Procurement of β-carotene, lycopene, lutein and zeaxanthin in households of Brazil's urban areas

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An assessment was made of the consumer accessibility by income to carotenoids in the eleven major Brazilian urban centers. The consumption data published by the POF (National Household Budget Survey, 1995-1996) and the Brazilian database on food carotenoids provided the basis for the study. The USDA-NCC Carotenoid Database for US foods was used whenever the carotenoid content was not found locally. Prudent individual daily intakes of beta-carotene (3 to 6mg), pro-vitamins A (5.2 to 6mg) and total carotenoids (9 to 18mg) were far from attained by the poorer households in all of the regions studied, but the availability rose as the level of income increased in all regions. The principal foods identified, which significantly contributed to the carotenoid supply were: (β-carotene) carrots, squash, mango and tomato, (lycopene) tomato, tomato sauce, watermelon and papaya, (lutein and zeaxanthin) corn flour, kale, lettuce and orange. The study suggests that consumption of carotenogenic foods in Brazil may have been low at the time, despite the wide natural distribution and abundance in the country. The implications that low consumption of carotenogenic foods may have on public health came to be better known in more recent years, but the data should be useful when comparing with the 2002/2003 POF.

Key words: Brazilian national consumption survey, carotenoids, fruit and vegetable consumption, food habits and income, nutrition education

Aquisição de β-caroteno, licopeno, luteína e zeaxantina em domicílios urbanos brasileiros

A disponibilidade dos carotenóides provitamínicos-A, licopeno, luteína e zeaxantina foi determinada e analisada segundo a renda nos domicílios de nove regiões metropolitanas brasileiras, no município de Goiânia e no Distrito Federal. Utilizaram-se para tanto os dados publicados pela Pesquisa de Orçamento Familiar 1995-1996 e a base nacional de dados em carotenóides. Quando o teor de carotenóides de um gênero não era encontrado, consultou-se a *USDA-NCC Carotenoid Database for US Foods*. As ingestões individuais diárias prudentes de beta-caroteno (3 a 6mg), carotenóides provitamínicos-A (5,2 a 6mg) e carotenóides totais (9 a 18mg) não puderam ser alcançadas em qualquer uma das regiões, mas a disponibilidade aumentou de acordo com os recebimentos em todas as regiões estudadas. Os principais alimentos identificados que contribuíram para o fornecimento de carotenóides nas regiões pesquisadas foram: cenoura, abóbora, manga e tomate (beta-caroteno), tomate, massa de tomate, melancia e mamão (licopeno) e fubá de milho, couve, alface e laranja (luteína e zeaxantina). O levantamento sugere que à época, existia baixo consumo de carotenóides de origem alimentar no Brasil, apesar de sua ampla abundância natural no país. As implicações que esse tipo de abstenção alimentar pode trazer para a saúde da população tornaram-se bem conhecidas em anos mais recentes, porém os dados podem ser úteis quando se fizer comparação com os das POF 2002/2003.

Palavras-chave: carotenóides, disponibilidade, POF, consumo de frutas e verduras, hábitos alimentares.

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Introduction

Epidemiological studies indicate that an abundant consumption of fruits and vegetables is associated with a low incidence of cancer, cardiovascular and age-related degenerative diseases (Block *et al.*, 1992; Willet, 1994; Ames *et al.*, 1995). Despite this important relationship between diet and health, Brazil like many other countries lack nation-wide data on the consumption of carotenoids as health indicators.

Among the more than 600 carotenoids encountered in nature, α-carotene, β-carotene, lycopene, lutein, zeaxanthin and β-cryptoxanthin are the major members of this family found in our diet, with β-carotene, α-carotene and β-cryptoxanthin exhibiting vitamin-A activity.

Besides the provitamin-A functionality of this restricted group, a general antioxidant and protecting activity to the human body is widely recognized, increasing immunocompetence and inhibiting the occurrence of mutagenesis and pre-malignant lesions. In general, carotenoids protect animal tissues by virtue of their physical-chemical properties by means of one or more of the following mechanisms: extinction of singlet oxygen species, quenching of peroxyl radicals, modulation of the metabolism of carcinogenic substances, inhibition of abnormal cell proliferation, enhancement of retinoid-mediated cell differentiation, stimulation of inter-cellular communication, enhancement of the immune response and blue light filtration (Olson, 1999). The ability that certain carotenoids to inhibit non-photochemical fluorescence and function as ancillary pigments in the macula of primates, has also been reported, while the consumption of lutein and zeaxanthin is associated with a lower risk of macular degeneration and cataract (Mares-Perlman *et al.*, 2002; Moeller et al., 2000).

Presently, the Institute of Medicine (2000) has not issued official recommendations for the ingestion of carotenoids. There are, however, statements alerting about the "prudent levels of ingestion" commensurate with good health, endorsed by US federal agencies and other organizations that recommend reasonable ingestions of fruits and vegetables. Based on population studies, the IOM suggests a daily prudent ingestion of 3 to 6mg of β-carotene from food sources, in order to maintain plasma levels within the range that is associated with a low risk of chronic diseases. Thus, food guides in the United States and the National Cancer Institute advice that adhering to the proposed diet would be equivalent to consuming from 5.2 to 6mg/day of provitamin-A carotenoids, from a varied diet containing fruits and vegetables (Lachance, 1997). Canadian food guides in turn recommend similar intakes (Health Canada, 1997), while other health institutes based on food consumption recommend approximately from 9 to 18mg/day (WCRF/AICR, 1997).

The Brazilian National Household Budget Survey (*Pesquisa de Orçamento Familiar*, POF) is a nation-wide direct food purchase survey, useful as an indirect estimate of food consumption by the population.

The present study analyzes the POF (1995-1996) data from the point of view of the household availability of carotenoids, particularly with regard to β-carotene, lycopene, lutein and zeaxanthin, in the nine contemporary Brazilian metropolitan regions, the Federal District and the municipality of Goiania. It was also desirable to identify the food items that most significantly contributed to the intake of such substances, according to ten revenue brackets in the population.

Methodology

The adopted procedure utilized the data on food purchases by 16,013 households (household availability) of the *Pesquisa de Orçamento Familiar* (POF 1995-1996; IBGE, 1997), and converted to *per-capita* availability of carotenoids. These data were collected and compiled by sampling the households of 10 metropolitan regions: Rio de Janeiro, Porto Alegre, Belo Horizonte, Recife, São Paulo, Belém, Fortaleza, Salvador, Curitiba, in addition to the Federal District and the city of Goiânia (IBGE, 2001). The survey specified expenses with regard to the family's total revenue, proceeding from wages and otherwise, divided into ten income levels. As a whole, these regions represented 37.7% of all city dwellers and 29.8% of the Brazilian population. Sample size calculation and random sorting of the households followed procedures described on pages 13-17 (IBGE, 1997). Among the limitations of the survey's data it is pertinent to mention the lack of information on availability by individual and the precise amount of the purchased food to be consumed (Helsing, Becker, 1991).

The levels of total income were ranked in terms of multiples of the Minimum wage (MW=R$112,00) and re-grouped into the following strata: up to 2MW, 2-3, 3-5, 5-6, 6-8, 8-10, 10-15, 10-15, 15-20, 20-30 and more than 30MW (IBGE, 2001).

In order to determine the *per-capita* food consumption for every household, per year, the IBGE divided the sum-total of food products acquired along the year by the number of individuals in each category. The information was collected by means of data sheets denominated "*Cadernetas de Despesa Coletiva*-POF 3", where detailed daily information was entered along seven consecutive days, including the description of the products characteristics, quantity, units, amount paid and place of purchase.

The groups of products were those acquired with the specific purpose of consumption within the household and included: cereals and legumes, leafy vegetables, fruits, coconut, nuts, flours, fecula and pasta, breads, meats, offal, fishes, birds and eggs, milk products, sugar and sugary products, salts and condiments, fats and oils, beverages and infusions, ready-to-eat foods, industrialized mixtures, among others. Some products did not have their consumption recorded due to incomplete information about quantity, representing 10.92% of the total expenses with food (IBGE, 1997).

Food carotenoid database

The carotenoid contents of the food items were preferentially those obtained and compiled by the carotenoid laboratory of the State University of Campinas, Brazil, and several others of Brazilian origin acquired by modern and accurate methods. When no Brazilian data were available on a specific food item, the USDA-NCC Carotenoid Database for U.S. Foods were used (Holden *et al.*, 1999). Details on the selection of the data for individual food items are available elsewhere (Padovani, 2003). A Microsoft Excel worksheet was designed for correcting the actual amounts purchased of those foods whose edible portion was not 100% (Silva, Monerat, 1986) into the possibly ingested portions and subsequently converting these into amounts of carotenoids ingested.

Food items purchased in minute amounts by the families were not itemized by the IBGE. For such miscellaneous or unidentified food items termed as "others" by the automatic recovery system (SIDRA of the IBGE), the average nutrient content of the specific food list of the IBGE was used (Padovani, 2003).

Results

Carotenoids

The household availability of the five most abundant food carotenoids acquired in the nine metropolitan regions of Brazil and the cities of Brasília-DF and Goiânia, are shown in Table 1. From these general data it became evident that the availability of β-carotene was low for the poorer strata of the population. Over-all, the procurement ranged from 189μg (São Paulo, revenue bracket ≤2MW) to 2654μg (São Paulo, bracket 20 – 30MW).

Considering the procurement for α-carotene, sources ample variation was also observed. Access to this carotenoid ranged from 26μg (São Paulo, ≤2MW) to 559μg per day (Belo Horizonte, 2 to 3 MW). With respect to β-cryptoxanthin, the lowest procurement (27μg) was found in Recife (≤2MW) while the highest was in Salvador (447μg), in families of more than 30MW.

The daily procurement for lycopene sources varied from 169 (Fortaleza, families with ≤2MW, to 3640μg (Salvador, stratum with >30MW). Furthermore, the daily procurement of zeaxanhtin and lutein, together, was found to be between 39 in the metropolitan region of Belém (≤2MW) and 854μg, in the Federal District (>30MW).

Identification of the principal food sources

Considering that the consumption profile of fruits and vegetables could be indicative of the prevalence of certain pathologies typical of a population and be linked to a socio-economic class, it was deemed important to attempt to identify the principal sources of these nutrients. In each region, the foods responsible for the bulk of the access of each carotenoid by the population were identified. The percent contribution of each food item are apparent in Tables 2, 3 and 4. For the sake of simplicity, only items that at any one revenue level contributed with 3% or more of the total procurement for each carotenoid, were considered.

Table 1: *Per-capita* procurement of the five principal carotenoids (μg/day) in the Brazilian metropolitan regions, Brasília and Goiânia, according to ten strata of family revenue (in multiples of the Minimum wage).

Urban Center and Revenue level (MW)	Micrograms per day				
	β-carotene	α-carotene	β-cryptoxanthin	lycopene	zeaxanthin and lutein
Belém					
< 2	237	35	38	385	39
2 to 3	336	66	37	429	67
3 to 5	354	65	40	530	63
5 to 6	478	101	69	483	110
6 to 8	487	90	59	514	110
8 to 10	520	104	67	696	118
10 to 15	603	166	85	798	126
15 to 20	576	119	93	774	142
20 to 30	797	201	102	730	168
> 30	938	176	156	1178	297
Fortaleza					
< 2	337	56	30	169	88
2 to 3	397	56	39	311	117
3 to 5	558	96	46	399	113
5 to 6	544	131	54	408	119
6 to 8	856	177	86	779	137
8 to 10	1026	280	94	752	158
10 to 15	671	177	81	649	155
15 to 20	750	199	129	817	132
20 to 30	870	208	108	614	157
> 30	1222	333	248	1336	380
Recife					
< 2	656	185	27	496	360
2 to 3	974	194	59	747	488
3 to 5	619	159	62	762	370
5 to 6	1043	326	86	1088	498
6 to 8	944	317	67	882	417
8 to 10	931	293	92	1227	314
10 to 15	1343	406	109	1300	382
15 to 20	906	240	136	1188	336
20 to 30	981	264	161	1562	280
> 30	1561	364	248	2242	468
Salvador					
< 2	473	118	31	641	142
2 to 3	563	141	59	852	160
3 to 5	716	199	57	979	152
5 to 6	687	201	65	1031	139
6 to 8	744	202	64	974	144
8 to 10	995	306	81	1691	166
10 to 15	851	196	75	1196	166
15 to 20	1353	357	165	1760	281
20 to 30	1624	399	169	2140	245
> 30	2225	556	447	3640	600

Table 1: *Per-capita* procurement of the five principal carotenoids (μg/day) in the Brazilian metropolitan regions, Brasília and Goiânia, according to ten strata of family revenue (in multiples of the Minimum wage). (continuation)

Urban Center and Revenue level (MW)	Micrograms per day				
	β-carotene	α-carotene	β-cryptoxanthin	lycopene	zeaxanthin and lutein
Brasília					
< 2	356	147	34	484	116
2 to 3	873	193	53	971	133
3 to 5	598	138	72	988	262
5 to 6	1115	209	101	1217	551
6 to 8	758	217	64	1157	274
8 to 10	1125	293	104	972	575
10 to 15	1352	331	150	1415	604
15 to 20	1223	359	145	1412	455
20 to 30	1391	355	165	1410	464
> 30	1907	412	338	1956	854
Goiânia					
< 2	509	95	60	922	154
2 to 3	844	234	69	1291	170
3 to 5	656	165	63	943	197
5 to 6	995	248	89	1607	280
6 to 8	936	218	96	1676	275
8 to 10	850	188	103	1458	260
10 to 15	1077	283	117	1311	345
15 to 20	1124	290	125	1255	327
20 to 30	1789	439	222	2171	647
> 30	1736	421	341	2617	612
Belo Horizonte					
< 2	502	120	39	513	310
2 to 3	1574	559	91	1525	359
3 to 5	738	240	88	885	296
5 to 6	819	236	118	993	310
6 to 8	942	315	98	896	280
8 to 10	930	279	146	1113	293
10 to 15	968	296	143	1123	406
15 to 20	1371	450	220	1170	426
20 to 30	1223	338	246	1646	455
> 30	1625	468	263	1758	448
Rio de Janeiro					
< 2	457	162	35	438	125
2 to 3	584	206	47	649	150
3 to 5	705	235	63	709	172
5 to 6	649	218	44	802	179
6 to 8	779	275	46	680	257
8 to 10	846	297	78	939	186
10 to 15	775	244	95	715	272
15 to 20	1268	396	139	984	289
20 to 30	952	221	144	1373	392
> 30	1345	450	180	1908	458

Table 1: *Per-capita* procurement of the five principal carotenoids (μg/day) in the Brazilian metropolitan regions, Brasília and Goiânia, according to ten strata of family revenue (in multiples of the Minimum wage). (continuation)

Urban Center and Revenue level (MW)	Micrograms per day				
	β-carotene	α-carotene	β-cryptoxanthin	lycopene	zeaxanthin and lutein
São Paulo	189	26	43	530	184
< 2	368	41	45	706	95
2 to 3	313	62	48	715	154
3 to 5	624	88	109	1040	180
5 to 6	793	121	118	1168	280
6 to 8	593	91	78	617	204
8 to 10	737	118	129	889	250
10 to 15	588	100	133	726	299
15 to 20	2654	207	301	2760	634
20 to 30	1260	191	268	1621	447
> 30					
Curitiba	253	42	59	708	516
< 2	273	38	72	1001	253
2 to 3	391	80	98	833	218
3 to 5	524	103	123	1215	219
5 to 6	375	80	117	823	218
6 to 8	633	121	171	943	377
8 to 10	613	93	176	1296	338
10 to 15	927	259	157	1881	361
15 to 20	786	146	246	1771	360
20 to 30	1144	202	332	1728	378
> 30					
Porto Alegre	421	85	97	843	106
< 2	780	142	82	1590	174
2 to 3	667	145	108	1221	224
3 to 5	566	103	116	1057	273
5 to 6	905	239	143	1357	288
6 to 8	807	166	109	1251	240
8 to 10	925	215	157	1505	292
10 to 15	864	173	228	1781	349
15 to 20	1030	255	246	1031	390
20 to 30	1208	308	321	1685	422
> 30					

Table 2 – Per-cent contribution of foods to the supply of β-carotene to households of the Metropolitan Regions and Municipalities of Goiania and Brasilia-DF.

Food Source	Monthly revenue (MW)									
	Up to 2	2 - 3	3 - 5	5 - 6	6 - 8	8 - 10	10 - 15	15 - 20	20 - 30	>30
Belém	%	%	%	%	%	%	%	%	%	%
Carrots	18.9	19.8	22.6	28.9	26,5	26,2	29,8	28,9	34,3	23,2
Tomato	14.1	12.6	14.9	10.5	12.1	12,3	9,3	13,1	8,0	11,7
Margarine	9.7	7.4	7.5	6.3	6.9	7,6	3,7	10,3	4,3	3,3
Green onions + parsley	6.8	4.3	5.2	4.5	3.5	3,7	3,0	4,3	2,6	3,0
Other tropical fruits	6.3	7.2	7.5	5.5	6.6	6,7	5,3	7,4	10,1	13,2
Fortaleza										
Mango	31.0	27.8	28.7	11.1	29.7	16.7	12.9	10.5	24.3	14.3
Carrots	23.0	16.9	28.2	36.2	28.0	46.7	40.4	46.5	38.3	39.6
Green onions + parsley	11.4	12.0	9.7	7.9	6.2	6.5	6.3	7.0	5.4	3.5
Margarine	6.3	5.5	5.1	6.2	3.3	3.2	5.3	3.7	4.0	3.5
Tomato	6.1	7.2	7.9	6.7	7.5	6.5	10.2	6.4	5.9	6.2
Recife										
Common squash	25.3	15.1	17.1	20.2	29.8	23.4	18.6	21.6	15.7	12.1
Sweetpotato	23.3	36.8	14.4	12.4	8.2	6.2	9.4	8.4	1.5	4.5
Carrots	19.8	16.4	22.9	31.9	26.3	29.8	34.0	20.9	29.6	26.4
Tomato	9.2	7.2	11.0	9.9	7.5	9.9	8.4	8.5	8.7	8.1
Mango	5.5	7.5	7.4	4.7	4.3	6.8	7.8	10.9	6.2	18.6
Salvador										
Carrots	26.8	26.6	24.7	23.9	23.2	20.7	23.7	29.3	23.2	25.1
Common squash	14.1	15.1	22.2	25.6	22.3	31.7	14.9	15.4	19.0	16.7
Mango	11.5	13.6	5.4	10.8	9.4	8.8	10.5	13.1	16.7	15.3
Tomato	11.0	11.6	10.8	10.7	8.6	6.1	10.4	5.8	7.3	7.4
Sweetpotato	6.4	5.2	5.3	1.2	6.1	4.9	9.6	4.3	6.5	5.2
Brasília										
Carrots	38.8	34.2	23.6	27.8	30.9	38.1	31.7	32.6	31.4	28.0
Common squash	33.1	6.8	14.2	5.1	19.2	8.9	10.7	19.1	13.7	9.7
Tomato	7.9	6.7	8.9	5.8	8.8	7.4	5.7	5.6	4.7	6.3
Goiânia										
Carrots	25.2	35.1	31.5	32.5	33.4	26.8	35.6	24.2	29.7	29.8
Other tropical fruits	21.9	13.9	15.2	12.8	13.2	14.8	10.2	13.6	15.2	10.1
Kale	11.7	4.6	10.0	9.4	10.8	11.3	13.4	13.2	14.2	15.5
Tomato	7.5	10.6	6.9	8.8	9.7	8.5	8.4	8.6	7.4	8.0
Common squash	7.5	14.5	12.8	12.1	8.7	12.1	11.3	20.6	13.2	12.9

Table 2 – Per-cent contribution of foods to the supply of β-carotene to households of the Metropolitan Regions and Municipalities of Goiania and Brasilia-DF. (continuation)

Food Source	Monthly revenue (MW)									
	Up to 2	2 - 3	3 - 5	5 - 6	6 - 8	8 - 10	10 - 15	15 - 20	20 - 30	>30
Belo Horizonte	%	%	%	%	%	%	%	%	%	%
Lettuce	21.4	1.8	3.3	3.3	3.2	2.7	3.2	3.5	3.0	3.9
Common squash	21.4	9.2	18.6	17.8	18.0	15.8	19.8	18.1	14.0	16.4
Carrots	16.9	56.1	35.4	31.1	39.7	35.5	30.7	37.3	31.3	31.8
Kale	10.5	2.5	2.3	6.9	3.1	4.3	5.6	6.0	6.1	4.3
Rio de Janeiro										
Carrots	42.7	50.2	39.0	38.2	43.4	48.8	35.5	38.1	27.4	40.3
Common squash	20.0	14.3	20.7	21.7	19.5	15.0	19.7	18.1	12.2	19.0
Tomato	10.2	101	9.5	9.8	7.0	9.8	7.5	6.0	6.6	6.0
Sweetpotato	7.1	4.5	5.6	3.3	3.2	4.4	6.5	2.8	2.0	1.7
São Paulo										
Carrots	18.6	17.7	25.8	18.6	22.8	13.4	19.6	27.5	11.3	21.0
Tomato	14.8	11.2	11.0	9.4	7.0	3.7	7.6	7.3	5.6	8.0
Lettuce	10.2	5.7	6.2	5.0	4.9	2.8	4.6	9.7	2.6	6.3
Kale	9.8	0.0	1.7	8.8	9.9	9.7	8.7	17.3	8.6	6.4
Curitiba										
Mango	21.3	5.9	7.6	19.0	11.3	14.8	20.8	2.9	15.6	24.4
Lettuce	12.4	7.4	10.1	11.2	7.3	9.8	11.6	7.6	11.1	7.5
Tomato	12.2	21.7	13.5	12.2	9.8	9.5	11.9	10.8	10.9	10.1
Corn meal (fubá)	12.0	3.9	1.7	0.9	1.6	1.8	1.3	0.8	1.1	0.3
Carrots	11.8	12.7	33.0	33.7	34.2	26.8	22.3	32.2	27.7	28.3
Porto Alegre										
Carrots	17.2	19.6	30.5	11.6	27.5	24.1	27.5	26.1	25.9	29.3
Common squash	17.2	11.9	7.8	17.3	19.1	11.5	13.1	7.6	16.8	14.6
Mango	14.1	9.5	3.5	0.0	5.8	21.7	9.5	0.0	9.6	9.7
Tomato	8.0	6.2	9.3	8.8	7.7	12.5	10.5	12.6	7.2	7.9
Sweetpotato	7.1	20.2	11.0	13.0	7.5	2.8	6.2	8.9	1.0	0.9

Listing was abridged to contain only food items that would contribute with at least ~6%

Table 3. Per-cent contribution of foods to the supply of lycopene to households of the Metropolitan Regions and Municipalities of Goiania and Brasilia-DF.

Food Source	Monthly revenue (MW)									
	Up to 2	2 - 3	3 - 5	5 - 6	6 - 8	8 - 10	10 - 15	15 - 20	20 - 30	>30
Belém	%	%	%	%	%	%	%	%	%	%
Tomato	52.6	59.8	60.5	63.0	69.7	56.0	42.8	59.3	53.2	55.9
Watermellon	26.6	19.7	18.5	6.7	1.7	10.8	31.5	4.0	11.4	6.8
Papaya (red)	13.2	11.2	10.0	18.7	10.3	12.5	14.8	18.2	9.3	21.2
Fortaleza										
Tomato	73.8	55.9	66.7	54.7	49.7	53.7	63.9	35.7	50.8	34.6
Papaya (red)	11.1	8.0	11.6	13.8	14.2	18.1	12.8	18.6	23.0	36.0
Watermellon	9.0	29.1	14.0	17.3	28.6	13.9	9.6	32.0	10.3	11.2
Recife										
Tomato	74.4	56.9	54.4	57.9	48.9	45.7	52.9	39.5	33.2	34.4
Watermellon	10.4	14.1	14.6	14.3	18.9	14.7	16.1	8.4	24.7	9.6
Tomato paste	7.2	12.6	16.4	12.0	14.7	25.1	12.0	20.1	21.2	25.9
Papaya (red)	4.4	9.4	8.2	9.2	9.6	10.1	11.1	17.8	10.2	16.6
Salvador										
Tomato	49.3	46.7	48.1	43.4	39.9	21.8	45.0	27.0	33.9	27.4
Tomate paste	24.8	20.6	21.6	33.0	19.5	39.5	24.1	27.5	26.3	37.3
Watermellon	17.7	22.5	19.1	9.1	29.3	29.6	20.1	23.8	23.2	22.1
Brasília										
Tomato paste	51.0	30.2	19.6	19.2	35.2	6.8	29.5	40.2	28.0	10.6
Tomato	35.2	36.6	32.7	32.5	34.9	51.9	33.0	29.4	28.4	37.5
Watermellon	7.0	27.2	40.3	39.0	23.4	25.6	20.7	19.3	30.5	27.4
Papaya (red)	5.0	3.8	5.2	6.6	4.5	11.3	9.4	6.9	8.3	16.3
Goiânia										
Watermellon	32.9	25.4	22.5	35.2	36.9	39.4	18.6	12.4	21.5	33.4
Tomato paste	27.2	18.7	36.2	21.5	18.7	16.5	23.8	19.7	17.2	11.7
Tomato	25.2	42.1	29.2	33.0	33.0	30.2	41.8	46.5	36.9	32.4
Other tropical fruits	10.2	7.6	8.9	6.7	6.2	7.2	7.0	10.3	10.5	5.6
Belo Horizonte										
Tomato paste	44.2	31.8	38.0	36.6	30.8	23.2	22.5	14.9	22.6	19.6
Tomato	32.4	52.1	38.4	30.8	41.4	39.0	39.2	40.6	32.3	38.2
Watermellon	17.9	9.5	13.4	16.2	17.9	18.2	24.5	9.4	21.6	12.8
Rio de Janeiro										
Tomato	64.9	55.4	57.0	48.1	49.0	53.5	49.2	47.0	27.7	25.8
Tomato paste	28.5	31.8	32.0	38.4	41.1	33.1	26.7	20.2	43.9	42.2
Papaya (red)	6.2	10.1	6.9	7.0	7.5	6.4	14.8	14.6	13.9	14.0

Table 3. Per-cent contribution of foods to the supply of lycopene to households of the Metropolitan Regions and Municipalities of Goiania and Brasilia-DF. (continuation)

Food Source	Monthly revenue (MW)									
	Up to 2	2 - 3	3 - 5	5 - 6	6 - 8	8 - 10	10 - 15	15 - 20	20 - 30	>30
São Paulo	%	%	%	%	%	%	%	%	%	%
Tomato paste	39.0	41.5	39.9	33.8	30.7	36.9	30.3	19.3	13.2	17.9
Tomato	32.0	35.4	29.4	34.4	28.9	21.4	38.2	36.1	32.6	37.7
Tomato sauce	18.2	1.1	8.2	14.0	4.9	17.2	11.2	13.1	12.5	18.5
Papaya (red)	9.6	7.8	6.8	11.1	9.7	12.1	10.0	13.2	11.6	15.6
Curitiba										
Tomato paste	66.1	45.3	38.5	37.2	45.7	19.4	44.5	30.4	25.9	16.9
Tomato	26.5	35.8	38.5	32.0	27.1	38.6	34.1	32.4	29.4	40.5
Watermellon	3.0	13.8	15.5	13.6	13.5	17.3	2.2	22.2	24.7	9.3
Papaya (red)	3.0	1.1	3.7	2.9	9.2	16.4	12.0	6.9	14.5	19.8
Porto Alegre										
Watermellon	47.2	53.2	26.8	38.9	30.7	18.6	22.5	26.1	5.5	17.3
Tomato	24.1	18.4	30.9	28.5	31.0	48.9	39.1	37.1	43.6	34.4
Tomato paste	17.9	24.8	34.0	19.5	26.5	21.6	22.9	18.8	20.0	21.4
Papaya (red)	8.9	1.6	5.0	9.6	7.9	6.2	10.0	12.2	13.4	19.4

Listing was abridged to contain only food items that would contribute with at least ~6%

Beta-carotene

As can be seen from Table 2, the food items that most strongly contributed to the supply of β-carotene in the great majority of the urban centers were carrots, squashes, mango and tomato. Carrots, a rich source (30-60μg/g), was one of the three most significant sources of β-carotene in all regions (average of ~30%), in spite of its contribution have ranged between 11.3 and 56.1%.

Notwithstanding the fact of leafy vegetables, like kale (couve), arugula (rúcula), Watercress (agrião), being rich sources of β-carotene, in addition to their important contribution as sources of folic acid and health promoting fibers, their presence in the Brazilian diet was low (generally <10% of the carotenoid contribution), except in Curitiba, São Paulo, Belo Horizonte and Goiânia. In Brasília and Porto Alegre, leafy vegetables appeared to be important only among the more affluent families.

Likewise and owing to the low intake of carotenogenic foods in general, relatively poor sources of β-carotene such as mangoes and tomatoes ranked as significant (3.7 to 14.9%) sources in the majority of the urban center's population. The value of 21.7%, found in Curitiba for the revenue level of between 2 and 3MW was considered an isolated event.

Lycopene

In the households of Brazilian metropolitan areas, Goiânia and Brasília-DF, the ranking of food items according to their per-cent contribution in lycopene was: tomatoes, tomato paste, watermelon and papaya (Table 3).

Red papaya, nearly absent from the shopping list of the poorer homes, was often detected as the fourth contributing source of lycopene, in the range of 10% or higher. Worthy of mention was the adoption of tomato paste by the lower bracket households, instead

Table 4 – Per-cent contribution of foods to the supply of lutein + zeaxanthin to households of the Metropolitan Regions and Municipalities of Goiania and Brasilia-DF.

Food Source	Monthly revenue (MW)									
	Up to 2	2 - 3	3 - 5	5 - 6	6 - 8	8 - 10	10 - 15	15 - 20	20 - 30	>30
Belém	%	%	%	%	%	%	%	%	%	%
Pear-orange	24.4	20.0	20.6	30.5	30.1	35.5	30.0	29.2	32.4	20.3
Kale	20.2	40.8	32.1	26.6	30.9	25.9	30.7	22.7	40.8	36.8
Hen's egg	15.4	10.2	9.2	5.3	5.3	5.7	3.4	4.2	4.6	2.3
Corn meal (*fubá*)	10.6	7.4	6.3	12.3	10.6	7.6	1.0	5.1	1.2	3.9
Lettuce	9.6	4.2	8.1	8.6	7.8	5.7	14.2	17.2	5.3	6.4
Fortaleza										
Corn meal (fubá)	51.9	54.6	46.3	45.5	25.9	40.0	44.6	17.5	17.2	36.7
Pear-orange	22.0	20.8	27.5	29.4	31.7	31.5	26.0	49.6	41.7	27.8
Hen's egg	7.2	5.1	6.6	6.7	5.9	4.9	4.3	6.3	3.7	2.0
Other feculas	6.6	4.1	3.7	3.7	5.1	1.9	1.2	3.6	4.8	2.3
Green pepper	5.6	6.3	7.1	6.2	10.0	9.6	10.2	8.7	8.9	5.4
Recife										
Corn meal (fubá)	73.5	73.4	73.9	67.5	67.8	52.1	47.6	39.2	24.6	11.0
Corn flakes	8.5	7.3	4.2	7.3	4.5	11.8	12.1	21.2	7.8	30.7
Pear-orange	6.2	8.4	10.0	11.3	9.1	15.4	15.8	20.7	21.2	22.6
Salvador										
Cron meal (fubá)	40.9	28.0	15.7	11.2	14.0	12.5	24.2	30.6	9.0	7.3
Green pepper	15.1	13.7	12.0	10.0	14.9	7.7	9.4	7.5	7.9	5.4
Corn flakes	11.9	20.5	11.0	16.5	6.5	13.8	0.8	1.2	1.8	35.0
Pear-orange	11.3	17.6	19.4	23.9	20.4	25.2	20.4	21.2	29.9	18.0
Common squash	4.9	5.5	10.9	13.1	12.0	19.7	7.9	7.7	13.0	6.4
Brasília										
Corn meal (fubá)	29.6	34.4	37.1	33.2	40.9	12.9	30.3	13.9	16.3	5.7
Pear-orange	26.8	26.7	18.4	7.8	7.5	12.5	10.4	18.9	14.7	13.9
Corn flakes	20.0	0.3	5.4	0.0	4.3	0.0	0.8	1.4	0.0	4.6
Common squash	10.5	4.6	3.4	1.1	5.5	1.8	2.5	5.3	4.2	2.3
Green pepper	4.4	1.6	1.6	0.9	2.4	1.1	1.3	1.6	1.9	1.1
Lettuce	3.7	20.0	7.4	6.1	8.3	7.0	6.9	9.9	9.0	10.5
Industrialized fruit juices	2.3	1.7	0.8	0.5	0.7	0.1	0.8	0.5	3.0	2.1
Water chresh	0.0	0.0	4.3	16.2	8.1	9.5	8.4	21.0	12.3	13.4
Kale	0.0	0.0	14.1	29.4	17.9	49.6	32.8	20.0	29.4	34.7

Table 4 – Per-cent contribution of foods to the supply of lutein + zeaxanthin to households of the Metropolitan Regions and Municipalities of Goiania and Brasilia-DF. (continuation)

Food Source	Monthly revenue (MW)									
	Up to 2	2 - 3	3 - 5	5 - 6	6 - 8	8 - 10	10 - 15	15 - 20	20 - 30	>30
Goiânia	%	%	%	%	%	%	%	%	%	%
Kale	42.1	24.9	36.3	36.4	39.9	40.3	45.7	49.7	42.8	48.1
Lettuce	16.8	18.6	17.1	18.5	21.2	21.6	12.7	18.3	13.0	11.6
Corn meal (fubá)	14.7	20.5	14.5	18.9	9.9	11.4	11.7	4.4	17.0	7.6
Pear-orange	7.2	8.2	6.9	5.3	8.5	7.4	10.1	9.7	7.7	6.6
Belo Horizonte	%	%	%	%	%	%	%	%	%	%
Lettuce	32.6	7.3	7.7	8.2	10.2	8.1	7.1	10.6	7.4	13.2
Corn meal (fubá)	31.3	50.3	46.6	31.8	32.3	30.9	41.0	14.7	29.9	7.2
Kale	18.7	12.2	6.3	19.9	11.4	15.0	14.6	21.1	17.8	17.0
Pear-orange	8.4	14.0	19.4	23.2	25.0	18.2	16.9	21.8	17.4	24.0
Rio de Janeiro										
Corn meal (fubá)	38.3	34.3	30.9	43.4	36.3	23.7	27.7	9.8	16.0	9.5
Pear-orange	17.3	19.0	15.3	8.6	9.0	17.6	13.4	16.9	10.8	7.3
Lettuce	12.0	14.7	14.6	9.3	9.9	14.9	15.5	11.3	8.6	14.2
Green pepper	8.6	3.9	4.4	2.0	3.2	5.2	3.0	3.2	1.5	1.9
Common squash	7.6	5.8	8.8	8.2	6.1	7.1	5.8	8.3	3.1	5.8
Kale	6.1	7.9	5.3	12.1	17.6	14.2	12.6	18.2	31.2	10.1
São Paulo										
Corn meal (*fubá*)	42.5	20.8	40.4	9.1	12.7	19.6	7.8	1.3	4.7	3.0
Pear-orange	15.1	30.2	14.0	22.7	13.8	16.8	16.2	17.8	11.4	14.0
Kale	11.1	0.0	3.8	33.3	30.8	30.9	28.0	37.1	39.2	19.8
Lettuce	9.9	20.9	11.8	16.3	12.9	7.5	12.8	17.9	10.4	16.5
Watercress	7.6	0.0	0.0	0.0	5.1	3.6	8.6	7.6	6.1	14.8
Curitiba										
Corn meal (fubá)	82.5	58.6	41.5	29.5	37.9	42.7	34.0	28.7	32.3	14.1
Pear-orange	5.8	24.4	22.0	30.5	22.5	14.7	18.0	17.4	20.9	20.1
Lettuce	5.7	7.4	16.9	25.0	11.8	15.4	19.7	18.4	22.8	21.3
Porto Alegre										
Corn meal (fubá)	18.6	10.6	26.5	21.0	10.5	25.3	13.2	20.7	3.3	7.5
Kale	18.0	31.5	29.5	35.8	43.1	29.0	35.1	30.4	46.6	36.2
Pear-orange	12.5	7.1	6.4	4.5	4.9	5.5	8.6	4.5	7.2	5.1
Lettuce	11.5	15.3	8.5	11.3	7.1	11.7	11.0	11.1	11.3	8.9
Persimmon	9.8	0.0	5.0	3.6	10.0	1.7	0.4	1.3	4.1	4.6
Common squash	7.1	5.5	2.4	3.7	6.2	4.0	4.3	2.0	4.6	4.3

of fresh tomatoes, as was the tomato sauce by the more affluent families. The apparent decrease in the consumption of tomato paste with the increase of revenue may be associated with concomitant increase in the number of meals outside of the domicile. It was interesting to notice that in Goiânia, the item "other tropical fruits", including the red guava, contributed more than in the remaining centers to the household availability of lycopene.

Lutein and Zeaxanthin

As in the case of β-carotene, leafy vegetables are among the richest sources of lutein. Outstanding contributions of this carotenoid, however, came from only kale and lettuce, while corn flour (*fubá*) and pear-oranges were for zeaxanthin (Table 4). The Northeast regions of Fortaleza, Recife and Salvador, notoriously ignored the consumption of leafs, although the zeaxanthin contained in corn flour was a fortuitous compensation.

Discussion

In the absence of a more appropriate database, we have attempted to use the data collected by the POF-IBGE (1995/96) for the approximate analysis of carotenoid consumption by the Brazilian urban population. From the point of view of characterizing the food and nutrient intake by the population, the limitations of this wide-reaching and geographically representative survey are well known. Among them are the exclusion of feeding outside the domicile and the unspecified ages of the members of the households surveyed. The results presented here, however, strongly suggest that by international standards, the Brazilian population falls short of consuming sufficient carotenogenic foods, in spite of the privilege of possessing one of the most varied and abundant supplies of fruits and vegetables of the world. As gathered from the nutritional and medical literature, this situation may impact the normal risk of certain diseases.

According to the US Institute of Medicine (IOM, 2001), adherence to the "Five-a-day for better Health" plan would imply in a prudent ingestion of fruits and vegetables supplying between 9 and 18mg of total carotenoids per day. According to our study, however, the highest rates of procurement were detected in Salvador (7.37mg revenue level of >30MW) and São Paulo (6.56mg, for the bracket 20 – 30MW) and were yet far distant from the commonly found values in the majority of the regions (between 1 and 3mg), depicting a scenario of low carotenoid intake in Brazilian urban centers.

Regarding the provitamin-A carotenoids, (prudent ingestion of 5.2 to 6mg; IOM, 2000), Both Salvador (3.2mg, >30MW) and São Paulo (3.2mg, 20 – 30MW) exhibited the highest procurement. Since only the lowest income population may not have sufficient access to sources of preformed vitamin A, the low consumption of this particular group of carotenoids may pose an inadequacy threat to the lower end of the income scale.

While the prudent ingestion of β-carotene (from 3 to 6mg) could be considered high by some, daily intakes of between 2 and 6mg are observed among adults in developed nations (WCRF/AICR, 1997). The present analysis shows, however, that with the exception of a restricted fraction of the Brazilian population (São Paulo, 2.6mg/day; 20 – 30MW and Salvador, 2.2mg, revenue >30MW), the great majority of the regions studied appeared by such standards to express low procurement of this nutrient.

For α-carotene, the NHANES III showed that in the United States 39 and 29μg/day are normally consumed by men and women in the same life stage and same percentile, respectively, whereas for β-cryptoxanthin, 102 (men) and 71μg/day (women) are consumed. Analogously, the consumption of lutein + zeaxanthin was 1,839 and 1,353μg/day, for men and women from 19 to 30 years, respectively. With respect to lycopene, the ingestions reported were 11,546 and 7,932μg/day, for 19 to 30 years, respectively (IOM, 2001).

In the majority of industrialized nations, vegetables and fruits are estimated to provide between 2 and 3mg/day of provitamin-A carotenoids, with β-carotene being the main contributor. According to the German National Food Composition Survey, the average ingestion of β-carotene has been 1.81mg/day. In Finland, ingestion ranges between 1.7 and 2.1mg/day, whereas in Holland the average is 3.0mg/day (European Commission, 2000).

A general trend emerges from our analysis that only affluent families may be ingesting similar

or nearly similar amounts of β-carotene in Brazil to those in the United States. The data show that families with revenues of >30MW in Recife, Belo Horizonte and Rio de Janeiro, >15MW in Salvador, >20MW in Goiânia, 10 – 15MW and >20MW in Brasília and São Paulo, surpass the daily level of 1.3mg consumed by the 50 percentile of men and women between the ages of 19 and 30y cited in the NHANES III.

On the other hand, the results presented here (Table 1) for α-carotene allow us to conclude that the *per-capita* procurement of this carotenoid was greater than the estimated intake for men and women with ages between 19 and 30y in the US (50 percentile of consumption). Additionally, a similar statement can be made with regard to β-cryptoxanthin.

Although the impact of this advantage on the general state of health of the population is not known, the significantly inferior purchase of lycopene and lutein + zeaxanthin food sources in Brazilian urban centers, would probably bear a negative impact on the prevalence rates of esophageal, lung and prostate cancer, with regards to lycopene and both age-related macular degeneration (AMD) and cataract, due to the lack of lutein + zeaxanthin. The carotenoid procurement estimated from the present study suggests that at the time this survey was conducted the dweller of large Brazilian urban centers was unnecessarily exposed to higher risks of certain diseases, upon which dietary carotenoids are recognized to exert various modulating effects.

Upon identification of the major food items contributing to the total carotenoid intake (Tables 2 – 4) it becomes evident that the population of the different regions of the country have their own preferences but that these are modulated by the level of income, with the possible influence of nutrition education.

Even in the absence of true carotenoid intake data by the population, it would be of interest to extend and compare the results of this study with the more recent IBGE 2002/2003 survey.

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