

Farmstead bread making potential of lesser yam (*Dioscorea esculenta*) flour in Nigeria

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Abstract

Randomly selected tubers of lesser yam (*Dioscorea esculenta*) were converted to flour and used in bread making experimentations after blending it with wheat flour (at varying levels of lesser yam inclusion), with sole white wheat flour as a control. In addition to sensory and specific loaf volume evaluations of the experimental bread samples, the chemical (proximate), selected functional properties and paste characteristics of the experimental lesser yam and wheat flours were also determined. Results showed that on dry matter basis, the wheat flour had 11.50% protein and 1.74% fat while the corresponding values for the lesser yam flour were 7.19% protein and 1.10% fat. The maximum gelatinization temperature of the lesser yam flour paste (91.7°C) and wheat flour paste (94.8°C) were $> 90^{\circ}\text{C} \leq 95^{\circ}\text{C}$ with none of the experimental pastes having a maximum viscosity of > 700 Brabender Units. Bread produced with 20% lesser yam inclusion had 87% specific loaf volume of the control sample and was not significantly ($P = 0.05$) scored lower than the sole wheat bread in overall acceptability, taste, appearance and softness by the sensory assessors. Interestingly, all the bread samples made with the experimental lesser yam flour had no observable cracks on their respective crusts.

Key Words: bread; composite flour; *Dioscorea esculenta*; farm gate technology; quality evaluation; Africa

Introduction

Lesser yam (*Dioscorea esculenta*) is one of the edible yams grown in Nigeria and some other countries along the west coast of Africa (Akoroda and Hahn, 1995; Raemaekers, 2001). The yam belt of West Africa accounts for the bulk of edible yam production in the whole world (Degras, 1993, Hahn et al., 1995; Scott et al., 2000). Probably because of the Asiatic origin of *D. esculenta* (Hahn et al., 1995), it is sometimes or confusingly called Chinese yam in the West Indies and West Africa in place of *Dioscorea alata* that is the true Chinese yam (Degras, 1993; Kissan Kerala, 2009).

Though lesser yam is well adapted to the yam growing zones of Nigeria, it is largely consumed in the local farmsteads and urban areas as boiled or fried yam, that is, without any other defined secondary or even tertiary food product from the starchy or carbohydrate rich edible tubers (Degras, 1993). The relatively short (sometimes about 2 months) shelf life of the harvested tubers at shaded tropical ambient condition (Opara, 2003) and the observed preference of Nigerian yam consumers of the indigenous yam species (especially white guinea yam or *Dioscorea rotundata*) over lesser yam in the preparation of local dishes (boiled and fried yam inclusive) seem to pose a serious constraint to the crop's expanded production in the country. Furthermore, flours made with many white yam cultivars (and even some water yam or *Dioscorea alata* genotypes) serve as secondary products for the

preparation of the locally cherished *amala* and yam fufu meals (Ukpabi and Omodamiro, 2008; Ukpabi et al., 2008). Early research work with food yam species in the West Indies showed that *D. esculenta* flour was among those that gave stiff dough for bread making (Martin, 1974; Martin and Ruberte, 1975). Ciacco and D'Appolonia (1978) and IITA (1988) also showed that flour samples from some water yam genotypes were not inferior to cassava flour in bread making. This is in spite of the fact that scientists, since the 1970s, have demonstrated that cassava can conveniently replace up to 20% of wheat (on dry matter basis) in bread making (Dendy et al., 1970; Crabtree et al., 1978; Palomar et al., 1981). In a recent study, Eddy et al (2007) used a food preference test to find that Nigerian bread consumers did not significantly ($P = 0.05$) prefer sole white wheat flour bread samples over those with 20% cassava flour inclusion. A similar scientific study that could show that appreciable lesser yam flour inclusion in the wheat based bread could give acceptable loaves for Nigerian consumers would not only enhance the importance and value of lesser yam in the rural farmstead, but could also assist in reducing its post harvest losses from prolonged storage. This investigation was therefore aimed at assessing the possibility of using locally produced lesser yam flour to replace or substitute at least 20% (w/w) wheat flour in the production of locally acceptable loaves of bread (without an industrial bread improver).

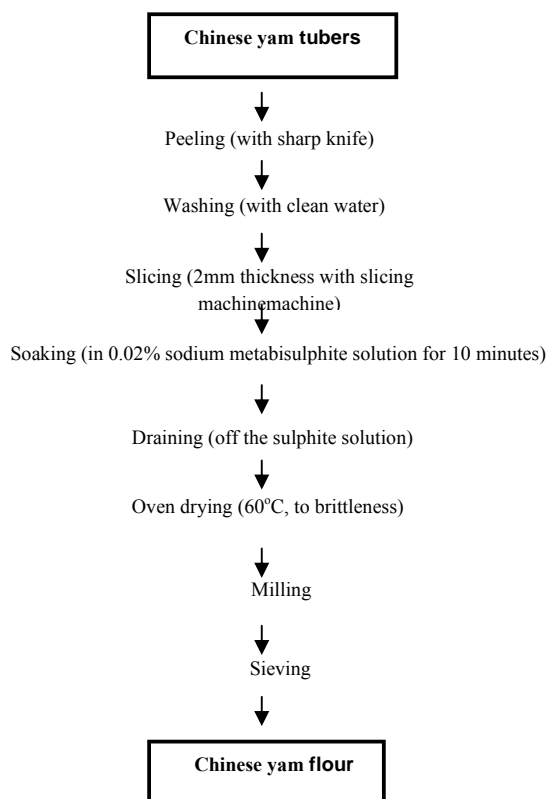


Fig 1. Flow chart for the production of the Chinese yam flour.

Materials and methods

Source of materials

Randomly selected lesser yam tubers used for the experimentation were randomly harvested from the outlying yam farms at National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria (05° 29'N; 07° 33'E). The white wheat flour (Golden P. brand), sugar (Dangote brand), salt (Dangote brand), margarine (Blue Band) and dried yeast (Angel brand) used for bread making were purchased at the Umuahia Main Market, Abia State, Nigeria. Vegetable oil used for the oil absorption capacity determination was also procured from this market. The laboratory chemicals used were of analytical grade and were made by BDH Ltd, Poole, England.

Production of lesser yam flour

The unit and sub-unit operations used in the production of the experimental lesser yam flour are shown in Figure 1. The farmstead operations which included dehydration of the slightly sulphited sliced peeled lesser yam tubers in an oven (oven BS, Gallenkamp, England), milling (with Thomas milling machine, Arthur H. Thomas Co. Philadelphia, PA, USA) and

sieving, produced a floury material of such fineness that all the aggregates passed through a 250 micron sieve. The produced flour was stored in sealed polyethylene bags until used for bread making (within one week).

Chemical analysis

Proximate analysis of the lesser yam and white wheat flours were carried out with standard methods (AOAC, 2000) in quadruplicates. Their proximate compositions on dry matter basis were also calculated with obtained mean values.

Pasting and functional properties

Brabender amylograph (Amylograph PT 100, Brabender GmbH & Co, Duisburg, Germany) was used to record the pasting properties (gelatinization temperatures and viscosities) of the experimental wheat and lesser yam flours in quadruplicates. The rapid method of the system (Brabender, 1993) was used for all the samples. The experimental pastes (without lumps) were made from 450mls of distilled water and 80g (dry matter equivalent) of the respective flour samples. The modified method of Abbey and Ibeh (1988) was used to determine the water absorption capacity (WAC) and oil absorption capacity (OAC) of the experimental flours in quadruplicates. Basically, 1g of flour samples were mixed (in a varl-whirl mixer) with 10ml of distilled water or vegetable oil (for WAC and OAC respectively) for 30 seconds and allowed to stand for 30 minutes at ambient room temperature (28-29°C) before being centrifuged at 5,000 rpm for 30 minutes. Measuring out the volumes of the supernatants was used to find the volumes of the remaining absorbed liquids (water and oil). Multiplication of the respective absorbed volumes by the respective liquid density (mass/volume) was used to get the expression of the OAC and OAC in g liquid/g sample.

Bread making

The experimental bread samples were made with the ingredients in Table 1 using the modified method of Onabolu et al (2003) as shown in Fig 2. The unit and subunit operations in the bread production (using adoptable farmstead level technology) included dough mixing (manual), fermentation, proofing (at 35°C, with heat from the sun) and mechanical baking (Ignis oven), with cooling (at ambient room temperature) for 1 hour as the last step before the relevant bread evaluations.

Specific loaf volume

The specific loaf volume (mass/volume) of the experimental bread samples was determined using seed displacement method (Crabtree et al., 1978; Giami et al., 2004). Rice was used in place of rapeseed for volume determinations.

Table 1. Ingredients for the experimental bread samples

	Wheat flour (g)	Lesser yam flour (g)	Sugar (g)	Margarine (g)	Dried yeast (g)	Salt (g)	Water* (ml)
Control (sole wheat)	600	-	38	35	20	2.5	330
80 wheat: 20 lesser yam	480	120	38	35	20	2.5	335
70 wheat: 30 lesser yam	420	180	38	35	20	2.5	340
50 wheat: 50 lesser yam	300	300	38	35	20	2.5	340
Sole lesser yam	-	600	38	35	20	2.5	350

*volume varied according to approx requirements

Sensory evaluation

Randomly selected 20 semi-trained panelists who were conversant with bread eating quality were used to organoleptically assess the fresh experimental bread samples for taste, flavour, appearance, sponginess, softness and overall acceptability using the modified method of Crabtree et al (1978). The sensory assessors used markings along 10cm lines to indicate their respective opinions on the test parameters (taste, flavour, appearance, sponginess, overall acceptability). These assessments were then converted into scores out of ten. The scoring skills of the panelists were earlier enhanced by a day training that involved pre-test repetitions of the used sensory test method (Jellinek, 1985, Iwe, 2002). The assessors were further requested to comment freely on the bread samples after their physical examinations of the samples.

Statistical analysis

Statistical Analysis System (SAS) software version 8(TS MO) licensed to International Institute of Tropical Agriculture, Ibadan, Nigeria (site 00222-06002) was used for the relevant statistical analysis.

Results and Discussion

The proximate composition of the experimental flours is as shown in Table 2. The obtained values for the lesser yam are similar to those given by Degras (1993) for dehydrated tubers of *D. esculenta*. The relatively low moisture content of the lesser yam flour (9.40%) as compared to the 67-86% moisture content of the crop's fresh tubers (Degras, 1993) will logically make for extended post harvest utilization of this perishable crop as low moisture activity in food materials discourages the growth of plant pathogenic micro-organisms (Okaka and Okaka, 2001; Opara, 2003). Infact, lesser yam flour kept in glass jars can store upto 24 weeks (Degras, 1993). The protein content of the experimental commercial white wheat flour is lower than the 12-14% recommended for strong whole wheat flour (Pomerantz,1987; Sidhu et al., 1999; Belderok et al., 2000) and showed that it is an all purpose wheat flour that could be used for bread making and biscuit making (Palomer 1981; Pomerantz,1987; Belderok et al., 2000). The paste characteristics of the wheat flour (Table 3) showed a maximum viscosity of 655 Brabender Units (B.U) and maximum gelatinization temperature of 94.8^oC that allow for adequate dough

formation and baking in bread making (Pomerantz, 1987; Belderok et al., 2000).

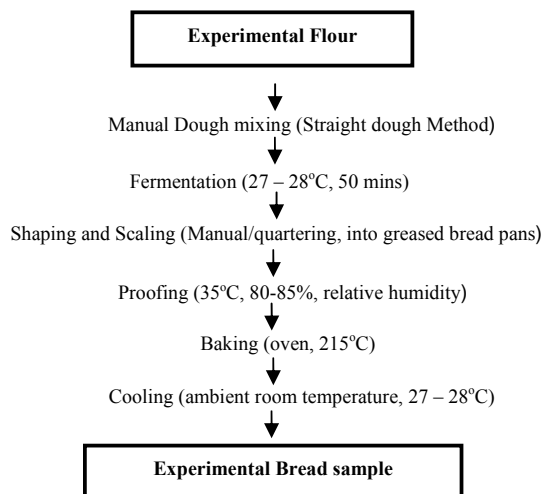


Fig 2.Flow chart for the production of the experimental bread sample

Table 2. Proximate composition of the experimental lesser yam and wheat flours

	Lesser Yam Flour	Wheat Flour
Moisture (%)	9.40±0.16 (0.00)	13.94±0.02 (0.00)
Crude Protein (%)	6.51±0.02 (7.19)	9.90±0.03 (11.50)
Fat (%)	1.00±0.00 (1.10)	1.50±0.01 (1.74)
Ash (%)	2.05±0.07 (2.26)	1.15±0.13 (1.34)
Crude fibre (%)	1.5±0.12 (1.66)	2.20±0.12 (2.56)
Carbohydrate (%)	79.54±2.17 (87.79)	71.31±2.14 (82.88)

*Values in bracket are on dry matter basis

The paste of the lesser yam flour has a comparable maximum gelatinization temperature (91.7^oC) and WAC (2.1g/g) with that of wheat flour (Table 3). WAC and OAC of flours are respectively used to determine their suitability for aqueous and fatty food systems (Abbey and Ibeh, 1988) as applicable to their observed limited extent in bread making. This means that lesser yam flour samples are suitable for hydrophilic systems and may have limited usage in hydrophobic food systems. Dough formation during bread making requires mixing of the flour and water, with many master bakers also incorporating fatty materials such as butter and margarine in the dough prior to baking (Fellows and Axtell, 2004). Just as in the cassava bread investigation in Nigeria (Eddy et al., 2007),

Table 3. Selected pasting and functional properties* of the experimental flours

Flour	Pasting Properties			Functional Properties	
	Min. GT (°C)	Max. GT (°C)	Max GV (BU)	WAC (g/g)	OAC (g/g)
Lesser Yam	87.2±0.1	91.7±0.0	311±4.6	2.1±0.0	1.9±0.0
Wheat	73.5±0.0	94.8±0.0	654±0.3	2.0±0.0	2.5±0.1

*Where Min. GT = Minimum Gelatinization Temperature; Max GT = Maximum Gelatinization Temperature; Max GV = Maximum Gelatinization Viscosity; WAC = Water Absorption Capacity; OAC = Oil Absorption Capacity; BU = Brabender or Amylograph Unit

Table 4. Sensory evaluation scores* of the Bread samples^L

Flour+	Taste	Flavour	Appearance	Sponginess	Softness	Overall Acceptability
Sole wheat	7.43a	7.43a	9.00a	5.17a	6.23a	7.71a
80W: 20 LY	6.67a	6.86ab	7.22a,b	5.32a	6.25a	7.04a,b
70W: 30LY	6.29a,b	6.86a,b	6.67b	5.97a	6.33a	6.47b
50W: 50LY	5.25b	5.23c	4.03c	3.96b	6.09a	4.06c
Sole lesser yam	4.05c	3.97d	1.22d	3.78b	6.39a	2.08d

^L scoring range: 0-10

*values in a column with the same letter do not differ significantly (P = 0.05) using Duncan's Multiple Range Test (DMRT)

†where W = wheat; LY = lesser yam

Table 5. Major comments on the lesser yam bread samples by the sensory panelists

S/no.	For	Against
1.	Most of the bread samples tasted well	The bread samples had varying yam flavour
2.	Some of the loaves have similar internal profile as white wheat bread	Crumbs of some of the bread samples have varying brownish colour shades
3.	The loaves can easily be marketed locally.	There is need to improve on the crumb colour of some bread samples
4.	All the bread samples can be used in the local breakfast menu	Relatively smallness of some bread samples.
5.	All the loaves had no cracks on their crusts	The yam bread samples seemed to be moister than the control (wheat bread).

the experimental bread samples produced (without any industrial bread improver) showed that bread made with 20% lesser yam flour inclusion had sensory scores that were not significantly different (P = 0.05) from those of sole wheat bread in all the used sensory parameters (Table 4). Even bread samples with 30% lesser yam flour inclusion were found relatively acceptable by the sensory assessors in the scored sensory parameters (Table 4). However remarks by the assessors (Table 5) indicated possible presence of slight yam flavour in some bread samples with lesser yam flour inclusion. The observed darkish or brownish colour of the crumbs of the lesser yam bread samples might be due to food browning (enzymatic and non enzymatic) that had been reported in thermally treated and reconstituted dehydrated yam materials (Okaka and Okaka, 2001). There might be a need to increase the level of sulphiting during the yam flour production, for the control of the oxidative food browning (Okaka and Okaka, 2001), if majority of the local bread consumers prefer whitish bread crumbs. The absence of cracks on the crusts of the experimental bread samples is not surprising as Brabender (1989) indicated that only flour pastes with more than 1000 B.U, maximum viscosity generally have cracks. Brabender

(1989) also recommended flour pastes with 300-700 B.U. for bread making and other baked products. Therefore, future research work needs to be done on the use of the lesser yam flour in the production of other baked products such as cakes and biscuits. The relatively lower specific loaf volume value obtained for the sole lesser yam bread samples (Table 6) may be attributed to their lack of the proteinous gluten that is responsible for the enhanced dough rise in leavened wheat bread (Sidhu et al., 1999; Belderok et al., 2000). Though bread with 20% lesser yam flour inclusion had 87% of the specific capacity of that of the control sample (Table 6), it might be necessary to further investigate how bread improvers can improve its specific loaf volume as scientists have used chemical improvers and even mucilaginous plant materials to increase specific loaf volume of non-wheat breads (Horiuchi et al., 2005; Lazaridou et al., 2007). Ciacco and D'Appolonia (1978) had oven shown that endogenous soluble non starch polysaccharides in yam that are lacking in cassava help to improve specific loaf volume. As with cassava processing (Onabolu et al., 1998; Ugwu and Ukpabi, 2002; Ukpabi, 2008), utilization of lesser yam in secondary and tertiary food processing in Nigeria may contribute in sustaining or

Table 6. Specific loaf volume of the bread samples as they relate to wheat bread

Bread sample	Specific loaf volume (ml/g)	Percentage of control
Control (Sole wheat)	3.98 ^a	100
80 wheat: 20 lesser yam	3.48 ^b	87.44
70 wheat: 30 lesser yam	3.40 ^b	85.43

even increasing the crop's production in the country. Micro scale processing of the lesser yam tubers at the farm gate level into flour and bread may also enhance the economic status of the farm stead dwellers if the business is well managed (Fellows and Axtell, 2004). Furthermore, post harvest losses of the crop, accruing from prolonged storage of the fresh tubers would be minimized through its processing into storable forms.

Conclusion

Wheat-lesser yam composite flour at the ratio of 80:20 w/w could be used for the production of bread that is comparable to those made with sole wheat bread flour in Nigeria. The production of both the lesser yam flour and bread samples can be handled with technologies that are adoptable at the farm-gate level in the country. Importance of the use of lesser yam in the country's down-stream food system cannot be overemphasized.

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Disclaimer

Mention of trade names of commercial products in this publication is solely for the purpose of production of specific information and does not imply recommendation or condemnation by National Root Crops Research Institute, Nigeria.

References

Abbey BW, Ibeh GO (1988) Functional properties of raw and heat processed cowpea (*Vigna unguiculata*, Walp) flour. *Journal of Food Science*, 53:1775-1777, 1791.

Akoroda MO, Hahu SK (1995) Yams in Nigeria: status and trends. *African Journal of Root and Tuber Crops*, 1(1): 38-41.

AOAC (2000) Official Methods of Analysis. 17th Edition, Association of Official Analytical Chemists, Washington D.C.

Belderok B, Mesdag J, Donner DA (2000) Bread-making quality of wheat: a century of breeding in Europe (Parts 1 & 2). Springer-Verlag, New York.

Brabender (1989) Brabender amylograph Instructional Manual No. 1732E, Brabender Ohg Duisburg, Germany.

Brabender (1993) Brabender Amylograph additional Instruction Manual for Amylograph PT1000, No. 170054-1E. Brabender Ohg, Duisburg, Germany.

Ciaccio CF, D'Appolonia BL (1978) Baking Studies with Cassava and Yam Flour 1. Biochemical composition of cassava and yam flour. *Cereal chemistry*, 55(3): 402-411.

Crabtree J, Krammer EC, Baldry J (1978) The incorporation of fresh cassava into bread. *Journal of Food Technology*, 13 (2): 149-153.

Degras L (1993) The Yam, a Tropical Root Crop. Macmillan Press, London. Pp 1-408

Dendy DAV, Clarke PA, James AW (1970) The use of blends of wheat and non-wheat flours in breadmaking. *Tropical Science*, 12(2): 131-142.

Eddy NO, Udoffia PG, Eyo D (2007) Sensory evaluation of wheat /cassava composite bread and effect of label information on acceptance and preference. *African Journal of Biotechnology*, 6: 2415-2418.

Fellows P, Axtell B (eds) (2004) Setting up and running a small flour mill or bakery. Opportunities in food processing series, CTA, Wageningen.

Giami SY, Amasisi T, Ekiyor G (2004) Comparison of breadmaking properties of composite flour from kernels of roasted and boiled African breadfruit (*Treculia africana*) seeds. *Journal of Raw Materials Research*, 1:16-25.

IITA (1988) 1987 Annual Report. International Institute of Tropical Agriculture, Ibadan.

Horiuchi R, Itou M, Sugihara Y, Fukuda M (2005) Effect of dry Okra on the specific loaf volume of bread. *Journal for the Integrated Study of Dietary Habits*, 16: 31-38.

Iwe MO (2002) Handbook of Sensory Methods and Analysis. Rejoint Communications Services, Enugu, Nigeria.

Jellinek G (1985) Sensory evaluation of Food – Theory and Practice, Ellis Horwood, Chichester, U.K.

Kissan Kerala (2009) Tuber Information: Lesser yam (*Dioscorea esculenta*). www.kissanerala.net/kissan/kissancontent/LESSERYAM.htm (accessed August, 2009).

Lazaridou A, Duta D, Papageorgiu M, Bele N, Biliaderis GC (2007) Effect of hydrocolloids on dough rheology and bread quality parameters in gluten-free formulations. *Journal of Food Engineering* 79: 1033-1047.

Martin FW (1974) Tropical yams and their potential. Part 1. *Dioscorea esculenta*. Agricultural Handbook No.457, USDA, Washignton D.C. 18p.

Martin FW, Ruberte R (1975) Flours made from edible yams (*Dioscorea* spp.) as substitute for wheat flour. *Journal of Agriculture for University of Puerto Rico*, 59(4): 255-263.

Okaka JC, Okaka ANC (2001) Food: Composition, Spoilage, Shelf life Extension. OJANCO Academic Publishers, Enugu, Nigeria. Pp 1-284

Onabolu A, Abass A, Bokanga M (2003) New food products from cassava, 2nd Edition. International Institute of Tropical Agriculture, Ibadan, Nigeria.

- Opara LU (2003) Yams: Post Harvest Operation. Massey University, Palmerston North, New Zealand (Edited by Mejia D, AGST/FAO) www.fao.org/inpho/content/compend/text/ch24.htm (last modified Aug. 2003).
- Palomar LS, Perez TA, Pascal GL (1981) Wheat flour substitution using sweet potato or cassava in some bread and snack items. *Annals of Tropical Research* 3(1): 8-17.
- Pomerantz Y (1987) *Modern Cereal Science and Technology*. VCH Publishers New-York, pp.258-333.
- Raemaekers RH (ed) (2001) *Crop Production in Tropical Africa*, DGIC, Brussels, Belgium
- Scott GJ, Rosegrant MW, Ringler C (2000) *Roots and tubers for the 21st Century :Trends, Projections and Policy Options*. International Food Policy Research Institute (IFPRI), Washington, D.C.
- Sidhu JS, Al-Hooti SN, Al-Sagar JM (1999) Effect of adding wheat bran and germ fractions on the chemical composition of high-fiber toast bread, *Food Chemistry*, 64 (4): 365-371.
- Ugwu BO, Ukpabi UJ (2002) Potential of soy-cassava flour cassava processing to sustain increasing cassava production in Nigeria. *Outlook on Agriculture*, 31(2): 129-133.
- Ukpabi UJ (2008) Transformation et utilisation du manioc: guide illustre. NRCRI, Umudike, Umuahia
- Ukpabi UJ, Omodamiro RM (2008) Assessment of hybrid white yam (*Dioscorea rotundata*) genotypes for the preparation of Amala. *Nigerian Food Journal*. 26(1), 111-118.
- Ukpabi UJ, Omodamiro RM, Ikeorgu JG, Asiedu R (2008) Sensory evaluation of amala from improved water yam (*Dioscorea alata*) genotypes in Nigeria. *African Journal of Biotechnology*, 7(8): 1134-1138.