POST HARVEST

Assessment of quality characteristics of exotic sweet potato genotypes for suitable food traits and processing attributes in Nigeria

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Abstract
Thirty one exotic sweet potato genotypes with three promising varieties (TIS8164, Ex- Igbariam and TIS 2532.OP.1.13) obtained from National Root Crops Research Institute (NRCRI), Umudike, were assessed for culinary and some attributes for processing. Dry matter and Starch contents of the genotypes were evaluated. The dry matter content (31.00 46.00%) obtained for the exotic genotypes compared favourably with NRCRI genotypes (41-46%). Over 85% of the genotype has dry matter above 30%. Starch content 14.00-28.50% was obtained which is within literature value of 21.6%, while the peel loss ranged from 12.00 -26.84%. Flour yield ranged from 16.20-35.00%. About 80% of the sweet potatoes are suitable for flour production, which can be used for preparation of many confectioneries such as cake, chin-chin, etc with advantage of high nutritive value due to the presence of â-carotene in those of orange fleshed roots. They are also good source of starch. The leaves of the experimental genotypes with expansive vegetative were simple palmate (25%) while 75% were simple non-palmate. Some of the boiled sweet potato genotypes leaves were subjected to sensory evaluation with a nine point hedonic scale. The randomly selected assessors generally found the experimental leaves (exotic and local checks) acceptable as boiled leafy vegetables (with varying degrees of likeness). The panelist observed that the leaves from some of the experimental genotypes could replace the convectional vegetables. In addition nice aroma from Julian was observed, hence could replace scent leaf. The leaves of variety TIS 8164 was also observed as a suitable replacement for packaging in the preparation of *Ekpan-nkwukwo-* a local Nigerian dish.

Keywords: Sweetpotato, Dry matter, Starch content, Genotype and Flour yield.

Introduction

Sweet potato (*Ipomoea batata* L (Lam) is an important food crop in the Tropics. It is an important crop that is consumed traditionally as a staple in many Sub-Sahara countries (Fuglic., *et al* 2006). It is the third most important food crop in east Africa and ranked seventh among the food crops produced in the world and has an annual production of 138 million metric tons (Edison, 2000).

It has highly biological value with all the essential amino acids. The carbohydrate is in a readily digestible and assailable form. Most of the starch is converted to maltose during cooking thereby making the sweet potato more of a sugary food than starchy food. Sweet potato protein has been reported to be the least affected by the processes of steaming, boiling, baking, etc (Bradbury *et al*., l984 and Chen and Bortey, 1995). The tuber is also rich in carotene (β-carotene) and mineral especially, the yellow varieties, (Bortey, 1995).The total carotenoid content of sweet potato has been found to range from 0 to > 20mg/100 of fresh weight depending on the variety (Akoroda and Teri, 1998).

The determination of culinary and other attributes for processing the leaf of sweet potato accessories is very important for end user's acceptability (Rodriguez, 1999).Though the tuberous roots of the crop serve as staples in many Nigerian homesteads, Ukpabi and Oji (1984) found that the cooked leaves were also cherished as leafy vegetables by many local consumers. The leaves serve as side dishes in Tawai. Young leaves are also eaten as leafy vegetable (Abidin, 2004).The leaves are good sources of vitamin A, C and B_2 riboflavin (FAO/WHO, 1992). The leaves contain 2.4mg/100g vitamin C and 709ug/100g.Vitamin A (Woolfe, 1992). Dry matter content is an indicator of sweet potato quality. Sweet potato starch has found many industrial applications both in the food, and non-food industries (Edmond, 1971).

Recently National Root Crops Research Institute (NRCRI), Umudike acquired some elite exotic sweet potato genotypes from International Centre for potato (CIP) through their substation in East Africa. There is always the need to screen acquired sweet potato accession for suitable root quality traits because sweet potato is cheap to grow and the maturity time is very short (3-5 months)

(Brabet., *et al* 1997-98). The necessity to assess the food utility potentials of these newly acquired genotypes led to this investigation.

Materials and Methods

Experimental Genotypes: The thirty one exotic sweet potato genotypes (NASPOT1,NASPOT2, NASPOT3,NASPOT4,NASPOT5,NASPOT6,Santo-Amaro,CIP199024.1,TanzaniaPale, Costanero(1870162), Jewel(44031), Centenial, K118, Nemanete,TIS8164,Cemsa 40000, Carrot C, CIP199024.2,CIP199034.1,CIP440443, CIP440203, CIP440203440203, TIS2532.OP.1.13, IMBY3102, CIP199005.14,CIP199005.2, Salyboro, 440060 and KEMB37) were assessed with three promising genotypes (TIS8164, Ex- Igbariam and TIS 2532.OP.1.13) in NRCRI, Umudike.

Characteristics of the sweetpotato leave of the genotypes

The colours of the respective leaves were recorded after observing the foliar configurations visually in triplicate.

Chemical analysis: Dry matter and Starch contents of the genotypes were evaluated by AOAC (1990) methods.

Preparation of the sweet potato flour: A standard method (Rodrignez, 1999) was used to produce flour from each of the tuberous roots of the sweet potato genotypes as shown in the flow chart. The peel loss (%) during the production was determined as well.

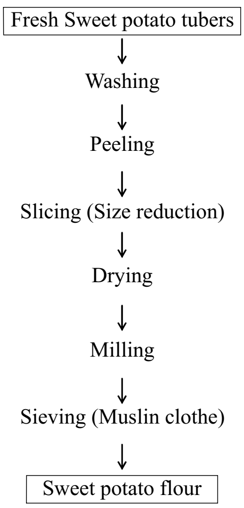

Fig 1: Flow Chart for the preparation of sweet potato flour.

Sensory evaluation of the leaves: The respective leaves were boiled at 100^{0}C for 10 minutes using an electric heater in a glass beaker (pyrex). Seven trained panelists (graduates of food science and allied disciplines) who were conversant with local leafy vegetables were used for the sensory evaluation with a nine point hedonic scale (Iwe, 2002). In the scoring scale 9 represented like extremely, 5, represented neither like nor dislike and 1 represented dislike extremely. The assessors were asked to comment freely.

Statistical analysis: The obtained experimental data (chemical analysis and sensory evaluation) were statistically analyzed with Statistical Analytical System (SAS) (9) software package to determine significant differences using Fisher LSD ($P< 0.05$).

Results and Discussions

Mean values of the percentage dry matter (DM) content, peel loss, starch content and flour yield of the genotypes are shown in Table 1. Generally the genotypes have relatively high dry matter content as over 85% of the genotype has dry matter above 30%. The obtained dry matter content 31.00 46.00% (CIP 199024.2 and TIS 8164 respectively) compared favuorably with NRCRI genotypes (41-46%) and is within the range of 19.9 45.4% work earlier reported by Woolfe, (1992). Average of 20% Starch content was obtained for about 80% of the sweet potato; this is within literature value of 21.6%, Woolfe, 1992. Hence, they are also good source of starch. The peel loss ranged from 12.00 26.84% which is a good attribute.

Flour yield gave average value of 26.40% which also agreed with Woolfe's work. About 80% of the genotypes are suitable for flour production since the flour yield ranged from 16.20-35.00%. The starch which can be used for preparation of many confectionery such as cake, chin-chin, with advantage of high nutritive value due to the presence of â-carotene in the orange/ yellow fleshed roots.

Table 2 shows the foliar characterization of the experimental genotypes (leaf colour, leaf shape /leaf size). The leaves of the experimental genotypes with expansive vegetative growth were simple palmate (25%) while 75% were simple non-palmate. The randomly selected sensory assessors generally found the experimental leaves (exotic and local checks) acceptable as boiled leafy vegetables (with varying degrees of likeness) as shown in Table 3.

The general comments by the assessors showed that some of the experimental genotypes could replace the convectional vegetables; these are shown in Table 4. In addition, the panelist observed nice aroma from Julian which could be used in replacement of scent leaf and possible use of the leaves of TIS 8164 for a replacement of wrapping in the preparation of Ekpan-nkwukwo- a local Nigerian dish.

Conclusions and Recommendations

The genotypes have relatively high dry matter content as over 85% of the genotype has dry matter above 30%. The peel loss are not high. The experimental leaves (exotic and local checks) can be eaten as boiled leafy vegetables and some could replace the convectional vegetables. About 80% of the sweetpotato samples are good source of starch. About 80% of the genotypes are also suitable for flour production.

Table 1: Potential qualities and processing characteristics of the sweet potato genotypes with good rooting system

Genotype	Dry matter (%)	Starch (%)	Peel loss (%)	Flour yield (%)
NASPOT 1	40.00	21.50	15.16	30.00
NASPOT 2	42.00	23.80	26.84	18.00
NASPOT 4	40.00	23.80	13.27	30.00
NASPOT 6	36.00	23.20	24.55	19.00
Santo Amaro	39.00	24.00	24.39	19.00
CIP 199024.1	42.00	28.50	18.53	31.00
Tanzania	40.00	18.30	12.50	30.00
Centennial	42.00	22.90	25.43	17.50
K118	41.00	27.50	11.60	32.50
Nemanete	42.00	21.60	15.43	32.00
Mugande	33.00	18.50	13.62	30.00
Helena	36.00	21.10	12.67	27.50
Carrot C	42.00	24.40	12.00	30.00
Mugamba	34.00	21.50	12.51	25.00
TIS8164	46.00	20.50	18.66	30.00
Cemsa	40.00	23.80	12.33	35.00
440203	35.00	17.80	19.01	30.00
TIS2532.OP.1.13	41.00	22.40	20.00	28.00
IMBY 310	40.00	19.00	14.98	25.00
CIP 199005.14	41.00	20.50	19.42	25.90
CIP 199024.2	31.00	18.10	18.25	20.00
Salyboro	36.00	18.80	14.59	30.00
440060	41.0	14.00	25.12	16.20
KEMB37	38.00	20.40	20.36	26.00

Mean of the triplicate data

Table 2: Foliar characterization of the experimental genotypes with expansive vegetative growth

Genotype	Leaf colour	Leaf shape/type	Leaf size
NASPOT 1	green only	simple (palmate)	medium
NASPOT2	green purple variegated	simple (palmate)	medium
NASPOT3	green purple variegated	simple (palmate)	big
NASPOT5	green purple variegated	simple (palmate)	big
Julian (440141)	green	simple (non-palmate)	medium
Salyboro (187017)	green	simple (non-palmate)	medium
Cemsa (40,000)	green	simple (palmate)	small
Santo-Amaro	green	simple (non-palmate)	small
Carrot C	green	simple (non-palmate)	small
CIP-99024.2	green	simple (non-palmate)	big
CIP-99034.1	green	simple (non-palmate)	big
CIP-440203	green	simple (non-palmate)	small
CIP-440443	green	simple (non-palmate)	medium
Ex-Igbariam	green/purple lines	simple (non-palmate)	medium
TIS8164	green/purple lines	simple (non-palmate)	big
TIS2532.OP.1.13	green	simple (non-palmate)	big

Table 3: Sensory evaluation of the sweet potato leaves

Sample	Appearance	Taste	G/accept
TIS2532.OP.1.13	6.40abcd	5.60cd	6.00bcd
Carrot C	6.40abcd	6.80abc	7.00ab
SANTO-AMARO	6.40abcd	6.20bcd	6.00bcd
CIP440203	5.80bcd	6.40bcd	6.00bcd
CIP199034.1	6.20bcd	5.80bcd	5.40cd
EX-IGBARIAM	7.20ab	7.0ab	6.80abc
SALYBORO	6.60abc	6.20bcd	6.20bcd
NASPOT 3	6.60abc	6.20bcd	6.20bcd
TIS 8164	8.00a	8.20a	8.00a
NASPOT 1	5.80bcd	5.80bcd	6.40bcd
CIP199024.2	5.40cd	5.20d	5.00d
NASPOT 5	6.20bcd	6.20bcd	5.60b
CEMSA	6.00bcd	5.40cd	5.80bcd
NASPOT 3	4.80d	5.80bcd	5.20d
JULIAN	6.20bcd	6.60bcd	6.00bcd
LSD	1.606	1.457	1.493

Table 4: Sensory assessors feed back on possible replacement of convectional vegetables with experimental sweet potato leaves.

Food forms	Convectional vegetables	Genotypes
Okro soup	Okro (Abelmosehus esculentus)	NASPOT 3/CIP440203
Ugu/Egusi soup	Ugu(Telfaria)	Ex-Igbariam/TIS8164
Ewedu soup	Ewedu(Corchorous olitorius)	Carrot C/Julian
Yam porridge	Green (Amarantus)	CIP199034.1/TIS8164
Ekpan- Nkwokor	Fresh Coco yam/ plantain leaves	CIP440203/ TIS8164
Jollof Rice	Scent leaf (Ocimum grattissimum)	Julian

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Synergistic action of α-Amylase and thermostable glucoamylase on cassava starch

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Abstract
Hydrolysis of cassava starch by synergistic action of α-amylase and thermostable fungal glucoamylase was investigated. Starches from three cassava varieties (TME419, 98/581, and 97/2205) were hydrolysed using optimum α-amylase/Glucoamylase ratio (1:5v/v) at 75°C and pH 6.0. The rate of hydrolysis of starch in cassava 98/581 was faster than that of Cassava TME419 and 97/2205 varieties. Optimum glucose yield (66.96-96.42%DE) was obtained at 12hour reaction time. The use of thermostable fungal glucoamylase shortens the process time for the production of glucose syrup from 48hour to 12hour. The enzyme is therefore envisaged to facilitate large-scale bioprocessing of cassava into value-added products such as glucose and considerably reduce post harvest losses.

Keywords: Cassava starch, thermostable glucoamylase, α-amylase

Introduction

Enzymatic hydrolysis of starch to glucose is a multistage process involving different microbial enzymes in successive steps. Two key enzymes involved are a thermostable bacterial alpha amylase and a fungal glucoamylase (Kim *et al.*, 2004). These enzymes catalyze the conversion of starch to glucose through liquefaction and saccharification processes. In the liquefaction process, starch slurry is gelatinized and liquefied at pH 6 and 95°C to 105 °C by an extremely thermostable alpha amylase which results into the partial hydrolysis of starch to maltose, maltodextrin and little glucose for about 2 hours with concomitant loss in viscosity (Abraham *et al.,* 1991).

The rapid liquefaction of the starch at high temperature (95°C) coupled with simultaneous pasteurization of the product ensures superior product quality over the conventional acid hydrolysis (Akinola and Ayanleye, 2004).The saccharification process with glucoamylase at a pH 4.5 and 60°C usually takes about 48hours before complete hydrolysis is attained (Idoko and Odo, 2002). Although the process yields larger amount of glucose as the end product, the resident time (48h) poses a great challenge to the use of glucoamylase for industrial conversion of starch to glucose. There are two major drawbacks to using fungal glucoamylase in the starch industry. First, the optimal temperature of fungal glucoamylase is much lower than that of microbial alpha amylase, resulting in the need for a cooling step and a low rate of catalysis. Second, at relatively high glucose concentrations, fungal glucoamylase condenses glucose into various small maltooligosaccharides, mainly maltose and isomaltose, depending on the source of the enzymes. The final glucose level during the saccharification step decreases due to the formation of di-saccharide or trisaccharide by products via this reverse reaction (Kim *et al*., 2004). This process is energy intensive thus increasing the production cost of starch-based products.The study was therefore conducted to investigate simultaneous hydrolysis of cassava starch using a combination of amylase and thermostable fungal glucoamylase with a view to reducing the process time.

Methods

Materials: Rice bran, soyabean flour, cassava starch, were obtained from local markets in Abeokuta. Starches from three varieties of cassava (TME419, 98/581 and 97/2205) were also obtained from IITA, Ibadan. Alpha-amylase (EC 3.2.1.1.α-1-4- glucan glucanhydrolase) from *Aspergillus niger* with activity 1000unit/ml solution in 1ml glucose was used for this research .

Glucoamylase Production: Glucoamylase production was carried out on a rice-bran solid state medium containing rice bran (10g),cassava starch (1g), and soyabean flour (3g) according to Akpan and Adelaja, (2004).The pH of the medium was adjusted to 4.5 with 0.1M HCl and sterilized at 121°C for 15min.The sterilized medium in a Petridish was inoculated with a loopful of spores of a 24hour old culture of amylase positive mutant of *Aspergillus oryzae SH6* and incubated at 30°C for 72h. The crude glucoamylase was recovered by mixing with acetate buffer (0.2M) (pH 4.5) in the ratio 1:5 (w/v) in a conical flask. The mixture was shaken on an orbital shaker at 150rpm at 28°C for 1h. The extract was then filtered using glass fibre microfilter. The filtrate was used as the crude amylase and stored at 4°C.

Synergistic action of the thermostable fungal glucoamylase with α–amylase: Glucose syrup was produced using three cassava varieties (TME419, 98/581 and 97/2205). The slurry of Cassava starch TME 419(20%w/v) prepared with distilled water (100ml) was gelatinized at 85°C. Alpha amylase and fungal glucoamylase (1:4v/v) were added simultaneously to the gelatinized starch (pH6.0) and the reaction mixture was incubated at 75°C for 12h. The experiment was carried out in triplicates. The yields of sugars were monitored using refractometer. Physical and Chemical tests were carried out on the prepared syrup. Test carried out were pH, dextrose equivalent, specific gravity, and total soluble solid and optical density according to Association of Official and Agricultural Chemists (A.O.A.C.) (1990).

Results and Discussion

The result presented in Figure 1 showed that a progressive increase in the reaction velocity with an increase in glucoamylase concentration. A maximum velocity (0.6DE/min) was obtained at optimum α amylase/ glucoamylase concentration (1:5 v/v). A further increase in the amount of glucoamylase does not increase the glucose yield. For most enzymatic reactions the speed of the reaction is proportional to the concentration of the enzyme at least during the earliest stages of the reaction (Ayernor *et al*., 2002).The reduction in velocity observed at the later stage of the reaction could obviously be due to the depletion of substrate or a limitation of reaction mixture, which becomes saturated at higher concentration or inhibition by products (Tucker and Woods,1991). Alpha amylase randomly hydrolyses α -1-4-glucosidic bonds of amylase and amylopectin but by-passes α -1-6 glucosidic bonds of amylopectin. The cleavage results in the production of a mixture of shorter oligosaccharides as an intermediate product which is then slowly degraded to yield maltose, glucose, maltotriose and α -limit dextrins (Abraham et al., 1991). Glucoamylase hydrolyses both α -1-6 glucosidic linkages as well as α -1-4 linkages and thus liberates glucose as the primary product of a step-wise hydrolysis of starch, dextrins and maltose (Akpan *et al.,* 1996; Pandey *et al.,* 2000).

Commercially available glucoamylase have been reported to be totally inactive at temperature above 60°C (Ali *et al.,* 1995, Pandey, 1995). Since the key to industrial saccharification of starch used in syrup production is gelatinization which is achieved by heating starch with water and thereby enhancing its bioavailability to amylolytic enzymes, a synergistic action between á amylase and thermostable glucoamylase is of considerable biotechnological interest which could permit the processes to be carried out at high temperature without requiring any cooling system(Rao et al.,2007).

Glucose production from cassava starch by synergistic action of thermostable glucoamylase and alpha-amylase required 12 h for complete hydrolysis of starch in contrast to the conventional step-wise starch hydrolysis which requires 24-48h due to slow hydrolysis of 1,6 α- glycosidic bonds in starch, the formation of condensation products and as well as pH and temperature barriers between the two enzymatic processes (Figure 2). The reduction in process time may be due to compatibility in terms of reaction conditions such as pH and temperature between the two enzymes which enhanced simultaneous hydrolytic actions on α-1,4 and α-1,6 glycosidic linkages of the starch molecules (Arasaratnam *et al.* 1993). This process leads to conservation of energy in addition to time reduction by avoidance of the reversion problem usually encountered with commercial glucoamylase preparations which contain transglucosylase as a contaminant and the inhibition of glucoamylase by glucose (Arasaratnam *et al*. 1993; Yu and Hang,1990; Zanin and Moraes, 1996)

The result of the physico-chemical properties of enzyme converted syrup as presented in Table 1 showed that syrups produced by the three cassava varieties had dextrose equivalent (66-92%) while the reducing sugars varied between 17.7% and 19.0%. Enzymatic processes normally produce syrups with high dextrose equivalent (DE) value, better quality and high yields Idoko and Odo (2002).

Conclusion

The thermostability of the novel fungal glucoamylase and its compatibility with alpha amylase in terms of reaction conditions enhanced synergistic actions between the two enzymes and consequently lead to reduction of process time to 12h and conservation of energy.

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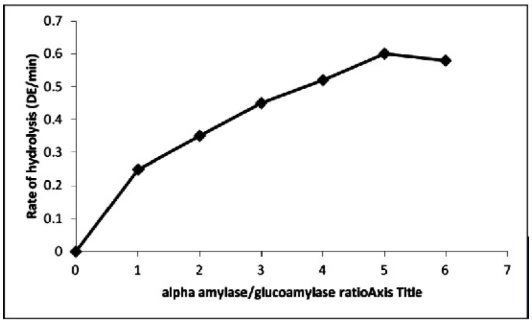

Figure 1. Effect of concentration on synergistic action of alpha amylase and glucoamylase on starch hydrolysis at pH6.0 and 75°C.

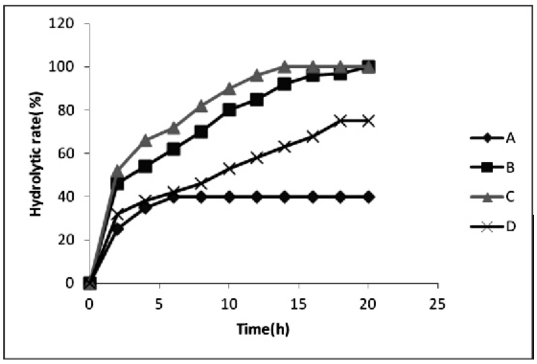

Figure 2: Synergistic actions of á-amylase with*A.oryzae* SH6 glucoamylase on Cassava TME 419 starch at pH6.0 and 75°C.

Legend: A= α-amylase, B= α-amylase + commercial glucoamylase, C= α-amylase + thermostable glucoamylase, D= Thermostable glucoamylase

Table 1. Characterization of enzyme converted syrups from cassava starch

Cassava variety	pH	Specific gravity	Reducing sugars %	Dextrose equivalent %	Total soluble solids %
TME419	5.90 [b]	1.0631 [a]	18.6 [b]	88.7 [b]	20.29 [b]
98/581	5.83 [a]	1.0714 [a]	19.0 [c]	96.42 [c]	18.39 [a]
97/2205	6.11 [c]	1.0738 [a]	17.7 [a]	69.07 [a]	18.74 [a]

Data are means of triplicate determinations

Chemical composition, functional and pasting properties of high quality cassava flour in Nigerian markets

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Abstract

Lately in the year 2002, the Federal Government of Nigeria came up with the Presidential Initiative on Cassava aimed at making cassava a cash crop and thereafter legislated a policy of 10% inclusion of high quality cassava flour (HQCF) in wheat flour for use in Nigeria. This stimulated increased production of HQCF by small-medium enterprises across Nigeria. Surprisingly, the flour milling industries stopped the purchase of HQCF from processors from April 2007 alleging non-availability of HQCF of the right quality specifications among other economic reasons. This study was therefore conducted to determine the chemical composition, functional and pasting properties of HQCF in the Nigerian markets. Five samples of HQCF were obtained from major SMEs factories across the country. The chemical and functional properties of the flour samples were determined using standard analytical procedures. The Starch (75.5 76.6%), sugar (8.28-8.57%), ash (0.7 0.8%) contents were within the Standard organization of Nigeria (SON) standards while pH (6.5-6.9) were within the neutral range characteristics of HQCF. HCN contents (3.17-6.53 mg HCN_{eqv} per 100 g) were within the recommended values by SON (<10 mg HCN_{eqv} per 100 g). Moisture content of the HQCF samples was slightly higher than 10% maximum recommended by SON. The chemical compositions of the HQCF samples were not significantly different except protein and HCN contents. Significant variation ($P<0.05$) was found in the functional properties of the HQCF samples. Winnosa sample had the highest bulk density (0.66 g/cm^3) while Agrivest and Jaffe had the lowest (0.58 g/cm^3). The oil absorption index ranged from 61.50% (Jaffe) to 72.50% (Fulcrum). Emulsion capacity ranged between 24.23 (Peak) and 42.74% (Jaffe). Peak flour had the highest foaming capacity (3.73%) while Jaffe had the lowest (1.48%). Dispersibility and water absorption capacity ranged from 71.50-80.50% and 73.00-78.50%, respectively.The flours showed high peak viscosities and low set back viscosities characteristics of cassava flour. The peak viscosity ranged from 132.84-333.46 RVU with Agrivest and Fulcrum flours having the least and highest values respectively. Breakdown viscosity, Final viscosity and setback viscosities ranged from 73.84-173.04 RVU, 88.88-215.75 RVU, and from 32.46-57.38 RVU, respectively. Fulcrum flour had the highest breakdown and final viscosities. Agrivest flour had the least breakdown viscosity while Winnosa flour had the least final and setback viscosities. Time to attain peak viscosity was lowest for Winnosa flour (4.30 min) and highest for Peak flour (4.60 min). The highest (79.20 °C) and lowest (76.00 °C) pasting temperature was recorded by Winnosa and Agrivest flour, respectively. The pasting profile of the HQCF flours were significantly different ($P<0.05$) except pasting temperature. The study concluded that the quality of HQCF sampled was within the limit set by the Standard Organization of Nigeria.

Keywords: High quality cassava flour, chemical composition, functional properties, pasting profile, quality and standards.

Introduction

Cassava (*Manihot esculenta* Crantz) is a root crop cultivated and consumed as a staple in many regions of the developing world. Cassava, the neglected crop of the down-trodden, is fast becoming an elite food crop in sub-Saharan Africa (Phillips *et al.*, 2006). Cassava had played and will continue to play a major role in efforts to alleviate the African food crisis because of its efficient production of food energy, year-round availability, tolerance to extreme stress conditions and suitability for peasant farming and food system in Africa (Hahn and Keyser, 1985; Hahn *et al.,* 1987, Maziya-Dixon *et al.,* 2007). The potential of the crop is large because it offers the cheapest source of food calories and the highest yield per unit area. Nigeria is the highest cassava producer in the world, producing a third more than Brazil and almost double the production capacity of Thailand and Indonesia (Phillips *et al.*, 2006; FAOSTAT, 2008). She currently produces over 44 million metric tonnes (MT) per annum (FAOSTAT, 2008); a figure expected to double by 2020. Although the world leader in cassava production, Nigeria is not an active participant in cassava trade in the international markets because most of her cassava is targeted at the domestic food market.

3 Lately in the year 2002, the Federal Government of Nigeria came up with the Presidential Initiative on Cassava aimed at making cassava a cash crop which led to the legislation of a policy of 10% inclusion of high quality cassava flour (HQCF) in wheat flour for utilization by the bakery, confectionery, noodles and other allied companies. This stimulated increased production of high quality cassava flour (HQCF) by small and medium scale enterprises across Nigeria. The direct consequence of the introduction of the policy of 10% HQCF inclusion in bread was that Nigeria flour milling industries required an annual demand of 300,000 mt of HQCF. To meet this demand, various stakeholders across the federation created awareness and encouraged the establishment of cassava small and medium enterprises (SMEs), which embarked massively on the production of HQCF in their factories.

Specifications were established by the regulatory agencies and other stakeholders. Several trainings and workshops were organized by governmental and non-governmental research institutions to train potential and existing SME owners and workers on techniques for producing HQCF with the right quality standards and specifications for inclusion in wheat flour for baking and confectionaries. Surprisingly, the flour milling industries stopped the purchase of HQCF from processors from April 2007 alleging non-availability of HQCF of the right quality specifications among other economic reasons. This study was therefore conducted to determine the chemical composition, functional and pasting properties of HQCF in the Nigerian markets.

Materials and Methods

High quality cassava flour analysed in this studies were obtained from different locations in Nigeria, viz:

1) Peak product enterprises, Km 16 17 Abeokuta Lagos express way Laala village, Abeokuta, Ogun State.
2) Winosa global resource limited, 14 market road Igbogila Abavo, Delta state.
3) Fulcrum Nigeria limited, km 12, Iju Ebiye road, Akinleye village, Ogun state.
4) Jaffe Nigeria limited, km 12 Abeokuta, Lagos express road Abule bus/stop Obada-Oko, Ogun state.
5) Agrivest Concept International limited, Agbadu cassava farm, Kabba Lokoja Express way, Kogi state.

Determination of chemical composition. The moisture, protein, ash, crude fiber and fat contents of the samples were determined using the AOAC (1990) method. The starch and total sugar contents were determined using a colorimetric method as described by Dubois *et. al*., (1956). The amylase content was determined using the method of Williams *et. al.* (1958), while cyanogenic potential was determined using the method described by Bradbury *et al.* (1999). Phytic acid and phytate contents were determined using the method of Harland and Oberleas (1986) and pH was determined by mixing 5 g flour in a beaker containing 25 ml of distilled water, allowed to stand for 30 minutes with constant stirring and pH measured with the aid of pH meter (AOAC 1990).

Determination of functional Properties: The bulk density was determined by the method of Wang and Kinsella (1996), water absorption capacity as described by Ruales *et al.* (1993)., dispersibility by kulkarni *et al.,* (1991), emulsion Stability by Hayta, *et al* (2002), foaming capacity and oil absorption capacity according to Sathe and Salunkhe (1981).

Determination of pasting properties: Pasting properties were determined using a Rapid Visco Analyser (RVA) (model RVA 3D+; Network Scientific, 5Australia). The sample was turned into slurry by mixing 3 g with 25 ml of water inside the RVA can and inserted into the tower, which was then lowered into the system. The slurry was heated from 50 to 95°C and cools back to 50°C within 12 min, rotating the can at a speed of 160 rpm with continuous stirring of the content with a plastic paddle. Parameters estimated were peak viscosity, trough, setback viscosity, final viscosity, pasting temperature and time to reach peak viscosity.

Statistical Analysis

All data obtained were subjected to statistical Analysis of variance (ANOVA) using SPSS (version 17, 2010). Means were separated using Duncan's Multiple Range Test (DMRT).

Result and Discussion

Chemical composition of high quality cassava flour in Nigerian market: Table 1 shows the chemical composition of HQCF from different markets in Nigeria. The chemical compositions of the HQCF samples were not significantly different except protein and HCN contents. Moisture content of the HQCF samples was slightly higher than 10% maximum recommended by SON (Sanni *et al*., 2005). The lower the initial moisture content of a product to be stored the better the storage stability of the product and the higher the efficiency of the drying method. Because this shows that considerable amount of moisture contained in the fresh sample or product had been removed. The high moisture content recorded by the HQCF analyzed in this study might be due to moisture absorption during storage in the factories warehouse. The moisture content of HQCF fresh from the flash dryer (used by all the SMEs where the HQCF was sourced) usually ranged from 5-10% (unpublished flash dryer production efficiency audit report by CAVA, Nigeria). Hence, there is the need for the SMEs producing HQCF in Nigeria to use packaging materials with very high moisture barrier properties. Also, the ambient air within their warehouse needs to be improved. This can be achieved by installing industrial air extractor to maintain the ambient relative humidity and temperature so as to minimize moisture absorption of the HQCF during storage. However, all the flour samples could still be stored for up to 7 months because their moisture contents were below the levels reported by Ukpabi and Ndimele (1990) who found that *gari* samples with a moisture content of < 16% but > 13% could be stored for 2-7 months without mould infestation. The Starch (75.5 76.6%), sugar (8.28-8.57%), ash (0.7 0.8%) contents were within the Standard organization of Nigeria (SON) standards while pH (6.5-6.9) were within the neutral range characteristics of HQCF. HQCF is simply unfermented cassava flour; hence, the almost neutral pH recorded by the samples analyzed is indicative of good GMP in the SMEs where the flours were sourced because fermentation of cassava produced acids which tend to shift the pH of fresh cassava mash to acidic medium. The phytic acid and phytate contents ranged from 7.45-8.15 mg/100 g and 2.65-3.00 mg/100 g, respectively while HCN contents of the flours (3.17-6.53 mg HCN_{eqv} per 100 g) were within the recommended values by SON (<10 mg HCN_{eqv} per 100 g) (Sanni *et al.* 2005). The values were considerably lower than that found in *gari*, *eba*, and cooked cassava root by Marfo *et al.,* (1990).

There is no general consensus on the safe levels of cyanide for both human and animal consumption (Maziya-Dixon *et al.,* 2007) by scientists and international regulatory agencies. Mahungu *et al.,* (1987) noted that a great danger of chronic poisoning might occur if roots with more than 150 mg HCN/kg are consumed. According to Koch *et al*., (1992), when the peeled portion contain <50 mg HCN/kg of freshly grated cassava, the cassava can be taken as harmless to the consumer. A concentration of between 50 mg HCN/kg and 80 mg HCN/kg may be slightly poisonous; 80100 mg HCN/kg is toxic while concentrations above 100 mg HCN/kg of grated cassava are fatal (Koch *et al*., 1992; Maziya-Dixon *et al.,* 2007). Presently in Nigeria, grating/crushing is being promoted in production of high quality cassava flour (HQCF) because it leads to production of flour with negligible amount of residual cyanide content after drying. The joint FAO/WHO Food Standards Programme Codex Committee on Contaminants in Foods (JECFA) 3rd Session held in the Netherlands in 2009 concluded that a level of up to 10 mg HCN/kg in the Standard for Edible Cassava Flour (CODEX STAN 176-1989) was not associated with acute toxicity (WHO, 1993). A review of the available data by European Food Safety Authority (EFSA Journal) in 2004 arrived at a similar conclusion (JECFA, 2009).

Functional properties of high quality cassava flour in Nigerian markets: The results of functional properties of high quality cassava flour from Nigerian markets are presented in Table 2. Significant variation (P<0.05) was found in the functional properties of the HQCF samples. Winnosa sample had the highest bulk density (0.66 g/cm^3) while Agrivest and Jaffe had the lowest (0.58 g/cm^3). The bulk density is an important parameter that determines the ease of packaging and transportation of particulate foods. The bulk density of the flours are comparable to values reported by Shittu *et al*. (2007) for HQCF from 43 cassava mosaic disease (CMD) resistant cassava varieties. The oil absorption index ranged from 61.50% (Jaffe) to 72.50% (Fulcrum). Oil absorption is an indication of the amount of oil that can be absorbed by the physical matrix of a food. It indicates the degree of hydrophobicity (Voutsinus and Nakai, 1983) of flour. Emulsion capacity ranged between 24.23 (Peak) and 42.74% (Jaffe). Peak flour had the highest foaming capacity (3.73%) while Jaffe had the lowest (1.48%). Dispersibility and water absorption capacity ranged from 71.50-80.50% and 73.00-78.50%, respectively. Dispersibility is a measure of the degree reconstitution of flour or flour blends in water, the higher the dispersibility the better the flour reconstitutes in water (Adebowale *et al*., 2005). Higher dispersibility values exhibited by all the HQCF analyzed are indicative of their ability to produce smooth dough in composite with wheat flour.

Pasting properties of high quality cassava flour in Nigerian markets: The pasting profile of high quality cassava flour samples from Nigerian markets are presented in Table 3. The peak viscosity ranged from 132.84-333.46 RVU with Agrivest and Fulcrum flours having the lowest and highest values, respectively. Breakdown viscosity, Final viscosity and setback viscosities ranged from 73.84-173.04 RVU, 88.88-215.75 RVU, and from 32.46-57.38 RVU, respectively. Fulcrum flour had the highest breakdown and final viscosities. Agrivest flour had the lowest breakdown viscosity while Winnosa flour had the least final and setback viscosities. Time to attain peak viscosity was lowest for Winnosa flour (4.30 min) and highest for Peak flour (4.60 min). The highest (79.20 °C) and lowest (76.00 °C) pasting temperature was recorded by Winnosa and Agrivest flour, respectively. The pasting profile of the HQCF flours were significantly different ($P<0.05$) except pasting temperature.

One of most common method for determining the pasting profile of starch-based food products is through an amylograph pasting profile. Information on pasting profile of flours have been used to correlate the functionality of starchy food ingredients in processes like baking (Idowu *et al*.,1996; Rojas, *et al*., 1999) and extrusion cooking (*Ruales et al*., 1993). The peak viscosity is the maximum viscosity attainable during the heating cycle; the trough is an index of starch granule stability to heating; setback viscosity is an index of retrogradation of linear starch molecules during cooling. It has been very difficult from past works to predict the wheatless bread making potentials of cassava flour from its amylograph pasting properties. However, in agreement with previous works, it was concluded that attaining gelatinization at a lower temperature led to improved bread baking quality (Defloor *et al*., 1994). High peak viscosity and stability (or low breakdown viscosity) were also associated with cassava starch which produces acceptable bread (Adeyemi *et al.,* 1978). The flours showed high peak viscosities and low set back viscosities characteristics of cassava flour. Further works are needed to really determine quantitatively how pasting properties of cassava flour relate to its functionality or end use especially in baking, pastry and confectionaries.

Conclusion

The quality characteristics of the five high quality cassava flour in the Nigerian markets investigated for their quality characteristics showed significant variation ($P<0.05$) in some of quality parameters evaluated. The functional properties of the flour samples were significantly different ($P<0.05$). Significant differences ($P<0.05$) were recorded in the pasting profile of the flour samples except pasting temperature. The qualities of HQCF sampled were within the limit set by the Standard Organization of Nigeria and Codex.

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Table 1: Chemical composition of high quality cassava flour in Nigerian markets

Composition (%)	Peak	Winnosa	Agrivest	Jaffe	Fulcrum
Moisture ns(%)	14.47	14.56	14.56	14.36	14.41
Protein (%)	0.96 a	1.49 c	1.31 bc	1.14 ab	0.96 a
Fat ns(%)	0.50	0.40	0.50	0.50	0.50
Amylose ns(%)	13.40	13.30	13.20	13.50	13.00
Sugar ns(%)	8.35	8.52	8.57	8.44	8.28
Starch ns(%)	75.6	76.6	75.5	75.9	75.7
Ash ns(%)	0.80	0.80	0.70	0.80	0.70
Crude Fibre ns	1.50	1.54	1.60	1.54	1.48
Phytic acid ns(mg/100g)	8.00	8.35	7.45	7.45	8.15
Phytate ns(mg/100g)	2.85	3.00	2.65	2.65	2.90
HCN (mg HCN eq√100g)	5.15 c	6.53 cd	3.17 a	4.36 b	5.94 c
pH ns	6.70	6.70	6.90	6.50	6.50

- Values are means of 2 replicates
- Mean values having different superscript within row are significantly different (P <0.05).
- ns not significantly different

Table 2: Functional properties of high quality cassava flour in Nigerian markets

Properties	Peak	Winnosa	Agrivest	Jaffe	Fulcrum
Bulk Density (g/cm3)	0.60 ab	0.66 c	0.58 a	0.58 a	0.63 bc
Oil Absorption Capacity (%)	70.50 c	66.25 b	66.00 b	61.50 a	72.50 c
Dispersibility (%)	78.00 b	80.50 c	79.00 bc	71.50 a	79.00 bc
Foaming capacity (%)	3.73 c	2.66 abc	2.06 ab	1.48 a	2.77 bc
Emulsion Capacity (%)	42.74 d	34.59 c	27.27 ab	24.23 a	32.69 bc
Water Absorption Capacity (%)	74.00 b	78.50 d	74.50 bc	76.00 c	73.00 a

- *Values are means of 2 replicates*
- *Mean values having different superscript within the same row are significantly different (P<0.05).*
- *ns not significantly different*

Table 3: Pasting properties of high quality cassava flour in Nigerian markets

Variables	Peak	Winnosa	Agrivest	Jaffe	Fulcrum
Peak (RVU)	279.30^{b}	132.84^{a}	158.46^{a}	277.58^{b}	333.46^{c}
Through (RVU)	134.27^{cd}	56.42^{a}	84.63^{b}	123.75^{c}	160.42^{d}
Break down viscosity (RVU)	145.09^{b}	76.42^{a}	73.84^{a}	154.34^{b}	173.04^{c}
Final viscosity (RVU)	185.54^{b}	88.88^{a}	122.75^{a}	181.13^{b}	215.75^{b}
Setback (RVU)	51.34^{a}	32.46^{b}	38.13^{b}	57.38^{a}	55.34^{a}
Pasting time (min)	4.60^{bc}	4.30^{a}	4.40^{ab}	4.50^{bc}	4.37^{ab}
Pasting temperature (^{0}C)^{ns}	78.9	79.2	76.0	78.8	78.4

◆Values are means of 2 replicates
◆Mean values having different superscript within row are significantly different ($P < 0.05$).
◆ns not significantly different ($P > 0.05$).

Adding value to Africa's cassava in a global environment

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Abstract

Based on experiences in the Cassava: Adding Value for Africa (C:AVA) project, this paper examines emerging issues and lessons for adding value to cassava, one of Africa's widely cultivated staples in ways that contribute to the global market environment as well as bring benefits to small holders on the continent. The main issues discussed include: competiveness in the supply of raw material, assisting smallholders to produce value-added products sustainably and competitively, ensuring and maintaining quality of products, selecting appropriate technologies for different circumstances and anticipating negative effects of the market environment on smallholders. One of the main challenges for value addition to a staple crop in Africa is finding 'champions' who are willing to make new investments with knowledge, skill and expertise requirements derived from other nations. The other is increasing the drying capacities for a tropical root crop through appropriate technologies that ensure production of high quality products in required volumes. One focus of the C:AVA project in the near future is to promote transfer of energy efficient Nigerian-made flash drier in collaboration with partners and fabricators from other C:AVA countries (Ghana, Uganda, Malawi and Tanzania). Improved energy efficiency will reduce fuel consumption, reduce operating cost and improve throughput of the dryers. An additional benefit will be reduction in emission of harmful greenhouse gases and their impact on global warming. It is anticipated that the knowledge and skills for further developing the value addition potential for cassava in all five countries will be enhanced. Benchmarking of key variables was used as an approach to understand differences between countries in terms of their abilities to develop high quality cassava flour value chains. It is clear that one strategy does not work in all countries and while positive government support for cassava development is helpful, the real driver is targeting markets according to realisable capacities of the smallholder actors in the value chain.

Keywords: Value addition, globalization, cassava, Africa

Introduction

Cassava is one of the most important food crops of Africa (Adebayo et al., 2009). It is consumed in different traditional dishes varying from country to country and across communities in a country. It is cultivated in the humid forest zones and the sub humid savanna of Africa and provides increased income for farming households; increased employment opportunities; potential to target development benefits to women; potential lower food prices for consumers; competitively priced raw materials and more convenience. Current studies have however identified clear gaps in the market for some cassava products in Africa (Table 1). In particular, a number of highly promising industrial and commercial use clusters have been identified (NEPAD, 2004; Sanni, 2005). The potential for further growth of fresh root and traditional processed products is limited because markets are generally saturated and growth will be mainly related to population increase. The most promising market to develop is that of high quality cassava flour (HQCF) and its use as a replacement for wheat flour in the bakery sector, in plywood manufacture and also as an alternative or component in traditional cassava products (e.g. instant fufu in Ghana; fermented fufu in Nigeria). The main reasons for focusing on HQCF are that value can be added at the rural household level by processing of the intermediate product (cassava grits or wet paste), thereby increasing incomes for farmers; the requirements for capital investment is lower and less environmental damage is caused than starch manufacture; and many farmers already know how to create the basic raw material for HQCF (grated cassava). Therefore a huge technology leap at the farmer level is not required to attain the developmental objective. Consequently, HQCF offers the easiest entry point, benefits the most smallholder farmers/processors in the immediate future and provides a springboard for investment in other products.

Table 1. Assessment of potential market opportunities for cassava roots in Africa

Product	Current Importance	Potential growth low investment	Potential growth high in vestment	Export potential
HQCF for bakery use	Low	High	High	Some
Improved version of traditional products (that use HQCF)	Very low	High	High	Some- but low
Industrial uses from Chips and Flours (e.g. plywood/ paperboard) (that use HQCF)	Low	Hig h	High	Difficult
Animal feed	Low	Some	High	Difficult/Some
Bio -ethanol	Very low	Some	Potentially high	Possible
Starch (modified)	Low	Marginal	Some	Possible
Value added products e.g MSG	None	Marginal	Possible	Difficult
Traditional processed pr oducts	High	Low	Low	Some-but low
Fresh roots	High	Low	Low	v. low

Based on experiences in the Cassava: Adding Value for Africa (C:AVA) project, this paper examines emerging issues and lessons for adding value to cassava, one of Africa's widely cultivated staples in ways that contribute to the global market environment as well as bring benefits to smallholders on the continent.

The challenge

One of the main challenges for value addition to a staple crop in Africa is finding 'champions' who are willing to make new investments with knowledge, skill and expertise requirements derived from other nations. The other is increasing the drying capacities for a tropical root crop through appropriate technologies that ensure production of high quality products in required volumes.

C:AVA approach

The C:AVA project approach is based mainly on three most potent intervention points to develop HQCF values chains (Table 2). Intervening at these critical points has been shown to have strong potential for sustainable value chains development in the HQCF market (UNAAB, 2007; van Oirschot et al, 2004; Adebayo, et al, 2003; Dipeolu et al, 2003; Dipeolu et al, 2001). The three intervention points are the priorities for this project and form the basis of Project Objectives. The key activities at these intervention points include enhancing access to finance, business skills, and appropriate technologies; ensuring quality of products and reliability of supply; and integration of activities within the value chain. Although there are a number of end-uses for HQCF, the project focuses on two of the highest volume end-uses of HQCF in

Table 2. The potent intervention points in the HQCF value chain

	Potent intervention points	Determinants of success
1	Ensuring consistent supply of quality raw materials (roots and grits)	Ability of farmers to profitably produce grits or roots at a competitive price. The supply must be sufficient and reliable in terms of volume and quality to sustain proces sing operations.
2	Developing financially -viable intermediaries	Ability to buy either roots or grits from farmers, assemble them and make and sell consistent high quality HQCF to end users.
3	Ensuring the confidence of end users of HQCF as a food in gredient	Availability of a consistent supply of competitively priced HQCF of sufficient quality

Main issues

The main issues for adding value to Africa's cassava in a global environment are:

1. Competiveness in the supply of raw material
2. Assisting smallholders to produce value-added products sustainably and competitively
3. Ensuring and maintaining quality of products
4. Selecting appropriate technologies for different circumstances
5. Anticipating negative effects of the market environment on smallholders
6. Ensuring that strategies for ensuring benefits for women and other disadvantaged groups

1. Competiveness of the raw material and assisting smallholders to produce value-added products competitively: In commercial interactions, competition is often encouraged as a means of ensuring quality and maintaining reasonable prices. Two forms for competition are prevalent at the smallholder level in the HQCF value chain. These are the competition to supply raw materials (cassava roots, grits or wet pastes) for alternative uses and the competition to meet quality and quantity requirements of larger scale buyers. In the first case, the challenge for extension services is to understand that smallholders have alternative uses for the cassava roots, grits and wet pastes other than the HQCF value chain. This may be cassava roots directed to gari or other traditional foods value chain or cassava grits of lower quality directed to lower quality cassava flour value chains such as lafun or cassava wet pastes meant for the fermented wet pastes value chain to be served as traditional fufu or agbelima. This understanding will enable extension services to work with smallholders in ways that acknowledge the needs of these other value chains as they try to work with smallholders to develop and contribute to the emerging chain for HQCF.

In the second case, large scale buyers of cassava roots, grits or wet pastes often make requirements for quantity and quality of raw materials that are not easily met by smallholders. This may include requirements concerning minimum quantity of raw materials that they will be willing to take from smallholders or specific level of whiteness or pH in the cassava grits or wet paste that smallholders need to meet before their products can be paid for by a large scale user. In this case, to meet quantity requirements extension services need to help organise and pull raw materials from several smallholders in an orderly and transparent manner to ensure that they meet specific quantity requirements and gain enough trust in doing so that all the smallholders in the supplying group can perceive the extension service provider as an unbiased helper who has their interest at heart.

In order to work with smallholders to meet the demand for specific quality requirements, the challenge for extension services is to provide simple, easily verifiable quality monitoring support for its group of smallholders. The quality monitoring exercise must be known to the end-user who buys the raw material from the smallholder groups. The extension service also needs to ensure that the group understands how this exercise helps them to compete against others in meeting the needs of the end-user. The final task for extension services that would make this process sustainable is to work with the end-user to secure a befitting reward for compliance with quality requirement or conversely a befitting punishment for failure to comply with quality requirements. The preference should be towards rewarding compliance rather than punishing deviance.

2. Working with a range of partners at different stages in the value chain to take pilot studies to scale: Recent studies have indicated that there is a significant market potential for unfermented cassava flours as partial or total replacement for wheat in food and for the manufacturing of plywood and paperboard in industry (Day et al., 1996). In industry, the application of cassava flour to replace wheat flour is used by the plywood industry as glue extender, and possibly the industrial starch used in paper board. In spite of considerable research on bread making and the use of composite flours, there has been little impact on commercial practice (except where government controls wheat imports as in Nigeria in 2002 to 2008). The most promising food products for cassava flour substitution on account of simplicity are pies/pastries, cakes, biscuits and doughnuts.

Pilot studies by the Natural Resources Institute (NRI), United Kingdom; the International Institute of Tropical Agriculture (IITA), and their collaborators in West Africa (University of Agriculture, Abeokuta ad the Food Research Institute, Accra) on the pros and cons of different methods for organizing processing and scales of production are just becoming widespread practices especially in Nigeria and Ghana. Small-scale processes using simple technology suited to village level enterprises have the advantage of being located very close to the production sites of cassava. This minimizes the transport costs associated with the movement of large quantities of relatively cheaper cassava roots (Adebayo et al., 2009).

Ensuring that these successful pilot cases become widespread practice is undoubtedly the job of a functional extension service. The experience in C:AVA have shown that extension services cannot do it alone. They need to work all along the value chain with other partners including private investors, banks and insurance companies, standards and food and drugs administration agencies as well as their traditional allies in the technology transfer circle - researchers. The ability and willingness to collaborate in this manner would be to the advantage of smallholders who are often highly dependent of the extension service because of their long standing history of working together.

3. Ensuring and maintaining quality of products: In many countries, people's perception of cassava and cassava products is that of a poor quality product meant for the poor or only be eaten when all else fails. This perception is gradually changing, but the changes in perception are fragile. It is important to ensure that African cassava products begin to have the 'label' of 'high quality'. It is also as important that this quality be maintained and sustained over time. This requires a lot of efforts from all stakeholders in the continent's cassava sector to make it work. A transparent commitment to quality of product is a non-negotiable requirement on the way forward.

4. Selecting and promoting appropriate technologies for different circumstances: The C:AVA strategy focuses in particular on the technical and financial aspects of the value chain, for example improving processing techniques and assisting actors in gaining access to credit. While these appear to have worked very well in Nigeria and Ghana, the project design in Tanzania and possibly Uganda and Malawi should have given more attention to more intangible factors that determine the project's outcomes such as advocacy and publicity campaign to raise awareness and create support amongst politicians as well as consumers; facilitation of permanent producer platforms to strengthen linkages between value chain actors, disseminate market information and new technologies and raising awareness on costs and reasonable prices for HQCF and its intermediate products. This is because value chains for HQCF in the sense that have been found in Nigeria and Ghana in the last one and a half year have been found very weak or non-existent in Tanzania. Even in Uganda, C:AVA is only hoping that the interests currently generated will produce some rapid results in the sector.

As a contribution to building the value chain for HQCF in the Tanzania, and possibly Uganda and Malawi where the value chains for HQCF are relatively younger than Nigeria and Ghana, there is the need for C:AVA and others to actively provide financial support for rural processors for processing equipment until they have built the requisite skills (technical, business and entrepreneurial) and confidence to stimulate determined investments in the chain.

The basis for this is that C:AVA experiences especially in Tanzania and partly in Uganda is that the circumstances under which smallholders operate differ between countries and in fact within countries and communities. For instance:

a. Unlike Nigeria, there is no deliberate government drive to make HQCF an important item in the government agenda.
b. Unlike Ghana and Nigeria, there is an absence of national or local champions leading the crusade to make HQCF a major player in the agenda
c. Unlike West Africa, the use of graters and presses in cassava processing is not widespread and where these machines are available, they are not made from stainless steel which is required for food grade products.
d. Particularly in Tanzania, the entrepreneurial spirit appears very low in the cassava sector and risk aversion appear rampant all through the chain from smallholder farmers to the potential end-users of HQCF.

In these varying circumstances, there is no 'quick fix' or formula for intervening in the HQCF value chain. Extension services need to fully understand the circumstances under which their smallholder groups operate and work within their peculiar limitation to recommend appropriate technologies for ensuring the sustainable inclusion of their smallholder groups in the value chain. It is also important for the extension services to prepare their smallholder group for taking on the next technological challenges within their peculiar circumstances.

5. Anticipating negative effects of the market environment on smallholders: The market environment is in a continuous state of flux. Larger actors often have larger capacities to absorb the shocks and variations in the market environment. Smallholders on the other hand, most of the time either do not have the resources or do not possess the required skills to cope with major movements in the large market. For instance, recent dynamics of the global economy is a factor influencing the cassava postharvest system. The impact of the global market for grains, fluctuating commodity prices including petroleum products are now showing its effects in the demand and supply of cassava. But extension services can and should help in this non-traditional aspect of their work. This may mean that extension officers themselves need to be provided additional training to understand the nature of the large market and prepare their smallholder groups to cope with its negative effects and take advantage of its positive ones.

6. Ensuring that strategies for ensuring benefits for women and other disadvantaged groups: The cassava postharvest system has assigned gender roles. Several studies have shown that cassava processing is traditionally women's business in many smallholder situations (Afolami and Ajani, 1995); but more recent studies have shown that as cassava processing become more commercialised, men begin to own and run cassava processing enterprises (Adebayo et al , 2003). Extension services need to bear in mind at all times this power equation and how their intervention may shift its balance for or against one group or the other within their smallholder groups or communities. This way, extension services would prevent or at least prepare remedial actions for interventions in the HQCF value chain that may injure women or other groups who may be disadvantaged by it.

A New Direction

One focus of the C:AVA project in the near future is to promote transfer of energy efficient Nigerian-made flash drier in collaboration with partners and fabricators from other C:AVA countries, particularly Ghana and Malawi). Improved energy efficiency will reduce fuel consumption, reduce operating cost and improve throughput of the dryers. An additional benefit will be reduction in emission of harmful greenhouse gases and their impact on global warming. It is anticipated that the knowledge and skills for further developing the value addition potential for cassava in all five countries will be enhanced.

Benchmarking of key variables was used as an approach to understand differences between countries in terms of their abilities to develop high quality cassava flour value chains.

It is clear that one strategy does not work in all countries and while positive government support for cassava development is helpful, the real driver is targeting markets according to realizable capacities of the smallholder actors in the value chain.

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Some culinary and sensory characteristics of Hausa potato (*Solenostemon rotundifolius Poir*) and Livingstone potato (Plectranthus esculentus N.E. Br.) tubers.

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Abstract
Presently, there is dearth of scientifically published information on the sensory and culinary characteristics of Hausa potato (*Solenostemon rotundifolius*) and Livingstone potato (*Plectranthus esculentus*). Therefore, matured tubers of these crops, harvested at National Root Crops Research Institute, Umudike, Abia State, Nigeria, were used to determine their fresh and cooked tuber characteristics. Results of the investigations showed that the thin skinned fresh tubers of both crops had cylindrical shape and weighed less than 100g. The mean dry matter and starch contents of Hausa potato were 28.62% and 15.14% respectively, while the corresponding values for the Livingstone potato were 13.17% and 5.57%. The mealy boiled tubers and crispy French fries from the peeled experimental tubers were found generally acceptable (as food) by selected trained sensory assessors. The use of these tuberous staples as potential sources of dietary fibre was also observed.

Keywords: Hausa potato, Livingstone potato, culinary characteristics, tubers, Nigeria.

Introduction

Hausa potato (*Solenostemon rotundifolius* Poir) and Livingstone potato (*Plectranthus esculentus* N.E. Br.) are amongst the lesser known tropical root crops in Nigeria, and some other Sub-Saharan Africa (SSA) countries (Demissie, 1997; Alleman and Coertze, 1997; Ukpabi, 2009). Though many communities in northern Nigeria consume these starchy tubers (mostly as boiled or fried pieces), there is dearth of information (in scientific literature) on their processing and culinary characteristics (NRC, 2006).

The little documented data on these seemingly endangered species are largely on their agronomic and eco-physiological characteristics (Rehm and Espig, 1991; Demissie, 1997; Alleman and Coertze, 1997; Schippers, 2000). With the current trend in global conservation of endangered or less known plant food species, National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria, in the past few years encouraged research activities on the production of these two crops (NRCRI, 2004; NRCRI, 2005). This is more-so as these crops, which are largely cultivated by women in Nigeria (NRCRI, 2006) and probably other SSA countries. are among the mandate crops of NRCRI. These recent research advances on the crops production led to a call for a concurrent research on their post-harvest handling and utilization as food.

The need for a detailed study on the post-harvest utilization of these crops, which have been cherished (without adequate documentation) as food items in some parts of Sub-Saharan Africa, cannot be overemphasized. Therefore, the objective of this study is to determine some relevant sensory and culinary characteristic of the tubers of Hausa potato and Livingstone potato.

Materials and Methods

The matured Hausa potato and Livingstone potato (var. Riyom) tubers used for this study were randomly harvested from the Experimental Farms of NRCRI, Umudike, Abia State, Nigeria. Tuber shape, tuber skin and flesh colours, and the cut flesh browning rate were determined visually. A time piece was used to monitor the browning rate determination, while a weighing balance (Sartorius LC120 IS) was employed in the tuber size (weight) determination.

The weighing balance and local tuber peeling methods (fresh tubers with a kitchen knife and boiled tubers with hand peeling) were used for the tuber peel loss determination (in quadruplicates), while the primary tuber peel thickness was measured with a ruler. Standard methods (AOAC, 1990) were used for the dry matter and starch content determinations of the crops' tuber flesh.

The cooking times of the tubers, using a laboratory hot- plate (Gallenhamp) , were determined with 1cm^3 pieces in boiling water (100^{o}C) and hot refined palm oil (Turkey brand) maintained at a temperature of 150^{o}C . Cooking the tuber pieces to softness was monitored with a table fork. Mealiness and crispiness of the boiled and fried tubers were sensorily evaluated by three food technologists at NRCRI, Nigeria. Salted and unsalted boiled peeled tubers and unblanched French fries prepared with the experimental tubers (as described by Smith, 1968) were used for systematic organoleptic tests. A 7-point Hedonic scale (Jellinek, 1985; Iwe, 2002) was used for the sensory evaluation of the boiled and fried tuber pieces (salted and unsalted) with 20 semi-trained panelists. The sensory assessors used for this organoleptic evaluation scored for colour, taste, texture and overall acceptability. These sensory panelists who were regular consumers of cooked potato (*S. tuberosum*) and yams (*Dioscorea* species) were also asked to comment freely on the cooked materials from the experimental tubers.

Results and Discussion

Tables 1 and 2 show some tuber and culinary characteristics of Hausa potato and Livingstone potato that would be of interest to food processors, chefs, dieticians and caterers. Though both crops have creamy-whitish tuber flesh colour, the relative faster browning rate of the Hausa potato over that of Livingstone potato (Table 1) makes the later a better choice for farm gate processing into whitish secondary food products (that is, in the absence of anti-browning agents). Okaka and Okaka (2001) had shown that 'browning' in peeled or cut fresh tropical tubers is largely due to the enzymatic oxidation of the plant phenolics by polyphenol oxidase (phenolase). The lower browning rate of the cut experimental tubers placed under water (Table 1) can therefore be explained by the fact that water (at ambient room temperature) usually has lower oxygen content than air. Anti browning agents such as sulphites are known to inhibit the enzyme activity of polyphenol oxidase (Okaka and Okaka, 2001). With the assistance of anti browning agents, Hausa potato with its relatively higher starch and dry matter contents (Table 1) can therefore serve as a good raw-material for industrial production of whitish flour and starch.

The high peel loss observed for the fresh tubers (of both crops) with kitchen knife peeling (Table 2) calls for lye or steam peeling (Smith, 1968) of the thin skinned tubers (Table 1) in large scale industrial utilization of the experimental tubers. The cooking times of the mealy experimental tubers (Table 2) show that their boiling times (in water) are lesser than their frying times in the hotter oil.

Table 1: Characteristics of the fresh tubers of Hausa potato and Livingstone potato.

Parameter	Hausa potato	Livingstone potato
Tuber size	Small(<100g)	Small (<100g)
Tuber shape	Cylindrical -ovoid	Cylindrical -elongated
Skin colour	Purplish -brown	Brown
Flesh colour	Cream	Creamy white
Browning rate* of cut tuber		
- in air	Fast	Slow
- under water	Medium	Slow
Dry matter content (%)	28.62 0.08	13.17 0.25
Starch content (%)	15.14 0.05	5.57 0.05
Primary peel	Thin skin (<1mm)	Thin skin (<1mm)

**Where fast = = 1minute; medium = = 10 minutes; slow = = 30 minutes*

Tables 3 and 4 respectively show the organoleptic evaluation results of the boiled tubers and French fries. The cream - whitish boiled tubers were generally acceptable by the test panelists. Feedbacks from the sensory assessors showed that they did not only like the salted boiled tubers of both crops but also felt that they tasted like boiled potato (*Solanum tuberosum*) or *Solanum* potato (Tables 3 and 5). The authors additionally observed that while the boiled Livingstone potato had slightly fibrous piths, the Hausa potato samples had more mealy central regions or piths.

Table 2. Important culinary nature of the experimental tubers.

Parameter	Hausa potato	Livingstone potato
Peel loss (%)		
- fresh, with knife	**28.75 ± 0.62**	**8.33 ± 0.96**
- boiled, with hand	**10.19 ± 1.03**	**21.09 ± 0.80**
Cooking time (1cm^3/min)		
-boiling (at 100 ^oC)	**10.20 ± 0.31**	**9.99 ± 0.42**
-frying (at 150 ^oC)	**5.25 ± 0.12**	**4.40 ± 0.15**
Mealiness (when boiled)	Slightly mealy	Mealy
Crispiness (sliced, fried)	Slightly crispy	Crispy

Table 3. Organoleptic evaluation of the boiled experimental tubers.

Samp le	Sensory score* #			
	Colour	Tas te	Texture	Overall acceptability
Hausa Potato (not salted)	4.20^b	5.20^a	5.20^a	5.00^a
Hausa potato (salted)	4.20^b	5.60^a	5.40^a	5.20^a
Livingstonepotato (not salted)	5.80^a	5.00^a	4.80^a	5.00^a
Livingstone potato (salted)	6.20^a	5.00^a	4.80^a	5.00^a

*Where 7 = like extremely; 4= neither like nor dislike; 1 = dislike extremely.

Column values with the same letter are not significantly different (P=0.05) using Duncan's New Multiple Range Test (DNMRT).

The golden brown coloured French fries made from the experimental tubers were also generally acceptable by the sensory panelists (Table 4). The observed brownish colour of the fried food materials might be due to non enzymatic browning (Okaka and Okaka, 2001). The fact that the Livingstone potato (*var. Riyom*) with low dry matter content (about 13%) gave acceptable French fries is not surprising as Okonkwo *et al* (1995) had indicated that low and high dry matter *Solanum* potato produced in Nigeria could be used to prepare French fries. A remarkable comment by the test panel (Table 5) is that the salted Livingstone potato French fries were crispy (unlike those of Hausa potato samples).

Table 4: Organoleptic evaluation of French fries made with the experimental tubers

	Sensory score* #			
Sample	Colour	Taste	Texture	Overall Acceptability
Hausa potato (not salted)	4.80 ^{a}	4.20 ^{a,b}	5.00 ^{a,b}	4.40 ^{b}
Hausa potato (salted)	4.80 ^{a}	5.60 ^{a,b}	4.80 ^{a,b}	5.30 ^{a,b}
Livingstone potato (not salted)	5.60 ^{a}	4.20 ^{b}	4.20 ^{b}	4.80 ^{a,b}
Livingstone potato (salted)	5.80 ^{a}	5.40 ^{a}	6.00 ^{a}	5.80 ^{a}

* As in Table 3.
# As in Table 3.

Earlier results from our research laboratory had shown that the protein, fibre and fat contents (on dry matter basis) of the edible portions of these experimental staples are 10.52%, 14.07%, 0.24% and 7.58%, 11.07%, 0.24% respectively for Livingstone potato and Hausa potato (NRCRI, 2005). The 7.58-10.52% protein content of these crops (on dry matter basis) compare favourably with 9.1% protein obtained for English mashed potato powder (Burton, 1989) and 2.1% protein for fresh potato in the Americas (Smith. 1968; Horton, 1987). The fibre contents of these low fat experimental crops are not inferior to the 1-2% fibre content obtained for boiled potato (Burton, 1989).

Table 5: Sensory Panelists' comments on the cooked experimental materials

For	Against
1. Boiled salted tubers of Hausa Potato and Livingstone potato tasted like those of Irish potato *(S. tuberosum)*.	1. Small fibrous strands were observed in the pith of boiled Livingstone potato tuber.
2. The cooked experimental materials had no off -flavours.	2. The unsalted French fries made with the experimental crops had slightly bland taste that might call for flavouring.
3. Information on the palatability of the experime ntal cooked materials should be extended to the public.	
4. The salted French fries samples were crispy with those of Livingstone potato being more crispy.	

Nutritionally, it had been observed that the average daily intake of dietary fibre of a person in industrialized countries of Europe and North America is frequently inadequate (< 20g) as compared with the 40-50g for African and Asian communities (Burkitt, 1980). Internationalizing the food use of these experimental tropical staples (especially Livingstone potato) could assist in enhancing the dietary fibre intake in the diets of European and North American societies that have inadequate fibre intake. Interestingly, some of the sensory panelists in this study had observed the presence of small fibrous strands in boiled Livingstone potato (Table 5). These interesting results from this investigation call for a more detailed nutritional study with the experimental crops.

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Development and dissemination of a manual cassava chipper in Cameroon

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Abstract

Cassava (*Manihot esculenta Crantz*) is the main starchy staple in many parts of Cameroon, with 80% of rural and urban households consuming cassava and cassava derived products on a daily basis. Cassava products are commercialized mostly to supply household consumer markets with a total estimated equivalent of 1.1 million ton fresh cassava consumed in 2002 mainly because processing rely highly on family labour. Because of the smallholder nature of farming systems and the low density of producers in more inaccessible areas, investment in immobile, motorized cassava processing equipment is often not economically justified by the production capacity in these areas. Hence, IITA developed manual cassava chipper that are, easily transported and don't rely on electricity or fuel and complex technology. This manual chipper was tested with farmers in several villages. It has a capacity to process up to 260 kg cassava per hour, which is enough for a several farming households to consume in two months. In January 2007, the IFAD-funded project, Programme National de Développement des Racines et Tubercules (PNDRT) embarked on a program to promote and disseminate an IITA manual cassava chipper within the framework of its efforts on value addition to enhance farmers' income in Cameroon. IITA in collaboration with PNDRT identified and trained 13 local fabricators and the chippers disseminated were fabricated locally. 100 machines are currently being used by over 100 groups of cassava growers in 25 villages totalling about 1500 farmers in the 10 regions of Cameroon. Several NGOs, CBOs and farmers' organizations in Cameroon have now engaged in the fabrication and dissemination of IITA manual cassava chipper. Users and beneficiaries of this processing technology are cassava growers and small agricultural machinery manufacturers. The design, specifications and the user's guide for the manual cassava chipper are available. We expect that this technology will improve the accessibility of mechanized processing and increase commercialization and subsequent income of cassava growers in Cameroon.

Keywords: Postharvest processing, cassava chips, cassava flour

Introduction

In Cameroon, cassava (*Manihot esculenta Crantz*) ranks first amongst root and tuber crops in terms of total production and consumption and the yearly production is estimated at 2.5 M tons, with the Centre, East and South regions being the most productive areas (PNDRT, 2005). It is the main starchy staple with 80% of rural and urban households consuming cassava and cassava derived products on a daily basis (Numfor and Ay 1987). Currently, however, there is a growing awareness of the potential of cassava as a source of food and of income. Cassava and its products (e.g., batons, paste, flour, fufu, gari, chikwangue and starch) are being sold both in Cameroon and elsewhere in Central Africa for the rapidly growing urban populations (Essono et al. 2008). This increase in demand for cassava has led to an increase in production far exceeding the previous traditional subsistence systems. However the perishability of the fresh cassava roots makes it imperative that processing occurs immediately after harvest as close as possible to production areas. In addition, they are bulky with about 70% moisture content and therefore transportation of the tubers to markets is difficult and expensive. The raw roots are not palatable and contain varying amounts of cyanide which is toxic to humans (Numfor and Ay 1987). Therefore, cassava must be processed in order to increase the self life of the products, facilitate transportation and marketing, reduce cyanide content and improve palatability.

During the rainy season, sunshine and ambient temperatures are relatively low for processing cassava, particularly in lowland humid areas where cassava is mainly grown. Cassava products are commercialized mostly to supply household consumer markets with a total estimated equivalent of 1.1 million ton of fresh cassava consumed in 2002 mainly because processing relies largely on family labour (PNDRT, 2005). The drudgery associated with traditional processing is enormous and the products from traditional processing methods are often contaminated with undesirable extraneous matter. Some of the products are therefore not hygienic and so are of poor market value (Essono et al. 2008). Because of the smallholder nature of farming systems and the low density of producers in more inaccessible areas, investment in immobile, motorized cassava processing equipment is often not economically justified by the production capacity in these areas. Hence, IITA developed a manual cassava chipper that is easily transported and does not rely on electricity or fuel and complex technology. This manual chipper was tested with farmers in several villages and is locally fabricated. It has a capacity to process up to 260 kg cassava per hour, which is enough for several farming households to consume in two months. In January 2007, the IFAD-funded project, Programme National de Développement des Racines et Tubercules (PNDRT) embarked on a program to promote and disseminate an IITA manual cassava chipper within the framework of its efforts on value addition to enhance farmers' income in Cameroon. This scheme fits within and complements programs of the Cameroonian government to promote high quality cassava flour. This paper presents a general overview of cassava processing and utilization of a manual cassava chipper by small-scale farmers and processors in Cameroon, and examines the opportunities for improving postharvest technologies.

Material and Methods

Rapid urbanization has led to an increased demand of cassava-based food items with increased prices in Cameroon (Dury et al. 2004). This growing trend of demand has continued with increased world market price of alternative carbohydrate sources based on imported rice and wheat. In 2005, Cameroon imported over 300.000 tonnes of wheat worth 73 million US$ (FAO, 2005). The IFAD funded PNDRT project is intended to increase production of cassava in Cameroon by supporting producers and their organizations to overcome some of the problems identified. These include improving yields with improved varieties and improving access to more efficient processing methods with improved processing facilities (Njukwe et al; 2010). These facilities were set up in 35 pilot villages to target not only the existing market with traditional cassava derived products, but also to explore potential markets for high quality cassava flour (HQCF) as a substitute for expensive wheat flour. Since processing machines are not available in remote areas, farmers harvest small quantities at a time, adjusted to the capacity they can process which is labour-intensive thus increasing market costs. To increase accessibility to processing equipment in a system where cassava is processed individually in a decentralized way at household level, IITA-Cameroon developed a manual cassava chipper suitable for this purpose.

The chipper is made of local material, cheap, easy to repair/clean, manually driven with no additional fuel costs, easy to transport and possible replacement of chipping with grating drum. The technology is useful in areas with difficulties to access markets and absence of electricity. In many villages of Cameroon, cassava flour is produced by drying chips that are manually cut or by drying grated cassava mash, using manual grating boards (Essono et al; 2008). Manual cutting and grating is prone to injuries and besides requires a lot of time. The quality of product varies as chips are too thick to dry fast and with unequal sizes. Chips also deteriorate quickly if left moist and can develop a problem with mycotoxins. To facilitate and promote local fabrication of IITA manual cassava chipper, 13 local fabricators were identified and trained. In the process of enhancing this local capacity, IITA equipment and utilization unit visited the fabricators to determine the capability of workshops to fabricate the machines and to evaluate the performance of the manual cassava chipper fabricated after the training. Materials used for fabrication are locally obtained and are non corrosive. Prior to the training of local fabricators, IITA had developed and tested several designs first on-station and subsequently on-farm. Demonstration tests were executed in the villages of Nkometou, Nkolmeyang, Ekoumdouma and Mbalmayo and over 300 participating farmers were asked to give their preference to a specific design and suggestions for further improvement. This input from farmers facilitated the design and specifications of the manual cassava chipper which is documented for use. Prior to the dissemination of the manual cassava chipper by PNDRT, IITA trained beneficiaries on its use, maintenance and care.

Results and Discussion

The production and consumption of chips is common in the center, east, west, adamawa and littoral regions of Cameroon where two types are distinguished. The fermented chips used to prepare fufu and the unfermented chips used to prepare flour that is mixed with corn for 'fufu mais' which is popular in the Foumban (Bamoum) area in the western region. Besides, local initiatives have been observed in substituting wheat for cassava and sweet potato flour, as is done in the Anglophone south-west and north-west regions where bread made of composite flour is sold under the name Kumba-bread. In some cities and in women empowerment centres of the ministry of women empowerment and the family (MINPROFF), wheat flour substitution for bakery products, snacks and other consumables from composite flour is being promoted. To enhance the processing of cassava into storable products of better price/weight ratio, PNDRT and IITA identified and selected 35 pilot villages in the main production zones in Cameroon to set up improved processing facilities. The manual cassava chippers disseminated by PNDRT are fabricated locally (fig 1) and 100 machines are currently being used by over 100 groups of cassava growers in 35 villages totalling about 1500 farmers in the 10 regions of Cameroon. Several NGOs, CBOs and farmers' organizations in Cameroon have now engaged in the fabrication and dissemination of IITA manual cassava chipper. Users and beneficiaries of this processing technology are cassava growers and small agricultural machinery manufacturers. The design, specifications and the user's guide for the manual cassava chipper are available. We expect that this technology will improve the accessibility of mechanized processing and increase commercialization and subsequent income of cassava growers in Cameroon.

In conclusion, monitoring and evaluation reveal that the manual cassava chipper perform better than the traditional method of cassava chip production. The introduction of the manual cassava chipper in villages without electricity and inaccessibility also enhanced the cultivation of cassava in these areas. This constitutes an attractive scheme for the deployment and promotion of improved cassava varieties with low cyanide contents and culinary qualities through on-farm participatory evaluation especially in an environment of increasing food demand. To ensure sustainable dissemination of manual cassava chipper beyond PNDRT intervention sites, a network of local fabricators is setup and periodic training is organized for new fabricators. The principle of periodic training is to ensure a continual and expanding supply of manual cassava chipper. This scheme fits within and complements programs of the Cameroonian government to promote high quality cassava flour. Increasing cassava production and processing can make significant contribution to food security, employment and diversification of income sources in rural and urban areas. We expect that this technology will improve the accessibility of mechanized processing and increase commercialization and subsequent income generation within small cassava producing communities.

Video showing manual cassava chipper http://www.youtube.com/watch?v=IKnBhCTJS6k&feature=channel.

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Fig 1: Engineer T. Diallo with local fabricators at the fabricators training workshop