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Feasibility of Using Orange-Fleshed Sweet Potato as an Alternative to Carrot in Nigerian Salad Preparations

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Abstract: Tuberous roots of two improved Orange Fleshed Sweet Potato (OFSP) genotypes (CIP 440215 and 440167) were assessed as alternative vegetables to the carotene rich carrot roots in the preparation of carrot based vegetable salads (fresh and parboiled). The results shown that the fresh largely tropical OFSP roots like carrot have sweet taste, fairly long shape and minimal gummy flesh latex. The carotenoid content of the fresh carrot was 5.09 mg/100 g while that of the OFSP roots was 3.87-5.97 mg/100 g. The sensory evaluation result of the salad samples shown that the fresh OFSP samples were liked much and compared favourably with that of fresh carrot sample. However, only OFSP var. CIP 440215 compared favourably with carrot in the preparation of parboiled vegetable salad. The potential of these OFSP genotypes grown in Nigeria as very good dietary sources of pro-vitamin A in local food industries and human nutrition was also observed.

Key words: Vegetable salad, carrot, OFSP, pro-vitamin A, CIP, food industries, human nutrition

INTRODUCTION

Sweet potato (*Ipomoea batatas* Lam.) is a largely tropical root crop that has started playing an important role in the food security, nutrition and economy of Nigeria and many other tropical Sub-Saharan African (SSA) countries (Horton, 1998; Woolfe, 1992). Research scientists working on this root crop have developed β-carotene rich Orange-Fleshed Sweet Potato (OFSP) genotypes that are adaptable to the tropical agro-ecosystems in SSA countries (Woolfe, 1992; Anderson *et al*., 2003; Degras, 2003). Though, β-carotene, α-carotene and β-cryptoxanthin are the important precursors of vitamin A (in human nutrition) amongst the plant carotenoids found in nature, β-carotene is considered the most important pro-vitamin A component in carotenoid rich foods (Parker, 1996; van Jaarsveld *et al*., 2005). Recent studies in Brazil have shown the predominance of trans β-carotene in the pro-vitamin A content of OFSP (Rodriguez-Amaya and Kimura, 2004).

Historically, carrot (*Daucus carota*), which is also a root vegetable has been widely used as an excellent source of pro-vitamin A (Rodriguez-Amaya and Kimura, 2004; Raemaekers, 2001). At the moment, this largely orange fleshed temperate crop that is devoid of gummy latex during its processing is extensively used in the preparation of vegetable salads in Nigeria. Unfortunately, availability of the crop in most Nigerian local markets is seasonal due to periodic cropping in the country (and other tropical SSA countries) at the few cool (15-21°C) agro-ecologies (Raemackers, 2001).

Carrot production in Nigeria is generally localized in the cool areas (such as high altitude Jos Plateau areas) that support the cultivation of temperate crops such as potato (*Solanum tuberosum*) (Agboola, 1979). Therefore, during its agricultural off-seasons, vegetable salad consumers, caterers, chefs and food processors from parts of the country that cannot grow carrot buy the root vegetables at exorbitant prices. All these necessitated the research into finding a viable alternative to carrot in local preparation of vegetable salad. Furthermore, any good pro-vitamin A rich tropical root vegetable that can serve as a partial or full replacement of carrot in the preparation of vegetable salad would likely be welcome by many local food processors, caterers and consumers in Nigeria and some other SSA countries.

This investigation was therefore, aimed at evaluating the possible use of the β-carotene rich OFSP as an alternative to carrot in vegetable salad preparation in Nigerian food industries and homes.

MATERIALS AND METHODS

Sources of materials: The two Orange Fleshed Sweet Potato (OFSP) genotypes (CIP 440215 and 440167) used for the experimentation were collected from the germplasm

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plot of the Sweet potato Programme, National Root Crops Research Institute (NRCRI), Umudike, Abia State, Nigeria, West Africa. These genotypes, which adapted to the local conditions were originally acquired by NRCRI, Umudike, Nigeria from the International Potato Centre (CIP), Lima, Peru through their outstation in East Africa. The other vegetables used for the experimental salad preparation (carrot, cucumber, green pepper and cabbage) were purchased from the Umuahia Main Market, Abia State, Nigeria. All the experimental roots and vegetables were randomly selected for the study in January 2007.

Characterization of the OFSP and carrot roots: The parameters used to characterize the experimental sweet potato and carrot roots were skin colour, flesh colour, shape, presence of latex, flesh hardness and taste. The authors used literature guidelines (Degras, 2003) and the assistance of their research colleagues (who are well versed in root tuber characterization) in determining these characteristics.

Chemical analysis: Moisture content of the fresh OFSP and carrot roots was determined in quadruplicate by the standard method of drying to constant weight. In the employed gravimetric method, the samples for dry matter determination were dried to constant weight in an Oven (Oven BS, Gallenkamp, England) at 70°C (Bainbridge *et al*., 1996a). The β-carotene content of the OFSP and the carrot samples were determined spectrophotometric in quadruplicate, by the method of Rodriguez-Amaya and Kimura (2004). Acetone and petroleum ether were used as the extraction solvents (with light exclusion) while the readings with the spectrophotometer (Jenway 6406, England) was at λ450 nm (with 1 cm glass cuvette).

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

Where,

A = Absorbence
volume = Total volume of extract
Ac = Absorption coefficient of β-carotene in petroleum either (2592)

Preparation of the vegetable salads: The washed fresh and parboiled (100°C, 3 min) diced carrot (1 cup) and their equivalent sweet potato root replacements (1 cup/genotype) were used to prepare the experimental vegetable salads (samples A-F) using the modified recipe of Oji (1999). In addition to the washed fresh and parboiled diced cabbage (1 small head), cucumber (1 large size) and green pepper (1 large size), the six prepared salad samples basically had the following β-carotene rich root vegetable composition:

- Sample A: Fresh sweet potato (var. CIP 440215)
- Sample B: Fresh carrot
- Sample C: Fresh sweet potato (var. CIP 440167)
- Sample D: Parboiled carrot
- Sample E: Parboiled sweet potato (var. CIP 440167)
- Sample F: Parboiled sweet potato (var. CIP 440215)
- None of these salad samples was dressed with salad cream

Organoleptic evaluation: Twenty semi-trained sensory assessors, who were randomly selected from regular consumers of carrot vegetable salad, were used for the sensory evaluation of the six experimental vegetable salad samples. A 7-point Hedonic scale was used for the organoleptic evaluation (Bainbridge *et al*., 1996b; Iwe, 2002). In the scoring of the relevant sensory parameters (taste and mouth feel), 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. The sensory assessors were also requested to comment freely.

Statistical analysis: Statistical Analysis System (SAS) software version 8 (TS MO) licensed to International Institute of Tropical Agriculture, Ibadan, Nigeria (site 0822206002) was used for the respective statistical analysis.

RESULTS AND DISCUSSION

The experimental sweet potato roots had similar orange colour (Table 1) as the carrot roots that are normally used in preparation of vegetable salad in Nigeria. The observed minimal quantity of the sticky latex in the flesh of the experimental OFSP roots (unlike those in some other sweet potato genotypes) make for easy use of the roots during salad preparation. The criteria for the selection of these orange fleshed genotypes in the first instance were largely based on flesh colour, root shape and absence of gummy latex. The root shape, taste and flesh hardness of the experimental sweet potato roots do not seem to be very different from those of carrot in SSA as partially documented by Raemaekers (2001) and shown in Table 1.

The β-carotene content (3.87-5.97 mg/100 g) of fresh OFSP roots (Table 2) seems to compare favourably with that of fresh carrot (5.09 mg/100 g). Raemaekers (2001)

Table 1: Tuber characteristics of the fresh sweet potato and carrot roots

Root sample[#]	Skin colour	Flesh colour	Shape	Presence of latex	Flesh hardness	Taste
OFSP (CIP 440167)	Light orange	Orange	Fairly long, oblong	Minimal	Easy	Sweet
OFSP (CIP 440215)	Light orange	Orange	Fairly long, pear shaped	Minimal	Easy	Sweet
Carrot	Light orange	Orange	Fairly long cylindrical	Not detected	Easy	Sweet

[#]OFSP: Orange Fleshed Sweet Potato

Table 2: Moisture and carotenoid contents[#] of the fresh sweet potato and carrot roots

Root sample	Moisture (%)	α-carotene (mg/100 g)*
Sweet potato (CIP 440167)	61.30[c]	5.97 (15.43)[a]
Sweet potato (CIP 440215)	78.60[b]	3.87 (18.08)[b]
Carrot	88.83[a]	5.09 (45.59)[a]

[#]Values with the same letter in a column do not differ significantly (p = 005). *Values in bracket were calculated on dry matter basis

had earlier given 4.2 mg as the carotene content of 100 g of the edible part of carrot on fresh weight basis. However, on dry matter basis, the carotenoid values obtained for the sweet potato samples (15.43-18.08 mg/100 g) are lower than that of the experimental carrot. Furthermore, fresh white and creamy fleshed sweet potato roots, unlike those of OFSP are known to have negligible amounts of the pro-vitamin A (Degras, 2003; Davidson *et al*., 1975).

In nutritional studies, 6 μg β-carotene is equivalent to 1 μg of retinol (the active form of vitamin A) (Woolfe, 1992; Davidson *et al*., 1975). Sweet potato and carrot are amongst the few carotenogenic root crops where, β-carotene predominates in their total carotenoid content (Rodriguez-Amaya and Kimura, 2004). Fortunately, 95% of the β-carotene content of the OFSP roots is made up of the trans isomer (Woolfe, 1992), which is considered as the most active form of pro-vitamin A (Woolfe, 1992; Bendich, 1994; Stahl *et al*., 1995). The cis form of β-carotene is known to have lower vitamin A activity than the trans form (Davidson *et al*., 1975; Bendich, 1994; Stahl *et al*., 1995; Rodriguez-Amaya and Kimura, 2004).

Therefore, these OFSP roots could serve as a very good dietary source of vitamin A in Nigeria. This is based on the fact that the international Recommended Daily Allowance (RDA) of vitamin A (in retinol equivalent) in adults (men and women) is 750 μg day^{-1} (Davidson *et al*., 1975). Davidson *et al*. (1975) also gave the RDA for children aged between 4-9 years as 300-400 μg day^{-1}, with lactating mothers having RDA of 1200 μg day^{-1}.

In addition to its carotene content, Woolfe (1992) gave the proximate composition of fresh sweet potato as 70% moisture, 1.5% protein, 0.3% lipid, 3.9% fibre and 26.1% total digestible carbohydrates. Carrot on the other hand, has 89.6 water, 1.1% protein and 8.7% digestible carbohydrates (Raemaekers, 2001).

The result of the organoleptic evaluation of the fresh vegetable salads. Table 3 shown that the two experimental sweet potato genotypes could serve as replacements

Table 3: Organoleptic evaluation scores[#] of the fresh salad samples

Sample	Mouth feel	Taste
Sweet potato (CIP 440167) salad	4.33[a]	4.61[a]
Sweet potato (CIP 440215) salad	4.27[a]	4.77[a]
Carrot salad	4.77[a]	5.00[a]

Table 4: Organoleptic evaluation scores[#] of the salad samples with parboiled roots

Sample	Mouth feel	Taste
Carrot salad	4.22[a]	3.83[a]
Sweet potato (CIP 440167) salad	3.38[b]	3.00[b]
Sweet potato (CIP 440215) salad	3.44[a,b]	3.50[a,b]

[#]Values with the same letter in a column do not differ significantly (p = 0.05)

of carrot in the preparation of fresh vegetable salad for Nigerian local consumers. However, in the organoleptic evaluation of the experimental vegetable salads with the parboiled (100°C, 3 min) root samples (Table 4) only sweet potato var. CIP 440215 compared favourably with carrot. This means that salad consumers in Nigeria now have a good pro-vitamin A rich alternative to carrot in the preparation of vegetable salad. This is more so as not up to 20% of the pro-vitamin A activity is lost in sweet potato roots during boiling (Rodriguez-Amaya and Kimura, 2004).

The lower preference accorded to the parboiled sweet potato (var. CIP 440167) may be due to the observed discolouration (orange to grayish brown) of the diced roots after the thermal treatment by the authors and the sensory assessors (Table 5). This organoleptic effect may not only be linked to its carotenoid content as observation in NRCRI has shown high incidence of non enzymatic browning (Okaka and Okaka, 2001) in boiled roots of some improved genotypes of sweet potato.

Furthermore, reducing sugar content enhances certain types of non-enzymatic browning in thermally processed tropical roots and tubers (Okaka and Okaka, 2001; Onimawo and Akubar, 2005). Though, Ukpabi (1987) got 0.6-1.8% reducing sugar content for raw roots of sweet potato cultivars in Nigeria, boiling in water has been shown to induce varying increases in the reducing sugar content based mainly on the non-uniform maltase and amylase activities in the crops genotypes (Degras, 2003).

The sensory assessors also seem to have liked the fresh vegetable salad samples over the parboiled samples even in the absence of salad cream (Table 5). Boiling has been found to reduce the pro-vitamin A activity in both carrot (Rock *et al*., 1998) and OFSP

Table 5: General comments of the sensory assessors

For	Against
The fresh salad samples are better	The parboiled salad samples are less preferred
All the fresh salad samples taste alike	Use of salad cream would enhance the likeness rating of the salad samples
The fresh sweet potato salad samples look like carrot's	The colour of one of the parboiled root samples was brownish or greyish

(Rodriguez-Amaya and Kimura, 2004; Hagenimana *et al*., 1999). Therefore, under good hygienic conditions, consumers of the fresh vegetable salads take in more carotenoids as the exterior parts of the leafy vegetables in the salad samples are also known to be rich in pro-vitamin A carotenoids (Davidson *et al*., 1975).

Interesting to note is the fact that the agronomic root yields of the locally adapted CIP OFSP genotypes (2-20 ton ha^{-1}) as observed in the on-going research in NRCRI are not inferior to 2 ton ha^{-1} recorded for carrot in Nigerian small village farms. As in carrot production (Raemaekers, 2001), the vegetatively propagated OFSP could also be harvested at 14-17 weeks after planting in our experimental farms in Nigeria.

CONCLUSION

The two experimental OFSP genotypes (CIP 440215 and 440167) could be used to replace carrot in the preparation of fresh vegetable salad by food processors in Nigeria. However, the observed browning of the boiled root sample of CIP 440167 genotype of sweet potato makes it an unlikely candidate for boiled salad. Based on taste and mouth feel sensory parameters, CIP 440215 genotype of sweet potato was not significantly different from carrot in the preparation of the parboiled vegetable salads. Therefore, CIP 440167 and 440251genotypes of sweet potato may be recommended to Nigerian food processors as possible replacements for carrot in fresh vegetable salad. However, only CIP 440215 can be used in place of carrot in boiled vegetable salad preparation.

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