Advances in Food Science and Technology ISSN: 6732-4215 Vol. 4 (6), pp. 001-005, June, 2016. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Potential utilization of orange-fleshed sweet potato genotypes roots in the creation of β-carotene rich chips in Nigeria

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Accepted 08 March, 2016

Orange-fleshed sweet potato (OFSP) varieties are being propagated in Nigeria to aid in combating dietary vitamin A deficiency in the country due to their high content of β-carotene (a precursor of vitamin A in humans). Tuberous roots of yellow and orange fleshed sweet potato (OFSP) genotypes were assessed in Nigeria for their potential usage in the production of fried pro-vitamin A rich chips. Results showed that while the fresh OFSP roots had 38.68 to 66.36 µg/g β-carotene content, their fried chips had 27.54 to 60.49 µg/g β-carotene content. Selected semi-trained Nigerian sensory assessors relatively liked these pro-vitamin A rich chips (that can serve as a functional food) with varying level of acceptance for most of the evaluated sensory parameters (sugariness, crispness and overall acceptability).

Key words: Orange-fleshed sweet potato, fried chips, β-carotene, pro-vitamin A, functional food, Nigeria.

INTRODUCTION

Sweet potato (*Ipomea batatas*) is an important staple food crop in Nigeria (Ukpabi, 2009). It is one of the starchy root crops that are generally consumed in the country as an energy giving food. On dry matter basis, the non carbohydrate macronutrient composition of the edible tuberous roots includes the following: 1.4 to 8.6% protein, 3.4 to 5.9% crude fibre, 0.3 to 1.9% lipid and 1.5 to 6.3% ash (Degras, 2003). The pro-vitamin A β-carotene pigment (a dietary precursor of vitamin A) is known to be responsible for the yellow to orange colouration of the flesh of tuberous roots of some sweet potato varieties (Degras, 2003; Rodriguez-Amaya and Kimura, 2004). In Nigeria, most of the sweet potato landraces have white fleshed roots with negligible amount of the pro-vitamin A pigment. However, Ijeh and Ukpabi (2004) had shown that a popular local yellow fleshed landrace (known as Ex-Igbariam) has appreciable but relatively limited quantity of β-carotene (3 µg/g fresh root sample). .

Recently (2005 to 2006), National Root Crops Research Institute (NRCRI), Umudike, Nigeria arranged and acquired some yellow and orange fleshed sweet potato genotypes with improved agronomic traits from International Potato Centre, Lima, Peru (known by its Spanish acronym of CIP) through its sub station in East Africa. These genotypes, especially those of orange fleshed sweet potato (OFSP), were bred as a tool for the global fight against vitamin A deficiency in areas that lack vitamin A rich food materials (Degras, 2003).

Sweet potato chips, which are similar to Irish potato chips, are some of the food forms that can be prepared with the edible roots of sweet potato (Woolfe, 1992). It was therefore deemed necessary at NRCRI for Nigeria to evaluate the CIP yellow and orange fleshed sweet potato genotypes (that adapted to the local agronomic conditions) for the production of palatable β-carotene rich chips that would be acceptable to Nigerian consumers; as locally acceptable food forms from β-carotene rich OFSP will greatly assist in combating vitamin A deficiency ailments amongst many poor citizens that lack sufficient dietary

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vitamin A intake.

MATERIALS AND METHODS

Source of materials

The tuberous roots of the five experimental orange and yellow fleshed sweet potato genotypes (CIP 440215, Costanero, Naspot 2(2), CIP 440167 and TIS 2532.OP.1.13) used for the study were randomly harvested from the experimental plots of NRCRI, Umudike, Nigeria (latitude 05° 29'N and longitude 07° 33'E) at 18 weeks after planting. The four exotic sweet potato genotypes (CIP 440215, Naspot 2(2) Costanero, and CIP 440167) were originally obtained from the CIP sub-station in East Africa while TIS 2532.OP.1.13 genotype (which served as the experimental check or control) was locally bred at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The refined, bleached (carotene free) vegetable oil (Turkey brand, Singapore) used for deep oil frying was purchased from Umuahia Main Market, Abia State, Nigeria.

Tuberous root characteristics

The parameters used to characterize the experimental sweet potato roots were skin color, flesh color, tuber shape, latex presence, flesh hardness and the flesh taste. The authors were assisted by their research colleagues and literature guidelines (Degras, 2003) in determining these characteristics. Kitchen knife cutting was used to assess the level of root hardness, while the other parameters were assessed with the relevant human sense organs.

Preparation of the fried sweet potato chips

As shown in Figure 1, the unit and sub-unit operations employed in the preparation of the chips included sorting, washing, peeling, chipping, salting and deep oil frying with vegetable oil at 140 to 150°C (for 2 to 3 min). In the process of preparing the sweet potato samples, peeling was done manually with kitchen knife while chipping was done mechanically with a chipping machine (Crypto Peerless, Birmingham, England). A kerosene stove (Butterfly, Germany) supplied the heat for the deep oil frying. The percentage peel loss of the fresh experimental tuberous roots and thickness (with a screw gauge to the nearest millimetre) of their respective circular shaped chippings (before frying) were determined with six randomly selected samples and recorded. The visually observed colour hues of the chips after frying were also recorded.

Chemical analysis

The dry matter content of the randomly selected experimental sweet potato roots was determined with the standard AOAC (2000) method by drying (their respective samples in quadruplicates) to constant weight in an oven (Oven BS, Gallenkamp, England) at 70°C. The method of Rodriguez-Amaya and Kimura (2004) as modified by Ukpabi and Ekeledo (2009) was used to determine the β-carotene content of the fresh and fried experimental samples in quadruplicates. Acetone and petroleum ether were used as the extraction solvents (with light exclusion) while the readings with the spectrophotometer (Jenway 6406, England) was at ƛ450 nm (with 1 cm glass cuvette).

$$\text{Carotene content (mg/100 g)} = \frac{\text{A x volume (mL) x } 10^3}{\text{Ac x sample weight (g)}}$$

Where; A = absorbance, volume = total volume of extract, Ac = absorption coefficient of β-carotene in petroleum ether (2592).

Sensory evaluation of the fried chips

Randomly selected twenty semi-trained panelists (who were regular consumers of fried chips) were used to sensorily assess the quality of the fried sweetpotato samples using a 7-point Hedonic scale (Jellinek, 1985; Iwe, 2002). In the sensory evaluation scoring (for crispness, sugariness and overall acceptability), 6 represented "like extremely", 5 represented "like very much", 4 represented "like much", 3 represented "neither like nor dislike", 2 represented "dislike much", 1 represented "dislike very much" and 0 represented "dislike extremely".

Statistical analysis

Statistical Analysis System (SAS) PC software (License site 0822206002) belonging to International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria was used for the mean separations and other statistical analysis.

RESULTS AND DISCUSSION

Table 1 shows that the roots of the experimental sweet potato genotypes had varying tuber shapes and rate of releasing the sticky whitish latex. All the experimental roots were found to be relatively easy to cut with a kitchen knife. It was observed that knife peeling of the genotypes with slender oblong roots (e.g. var. CIP 440167) and segmented roots (e.g. Costanero) may lead to relatively high tuber peeling loss (Table 2). Ukpabi et al. (2008) had found that irregular tuber shape adversely affected the percentage manual peeling loss of water yam (*Dioscorea alata*) during its processing into flour. The root tuber shapes and sizes probably also affected the thickness (1 to 2 mm) of the fresh root chippings before their deep oil frying.

In the chemical analysis, the results in Table 3 show that the fresh root samples had varied dry matter contents of 21.4 to 38.7% that are similar to the values (17.8 to 38.2% dry matter) given by Tewe (1994) for fresh sweet potato roots in Nigeria. On fresh weight basis, the exotic orange fleshed roots from CIP had β-carotene content of 59.70 to 66.36 µg/g (Table 3). This is in sharp contrast to the β-carotene content of 6.15 µg/g obtained for their yellow fleshed sweet potato variety (from Costanero genotype). The local experimental check (TIS 2532.OP.1.13) also had appreciable high β-carotene content of 38.68 µg/g. Interestingly, Rodriguez-Amaya and Kimura (2004) had shown that the relatively heat stable carotenoid content of sweet potato is made up of about 95% *all trans* β-carotene that is more nutritionally important as a precursor of vitamin A in human diet than its *cis* β-carotene stereo isomer.

Though the fried chips from the CIP yellow fleshed sweet potato had only 0.97 µg/g β-carotene, its orange fleshed counterparts had β-carotene content of 27.54 to

Table 1. The experimental fresh root tuber characteristics.

Genotype	Skin colour	Flesh colour	Tuber shape	Latex presence	Ease of cutting	Flesh taste
CIP440215	Light orange	Orange	Pear shaped with tail	Minimal	Easy	Very sweet
Costanero	Brown	Yellow	Segmented and oblong	Small	Easy	Moderately sweet
TIS2532.OP.1.13	Brown	Orange	Pear shaped	Minimal	Easy	Very sweet
CIP440167	Light orange	Orange	Oblong and slim	Small	Easy	Sweet
Naspot2 (2)	Brown	Orange	Fusiform	Much	Easy	Sweet

Table 2. Tuber peeling loss and thickness of raw chippings before frying.

Genotype	Peeling loss (%)*	Raw chipping thickness (mm)
CIP 440215	22.22^{c}	2
Costanero	33.33^{b}	1 - 2
TIS2532.OP.1.13	16.67^{d}	2
CIP 440167	40.00^{a}	2
Naspot 2(2)	33.33^{b}	1- 2

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

Table 3. Dry matter and carotenoid content of fresh roots and their fried chips of the chips β- carotene levels*.

Genotype	Dry matter percentage	β-Carotene (µg/g)	
	Fresh root	Fresh root	Fried chips
CIP440215	33.50^{b}	63.90^{ab}	27.54^{d}
Costanero	32.60^{b}	6.15^{d}	0.97^{e}
TIS22532.op.1.13	21.40^{c}	38.68^{c}	36.80^{c}
CIP440167	24.30^{c}	66.36^{a}	60.49^{a}
Naspot 2(2)	38.70^{a}	59.70^{b}	49.58^{b}

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

60.49 µg/g. The experimental chips (fried for 2 to 3 min) showed varying levels of post processing losses in their determined carotene content; based probably on their respective genotypic response to the processing steps used in this study. Bengtsson et al. (2008) shows that 78% of *all-trans*-β-carotene can be lost in 10 min deep oil frying of the fresh OFSP.

In human nutritional studies, vitamin A activity is expressed as retinol equivalent, and many earlier investigations had shown that 6 µg of *all-trans*-β-carotene has the biological (vitamin A) activity of 1 µg retinol (Okaka et al., 2002). The vitamin A recommended dietary allowance (RDA) for adults (men and women) and children (4 to 9 years) is 0.75 and 0.3 to 0.4 mg/day retinol activity equivalents (REA)/day, respectively (Okaka et al., 2002; Ukpabi and Ekeledo, 2008). It has also been shown that the human got more readily absorbs the fat soluble carotenes in dietary oily foods (Heimann, 1980). While fresh sweet potato flesh has fat content of only <1% (Degras), Ukpabi et al. (2007) gave the mean fat content of fried cocoyam (eddoe) chips that were produced with similar materials as those of the experimental samples (at NRCRI, Nigeria) as 7.85%. Furthermore, Mills et al. (2009) showed that dietary fat content of ≥6% greatly enhanced β-carotene bio-efficacy in Mongolian gerbils. Therefore, the chips produced from the experimental orange fleshed genotypes of sweet potato can be considered as functional food samples that may be regarded as very good sources of dietary vitamin A for Nigerians. More importantly, most of these food samples were found generally acceptable by the local Nigerian sensory test panelists (Table 4).

However, it should be noted that the level of acceptance of fried chips made from CIP 440167 genotype in the evaluated sensory parameters was generally lower than those made from CIP440215 genotype. In addition, the colour assessment of the fried chips' crusts (Table 5) show that the chip samples from CIP 440167 genotype had dark grey colour in the inside (unlike the others samples that had yellow to deep

Table 4. Sensory evaluation scores*# of the experimental chips.

Genotype	Crispness	Sugariness	Overall acceptability
CIP 440215	4. 60[a]	4.30[a]	4.30[a]
Costanero	4.00[a]	3.85[b]	3.75[ab]
Naspot 2(2)	3.45[bc]	4.05[a]	3.95[a]
TIS 2532.OP.1.13	3.30[bc]	4.25[a]	3.75[ab]
CIP 440167	2.85[c]	3.20[b]	3.20[b]

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

Table 5. Colour assessment of the chips' crusts after frying.

Genotype	Outside	Inside
CIP 440215	Orange	Orange
Costanero	Yellow	Yellow
Naspot 2(2)	Orange	Deep orange
TIS 2532.OP.1.13	Orange	Orange
CIP 440167	Orange	Dark grey

orange colour on the inner circular) due probably to enzymatic browning. Ukpabi (1988) had earlier reported genotypic effect on the occurrence of differential levels of food "browning" in cut roots of sweet potato (before and after cooking).

It is however hoped that the addition of food flavorings and generally regarded as safe (GRAS) additives would even enhance the level of consumer acceptability of these sweet potato chips in Nigeria when produced industrially. However, it might be necessary for food biochemists, human nutritionists and stereo (organic) chemists in advanced analytical laboratories to further undertake more detailed studies on possible effect of using industrial deep fryers on the geometrical or *cis-trans* isomerism of β-carotene molecules in the experimental OFSP samples. The possible positive role of the plant phenolics (that cause oxidative food browning) in lowering post cooking loss of β-carotene (as observed in CIP440167 chip sample) may also be investigated.

Conclusion

This study showed that the possibility exists for the use of roots of orange fleshed sweet potato (OFSP) genotypes in the production of provitamin A (β-carotene) rich chips that Nigerian food consumers will appreciate. This functional food product will potentially serve as a useful tool in alleviating vitamin A deficiency in Nigerian communities where the syndrome is endemic.

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