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β-carotene Content of Some Commonly Consumed Vegetables and Fruits Available in Delhi, India

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Abstract

Most of the vitamin A in the diet comes from plant food sources in developing countries. This study was designed with an objective of determining β-carotene content of a total of 26 types of green leafy vegetables, tubers, other vegetables and fruits obtained from four wholesale markets in Delhi, India using HPLC. There was a wide variation in β-carotene content of green leafy vegetables, with means ranging from 2199 µg/100 g in *Basella rubra* to 7753 µg/100 g in *Amaranthus gangeticus*. A large variation was observed in β-carotene content of fruits and the mango varieties tested, ranging from undetectable levels in strawberry and 808.60 µg/100 g in *totapuri* mango up to 11789 µg/100 g in *alphonso* mango. Approximately 65 g and 100 g of a green leafy vegetable would meet daily requirement of a preschooler and older child/adult respectively. Mango has considerable amount of β-carotene, and consuming a medium-sized bowl by preschool children would meet 99% of Recommended Dietary Allowances (RDA). The information generated is useful in identifying types of fruits and vegetables with higher concentration of the provitamin A in low income economies where fruits and vegetables are expensive. Individuals need to consume only small quantities of these vitamin A rich foods to meet daily requirement.

Keywords: β-carotene; Green leafy vegetables; Fruits; Mango varieties; HPLC; Portion sizes

Introduction

Vitamin A is essential for normal vision, maintaining the integrity of epithelial tissues and for a wide variety of other metabolic functions. Micronutrient malnutrition especially deficiency of vitamin A is globally affecting over 3 billion people. According to World Health Organization (WHO), Vitamin A Deficiency (VAD) has affected about 190 million preschool-aged children and 19 million pregnant women, mostly in Africa and South-East Asia [1]. Prevalence of subclinical vitamin A deficiency is around 62% in preschool children in India [2,3].

Studies from developing regions suggest that up to 80% of the dietary intake of vitamin A comes from provitamin A rich food sources. Vitamin A occurs as provitamin A carotenoids, which are synthesized as pigments by many plants and are found in green, orange, and yellow plant tissues. These provitamins or precursors-alpha-carotene, beta-carotene, gamma-carotene, and cryptoxanthine (all of which contain β-ionone rings) are found in plant foods. In animal food products their presence can be explained by the fact that animals consume plants rich in these provitamins. There are more than 500 different carotenoids out of which about 60 have provitamin A activity. These can be cleaved by animals to yield at least one molecule of retinol. In practice, however, only five or six of these provitamins are detected in commonly consumed foods of which β-carotene is the most predominant and active [4].

A food based approach is best to combat vitamin A deficiency among groups at risk of deficiency. The poorer segments of the population in India are dependent on plant foods, which provide β-carotene to meet their requirements of vitamin A. Green Leafy Vegetables (GLVs) are grown abundantly in India and are relatively inexpensive. However, these are not liked by most, especially children. Other vitamin A rich fruits and vegetables are relatively more expensive. β-carotene content of some commonly consumed vegetables and a fruit was estimated to identify types which had the highest amount of the pro-vitamin A. The quantity of these food items which would contribute to meeting the requirement of children and adults was also assessed.

Materials and Methods

Method of sampling of fruits and vegetables

About 161 **s**amples of commonly consumed sources of β-carotene like 13 types of green leafy vegetables (n=84 samples), 3 types of roots and tubers (n=12 samples), 3 types of other vegetables (n=10 samples), 12 varieties of mango (n=34 samples), and 6 types of other fruits (n=21 samples) were purchased from four different whole sale markets (*mandis*) of Delhi. These included Azadpur (north Delhi) supplying fruits and vegetables to a significant part of Delhi, Okhla *mandi* (south Delhi), Shahadra *mandi* (east Delhi) and Keshopur *mandi* (west Delhi). Each type and variety of fruit and vegetable was picked up from three different vendors and locations in each market. These samples were pooled and homogenised to give a uniform single composite sample representing each market. Then these samples were analysed for β-carotene content in duplicate.

Laboratory estimation of β-carotene

Extraction: For the extraction of β-carotene, the procedure outlined in AOAC Official Method 941.15- 'Carotene in Fresh Plant Materials and Silages' [5] was followed. Samples were finely cut with scissors or knife, ground in mortar pestle and 2–5 g weighed test portion was extracted with 40 ml acetone, 60 ml petroleum ether, and 0.1 g magnesium carbonate, and then blended for 5 min. Filtration was done with the aid of a suction pump and sample was decanted into separator. Residue was washed with two 25 ml portions acetone, then with 25 ml

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petroleum ether, and then extracts were combined. The combined extract was evaporated to dryness and residue was re-dissolved in acetone. Volume was made up to 1 to 5 ml using acetone depending upon the matrix. The sample was then analyzed by high performance liquid chromatography (HPLC).

HPLC analysis: The HPLC instrumentation included a 5 μm C18, 4.6 × 250 mm (Varian Associates, Sunnyvale, USA) for β-carotene analyses. A mixture of acetonitrile (CH_3CN), methanol (CH_3OH) and acetone in the ratio 60:30:10 served as the mobile phase for β-carotene analysis at a flow rate of 1.2 ml per minute. Peak responses of β-carotene were measured at wavelengths of 450 nm [6]. Pure standards of all-trans-β-carotene were obtained from Sigma Aldrich. Purity of the standards was checked by HPLC analysis. Working solutions of β-carotene were analyzed with each batch of samples on the day of analysis.

Quality control of the analytical methods: The method was validated with regard to accuracy, linearity and precision. Analytical testing was done in NABL accredited laboratory. Reproducibility was checked by extracting the sample three times and calculating recovery and Coefficient of Variance (CV). The recovery was checked by spiking the plant matrix with known amounts of pure standard of β-carotene. Good laboratory practices were followed to ensure appropriate sample preparation and analysis. All chemicals used were of HPLC grade.

Statistical analysis

The mean, standard deviation and range of β-carotene content for each fruit and vegetable was reported. All data were analyzed using the SPSS version 22 software. The differences in mean values were tested using one-way Analysis of Variance (ANOVA) and post hoc analysis using Tukey HSD test. The value of $p<0.05$ was considered to be statistically significant.

Results and Discussion

Results for recovery assays

Samples of plant matrices were spiked at the level of 20 mg/kg of pure β-carotene standard. Intra-laboratory reproducibility of the method was estimated by reporting mean recovery, standard deviation and CV. The percentage recovery of β-carotene was found to be 90.08 ± 2.2% with a CV or percent relative standard deviation (%RSD) of 2.52%.

Green leafy vegetables

There was a significant variation in β-carotene content of green leafy vegetables with the values ranging from 2199 μg/100 g in *Poi* leaves (*Basella rubra)* to 7753 μg/100 g in *chaulai* leaves (*Amaranthus gangeticus*) ($p<0.05$) (Table 1). Spinach leaves (*Spinacia oleracea)* had β-carotene in the range of 2966–3967 μg/100 g with the average value 3468 ± 296 μg/100 g. In Indian Food Composition Tables (IFCT) [7], the β-carotene content of spinach has been reported as 2605 ± 521 μg/100 g. The results of the present study were similar to the previously reported results ranging from 3000 to 5000 μg/100 g [8-13]. However, higher amounts of β-carotene in spinach leaves have also been reported ranging from 5000 μg/100 g to 152100 μg/100 g [14-19].

Coriander (*Coriandrum sativum*) had β-carotene in the range of 5404-5728 μg/100 g and results are in agreement with earlier published data [8,10,20]. Higher values of 67500 μg of β-carotene/100 g have been reported in coriander leaves in a study conducted in south India [21]. However, lower values of 3167-3808 μg of β-carotene/100 g have been reported in IFCT, US data base and a study of Malaysia [7,17,19]. Fenugreek leaves (*Trigonella foenum graecum*) had β-carotene in the range of 4826-5838 μg/100 g which is nearly similar to the amount of 4230-4350 μg/100 g reported by Indian authors earlier [22,23]. Although higher values of β-carotene in fenugreek leaves (9245 ± 974 μg/100 g) were reported in IFCT [7]. Other studies conducted in south India also had reported higher values of 9200 and 12130 μg of β-carotene/100 g respectively in fenugreek leaves [11,16].

In the present study β-carotene found in *chaulai* leaves (*Amaranthus gangeticus)* was in the range of 6418-8865 μg/100 g which was nearly similar to the values reported by authors of IFCT as 8553 μg/100 g [7]. Studies conducted in south India have also reported values (5760-8600 μg/100 g) of β-carotene in amaranth leaves nearly similar to values of present study [11,24,25]. While, one study conducted in Mysore, India has even reported higher value as 18670 μg of β-carotene/100 g of amaranth leaves than present study [21]. Lower values (1526-1709 μg/100 g) than present study have been reported in a study conducted in Bangladesh [26]. There are many edible varieties of amaranth in different parts of the world. It has been reported that *Amaranthus viridis* had β-carotene content in the range of 3200 μg/100 g to 58950 μg/100 g [11,19-21,24,27]. It has been reported that other species like *Amaranthus cruentus* from south India had 7600 μg of β-carotene content per 100 g [27] while *Amaranthus tricolor* had 1601 μg to 9600 μg of β-carotene/100 g reported in other studies [10-11,19,27-30].

S. No.	Food sample-Local/Botanical name	Number of samples analyzed (n=84)	β-carotene (μg/100 g) range	β-carotene* (μg/100 g) Mean ± SD
1.	Spinach leaves (*Spinacia oleracea)*	20	2966-3967	3468 ± 297[e]
2.	Fenugreek leaves (*Trigonella foenum graecum*)	10	4826-5838	5438 ± 373[c]
3.	Mustard leaves (*Brassica campestris var. sarason*)	6	4224-4355	4327 ± 70[d]
4.	Radish leaves (*Ruphanus sativus*)	6	3889-4504	4203 ± 251[de]
5.	Mint leaves (*Mentha spicata*)	4	3872-4375	4206 ± 289[de]
6.	Bathua leaves (*Chenopodium album*)	6	4233-4341	4300 ± 58[de]
7.	Coriander (*Coriandrum sativum*)	4	5404-5728	5566 ± 229[bcd]
8.	Curry leaves (*Murraya koenigii*)	4	5403-5822	5612 ± 296[bcd]
9.	*Poi* leaves or Mayalu (*Basella alba)*	4	1926-2655	2199 ± 397[f]
10.	*Nadi/Kalmi* leaves (*Ipomea aquatica)*	4	6340-8083	7212 ± 1232[ab]
11.	*Chaulai* leaves (*Amaranthus gangeticus*)	6	6418-8865	7753 ± 1104[a]
12.	Colocasia Leaves (*Colocasia anti-quorum*)	6	6255-6729	6494 ± 199[b]
13.	*Kulfa* leaves or *paruppukeerai* (*Portulaca oleracea*)	4	3588-3991	3789 ± 286[de]

*Values with different alphabet superscripts are significantly different at $p<0.05$

Table 1: β-carotene content of some common GLV.

The availability of greens improves during winters in Delhi. Mustard leaves (*Brassica campestris var. sarason)* are one of the most commonly consumed green leafy vegetables in North India during winters. The β-carotene content was found to be nearly similar in mustard leaves (4224-4355 µg/100 g), radish leaves (*Ruphanus sativus*)-3889-4504 µg/100 g, *bathua* leaves (*Chenopodium album)*–4233-4341 µg/100 g and mint leaves (*Mentha spicata*)-3872-4375 µg/100 g in the present study. In IFCT nearly similar amounts of β-carotene (3808 µg/100 g) have been reported in mint leaves [7]. The amounts of β-carotene in mustard leaves are comparable with those in green leafy Brassica species tested in Switzerland 2100–6800 µg/100 g [31]. Values lower than the present study have also been reported for Indian mustard leaves-1680 µg/100 g [32] and 2619 ± 372 µg/100 g [7]. Authors from Bangladesh reported the β-carotene content of commonly consumed Bangladeshi vegetables. They reported 1404 ± 36.1 µg/100 g in mustard leaves and 1871 ± 875 µg/100 g in radish leaves which are lower than the results obtained in the present study [26]. Lower values (2300 and 2591 µg/100 g respectively) as compared to present study have been reported in radish leaves in IFCT and a study from south India [7,11] while very high content of β-carotene (11200 µg/100 g) was also reported in radish leaves by some Indian authors [16]. About 5200–6300 µg of β-carotene/100 g were reported in 23 samples of *Brassica oleracea* cultigens of Durham, New Hampshire, USA [33].

Lower value of 1075 µg of β-carotene/100 g in *bathua* leaves has been reported in IFCT [7] while some other authors [21,27,34] have reported higher β-carotene content (9300 µg/100 g; 26380 µg/100 g and 114610 µg/100 g respectively) in *bathua* leaves as compared to the present study. Results of β-carotene in mint leaves (*Menthaspicata*) are in agreement with other previously published data [10,11]. However, wide variations in the β-carotene values (2133 µg to 10600 µg/100 g) have been reported in some other studies [14,17,21].

Less commonly consumed green leafy vegetables like curry leaves (*Murrayakoenigii*) had β- carotene in the range of 5403-5822 µg/100 g. However higher concentrations in the range of 7100-9328 µg/100 g have been reported in IFCT [7] and by other authors [11-19, 21,22]. *Kulfa* leaves or *paruppu keerai* (*Portulacaoleracea*) were found to be a good source of β-carotene (3588-3991 µg/100 g), with nearly similar amounts (3200 µg of β-carotene per 100 g) being reported by authors from Brazil [20]. Higher amounts of 27050 µg of β-carotene per 100 g in *paruppu keerai* of Mysore, India [21] have been reported. Lower values as compared to present study as 586 µg and 3200 µg of β-carotene per 100 g in *paruppu keerai* have been reported in a study from south India and southern Thailand respectively [35,36]. *Poi* leaves (*Basella alba rubra*) had lower amounts of β-carotene in the range of 1926-2655 µg/100 g, nearly similar to values reported in IFCT (2473 µg/100 g). However, very high values in the range of 32420-43820 µg/100 g have also been reported in previously published data [16,21]. The reason for difference in the carotenoids content could be because of the different geographical locations, inherited biological variability in the varieties and species or cultivar, part of the plant, degree of maturity/ripeness at harvest, cultivation conditions, seasonal variation, the effect of climatic conditions, variation of fertilizer, different soil conditions, postharvest handling practices, shelf time before purchasing, method for sampling, preparation and estimation [37].

Some less commonly consumed vegetables like *Ipomea aquatica* leaves (7212 µg/100 g) and colocasia leaves (6493 µg/100 g) had good amounts of β-carotene. Some Indian authors have also reported β-carotene of colocasia leaves as 5500 µg/100 g [11] and 5758 µg/100 g in IFCT [7]. Small amounts of these incorporated into diets of children can effectively increase intake of the vitamin and help in combating vitamin A deficiency.

Tubers and other vegetables

Provitamin A sources are green, red, yellow and/or orange colored vegetables like sweet potato, pumpkin, carrot, capsicum, green chillies. β-carotene content of various tubers and vegetables differed significantly ($p<0.05$) and has been presented in Table 2.

Two types of commonly consumed carrots were analyzed in this study. The mean concentration of β-carotene in red carrot *(Daucus carota)* was 1187 ± 188 µg/100 g while orange carrot had 1906 ± 52 µg/100 g. IFCT reported higher values in red and orange carrot (2706 and 5423 µg/100 g respectively) as compared to present study [7]. Also, the results of the present study for carrot were far lower than the other studies. There was a wide variation reported in the β-carotene contents starting from 2200 µg/100 g up to 128400 µg/100 g in earlier published studies [10-13,15,17,25,38-43].

Published results have reported wide disparity in the contents of β-carotene due to difference in varieties of sweet potato (*Ipomea batatas*) tested. The results of present study (605.33-1810 µg/100 g) are far lower than the previously published reports [44-47]. Amount of β-carotene was also found varying amongst ten clones of sweet potato (5.85 to 13.63 mg/100 g of fresh weight) possessing different intensities of dark orange-flesh color studied in India [48]. It was found in an Indian study that the variety-'kiran' (yellow fleshed) of sweet potato had a significant amount of β-carotene (approximately 1870 µg/100 g) [11]. β-carotene content was reported as 5376 µg/100 g in IFCT [7] and in the range of 9180 to 9500 µg/100 g in USDA-NCC Carotenoid Database [17].

In the present study, the concentration of β-carotene was found to be very low (36.33 ± 5.19 µg/100 g) in green pepper (capsicum *annuum*) and this result was in agreement with the previously published results

S. No.	Food sample-Local/Botanical name	Number of samples analyzed (n=22)	β-carotene (µg/100 g) range	β-carotene (µg/100 g)* Mean ± SD
		Tubers (n=12)		
1.	Red Carrot (*Daucus carota*)	4	913-1331	1187 ± 188[b]
2.	Orange Carrot(*Daucus carota*)	4	1845-1970	1906 ± 52[a]
3.	Sweet potato (*Ipomea batatas*)	4	605-1810	708 ± 145[c]
		Other Vegetables (n=10)		
4.	Green chillies (*Capsicum annum*)	2	980-1017	998 ± 26[bc]
5.	Capsicum (*Capsicum annum*) (bell pepper)	2	33-40	36 ± 5[d]
6.	Pumpkin (*Cucurbita maxima*)	6	405-520	470 ± 52[c]

*Values with different alphabet superscripts are significantly different at $p<0.05$

Table 2: β-carotene of some tubers and other vegetables.

ranging from 38 µg/100 g to 270 µg/100 g [8,11-13,17,36,40-49]. Authors have observed wide range of concentrations of β-carotene content-10.4 µg/100 g to 1524 µg/100 g in fresh red, yellow and orange peppers of Italy. β-carotene was significantly higher in concentration in red peppers as compared to yellow and orange peppers [50]. Other authors have observed a range of 2379–12450 µg/100 g of β-carotene in *Capsicum annuum* (red pepper) cultivars of US and Turkey [17,51] while in the European database it was reported as low as 480 µg/100 g [40]. Another study reported 153 µg/100 g of trans β-carotene in red peppers of Boston, USA [8]. In IFCT also low values of β-carotene-328, 166 and 246 µg/100 g was reported in green, yellow and red varieties of capsicum respectively [7].

Amount of β-carotene in green chillies (*Capsicum annum*) was in the range of 980-1017 µg/100 g. These results were in agreement with values ranging from 1020 to 1130 µg/100 g reported in Indian studies [11,36]. Although lower values (468 µg/100 g) have also been reported Malaysian green chillies [19]. In IFCT, amount of β-carotene was reported in the range of 207 to 294 µg/100 g in 7 different varieties of green chillies [7]. In the present study β-carotene levels detected in pumpkin (*Cucurbita maxima*) were in the range of 405-520 µg/100 g. In IFCT the amount of β-carotene was reported in two types of pumpkin. Pumpkin, green, cylindrical had 363 µg/100 g while pumpkin, orange, round (*Cucurbita maxima*) had 149 µg/100 g [7]. Wide range of concentrations were obtained (310–2900 µg/100 g) in *C. maxima* in earlier studies [25,26,52,53]. In a study from Brazil, the range of β-carotene was found varying from 14195 to 24422 µg/100 g in two samples of raw pumpkins (*C. moschata* Duchesne) [54]. Authors determined β-carotene in three species of pumpkin (*Cucurbita pepo, C. maxima* and *C. moschata*) from Austria and found these to range from 1400 to 7400 µg/100 g [55]. It has been reported in other studies from Brazil, that the *C. maxima* 'Exposição' and *C. moschata* 'Menina Brasileira' had all-trans-β-carotene as the major carotenoid among primary carotenoids (α-carotene, β-carotene and lutein) [56,57]. A few varieties have α- and β-carotene as major carotenoids, whereas ß-carotene dominates in other varieties [57,58]. In Indian studies levels of β-carotene in pumpkins were in the range of 1160 to 1180 µg/100 g [11,36]. The concentration of β-carotene found in present study is much more than the 57.8 µg/100 g reported from Malaysia in *C. maxima* [19].

Fruits

The values of β-carotene in fruits were ranging from undetectable levels in strawberry to 11789 µg/100 g in *alphonso* variety of mango (Table 3). β-carotene content in ripe tomato (*Lycopersicon esculentum)* was found to be 316.6-341.2 µg/100 g which were nearly similar to the results published in earlier studies [17,41]. Other authors have reported values in the range of 415 µg/100 g up to 740 µg/100 g [11-13,40,42]. In IFCT values of β-carotene were reported as 1513 µg/100 g in tomato, ripe, hybrid and 905 µg/100 g in tomato, ripe, local varieties [7]. β-carotene ranged from 280 to 620 µg/100 g in 12 varieties of Hungarian salad tomato [58]. Low concentration of 59.7 µg/100 g has been reported in tomato from Hyderabad, India [36]. In a study from Boston USA, negligible amounts of β-carotene were reported in tomato [8].

The β-carotene content of papaya (*Carica papaya*) averaged 185.02 ± 34.28 µg/100 g and ranged from 153.2-219 µg/100 g in the present study, which were similar to the previously published values [17,19,42]. β-carotene was estimated as 190 µg/100 g to 560 µg/100 g in fresh papaya pulp in a study in Brazil [59]. However, the average values reported were higher in IFCT (694 µg/100 g) and also in other studies which reported mean values as 471 µg/100 g [60] and 440 µg/100 g [61].

β-carotene levels ranging from 80.5 to 410.3 µg/100 g were reported among 5 cultivars of papaya belonging to different locations grown in Hawaii [62]. It was observed that the β-carotene was significantly high in red fleshed papaya (700 µg/100 g DW) as compared to yellow-fleshed papaya (140 µg/100 g DW) [63]. The reasons suggested for the wide range in the β-carotene values were varietal differences, differences in maturity and ripening.

The amount of β-carotene in Orange (*Citrus aurantium)* was in the range of 12.62-49.63 µg/100 g. The results were in agreement with the earlier reported studies [7,11,12,17,40,61]. A study from Thailand found β-carotene content as 211 µg/100 g in *sainahmphung* variety of orange [60]. Guava (*Psidium guajava*) had 26.9-44.8 µg/100 g which was higher than 1 µg/100 g reported in guavas from south India [11]. The value was however lower as compared to 984 µg/100 g reported in guavas from Indonesia [61] and 298 µg/100 g in white flesh guavas and 267 µg/100 g in pink flesh guavas reported in IFCT [7]. The amounts of β-carotene in fruits determined in this study were nearly similar to those previously reported [52,61,17,19].

In our study β-carotene content was not quantifiable in strawberry (*Fragaria vesca*), being present at levels below detection limit (DL-4 mcg/100 g). In Cape gooseberry (*Physalis peruviana*) the β-carotene content was in the range of 775.21-857.71 µg/100 g. A study from Bulgaria has reported 4.9 µg of β-carotene/100 g of strawberries [64]. Strawberries from Norfolk, UK had 11 µg of β-carotene/100 g [12], and 8 µg/100 g was reported in the European database [40]. Authors of IFCT also reported very low values of 2.19 µg/100 g [7].

A large variation in amounts of β-carotene was observed in the mangoes (*Mangifera indica*) tested (Table 4). The values were ranging from 808.60 µg/100 g in *totapuri* mango up to 11789 µg/100 g in *alphonso* mango. Other authors have observed as much as 13000 µg/100 g in *alphonso* varieties from India [65]. Highest values were obtained in *alphonso* variety. The lowest values were obtained in the present study in *totapuri, chausa, gola, kesar* and *pairy* variety (808.60 to 1284.5 µg/100 g). The values are nearly similar to the results reported in the European carotenoid database (1300 µg/100 g) [40]. In IFCT amount of β-carotene was reported in 7 varieties (*banganapalli, gulabkhas, himsagar, kesar, neelam, paheri and totapari*) of mango in the range of

S. No.	Food sample-Local/botanical Name	Number of samples analysed (n=21)	β-Carotene (µg/100 g) range	β-carotene (µg/100 g)* Mean ± SD
1.	Papaya (*Carica papaya*)	6	153-219	185 ± 34[c]
2.	Orange (*Citrus aurantium*)	4	13-49	32 ± 19[d]
3.	Guava (*Psidium guajava*)	2	27-45	36 ± 13[d]
4.	Tomato (*Lycopersicon esculentum*)	5	317-341	332 ± 14[b]
5.	Cape gooseberry (*Physalis peruviana*)	2	775-858	816 ± 58[a]
6.	Strawberry (*Fragaria vesca*)	2	#ND (DL-4)	-

*Values with different superscripts alphabets are significantly different at p<0.05; #ND: Not Detectable; DL: Detection Limit (4 mcg/100 g)

Table 3: β-carotene of some common fruits.

602 to 1291 μg/100 g [7]. *Kesar* and *totapari* had 1264 and 602 μg/100 g respectively which is similar to the results obtained in present study. For the varieties *dinga, langda, safeda, sinduri, dusheri*a range of values (1632.91 -2456.66 μg/100 g) was obtained in the present study, which is similar to 1700 μg/100 g reported by other Indian authors [11]. Low values of 445 μg/100 g has been reported in mangoes in US database [17], 615 μg/100 g in mangoes from Malaysia [19], 553 μg/100 g in mangoes from Indonesia [61] and 142 μg/100 g in mangoes of USA were also reported [8]. A study from Thailand reported β- carotene in the range from 21.2 to 308 μg/100 g in different mango varieties [60]. Hence a wide variation can be observed in the amounts of β-carotene present in mango due to availability of so many varieties. Consuming mangoes with a low amount of vitamin A will not contribute majorly to the daily intake of this vitamin unless a sufficient quantity is consumed. However, mangoes with a higher β-content will definitely contribute to meeting daily requirements even if consumed in small quantities.

Typical portion sizes of fruits and vegetables

Quantities of raw fruits or cooked vegetables to be consumed to meet Recommended Dietary Allowances (RDA) for β-carotene were standardized using household measures and have been presented in Table 5. Percent RDA met from consuming one bowl of raw fruit or cooked vegetable was also calculated. The average β-carotene estimated in green leafy vegetables was 4966 μg/100 g. On an average daily consumption of 100 g of a green leafy vegetable would be enough to meet more than 100 % RDA among children and adults. When taking amaranth leaves, the GLV with highest concentration of β-carotene (that is 7753 μg/100 g), only 62 g needs to be consumed to meet daily requirement of an adult and young child aged between 7 to 9 years. For children less than 7 years, 42 g of raw amaranth leaves would be enough for meeting the RDA of β-carotene. Consuming 140 g of spinach by adults and children (7 to 9 years) and 93 g of spinach by preschool children (1 to 6 years) would be able to meet the RDA of β-carotene. 100 g of a GLV when cooked would fill half a medium sized bowl (200 ml) as a dry preparation.

In case of other vegetables, the amount of β-carotene was less; hence more number of servings would be required to meet RDA. Percent RDA met from one medium bowl was less than 50% in case of carrot, pumpkin and sweet potato. In case of fruits, β-carotene amount in papaya was found to be very less and therefore higher number of servings would be required to meet RDA. However, since one vegetable or fruit need not contribute to 100% of the requirements, one serving contributing around 25-30% of the RDA, can be considered as a good source. Fruits and vegetables having low amounts would have to be eaten in unreasonably large amounts thus multiple sources of vitamin A in the diet will help to meet requirements. For instance, only 5- 7 percent of RDA would be met after consuming one medium bowl of papaya. Mango has considerable amount of β-carotene, and consuming a medium bowl would be sufficient to meet 99 % of RDA of preschool children.

Children are fussy about eating their vegetables. Vegetables can be incorporated in dishes in forms acceptable to children or by disguising their presence. For instance, GLVs can be kneaded into the dough of

S. No.	Name	Number of samples analysed (n=34)	β-carotene (μg/100 g) range	β-carotene (μg/100 g)* Mean ± SD
1.	*Alphonso*	2	10775-11789	11282 ± 717[a]
2.	*Safeda*	4	1875-2208	2031 ± 179[bc]
3.	*Sinduri*	4	2099-2310	2204 ± 149[bc]
4.	*Langda*	4	1720-1911	1787 ± 107[bcd]
5.	*Chausa*	4	950-1282.19	1018 ± 237[de]
6.	*Totapuri*	2	745.21-872	809 ± 90[e]
7.	*Gola*	2	1200-1234	1217 ± 24[cde]
8.	*Dinga*	2	1576-1689	1633 ± 79[bcde]
9.	*Dusheri*	4	2000-2840	2457 ± 425[b]
10.	*Kesar*	4	1108-1335	1222 ± 160[cde]
11.	*Pairy*	2	1280-1290	1284 ± 8[cde]

*Values with different superscripts alphabets are significantly different at $p<0.05$

Table 4: β-carotene of some common varieties of mango (*Mangifera indica*).

S. No.	Vegetable/Fruit	Average β-carotene (μg/100g)	Raw quantity to be consumed to meet RDA* (in grams)-		Quantity of raw fruit or cooked vegetable to be consumed to meet RDA in household measures#		Raw quantity of fruit or vegetable^ fitting in a medium bowl (g)	Percent RDA met from consuming one bowl of raw fruit or cooked vegetable	
			Preschool children (1-6 years)	Other children and adults	Preschool children (1-6 years)	Other children and adults		Preschool children (1-6 years)	Other children and adults
1.	All GLVs (average)	4967	65	97	Little more than ¼th bowl	Approximately half a bowl	205	318	212
2.	Amaranth leaves (highest amount of β-carotene)	7753	42	62	Little less than ¼th bowl	Little more than ¼th bowl	205	497	331
3.	Spinach leaves (most commonly consumed)	3468	93	140	Half of a bowl	Little less than ¾th of bowl	205	222	148
4.	Carrot	1187	275	400	Little more than 2 bowls	3 bowls	130	41	27
5.	Sweet potato	708	452	680	3 bowls	5 bowls	140	31	21
6.	Pumpkin	470	682	1022	Little more than 3.5 bowls	Little less than 5.5 bowls	190	28	19
7.	Papaya	185	1760	2640	14 bowls	21 bowls	125	7	5
8.	Tomato	332	965	1450	Little more than 5 bowls	Little more than 7.5 bowls	185	19	13
9.	Cape gooseberry	816	395	590	3 bowls	Little less than 5 bowls	125	32	21
10.	Mango (average)	2450	155	200	Little more than a bowl	One and a half bowl	130	99	66

*Recommended Dietary Allowances (RDA) of β-carotene is 3200 μg/100 g for children from 1 to 6 years and 4800 μg/100 g for children of all other ages and adults as per ICMR, 2010; #One medium bowl=200 ml; ^Raw weight of vegetable which after cooking fits in one medium bowl

Table 5: Standardization of quantities to be consumed to meet RDA and estimated vitamin A contribution of an average portion size of fruits and vegetables to the RDA for all age groups.

breads and other vegetables can be pureed/mashed and used as the base for gravies or as stuffing. Preparing meals for children with small quantities of vegetables yet higher concentration of β-carotene may be a sensible approach to reduce risk of deficiency of vitamin A among them.

Conclusion

Wide variation was observed in the values of selected fruits, green leafy and other vegetables consumed in Delhi. Among green leafy vegetables the highest amount of β-carotene was found in amaranth leaves followed by *Ipomea aquatica* leaves and colocasia leaves. Knowing that young children are prone to vitamin A deficiency, this information can be used by mothers to plan their meals by including the minimum amount of β-carotene rich fruits and vegetables in dishes. These can be incorporated in their meals in forms acceptable to the children.

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