Original research article

**Fruits and vegetables in the Brazilian Household Budget Survey (2008-2009):
carotenoid content and assessment of individual carotenoid intake**

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Abstract

We studied the dietary sources of carotenoids from fruit and vegetables and their intake by the Brazilian population. The β -carotene, α -carotene, β -cryptoxanthin, lycopene, lutein, zeaxanthin, neoxanthin, violaxanthin concentrations in raw fruits and vegetables were compiled (19 fruits, 24 vegetables, and mixed fruit and salad dishes), using data from foods collected and analyzed in Brazil, by means of HPLC-DAD. The food intake was obtained from the Food Consumption Module of the Household Budget Survey (2008-2009), recorded in 13569 households, representatives of all Brazilian regions. Vegetables contributed more to vitamin A intake than fruits (70.3% vs 21.5% retinol equivalents), raw salads, pumpkin, kale and carrot being the main contributors. The mean dietary intakes of fruits (86 g/d) and vegetables (64 g/d) did not meet the recommendation of the WHO/FAO. All food items supplied β -carotene (0.9 mg/p/d), the major contributors being kale, pumpkin and mango. β -Cryptoxanthin (0.1 mg/p/d) was mostly supplied by orange, tangerine and papaya (87.4% of its intake). Lycopene (0.7 mg /p/d) was found only in guava, watermelon and tomato. Lutein (0.8 mg/p/d), violaxanthin and neoxanthin (0.6 and 0.2 mg/p/d, respectively), were mainly supplied by green leafy vegetables and α -carotene (0.16 mg/p/d) and zeaxanthin (0.06 mg/p/d) by a small number of foods.

Abbreviations

BP, Brazilian population; HBS, Household Budget Survey; FCM, Food Consumption Module; RE, Retinol Equivalent.

Keywords: fruits and vegetables; HPLC; carotenoids; household budget survey; retinol equivalents; dietary intake.

1. Introduction

Carotenoids are a class of natural pigments that are widely distributed in vegetables and fruits and also used as food additive. Apart from their properties as yellowish-red colorants properties, carotenoids take part in important functions and physiological actions, the most widely known of which is provitamin A activity. Vitamin A is essential for normal vision, gene expression, embryonic development and immunological function. Since vitamin A is not synthesized by the human body, it needs to be obtained through the diet, either preformed or from the conversion of provitamin A carotenoids (mostly β -carotene, α -carotene and β -cryptoxanthin) (IOM, 2000 & 2001).

There is growing evidence of the association between high consumption of fruits and vegetables and a lower risk of mortality from several diseases, especially cardiovascular diseases, type 2 diabetes and cancers (WHO/FAO, 2003a; Dauchet et al., 2006; WCRF, 2007; Shardell et al., 2011; Sluijs et al., 2015; Wang et al., 2014). In addition to their provitamin A activity, they have other important physiological roles related to eye health and the prevention of age-related ocular diseases (mainly macular degeneration) attributed to the yellow macular pigments lutein and zeaxanthin (Sabour-Pickett et al., 2012; National Eye Institute, 2013). The accumulation of lycopene in some human organs may allow for multiple mechanisms of action, including antioxidant activity (Story et al., 2010). Neoxanthin and violaxanthin are carotenoids of increasing interest due to their biological activities in animals and *in vitro* studies. Neoxanthin acts as an inhibitor of chemically-induced carcinogenesis and is involved in reducing the viability of prostate cancer cells (Asai et al., 2004; Maiani et al., 2009). Although their presence in green vegetables has been known for a long time, they are seldom included in food composition databases (with some exceptions, such as the Brazilian

food composition database, which includes violaxanthin) (Rodríguez-Amaya et al., 2008).

Data from the Brazilian National Survey on Demography and Health of Children and Women (2006) pointed out that 17.4% of children under five years of age have vitamin A deficiency, and the highest prevalence rates were found in the Southeast (21.6 %) and Northeast (19%) regions of Brazil (Brazil, 2009). In addition, the World Health Organization (WHO) reports that worldwide vitamin A deficiency affects approximately 19 million of pregnant women and 190 million preschool age children, mostly in regions of Africa and Southeast Asia (WHO, 2009).

Considering the importance of fruits and vegetables, as major sources of carotenoids and of provitamin A intake among populations and their relationship to the risk for developing chronic diseases (Van den Berg et al., 2000; WHO/FAO, 2003a; Maiani 2009; Sluijs et al., 2015; Wang et al., 2014), the aim of this study was to identify the main dietary sources of carotenoids from fruit and vegetables and, to determine the intake of the major dietary carotenoids by the Brazilian population.

2. Material and methods

2.1. Carotenoid composition in fruits and vegetables

The carotenoid concentration (β -carotene, α -carotene, β -cryptoxanthin, lycopene, lutein, zeaxanthin, neoxanthin and violaxanthin) of raw fruits and vegetables was obtained from the literature. Of the available literature, the priority was the usage of data from foods collected and analyzed in Brazil, by means of high-performance liquid chromatography and diode-array detection (HPLC-DAD); only data for cabbage and

chard were obtained by open column chromatography. Reversed-phase chromatography with either C₁₈ or C₃₀ columns was used in all the studies, except that of Mercadante & Rodriguez-Amaya (1998). In the few cases in which the carotenoid composition was not available for a food harvested in Brazil, the data were obtained from HPLC analyses from Spain: cucumber, chayote, potato, squash, onion, cauliflower, (Granado et al., 1992) and, tangerine, lime and, pear [Olmedilla et al., 1993]), or Italy (grape, [Crupi et al., 2010]) and, from a European database (beet and eggplant [O'Neill et al., 2001]). In order to harmonize the carotenoid concentrations reported in different papers, we used the mean value, even when the range was given.

In all the studies, exhaustive extraction was carried out either by maceration or stirring, with different sample weights, solvent volume, numbers of extractions and extraction times in order to attain a colorless food residue. The solvent most frequently used for extraction was by far acetone (Almeida-Muradian et al., 1995; Assunção & Mercadante, 2003; Barreto et al., 2011; De Azevedo-Meleiro & Rodriguez-Amaya, 2005a, 2007, 2009; De Costa et al. 2003; De Rosso & Mercadante, 2005, 2007; De Sá & Rodriguez-Amaya, 2003; Facundo et al., 2015; Gama & Sylos, 2005; Kimura et al., 2007; Mercadante & Rodriguez-Amaya, 1998; Niizu et al., 2003, 2005; Ribeiro et al., 2010; Sentamin et al., 2007; Silva & Mercadante, 2002); tetrahydrofuran (Granado et al., 1992) and hexane/diethyl ether (1:1) (Crupi et al., 2010) were also used. Saponification was employed in only a few studies (De Azevedo-Meleiro & Rodriguez-Amaya, 2005a; Crupi et al., 2010; Facundo et al., 2015; Kimura et al., 2007; Niizu & Rodriguez-Amaya, 2003, 2005).

Diode array detection was used for quantification in all the papers and carotenoid contents were determined by external calibration curves of the main carotenoids found in the samples, but an internal standard was used in one study

(Mercadante & Rodriguez-Amaya (1998). Moreover, *cis*-isomers were estimated using the curve of the corresponding all-*trans*-carotenoid.

2.2. Data source and dietary data collection

The general data were obtained from the 2008-2009 Household Budget Survey (HBS) conducted by the Brazilian Institute of Geography and Statistics (IBGE , 2011) on a probabilistic sample of 55,950 households. The individual dietary intake was obtained from the Food Consumption Module (FCM) of the HBS, recorded on two non-consecutive days in 13,569 households during one week for all residents over the age of 10 years, considering both food and beverage ingested in and outside the home. The sampling was representative of all Brazilian regions, taking into account capitals of all states, urban and rural areas. The average food intake, energy and nutrients were analyzed for the total population, according to gender, age group, geographic region, household location (urban or rural) and socioeconomic levels (IBGE, 2011).

The FCM-HBS shows 1,971 different food items that were grouped according to their similarities (IBGE, 2010). The group of fruits and vegetables was employed to calculate the carotenoid intake, and includes 19 fruits and 24 vegetables, for some of which individual intake data are available (10 fruits and 11 vegetables), and information on mixed dishes (fruit salad, raw salads and other salads). The food composition and proportions of each of the latter items were based on Fisberg & Vilar (2002) as follows:

1) **Fruit salad** (mixture of apple [20%], banana [20%], papaya [20%], orange [20%] and pineapple [20%]); 2) **Raw salad** (mixture of lettuce (25%), rucola (arugula) [25%], watercress [10%]; tomato [25%], onion [10%] and carrot [5%]); 3) **Other widely consumed fruits**: strawberry (20%), melon (15%), peach (15%), pear (10%), cashew-

apple (10%), passion fruit (10%), guava (10%), acerola (5%) and lemon (5%); 4) **Other**
salads: broccoli (20%), cauliflower (20%), rucola (arugula) (20%), spinach (10%), beet
(10%), chard (10%) and escarole (10%); and 5) **Other vegetables:** onion (20%),
zucchini (20%), beet (15%), eggplant (15%), broccoli (10%), cauliflower (10%) and red
pepper (10%). In addition, items mentioned by less than 1% of the subjects were
grouped either as other fruits (n=9) or other vegetables (n=4).

2.3. Calculations

In this study, the data from the FCM-HBS on the mean consumption of foods by the
Brazilian population (BP), defined as individuals of both sexes over the age of 10
years, were used for calculations.

The individual carotenoid contents (β -carotene, α -carotene, β -cryptoxanthin, lycopene,
lutein, zeaxanthin, neoxanthin and violaxanthin) of each food item were multiplied by
the amount of food consumed (g of food per person per day), giving an estimate of the
carotenoid intake from each specific food. The carotenoid intakes from these foods were
added up to yield individual and total carotenoid intakes, as well as their relative
contribution.

The contribution of each food to the vitamin A intake ($\mu\text{g/day}$) was calculated according
to WHO/FAO (2002) as retinol equivalent (RE) = (β -carotene/6) + (α -carotene/12) +
(β -cryptoxanthin/12).

3. Results

The concentrations of the main dietary carotenoids in the fruits (n=19) and vegetables

(n=24) most frequently consumed by the Brazilian population are shown in table 1.

Moreover, information on the part of the plant consumed and the scientific name, along with the name in Portuguese and in English, is provided.

β -Carotene was present in most of the fruits and vegetables, at higher concentrations in vegetables (pumpkin, carrot, spinach and kale contain more than 4 mg β -carotene /100 g) than in fruits (the highest content, 0.9 mg/100 g, was found in mango). Pumpkin and carrots were also the best sources of α -carotene (> 2.5 mg/100 g). β -Cryptoxanthin was found in fruits, mainly in tangerine and peach (0.8 and 0.6 mg/100 g, respectively). Major sources of lycopene were red guava (6.2 mg/100 g), watermelon and tomato (3.6 mg/100 g in both). The best sources of lutein were green leafy vegetables, such as spinach, watercress and kale (more than 5 mg lutein/100 g). Zeaxanthin was found in very few foods, being supplied mainly by orange and potato (2.4 and 0.02 mg/100 g, respectively).

Neoxanthin and violaxanthin were found mainly in green leafy vegetables, e.g. rucola (arugula), watercress and kale, which had levels of these two pigments of over 1.2 and 2.6 mg /100 g, respectively) and in mango (0.3 and 3 mg/100 g, respectively). However, it is important to note that these xanthophylls were not analyzed in several of the items reported in table 1 partly because for a long time lutein and zeaxanthin could not be separated by HPLC. Among the mixed dishes, those containing leafy vegetables, are rich sources of lutein (3 mg /100 g) and β -carotene (2 mg /100 g).

Table 2 shows the food intake (g/person/day) and the daily intake of the provitamin A carotenoids (α -carotene, β -carotene and β -cryptoxanthin), expressed in μ g/person/day,

as well as their contribution to the vitamin A intake expressed as RE/person/day. The data are provided for the BP and for the population grouped according to gender.

All the food items supplied β -carotene to the dietary intake of the BP, the highest contributions being those of kale and pumpkin (0.16 and 0.14 mg /p/d, respectively), whereas the contribution of the group of fruits (e.g. from mango) was relatively low . However, α -carotene was provided by a limited number of foods (pumpkin, at 0.06 mg /p/d, was the main contributor). β -Cryptoxanthin was found only in fruits. 87.4 % of the daily intake was supplied by orange, tangerine and papaya (0.05, 0.04 and 0.02 mg /p/d, respectively), or 96.5% when the contribution of the group of other fruits was included. Fruit salad also made a relevant contribution to the β -cryptoxanthin intake, as did raw salads to the β -carotene and α -carotene intakes. There were no gender-related differences in intake profiles.

The provitamin A carotenoids that contributed the most to vitamin A were β -carotene (86.4%) and, to a lesser extent, α -carotene (7.7%) and β -cryptoxanthin (5.9%). Vegetables contributed more than fruits to the vitamin A intake supplied by provitamin A carotenoids (70.3% vs 21.5% RE), with raw salads (which included tomato, onion and carrot), pumpkin, kale and carrot being the main contributors. The fruits that provided the greatest amounts were orange, mango and banana. Raw salads contributed the most to the RE from fruit and vegetables in both women (7%) and men (4.7%) in the BP.

Table 3 summarizes the daily intakes of the non-provitamin A carotenoids (lycopene, lutein, zeaxanthin, neoxanthin and violaxanthin) and, the food intake (g/person/day) in

the BP, overall and grouped according to gender. Lutein was widely distributed among fruits and vegetables, the major contributors to its intake being raw salads (because of the inclusion of rucola (arugula) and watercress), kale, orange and the subgroup of other salads (0.3, 0.2, 0.06, 0.05 mg /p/day, respectively). Two vegetables (kale and curly lettuce) and raw salad and other salads represented 80% of the lutein intake. Three fruits (orange, banana and açai) along with fruit salad, provided 9.2% of the lutein intake. However, zeaxanthin intake depended on fewer items, mainly oranges (86.1%), mango, fruit salad and potato.

Lycopene was also supplied by very few fruits (papaya and watermelon) and vegetables (tomato). Papaya, watermelon and fruit salad supplied 44% of the intake of lycopene and another 55% came from the group of vegetables, namely tomato and raw salads . The lycopene intake from papaya, usually eaten at breakfast in Brazil, is quite higher in women than in men (0.1 vs 0.07 mg/p/d).

The violaxanthin intake is higher than that of neoxanthin, and is mainly supplied by raw salads (0.2 and 0.1 mg/p/d, respectively), kale (0.1 and 0.05 mg 45 µg/p/d, respectively) and mango 0.2 and 0.02 /p/d, respectively).

4. Discussion

We present data on the intake, among the BP, of individual carotenoids from fruits and vegetables, which are the groups that contribute the most to carotenoid intake in the overall population. We should point out that, to avoid biases due to the analytical methodology, which can lead to important under or overestimations of the carotenoid intakes and RE (Granado et al., 1996), in the present study, we only use data on the

carotenoid contents in Brazilian foods analyzed by HPLC. Since other food-related factors that can also influence carotenoid contents, such as variety, ripeness, preparation of foods, etc. (Maiani et al., 2009) should be taken into account on comparing data, we supply information on the scientific name and the part of the plant analyzed in raw form.

The HBS employed in the present study was used recently to estimate daily intake of carotenoids (β -carotene, α -carotene, β -cryptoxanthin, lycopene, lutein+zeaxanthin) by the *Bolsa Familia* beneficiary population (more exposed to food and nutrition insecurity) (Sartori & Silva, 2014) since this is a direct cash transfer program targeting families living in poverty and extreme poverty throughout the country. On comparing our data (2.7 mg /p/d of those six carotenoids mentioned above) with those obtained for foods in category 1 of the study by Sartori & Silva (fresh or subjected to minimal processing) (2.2 mg /p/d total carotenoids), the differences in the individual fruit and vegetables (or in the proportions in the case of mixed dishes) assessed in the two studies may be an important factor in the difference of 20% between their findings and ours in terms of total carotenoid intake. In fact, this discrepancy is mainly due to the disparity in the results found for α -carotene (0.2 vs 0.05 mg /p/d) and β -cryptoxanthin (0.1 vs 0.06 mg /p/d), since the values reported for β -carotene (0.92 vs 0.93 mg /p/d) were similar. The lycopene intakes were comparable (0.66 vs 0.58 mg/p/d), but we found higher lutein + zeaxanthin intakes (0.8 vs 0.6). In both studies, the carotenoid contents in foods harvested in Brazil were prioritized. In our study, we only assessed the contribution of fruits and vegetables to the intake of carotenoids, but Saroti & Silva also took into account other raw foods such as herbs, honey, meat, fish, eggs, milk, etc.; thus, a higher rather than lower intake would be expected. Other factors that could explain the

disparities, particularly those found in lutein+zeaxanthin, α -carotene and β -cryptoxanthin, are differences in the methods used to analyze the carotenoids. For example, nearly all the data included in this study was generated by HPLC, while Sartori & Silva also used data obtained by column chromatography.

Although fruits and vegetables from the native biodiversity are regionally consumed in Brazil, the HBS is restricted to commonly consumed foods, and they are often poorer in carotenoids than some native foods (De Rosso & Mercadante, 2007; Silva, Rodrigues, Mercadante, De Rosso, 2014). Thus, the estimate of the carotenoid consumption may be imprecise due to regional eating habits.

The data on individual carotenoid intake from fruits and vegetables by the BP can be compared with that of the Spanish population, obtained from food consumption data recorded, during a similar period 2009-2010 (Beltrán-de-Miguel et al., 2015; Estévez-Santiago et al, 2016), since both studies only considered carotenoid contents generated by HPLC. Dietary intake of provitamin A carotenoids was higher in Spain than in Brazil (1.8 vs 1.2 mg/p/d) due to higher intakes of all the provitamin A carotenoids (β -carotene 1.3 vs 0.9 mg /p/d; α -carotene 0.3 vs 0.2 mg /p/d and β -cryptoxanthin 0.2 vs 0.1mg /p/d). The intakes of lutein +zeaxanthin were similar (0.84 in Spain vs 0.83 mg/p/d in Brazil) but that of lycopene was higher in Spain than in Brazil (3.0 vs 0.7 mg /p/d). There is also a marked difference in fruits and vegetables consumption, which is much higher in Spain (490 g/p/d) than in Brazil (150 g/p/d). This can be partially explained by the mode of dietary assessment (analysis of individual consumption vs household budget survey) and by the age range of the subjects (18-64 y in Spain vs over 10 y in Brazil).

The fruit and vegetable intake in Brazil is also much lower than that reported in the United States (US) population, 258 g fruit (1.09 cup-equivalent), and 334 g of vegetables (1.41 cup-equivalent) (NHANES, 2009-2010). In the US population (aged 2 years and over), the intake of every carotenoid was around twice that of the consumption reported in Brazil (β -carotene: 1.9 vs 0.9 mg /p/d; α -carotene 0.4 vs 0.2 mg /p/d; β -cryptoxanthin 0.2 vs 0.16 mg /p/d; lutein+zeaxanthin 1.4 vs 0.8 mg /p/d; lycopene 5.1 vs 0.7 mg /p/d). NHANES dietary intake was estimated in adults (over 20 y) by means of two 24-h recall registers, and the differences in the food carotenoid composition cannot justify the wide differences in carotenoid intake in the two populations. However, the difference in lycopene intake reported in the present study compared to the findings in Spain and the US is related to the food items considered, i.e. only raw fruits and vegetables (tomato, papaya, watermelon and raw salad an fruit salad) in Brazil, whereas the whole diet, including a large number of processed tomato products and manufactured foods that contain lycopene, in general, in higher amounts than those found in fresh foods (Clinton et al., 1998; Story et al., 2010) was considered for the lycopene intake assessment in Spain and in USA.

Based on the limited data available on neoxanthin and violaxanthin, their intakes in the BP are lower than those described in the population of Luxembourg, where those intakes are twice those of the present study (0.5 vs 0.2 and 1.2 vs 0.6 mg /p/d of neoxanthin and violaxanthin, respectively) (Biehler et al., 2012). To our knowledge, there are no recommendations for the intake of neoxanthin and violaxanthin. Regarding lutein and zeaxanthin, available evidence, mainly based on their biological activities and on epidemiological and intervention studies, suggests that their intake be increased to

reduce risk of certain chronic diseases (Granado *et al.*, 2003) by promoting the consumption of green-colored foods (USDA, 2011) or lutein supplements (i.e. 7 - 10 mg/d) (Olmedilla *et al.*, 2003; AREDS2 Research Group, 2013), to reach levels much higher than current the lutein and zeaxanthin intake in the BP. In the case of lycopene, although the evidences on the role of lycopene/ tomato intake in prostate cancer and cardiovascular diseases, more research is needed to illustrate its potential in preventing several chronic diseases (Chen *et al.*, 2013; Riccioni *et al.*, 2008).

The dietary intake of fruits and vegetables in this study (150 g/day: 86 g/day fruits and 64 g/day vegetables) does not meet the amount of fruits and vegetables recommended by the WHO/FAO (2003b) (400 g/day, excluding potatoes and starchy tubers). In the Brazilian diet, the provitamin A carotenoids supplied by vegetables and fruits represent 22.1% of the recommended vitamin A intake (IOM, 2001), expressed in RE (26.4% women, 18.9% men) or 11.1% if expressed in retinol activity equivalents. This can be considered a low contribution of fruits and vegetable to the vitamin A compared with the 37.3% reported in Spain (Beltrán-de-Miguel *et al.*, 2015) and with the 44.8% of the vitamin A intake supplied by the total provitamin A carotenoid intake in the US population (362.1 µg RE supplied by provitamin A carotenoids), calculated from the NHANES 2009-2010 data. In Brazil, the contribution of vegetables (70.3%) to the vitamin A intake is higher than that of fruits (21.5%) as has also been reported in Spain (32.9% and 4.4 %, respectively) (Beltrán-de-Miguel *et al.*, 2015).

5. Conclusions

According to the data obtained from the Household Budget Survey (2008-2009), the mean dietary intake of fruits and vegetables (150 g /d: 86 g/d fruit and 64 g/d

vegetables) is very low in Brazil and does not meet the intakes recommended by the WHO/FAO. However, it could be underestimated as the HBS considers only the commonly consumed foods and not those fruits and vegetables from the native biodiversity that are regionally consumed in Brazil. Thus, the estimation of carotenoid consumption may be imprecise due to regional eating habits.

The identification of the major common sources of the dietary carotenoids and their intakes in the Brazilian population can be useful for decisions makings related to the public health setting, regarding both nutritional aspects and prevention of chronic diseases.

Conflict of interest

The authors have no conflict of interest.

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Highlights

- Individual intake of major dietary carotenoids was assessed in Brazilian population
- Vegetables are higher contributors than fruits to the vitamin A intake (70 vs 22% RE)
- The non-provitamin vs provitamin-A carotenoids intake is nearly twice in Brazilians

588 **Table 1.** Carotenoid content (µg/100 g fresh weight) of fruits and vegetables most frequently consumed in Brazil.

English name	Portuguese name	Scientific name	Part used	α-carotene	β-carotene	β-cryptoxanthin	Lycopene	Lutein	Zeaxanthin	Neoxanthin	Violaxanthin	Reference
Fruits												
Açaí	Açaí	<i>Euterpe oleracea</i> Mart	fruit	45	240*	n.d.	n.d.	150	n.d.	n.d.	n.d.	Ribeiro <i>et al.</i> , 2010
Apple	Maçã	<i>Malus domestica</i> Borkh.cv. Gala	fruit	n.d.	65	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	West <i>et al.</i> , 1993
Banana	Banana	<i>Musa</i> sp cv. Prata and cv. Nanico	fruit	141*	107*	n.d.	n.d.	50	n.d.	n.d.	n.d.	Facundo <i>et al.</i> , 2015
Grape	Uva	<i>Vitis vinifera</i> L cv. Merlot	fruit	n.d.	201*	n.d.	n.d.	85*	10	10	11	Crupi <i>et al.</i> , 2010
Mango	Manga	<i>Mangifera indica</i> cv. Keitt and cv. Tommy Atkins	fruit	n.d.	920	27	n.d.	n.d.	67	343	3157*	Mercadante <i>et al.</i> , 1998
Orange	Laranja	<i>Citrus sinensis</i> Osbeck cv. Valencia	fresh juice	87	90	248	n.d.	278	238	n.d.	136	Gama <i>et al.</i> , 2005
Papaya	Mamão	<i>Carica papaya</i> L. cv. Golden	fruit	n.d.	49	331	1448*	6	0	0	9*	Barreto <i>et al.</i> , 2011
Pineapple	Abacaxi	<i>Ananas comosus</i> L.	fruit	n.d.	30	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	West <i>et al.</i> , 1993
Tangerine	Tangerina	<i>Citrus reticulata</i> Blanco	fruit	0	213	843	0	0	0	n.d.	n.d.	Olmedilla <i>et al.</i> , 1993
Watermelon	Melancia	<i>Citrullus lanatus</i> (Thunb.) Matsum & Nakai	fruit	n.d.	365	n.d.	3550	n.d.	n.d.	n.d.	n.d.	Niizu <i>et al.</i> , 2003
Fruit salad ^a	Salada de frutas			54	73	141	290	95	71	n.d.	43	
Other fruits ^b	Outras frutas ^b			4	171	149	615	5	0.3	0.3	3	
Acerola, West Indian cherry	Acerola	<i>Malpighia puniceifolia</i> L. cv. <i>Waldy Cati</i> 30 and cv. <i>Olivier</i>	fruit with skin, without seed	26	856	36	n.d.	64	2	5	1	De Rosso <i>et al.</i> , 2005

Cashew apple	Caju	<i>Anacardium occidentale</i> L. var. red and var. yellow	pseudofruit with skin	29	58*	45*	n.d.	8	1	n.d.	5	Assunção <i>et al.</i> , 2003
Guava, red	Goiaba (vermelha)	<i>Psidium guajava</i> L. var. Ogawa ans var. Paluma	fruit	n.d.	330	n.d.	6150	n.d.	n.d.	n.d.	n.d.	Rodriguez-Amaya <i>et al.</i> , 2008
Lime	Limão	<i>Citrus aurantifolia</i> (Christm.) Swingle	fruit	n.d.	0	14	0	2	1	n.d.	n.d.	Olmedilla <i>et al.</i> , 1993
Melon	Melão	<i>Cucumis melo</i> L. var. Amarelo	fruit	n.d.	10	n.d.	n.d.	traces	n.d.	n.d.	traces	Casagrande <i>et al.</i> , 2006
Peach	Pêssego	<i>Prunus persica</i> L. var. Diamante	fruit	n.d.	40	640*	n.d.	n.d.	n.d.	n.d.	12	Sentamin <i>et al.</i> , 2007
Pear	Pera	<i>Pyrus communis</i> L.	fruit without skin and seeds	0	2	3	4	11	0	n.d.	n.d.	Olmedilla <i>et al.</i> , 1993
Passion fruit	Maracujá	<i>Passiflora edulis</i> f. <i>flavicarpa</i> O. Deg.	pulp with seeds	n.d.	763*	136	n.d.	n.d.	n.d.	n.d.	n.d.	Silva <i>et al.</i> , 2002
Strawberry	Morango	<i>Fragaria elatior</i> , (Thuill) Ehrh.	fruit	n.d.	21	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Souza <i>et al.</i> , 2004
Vegetables												
Cabbage	Repolho	<i>Brassica oleracea</i> L. var. capitata L.	leaf	n.d.	38	n.d.	n.d.	18	n.d.	n.d.	n.d.	Almeida-Muradian <i>et al.</i> , 1995
Chayote	Chuchu	<i>Sechium edule</i> (Jacq.) Sw.	fruit	0	11	0	0	16	0	n.d.	n.d.	Granado <i>et al.</i> , 1992
Carrot	Cenoura	<i>Daucus carota</i> L. cv. Nantes	tuber	3500	6150	n.d.	n.d.	510	n.d.	n.d.	n.d.	Niizu <i>et al.</i> , 2005
Cassava	Mandioca	<i>Manihot esculenta</i> Crantz var. IAC 576-70	root	n.d.	269*	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Kimura <i>et al.</i> , 2007
Cucumber	Pepino	<i>Cucumis sativus</i> L.	fruit	0	11	0	0	16	n.d.	n.d.	n.d.	Granado <i>et al.</i> , 1992

Curly lettuce	Alface crespa	<i>Lactuca sativa</i> L.	leaf	n.d.	1550	n.d.	n.d.	1430	n.d.	760	1870	Niizu <i>et al.</i> , 2005
Kale	Couve	<i>Brassica oleracea</i> L. cv. Manteiga	leaf	n.d.	4120	n.d.	n.d.	5252	n.d.	1178	3010	De Azevedo <i>et al.</i> , 2005a
Potato	Batata	<i>Solanum tuberosum</i> L.	tuber	0	1.5	0	0	44	21	n.d.	n.d.	Granado <i>et al.</i> , 1992
Pumpkin	Abóbora or jerimum	<i>Cucurbita moschata</i> Duchesne cv. Menina Brasileira and cv. Goianinha	pulp without skin and seeds	2530	6170	n.d.	n.d.	1785	n.d.	705	tr	De Azevedo-Meleiro <i>et al.</i> , 2007
Sweet potato	Batata-doce	<i>Ipomoea batatas</i> L. Lam. var. IAC 60-M-3-Brasília	tuber	n.d.	1150*	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	Kimura <i>et al.</i> , 2007
Tomato	Tomate	<i>Lycopersicon esculentum</i> Mill. cv. Carmen	fruit	n.d.	320	n.d.	3540	100	n.d.	n.d.	n.d.	Niizu <i>et al.</i> , 2005
Raw salads ^c				175	1757	n.d.	885	2219	traces	820	1471	
Onion	Cebola	<i>Allium cepa</i> L.	bulb	0	1	0	0	2	traces	n.d.	n.d.	Granado <i>et al.</i> , 1992
Rucola (arugula)	Rúcula	<i>Eruca sativa</i> Mill.	leaf	n.d.	2840	n.d.	n.d.	5000	n.d.	1810	2970	Niizu <i>et al.</i> , 2005
Watercress	Agrião	<i>Nasturtium officinale</i> R.Br.	leaf	n.d.	2720	n.d.	n.d.	5610	n.d.	1770	2610	Niizu <i>et al.</i> , 2005
Other salads ^d				4	1939	n.d.	n.d.	2942	n.d.	828	1188	
Beet	Beterraba	<i>Beta vulgaris</i> L.	root	n.d.	0	n.d.	0	n.d.	n.d.	n.d.	n.d.	O'Neill <i>et al.</i> , 2001

Broccoli	Brócolis	<i>Brassica oleracea</i> L. <i>var. italica</i> Plenck	boiled flower heads	n.d.	1893	n.d.	n.d.	3510	n.d.	747	530	De Sá <i>et al.</i> , 2003
Cauliflower	Couve-flor	<i>Brassica oleracea</i> L. <i>var. Botrytis f.</i> <i>cauliflora</i> Duch.	buds + stalk	0	2	0	0	4	0	n.d.	n.d.	Granado <i>et al.</i> , 1992
Chard	Acelga	<i>Beta vulgaris</i> L. <i>var. cicla</i>	leaf+stalk (white)	35	2700	n.d.	n.d.	2700	n.d.	n.d.	92	de Costa <i>et al.</i> , 2003
Escarole	Escarola	<i>Cichorium endivia</i> L. Valdena	leaf	n.d.	2795	n.d.	n.d.	3895	n.d.	1425	2065	De Azevedo-Meleiro <i>et al.</i> , 2005b
Spinach	Espinafre	<i>Spinacia oleracea</i> L.	leaf	n.d.	4423	n.d.	n.d.	5793	n.d.	1743	2725	De Azevedo-Meleiro <i>et al.</i> , 2005b
Other vegetables ^e	Outras verduras			n.d.	268	1.2	n.d.	596	traces	75	80	
Eggplant or aubergine	Berinjela	<i>Solanum melongena</i> L.	fruit	n.d.	50	n.d.	n.d.	900°	n.d.	n.d.	n.d.	O'Neill <i>et al.</i> , 2001
Green beans or French beans	vagem	<i>Phaseolus vulgaris</i> L.	boiled	n.d.	163	n.d.	n.d.	250	n.d.	traces	traces	De Sá <i>et al.</i> , 2003
red bell pepper	pimentão vermelho	<i>Capsicum annuum</i> L. <i>Hybrid FI Magali</i>	fruit with skin, without seeds	n.d.	580	n.d.	n.d.	750	n.d.	n.d.	270	De Azevedo-Meleiro <i>et al.</i> , 2009
squash / zucchini	abobrinha	<i>Cucurbita pepo</i> L. <i>var. Medullosa, Alef.</i>	fruit	n.d.	21	6	n.d.	108	n.d.	n.d.	n.d.	Granado <i>et al.</i> , 1992

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591 * sum of all-*trans* + *cis* isomers

592 n.d.: not analyzed

593 0: not reported^a, ^b, ^c, ^d, ^e: calculated according the percentages in mixed dishes

594 ^a fruit salad (apple, 15%; banana, 20%; papaya, 20%; orange cv. Pera, 30%; pineapple, 15 %); ^b other fruits (strawberry, 15%; melon, 15 %; peach, 20%; pear,
595 10 %; cashew apple, 10 %; passion fruit, 10 %; acerola or West Indian cherry, 5%; lime, 5 %; guava red, 10 %); ^c Raw salads (curly lettuce, 25 %; rucula or
596 arugula, 25 %; watercress, 10 %; tomato, 25 %; onion, 10 %; carrot, 5 %); ^d other salads (broccoli, 20 %; cauliflower, 20 %; spinach, 10 %; rucula or arugula,
597 20 %; beet, 10 %; chard, 10 %; escarole, 10 %); ^e other vegetables (onion, 20 %; beet, 15 %; eggplant or aubergine, 15 %; red bell pepper, 10 %; squash /
598 zucchini, 20 %; broccoli, 10 %; cauliflower, 5 %; green beans or French beans, 5 %)

599 **Table 2.** Provitamin A carotenoid daily intake (µg/person) of Brazilian fruits and vegetables.

Fruit / vegetable	Food intake (g food/p/day)			α -carotene			β -carotene			β -cryptoxanthin			RE		
	BP	Women	Men	BP	Women	Men	BP	Women	Men	BP	Women	Men	BP	Women	Men
Fruits															
Açaí	3.0	2.4	3.5	1.4	1.1	1.6	7.2	5.8	8.4				1.3	1.1	1.5
Apple	11.6	13.5	9.5				7.5	8.8	6.2				1.3	1.5	1.0
Banana	18.6	18.8	18.3	26.2	26.5	25.8	19.9	20.1	19.6				5.5	5.6	5.4
Fruit salad	2.2	2.4	2.0	1.2	1.3	1.1	1.5	1.6	1.4	3.1	3.4	2.8	0.6	0.7	0.6
Grape	1.2	1.1	1.3				2.4	2.2	2.6				0.4	0.4	0.4
Mango	4.7	4.5	4.9				43.2	41.4	45.1	1.3	1.2	1.3	7.3	7.0	7.6
Orange	20.6	20.7	20.4	17.9	18.0	17.7	18.5	18.6	18.4	51.1	51.3	50.6	8.8	8.9	8.8
Other fruits	7.7	8.6	6.7	0.3	0.4	0.3	12.9	14.4	11.2	11.5	12.8	10.0	3.1	3.5	2.7
Papaya	6.4	7.9	4.7				3.1	3.9	2.3	21.2	26.1	15.6	2.3	2.8	1.7
Pineapple	1.4	1.6	1.1				0.42	0.5	0.3				0.1	0.1	0.1
Tangerine	4.5	4.8	4.2				9.6	10.2	8.9	37.9	40.5	35.4	4.8	5.1	4.4
Watermelon	4.2	4.8	3.6				15.3	17.5	13.1				2.6	2.9	2.2
<i>Subtotal</i>	86.1	91.1	80.2	47.0	47.3	46.5	141.5	145.0	137.5	126.1	135.3	115.7	38.1	39.4	36.4
Vegetables															
Cabbage	1.0	1.0	0.9				0.4	0.4	0.3				0.1	0.1	0.1
Chayote	0.8	0.8	0.7				0.1	0.1	0.1				0.0	0.0	0.0
Carrot	0.9	1.1	0.8	31.5	38.5	28.0	55.4	67.7	49.2				11.9	14.5	10.5
Cassava	6.1	5.4	6.9				16.4	14.5	18.6				2.7	2.4	3.1
Cucumber	0.6	0.5	0.7				0.1	0.1	0.1				0.0	0.0	0.0
Curly lettuce	3.6	3.9	3.3				55.8	60.5	51.2				9.3	10.1	8.5

Kale	3.8	4.1	3.6				156.6	168.9	148.3				26.1	28.2	24.7
Other salads	1.4	1.6	1.3	0.0	0.1	0.0	27.1	31.0	25.2	0.0	0.0	0.0	4.5	5.2	4.2
Other vegetables	4.6	4.4	4.8	0.0	0.0	0.0	12.3	11.8	12.8	0.1	0.1	0.1	2.1	2.0	2.1
Potato	14.7	14.0	15.4				0.2	0.2	0.2						
Pumpkin	2.3	2.2	2.4	58.2	55.7	60.7	141.9	135.7	148.1				28.5	27.3	29.7
Raw salads	14.8	15.8	13.7	25.9	27.7	24.0	260.1	277.6	240.7				45.5	48.6	42.1
Sweet potato	2.5	2.3	2.6				28.8	26.5	29.9				4.8	4.4	5.0
Tomato	6.5	5.8	7.3				20.8	18.6	23.4				3.5	3.1	3.9
<i>Subtotal</i>	63.6	62.9	64.4	115.6	83.3	84.7	776	730.8	679.9	0.1	0.1	0.1	139	128.7	120.3
TOTAL	149.7			162.6			917.5			126.2			177.1	185.1	170.5

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601 BP: Brazilian population; RE: Retinol equivalents

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610 **Table 3.** Non-provitamin A carotenoid daily intake ($\mu\text{g}/\text{person}$) of Brazilian fruits and vegetables.

Fruit / vegetable	Food intake (g/p/d)			Lycopene			Lutein			Zeaxanthin			Neoxanthin			Violaxanthin		
	BP	Women	Men	BP	Women	Men	BP	Women	Men	BP	Women	Men	BP	Women	Men	BP	Women	Men
Fruits																		
Açaí	3.0	2.4	3.5				4.5	3.6	5.3									
Apple	11.6	13.5	9.5															
Banana	18.6	18.8	18.3				9.3	9.4	9.2									
Fruit salad	2.2	2.4	2.0	6.4	7.0	5.8	2.1	2.3	1.9	1.6	1.7	1.4				0.9	1.0	0.9
Grape	1.2	1.1	1.3				1.0	0.9	1.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Mango	4.7	4.5	4.9							3.1	3.0	3.3	16.1	15.4	16.8	148.4	142.1	154.7
Orange	20.6	20.7	20.4				57.3	57.5	56.7	49.0	49.3	48.6				28.0	28.2	27.7
Other fruits	7.7	8.6	6.7	47.4	52.9	41.2	0.4	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.2
Papaya	6.4	7.9	4.7	92.7	114.4	68.1	0.4	0.5	0.3							0.6	0.7	0.4
Pineapple	1.4	1.6	1.1															
Tangerine	4.5	4.8	4.2															
Watermelon	4.2	4.8	3.6	149.1	170.4	127.8												
<i>Subtotal</i>	86.1	91.1	80.2	295.6	344.6	242.9	75.0	74.7	74.7	53.8	54.1	53.4	16.2	15.6	17.0	178.2	172.3	184.1
Vegetables																		
Cabbage	1.0	1.0	0.9				0.2	0.2	0.2									
Chayote	0.8	0.8	0.7				0.1	0.1	0.1									
Carrot	0.9	1.1	0.8				4.6	5.6	4.1									
Cassava	6.1	5.4	6.9															
Cucumber	0.6	0.5	0.7				0.1	0.1	0.1									
Curly lettuce	3.6	3.9	3.3				51.5	55.8	47.2				27.4	29.6	25.1	67.3	72.9	61.7

Kale	3.8	4.1	3.6				199.6	215.3	189.1				44.8	48.3	42.4	114.4	123.4	108.4
Other salads	1.4	1.6	1.3	0.0	0.0	0.0	41.2	47.1	38.2	0.0	0.0	0.0	11.6	13.3	10.8	16.6	19.0	15.4
Other vegetables	4.6	4.4	4.8	0.0	0.0	0.0	21.2	20.3	22.1	0.0	0.0	0.0	3.4	3.3	3.6	3.7	3.5	3.8
Potato	14.7	14.0	15.4				6.5	6.2	6.8	3.1	2.9	3.2						
Pumpkin	2.3	2.2	2.4				41.1	39.3	42.8				16.2	15.5	16.9			
Raw salads	14.8	15.8	13.7	131.0	139.8	121.2	328.4	350.6	304.0	0.0	0.0	0.0	121.3	129.5	112.3	217.7	232.4	201.5
Sweet potato	2.5	2.3	2.6															
Tomato	6.5	5.8	7.3	230.1	205.3	258.4	6.5	5.8	7.3									
<i>Subtotal</i>	63.6			361.1	345.2	379.7	701	740.3	657.6	3.1	2.9	3.2	224.7	239.5	211.0	419.7	451.3	390.9
		62.9	64.4															
TOTAL	149.7			656.7			776			56.9			240.9			597.9		

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612 BP: Brazilian population

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