Article

Variability of Carotenoids in Yellow-fleshed Cassava (*Manihot esculenta* Crantz) clones

by

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Abstract

Cassava (Manihot esculenta Crantz) is an important food security crop for many tropical and sub-tropical countries. Yellow-fleshed tubers of cassava contain β-carotene which is a precursor of vitamin A. Out of 16 local yellow- fleshed clones, only four clones possessed moderate amount of total carotenoids (3.6-6.4µg/g f.wt.) and β –carotene (2.2-2.8 µg/g f.wt.) coupled with good cooking quality. The analysis of 150 high carotene clones indicated that 35 clones possessed 10.0-13.6 µg total carotenoids /g f.wt. and 6 clones had 10.1-11.1 µg β –carotene /g f.wt.. There was no difference in the protein content between the white-fleshed and yellow-fleshed tubers. The studies indicated that yellow- fleshed cassava is a good source of pro-vitamin A .

Key words: Variabilty , carotenoids, vitamin A, yellow-fleshed cassava

Introduction

Cassava (Manihot esculenta Crantz) is cultivated in the tropical regions for its starchy tubers. The tubers are used for human consumption, animal feed and as raw material in many industries. Cassava tubers are rich in carbohydrates, but deficient in many proteins and many essential micronutrients. Tuber flesh color and good culinary quality are important traits for consumption of cassava as staple food. In most of the cultivated cassava clones the tuber flesh color is white or cream; these varieties contain negligible amounts of carotenoids (1). However several cassava varieties have yellow flesh color, and contain moderate amounts of carotenoids/ β-carotene (2). Yellow pigmented cassava is known to be cultivated in a limited way in Colombia, Philippines, Jamaica and some African countries (3). The Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram maintains about 500 high carotene cassava clones through gene pool development (4). The deficiency of vitamin A is a serious public health problem in many parts of India, as it causes eye damage, which when severe, can result in blindness, especially in children. Vitamin A is produced in the human body from its precursor β-carotene and 60% of the dietary vitamin A is estimated to come from pro vitamin A or β-carotene. The consumption of carotene rich foods is the most effective intervention for vitamin A deficiency. Since cassava is a major staple food crop, the use of yellow- fleshed cassava

varieties containing even moderate amounts of carotene can help in combating vitamin A deficiency. The present study was taken up to identify local yellow-fleshed cassava clones with good cooking quality, study the variability in total carotenoids and β-carotene content of yellow-fleshed local clones as well as high carotene clones from the germplasmand determine the difference in protein content between yellow and white –fleshed tubers of cassava.

Materials and Methods

Several yellow-fleshed cassava clones with good cooking quality were collected, from the different parts of Kerala and TamilNadu and planted in the CTCRI farm. About 150 high carotene clones available in the cassava germplasm was also utilized for the present study. Tuber samples were collected at the 10th month stage for the analysis of total carotenoids, β-carotene, dry matter and protein content.

Carotenoids were extracted and separated based on the procedure described in Association of Official Agricultural Chemists (5) using alumina as adsorbent. The concentration of total carotenoids and β-carotene was calculated by determining OD at 450nm. A calibration curve with standard β-carotene was used for the calculation of β-carotene in the test sample.

The dry matter percentage in tubers was determined by drying 20g of fresh tuber slices in an oven at 50°C till a constant weight was obtained. From the weight of dried sample, percentage of dry matter was calculated.

The protein content of selected yellow-fleshed and white-fleshed local cassava tubers was determined by the Kjeldahl procedure (6). Dried powdered tuber samples were digested (after removal of nonprotein nitrogen) , reduced nitrogen was estimated using an autoanalyzer and the nitrogen value was multiplied with the factor 6.25 to compute the protein content.

Results and Discussions

The results of the analysis of carotenoids of local clones are given in table-1.Out of several local clones collected, only 16 clones had yellow- fleshed tubers. Sree Visakham was a yellow- fleshed cassava hybrid released from CTCRI.

Table-1: Total carotenoids and β- carotene of local cassava clones

Sl No	Local clones	Flesh colour	Total carotenoids (µg/g f.wt)	β carotene (µg/g f.wt)	% of total to b- carotene	Dry matter (%)
1	Zoen kunnu	yellow	6.4	2.8	43.7	40.0
2	Chirakkarode	yellow	4.9	2.2	44.9	41.5
3	Narayana kappa	yellow	4.1	2.7	65.8	41.5
4	I-5	yellow	3.6	2.3	63.8	39.8
5	SreeVisakham	Light yellow	2.7	1.4	51.8	40.0
6	I-6	Light Yellow	2.7	0.8	29.6	36.5
7	NTA	Light Yellow	2.5	0.7	28.0	39.4
8	Ambakkadan	Light yellow	2.0	1.8	90.0	40.8
9	Kaliyan yellow	Cream	1.8	0.7	38.8	35.7
10	Kandhari	Cream	1.7	1.6	94.1	47.8

	padarppan					
11	Narukku-II	Cream	1.7	1.1	64.7	33.5
12	I-2	Cream	1.6	0.4	25.0	37.1
13	Narukku-I	Cream	1.4	0.9	64.2	31.5
14	Narukku-III	Cream	1.2	0.7	58.3	32.5
15	Kalikalan	Cream	1.1	1.0	90.9	41.3
16	I-3	Cream	0.5	0.4	80.0	40.3

Among the 16 local clones, only four local clones viz. Zeon kunnu, Chirakkarode,

Narayanakappa and I-5 showed moderate amount of total carotenoids (3.6-6.4µg/g f.wt.) and β-carotene content of (2.2-2.8µg/g f.wt.) coupled with good cooking quality. Dry matter ranged from 40-42%. The released variety Sree Visakham possessed total and β-carotene content of 2.7 and-1.4µg/g f.wt. respectively. Even though all the clones had good cooking quality, the total and β-carotene content was low. The concentration of β-carotene in different clones ranged from 25-90% of the total carotenoids, indicating that several yellow-fleshed tubers contained other carotenoids in addition to β-carotene. There was a positive relationship between the tuber flesh color and total carotenoids.

Distribution of carotenoids in germplasm accessions

The carotenoid and b-carotene content in 35 high carotene clones from the germplasm is given in table-2. Out of the total 150 clones, 35 clones contained >10 µg carotenoids/g f.wt. A wide range of variability was observed for total carotenoids , b-carotene and dry matter in these 35 clones. The variation in total carotenoids was 10.0-13.6µg/g f.wt, b-carotene 7.0-11.1µg/g f.wt. and dry matter 18-36%. Six clones had >10µg β-carotene /g f.wt. All the clones showed varying intensities of yellow to dark-orange flesh colour. There was a positive association between total carotenoids and color of the tuber flesh. Most of the high carotene clones had low dry matter and poor cooking quality. However, the tuber of all the clones were suited for making fried chips which had an attractive golden yellow color (7).

Table-2 Carotenoid content in yellow-fleshed cassava germplasm accessions

Sl.No.	Clones	Total carotenoid (µg/g f.wt)	b carotene (µg/g f.wt)	% of total to b- carotene	% of Dry weight
1	C – 18	10.0	7.6	76.0	18.3
2	C-39	10.0	8.4	84.0	24.2
3	C-137	10.1	7.3	72.2	23.4
4	C-31	10.1	8.3	82.1	24.0
5	C-42	10.1	8.5	84.1	21.0
6	C-34	10.1	8.5	84.1	24.6
7	C-129	10.2	7.5	73.5	22.6
8	C-144	10.2	8.5	83.3	18.5
9	C-82	10.2	8.4	82.3	24.5
10	C-61	10.2	8.6	84.3	20.8
11	C-98	10.3	8.4	81.5	21.9
12	C-108	10.3	7.7	74.7	25.3
13	C-119	10.3	7.8	75.7	20.1
14	C4 – OP – 1 – 03	10.4	8.3	79.8	32.0

15	99-OP-3-3	10.7	7.6	71.0	21.5
16	C – 23	10.7	8.0	74.7	20.1
17	C-64	10.7	8.8	82.2	22.3
18	C-81	10.8	8.7	80.5	24.8
19	C-47	10.8	9.2	85.1	20.0
20	02 – OP – 3 – 03	10.9	7.8	71.5	32.4
21	C-125	11.0	7.0	63.6	20.5
22	C-127	11.3	8.5	75.2	23.9
23	C-132	11.4	7.8	68.4	19.3
24	C-62	11.4	9.2	80.7	24.6
25	C – 11	11.9	8.9	74.7	32.2
26	C-20	12.0	10.2	85.0	25.0
27	GD – 62 / B	12.1	7.7	63.6	33.5
28	C-50	12.2	9.9	81.1	22.1
29	99-OP-1	12.3	8.8	71.5	35.6
30	C-99	12.3	10.1	82.1	23.0
31	C-72	12.3	10.5	85.3	25.5
32	C-149	12.4	10.2	82.0	34.4
33	99-OP-15	13.4	7.8	58.2	31.3
34	C – 19	13.4	10.1	75.3	21.0
35	C-71	13.6	11.1	81.6	25.1

Protein content in white and yellow-fleshed clones

White and yellow-fleshed tubers were analysed for protein in order to determine whether any difference exists between these clones. The data showed that protein content ranged from 1.5-3.1 % on dry weight basis (Table-3). There was no significant difference in the percentage of protein between the white and yellow-fleshed tubers.

Table-3 Protein (%) in yellow-fleshed and white-fleshed local cassava tubers.

	Local clones	Protein (% dw)
Yellow-fleshed clones	Narayana kappa	2.9
	Zeon kunnu	2.4
	Chirakkarod	1.5
	I-5	3.1
	Ambakkadan	2.4
White-fleshed clones	T.P White	2.4
	T.P Brown	2.4
	I-4	2.0
	Raman kappa	2.9

The potential of cassava as a source of carotenoids is being extensively studied in several germplasm collections globally and variability in carotene content among cassava varieties has been reported (8,9). The possibility of increasing the concentration of carotene 3-fold (0.42-1.38 mg/100g f.wt.) through cycles of recurrent selection was demonstrated by Jos et al (4) Oliveira et al (10) observed that in the yellow sweet cassava varieties the total carotenoids varied from 2.64-14.15 µg/g f.wt (0.2-1.4mg/100g f.wt.) and β-carotene ranged from 1.99-8.11µg/g f.wt. (0.199-0.81mg/100g f.wt.) Iglesius et al (11) studied the

range of variability for carotene content in a sub-set of the global cassava germplasm collection, and found a broad distribution of concentration from 0.1-2.4 mg/100g f.wt. Chavez et al (12) reported that the average total carotenoids analysed from different portions of cassava varied from 3.73-4.10µg/g f.wt. which is lower than the values obtained in our study.

In the present study four local clones were identified with good cooking quality and moderate amounts of total carotenoids (3.6-6.4 µg/g f.wt.) and β-carotene (2.2-2.8 µg/g f.wt.). Analysis of germplasm revealed 35 high carotene clones containing 10.0-13.6 µg total carotenoids /g f.wt. and 6 clones with β-carotene of 10.1-11.1µg/g f.wt., Although these high carotene accessions had poor cooking quality, they were good for making fried chips, which would therefore be a good source of pro-vitamin A. High levels of carotene (2 mg/100g f. wt.) were reported by Iglesius et al (11), who suggested that such high levels could be combined with other agronomic and root quality traits to have a good cassava cultivar.

The studies also showed that there was a close relationship between the total carotenoid content and tuber flesh color, as reported earlier by Iglesius (11) and Chavez (12). However the percentage of β-carotene showed a large range of variation in different accessions, suggesting that other carotenoids also contributed to the yellow color. Several Brazilian cultivars are rich in lutein and β-carotene (9). There was no difference in the protein content in white and yellow-fleshed tubers. Chavez et al (13) observed 5.75-8.31% of crude protein(based on total nitrogen) in improved clones of cassava which may be due to the genetic introgression from cultivated Manihot sps.

Significant progress in increasing the total and β-carotene content can be achieved by incorporating these high carotene clones as parents through the recurrent selection programme of cassava. It can be concluded that, in view of the sustainable food based approach for alleviating vitamin A deficiency, consumption of yellow-fleshed cassava can improve the vitamin A status and contribute to overcome vitamin A deficiency.

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