Dioscorea alata*) with lafun to obtain a seemingly yam flour. Water yam flour elubo replacement substitute with cassava flour lafun were evaluated in terms of the chemical, functional properties of the flour and sensory attributes of its cooked thick paste amala. The water yam and cassava flours were blended in the ratios of 100:0, 90:10, 80:20, 70:30, 60:40, 50:50 respectively and 100% yam flour elubo as the control. The pH decreased from 3.82 to 3.42 and cyanide content increased from 0.020 to 0.032 mg HCN/100g as the amount of lafun in water yam flour was increased. Bulk density (0.55-0.67g/ml), Water binding capacity (278.51-381.18%) and water absorption index (61.67-84.21%) increased with increase in amount of lafun in water yam flour, thus improving the reconstitution ability. The peak, trough and final viscosities increased; there was no significant difference ($p>0.05$) in breakdown and setback viscosities respectively while peak time and pasting temperature decreased, as the amount of lafun in water yam flour was increased. The amala paste prepared from sample 70:30 was the most acceptable in terms of colour, taste and aroma.

Introduction

Yam is a common name for some species in the genus Dioscorea. These are perennial herbaceous vines cultivated for the consumption of their starchy tubers in Africa, Asia, Latin America and Oceania (Akissoe *et al*., 2003). They are cultivated throughout the tropics and in parts of the sub-tropics and temperate zones (Kordylas, 1990). There are over 150 species of yam grown throughout the world (Purseglove, 1991). Babaleye (2003) reported that yams contribute more than 200 dietary calories per capita daily and also serve as a source of income for more than 150 million people in West Africa.

The yam tubers can be stored for periods up to 4 or even 6 months at ambient temperature (30 ± 2 °C) better than cassava, potato, sweet potato and aroids (Coursey, 1983). However post harvest losses at various stages from production such as handling, marketing, distribution and processing have been reported as 10-60% of total crop (National Academic Sciences NAS, 1978). These include losses in quantity and tuber quality arising from physical damage, rodents attack, fungal and bacterial diseases and physiological processes such as sprouting, dehydration and respiration. To overcome the problem of perishability 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 Bénin (Bricas *et al*., 1997; Akissoe, 2001; Mestres *et al*., 2004). Dry-yam tubers are processed by peeling, slicing, blanching in hot water (at 40-50˚C for 1-3 h), steeping for a day and drying to brittleness at 60°C. The resulting dried tuber/slice is referred to as gbodo in Nigeria (Onayemi and Potter, 1974; Ige and Akintunde 1981; Babajide *et al*., 2008). 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 local consumers like swallowing small hand cut chunk of the brownish food with a preferred soup (Hahn *et al*., 1987). The processing of yam traditionally depends on the species, for instance white yam (*Dioscorea rotundata* or *D. esculenta*) are always preferred for production of gbodo and pounded yam (Ajibola *et al*., 1988) due to better textural quality of the final product. Water yam (*Dioscorea alata*) is

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always preferred for use in preparing porridge such as ikokore mainly eaten by the Ijebu people of South-Western Nigeria and Ojojo (grated and fried water yam) with no appreciable economic secondary food product (Ukpabi *et al*., 1992).

Preliminary investigation by Babajide *et al*. (2007) revealed that 3.4% of the local processors use water yam for production of gbodo in some processing areas. This is because during the off season of yam (*D. rotundata*), water yam (*D. alata*) is usually in season and its cheaper than yam. Also, many gbodo processors and yam flour elubo sellers mix flours from other sources (such as cassava and yam peels) to the elubo so as to increase their profit. In other words, some retailers of elubo flour mix cassava flour lafun with water yam or yam peel flour in order to change the unacceptable dark brown colour to light brown also to improve the pasting and textural properties of the cooked paste amala .

Cassava (*Manihot esculenta* Crantz) is one of the most important food crops in the tropics (Anon, 1990). The production of cassava for human consumption has been estimated to 65% of fermented cassava food products (lafun, fufu, tapioca, pupuru and gari) while 25% is for industrial use - mostly as starch and 6% animal feed while 10% is lost as waste (Fish and Trum, 1993). The functional and sensory properties of amala made from water yam (*D. alata*) elubo flour could be appreciably enhanced if part of the water yam flour elubo is substituted with cassava flour lafun as the white colour of lafun could reduce the dark brown colour of water yam flour and its paste. Likewise the higher pasting viscosity of lafun could also improve the texture (hand feel) of water yam amala. Thus, the objective of this research was to evaluate the quality attributes (pH, HCN content and functional properties) of water yam-cassava flour elubo and the sensory evaluation of its amala, thus, knowing the best flour proportion of water yam to cassava that will compare favourably well with yam flour elubo.

Materials and Methods

Raw materials

Matured water yam (*Dioscorea alata*), yam (*Dioscorea rotundata*) tubers and cassava sweet variety (*Manihot esculenta*) roots were purchased from a local market in Abeokuta, Nigeria and processed into water yam, yam flours elubo and cassava flour lafun respectively.

Production of yam and water yam flours

Water yam and yam flours were processed respectively, according to the method described by Babajide *et al*., (2008). The yam tubers were peeled, washed, sliced into 2.0 cm thickness and heated in water bath (Clifton, England) at 50 ^{o}C for 2 h. After heating, the yam slices were steeped in the same water for 24 h. The yam slices were drained and dried in a LEEC cabinet dryer at 60 ^{o}C for 2 days to obtain constant moisture content of 8%. The dried yam slices were then milled into flour using a locally fabricated plate mill.

Production of cassava flour

The method described by Oyewole and Afolami, (2001) was used to produce cassava flour lafun. The roots were peeled, washed, steeped in water for 3 days and pulped. The cassava pulp was pressed using a screw press so as to reduce the water content. The pressed pulp was dried using a LEEC cabinet dryer at 60 °C for 2 days to obtain constant moisture content of 8% then milled into flour using a locally fabricated plate mill.

Water yam and cassava flours blending

The water yam and cassava flours were mixed at the ratios of 100:0, 90:10, 80:20, 70:30, 60:40, 50:50 respectively. A 100% yam flour elubo served as the control sample.

Preparation of amala paste from water yam-cassava flour

A 50 g of water yam-cassava flour was stirred in 175 ml boiling water to make smooth thick paste of amala which was cooked for 20 min, with constant stirring to achieve a constant consistency (Babajide *et al*., 2008). The amala for each sample was then packaged in polyethylene film respectively before sensory evaluation.

pH and HCN content

pH was determined using the method described by Sanni *et al*., (2006) while HCN content was determined as described by Essers *et al*. (1993).

Functional properties

The bulk density of the sample was determined according to the method of Wang and Kinsella (1976) while the Water Binding Capacity of the flour was determined using Medcalf and Gillies (1965) method. The Water Absorption Index was determined using the method of Anderson (1982) while the Dispersibility was determined using the method described by Kulkarni *et al*. (1991). The pasting properties of the flour samples were determined using a Rapid Visco Analyser RVA (model RVA 3D+, Newport Scientific, Narrabeen, Australia).

Sensory evaluation

The sensory evaluation for amala (30 g) of each sample was carried out in a well-lit sensory laboratory. A 20 member panelists consisted of male or female adults who are familiar with the samples were used. Each conducted an independent assessment in separate sensory booths 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 by a 9 point Hedonic scale (9 = like extremely and 1 = dislike extremely). Ranking was also carried out for water yam-cassava and yam amala with the best ranked 7 while the least was ranked 1 (Ihekoronye and Ngoddy, 1985).

Data analysis

All data obtained were subjected to one-way analysis of variance (ANOVA) except for sensory analysis which were subjected to two-way ANOVA and means were separated by Duncan Multiple Range Test using SPSS (16.0 version) (SPSS Inc., USA).

Table1. pH, HCN content and functional properties of water yam-cassava flour

water yam : cassava flour	pH	HCN Content (mgHCN/100g)	Bulk Density (g/ml)	Water Binding Capacity (%)	Water Absorption Index %
100:0	$3.82^{b}\pm0.03$	0	$0.55^{b}\pm0.21$	$278.51^{h}\pm12.85$	$61.67^{d}\pm0.04$
90:10	$3.83^{b}\pm0.09$	$0.020^{c}\pm0.013$	$0.56^{b}\pm0.06$	$283.46^{g}\pm23.94$	$75.32^{c}\pm0.01$
80:20	$3.80^{b}\pm0.05$	$0.022^{c}\pm0.006$	$0.58^{b}\pm0.06$	$305.22^{f}\pm6.11$	$79.61^{c}\pm0.06$
70:30	$3.78^{b}\pm0.24$	$0.024^{c}\pm0.009$	$0.68^{a}\pm0.04$	$326.70^{d}\pm8.75$	$84.14^{b}\pm0.03$
60:40	$3.52^{c}\pm0.18$	$0.029^{bc}\pm0.014$	$0.67^{a}\pm0.01$	$359.62^{c}\pm20.38$	$82.45^{b}\pm0.05$
50:50	$3.42^{d}\pm0.02$	$0.032^{b}\pm0.012$	$0.67^{a}\pm0.01$	$381.18^{b}\pm5.76$	$84.21^{b}\pm0.10$
Control	$4.12^{a}\pm0.19$	0	$0.65^{a}\pm0.05$	$315.07^{e}\pm34.01$	$83.86^{b}\pm0.03$
Lafun	$3.34^{e}\pm0.04$	$0.062^{a}\pm0.008$	$0.68^{a}\pm0.02$	$421.68^{a}\pm28.63$	$88.17^{a}\pm0.02$

Means with the same superscript in a column are not significantly different from each other (P>0.05). ± S.D (n=3) = standard deviation 100:0 = water yam-cassava flour, 90:10 = water yam-cassava flour, 80:20 = water yam- cassava flour, 70:30 = water yam- cassava flour, 60:40 = water yam- cassava flour, 50:50 = water yam- cassava flour, Control = yam flour, *lafun*= cassava flour

Table 2. Pasting properties of water yam-cassava flour

water yam : cassava flour	Peak Viscosity (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temp (°C)
100:0	212.00^{f}	108.47^{ef}	103.42^{d}	230.58^{f}	122.44^{d}	5.74^{a}	80.85^{ab}
90:10	240.08^{e}	114.50^{e}	126.58^{c}	235.75^{e}	120.25^{d}	5.53^{a}	78.95^{ab}
80:20	241.75^{e}	120.50^{de}	121.25^{c}	238.25^{e}	118.75^{d}	5.32^{ab}	75.90^{b}
70:30	246.33^{e}	124.92^{d}	121.42^{c}	254.08^{d}	131.17^{c}	5.24^{b}	71.85^{c}
60:40	256.67^{d}	129.75^{d}	126.92^{c}	250.75^{d}	122.00^{d}	5.18^{b}	70.85^{c}
50:50	284.92^{c}	157.25^{c}	125.67^{c}	286.67^{c}	127.42^{cd}	4.90^{bc}	70.50^{c}
Control	342.92^{b}	193.83^{b}	142.08^{b}	338.67^{b}	145.83^{b}	4.87^{bc}	82.35^{a}
Lafun	362.07^{a}	201.46^{a}	170.10^{a}	369.42^{a}	168.96^{a}	4.30^{c}	68.40^{d}

Means with the same superscript in a column are not significantly different from each other (P>0.05). ± S.D (n=3) = standard deviation 100:0 = water yam-cassava flour, 90:10 = water yam-cassava flour, 80:20 = water yam- cassava flour, 70:30 = water yam- cassava flour, 60:40 = water yam- cassava flour, 50:50 = water yam- cassava flour, Control = yam flour, *lafun*= cassava flour

Results and Discussion

pH and HCN content of water yam-cassava flour

There was no significant difference (p>0.05) in the pH of water yam-cassava flours as the inclusion of cassava flour lafun was increased from 0% up to 30% i.e 3.82, 3.83, 3.80 and 3.78 respectively (Table 1). As the percentage of lafun in water yam flour was increased, the pH reduced gradually probably because the pH of lafun was the lowest (3.34). This could be because the production of lafun involved a 3-day steeping period (Oyewole and Afolami , 2001) during which fermentation takes place while yam was steeped for 1 day (Babajide, 2008). The HCN content of water yam-cassava elubo and lafun ranged from 0.020 to 0.062 mgHCN/100g (Table 1) which were very much lower than the maximum level of 2 -3 mgHCN/100g that can be present in a processed cassava product (International Institute for Tropical Agriculture (IITA), 1989; Nwokoro, 2005). Although the amount of cyanide present in lafun was very insignificant, the increased level of lafun inclusion in the water yam-cassava flour led to gradual increase in HCN content while there was no cyanide in 100% water yam and yam flours respectively.

Functional properties of water yam-cassava flour

In Table 1, there was no significant difference (p>0.05) in bulk density (BD) of water yam-cassava flour as the amount of cassava flour (lafun) added to water yam increased from 0 to 20% (0.55 - 0.58 g/ml). Further inclusion of lafun (30 - 50%) in water yam flour gave 0.67 – 0.68 g/ml BD which were not significantly different (p>0.05) from those of the yam flour (control) (0.65 g/ml) and lafun (0.68 g/ml). The bulk density increased gradually and insignificantly (p> 0.05) with increase in percentage lafun flour until 30% level of inclusion when the BD increased significantly to 0.67 g/ml. This could indicate that lafun and the control were – a little denser than water yam flour. This may be attributed to the particle size of cassava flour granules, a bed of fine particles will compact with loading as the packing order of the particles is disturbed (Karuna *et al*., 1996; Bates, 2002).

There were significant differences (p<0.05) in the water binding capacity (WBC) of water yam-cassava flours, the control and lafun samples (Table 1). Lafun had the highest value of 421.68% for WBC while 100% water yam flour had the lowest value of 278.58%. As the percentage of lafun in the water yam flour increased, the WBC increased even above that of control sample as from 30% lafun flour inclusion. Addition of lafun to water yam flour gave high WBC, thus improve the reconstitution ability (Kulkarni, 1991) and textural properties of paste obtainable from water yam - cassava flour. It has been reported that water binding by starches is a function of several parameters such as size, shape, conformational characteristics, hydrophilic and hydrophobic balance in the molecule, carbohydrate associated with proteins, thermodynamic properties of the system and the solubility of starch molecules (Chou and Morr, 1979). The water absorption index (WAI) increased as the percentage of lafun was increased in water yam-cassava flour but as from 30-50% inclusion of lafun, the WAI (82.45-84.21%) were not significantly different ($p>0.05$) from each other. This increase could be because lafun flour is highly viscose and upon gelatinisation, it swells and cause the expansion of starch granules as well as that of some other structural components (Naraya and Moorthy, 2002).

The pasting characteristics of water yam-cassava flour blends are shown in Table 2. When heat is applied to starch based foods in the presence of water, a series of changes occur known as gelatinisation and pasting which influence the quality and aesthetic considerations in food industry, as it affects the texture, digestibility and starchy foods (Adebowale, 2005). Peak viscosity ranged from 212.00 RVU for water yam flour (100:0) to 362.07 RVU for lafun while that of yam flour (control) was 342.92 RVU. The peak viscosity of water yam - cassava flour (50:50) was 284.92 RVU next to the value obtained for the control. The peak viscosity increased as the percentage of lafun in water yam flour was increased, thus further inclusion of lafun beyond 50% could bring the peak viscosity of water yam–cassava flour to the same value as that of control. There was no significant difference ($p> 0.05$) in peak viscosities of samples 90:10, 80:20 and 70:30 i.e samples with 10-30% lafun inclusion. High peak viscosity is an indication of high starch content which also relate to water binding capacity of starch (Olkku and Rha, 1978; Osungbaro, 1990). The relatively high peak viscosity of lafun showed that the flour could be suitable for increasing the gel strength and elasticity water yam–cassava flour blends.

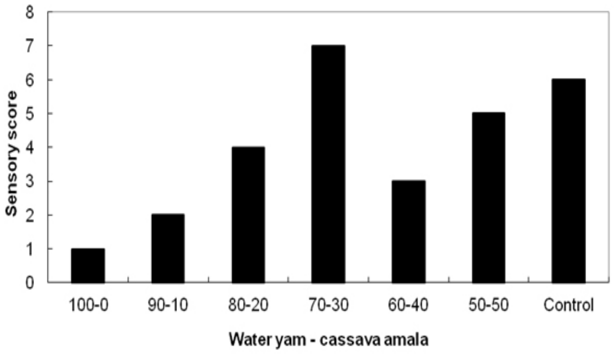
The minimum viscosity at constant temperature phase of the RVA profile and the ability of paste to withstand breakdown during cooling is referred to as the trough. The trough ranged from 108.92 RVU for water yam-cassava flour (100:0) to 201.46 RVU for lafun followed by that of the control (193.83 RVU). The trough increased as the amount of lafun inclusion was increased and there were significant differences ($p<0.05$) in the trough except for samples 70:30 (124.92 RVU) and 60:40 (129.75 RVU). The breakdown viscosity is an index of the stability of starch (Fernandez de tonella and Berry, 1989). Sample 100:0 had the lowest breakdown (103.42 RVU) while lafun had the highest breakdown viscosity as 170.10 RVU. As the percentage lafun in water yam-cassava flour was increased, the breakdown viscosities were not significantly different ($p>0.05$) from each other (121.25 -126.92 RVU for samples which had 10-50% lafun inclusion). This could be an indication that the starches of cooked water yam and cassava flours were stable. The final viscosity is the change in the viscosity after holding cooked starch at 50 ^{o}C. It is one of the most common parameter used to define the quality of a particular starch-based sample, as it indicates the ability of the material to form a viscous paste or gel after cooking and cooling as well as the resistance of the paste to shear force during stirring (Adeyemi and Idowu, 1990; Adebowale, 2008). Although the final viscosity increased as the amount of lafun inclusion was increased, significant differences ($p<0.05$) exist between the pastes of water yam–cassava flours and the control, with sample 100:0, having the lowest value of 230.58 RVU while lafun had the highest value of 369.42 RVU followed by the control (338.67 RVU).

There was no significant difference ($p>0.05$) in the setback values of water yam-cassava flours as the inclusion of lafun was increased (118.75-122.44 RVU) except for sample 70:30 (131.17 RVU) and 50:50 (127.42 RVU) which varied slightly. Lafun had the highest setback value (168.96 RVU) followed by the control (145.83 RVU) Lower setback values were observed for water yam-cassava flour samples which could lead to higher retrogradation during cooling. This is because the higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the product made from the flour (Adeyemi and Idowu, 1990). The peak time which is a measure of the cooking time, ranged from 4.30 min for lafun to 5.74 min for sample 100:0. Peak time reduced gradually as the level of inclusion of lafun increased but there was no significant difference ($p>0.05$) in the peak time for sample 50:50 and the control as 4.90 and 4.87 min respectively. Lafun had the lowest peak time (4.30 min) and pasting temperature (68.40^{o}C) thus, its inclusion in water yam flour could have caused the gradually reduction in peak time and pasting temperature. 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 characterised by the initial change due to the swelling (Emiola and Delarosa, 1981). As the percentage of lafun in water yam flour was increased, the pasting temperature increased gradually but there was no significant difference ($p>0.05$) in values obtained for samples 70:30, 60:40 and 50:50 (71.85

Table 3. Sensory score of amala paste made from water yam-cassava flour

water yam : cassava flour	Colour	Taste	Mouldability	Aroma	Overall acceptability
100:0	4.65[e]	5.10[c]	5.10[e]	5.55[d]	5.30[e]
90:10	6.00[d]	6.20[b]	5.20[e]	5.70[c]	5.70[d]
80:20	7.30[c]	6.25[b]	6.10[d]	6.30[ab]	6.45[c]
70:30	7.70[a]	6.50[a]	6.50[c]	6.75[a]	7.40[a]
60:40	7.25[c]	6.50[a]	7.40[b]	6.20[b]	7.15[b]
50:50	7.20[c]	6.50[a]	7.70[a]	6.30[ab]	7.20[b]
Control	7.50[b]	6.30[ab]	6.65[c]	6.70[a]	7.40[a]

Means with the same superscript in a column are not significantly different from each other (P>0.05). ± S.D (n=3) = standard deviation 100:0 = water yam-cassava flour, 90:10 = water yam- cassava flour, 80:20 = water yam- cassava flour, 70:30 = water yam- cassava flour, 60:40 = water yam- cassava flour, 50:50 = water yam- cassava flour, Control = yam flour, *lafun*= cassava flour



100-0 = water yam-cassava flour, 90-10 = water yam- cassava flour, 80-20 = water yam-cassava flour, 70-30 = water yam- cassava flour, 60-40 = water yam- cassava flour, 50-50 = water yam- cassava flour, Control = yam flour

Figure 1. Bar chart for ranking of "amala" paste made from water yam-cassava "elubo" flour

to 70.85 and 70.50°C respectively). There was an indication that the more lafun was added to water yam flour, the more the pasting temperature tends towards that of lafun which was lower than that of the control sample (82.35°C).

Sensory evaluation of thick paste (amala)

In Table 3, there were significant differences ($p<0.05$) in the colour of amala made from water yam-cassava flour samples except for samples 80:20, 60:40 and, 50:50. Sample 70:30 had the highest value of 7.70 "like very much" for colour followed by the control (7.5) which were "like very much" and "like moderately" while sample 100:0 had the lowest value of 4.65 for colour as "neither like nor dislike". There was no significant difference ($p>0.05$) in taste of amala made from samples 70:30, 60:40 and 50:50 having the highest value of 6.5 which is between "like moderately" and "like slightly" followed by the control (6.30) as "like slightly" while sample 100:0 had the lowest value of 5.10 as "neither like nor dislike".

Mouldability increased as the inclusion of lafun increased. Significant differences ($p<0.05$) occurred in mouldability of amala made from water yam-cassava flour except for samples 70:30 and the control (6.50 and 6.65 respectively). which were "like moderately" while sample 100:0 had the lowest value of 5.10. The aroma of amala made from sample 70:30 was liked best as "like moderately" (6.75) which was not significantly different ($p>0.05$) from that of control (6.70) while that of sample 100:0 was the lowest (5.55) which was between "like slightly" and "neither like nor dislike".

Amala made from samples 70:30 and the control had the highest value for overall acceptability (7.40 as "like moderately" respectively) while that of sample 100:0 had the lowest vale of 5.30. Figure 1 showed the bar chart for ranking of amala made from water yam-cassava flour and yam flour (control). Sample 70:30 was ranked best while sample 100:0 was ranked lowest.

Conclusion

The use of water yam flour in the preparation of thick paste amala could be improved in terms of the functional and sensory properties, by adding appropriate proportion of cassava flour lafun to it. Samples containing 30, 40 and 50% lafun exhibited the most desirable in terms of WBC and WAI, thus improve the reconstitution ability compared with yam flour, while sample containing 30% cassava flour exhibited the best for the sensory evaluation. Also, addition of lafun to water yam flour could lead to increase in its pasting properties. Water yam – cassava flour of varied inclusion of lafun could be produced based on the demand on the level of pasting for the final product amala by the consumer as observed for the sensory attribute (mouldability). Water yam-cassava flour can be used as a substitute for yam flour, thus enhancing its economic importance and reducing the dependence on yam for the production of elubo and amala.

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