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Household availability and sources of carotenoids important to health in Brazilian urban centers by income in 2017/2018

Disponibilidade domiciliar e fontes de carotenoides importantes na saúde nos centros urbanos brasileiros segundo a renda em 2017/2018

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ABSTRACT

Objective

Low carotenoid intake is associated with the incidence of chronic noncommunicable diseases. Given the large diversity and specificity of chemical structures and functions, along with the wide Brazilian geodiversity, it should be important for health to examine the cross-sectional distribution of carotenoid availability. Considering family incomes, the authors have calculated and analyzed the individual household availability of α -carotene, β -carotene, β -cryptoxanthin, lycopene, and lutein/zeaxanthin according to income in the eleven largest Brazilian urban centers in 2017-2018.

Methods

Data from the Brazilian Institute of Geography and Statistics' latest Family Budget Survey on monetary food acquisitions and food composition tables were used to calculate the individual carotenoid contents of both vegetable and animal food sources.

Results

The family acquisitions of carotenogenic foods showed to be insufficient for most families living in these urban centers, except Salvador, Belem, Belo Horizonte, and Porto Alegre, where certain key-carotenoid sources did reach the higher income groups. The main foods identified that contributed to the supply of carotenoids were carrot and common squash (α -carotene), common squash, carrot, scallion/parsley, mango, and tomato (β -carotene), papaya, orange, and tangerine (β -cryptoxanthin), tomato sauce, tomato paste, guava, watermelon and papaya (lycopene) and scallion/parsley, kale, egg, corn meal and corn flakes (lutein/zeaxanthin).

Conclusion

Based on the home availability of specific carotenoids estimated in the present study, it is concluded that the population was not reasonably well protected against chronic diseases given the low acquisition of key carotenoid sources in these urban centers, especially among the lower-income class.

Keywords: Carotenoid availability. Family Budget-2017-2018 Survey. Food consumption.

RESUMO

Objetivo

A baixa ingestão de carotenoides está associada à incidência de doenças crônicas não transmissíveis. Dada a grande diversidade e especificidade das estruturas e funções químicas, juntamente com a ampla geodiversidade brasileira, é importante para a saúde examinar a distribuição transversal da disponibilidade de carotenoides. Considerando a renda familiar, os autores calcularam e analisaram a disponibilidade individual e domiciliar de α -caroteno, β -caroteno, β -criptoxantina, licopeno e luteína/zeaxantina de acordo com a renda nos onze maiores centros urbanos brasileiros em 2017-2018.

Métodos

Dados do Instituto Brasileiro de Geografia e Estatística da última Pesquisa de Orçamentos Familiares sobre aquisições monetárias de alimentos e tabelas de composição de alimentos foram utilizados para calcular os teores individuais de carotenoides de fontes alimentares vegetais e animais.

Resultados

As aquisições familiares de alimentos carotenogênicos mostraram-se insuficientes para a maioria das famílias residentes nesses centros urbanos, com exceção de Salvador, Belém, Belo Horizonte e Porto Alegre, onde algumas fontes de carotenoides-chave alcançaram os grupos de renda mais elevados. Os principais alimentos-fonte de carotenoides identificados foram cenoura e abóbora comum (α -caroteno), abóbora comum, cenoura, cebolinha/salsa, manga e tomate (β -caroteno), mamão, laranja e tangerina (β -criptoxantina), molho de tomate, pasta de tomate, goiaba, melancia e mamão (licopeno) e cebolinha/salsa, couve, ovo, fubá e flocos de milho (luteína/zeaxantina).

Conclusão

Com base na disponibilidade domiciliar de carotenoides específicos estimada no presente estudo, conclui-se que a população não estava razoavelmente bem protegida contra doenças crônicas dada a baixa aquisição de fontes de carotenoides-chave nesses centros urbanos, especialmente entre as classes de renda mais baixa.

Palavras-chave: Disponibilidade de carotenoides. Pesquisa de orçamentos familiares 2017-2018. Consumo alimentar.

INTRODUCTION

Chronic Noncommunicable Diseases (NCDs) are one of the major public health problems in Brazil and the world. They respond to large numbers of premature deaths, impact the quality of life of those affected, and have negative economic consequences on society and health systems [1,2]. Estimates from the World Health Organization (WHO) indicate that worldwide, NCDs were responsible for 74% of deaths in 2019 [3]. In Brazil, 54.7% of the deaths recorded (41.8% prematurely) were caused by chronic NCDs, while 11.5% were caused by other diseases [4,5].

Many chronic diseases are mediated by systemic inflammation, oxidative stress, and increased plasma concentrations of F2-isoprostane, malondialdehyde, and 8-hydroxyguanosine. In addition, an important biological function seems to be activating the body's antioxidant defense system through the expression of superoxide dismutase, catalase, and glutathione-peroxidase. These effects probably result from interactions with transcription factors such as the nuclear erythroid 2-related factor 2 (Nrf-2) [6].

However, due to their high content of antioxidant compounds [7], both clinical and epidemiological studies show an inverse association between fruit and vegetable intake and the incidence of chronic diseases such as type-2 diabetes and diabetes, cardiovascular diseases [8], cancer [9,10] and all causes of mortality [11].

Approximately one hundred carotenoids are found in foods. These molecules exhibit colors ranging from yellow to orange or red in fruits, vegetables, egg yolks, cooked crustaceans, and some fishes [12]. While fruits and vegetables are the major contributors of carotenoids to the human diet, α -carotene, β -carotene, β -cryptoxanthin, lycopene, lutein, and zeaxanthin are the most common food carotenoids [13]. Beta-carotene is the most widely distributed. Alpha-carotene, β -carotene, and β -cryptoxanthin are provitamin-A carotenoids because they can be converted to retinol by the body [10,13,14].

Higher tissue and plasma concentrations of carotenoids are associated with lower risks of some types of cancer [15-21], heart disease [22-24] and all causes of mortality [25,26]. These associations could be used as indicators for the establishment of carotenoid requirements. However, it cannot be said with certainty that such facts are due to the carotenoids per se or to other substances found in carotenoid-rich foods [13].

For this reason, the Institute of Medicine (IOM) [13] preferred to refer to “prudent intake levels” rather than the necessary intake levels. Federal agencies in the United States and other organizations have issued recommendations regarding the intake of fruits and vegetables. Thus, the Food Guidelines of the United States and the National Cancer Institute state that adherence to the proposed diet would be equivalent to consuming 5.2 to 6 mg/day of pro-vitamin A carotenoids derived from a varied diet, including fruits and vegetables [27].

Food guides in Canada recommend similar levels (Health Canada, 1997). Other food-based profiles recommend consuming approximately 9 to 18 mg/day of total carotenoids as a protective measure against cancer [28].

In turn, the IOM, in 2000, based on the study of several populations, advised the prudent intake of 3 to 6 mg/day of β -carotene from food sources to maintain plasma levels at intervals associated with a lower risk of various chronic diseases [13].

Donaldson [29], based on 62 noninterventional studies, proposed that a serum concentration of total carotenoids <1000nmol/L reflects a very high risk of developing chronic diseases, 1000-1500nmol/L a high risk, 1500-2500nmol/L a moderate risk, 2500-4000nmol/L a low risk and >4000nmol/L a very low risk.

Based on Donaldson’s suggestion, Bohm [30] added that an intake indicative of a varied and healthy diet should supply 11.8 mg/day of total carotenoids or 0.7 of α -carotene, 4.1 of β -carotene, 0.3 of β -cryptoxanthin, 4.6 of lycopene, and 2.2 mg/day of lutein/zeaxanthin.

Although the *Pesquisas de Orçamentos Familiares* (POF, Brazilian Family Budget Survey) food availability data do not represent actual consumption, the dietary pattern of the population and its evolution over time can be discerned [31].

Therefore, this study analyzed the POF data of 2017/18 from the perspective of home availability of the nutritionally relevant carotenoids, α -carotene, β -carotene, β -cryptoxanthin, lycopene, lutein, and zeaxanthin, in the nine Brazilian metropolitan regions, the Federal District of Brasilia, and Goiania. The study judiciously identified the foods that contributed most to the availability of these substances, according to the ten income strata.

METHODS

The food acquisition data from the 2017-2018 Family Budget Survey were provided by the *Instituto Brasileiro de Geografia e Estatística* (IBGE, Brazilian Institute of Geography and Statistics). The acquisitions by Brazilian families were spread monetary wise in: up to 2 Minimum Wages (MW), more than 2 to 3 MW, more than 3 to 5 MW, more than 5 to 6 MW, more than 6 to 8 MW, more than 8 to 10 MW, more than 10 to 15 MW, more than 15 to 20 MW, more than 20 to 30 MW and more than 30 MW. The metropolitan areas studied were Belem (North Region), Fortaleza, Recife, Salvador (Northeast region), Belo Horizonte, Rio de Janeiro, Sao Paulo (Southeast region), Curitiba, and Porto Alegre (South region), and the municipality of Goiania and Brasilia (DF) (Midwest region). They were indistinctly denominated "Urban Areas" (UAs) for simplicity. The 11 UAs used in this study were selected as the most populous, most widely distributed across the country, and most consistently surveyed cities since 1974. They comprise about 30% of the Brazilian population [32].

The collection instruments used in POF 2017-2018 were organized according to the type of information to be researched. There were seven instruments. The Collective Acquisition Booklet (POF 3) was used as the instrument to collect information on the foods and beverages purchased exclusively for household consumption by the family. A detailed description of each product purchased, the quantity, the unit of measurement (weight or volume), the value of the expenditure in reais, the place of purchase, and the form of product acquisition.

The data on carotenoids were primarily obtained from the Brazilian Table of Food Composition in Carotenoids [12] (26 items, 23.9%), the US Department of Agriculture (USDA) table (66 items, 60.5,1%) available in Food Data Central, US Department of Agriculture [33], and the Food Carotenoid of the School of Food Engineering (Unicamp) Laboratory (17 items, 15,6%) (unpublished data).

The Microsoft Excel program was used to process the availability data. To obtain the edible part of the food, information from Silva and Monnerat [34] and from the population survey of the Brazilian Institute of Geography and Statistics of 1977 [35] was used. The Department of Agriculture of the United States [33] was consulted for information not found in national databases. For food items termed as "other" (foods not identified by the IBGE), the mean nutrient contents of the foods identified by the IBGE belonging to the specific groups were consulted.

RESULTS AND DISCUSSION

The Availability of Carotenoids in Urban Centers

The household availability in the UAs of α -carotene ranged from 14 to 1,266 $\mu\text{g}/\text{day}$, whereas β -carotene varied from 225 to 3,724 $\mu\text{g}/\text{day}$ and β -cryptoxanthin from 15 to 791 $\mu\text{g}/\text{day}$. In addition, lycopene varied from 103 to 4,879 $\mu\text{g}/\text{day}$, and lutein/zeaxanthin from 205 to 3,007 $\mu\text{g}/\text{day}$ (Table 1).

In general, carotenoid availability increased according to income, although with sizable fluctuations. Levels of availability compatible with those of ingestion advocated by Bohm et al. [30] were attained in Salvador, Belem, Belo Horizonte, and Porto Alegre, where the upper-income strata preferred more expensive food items and richer sources of key carotenoids.

Thus, in Salvador, the availability of α -carotene in the stratum >20 to 30 MW was 821 $\mu\text{g}/\text{day}$ and 1,266 in the stratum >30 MW. The β -carotene was 3,724 $\mu\text{g}/\text{day}$ for stratum >20 to 30 MW and 3,457 for stratum >30 MW.

Table 1 – Per capita availability of the five main carotenoids ($\mu\text{g/day}$) in Urban Areas according to the income stratum in multiples of minimum wage.

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Income Stratum (MW)	Carotenoid ($\mu\text{g/day}$) and Urban Areas ^a										
	α -carotene										
	GO	DF	BP	FT	RF	SV	BH	RJ	SP	CR	PA
Up to 2	111	109	31	82	174	91	165	78	95	46	124
>2 to 3	264	180	35	73	149	306	134	118	107	145	118
>3 to 5	113	134	102	104	225	252	230	122	92	112	129
>5 to 6	216	139	134	100	205	379	276	212	172	213	169
>6 to 8	128	241	155	186	213	243	200	198	162	119	220
>8 to 10	180	228	222	271	272	644	270	234	215	179	263
>10 to 15	275	187	87	164	298	135	355	220	287	308	191
>15 to 20	472	322	497	224	352	605	230	338	122	103	141
>20 to 30	403	143	14	260	304	821	278	169	349	273	299
>30	350	183	589	33	389	1266	466	439	210	553	528
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	β -carotene										
Up to 2	472	439	225	379	550	414	525	323	398	290	499
>2 to 3	658	589	377	354	514	879	536	464	419	657	466
>3 to 5	454	472	505	581	685	776	774	481	514	610	556
>5 to 6	836	550	544	550	601	1090	806	786	729	728	535
>6 to 8	644	844	489	835	671	947	673	626	898	585	671
>8 to 10	823	517	1461	480	904	483	540	568	817	540	737
>10 to 15	1384	715	769	639	876	884	1245	854	1355	1437	764
>15 to 20	2201	1076	1174	836	1054	1645	1122	1439	799	715	746
>20 to 30	1403	830	429	1115	1125	3724	1194	697	1551	1008	1057
>30	930	748	3057	331	1116	3457	2219	1670	1005	1728	1850
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	β -cryptoxanthin										
Up to 2	98	43	15	34	47	23	23	38	43	63	60
>2 to 3	35	60	17	26	49	49	43	34	40	74	35
>3 to 5	76	65	31	49	72	42	62	52	64	67	87
>5 to 6	47	58	38	45	75	112	62	54	95	50	65
>6 to 8	125	75	17	92	83	120	95	52	151	74	72
>8 to 10	139	56	107	82	57	50	84	60	163	79	154
>10 to 15	232	74	190	98	102	119	111	55	135	203	161
>15 to 20	247	83	64	82	283	203	142	210	62	130	140
>20 to 30	89	146	23	126	135	791	173	119	263	119	119
>30	86	118	25	53	209	358	401	103	270	299	402
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	Lycopene										
Up to 2	526	568	103	300	701	575	494	400	651	805	653
>2 to 3	339	789	378	313	583	929	678	441	596	711	616
>3 to 5	892	544	388	685	938	890	889	636	953	1079	744
>5 to 6	906	728	362	501	796	1658	764	937	930	1242	781
>6 to 8	2290	682	220	824	854	1004	677	648	1453	1088	669
>8 to 10	676	770	1623	758	1072	890	526	939	1095	1590	1488
>10 to 15	2444	848	870	907	840	2085	924	1233	2168	1753	1202
>15 to 20	3103	1197	1595	1034	1946	1913	1459	1295	1775	1117	1404
>20 to 30	555	1581	291	940	1118	4879	1069	1373	1336	1356	1896
>30	1684	1290	3454	1380	738	2802	4641	1929	1411	1468	2060
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	Lutein/zeaxanthin										
Up to 2	319	280	242	316	522	284	295	264	263	315	306
>2 to 3	205	334	408	309	434	452	333	290	269	564	291
>3 to 5	292	344	312	560	592	438	358	321	354	495	379
>5 to 6	493	339	355	412	527	504	423	505	434	331	338
>6 to 8	407	459	264	784	423	660	499	313	627	493	411
>8 to 10	548	470	780	309	549	331	276	341	586	531	505

Table 1 – Per capita availability of the five main carotenoids ($\mu\text{g}/\text{day}$) in Urban Areas according to the income stratum in multiples of minimum wage.

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Income Stratum (MW)	Carotenoid ($\mu\text{g}/\text{day}$) and Urban Areas ^a										
	α -carotene										
	GO	DF	BP	FT	RF	SV	BH	RJ	SP	CR	PA
	Lutein/zeaxanthin										
>10 to 15	819	395	1198	427	613	473	656	476	1053	821	533
>15 to 20	733	866	614	612	922	631	749	832	813	819	543
>20 to 30	861	608	270	738	1090	2583	559	709	1140	517	638
>30	238	488	3007	371	872	1481	1305	1074	907	1479	1152

Note: ^a Intake indicative of a varied and healthy diet should supply 11.8 mg/day of total carotenoids, 0.7 of α -carotene, 4.1 of β -carotene, 0.3 of β -cryptoxanthin, 4.6 of lycopene, and 2.2 mg/day of lutein/zeaxanthin [30]. Prudent intake levels suggested by 5.2 to 6.0 mg/day provitamin A carotenenes, 9 to 18 mg/day of carotenoids and 3 to 6 mg/day of β -carotene [13]. GO: Municipality of Goiânia; DF: Brasília-DF; BP: Metropolitan Region of Belém do Pará; FT: Metropolitan Region of Fortaleza; RF: Metropolitan Region of Recife; SV: Metropolitan Region of Salvador; BH: Metropolitan Region of Belo Horizonte; RJ: Metropolitan Region of Rio de Janeiro; SP: Metropolitan Region of São Paulo; CR: Metropolitan Region of Curitiba; PA: Metropolitan Region of Porto Alegre; MW: Minimum Wage.

Likewise, the availability of β -cryptoxanthin and total carotenoids reached 791 and 358 $\mu\text{g}/\text{day}$ and 12,797 and 9,364 $\mu\text{g}/\text{day}$ in the last two highest-income strata, respectively. For lycopene and lutein/zeaxanthin, Salvador exceeded the recommendation only in the stratum of >20 to 30 MW, with 4,879 $\mu\text{g}/\text{day}$ for lycopene and 2,583 for lutein/zeaxanthin. Belem, Belo Horizonte, and Porto Alegre achieved availabilities above the recommended carotenoid intake only in stratum >30 MW. Belem availed 3,057 $\mu\text{g}/\text{day}$ of β -carotene, and 3,007 $\mu\text{g}/\text{day}$ of lutein and zeaxanthin. Belo Horizonte reached the availability of 401 of β -cryptoxanthin and 4,641 $\mu\text{g}/\text{day}$ of lycopene, and Porto Alegre reached the availability of 402 $\mu\text{g}/\text{day}$ of β -cryptoxanthin.

The lowest household availabilities occurred in Belem in the stratum of up to 2 MW, whereas the highest occurred in Salvador in the stratum of >20 to 30 MW. Exceptions were the lower availability of α -carotene (14 $\mu\text{g}/\text{day}$) in Belem (stratum of >20 to 30 MW) and lutein/zeaxanthin (205 $\mu\text{g}/\text{day}$, >2 to 3 MW) in Goiania. On the other hand, the exceptions for the highest values were α -carotene in Salvador (1,266 $\mu\text{g}/\text{day}$, stratum >30 MW) and lutein/zeaxanthin in Belem (3,007 $\mu\text{g}/\text{day}$, stratum >30 MW).

Identification of Foods that Contributed to the Availability of Carotenoids

Overall, the availability of carotenoids or the acquisition of carotenoid-rich foods was very low in most UAs and income strata.

α - carotene

Carrots and common squash were the foods that most contributed to the availability of α -carotene in most UAs. In fact, the relative participation of carrots, common squash, and bananas ranged from 44.6 (Recife MW>30) to 99.8% (Belem MW>6 to 8). Bananas were an important source of α -carotene in Belem, Fortaleza, Recife, and Salvador. Thus, in the North and Northeast, these three foods accounted for between 66.9 and 99.7% of the total availability of α -carotene. Carrots and common squashes alone contributed between 50.6 and 92.7% of the availability, while carrots were the greatest contributor in most income strata (Table 2).

In Goiania (Midwest region), carrots, common squash, and bananas accounted for 86.5 and 97.3% of the availability of α -carotene, while Brasília (DF) accounted for 92.4 and 98.1%. Brasília (DF) was more dependent on common squash for the supply of α -carotene.

Table 2 – Relative participation (%) of food in the availability of α -carotene for families in the Urban Areas.

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Food Sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	> 10 to 15	>15 to 20	>20 to 30	>30
Goiania										
Carrot	60.0	23.5	55.2	54.3	65.8	39.9	41.7	43.5	42.0	56.4
Common squash	25.7	71.9	26.7	34.8	15.3	33.3	46.1	26.0	41.8	31.6
Other bananas	6.5	0.5	3.5	2.1	6.8	18.3	0.0	7.6	3.1	4.0
Banana-silver	4.1	3.1	9.1	6.1	2.6	4.8	8.9	5.6	0.8	0.0
Plantain	0.0	0.0	0.0	0.0	3.2	0.0	0.0	15.3	6.4	0.0
Other tropical fruits	0.0	0.1	0.2	0.4	1.6	0.0	0.4	0.3	0.0	7.8
Total	96.3	99.1	94.7	97.8	95.4	96.3	97.1	98.3	94.1	99.9
Brasilia-DF										
Common common squash	45.3	45.8	54.3	64.3	49.9	52.0	34.0	44.4	39.8	29.9
Carrot	43.4	43.5	28.7	23.7	42.7	32.1	48.6	41.9	36.7	39.7
Banana-silver	5.7	6.9	9.2	4.5	4.1	4.8	5.8	4.9	10.5	12.1
Other bananas	2.3	1.4	1.4	2.3	0.6	2.1	8.3	2.1	5.8	4.8
Plantain	0.0	0.0	0.0	0.0	0.9	1.5	0.0	0.0	0.0	5.9
Total	96.7	97.6	93.6	94.8	98.1	92.4	96.7	93.2	92.7	92.4
Belem do Para										
Common squash	28.5	0.0	21.8	16.9	8.7	33.1	0.0	45.1	0.0	0.0
Carrot	18.6	72.8	60.0	74.3	82.8	54.3	0.0	45.8	0.0	59.2
Other bananas	17.8	2.8	0.0	0.0	4.0	1.4	0.0	0.0	0.0	35.6
Banana-silver	14.9	14.6	7.6	2.8	4.3	6.0	80.0	4.7	66.9	0.0
Plantain	12.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other non -alcoholic beverages	0.8	0.0	0.3	0.0	0.0	0.0	0.0	0.0	18.6	0.0
Other oranges	0.7	1.2	0.1	0.1	0.0	0.0	6.1	0.0	0.0	0.0
Ice cream	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	5.2	0.0
Corn grain	0.0	0.8	0.1	0.0	0.0	0.0	8.1	0.0	3.8	0.0
Total	94.3	92.1	89.8	94.2	99.7	94.8	94.8	95.7	94.5	94.8
Fortaleza										
Carrot	64.0	66.1	72.2	76.5	70.5	39.0	67.7	49.2	57.7	0.0
Banana-silver	14.2	10.4	12.4	6.9	7.7	36.9	7.9	11.1	7.2	90.0
Common squash	10.8	6.7	4.4	9.8	15.1	11.6	10.8	29.5	11.9	0.0
Other bananas	7.9	11.9	3.9	1.9	1.4	10.3	8.8	4.6	16.8	0.0
Other starches	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	7.6
Total	96.8	95.2	93.0	95.1	94.7	97.7	95.2	94.5	93.6	97.6
Recife										
Carrot	46.8	45.3	46.8	52.6	70.3	50.1	34.1	28.2	52.9	9.2
Common squash	32.7	36.5	29.8	27.8	10.9	25.4	26.5	13.0	0.0	31.5
Plantain	10.1	5.8	10.3	7.3	11.6	13.8	31.1	43.3	37.6	46.7
Banana-silver	4.7	5.8	5.4	3.7	2.8	5.3	3.8	5.1	2.6	3.9
Corn flakes	3.1	2.8	3.6	5.5	1.3	1.6	2.8	3.3	1.2	2.2
Total	97.3	96.1	96.0	96.9	97.0	96.2	98.3	93.0	94.3	93.5
Salvador										
Plantain	31.3	9.8	15.9	27.4	42.0	5.6	20.8	27.2	24.7	1.4
Carrot	28.7	47.8	55.9	38.8	24.1	43.7	27.6	60.4	53.9	42.0
Common squash	23.9	33.3	21.8	28.4	18.4	20.3	28.3	6.2	6.5	50.7
Banana-silver	8.3	5.3	3.4	3.1	8.0	23.4	18.2	5.0	11.6	3.8
Total	92.2	96.2	97.1	97.8	92.4	93.0	95.0	98.8	96.6	98.0
Belo Horizonte										
Common squash	64.9	42.8	43.4	37.5	60.0	33.3	44.4	31.9	43.7	52.9
Carrot	28.0	45.7	43.8	54.7	33.3	47.2	45.1	45.0	35.5	33.6
Banana-silver	4.6	5.0	3.7	5.9	3.1	15.4	6.4	12.9	12.5	5.9
Other bananas	0.9	2.7	2.2	0.4	0.9	2.6	2.2	7.6	0.0	0.0
Total	98.4	96.2	93.0	98.4	97.4	98.5	98.0	97.4	91.7	92.5

Table 2 – Relative participation (%) of food in the availability of α -carotene for families in the Urban Areas.

2 of 2

Food Sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	>20 to 30	>30
Rio de Janeiro										
Carrot	56.3	64.9	51.6	50.2	70.1	48.7	44.4	54.5	72.1	53.7
Common squash	25.3	24.6	37.3	36.1	20.2	34.4	30.1	30.5	6.5	36.4
Banana-silver	8.6	6.2	6.2	8.0	7.4	11.5	6.9	8.1	6.8	4.2
Banana-silver	8.6	6.2	6.2	8.0	7.4	11.5	6.9	8.1	6.8	4.2
Plantain	2.4	0.0	0.7	0.9	0.0	2.0	13.8	1.9	2.1	0.0
Corn flakes	0.3	0.1	0.2	0.1	0.0	0.6	0.2	0.0	6.3	0.3
Total	92.9	95.9	95.9	95.4	97.7	97.1	95.4	95.1	93.8	94.5
Sao Paulo										
Carrot	66.2	54.4	56.8	65.4	50.8	61.5	55.8	69.3	46.2	40.7
Common squash	22.3	37.0	28.6	22.2	34.4	14.2	34.7	0.0	41.5	41.3
Other bananas	3.7	3.2	3.2	3.0	2.7	0.8	0.8	0.0	2.0	7.0
Banana-silver	2.1	2.6	4.1	4.3	5.8	8.1	3.5	11.0	3.0	4.3
Corn flakes	0.6	0.5	0.2	0.0	1.2	4.8	0.5	5.1	0.3	0.1
Other tuberous vegetables	0.0	0.1	0.4	0.3	0.3	5.8	0.8	1.5	2.9	2.2
Total	95.0	97.8	93.4	95.2	95.2	95.0	96.1	86.9	95.9	95.7
Curitiba										
Carrot	35.9	49.9	65.4	84.7	53.0	62.9	32.2	55.5	52.8	61.4
Common squash	31.1	43.2	21.0	6.8	28.7	17.8	57.0	12.2	42.3	19.5
Plantain	8.4	0.0	0.0	4.1	0.0	0.0	0.8	0.0	0.0	0.0
Other bananas	8.2	0.7	2.8	2.0	3.0	0.5	0.9	1.6	0.0	0.0
Corn grain	7.2	0.2	2.2	0.2	1.1	8.3	0.3	1.0	0.9	0.3
Corn flakes	3.0	0.0	0.2	0.0	2.8	2.1	0.2	17.6	0.4	6.9
Banana-silver	2.7	2.6	3.2	0.2	6.4	4.8	5.1	2.0	0.8	1.0
Other fruit -bearing vegetables	1.2	0.2	0.6	0.1	2.1	1.0	1.5	5.2	0.5	10.6
Total	97.8	96.8	95.5	98.2	97.1	97.4	97.9	95.1	97.6	99.7
Porto Alegre										
Common squash	54.3	50.6	42.3	39.2	37.8	3.9	37.8	0.0	37.2	6.3
Carrot	38.8	40.3	50.1	54.9	56.9	82.1	52.0	81.2	48.1	82.8
Banana-silver	3.6	4.9	3.5	1.2	1.3	6.1	5.4	11.5	8.8	6.3
Total	96.7	95.8	95.9	95.4	96.1	92.1	95.2	92.8	94.1	95.4

Note: MW: Minimum Wage.

In Belo Horizonte, common squash was the main source of this carotenoid in the lowest-income group (≤ 2 MW) and the highest-income groups (> 20 MW). In Rio de Janeiro and Sao Paulo, carrots were the main source of α -carotene.

In the Southern region, in Curitiba, carrots had a greater role in the supply of α -carotene, and in Porto Alegre, common squash was more important in the ≤ 3 MW range.

β -Carotene

The foods that most contributed to the availability of β -carotene in UAs were common squash, carrot, scallion/parsley, mango, and tomato (Table 3).

In Belem (North) the common squash, carrots, scallion/parsley, and kale contributed between 18,3 and 74.8% of the availability of β -carotene. Carrots had the greatest contribution only in four income strata, while Scallion/Parsley had the greatest contribution in six income strata. Furthermore, the contribution of carrots was higher for the income stratum > 6 to 8 compared to that for > 10 to 15, but increased for stratum > 15 to 20 and decreased in the two highest strata.

Table 3 – Relative participation (%) of food in the availability of β -carotene for families in the Urban Areas.

1 of 3

Food sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	>20 to 30	>30
Goiânia										
Carrot	21.8	14.6	21.3	21.7	20.2	21.3	12.8	14.4	18.7	32.8
Common squash	12.8	61.3	14.1	19.0	6.4	24.4	19.4	11.8	25.5	25.2
Mango	10.6	1.1	4.5	3.2	8.6	0.0	4.2	26.2	0.0	0.0
Tomato	8.8	5.5	6.0	7.8	13.2	7.6	11.2	4.3	8.5	4.0
Scallion/parsley	6.4	1.1	2.8	10.3	1.4	6.6	14.5	2.9	1.3	0.0
Kale	6.1	1.6	9.0	7.3	1.6	0.0	6.5	10.2	5.7	0.0
Lettuce	4.1	0.6	4.9	7.1	4.1	0.0	5.6	0.7	3.9	3.9
Tomato paste	2.4	0.0	3.5	0.5	9.1	0.3	3.0	0.4	0.0	1.1
Sweet potato	2.3	0.9	1.9	0.3	2.0	4.4	0.8	3.0	5.7	0.0
Other bananas	2.1	0.3	1.2	0.7	1.8	8.6	0.0	2.2	1.2	2.0
Vegetable margarine	2.0	0.7	3.6	3.7	2.3	5.1	0.2	0.8	0.0	0.8
Papaya	1.7	1.0	3.6	0.0	4.4	3.0	5.2	4.6	2.1	0.7
Tomato Sauce	1.4	0.6	0.7	1.7	5.9	0.3	0.8	0.7	0.3	5.0
Watermelon	1.0	2.3	6.2	4.8	0.0	2.3	5.0	8.6	0.0	0.0
Potatoes, unspecified	0.0	0.4	0.0	0.2	0.0	0.0	0.0	0.0	6.6	0.0
Other tropical fruits	0.0	0.1	0.3	0.5	1.6	0.0	0.4	0.3	0.0	14.1
Total	83.5	92.0	83.6	88.8	82.7	83.9	89.4	91.2	79.3	89.7
Brasília-DF										
Common squash	23.7	29.7	32.7	34.5	30.2	28.4	18.8	28.2	14.5	15.5
Carrot	16.6	20.5	12.6	9.3	18.8	12.8	19.6	19.4	9.7	15.0
Scallion/parsley	14.6	8.4	6.4	11.7	7.1	5.6	4.8	4.7	4.0	5.9
Mango	8.5	6.6	12.8	4.8	10.5	7.1	14.4	4.0	14.2	12.7
Tomato	4.3	4.9	3.9	6.7	6.2	4.1	6.4	5.9	5.9	3.8
Papaya	1.9	2.6	2.3	2.2	2.4	2.5	2.6	2.0	5.1	4.9
Kale	1.8	1.3	1.0	5.1	2.5	2.7	2.8	3.1	5.2	2.2
Sweet potato	1.5	1.8	0.7	2.4	2.5	1.1	2.8	1.4	2.0	6.0
Cauliflower	0.5	0.2	0.5	0.0	0.3	0.6	0.2	1.5	5.1	1.1
OFFV	0.2	0.5	0.5	1.1	1.2	1.9	0.6	6.7	5.5	1.3
Total	73.6	76.5	73.3	77.7	81.7	66.8	73.0	76.8	71.2	68.6
Belém do Pará										
Scallion/parsley	25.8	52.9	20.5	17.7	19.7	10.8	59.2	0.0	10.3	31.7
Kale	24.3	0.0	3.4	0.0	8.8	0.0	0.0	0.0	8.0	18.1
Common squash	8.3	0.0	9.3	8.8	5.8	23.9	0.0	40.5	0.0	0.0
Vegetable margarine	7.1	6.4	6.0	11.2	6.0	6.1	0.5	0.0	1.9	0.0
Carrot	3.9	10.4	18.7	28.3	40.5	28.5	0.0	30.0	0.0	17.6
Other bananas	3.3	0.3	0.0	0.0	1.7	0.7	0.0	0.0	0.0	9.3
Lettuce	3.0	2.2	2.2	0.0	0.0	1.4	0.0	2.4	0.0	7.2
OFFV	2.9	8.2	4.5	7.6	0.0	0.0	6.3	0.0	1.0	0.0
Tomato	2.5	3.9	3.6	1.7	5.9	1.1	0.0	0.0	13.9	5.1
Banana-silver	1.9	1.3	1.4	0.6	1.3	1.9	8.5	1.9	2.0	0.0
Tomato Sauce	0.6	1.6	0.9	0.5	0.0	0.3	6.3	0.0	0.8	0.0
Tomato paste	0.2	1.6	0.2	0.0	0.5	0.0	0.0	0.0	0.0	5.0
Guava	0.1	0.7	0.6	1.7	0.0	4.1	0.0	5.5	0.0	0.0
Acerola	0.0	0.0	7.7	8.5	0.0	17.1	0.0	19.8	0.0	0.0
Mango	0.0	0.0	4.9	0.0	0.0	0.0	0.0	0.0	52.4	0.0
Fruit sweet paste	0.0	0.3	0.1	0.1	0.0	0.0	6.8	0.0	0.0	0.0
Total	83.9	89.7	83.8	86.8	90.3	95.9	87.5	100.0	90.3	94.0

Table 3 – Relative participation (%) of food in the availability of β -carotene for families in the Urban Areas.

2 of 3

Food sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	>20 to 30	>30
Fortaleza										
Scallion/parsley	32.8	36.3	31.2	32.8	28.1	5.1	13.5	3.9	19.6	23.4
Carrot	21.3	21.1	20.0	21.5	24.2	21.5	26.9	20.3	20.8	0.0
Mango	5.9	4.1	6.3	8.8	6.6	4.1	9.5	8.5	6.2	0.0
Common squash	4.9	2.9	1.7	3.8	7.1	8.8	5.9	16.7	5.9	0.0
Vegetable margarine	4.9	6.1	6.2	7.2	4.6	1.7	3.6	3.1	1.4	0.0
Tomato	3.8	2.9	3.4	4.4	4.0	3.2	4.0	4.0	3.6	10.2
Banana-silver	2.9	2.0	2.1	1.2	1.6	12.3	1.9	2.8	1.6	8.4
Other bananas	2.3	3.3	1.0	0.5	0.4	5.0	3.1	1.7	5.3	0.0
Papaya	1.9	1.8	2.0	2.8	2.9	5.9	4.1	2.5	4.5	5.4
Kale	1.5	0.4	0.7	0.0	0.0	8.3	0.0	12.7	3.7	0.0
Watermelon	1.3	0.9	2.6	0.8	1.1	0.0	2.5	2.3	1.1	5.6
Acerola	0.7	2.3	1.5	1.8	2.7	0.0	0.0	0.0	5.8	0.0
Passion fruit	0.7	1.0	2.9	1.4	1.4	4.4	1.7	1.0	0.6	10.1
Tomato paste	0.4	0.5	0.0	0.0	0.0	0.0	0.1	1.0	0.0	8.3
Total	90.4	87.2	85.3	89.6	86.3	84.9	83.0	84.1	84.1	74.3
Recife										
Carrot	22.9	20.3	23.8	27.8	34.5	25.3	17.9	14.5	22.1	5.0
Common squash	22.0	22.5	20.8	20.2	7.3	17.6	19.1	9.2	0.0	23.3
Vegetable margarine	6.8	6.4	6.8	5.5	4.2	1.5	3.7	1.6	0.8	0.0
Tomato	5.0	4.8	4.3	6.8	4.9	6.1	3.0	4.4	3.4	3.2
Plantain	4.5	2.3	4.7	3.5	5.2	6.3	14.8	20.2	14.2	22.8
Scallion/parsley	4.4	0.8	1.7	0.9	0.0	2.2	4.0	2.7	11.6	3.8
Sweet potato	4.1	6.2	4.2	2.4	1.7	3.7	5.4	2.3	7.6	4.6
OFFV	3.1	4.3	2.7	2.7	3.5	3.8	2.5	3.3	5.7	2.8
Kale	2.2	4.4	0.8	1.6	9.4	3.3	5.1	2.3	0.0	0.0
Papaya	1.6	2.1	3.0	4.6	4.7	1.6	4.1	7.5	2.2	6.6
Lettuce	1.0	0.8	2.3	1.0	1.8	2.1	1.9	3.4	7.1	3.6
Total	77.6	74.9	75.1	77.0	77.2	73.5	81.5	71.4	74.7	75.7
Salvador										
Mango	11.5	5.9	6.0	5.5	7.2	8.3	25.3	2.3	12.4	7.9
Common squash	11.1	24.5	15.1	21.0	10.0	8.0	9.2	4.8	3.0	39.4
Carrot	9.7	25.7	28.1	20.9	9.5	12.6	6.5	34.3	18.4	23.8
Plantain	9.6	4.7	7.2	13.4	15.0	1.5	4.4	14.0	7.6	0.7
Vegetable margarine	7.9	2.9	2.9	3.5	3.7	3.2	3.8	1.0	0.0	0.3
Scallion/parsley	7.7	6.1	5.9	3.0	7.8	4.8	8.1	4.7	4.2	4.3
Tomato	7.1	5.6	4.5	3.8	4.3	7.1	2.5	3.7	1.2	1.8
OFFV	4.2	3.0	3.3	1.3	2.1	4.0	2.3	3.1	14.2	2.2
Sweet potato	4.1	1.7	2.0	1.6	2.3	10.8	3.6	4.8	1.3	1.3
Kale	2.3	1.7	4.6	3.6	11.3	3.0	4.4	2.5	10.4	1.7
Tomato Sauce	2.0	2.2	1.6	1.9	1.6	5.1	3.9	2.5	0.9	0.2
Papaya	0.9	1.5	1.1	3.6	2.3	2.8	4.2	4.4	8.5	2.7
Total	78.0	85.5	82.2	83.0	77.2	71.3	78.3	82.1	82.0	86.3
Belo Horizonte										
Common squash	43.4	22.8	27.3	27.2	37.7	18.9	26.8	13.9	21.6	23.6
Carrot	13.7	17.7	20.1	28.9	15.3	19.5	19.9	14.2	12.8	10.9
Kale	9.3	12.5	5.8	8.8	9.6	6.3	7.7	22.1	6.7	6.8
Mango	5.5	7.8	12.2	5.5	1.0	10.2	13.0	6.4	20.5	13.0
Tomato	3.2	4.9	3.8	5.7	4.8	6.6	3.7	7.4	3.2	4.3
Packaged fruit juice	1.1	1.0	0.6	0.9	1.2	8.1	0.8	1.8	2.6	0.9
Papaya	0.4	1.8	1.9	2.5	2.6	4.4	2.1	4.4	5.3	6.9
OFFV	0.4	2.5	1.6	0.5	1.4	0.3	1.2	4.9	0.2	5.8
Total	76.9	71.1	73.2	80.0	73.6	74.3	75.3	75.0	72.9	72.1

Table 3 – Relative participation (%) of food in the availability of β -carotene for families in the Urban Areas.

3 of 3

Food sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	>20 to 30	>30
Rio de Janeiro										
Carrot	21.0	25.4	20.2	21.0	34.3	21.1	17.7	19.8	27.0	21.8
Common squash	13.0	13.2	20.0	20.7	13.5	20.4	16.5	15.2	3.3	20.3
Vegetable margarine	7.5	5.8	4.9	5.8	3.5	5.2	4.0	3.5	4.9	1.4
Kale	7.3	7.3	7.3	5.1	4.8	3.8	5.0	5.3	11.0	8.7
Scallion/parsley	6.6	4.7	4.7	9.8	2.9	3.9	6.3	3.3	1.3	4.8
Tomato	5.3	3.5	3.7	2.8	3.7	3.3	3.5	7.4	5.9	3.8
Mango	4.8	12.5	9.0	5.9	11.4	8.9	11.1	13.6	4.4	7.1
Tomato Sauce	3.4	2.7	3.4	2.7	2.2	5.3	4.0	1.3	3.7	3.9
Cauliflower	0.5	2.2	1.9	1.7	0.9	0.0	1.7	1.5	5.8	4.6
Total	69.3	77.4	75.1	75.5	77.4	71.8	69.7	70.9	67.2	76.4
São Paulo										
Carrot	24.3	21.5	15.7	23.8	14.2	12.1	18.3	16.4	16.1	13.1
Common squash	11.2	20.1	10.8	11.1	13.2	3.8	15.6	0.0	19.8	18.3
Kale	9.4	7.3	4.9	10.8	5.0	3.9	6.2	5.2	5.0	6.0
Mango	8.8	6.7	12.2	14.9	18.0	30.9	10.1	10.1	11.7	7.7
Tomato Sauce	6.3	5.1	4.0	4.6	3.2	2.5	3.5	4.0	1.3	3.2
Tomato	6.0	5.5	4.2	2.8	5.0	6.3	4.9	4.1	5.4	2.9
Vegetable margarine	5.7	5.6	4.0	3.1	2.9	2.4	2.1	3.4	1.1	0.9
Lettuce	4.6	5.1	5.2	4.0	4.9	3.6	4.4	3.4	2.4	5.4
Scallion/parsley	3.1	2.7	7.7	3.2	4.4	3.5	3.4	12.1	1.9	3.1
OFFV	2.8	1.4	5.3	1.5	2.4	4.8	5.3	5.6	11.1	8.1
Watermelon	0.6	1.9	4.7	0.2	3.5	3.0	2.2	9.8	1.3	1.5
Chard	0.5	0.0	1.1	1.5	1.1	0.0	4.6	3.1	1.7	5.7
Total	83.3	82.9	80.0	81.6	77.8	77.0	80.7	77.2	78.9	75.8
Curitiba										
Vegetable margarine	11.0	2.6	3.6	2.6	3.9	4.0	1.2	4.0	2.5	0.9
Common squash	10.5	20.2	8.1	4.2	12.4	7.1	25.9	3.7	24.3	13.2
Carrot	8.8	17.0	18.5	38.4	16.7	18.3	10.7	12.3	22.1	30.4
Mango	8.4	5.9	15.1	12.8	10.1	11.0	19.6	21.4	11.7	14.1
Lettuce	7.8	4.1	5.3	7.7	4.2	2.6	2.6	2.3	5.6	3.7
Tomato Sauce	5.7	2.0	6.6	7.4	5.3	8.7	4.1	4.0	3.3	2.3
Tomato paste	5.6	2.0	1.0	0.1	2.2	1.3	0.5	2.0	0.3	0.3
Kale	5.1	7.6	6.4	0.0	2.4	2.7	9.6	7.4	2.2	0.0
Tomato	4.6	3.0	4.0	3.8	7.4	4.8	3.0	3.5	5.1	5.8
Scallion/parsley	2.4	9.2	8.2	3.7	9.1	6.3	5.4	2.3	3.3	3.0
Watermelon	1.0	0.0	1.2	0.2	1.2	7.9	1.0	0.0	4.0	0.0
Other Fruit -bearing vegetables	0.5	0.2	0.3	0.0	1.1	0.5	0.9	2.1	0.4	9.3
Chard	0.0	7.4	1.4	0.0	2.8	0.0	0.0	0.0	0.0	0.0
Total	71.5	81.2	79.8	81.0	78.7	75.3	84.6	64.9	84.7	82.9
Porto Alegre										
Common squash	28.5	27.1	20.9	26.3	26.3	1.5	20.0	0.0	22.3	3.8
Carrot	14.9	15.7	18.0	26.8	28.9	23.5	20.0	23.8	21.1	36.5
Scallion/parsley	8.0	1.8	4.2	3.3	2.4	4.8	4.3	3.4	3.1	2.7
Lettuce	7.7	4.0	7.8	3.6	2.7	2.8	4.7	2.4	2.9	4.4
Kale	5.6	8.8	10.9	3.0	5.6	1.0	6.7	4.7	0.0	2.5
Mango	5.4	3.6	3.0	3.0	0.0	15.3	5.5	16.6	4.4	6.3
Tomato	4.8	5.9	6.5	3.5	6.7	5.0	6.7	8.5	6.6	6.4
Vegetable margarine	4.4	6.1	6.3	3.8	2.5	3.0	1.4	1.2	0.6	1.6
Tomato Sauce	3.8	3.4	3.6	1.7	1.2	2.5	1.9	1.6	5.4	0.8
Watermelon	2.4	2.7	0.2	5.1	0.8	4.5	0.7	0.9	0.0	0.0
Papaya	2.2	1.7	2.3	2.8	1.8	5.9	5.5	5.6	3.4	6.0
Sweet potato	2.0	5.2	2.6	1.9	1.6	4.4	2.0	0.8	2.8	1.7
OFFV	1.4	0.9	1.2	1.7	6.5	4.6	4.6	9.3	10.3	11.8
Total	91.2	86.9	87.6	86.2	87.0	78.9	83.9	78.9	82.9	84.5

Note: MW: Minimum Wage; OFFV: Other leafy and floral vegetables.

In Fortaleza (Northeast), the scallion/parsley combination was important in the lower -income strata, and carrots started to have a greater contribution above the income stratum >8 to 10 MW. Although mango appeared with a maximum relative participation of 9.46% in the stratum >10 to 15 MW, it ranked third in Fortaleza.

In Recife, carrots and common squash contributed similar amounts up to MW >5 to 6. Together, they accounted for more than 40% of the income in most income strata.

In Salvador, common squash and carrot were the greatest contributors to the β -carotene availability, while participation of mangoes was only emerging. Noteworthy was the significant participation of foods poor in carotenoids. This was consistent with the low acquisition of foods rich in carotenoids in the Northeast.

Foods rich in β -carotene, such as kale, became more important and reached more than 10% in families with income strata >15 to 20 in Goiania, the Midwest region. Carrots and common squash contributed between 26.2 and 75.9% of β -carotene, and the relative share of mango and tomato varied from 4.0 to 30.5%.

The major UAs of the southeastern region had the following foods as the main contributors of β -carotene: common squash, carrots, kale, and mango. The common squash had the largest relative share in Belo Horizonte and carrots in Rio de Janeiro and Sao Paulo. In Belo Horizonte, kale was a major source of β -carotene.

In the South region, the participation of common squash, carrots, kale, and mango stood out as sources of β -carotene. Tomatoes had a participation percentage greater than 5% in most income strata in Porto Alegre.

β -cryptoxanthin

Papaya, orange, and tangerine were the main sources of β -cryptoxanthin in the urban areas of Goiania and Brasilia (DF) (Table 4).

Table 4 – Relative participation (%) of food in the availability of β -cryptoxanthin for families in the Urban Areas.

1 of 3

Food sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	> 20 to 30	>30
Goiania										
Persimmon	47.8	0.0	0.0	0.0	0.0	25.3	10.8	0.0	0.0	0.0
Papaya	16.8	38.7	44.2	0.0	45.7	36.3	62.6	82.9	66.1	14.9
Tangerine	9.4	39.9	19.5	44.1	16.4	17.1	17.7	0.0	0.0	0.0
Other oranges	7.7	0.0	15.4	28.0	4.5	1.6	0.0	6.3	0.0	0.0
Lime orange	5.6	0.0	0.0	0.0	4.0	1.3	0.5	0.0	0.0	0.0
Cornmeal	2.4	0.4	1.4	2.1	6.5	2.4	0.0	0.0	0.0	0.0
Fruit sweet paste	2.2	0.0	4.0	1.9	0.0	3.0	0.0	1.7	6.7	0.0
Packaged fruit juice	1.8	1.4	1.0	4.7	1.5	1.1	1.1	0.3	5.8	10.7
Passion fruit	0.9	6.3	3.2	1.6	1.9	0.0	0.9	0.0	0.0	0.0
Corn on the cob	0.7	0.9	1.1	1.7	1.3	1.1	1.5	0.0	7.0	0.7
Pear-orange	0.6	0.9	1.9	0.5	2.5	2.3	0.6	0.3	2.2	5.0
Pineapple	0.1	0.9	2.5	2.3	1.6	1.7	0.9	0.0	0.0	16.8
Other tropical fruits	0.0	0.9	0.5	2.7	2.5	0.0	0.7	0.8	0.0	46.8
Total	96.1	90.2	94.5	89.6	88.5	93.3	97.4	92.2	87.8	95.0
Brasília (DF)										
Papaya	38.4	52.4	33.6	42.0	55.3	45.9	51.2	51.6	58.3	63.7
Tangerine	36.9	16.5	35.7	9.9	15.9	23.1	12.5	16.0	18.1	12.5

Table 4 – Relative participation (%) of food in the availability of β -cryptoxanthin for families in the Urban Areas.

2 of 3

Food sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	>20 to 30	>30
Other oranges	7.4	3.5	4.6	4.5	5.3	1.9	9.5	4.3	3.3	3.3
Fruit sweet paste	1.4	0.8	0.5	10.0	1.5	1.1	1.8	0.0	0.8	0.9
Cornmeal	1.2	10.4	2.3	0.8	8.2	0.0	2.5	0.0	1.0	2.6
Other temperate fruits	0.9	1.1	2.1	0.0	0.7	8.6	0.9	0.8	0.2	0.3
Packaged fruit juice	0.9	0.8	1.4	3.1	2.2	5.0	3.2	5.2	2.1	4.0
Lime orange	0.3	0.0	1.8	21.8	0.0	1.9	0.6	0.0	0.2	0.0
Persimmon	0.0	3.1	5.9	0.0	0.0	0.0	1.9	4.3	3.8	1.0
Total	87.4	88.6	88.0	92.1	89.2	87.4	84.0	82.3	87.9	88.3
Belém do Pará										
Papaya	36.9	16.5	23.2	40.1	88.7	7.6	0.0	0.0	0.0	0.0
Other oranges	14.9	25.8	4.4	4.4	0.0	0.0	29.3	0.0	0.0	0.0
Lime orange	6.2	4.5	1.8	0.0	0.0	7.0	0.0	0.0	19.0	0.0
Cornmeal	5.9	11.6	9.4	0.0	0.0	0.0	0.0	0.0	15.3	0.0
Kale	5.1	0.0	0.8	0.0	3.6	0.0	0.0	0.0	2.1	30.7
Chicken egg	3.8	3.3	1.3	2.5	3.8	2.4	0.8	4.9	3.6	26.2
Tangerine	2.6	0.0	23.4	16.3	0.0	29.0	0.0	0.0	36.2	0.0
Pear-orange	2.1	2.9	0.8	0.0	0.0	26.7	0.0	61.5	9.1	0.0
Other non -alcoholic beverages	1.7	0.0	0.9	0.0	0.0	0.0	0.0	0.0	11.2	0.0
Water banana	1.6	2.3	0.4	6.0	0.0	0.7	0.0	0.0	0.0	0.0
Other bananas	0.9	0.1	0.0	0.0	0.9	0.2	0.0	0.0	0.0	20.0
Fresh cucumber	0.8	0.5	0.6	0.9	0.0	0.3	0.0	0.0	0.0	17.4
Acerola	0.0	0.0	11.5	11.1	0.0	21.4	0.0	33.6	0.0	0.0
Other tropical fruits	0.0	0.0	10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fruit sweet paste	0.0	16.9	2.5	3.2	0.0	0.0	68.6	0.0	0.0	0.0
Total	82.3	84.4	91.8	84.5	96.9	95.3	98.7	99.9	96.4	94.3
Fortaleza										
Papaya	41.8	50.2	47.3	69.2	52.5	70.3	54.0	52.2	80.0	69.3
Tangerine	15.8	2.2	3.7	11.0	12.6	6.3	13.9	18.3	3.2	0.0
Persimmon	11.1	0.0	0.0	0.0	0.0	0.0	6.6	0.0	0.0	0.0
Other oranges	7.2	7.5	2.5	2.5	1.3	4.1	1.3	1.0	1.6	0.0
Cornmeal	5.3	9.2	15.4	0.5	16.1	2.1	5.7	0.0	0.0	0.0
Passion fruit	1.7	3.1	7.9	3.8	2.9	5.9	2.6	2.2	1.1	14.5
Pear-orange	1.3	0.8	1.3	1.4	1.0	1.0	1.8	5.5	0.3	0.0
Avocado	1.0	1.9	1.4	0.5	0.5	0.5	0.4	5.5	0.9	0.0
Pineapple	0.5	3.2	1.3	1.7	1.3	1.5	2.1	2.5	1.8	6.4
Total	85.8	78.1	80.9	90.6	88.3	91.6	88.5	87.2	88.9	90.2
Recife										
Papaya	38.7	44.3	56.7	74.5	77.0	51.0	72.0	56.6	37.4	71.2
Cornmeal	33.4	28.7	15.2	10.7	3.9	10.3	1.7	0.7	5.5	2.1
Tangerine	5.8	1.3	5.6	0.0	1.9	2.7	6.8	23.5	23.7	8.7
Fruit sweet paste	3.9	3.2	1.9	1.9	3.3	0.0	0.0	6.4	2.3	0.0
Passion fruit	1.5	1.8	1.2	0.7	0.9	2.7	1.2	0.0	5.6	4.1
Lime orange	0.9	0.0	2.1	2.4	0.5	0.9	0.0	0.0	10.0	0.0
Marmalade jam in syrup	0.7	0.0	0.2	0.0	0.0	6.8	0.0	0.0	0.0	4.6
Other tropical fruits	0.6	1.3	1.5	0.0	0.6	3.1	0.4	6.8	2.7	1.4
Total	85.5	80.6	84.4	90.3	88.1	77.6	82.1	94.1	87.1	92.1
Salvador										
Papaya	32.1	52.8	42.6	71.8	36.8	54.6	62.5	71.9	81.0	53.0
Other oranges	11.6	3.2	5.6	1.5	1.6	2.2	2.2	0.0	3.8	10.6
Tangerine	9.7	7.2	14.6	10.0	13.0	12.0	7.9	14.0	4.8	16.7
Cornmeal	9.2	8.6	7.0	1.0	1.1	1.8	4.2	0.6	0.0	1.2
Passion fruit	8.2	2.5	3.6	1.2	2.0	1.8	3.0	3.1	2.4	1.4
Pineapple	5.5	2.2	2.7	0.3	1.1	1.5	1.3	1.0	0.9	2.4
Fruit sweet paste	3.8	6.0	4.9	1.2	3.5	1.7	10.3	2.7	0.1	1.1
Lime orange	2.8	0.0	0.8	1.3	2.6	6.4	0.0	0.0	0.4	0.0
Persimmon	0.0	0.0	0.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0
Total	82.9	82.6	81.8	88.3	91.6	82.0	91.4	93.3	93.5	86.4

Table 4 – Relative participation (%) of food in the availability of β -cryptoxanthin for families in the Urban Areas.

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Food sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	>20 to 30	>30
Belo Horizonte										
Papaya	20.2	44.5	46.9	65.8	38.0	57.5	48.9	69.8	74.6	77.0
Tangerine	19.4	12.0	20.8	0.0	32.4	15.2	16.2	12.3	8.1	8.6
Cornmeal	12.3	9.2	5.4	3.8	10.7	1.5	3.2	0.0	0.0	0.0
Other oranges	6.5	3.3	5.1	3.1	0.0	5.3	8.4	3.3	0.0	0.0
Water banana	6.1	3.2	2.3	2.5	1.4	1.1	0.6	1.8	0.4	0.2
Lime orange	5.2	7.4	1.1	0.3	0.7	2.5	0.0	0.0	4.0	3.1
Packaged fruit juice	4.7	2.6	1.5	2.3	1.6	10.5	1.8	2.8	3.6	1.0
Pear-orange	4.7	3.4	2.8	6.4	1.8	1.4	2.3	0.5	2.6	0.8
Persimmon	0.0	0.0	0.0	0.0	5.4	0.0	5.3	0.0	0.0	0.0
Total	79.2	85.6	85.8	84.3	92.1	95.0	86.7	90.6	93.4	90.7
Rio de Janeiro										
Papaya	36.0	16.7	46.3	49.1	35.5	33.4	48.6	59.6	31.1	32.6
Tangerine	21.5	12.6	14.3	12.6	17.4	18.0	5.3	17.4	30.7	35.2
Cornmeal	11.4	4.6	6.7	6.5	2.5	6.7	3.2	0.9	0.7	2.6
Persimmon	7.5	34.2	11.7	0.0	19.0	9.7	3.6	0.0	17.1	0.0
Orange-select	3.7	2.0	0.5	1.8	2.2	0.8	5.2	1.9	5.7	0.0
Packaged fruit juice	1.8	2.8	2.8	6.0	2.3	4.8	6.2	2.2	3.7	7.4
Fruit sweet paste	1.4	0.5	1.8	1.7	1.9	4.0	7.5	3.7	3.1	0.0
Total	83.3	73.3	84.0	77.7	80.7	77.4	79.8	85.7	92.1	77.8
São Paulo										
Papaya	49.0	45.3	37.2	45.9	56.4	48.2	50.5	38.5	41.6	32.5
Tangerine	16.9	19.6	20.0	31.3	19.2	12.6	19.0	18.3	22.8	22.7
Cornmeal	6.4	5.0	0.9	0.4	2.6	2.5	0.7	4.9	1.8	0.5
Persimmon	5.3	2.2	13.4	0.0	6.6	24.0	7.9	0.0	16.4	33.7
Packaged fruit juice	0.6	1.6	1.8	2.7	1.3	1.7	3.1	5.8	1.0	1.4
Total	78.3	73.7	73.3	80.4	86.2	88.9	81.1	67.5	83.6	90.8
Curitiba										
Tangerine	35.8	9.3	17.9	19.2	12.5	10.8	27.3	21.6	0.0	43.5
Papaya	25.2	57.9	29.9	31.2	39.2	32.7	18.1	49.0	43.9	35.9
Persimmon	11.8	6.7	16.0	0.0	22.3	25.9	35.9	0.0	30.6	0.0
Cornmeal	7.3	5.3	10.6	1.9	1.5	5.3	1.7	4.1	3.4	0.0
Water banana	4.3	3.0	4.5	5.0	3.7	4.3	1.4	4.0	3.6	1.2
Canned green corn	4.2	0.0	4.4	1.5	1.4	5.5	0.4	1.9	3.9	0.0
Fruit sweet paste	4.0	0.7	2.3	9.2	1.1	0.8	3.2	0.5	0.0	10.9
Other oranges	2.2	1.9	1.3	7.9	1.7	0.7	1.0	0.0	0.0	0.0
Lime orange	0.0	1.4	0.6	0.0	1.2	1.1	0.0	1.4	5.7	1.1
Total	94.7	86.2	87.7	76.0	84.5	87.1	88.9	82.4	91.0	92.7
Porto Alegre										
Papaya	36.9	46.0	30.2	47.4	34.6	57.1	53.4	60.9	60.7	56.0
Tangerine	36.2	16.4	31.8	17.4	26.8	9.9	29.5	14.8	4.2	19.7
Persimmon	6.0	0.0	17.8	15.8	21.3	9.6	0.0	11.8	16.4	10.4
Water banana	3.5	10.0	3.0	4.1	3.1	2.0	2.3	2.1	1.3	1.1
Lime orange	2.0	6.1	0.8	2.4	0.0	1.6	0.6	0.0	1.7	1.1
Total	84.6	78.4	83.6	87.1	85.8	80.2	85.8	89.6	84.3	88.4

Note: MW: Minimum Wage.

In Belem, papaya, unspecified oranges, and lime-orange were the main sources of β -cryptoxanthin, whereas papaya and tangerine accounted for between 51 and 83.2% of the availability in Fortaleza. In Recife, cornmeal had a significant relative share among families with an income of ≤ 6 MW and in the stratum >8 to 10 MW. In Salvador, papaya and tangerine provided the

highest availability of β -cryptoxanthin in most income strata, and cornmeal, more than 7% in the income strata of up to 5 MW.

In the remaining urban areas, papaya and tangerine were the major suppliers of β -cryptoxanthin. It was noteworthy that cornmeal was very important in the lower income strata and that persimmon was significantly more important in Rio de Janeiro, Sao Paulo, Curitiba, Porto Alegre, and Goiania.

Lycopene

The foods that most contributed to the supply of lycopene were tomato sauce, tomato paste, guava, watermelon, and papaya (Table 5). Tomato sauce was very important in all regions, whereas tomato paste had a significant relative share in Goiania, Salvador, Rio de Janeiro, Curitiba, and Porto Alegre. Other foods that contributed with at least 10% to most income strata were guava in Belem and Fortaleza, papaya, except for Belem, Rio de Janeiro, and Curitiba, and watermelon in all regions except Belem, Rio de Janeiro, and Curitiba and Porto Alegre. Tomato, a food rich in lycopene, did not attain 10% in most income strata.

Table 5 – Relative participation (%) of food in the availability of non-provitamin-A carotenoids (lycopene, lutein and zeaxanthin for families in the Urban Areas. 1 of 4

Food sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	>20 to 30	>30
Lycopene										
Goiania										
Tomato paste	47.0	0.0	37.9	9.3	55.1	7.8	36.0	5.7	0.0	12.6
Tomato Sauce	23.0	19.3	6.1	27.2	29.8	6.8	7.6	9.2	11.6	49.5
Papaya	9.9	12.5	11.8	0.0	7.8	23.4	18.6	20.7	33.3	2.4
Tomato	8.7	11.7	3.4	7.8	4.0	10.1	6.9	3.3	23.6	2.4
Watermelon	8.3	42.6	30.8	42.9	0.0	27.5	27.3	59.4	0.0	0.1
Other prepared foods	2.1	11.4	0.8	0.0	2.4	0.0	0.0	1.3	17.0	20.2
Guava	0.0	0.0	5.0	4.9	0.0	23.8	3.1	0.0	0.0	0.0
Total	99.0	97.5	95.8	92.1	99.1	99.4	99.5	99.6	85.5	87.2
Brasilia-DF										
Tomato Sauce	36.0	22.9	51.5	47.5	7.5	34.6	35.7	46.3	29.8	10.6
Watermelon	32.0	26.0	4.1	20.2	39.6	23.4	11.5	9.7	14.1	11.9
Guava	13.4	3.8	5.9	0.0	6.0	3.1	6.4	1.4	6.6	9.4
Papaya	9.2	12.5	12.6	10.4	19.1	10.5	13.9	11.3	16.9	18.2
Tomato	3.7	4.0	3.7	5.6	8.4	3.0	5.9	5.8	3.4	2.4
Tomato paste	2.7	24.2	9.0	8.1	10.4	16.7	16.2	13.9	21.0	1.3
Other prepared foods	1.8	1.2	6.9	0.2	4.0	5.2	8.3	7.6	4.3	15.6
Frozen food	1.0	5.1	4.9	8.1	5.0	2.7	2.0	3.9	2.8	30.5
Total	99.8	99.7	98.6	100.1	100.0	99.2	99.9	99.9	98.9	99.9
Belém do Pará										
Tomato Sauce	24.7	28.7	20.4	13.2	0.0	5.1	100.0	0.0	22.3	0.0
Papaya	16.3	2.3	5.8	13.2	20.9	1.6	0.0	0.0	0.0	0.0
Watermelon	12.0	6.7	38.5	0.0	40.7	0.0	0.0	0.0	55.2	0.0
Guava	8.0	18.4	17.9	61.6	0.0	92.1	0.0	100.0	0.0	0.0
Tomato paste	7.1	34.0	5.5	0.0	24.1	0.0	0.0	0.0	0.0	95.1
Tomato	6.0	4.2	5.1	2.9	14.3	1.1	0.0	0.0	22.4	4.9
Total	74.1	94.3	93.2	90.9	100.0	99.9	100.0	100.0	99.9	100.0
Fortaleza										
Guava	38.8	44.7	47.0	24.8	27.1	48.6	3.1	0.0	23.9	0.0
Watermelon	16.2	10.4	21.6	9.0	11.2	0.0	17.2	18.4	13.2	13.1
Papaya	15.0	13.2	10.6	19.5	18.5	23.9	18.3	12.9	33.6	8.3
Tomato paste	11.0	11.3	0.0	0.0	0.0	0.0	1.6	16.6	0.0	42.8

Table 5 – Relative participation (%) of food in the availability of non-provitamin-A carotenoids (lycopene, lutein and zeaxanthin for families in the Urban Areas.

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Food sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	>20 to 30	>30
Lycopene										
Tomato Sauce	7.8	12.2	13.2	33.7	36.5	25.2	53.0	35.8	23.6	10.0
Tomato	5.2	3.6	3.1	5.3	4.5	2.2	3.1	3.5	4.7	2.7
Total	94.0	95.4	95.5	92.3	97.8	99.9	96.3	87.2	99.0	76.9
Recife										
Tomato Sauce	46.0	23.6	39.1	11.8	18.4	36.1	9.9	15.1	29.3	29.2
Tomato paste	25.8	23.0	7.3	20.9	24.5	29.6	29.1	11.9	31.4	0.0
Papaya	8.2	11.7	13.7	22.0	23.3	8.6	27.3	25.8	14.2	63.1
Watermelon	7.3	14.5	8.5	33.4	12.9	17.1	10.5	0.0	11.2	0.0
Guava	6.3	15.0	12.4	3.0	1.5	0.0	16.3	35.9	2.4	0.0
Tomato	4.3	4.7	3.4	5.6	4.2	5.6	3.4	2.6	3.7	5.3
Total	97.9	92.5	84.4	96.7	84.8	97.0	96.5	91.3	92.2	97.6
Salvador										
Watermelon	33.1	8.4	22.9	25.9	17.6	22.3	18.2	20.4	11.7	29.3
Tomato paste	25.4	32.6	20.0	27.9	34.4	3.6	37.3	7.1	20.7	0.0
Tomato Sauce	25.2	37.5	24.2	21.9	26.9	49.7	29.9	37.9	12.7	3.9
Guava	5.5	5.0	17.9	6.2	0.0	7.8	2.2	5.9	10.1	29.4
Papaya	4.0	8.8	6.3	15.2	13.8	9.5	11.2	23.9	41.1	21.2
Total	93.2	92.3	91.3	97.1	92.7	92.0	98.8	95.2	96.3	83.8
Rio de Janeiro										
Tomato Sauce	48.3	50.7	45.5	40.1	37.6	56.8	49.7	26.0	33.3	60.5
Tomato paste	18.5	18.0	26.5	18.0	10.9	21.9	16.2	7.0	21.0	7.0
Papaya	10.7	4.0	11.9	8.9	9.0	6.7	6.8	30.3	8.5	5.5
Watermelon	8.3	9.0	4.3	20.0	12.3	5.7	10.0	14.4	8.4	9.1
Tomato	4.7	4.0	3.0	2.6	3.9	2.2	2.7	9.0	3.3	3.6
Guava	2.5	2.6	0.5	5.4	6.1	1.9	1.6	0.0	5.9	0.0
Other prepared foods	1.9	2.7	4.6	2.2	14.1	2.3	5.3	11.9	11.9	9.1
Total	94.9	91.0	96.3	97.2	93.9	97.5	92.3	98.6	92.3	94.8
Sao Paulo										
Tomato Sauce	69.1	64.0	38.3	64.9	35.8	33.3	39.5	32.5	27.2	40.9
Papaya	10.0	9.6	7.8	14.8	18.4	22.4	9.8	4.2	25.7	19.5
Watermelon	3.5	12.9	24.8	1.7	20.9	22.0	13.6	42.8	14.6	10.5
Other prepared foods	0.7	3.8	2.7	9.5	7.7	13.3	7.5	9.9	21.3	13.4
Frozen food	0.0	3.2	15.8	1.8	2.9	1.5	14.3	3.8	3.1	2.3
Total	83.3	93.5	89.4	92.7	85.7	92.5	84.7	93.2	91.9	86.6
Curitiba										
Tomato paste	43.5	38.8	12.3	1.5	25.3	9.5	9.2	27.9	5.0	6.4
Tomato Sauce	36.7	33.5	66.9	77.6	51.0	53.0	60.6	45.5	43.2	47.5
Papaya	6.2	18.8v	5.8	3.9	8.4	5.1	6.6	17.9	12.1	22.9
Guava	3.6	0.0	1.0	2.1	0.0	0.0	2.8	0.0	0.0	15.3
Watermelon	3.6	0.0	6.5	1.1	6.1	26.2	8.2	0.0	28.9	0.0
Tomato	1.8	3.1	2.5	2.5	4.4	1.8	2.7	2.4	4.2	7.4
Total	95.4	94.2	95.0	88.7	95.2	95.6	90.1	93.7	93.4	99.5
Porto Alegre										
Tomato Sauce	52.3	46.4	48.0	20.3	21.1	22.0	22.0	15.6	54.1	12.5
Watermelon	18.0	20.2	1.4	34.0	8.2	21.8	4.3	4.9	0.0	0.0
Tomato paste	13.9	11.0	21.1	16.9	19.0	15.4	13.3	4.5	7.0	2.7
Papaya	10.6	8.2	11.1	12.3	11.7	18.5	22.4	19.0	12.0	34.2
Tomato	4.0	4.9	5.4	2.6	7.3	2.7	4.6	5.0	4.0	6.2
Other prepared foods	1.2	5.9	6.7	12.9	22.5	10.1	28.6	41.7	22.8	44.2
Total	100.0	96.6	93.7	99.0	89.8	90.5	95.2	90.7	99.9	99.8
Lutein and zeaxanthin										
Goiania										
Kale	12.6	7.1	19.3	17.1	3.5	0.0	15.2	42.5	12.8	0.0
Scallion/parsley	11.8	4.3	5.4	21.9	2.7	12.4	30.6	10.8	2.7	0.0

Table 5 – Relative participation (%) of food in the availability of non-provitamin-A carotenoids (lycopene, lutein and zeaxanthin for families in the Urban Areas.

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Food sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	>20 to 30	>30
Lutein and zeaxanthin										
Chicken egg	8.5	11.4	6.9	7.3	13.8	13.1	5.4	4.0	6.6	13.7
Cornmeal	6.6	0.6	3.1	1.7	17.7	5.4	0.0	0.0	0.0	0.0
Lettuce	6.0	2.0	7.7	12.0	6.5	0.0	9.4	2.2	6.3	15.4
Common squash	3.6	37.0	4.1	6.1	1.9	6.9	6.2	6.7	7.8	18.6
Pear-orange	1.3	1.0	3.3	0.3	5.3	4.0	1.2	0.6	1.6	12.3
Cauliflower	0.0	0.0	0.9	0.0	2.3	5.1	0.0	0.0	13.1	0.0
Total	50.4	63.4	50.7	66.4	53.7	46.9	68.0	66.8	50.9	60.0
Brasilia (DF)										
Scallion/parsley	28.6	18.6	11.0	23.8	16.2	7.7	10.9	7.3	6.8	11.4
Chicken egg	9.3	7.6	11.4	4.8	9.6	6.4	9.4	8.3	9.0	7.2
Corn flakes	7.4	14.0	25.5	14.0	7.7	20.0	9.0	28.3	5.1	15.2
Common squash	7.0	9.9	8.5	10.6	10.5	5.9	6.4	6.6	3.7	4.5
Kale	3.9	3.2	1.8	11.5	6.4	4.2	7.0	5.3	9.8	4.7
Cornmeal	1.7	16.4	3.8	1.1	11.8	0.0	4.1	0.0	2.2	5.5
Cauliflower	1.3	0.5	1.3	0.0	1.0	1.2	0.5	3.3	12.5	3.1
OFFV	0.7	1.5	1.3	3.0	3.7	3.6	2.0	14.6	13.3	3.4
Chard	0.0	0.0	0.0	0.0	0.0	15.7	3.1	0.0	5.1	0.0
Total	59.9	71.7	64.6	68.8	66.9	64.7	52.4	73.7	67.5	55.0
Belém do Para										
Kale	31.2	0.0	7.6	0.0	22.6	0.0	0.0	0.0	17.5	25.5
Scallion/parsley	30.1	60.9	41.3	33.9	45.6	25.3	47.5	0.0	20.5	40.3
Chicken egg	12.9	7.4	7.4	15.0	13.1	18.3	6.7	28.1	16.7	12.0
OFFV	4.7	13.2	12.8	20.6	0.0	0.0	7.1	0.0	2.9	0.0
Total	78.9	81.5	69.1	69.5	81.3	43.6	61.3	28.1	57.6	77.8
Fortaleza										
Scallion/parsley	49.3	51.9	40.4	54.7	37.4	9.9	25.2	6.7	37.0	26.0
Chicken egg	17.7	15.2	12.6	6.5	9.8	17.7	11.3	12.5	5.4	14.3
Cornmeal	5.1	6.8	11.9	0.4	16.7	4.9	11.5	0.0	0.0	0.0
Kale	2.6	0.6	1.0	0.0	0.0	18.0	0.0	24.0	7.6	0.0
Corn flakes	1.4	4.5	12.5	15.6	4.4	12.3	4.0	6.6	10.5	0.0
Total	76.1	79.0	78.4	77.2	68.3	62.8	52.0	49.8	60.5	40.3
Recife										
Cornmeal	26.6	28.3	16.3	13.4	6.6	9.5	2.5	2.0	6.0	4.4
Corn flakes	22.0	20.6	29.5	46.2	14.6	18.7	29.3	27.5	7.4	21.2
Chicken egg	10.5	9.9	10.3	9.4	11.1	9.8	13.0	7.8	17.8	3.5
Scallion/parsley	5.8	1.1	2.5	1.3	0.0	4.5	7.1	3.8	15.0	6.0
OFFV	5.7	9.0	5.4	5.4	9.9	11.0	6.2	6.6	10.3	6.2
Total	70.6	68.9	64.0	75.7	42.2	53.5	58.1	47.7	56.5	41.3
Salvador										
Chicken egg	16.2	10.2	12.4	8.0	6.2	24.8	17.6	6.3	5.5	3.9
Corn flakes	16.1	12.8	8.8	12.2	12.9	11.4	3.2	1.5	0.0	3.6
Scallion/parsley	14.0	14.7	13.1	8.0	14.0	8.8	18.9	15.4	7.6	12.4
OFFV	10.7	10.4	10.3	5.0	5.4	10.3	7.7	14.2	35.9	9.1
Kale	4.5	4.7	11.3	10.9	22.4	6.1	11.5	9.0	20.6	5.4
Total	61.5	52.8	55.9	44.1	60.9	61.4	58.9	46.4	69.6	34.4
Belo Horizonte										
Kale	23.0	27.9	17.3	23.3	18.0	17.0	20.2	45.8	19.9	15.9
Common squash	14.6	6.9	11.2	9.8	9.6	7.0	9.6	3.9	8.7	7.6
Chicken egg	9.7	10.4	5.8	8.9	7.4	17.5	8.3	6.5	10.4	10.3
Cornmeal	8.6	10.5	8.1	4.9	17.8	3.9	4.7	0.0	0.0	0.0
Scallion/parsley	7.1	4.6	7.5	4.6	6.6	1.5	11.6v	5.5	8.0	4.6
Total	63.0	60.3	49.9	51.5	59.4	46.9	54.4	61.7	47.0	38.4

Table 5 – Relative participation (%) of food in the availability of non-provitamin-A carotenoids (lycopene, lutein and zeaxanthin for families in the Urban Areas. 4 of 4

Food sources	Monthly revenue (MW)									
	Up to 2	>2 to 3	>3 to 5	>5 to 6	>6 to 8	>8 to 10	>10 to 15	>15 to 20	>20 to 30	>30
Lutein and zeaxanthin										
Rio de Janeiro										
Cornmeal	14.4	4.8	9.5	6.2	3.6	10.3	3.2	2.1	1.0	2.2
Chicken egg	12.7	16.2	10.1	10.6	13.8	15.4	8.5	10.7	4.0	7.9
Kale	12.4	16.1	15.1	11.0	13.2	8.8	12.3	12.8	14.9	18.7
Scallion/parsley	10.1	9.5	8.9	19.0	7.4	8.0	14.2	7.1	1.5	9.4
OFFV	7.1	5.2	6.7	5.9	4.7	11.1	6.6	12.2	4.9	8.0
Corn flakes	1.7	1.2	1.2	1.2	0.0	6.2	2.2	0.0	32.4	2.8
Cauliflower	1.1	6.3	5.0	4.8	3.3	0.0	5.3	4.7	10.3	12.8
Total	59.5	59.3	56.5	58.7	46.0	59.8	52.3	49.6	69.0	61.8
São Paulo										
Kale	19.7	15.8	9.8	25.0	9.9	7.5	11.0	7.1	9.5	9.1
Chicken egg	10.6	12.4	8.8	8.7	7.1	8.1	4.9	4.3	3.6	5.6
OFFV	7.4	3.8	13.6	4.4	6.0	11.9	11.9	9.7	26.4	15.7
Scallion/parsley	5.9	5.3	14.0	6.8	7.9	6.1	5.5	14.9	3.3	4.3
Corn flakes	4.8	4.4	1.4	0.0	6.8	18.2	3.1	16.5	1.7	0.7
Corn grain	2.9	5.1	4.8	6.1	7.0	3.2	5.8	10.8	7.8	3.5
Chard	2.4	0.0	5.0	7.7	4.8	0.0	17.8	9.1	7.0	19.0
Total	53.7	46.8	57.4	58.7	49.5	55.0	60.0	72.4	59.3	57.9
Curitiba										
Corn grain	22.7	1.0	10.8	2.9	5.8	34.1	2.4	2.6	9.7	2.3
Cornmeal	12.8	6.1	12.6	2.5	1.9	6.9	3.7	5.7	6.8	0.0
Corn flakes	9.4	0.0	1.0	0.0	14.7	8.8	1.7	47.5	4.3	55.1
Chicken egg	6.8	5.3	8.0	10.5	11.2	8.1	6.5	2.2	9.1	2.8
Kale	6.5	12.2	10.9	0.0	3.9	3.8	23.3	8.9	5.8	0.0
Scallion/parsley	2.8	13.4	12.7	10.2	13.5	7.9	11.9	2.5	8.0	4.4
Chard	0.0	26.1	5.2	0.0	10.1	0.0	0.0	0.0	0.0	0.0
Total	61.0	64.1	61.2	26.1	61.1	69.6	49.5	69.4	43.7	64.6
Porto Alegre										
Scallion/parsley	16.4	3.6	7.7	6.5	4.8	8.8	7.7	5.8	6.4	5.5
Kale	12.7	19.5	22.2	6.6	12.6	2.0	13.2	9.0	0.0	5.5
Lettuce	12.5	6.3	11.4	5.7	4.3	4.1	6.7	3.3	4.8	7.1
Chicken egg	10.5	18.0	11.2	10.0	11.3	11.0	15.3	8.2	10.4	7.5
OFFV	4.1	2.5	3.1	4.6	18.5	11.8	11.5	22.3	30.0	33.2
Total	56.2	49.9	55.6	33.4	51.5	37.7	54.4	48.6	51.6	58.8

Note: MW: Minimum Wage; OFFV: other leafy and floral vegetables.

Lutein and Zeaxanthin

Scallion/parsley, kale, chicken eggs, cornmeal, and cornflakes were the foods that most significantly contributed to the supply of lutein and zeaxanthin (Table 5).

In Belem, the scallion/parsley combination and chicken eggs were the greatest contributors to these oxycarotenoids. In addition, kale stood out with a share of 10% (≤ 2 , >6 to 8, and >20 MW). The food group “other leafy and floral vegetables” became important in households with incomes between >2 MW and ≤ 6 MW.

In Fortaleza, besides the scallion/parsley and chicken egg, other foods were important in the global supply of these carotenoids. The cornmeal and corn flakes, considered together, reached significant percentages from stratum >3 MW and up to >10 to 15 MW. Recife’s highest contribution percentages came from cornmeal, cornflakes, and eggs. In Salvador, the main sources were eggs, cornflakes, scallion/parsley, other leafy and floral vegetables, and kale.

In the Southeast region, kale was the food that most contributed to the supply of lutein and zeaxanthin. In Belo Horizonte, chicken eggs, common squash, and cornmeal were complementary. In Rio de Janeiro, kale and chicken eggs contributed the most to the supply of carotenoids. Other foods that contributed more than 10% were cornmeal, scallion/parsley, other leafy and floral vegetables, cornflakes, and cauliflower; the latter was important only for strata >20 MW. In the UA of Sao Paulo, the supply of lutein and zeaxanthin involved a broader list of foods. Thus, kale and other leafy and floral vegetables, had the greatest relative contribution, followed by chicken eggs, scallion/parsley, corn flakes, corn grain, and chards.

In the South, Curitiba obtained lutein and zeaxanthin from sources such as scallion/parsley, corn, cornmeal, cornflakes, chicken eggs, kale, and chard. Together, these contributed between 43.1 and 71.3% of the total carotenoids. In Porto Alegre, kale and chicken eggs were the most important suppliers of lutein and zeaxanthin, and the availability of these carotenoids from other leafy and floral vegetables was important for strata >6 MW.

In the Central-West region, lutein and zeaxanthin were provided by kale and chicken eggs (Goiania), parsley/scallion (Brasilia-DF and Goiania), and corn flakes (Brasilia-DF). Other foods had a relative participation above 10% in certain income strata, i.e., common squash, cornmeal, cauliflower, other leafy and floral vegetables, chard, lettuce, canned green corn, and pear-oranges.

The present results contain some obvious limitations due to the difference between home availability and effective individual consumption, in addition to home processing methods, horticultural practices, and large edaphoclimatic factors. Nevertheless, home availability data permit the establishment of populational feeding patterns and the comparison of their evolution over time [36]. Another important limitation of this study stems from the regionality of eating habits and the difficulty of identifying every food item of the widely diverse Brazilian diet.

The Brazilian and Global Panoramas

The few studies [37-42] that have been conducted using a sub-sample of the same national survey employed in this study. Whereas the present study seeks to address home availability of carotenoids, the cited works aim at determining actual intakes. Given also that our objective was to characterize the major urban centers of the survey, comparisons of data using whole-country or geopolitical region cross-sectional approaches may render such comparisons somewhat difficult to interpret. Our study limited itself to describe the flow of food carotenoid sources into the kitchens of Brazilian homes in each of the 11 UAs and spread them across 11 income brackets.

Padovani and Amaya-Farfan (2006) [43], based on the food acquisition of the 1995/96 POF, for instance, a study revealed that carotenoid household availabilities in urban areas was low [43]. However, β -cryptoxanthin availabilities greater than 0.30 mg/day were observed in the regions of Goiania (0.34), Brasilia-DF (0.41), Curitiba (0.33) and Porto Alegre (0.32 mg/day) in the income range >30 MW.

Morato and Silva [37] analyzed the availability of carotenoids in large regions of Brazil in 2002-2003. The authors found that the values identified were below those indicated in the literature for the reduction of the risk of chronic diseases. Regarding β -carotene, the intake varied between 0.55 and 2.89 in rural and urban areas, α -carotene between 0.09 and 0.27 and β -cryptoxanthin between 0.04 and 0.21, lycopene between 0.46 and 1.5, and lutein/zeaxanthin between 0.3 and 1.84mg/day.

A third study, Gaino and Silva [38] compared the availabilities in Brazilian geopolitical regions in rural and urban households between 2002/03 and 2008/09. They found that the availability of

β -carotene and lutein/zeaxanthin was higher in rural areas contrasting with the higher access to α -carotene, β -cryptoxanthin, and lycopene in urban areas. The average availability of carotenoids, despite the increase in 2000/09, was still not significant in Brazilian households.

More recent studies on personal carotenoid intake, including total and some of the specific carotenoids of the present study, α -carotene, β -carotene, lycopene, and lutein, have shown that consumption was higher among subjects in the highest income brackets, whereas those of β -cryptoxanthin and zeaxanthin were higher at the lowest income group [40]. In another study, it was found that the median (25th–75th percentiles) of energy-adjusted total carotenoid intake in 2017–2018 was 12.2 (6.0–22.6) mg/1000 kcal/d, and increased in 3.7mg/d from 2008 to 2009. The carotenoids most highly consumed were β -carotene, lutein, and lycopene [41].

In another study on the consumption of bioactive compounds across the geopolitical regions, the same authors found the highest intakes of β -carotene, lycopene, neoxanthin, violaxanthin and total carotenoids in the Midwest region. The North region, on the other hand, exhibited the lowest energy-adjusted intakes of total carotenoid, β -carotene, lycopene, neoxanthin and violaxanthin [42].

Foreign studies [44,45] made it possible to estimate the mean carotenoid intake of Spaniards between 18 and 64 years old. They estimated the intakes of 0.27, 1.49, 0.32, 3.06, and 1.24mg/day of α -carotene, β -carotene, β -cryptoxanthin, lycopene, and lutein/zeaxanthin, respectively.

In Italy, the mean intake was estimated to be 0.15, 2.60 and 0.17, mg/day of α -carotene, β -carotene, and β -cryptoxanthin, respectively. Women consumed 2.21 and men 2.27mg/day of lutein and zeaxanthin. Men consumed 6.54 whereas women 2.21mg/day of lycopene [46]. In Luxemburg, national daily per capita intake was assessed as 7.6 mg/day of α - and β -carotene, 1.4mg/day of β -cryptoxanthin, 1.8mg/day of lycopene, 1.5mg/day of lutein, and 0.3mg/day of zeaxanthin [47].

In Canada and the United States, estimates of food intake for Afrocanadians have been reported to be 0.42, 3.30, 0.11, 2.14, and 2.46mg/day for α -carotene, β -carotene, β -cryptoxanthin, lycopene, and lutein/zeaxanthin, respectively. For non-Afroamericans, mean intakes of 0.56, 3.40, 0.14, 4.10, and 2.29mg/day of α -carotene, β -carotene, β -cryptoxanthin, lycopene, and lutein/zeaxanthin, respectively, have been estimated [48].

It is noteworthy that, in relation to β -carotene, lycopene and lutein/zeaxanthin, the availability values were lower in all regions and income brackets than the intakes reported by foreign countries. The availability of α -carotene estimated in our study was higher in most regions and income brackets than in Italy, while In Spain, our availabilities turned out lower for most income brackets in most regions than their intake values.

During the International Year of Fruits and Vegetables (FV) in 2021, the importance of encouraging the production and improvement of the supply and marketing strategies of these foods was emphasized for ensuring food and nutritional security [49]. Factors external to communities and individuals, of social, economic, and political nature, can decisively affect the supply and access of foods thus impacting the nutritional situation of the population. To effectively increase the consumption of FV, it is therefore necessary to align the entire food system, including food quality, with education, social assistance, the environment, and general living standards of the population [50].

CONCLUSION

The study of family acquisitions of carotenogenic foods identified the main foods present in large Brazilian Urban Areas as sources of the most relevant carotenoids for good health in a year

immediately prior to the Coronavirus Disease 2019 (COVID-19) pandemic. With rare exceptions, the acquisitions appeared to be low, independent of family income. Exceptions were Salvador (for all carotenoids studied), Belem (for β -carotene and lutein/zeaxanthin), Belo Horizonte (for β -cryptoxanthin and lycopene), and Porto Alegre (for β -cryptoxanthin) in the highest income groups. The main foods identified that contributed to the supply of carotenoids in the surveyed regions were carrots and common squash (α -carotene), common squash, carrot, scallion/parsley, mango, and tomato (for β -carotene), papaya, orange, and tangerine (for β -cryptoxanthin), tomato sauce, tomato paste, guava, watermelon and papaya (for lycopene), and scallion/parsley, kale, egg, cornmeal, and corn flakes (for lutein/zeaxanthin). The acquisition of sources containing key carotenoids estimated in the present study suggests that the population were ironically under considerable risk to contract chronic diseases given the low acquisition of key carotenoids in health in the households of these urban centers, especially among families with lower income. Given that our results on home availability by UAs are consistent with those on individual consumption of the Brazilian population by other authors, we can only emphasize the need to make fruits and vegetables more accessible through public policies that include firstly education.

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