CAROTENOID COMPOSITION AND VITAMIN A VALUE OF A SQUASH AND A PUMPKIN FROM NORTHEASTERN BRAZIL

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SUMMARY

The carotenoid composition of a squash and a pumpkin from Northeastern Brazil was determined. Nineteen carotenoids were detected in *Cucurbita moschata* variety "Baianinha"; ß-carotene was the principal carotenoid, contributing about 74% of an average total carotenoid content of 317.8µg/g. In *C. maxima* variety "Jerimum Caboclo", 11 carotenoids were found with lutein, and ß-carotene as the major pigments accounting for about 60% and 27%, respectively, of an average total carotenoid content of 78.4 µg/g. The abundance of ß-carotene in the *C. moschata* variety "Baianinha" makes this squash one of the richest sources of provitamin A. The average vitamin A value was 43,175 IU (International Units) per 100 g or 4,317 RE (retinol equivalents) per 100 g. Its vitamin A values is more than 11 times that of *C. maxima* variety "Jerimum Caboclo" and five times that of *C. moschata* cultivar "Menina Verde", the squash found previously to be highest in provitamin A among the *Cucurbita* vegetables most commercialized in São Paulo (Southeastern Brazil).

INTRODUCTION

Most of existing data on the vitamin A value of foods had been based on the total carotene content, and are becoming widely considered as unreliable, because of the possibility of including inactive carotenoids and of grouping less active carotenoids with ß-carotene.

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There is general agreement on the necessity of obtaining new data by methods which remove interfering carotenoids, and quantitate the provitamins separately. The vitamin A value could then be calculated, taking into account only active carotenoids with their respective activities.

The importance of determining the complete carotenoid composition of foods has also become increasingly recognized, because of an apparently wider physiological function of carotenoids, beyond their role as precursors of vitamin A. The inhibitory effect against certain types of cancer, for example, appears to be not restricted to provitamins (1, 2).

In a previous paper (3), the carotenoid composition of the squashes and pumpkins most commercialized in the State of São Paulo, Brazil, were reported. A complex pattern was obtained, consisting of 13-15 carotenoids in each *Cucurbita* vegetable. Distinct varietal differences were observed, but between samples, variations were also noted. The *Cucurbita moschata* cultivar "Menina Verde" was richest in carotenoids, followed by the hybrid "Tetsukabuto" and the *C. maxima* cultivar "Exposição". *C. moschata* at the immature stage; however, it was low in carotenoids. This was also true for *C. pepo* cultivar "Caserta", which is consumed only when immature. The total carotenoid content and vitamin A value increased about 15- and 26-fold, respectively, from the immature to mature *C. moschata*. Peeling reduced the carotenoid concentration of the immature vegetables drastically: the vitamin A values of the pulp being only one-fifth of those of the whole vegetables. ß-carotene predominated in the *C. moschata* (mature) and *C. maxima*, while lutein was the major carotenoid of the other vegetables.

The present paper deals with the carotenoid composition of a squash and a pumpkin from Northeastern Brazil, a region where vitamin A deficiency and overall malnutrition are considered a serious problem, especially in certain areas. Although found in markets all year round, these vegetables are not grown commercially, and are thus designated simply as varieties, to differentiate them from those produced commercially, which are designated as cultivars (cultivated varieties).

MATERIAL AND METHODS

Materials

Samples of the squash *C. moschata* variety "Baianinha" were obtained from Salvador, Bahia, and those of the pumpkin *C. maxima* variety "Jerimum Caboclo" were collected from Recife, Pernambuco. These vegetables are described in detail in Table 1.

Sample Preparation

Each sample was prepared by cutting the fruit radially into eight

TABLE 1

DESCRIPTION OF THE SQUASH AND PUMPKIN ANALYZED

Vegetable		
Cucurbita moschata **Variety "Baianinha"**	**12-14 cm longitudinal diameter** **14-17 cm transverse diameter** **0.9-1.2 kg**	**Yellow exterior, smooth surface with slight ribbing, dark orange pulp, spherical**
Cucurbita maxima **Variety "Jerimum Caboclo"**	**10-12 cm longitudinal diameter** **15-26 cm transverse diameter** **0.3-1.6 kg**	**Grayish-green exterior, smooth surface with prominent ribbing, yellow-orange pulp, spherical but flattened at both stem and blossom ends**

sections. Four opposite sections were taken and, after removal of the seeds, they were peeled, cut into smaller pieces and mixed. A portion (Ca 250g) was homogenized with water (3:1) in a Waring blender. Aliquots equivalent to 25 g for the *C. moschata* and 60g for the *C. maxima* were submitted to analysis.

Carotenoid Determination

The carotenoid composition was determined according to procedures previously described (4).

The sample was blended with about 150 ml cold acetone and hyflosupercel in a Waring blender for 1 or 2 minutes and filtered through a Buchner funnel. Blending and filtration were repeated until the residue was devoid of color (2 or 3 times). The carotenoids were transferred to petroleum ether by adding small portions of the combined acetone extract to petroleum ether (about 100 ml) in a separatory funnel. After each addition, water was poured gently and the two layers were allowed to separate, without agitation, to avoid the formation of emulsion, and the lower aqueous layer was discarded. When the entire extract had been added, the petroleum ether layer was washed five times with water to remove residual acetone and collected in an Erlenmeyer flask. An equal volume of 10% KOH in methanol was added, and the mixture was left overnight at room temperature in the dark. The alkali was washed off in a separatory funnel with water (five times). If rinse water was colored, it was reextracted with fresh petroleum ether. The pigment solution was then dried with anhydrous sodium sulfate and concentrated in a rotatory evaporator at a temperature not exceeding 35°C.

The carotenoids were first separated in a MgO:Hyflosupercel (1:2) column developed successively with increasing concentration of ethyl ether (1-5%) and acetone (2-100%) in petroleum ether. Unresolved fractions were rechromatographed in another MgO:Hyflosupercel (1:2) column for the apolar carotenoids and neutral alumina (activity II or III) for the more polar pigments.

Fractions from both columns containing acetone were washed free of this solvent with water, and dried over sodium sulfate. The fractions were either concentrated or diluted, as needed, transferred to suitable volumetric flasks and the volumes completed with petroleum ether. The absorption spectra were taken from 550 to 350nm in a double-beam recording Perkin Elmer spectrophotometer, Model 356.

The carotenoids were identified through a combination of several parameters: 1) visible absorption spectra; 2) position on the column; 3) TLC Rf values; and 4) chemical reactions such as acetylation with acetic anhydride, methylation with acidified methanol, iodine catalyzed isomerization and epoxide tests. The identification procedure and interpretation of the results have been described previously in detail (4).

Quantitation was based on the maximum absorbance as described by Davies (5), using tabulated absorption coefficients. The

vitamin A values were calculated according to NAS-NRC (6), using the provitamin A activities tabulated by Bauernfeind (7). By definition, 1 IU (International Unit) is equivalent to 0.6 μg of ß-carotene or 1.2 μg of the other precursors; 1 RE (retinol equivalent) is equal to 6 μg ß-carotene or 12 μg of the others provitamins.

RESULTS AND DISCUSSION

Carotenoid Composition

Table 2 shows that the *C. moschata* variety "Baianinha" is notably rich in carotenoids, both in terms of the amounts and the number of different carotenoids detected. A total of 19 carotenoids were encountered, of which ß-carotene predominated, making up about 74% of an average total carotenoid content of 317.8 μg/g.

Eleven carotenoids were found in the *C. maxima* variety "Jerimum Caboclo". Lutein and ß-carotene were the major pigments, accounting for about 60% and 27% of a mean total carotenoid content of 78.4 μg/g.

The squash "Baianinha" thus presented a β-carotene and total carotenoid content almost 10 and four times greater, respectively, than those of the pumpkin "Jerimum Caboclo".

As with the squashes and pumpkins most commercialized in the State of São Paulo (3), appreciable variations between samples of the same Cucurbita were observed. These had been attributed to the long period during which the squashes and pumpkins could be harvested, and their much longer shelf life. While other fruits and vegetables need to be harvested and consumed within a short period, squashes and pumpkins keep for months, during which time the biochemical processes continue. There was no attempt to choose the samples analyzed according to exact maturity stages or time after harvest, so as to reflect the type of variation the consumers are exposed to. It is thus understandable that the between sample variations that could be discerned from Table 2 are greater than those observed in the other fruits and vegetables we have also studied.

Vitamin A Value

The abundance of β-carotene in the *C. moschata* "Baianinha" makes this squash one of the richest sources of provitamin A. Its vitamin A value is more than 11 times that of the *C. maxima* "Jerimum Caboclo" (Table 3).

The "Baianinha" also surpassed the richest source among the squashes and pumpkins commercialiezed in São Paulo. Its vitamin A value is about five times that of *C. moschata* cultivar "Menina Verde". Except for certain varieties of palm fruits, the vitamin A value of Baianinha is, in fact, the highest among more than 40 different fruits and vegetables we have so far analyzed (8).

Lee, Smith and Robinson (9) compared the carotene composition

TABLE 2

CAROTENOID COMPOSITION OF *Cucurbita moschata* VARIETY "BAIANINHA" AND *Cucurbita maxima* VARIETY "JERIMUM CABOCLO"

Carotenoid	Concentration (μg/g)*			
	C. moschata variety "Baianinha"		*C. maxima* variety "Jerimum Caboclo"	
	Range	Mean	Range	Mean
α-Carotene	16.8-82.5	47.1	0.2-0.6	0.4
β-Carotene	125.4-294.4	234.6	14.2-34.8	21.0
5,6-monoepoxy-β-carotene	ND-2.2	0.8	ND	ND
Cis-ε-carotene	4.9-30.4	19.0	1.5-2.7	2.1
α-Zeacarotene	ND-1.7	0.8	ND	ND
Neurosporene	ND-tr	tr	ND	ND
Mutatochrome	ND-tr	tr	ND	ND
δ-Carotene	tr-0.7	0.4	ND	ND
Unidentified**	tr-1.9	1.0	tr	tr
α-Cryptoxanthin	2.2-2.8	1.8	tr-6.7	2.6
Zeinoxanthin	tr-6.8	2.5	ND	ND
5,6-monoepoxy-α-cryptoxanthin	ND	ND	ND-8.8	2.9
Cis-5,6,5',8'-diepoxy-cryptoxanthin	ND-0.3	tr	ND	ND
Lutein	4.8-14.8	8.5	6.4-128.7	47.1
Cis-lutein	ND	ND	ND-0.4	0.1
Zeaxanthin	ND	ND	ND-0.2	tr
Taraxanthin	ND-tr	tr	ND-6.0	2.0
Cis-flavoxanthin	ND-0.7	0.3	ND-0.6	0.2
Cis-violaxanthin	tr-0.9	0.6	ND	ND
Luteoxanthin	ND-0.9	0.2	ND	ND
Cis-luteoxanthin	ND-0.5	0.2	ND	ND
Auroxanthin	ND-0.3	tr	ND	ND
Total	187.2-404.8	317.8	18.2-186.6	78.4

* Range and means of 3 samples for each vegetable collected at different times during the year.

** Calculated on the basis of the absorptivity of ß-carotene.

ND = not detected; tr = trace.

TABLA 3

COMPARISON OF THE VITAMIN A A VALUE OF BRAZILIAN SQUASHES AND PUMPKINS

Vegetables	Provitamins**	Vitamin A value***			
		IU/100 g		RE/100 g	
		Mean	SD	Mean	SD
C. moschata variety "Baianinha"	α-carotene (9.1%), β-carotene (90.6%) α-cryptoxanthin (0.3%)	43,175	16,209	4,317.5	1,602.9
C. maxima variety "Jerimum Caboclo"	α-carotene (0.9%), β-carotene (93.4%) α-cryptoxanthin (5.7%)	3,745	2,236	374.5	233.6
C. moschata cultivar "Menina Verde"	α-carotene (22.2%), β-carotene (75.9%) mutatochrome (0.5%), α-cryptoxanthin (1.4%)	8,624	5,594	862.4	559.4
C. máxima cultivar "Exposição"*	α-carotene (0.3%), β-carotene (96.2%) mutatochrome (0.3%), α-cryptoxanthin (3.2%)	2,875	1,801	287.5	180.1
Hybrid "Tetsukabuto"*	α-carotene (0.6%), β-carotene (72.9%) mutatochrome (0.2%), α-cryptoxanthin (26.3%)	2,956	901	295.6	90.1

* Taken from Arima and Rodríguez-Amaya (3) for comparison purposes.

** Numbers in parenthesis represent the per cent contributions of the provitamins.

*** Means and standard deviations of 3 samples for the first two vegetables and of 5 samples for the last three vegetables collected at different times during the year. All the data refer to mature vegetables.

of three cultivars and three breeding lines of winter squash grown in an experiment station in the U.S. The vitamin A value ranged from 142-297 RE/100g, that is, 14-30 times lower than the average vitamin A value of "Vaianinha".

The results clearly show that the squash "Baianinha" merits commercial production and wider distribution in Brazil and other developing countries having similar climatic conditions. Since squashes are easy to grow and can be available all year round, it is the type of crop which, if given due importance, can be of great help in alleviating the problem of vitamin A deficiency in the poorer areas of the world.

Several other aspects can be pointed out from the data on Table 3: 1) The squashes are in general higher in provitamin A than the pumpkins; 2) varietal differences are sufficient to emphasize the importance of specifying the cultivar or variety in Food Composition Tables; 3) the *Cucurbita* which showed the least variation was the hybrid "Tetsukabuto" which is grown from selected imported seeds and propagated under controlled commercial production conditions. It is thus possible to diminish variations between lots. Interestingly, the hybrid "Tetsukabuto" is gaining wider acceptance at the expense of the native squashes and pumpkins, a reflection of the tendency in developing countries to value imported crops without taking into consideration that local ones could be better from the nutritional and agronomic standpoints.

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RESUMEN

Se determinó la composición en carotenoides de dos tipos de calabazas de la región noreste del Brasil. Se detectaron 19 carotenoides en la variedad "Baianinha" de *Cucurbita moschata*, en la que el principal carotenoide es el β-caroteno, representando alrededor de 74% del promedio de 317.8 μg/g de carotenoide total. En la variedad "Jerimum Caboclo", de la especie *C. maxima*, se encontraron 11 carotenoides, de los cuales luteína y β-caroteno representan aproximadamente 60 y 27%, respectivamente, del promedio total de 78.4 μg/g. La abundancia de ß-caroteno en la variedad "Baianinha" de *C. moschata* hacen de esta calabaza una de las más ricas fuentes conocidas de pro-vitamina A. El promedio de valor de vitamina A fue de 43,145 (Unidades Internacionales) UI por 100g, o 4,317 ER (equivalentes de retinol) por 100g. Su valor vitamínico A es más de 11 veces el de la variedad "Jerimum Caboclo" de *C. maxima*, y más de cinco veces el valor del cultivar "Menina Verde" de *C. moschata*, la calabaza que anteriormente se conocía como la de mayor contenido de pro-vitamina A, entre las calabazas comercializadas en São Paulo, región sureste del país.

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