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Carotenoid Composition and Vitamin A Value of the Brasilian Fruit *Cyphomandra betacea*

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ABSTRACT

The carotenoid pigments of the fruit of the Tree Tomato Cyphomandra betacea *were identified and quantified. β-carotene, β-cryptoxanthin, ζ-carotene, 5,6-monoepoxy-β-carotene, lutein and zeaxanthin were detected in both the pulp and the peel. The quantitative patterns of the pulp and the peel were similar, with cryptoxanthin and β-carotene predominating. The high average vitamin A value (2475 IU/100 g edible portion) is due to the principal carotenoids that have provitamin A activity.*

INTRODUCTION

The Tree Tomato, *Cyphomandra betacea*, a branching shrub of 12–14 ft, native to Brasil, belonging to the family Solanaceae (Perry, 1972), bears oval-shaped fruits with reddish–brown peel, orange pulp and dark red seeds. The edible pulp has a taste reminiscent of that of the tomato and an aroma which has been described as 'guava-like' by some people and 'tomato-like' by others. The seed has an aroma which resembles that of passionfruit. In Brasil the fruit is more commonly encountered in the state of Minas Gerais and is commonly called 'Mineiro tomato'.

As part of our continuing programme to characterise the pigments of Brasilian fruits, the carotenoid pigments of the *C. betacea* fruit were

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determined. Identification of these pigments has not been previously reported in the literature.

MATERIALS AND METHODS

Materials

The ripe fruits were collected from a local garden; the peel and the pulp were separated and analysed separately. For the quantitative analysis of the carotenoids, three determinations of composite samples of six to seven fruits were undertaken. The average weight of the fruits was 50 g. For each determination, the total amount of peel (14–17 g) was taken for analysis. The pulp was combined and homogenised in a Waring blendor and a 50 g portion was utilised for the quantitative analysis.

Carotenoid determination

The carotenoids were extracted with cold acetone, transferred to light petroleum, saponified and separated on a MgO:HyfloSupercel (1:2) column with a gradient of ether and acetone in light petroleum as developing solvent. Fractions obtained from this column were rechromatographed on an alumina column also developed with a gradient of ether and acetone in light petroleum to verify if minor carotenoids were present, masked by the principal pigments. Identification was accomplished on the basis of the visible absorption spectra, affinities on the column and thin layer plates and specific chemical reactions. Quantitation was based on the maximum absorbance. Details of the extraction, separation, identification and quantitative determination had been described previously (Rodriguez *et al.*, 1976). Unsaponified extracts were also submitted to column and thin layer chromatography to verify if hydroxylated carotenoids were free or esterified.

Calculation of the vitamin A value

The vitamin A value was calculated considering the provitamin A activity of the individual active carotenoids as tabulated by Bauernfeind (1972) and assuming that 0·6 μg β-carotene or 1·2 μg cryptoxanthin is equivalent to 1 IU (NAS–NRC, 1980).

RESULTS AND DISCUSSION

Carotenoids of the pulp and the peel

The carotenoids of both the pulp and the peel separated into six bands on the MgO:HyfloSupercel column. Rechromatography of the fractions on an alumina column did not yield other bands.

Fractions 1 and 2 were identified as β-carotene and ζ-carotene, respectively, by their typical absorption spectra and chromatographic behaviour.

Judging from its absorption spectrum, fraction 3 could either be *cis*-β-carotene or 5,6-monoepoxy-β-carotene. Iodine catalysed isomerisation showed that the pigment was in the *trans* form. Addition of 0·1 N HCl to an ethanolic solution of the pigment shifted the maxima to shorter wavelengths by 20 nm, consistent with the isomerisation of a single 5,6-epoxy function to the furanoid (5,8-) form. Fraction 3 was thus identified as 5,6-monoepoxy-β-carotene.

The R_F values on the silica gel plates reflected the presence of hydroxyl groups in fractions 4 (mono-), 5 (di-) and 6 (di-). This was confirmed by the positive reaction to acetylation by acetic anhydride. Fraction 4 exhibited a spectrum similar to β-carotene and responded negatively to methylation with acidified methanol and dehydration with acidic chloroform, demonstrating the non-allylic position of the hydroxy substituent. The pigment was therefore identified as β-cryptoxanthin.

The spectrum with maxima at wavelengths slightly lower than those of β-carotene suggested that fraction 5 could be *cis*-zeaxanthin or lutein. Iodine catalysed isomerisation demonstrated the *trans* nature of the pigment. In acidified methanol, the pigment assumed the R_F value of a monohydroxy carotenoid, consistent with the methylation of a single allylic hydroxy substituent. Response to dehydration was negative, showing that the allylic position was not in conjugation with the polyene chain, confirming fraction 5 as lutein.

Since the absorption curve was similar to that of β-carotene and response to methylation and dehydration was negative, fraction 6 was identified as zeaxanthin.

Chromatographic behaviour on column and thin layer before and after saponification demonstrated that the hydroxyl carotenoids were mostly esterified.

Quantitative composition and vitamin A value

The pulp and the peel demonstrated similar quantitative patterns (Table 1). In both cases, cryptoxanthin ($10{\cdot}0 \pm 2{\cdot}8\ \mu g/g$ in the peel and $13{\cdot}9 \pm 4{\cdot}2\ \mu g/g$ in the pulp) and β-carotene ($8{\cdot}8 \pm 3{\cdot}5\ \mu g/g$ in the peel and $7{\cdot}9 \pm 3{\cdot}6\ \mu g/g$ in the pulp) predominated. Although α-carotene was not detected, the dihydroxy derivative, lutein, was present in higher amounts than zeaxanthin, the dihydroxy derivative of β-carotene, especially in the pulp.

TABLE 1

Carotenoid content (μg/g Fresh Weight) and Vitamin A Value (IU/100 g Edible Portion) of the *Cyphomandra betacea* Fruits

Carotenoid/Vitamin value	*Peel*		*Pulp*	
	Range	*Mean**	*Range*	*Mean**
β-Carotene	6·2–12·8	8·8 ± 3·5	4·9–11·8	7·9–3·6
ζ-Carotene	Trace	Trace	Trace	Trace
5,6-Monoepoxy-β-carotene	0·4–0·8	0·6 ± 0·2	0·3–0·4	0·3 ± 0·1
Cryptoxanthin	6·8–12·3	10·0 ± 2·8	9·8–18·2	13·9 ± 4·2
Lutein	1·1–1·7	1·5 ± 0·3	1·0–2·5	1·7 ± 1·1
Zeaxanthin	0·6–1·7	1·1 ± 0·6	0·2–1·1	0·6 ± 0·6
Total carotenoids	15·1–28·6	22·0	15·5–30·3	24·3
Vitamin A value	—	—	1634–3483	2475

* Each value is the mean of three determinations of composite samples of six to seven fruits.

The vitamin A value of this fruit comes mainly from β-carotene (100% activity) and cryptoxanthin (50% activity). Since half of the molecule is unsubstituted, 5,6-monoepoxy-β-carotene theoretically should have 50% activity. According to Bauernfeind's (1972) Table, however, it only has 21% activity. Considering this low activity and its low levels in this fruit, the contribution from this pigment was considered negligible.

Compared with some popular Brasilian fruits considered to be good sources of provitamin A, the average vitamin A value of 2475 IU/100 g edible portion (fresh weight) of *C. betacea* (Table 1) is higher than values quoted for banana (800–1167 IU/100 g) and papaya (1200–1650 IU/100 g) and within the range given for mango (1000–6000 IU/100 g)

(ITAL, 1980). The latter values, however, need verification since they were obtained using methods which did not separate individual carotenoids and could, therefore, overestimate or underestimate the actual provitamin A activity.

The vitamin A value of *C. betacea* is also higher than the average of 750 IU/100 g of tomatoes (Klein & Perry, 1982). This is to be expected since the principal carotenoids of *C. betacea* are potent vitamin A precursors while lycopene, the major pigment of tomato, has no provitamin A activity (Bauernfeind, 1972). The vitamin A value of *C. betacea*, however, falls much lower than the average of 15 288 IU/100 g of carrot (Klein & Perry, 1982), a foodstuff traditionally considered to be an extremely rich source of provitamin A.

Obviously, the carotenoids are responsible for the orange colour of the pulp. The red tinge of the peel and the dark red colour of the seeds are, however, due to anthocyanins. These latter pigments have been characterized and the results of this concurrent study are reported separately.

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