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EFFECT OF HARVESTING PERIODS AND PROCESSING METHODS ON CAROTENOID PROFILE OF YELLOW TRIFOLIATE YAM FLOUR

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ABSTRACT

Trifoliate yam (Dioscorea dumetorum) unlike other yam tubers are not harvested immediately after maturity but are left in the ground until needed as food due to hardening process which occurs few hours after harvesting. Yellow trifoliate yam pigment contains high carotenoids which are of benefit in human diet. Storage of trifoliate yam in the ground after maturity and processing of the tuber could have effect on the carotenoid contents of the tuber. Therefore, carotenoid profiles of yellow trifoliate yam flour as affected by periods of harvesting within four months of consecutives farming season and different processing methods was assessed. Freshly harvested yellow trifoliate yam was made into four treatments flour using four processing methods as follow: Raw Flour (oven dried at 60^{o}C), Soaked Flour (water deep at 29±2^{o}C) and dried (oven dried at 60^{o}C), Blanched Flour (water deep at 60^{o}C) and dried (oven dried at 60^{o}C), Parboiled Flour (water deep at 100±2^{o}C) and dried (oven dried at 60^{o}C). The treated flour samples were subjected to carotenoid profile using gas chromatography (model no HP6890 powered with HP ChemStation Rev. A 09.01 [1206] software). The major carotenoids detected in yellow trifoliate cultivar were carotene (31.61-81.03 µg/100 g) and β-cryptoxanthin (29.03-35.72 µg/100 g). Other carotenoids detected were viola-xanthin, lycopene, astaxanthin and antheraxanthin. Total carotenoids content (129.69 µg/100 g) of parboiled flour sample harvested at 7 months was higher than other samples. Harvesting of trifoliate yam tubers at 11 months provided yam with high concentration of carotenoids coupled with parboiling processing methods.

Keywords: *Carotenoids, Harvesting periods, Processing methods, Yellow trifoliate yam*

INTRODUCTION

Yam (*Dioscorea* spp.) constitute a staple food crop for over 100 million people in the humid and sub-humid tropics (Mignouna *et al*., 2003). Two types of pigments that are known to occur in yams are anthocyanins and carotenoids. Yellow or pale yellow yams have low carotenoid contents but *D. dumetorum* has more yellow pigmentation than other species (IITA, 2008)**.** Carotenoids were reported to be the source of the yellow colouring of *D. dumetorum* (yellow type) (IITA, 2008). Over 600 carotenoids have been identified, of which about twenty four occur in human diet (Haynes et al., 2010; Dutta *et al*., 2005). They are bioactive substances in human diet (Lashmanova *et al*., 2012) and are essential health-protecting compounds involved in human vision, immunity, embryonic development, and reproduction (Von-Lintig, 2010; Cao *et al*., 2012).

Carotenoids act as a powerful antioxidant that neutralizes free radicals and stimulates the genes that prevents cell from becoming cancerous (IITA, 2008). Carotenoids are important due to their conversion to vitamin A (Akinwale *et al*., 2010). Deficiency of vitamin A is mainly due to inadequate dietary intake of vitamin A or its precursor (Akinwale *et al*., 2010). Therefore, one of the alternative ways of combating vitamin A deficiency is through diet diversification (Fonseca et al., 2008). Consumption of carotene-rich food is a sustainable approach to combat vitamin A deficiency (Chakravarty, 2000). Carotenoid contents of food stuff such as rice, carrots, tomatoes, sorghum, root and tubers had been studied (Lamberts and Delcour, 2008; Sulaeman *et al* 2001; Elizade-Gonzalez and Hernandez, 2007; Afify *et al*., 2012; Mech-Nowak *et al*., 2012) but there is dearth of information on the carotenoid profiles of yellow trifoliate yam flour.

Processing of food had been reported to have effect on the carotenoid contents of food stuffs. Sulaeman *et al*. (2001) observed high retention of carotenoids during processing while Elizade-Gonzalez and Hernandez (2007) and Lambert and Delcour (2008) observed drastic reduction in the carotenoid contents of cooked tomatoes and parboiled rice. Carotenoid stability in food during processing is essential to achieve products with desired colour and nutritional quality (Hagenimana *et al*., 1999). Therefore, the objective of this work was to evaluate the effect of harvesting periods and processing methods on carotenoid profile of yellow trifoliate yam flour

MATERIALS AND METHODS

Two setts of trifoliate yam tubers consisting of white and yellow were collected from Esa-Oke farm settlements in Osun State of Nigeria. Trifoliate yam setts weighing 850 – 900 g were planted in mounds with 10 per row and spacing of 1m X 1m on a plot of land. Thirty samples were planted per each cultivar. The planting was done on 20th March 2010 and sprouting of some of the yam setts occurred on 26th of April 2010. These trifoliate yam setts were marked and used for the study. After sprouting and vines establishment, the yams were staked with stakes. The plot of land was kept weed-free manually at a month interval after planting. There was no application of chemicals of any kind applied either as fertilizer, pest control or herbicides. The yam tubers were harvested in a month interval starting from 26th November, 2010 to 26th March, 2011. The experiment was repeated in 20th November, 2011to 20th March, 2012 and 20th November, 2012-20th March, 2013 (Abiodun and Akinoso, 2014a,b).

Preparation of raw flour

The freshly harvested yam tuber was washed, drained and peeled. The peeled tuber was sliced (0.5 mm thickness) and dried in the hot air oven at 60 ^oC for 48 h. The dried chips were milled into flour with hammer mill and sieved with 600 µm sieve size. The flour samples were sealed in polythene bag and labelled as Raw Flour (Abiodun and Akinoso, 2014a).

Preparation of soaked raw flour

The freshly harvested yam tuber was washed, drained and peeled. The peeled tuber was sliced (0.5 mm thickness), soaked in water at ambient temperature (29 ± 2^oC) for 1 h and dried in the hot air oven at 60 ^oC for 48 h. The dried chips were milled into flour with hammer mill and sieved with 600 µm sieve size. The flour samples were sealed in polythene bag and labelled as Soaked Raw Flour (Abiodun *et al.*, 2009; Abiodun and Akinoso, 2014a)

Preparation of blanched (60 ^{o}C) flour samples

The freshly harvested yam tuber was washed, drained and peeled. The peeled tuber was sliced (0.5 mm thickness) and soaked in warm water (60 ^{o}C) for 10 min. The sample was soaked in the water for 12 h at ambient temperature and dried in the oven 60 ^{o}C for 48 h. The dried chips were milled into flour with hammer mill and sieved with 600 µm sieve size. The flour samples were sealed in polythene bag and labelled as Blanched Flour (Ukpabi and Omodamiro, 2008; Abiodun and Akinoso, 2014a).

Preparation of parboiled samples

The freshly harvested yam tuber was washed, peeled, sliced (0.5 mm thickness) and parboiled for 10 min in water bath maintained at 100±2 ^{o}C. The samples were dried in an oven set at 60 ^{o}C for 48 hrs. The dried chips were milled into flour with hammer mill and sieved with 600µm sieve size. The flour samples were sealed in polythene bag and labelled as Parboiled Flour (Ekwu *et al.*, 2005; Abiodun and Akinoso, 2014a).

Carotenoids profile determination

Flour sample (5.0 g) of the pulverised sample was homogenised with 75 mL acetone and kept at room temperature (29±2 ^{o}C) for 1 h in the dark. The homogenate was filtered through filter paper by suction. Extraction was repeated three times with the same volume of acetone. The extracts were combined and evaporated under reduced pressure and the residue was re-extracted with a mixture of diethyl ether and petroleum ether in equal ratio. The extract was poured into the round bottom flask. It was concentrated using rotary evaporator. Then the concentrated extract was dried by using the anhydrous sodium sulphate before gas chromatography analysis. Experimental conditions for capillary GC analysis were developed under the following conditions. Capillary column (Crosslinked 5% phenylmethylsiloxane, 50 m X 0.32 mm (i.d.), with 0.17 µm film thickness, model no HP6890 powered with HP ChemStation Rev. A 09.01 [1206] software), injector temperature 250ºC, carrier gas nitrogen (1 mL/min), split ratio 1/20, injection volume 0.2 µl. GC initial oven temperature was kept at 60 ºC, first ramping was at 10 ºC/min for 20 min, second ramping was at 15 ºC/min for 4 min. The quantification of the carotenoids was achieved using standards including violaxanthin, lutein, carotene, β-cryptoxanthin, astaxanthin, xanthophylls (Takagi, 1985). All analyses were carried out in triplicates. The mean and standard deviation of the replicate data obtained were calculated. The data were evaluated for significant differences in their means using Analysis of Variance at $p \leq 0.05$. Differences between the means were separated using Tukey's test.

RESULTS AND DISCUSSION

The carotenoid contents of trifoliate yam are presented in Table 1. The major carotenoids detected in yellow trifoliate cultivar were carotene (31.61-81.03 µg/100 g), β-cryptoxanthin (29.03-35.72 µg/100 g) and lycopene (6.61-11.41 µg/100 g). The major carotenoid in trifoliate yam flour was carotene followed by β-cryptoxanthin. Other carotenoids present such as violaxanthin (0.54-0.98 µg/100 g), astaxanthin (1.32-3.10 µg/100 g) and anthaxanthin (1.12-2.90 µg/100 g) were present in low levels in the flour samples. Within the treatments, no significant differences ($p>0.05$) was observed in the β-crptoxanthin contents of the raw yellow trifoliate yam flour from 10-11 months but the lycopene and carotene contents at 10 months were significantly different ($p<0.05$) from other samples at other periods.

Among the treatments, the raw flour at 10-11 months had higher β-crptoxanthin (35.72 µg/100 g) which was significantly different ($p<0.05$) from other samples. Lycopene (11.41 µg/100 g) was higher in the raw flour sample harvested at 10 while the carotene contents (77.81-81.03 µg/100 g) of the parboiled samples were significantly different ($p<0.05$) from other treatments. The carotene contents (81.03 µg/100 g) of parboiled sample harvested at 7 months was higher than other samples. There was rapid reduction from 403 to 292 µg/100 mg in the β-carotene contents of guajillo tomato after cooking (Elizalde-Gonzalez and Hernandez-Ogarcia, 2007). Anthaxanthin (2.90 µg/100 g) and astaxanthin (3.10 µg/100 g) contents were higher in raw flour sample harvested at 9 months while violaxanthin (0.98 µg/100 g)was higher in the parboiled flour sample harvested at 10 months. The total carotenoid contents of the tubers were higher than all the flour samples at various harvesting periods as presented in Table 2. Reduction in the total carotenoids may be due to the treatments given to the flours. The highest total carotenoid value was observed in the tuber harvested at 11 months (206.91 µg/100 g).

The carotenoids of roots and tubers such as yellow potato (26 µg/100 g), breadfruit (76 µg/100 g), tannia (46 µg/100 g) and taro (35 µg/100 g) were observed by Tee *et al*. (1995) to be lower than the values obtained for the trifoliate yam tubers used in this work. The highest total carotenoids value recorded for fresh potato varieties ranged from 0.2 to 63.2 mg/100g (Hagenimana *et al*., 1999). Among the treatments, the parboiled trifoliate yam flour harvested at 7 months had the highest carotenoids content (129.69 µg/100 g). The total carotenoid contents of parboiled samples were higher than other treatments. This may be due to inactivation of enzyme lipoxygenase, which is known to catalyze oxidative decomposition of carotenoids (Elbe and Schwartz, 1996).

At 7 months, the blanched flour was slightly higher than the raw and soaked flour samples. At 8 and 9 months, the soaked flour samples had the least carotenoid contents while at 10 and 11 months the blanched flour samples had the least carotenoid contents. Akin-Idowu *et al*. (2009) reported carotenoid contents of 3.40-10.86 µg/g in tuber and boiled yellow yam. The values were higher than the observed values for parboiled trifoliate yam. Decrease in the treated samples was in agreement with the findings of Akin-Idowu *et al*. (2009). Decrease in the total carotenoid contents was observed in the boiled and pounded yellow yam due to oxidation and degradation upon exposure to heat, light, acids, metals and enzymes (K'osambo *et al*., 1999). The raw flour samples had higher carotenoid contents at 8-11 months than the soaked and blanched flour samples. This corroborates the finding of Affiy *et al*. (2012) who reported drastic reduction of β-carotene in the soaked sorghum flour. Lamberts and Delcour (2008) also observed reduction in the carotenoid levels of parboiled rice below the limit of quantification. This decrease was explained to be as a result of loss of soluble solids in the soaking medium, oxidation of carotenoids during soaking, destruction of carotenoids during steaming and differences in extraction efficiency caused by the hydrothermal treatment of brown rice.

Table 1: Effect of Processing Methods on the Carotenoid Profiles of Yellow Trifoliate Yam Flours

Pre-treatment methods	Harvesting periods (months)	β-cryptoxanthin (μg/100 g)	Lycopene (μg/100 g)	Carotene (μg/100 g)	Anthaxanthin (μg/100 g)	Astaxanthin (μg/100 g)	Violaxanthin (μg/100 g)
Raw flour	7	31.63±0.01^{l}	8.40±0.14^{k}	43.77±0.04^{o}	1.28±0.04^{l}	1.96±0.01^{m}	0.62±0.01^{i}
	8	35.12±0.01^{c}	9.13±0.04^{f}	44.96±0.01^{m}	2.30±0.01^{cd}	2.45±0.01^{fg}	0.71±0.01^{ef}
	9	35.21±0.01^{b}	10.45±0.01^{d}	49.95±0.02^{g}	2.90±0.01^{a}	3.10±0.01^{g}	0.94±0.01^{b}
	10	35.72±0.01^{a}	11.41±0.01^{a}	50.93±0.01^{f}	2.47±0.01^{b}	2.71±0.03^{a}	0.74±0.01^{e}
	11	35.72±0.02^{a}	9.52±0.01^{o}	49.51±0.01^{h}	2.34±0.01^{c}	2.69±0.01^{b}	0.60±0.01^{i}
Soaking (ambient)	7	34.06±0.06^{g}	7.11±0.01^{n}	42.82±0.03^{p}	1.16±0.02^{n}	1.94±0.02^{n}	0.54±0.01^{k}
	8	30.05±0.01^{o}	7.74±0.05^{l}	40.52±0.01^{s}	1.12±0.01^{n}	1.32±0.01^{o}	0.49±0.01^{l}
	9	30.85±0.05^{m}	6.76±0.02^{o}	42.10±0.01^{r}	1.25±0.04^{lm}	2.08±0.10^{l}	0.57±0.01^{j}
	10	34.60±0.01^{d}	10.73±0.01^{b}	45.93±0.02^{k}	2.25±0.04^{ef}	2.65±0.01^{c}	0.81±0.01^{c}
	11	32.21±0.04^{j}	7.58±0.01^{m}	44.26±0.01^{n}	1.62±0.01^{k}	2.22±0.01^{j}	0.66±0.01^{h}
Blanched (60 °C)	7	30.14±0.01^{n}	10.44±0.04^{d}	45.09±0.02^{l}	2.13±0.03^{fgh}	2.57±0.01^{d}	0.73±0.04^{fg}
	8	33.43±0.01^{i}	8.29±0.02^{k}	46.27±0.04^{j}	1.76±0.03^{j}	2.25±0.02^{i}	0.66±0.01^{h}
	9	32.06±0.01^{k}	10.55±0.01^{o}	46.91±0.01^{i}	2.25±0.01^{de}	2.51±0.02^{e}	0.70±0.01^{g}
	10	33.55±0.01^{h}	7.78±0.02^{l}	42.76±0.01^{q}	1.23±0.01^{lm}	2.19±0.10^{k}	0.59±0.01^{j}
	11	29.86±0.01^{p}	6.61±0.01^{p}	39.61±0.01^{t}	1.18±0.03st	1.94±0.01^{n}	0.54±0.01^{k}
Parboiling	7	34.23±0.01^{f}	9.09±0.01^{f}	81.03±0.02^{a}	2.11±0.01^{gh}	2.32±0.01^{h}	0.92±0.01^{b}
	8	29.03±0.02^{r}	8.89±0.01^{g}	80.64±0.01^{c}	2.00±0.01^{i}	2.64±0.01^{c}	0.97±0.01^{a}
	9	34.47±0.02^{e}	8.43±0.02^{j}	77.71±0.01^{e}	2.22±0.01^{ef}	2.47±0.01^{f}	0.68±0.01^{h}
	10	32.04±0.01^{k}	8.64±0.01^{h}	80.77±0.01^{b}	2.17±0.01^{fg}	2.32±0.01^{h}	0.98±0.01^{a}
	11	29.11±0.01^{r}	8.55±0.02^{i}	79.44±0.02^{d}	2.12±0.02^{h}	2.42±0.01^{g}	0.84±0.01^{c}

Values with the same letter down the column were not significant different ($p \leq 0.05$)

Table 2: Effect of Harvesting Periods and Processing Methods on the Total Carotenoid Content in Yellow Trifoliate Yam Flour

Harvesting Periods (months)	Trifoliate yam tuber	Raw flour	Soaked flour (ambient)	Blanched flour(60 ^oC)	Parboiled flour
7	189.34±0.10^c	87.56±0.04^e	87.55±0.09^c	91.06±0.03^c	129.69±0.05^a
8	186.21±0.09^d	94.62±0.07^d	81.22±0.03^e	92.64±0.06^b	124.14±0.05^d
9	185.32±0.14^e	102.57±0.05^b	83.47±0.05^d	94.95±0.03^a	125.95±0.02^c
10	199.62±0.03^b	103.94±0.63^a	96.94±0.04^a	87.97±0.05^d	122.41±0.11^e
11	206.91±0.11^a	100.41±0.11^c	88.50±0.06^b	79.74±0.06^e	126.91±0.01^b

Values with the same superscripts along the column were not significant different ($p \leq 0.05$)

Reduction in the total carotenoid content may also be due to the processing methods given to the yam chips coupled with drying all the samples in the oven at 60 ^oC and milling into flour. Hagenimana *et al*. (1999) reported that drying sweet potato roots at 65^oC for 12 hrs reduced total carotenoid contents by 30 % while Lamberts and Delcour (2008) observed reduction in total carotenoid contents of brown rice after milling. Carotenoids are generally stable in their natural environments but when food is heated or when they are extracted into solution, in oils or organic solvents, they become much more labile (Coultate, 2002). Carotenoid acts as a powerful antioxidant that neutralizes free radicals and stimulates the genes that prevents cell from becoming cancerous. They serve as precursors to vitamin A (provitamin A) (IITA, 2008).

CONCLUSIONS

Carotenoid profile of trifoliate yam flour as affected by harvesting periods and pre-processing methods were evaluated. Carotene was the major carotenoid in the yam flour. Harvesting of yam tuber at early stage (7 months) and processed using parboiling method retained the carotenoids than other method.

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Carotenoid Profile of Yellow Trifoliate Yam Flour

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