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Full Length Research Paper

Sensory evaluation of amala from improved water yam (*Dioscorea alata*) genotypes in Nigeria

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Production of improved water yam (*Dioscorea alata*) genotypes that are suitable for the preparation of amala (a popular darkish Nigerian food) would likely enhance the economic importance of the crop in Nigeria. Fermented flour (oven dried and sun dried) made from tubers of eight improved *D. alata* genotypes (TDa 00/00364, TDa 00/00194, TDa 00/00103, TDa 00/00104, TDa 99/00240, TDa 99/01176, TDa 98/01166, Um 680) and two landraces (TDa 92-2, Ominelu) were reconstituted into amala, and organoleptically evaluated. Relevant characteristics of the experimental yam tubers, and their intermediate products (chips and flour), were also evaluated for desirable qualities. Results showed that the tubers shape could affect the percentage peel loss of the tubers during processing. The dry matter content of the experimental fresh tubers varied from 20.05 to 45.63%, while the moisture content of the oven dried fermented (pH 5 - 6) yam flour (elubo) samples (used for the amala preparation) ranged from 8.30 to 9.80%. The colour observed in the amala samples varied from light brown to black. Though most of the experimental genotypes could be used in preparing amala, only TDa 00/00194 and TDa 00/0364 were highly rated (in relevant sensory parameters) for the preparation of the foodstuff (which is traditionally made from processed tubers of some *Diosocrea rotundata* cultivars).

Key words: Sensory evaluation, water yam, improved genotypes, amala, Nigeria.

INTRODUCTION

Amala is a popular starchy ethnic food that is prepared by reconstituting (cooking and stirring with boiled water) fermented yam flour (elubo), produced traditionally from processed tuber flesh of certain white yam (*Dioscorea rotundata*) cultivars in Nigeria (Coursey, 1981; NRCRI, 1983; Orkwor, 1998). The local consumers usually like swallowing small hand-cut chunks of the darkish food with a preferred soup (Hahn et al., 1987). Though amala is largely eaten by ethnic Yorubas of south-western Nigeria, its popularity as a "fufu" like meal is increasing amongst non-ethnic Yoruba consumers in Nigeria and some other countries on the west coast of Africa. With a recent annual production of above 27 million metric tonnes (FAO, 2003), Nigeria is the world's largest producer of edible yams, with *D. rotundata* and *D. alata* as the two most cultivated yam species in the country. Unlike most harvested fresh yams, intermediate or secondary yam products used for the preparation of amala (dehydrated yam chips and "elubo") have the potential of remaining wholesome after six months of storage at ambient conditions in Nigeria (Ukpabi et al., 1996; Iheko-ronye, 1999; Ukpabi and Omodamiro, 2007). Though white yam has various secondary uses in Nigeria (Oti and Ukpabi, 1992), water yam is mainly eaten in the country as boiled and fried yam (with no appreciable economic secondary food products).

Many Nigerian farming communities that cherish amala dishes are generally known to grow landraces of *D. alata.* Unfortunately, only a few of these landraces (such as Ominelu cultivar) produce yam tubers that give fairly acceptable amala after processing. In the country, some improved water yam genotypes (developed in Nigeria) are officially being released (in 2007) to the local farmers while some genotypes are undergoing pre-release trials nationwide. Therefore, knowledge of the improved *D. alata* genotypes that are suitable for the preparation of amala would probably catalyze the crop's production (and probably processing) in these localities and important

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"elubo" processing communities in the country. The use of relevant sensory parameters to investigate the suitability of these improved *D. alata* genotypes (which are adapted to the major yam zones in Nigeria) in the preparation of amala is, therefore, the objective of this study.

MATERIALS AND METHOD

Source of materials

The tubers of eight improved water yam genotypes (TDa 98/01166, TDa 98/01176, TDa 99/00240, TDa 00/00103, TDa 00/00104, TDa 00/00194, TDa 00/00364, Um 680) and two landraces (TDa 92-2, Ominelu) used for this study were harvested in December, 2006 (7 months after planting) from the experimental plots of Yam Programme, National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria. Except for Ominelu (local landrace and control) and Um 680 (that was developed in NRCRI), the remaining new improved genotypes (with TDa 92-2 that served as an international control) were originally collected from International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The randomly selected experimental tubers, which were of small marketable size (1 - 2 kg), were processed (within 2 months of harvest) for the completely randomized experiments.

Production of "elubo" (fermented yam flour)

The unit and subunit operations used in the production of the "elubo" samples are shown in Figure 1. The chipping of the manually peeled yam tubers was mechanically done, while the fermentation of the fresh yam chips (95 mm long, 5 mm thick mean size) steeped in water lasted for 24 h at ambient room temperature of 26 - 29°C. Half of the washed fermented samples was oven dried (60°C) while the remaining half was sun-dried (on raised platforms) to brittleness, before the mechanically milling to flour.

Preparation of amala

The "elubo" was made into amala by mixing one part of the "elubo" sample with approximately 1.5 parts of boiling water (v/v) in a 1 L heat resistant glass beaker. The paste was further cooked (with stirring), with an electric laboratory hot-plate (Gallenhamp brand), set at medium heat until it is done.

Tuber shape and peel loss determination

Manual peeling with sharp kitchen knife was used to determine the percentage peel loss of the experimental yam tubers (in quadruplicates). The authors used literature guidelines and the assistance of their research colleagues (who are well versed in tuber shape characterization) in determining the shape of the experimental yam tubers.

Colour determination

The colour of the experimental tuber flesh, dried chips, "elubo" and amala samples were visually done by the authors, with the assistance of their colleagues and a computer colour chart (M.S Word 2003).

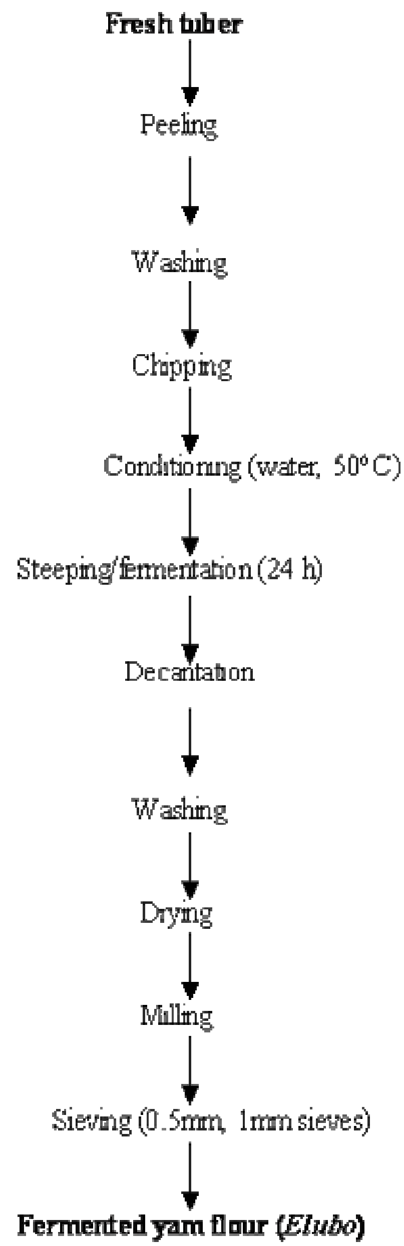

Figure 1. Flow chart for the production of "elubo".

Laboratory analysis

The dry matter content of the fresh tuber and the moisture content of the "elubo" samples were determined in quadruplicates with standard methods (Bainbridge et al., 1996; AOAC, 1997). The pH of the "elubo" samples was determined.

Sensory evaluation

Randomly selected 20 semi-trained panelists, drawn from the ethnic Yoruba population living in the vicinity of NRCRI, were used to

Table 1. Selected tuber characteristics of the experimental genotypes.

Genotype	Whole tuber		Tuber flesh	
	Shape	Peel loss (%)*	Colour	Dry matter (%)*
TDa 92-2	Branched	24.33[c]	Purple/cream	26.97[e]
TDa 00/00364	Branched	25.41[c]	Cream	28.10[e]
TDa 00/00194	Oblong	19.45[c]	Cream	26.77[e]
TDa 00/00/03	Branched	27.07[bc]	Cream	29.37[d,e]
TDa 00/00/104	Branched	26.41[c]	Cream/scanty purple	34.03[c,d]
TDa 99/00240	Branched	37.66[b]	Cream mixed with pink	29.43[e]
TDa 98/0176	Palmitate	45.61[ab]	Cream	45.63[a]
TDa 98/01166	Palmitate	52.44[a]	Cream	37.10[b,c]
Um 680	Oblong/ branched	22.33[c]	Purple/cream	33.07[c,d]
Ominelu	Oblong with contour	37.66[b]	White	39.90[b]

*Values in a column with same letter are not significantly different (P = 0.05) using DMRT.

organoleptically assess the prepared amala samples for colour, hand feel (texture) and general acceptability. All the selected sensory assessors were familiar or conversant with amala and could discriminate between and describe different qualities of the food. The assessors were requested to physically examine the amala samples and score according to their respective degree of likeness with a seven point Hedonic scale (Jellinek, 1985; Iwe, 2002). In the used (0 - 6) scale, 6 = 'like extremely', 5 = 'like very much', 4 = 'like much'; 3 = 'neither like nor dislike', 2 = 'dislike much', 1 = 'dislike very much' and 0 = 'dislike extremely'. The scoring skill of the sensory assessors was enhanced by a day training that involved pre-test repetitions of the used sensory test method (Jellinek, 1985).

Statistical analysis

Statistical Analysis System (SAS) software version 8 (TS MO) licensed to International Institute of Tropical Agriculture, Ibadan, Nigeria (site 0022206002), was used for the mean separations and other statistical analysis.

RESULTS AND DISCUSSION

Table 1 shows the major tuber characteristics of the experimental water yam genotypes that may likely affect the primary processing of the crop. The observed processing peel loss varied from 19.45 to 52.44% and seems to have been affected by the tuber shape. In tuber crops processing, low peel loss and high dry matter content usually enhance the yield of the secondary product (Okaka and Okechukwu, 1993; Okaka and Okaka, 2001). The obtained tuber dry matter content of most of the experimental genotypes (Table 1) compared favourably with 27 - 35% dry matter content given by Degras (1993) for typical *D. alata* cultivars or genotypes.

Though most of the experimental tuber samples had creamy flesh colour (Table 1), the colour hues (of cream, grey, purple and brown) of the secondary products (dried chips and "elubo") in Table 2 indicated enzymatic (oxidative) browning reactions (Okaka and Okechukwu,

Table 2. Colour of the experimental dried chips, "elubo" and amala.

Genotype	Dried chips	Elubo	Amala
TDa 92-2	Dark brown	Brown	Dark brown
TDa 00/00364	Tan	Dark brown	Dark brown
TDa 00/00194	25% Grey	Cream	Light brown
TDa 00/00103	Brown	Brown	Dark brown
TDa 00/00/104	Light brown	Tan	Black
TDa 99/00240	Brown	Brown	Brown
TDa 98/01176	Brown	Brown	Brown
TDa 98/01166	Light brown	Cream	Light brown
Um 680	Light purple	25% grey	25% grey
Ominelu	25% grey	Cream	Light brown

1993; Okaka and Okaka, 2001) that seem to vary amongst the genotypes. Ozo and Caygill (1986) had specifically reported genotypic effect on the rate or extent of enzymatic browning during water yam (*D. alata*) processing.

The colour shades of the prepared (cooked) amala samples (light brown to black) in some cases were darker than their respective "elubo" raw materials, with only the amala sample made from TDa 00/00104 giving a complete black colouration (Table 2). The observed darker colouration of the cooked amala samples may be attributed to non enzymatic browning reactions which include Maillard reactions and ascorbic acid oxidation (Onimawo and Akubor, 2005). In this investigation, the pH range for the dry *elubo* samples was approximately 5 - 6 (Table 3). This low acidic pH might minimize Maillard reactions as Okaka and Okechukwu (1993) found that alkaline pH encourages Maillard reactions in thermally processed yam materials. Based on the fact that the ascorbic acid (vitamin C) content recorded for fresh tubers of water yam (from different genotypes) range from

Table 3. Moisture content and pH of the *elubo* samples from the experimental dried yam chips.

Genotype	Moisture content (%)*		pH	
	Oven dried	Sun dried	Oven dried	Sun dried
TDa 92-2	8.50^{a}	9.00^{b}	5.25^{bc}	5.51^{ab}
TDa 00/00364	8.90 ^{a}	8.40 ^{b}	4.99 ^{c}	5.01 ^{bc}
TDa 00/00194	8.30 ^{a}	10.00 ^{a,b}	5.01^{c}	5.l6 ^{bc}
TDa 00/00103	9.80 ^{a}	10.70 ^{a}	4.99^{c}	5.40 ^{bc}
TDa 00/00/104	8.70 ^{a}	9.30 ^{a,b}	5.33^{ab}	5.63 ^{a}
TDa 99/00240	8.50 ^{a}	9.80 ^{a,b}	5.00^{c}	5.28 ^{bc}
TDa 98/01176	8.80 ^{a}	9.90 ^{a,b}	5.72^{a}	5.99 ^{a}
TDa 98/01166	8.50 ^{a}	10.00 ^{a,b}	5.98^{a}	5.00 ^{c}
UM680	9.60 ^{a}	9.80 ^{a,b}	5.21^{bc}	4.95 ^{c}
Ominelu	9.30 ^{a}	9.20 ^{a,b}	5.60^{a}	5.27 ^{bc}

*Values in a column with same letter are not significantly different (P = 0.05) using DMRT.

Table 4. Sensory evaluation scores# of the experimental amala.

Genotype	Colour*	Handfeel*	General acceptability*
TDa 92-2	4.05^{a,b}	4.35^{b}	3.90^{a,b}
TDa 00/00364	3.95^{a,b}	4.65^{a}	4.00^{a,b}
TDa 00/00194	4.15^{a,b}	4.65^{a}	4.20^{a}
TDa 00/00103	2.65^{c}	2.90^{e}	2.65^{c}
TDa 00/00/104	3.85^{a,b}	3.60^{d}	3.75^{a,b}
TDa 99/00240	3.60^{a,b,c}	3.50^{d}	3.45^{a,b}
TDa 98/01176	3.00^{b,c}	2.95^{e}	2.95^{b,c}
TDa 98/01166	4.00^{a,b}	3.95^{c}	3.80^{a,b}
Um 680	3.80^{a,b,c}	4.05^{c}	4.05^{a,b}
Ominelu	4.55^{a}	4.40^{b}	3.85^{a,b,c}

*Values in a column with same letter are not significantly different. (P = 0.05) using DMRT.
#Where 0 =Dislike extremely; 3 =neither like nor dislike; 6 = Like extremely.

from 4 - 12 mg/100g (Degras, 1993), the effect of the envisaged post processing remnant of the vitamin on the colouration of amala samples needs to be further investigated. Furthermore, the observed differences in the darkish or brownish colouration of the amala from the different genotypes may also be largely due to their respective phenolic content and or phenolase activity as Ozo and Caygill (1986) had specifically identified the tuber polyhydric catechin (flavan-3-ol) and o-dyhydro-xyphenoloxidase as the major factors in the oxidative browning of processed yam.

In the course of this study, there was no observed colour difference in the “elubo” samples from the oven dried and sun-dried water yam chips (of the experimental genotypes) and amongst the cooked amala samples prepared from their respective samples. Even the pre-trial sensory evaluation scores of the respective amala samples (from the oven dried and sun dried materials) did not also indicate any differences amongst those from the same genotype.

Table 4 shows the sensory evaluation results of the amala samples (from the oven dried experimental materials). The amala samples made from TDa 00/00103 and to some extent TDa 98/01176 were rated lowly by the test panelists. The panelists on the other hand, seemed to have rated the amala samples from TDa 00/00194 and TDa 00/00364 highly (in combined scoring for colour, hand-feel and general acceptability). The amala samples from these genotypes were both rated higher than the local and international checks (Ominelu and TDa 92-2) in the hand feel (texture) sensory parameter. Hahn et al. (1987) had earlier observed that ‘hand feeling’ is more important than ‘mouth feeling’ in consumers’ acceptability of “fufu” like pounded yam and amala in Nigeria. The rest of the experimental genotypes (from the scores of the panelists) could also be used in the production of “elubo”, the immediate raw material for the preparation of amala in Nigeria. Future in-depth research on the physico-functional properties of amala samples by researchers might further elucidate the causative factors of the observed sensory differences amongst the experimental genotypes.

The 8.30 - 9.80% moisture content of the fermented yam flour (elubo) from the oven dried chips (Table 3) satisfies the ≤10% moisture content for prolonged shelf-life (up to 6 months) for well packaged dehydrated yam products (Okaka and Okechukwu, 1993). The moisture level (8.40 – 10.70%) of the sun dried "elubo" samples also shows that resource local farmers in Nigeria could use sun-drying in producing storable materials (from *D. alata*) for the preparation of amala in their communities. Ukpabi et al. (1996) found that poor shelf life of yam products could adversely affect food security in some Nigerian communities that have yam based farming systems.

In a farmer participatory field evaluation trial in the yam belt of Nigeria in 2006, the highly rated (for amala preparation) TDa 00/00364 and TDa 00/00104 genotypes out-yielded the local best (NRCRI, 2006). In addition to the official release of TDa 99/00240, TDa 98/01176 and TDa 98/001166 water yam genotypes to the local farmers in 2007, TDa 00/00103, TDa 00/00104, TDa 00/194 and TDa 00/00364 genotypes are the new improved water yam genotypes undergoing pre-release trials nation wide. These water yam development advances in the country can be attributed to the fruitful research collaboration between IITA and NRCRI.

Conclusion

This investigation shows the feasibility of using some improved genotypes of *D. alata* in the preparation of amala, a popular darkish ethnic food that is usually prepared with some *D. rotundata* cultivars in Nigeria. Amongst these improved *D. alata* genotypes, fermented yam flour (elubo) made from the tubers of TDa 00/00194 and TDa 00/00364 genotypes gave highly rated (by sensory assessors) amala samples after their recon-stitution. Parameters for selecting *D. alata* genotypes for this kind of food processing activity would need to include consumer acceptability, food browning, tuber shape, high dry matter content, and low peel loss.

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REFERENCES

AOAC (1997). Official Methods of Analysis of Association of Official Analytical Chemists, Washington D.C.

Bainbridge Z, Tomlins K, Wellings K, Westby A (1996). Methods of Assessing Quality Characterisics of Non-Grain Starch Staples. Part 3. Laboratory Methods. Natural Resources Institute, Chatham, U.K.

Coursey DG (1981). Interaction of yam and man. J. D'agric. Trop. Bot. Appl. 28: 5-21.

Degras L (1993). The Yam. A Tropical Root Crop. Macmillian Press, London. p. 31-38.

FAO (2003). Food and Agricultural Organization of the United Nations statistic data. www.fao.org.

Hahn SK, Osiru DSO, Akoroda MO, Otoo JA (1987). Yam production and its future prospects. Outlook Agric., 16: 105-110.

Ihekoronye AI (1999). Manual on small Scale Food Processing; A Guide to opportunities in small scale processing. The Academic Publishers, Nsukka, Nigeria.

NRCRI (1983). National Root Crops Research Institute, Umudike, (1983). Annual Report, NRCRI, Umudike, Umuahia, Nigeria.

NRCRI (2006). National Root Crops Research Institute, Umudike, (2006). Annual Report, NRCRI, Umudike, Umuahia, Nigeria (in press).

Okaka JC, Okaka ANC (2001). Food: Composition, Spoilage, Shelf-life Extension. OCJANKO Academic Publishers, Enugu.

Okaka JC, Okechukwu PE (1993). Yam Processing: Problems and prospects. In: Advances in Yam Research: Production and Post Harvest Technologies of the yam tubers. GO Osuji (editor), Prairie View A & M University, Prairie View, Texas. p. 78-90.

Onimawo IA, Akubor PI (2005). Food Chemistry. Integrated Approach with Biochemical Background. AMBIK Press, Benin City, Nigeria. pp. 157-167.

Orkwor GC (1998). The Importance of yams. In: Food Yams. Advances in Research, Okwor GC, Asiedu R, Ekanayake IJ (Eds). IITA (Ibadan) and NRCRI (Umudike), Nigeria, pp. 1-12.

Oti E, Ukpabi UJ (1992). Yam storage, processing and utilization. Root Crops Research and Technology Transfer Training Manual, NRCRI, Umudike, Umuahia, Nigeria, pp. 41-50.

Ukpabi UJ, Omodamiro RM (2007). Potential use of polyethylene film in storing elubo in Nigeria. In: Food Professionalism: A Critical Pathway to Industrialization, Elemo GN (ed). Proceedings of 31st Annual Conference of Nigerian Institute of Food Science and Technology, Abuja. pp. 255-256.

Ukpabi UJ, Udealor A, Malize N (1996). Management of crop production-Crop Processing and Storage. In: Diagnostic survey of farming systems of Onitsha zone of Anambra ADP, SO Odurukwe, A Udealor (Eds). NRCRI, Umudike, Umuahia, Nigeria. pp. 53-60.