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Carotene content of coriander leaves (*Coriandrum sativum*), Amaranth, Red (*Amaranthus Sp*, Green garlic (*Allium sativum*) and Mogri (*Raphanus caudatus*) and its products

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ABSTRACT

Food based approach is a more practical and sustainable approach to combat micronutrient deficiencies including vitamin A deficiency in India. However several gaps of knowledge with respect to the stability of β- carotene from foods and therefore its bioavailability exist. The present study aimed to assess the total and beta- carotene content of 4 vegetables (*Coriandum sativum*), Amaranth, Red (*Amaranthus sp*); Green garlic (*Allium Sativum*) and Mogri (*Raphanus caudatus*); and study the stability of beta carotene using minimal processing and addition of weak acids from foods, and product development using of coriander leaves. Results indicate that among the four vegetables, beta-carotene content of coriander was highest (2921.79 µg / 100 g) and lowest for mogri (425.15µg/100g). When coriander leaves were macerated alone in an electric mixer grinder and with green chilies, lemon or both, retention of beta carotene was 72.3%, 149.81%, 98.2%, and 182% resp. indicating the enhancing effects of green chillies and lemon juice of β- carotene retention. The fresh coriander leaves when incorporated into a recipe retained 75.47% of total carotene and 74.185 of β- carotene and was found to be highly acceptable using the composite score and hedonic test. The study indicates that minimal processing and usage of green chillies and lime in carotene rich foods enhance its retention. Efforts should be directed towards development of acceptable recipes incorporating green leafy vegetables and thereby resulting in an increased intake of β-carotene rich indigenous foods.

INTRODUCTION

Food based approach is a more practical and sustainable approach to combat several problems including vitamin A deficiency in India (Nambiar and Kosambia, 2013). However, several gaps of knowledge with respect to the stability of beta carotene from foods and therefore its bioavailability exist (Nambiar and Seshadri, 2001).

Sub clinical vitamin A deficiency still exist in India due to poor hepatic reserves with which the infant is born consequent to inadequate dietary intake of mother during pregnancy, frequent episodes of infection, inability of the communities to purchase the vitamin A rich foods, culture reasons (Underwood, 1994; Newman, 1993). Out of the several strategies to reduce vitamin A deficiency, the dietary approach is increasingly being emphasized because it is sustainable, provides nutrients and phytochemicals other than vitamin A and adds variety to the diet (Reddy, 1995; Gopalan, 1992; Nambiar and Seshadri , 1998, Nambiar et al, 2005). In Indian diets, vegetables play a very important role as a source of vitamin A as more than 85% of the intake of vitamin A is derived from carotenoids (Narasinga Rao, 1991). However, there has recently been growing realization that apparent adequacy of dietary intake of vitamin A in the form of carotenoids does not necessarily ensure adequate status. There are several factors identified, which effect the bioavailability and bioconversion of carotenes to Vitamin A (Erdman et al, 1993). Carotenoids and retinol are affected by pH, enzymatic activity, light and oxidation associated with the Conjugated double bond system. Fresh plant tissue may contain enzymes that are only activated during and following processing. As a consequence of these chemical changes, the preformed Vitamin A or pro Vitamin A content of the raw form of a food item may be reduced in food preparation. Carotenoids are subject to isomerization oxidation during processing and storage, the practical consequences being loss of colour and biological activity and formation of volatile compounds

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that impart desirable or undesirable flavor to some foods. The carotene content of unprocessed fresh vegetables and fruits is not necessarily indicative of how much carotene is consumed. Studies have shown that β-carotene losses are greater when vegetables are cooked for extended period of time. Bhaskarachary *et al.*,(1999) have reported that interactions between β-carotene and other biologically active compounds such as polyphenols and Vitamin C enhanced the stability of β-carotene from 6 varieties of green leafy vegetables. Madhavapeddi *et al.*, (1994) have also reported that preparation of amaranth and *palak dhal* involving sautéing in the presence of weak organic acids found in tamarind and tomatoes increased the retention of β-carotene. Augmentation of production of green leafy vegetables per se is not an answer to the current problems of vitamin A deficiency (Reddy, 1998). Efforts should be directed towards development of acceptable recipes incorporating green leafy vegetables and thereby resulting in an increased intake of β-carotene rich indigenous foods (Seshadri, 1996).

The major objectives of the present study were:

1) To assess the total and beta carotene content of four GLVs namely coriander leaves (*Coriandum sativum*), Amaranth, Red (*Amaranthus sp*); Green garlic (*Allium Sativum*) and Mogri (*Raphanus caudatus*).

2) To assess the retention of beta carotene using minimal processing (maceration) and use of food based weak acids from chillies and lime

3) To standardize a traditional Gujarati recipe using Coriandum sativum leaves and assess the retention of beta carotene.

METHODS AND MATERIALS

Sampling for the analysis of total and β- carotene

From 4 local retail markets, 250 g of vegetables were procured, mixed, edible portion separated and 10 g leaves were separated for moisture estimation and 5 g for total and β-carotene estimation. The analysis was done within 1 hour of procurement. All the analysis was done in duplicates.

Processing of coriander leaves (maceration) with use of ingredients that may enhance stability of β-carotene

Coriander leaves are commonly consumed in the form of *chutney*, which involve minimal processing (macerating). Using an electric mixer grinder, using a variety of ingredients (Nambiar, 1998) which may have an enhancing effect on the stability of β-carotene, 4 types of chutneys were prepared and retention of carotene was studied. These were:

1) Fresh coriander leaves only: wherein 50 g of fresh coriander leaves were macerated in an electric mixer grinder.

2) Fresh coriander leaves with green chillies: wherein 50g of fresh coriander leaves were macerated with 5g of green chillies.

3) Fresh coriander leaves with lemon juice: wherein 50g of fresh coriander leaves were macerated with 5 g of lemon juice.

4) Fresh coriander leaves with green chillies and lemon juice: wherein 50g of fresh coriander leaves were macerated with 5g of green chillies and 5g of lemon juice.

For each trail, from the 250 g of coriander leaves 50g were analyzed for retention of total and β-carotene on maceration only fresh coriander leaves and other 50g were used to analyses the retention of total and β-carotene when macerated with either chilies, lemon or using both.

Selection and standardization of a recipe using fresh coriander leaves

In order to prepare β –Carotene rich recipe for vulnerable population and study the cooking losses, a common product of Gujarat, Western India, namely, *dhebra*, which is a shallow fried bread made out of wheat flour and *bajra* flour and spices and shallow fried using oil on an iron *tava* was developed, based on the following considerations:

It was culturally acceptable, easy to prepare and inexpensive recipe in Gujarat. Based on the result on processing losses by Seshadri (1997) and Nambiar (1998), which have shown that among the steaming, sautéing, baking, boiling and shallow frying, the latter retained maximum amount of β- carotene on processing, using drumstick and radish leaves.

Standardization of recipe

A standardized recipe of *dhebra* used in our earlier paper using radish leaves (Nambiar and Seshadri, 1998) was selected and standardized in the Institution Management Laboratory of the Department using various levels of coriander leaves (30-100g). Organoleptic evaluations were done using composite score card and hedonic ranking scale using a panel of 30 semi trained judges. The age of panel members ranged from 22-45 years. It was taken care that persons who served as panel members were in good health and refrained from smoking, chewing gums, eating and drinking for 30 min before the test. Water was provided to the panelists to facilitate sensory evaluation. Each judge evaluated each recipe on 3 occasions.

Sensory evaluation was carried out in the Institute management laboratory of foods and nutrition department which was quiet area free from distraction. Care was taken to serve the *dhebra* at a temperature at which it is eaten. The critical appraisal of the panel was noted and suggestions which were feasible and could improve any of the attributes and thereby overall acceptability were considered. Improvements were made before carrying out the total and β-carotene estimation.

Score card

Two scores based on composite score test and hedonic test were developed. Composite score test had a score of 1-5 score ranging from highly acceptable to highly unacceptable. Attributes to be scored were appearance, color, flavor, taste, texture, after taste and overall. To evaluate the general acceptability of the product a 9 point Hedonic scale was used which ranged from liked extremely to dislike extremely.

Chemical analysis

The moisture content of fresh vegetables was determinate by the method given by NIN (1983). Carotenoid pigments are extract by a suitable extraction purified and purified by saponification. The carotenoids are then quantified by measuring spectrophotometerically at 450nm (Zakaria & Simpson, 1979). For the standard curve, β-carotene standard from Sigma chem. Co. Lowis, USA was used and concentration was calculated from the molecular extinction coefficient (2500). Beta carotene content was estimated by method given by association of Analytical chemists (1980).

Statistical analysis

Means and standard errors were calculated for the moisture content, total carotene, β-carotene and rehydration ratio. One way ANOVA was used to test the differences in mean values for total and β- carotene of coriander leaves on macerating using different ingredients.

RESULTS AND DISCUSSION

Moisture, total carotene and β-carotene content

The moisture content of 4 vegetables ranged from 81.1% to 93.27% Mogri (*Raphanus caudatus*) had maximum moisture (84.5%) followed by red chawli (*Amaranthus sp*. 82.24%) coriander leaves coriander leaves (*coriandrum sativum* 84.55%) and least in green garlic (*Allium sativum* 81%). The total carotene content ranged from 2320.521µg/100g to 12079.73µg/100g FW. Coriander leaves contained the highest total carotene (12079.733µg/100g) followed by red chawli (9886.326µg/100g) and green garlic (6707.235µg/100g). Mogri had the lowest total carotene (2320.531µg/100g) content.

The beta-carotene content ranged from 425.155µg/100g to 2921.797µg/100g. The distribution of β-carotene in foods followed a pattern similar to that of total carotenes with coriander leaves having the highest β-carotene (2921.797µg/100g) and mogri having the lowest (425.155µg/100g). The β-carotene as percent of total carotene for 4 carotene containing foods ranged from 18.32% to 35.43% indicating that there are other carotenoids present along with β-carotene which added to the total carotene content. The β-carotene as percent of total carotene of coriander leaves was 24.18% whereas that reported by NIN (2010) was 32%, indicating regional variations (Table 1).

Effects of maceration using different ingredients on total carotene and β-carotene content of coriander leaves

The retention of total carotene ranged from 58% to 131 % with highest retention in fresh coriander leaves with chillies (131.06%), followed by fresh coriander leaves with lemon juice and green chillies (126.31%), fresh coriander leaves (71.2%) and fresh coriander leaves with lime juice (58.39%) (Table 2). The total carotene content of green chillies analyzed in the laboratory was 2035 µg/100g. However only 5g of green chillies were added to 50 g fresh coriander leaves while macerating from which 5g sample was taken for analysis. Therefore the amount of total carotene contributed by green chillies in 0.5g (10.179 µg) is negligible. The beta carotene retention in case of fresh coriander leaves when macerated was 72.33%. Similar results were shown by Padmavati *et al.*,(1992) wherein coriander leaves and curry leaves when macerated retained 76% of β- carotene. When other ingredients were added such as green chillies and lemon and both, the percent retention of β-carotene improved significantly i.e. from 98.2% to 182.11%. These results show an enhancing effect of green chillies and lemon juice on stability of β- Carotene. Bhaskarachary *et al.*,(1999) have reported that presence of certain polyphenols, weak acids and vitamin C have enhanced the stability of food matrix.

Madhavapeddi *et al.*,(1994) have suggested that the presence of tamarind and tomato in amaranth and palak dhal could have resulted in a better retention (71.77%) of β-carotene. The high content of β-carotene in coriander leaves when macerated with green chillies (149.81% retention) and with green chillies and lemon juice (182.11% retention) was observed. The β-carotene of green chillies (948.40µg/100g) was negligible as only very small amount was added to chutney. Statistically also, the results of total and β- carotene were highly significant (at $p < 0.01$) indicating that these ingredients have enhancing effect on β-carotene stability. Therefore it can be recommended that β-carotene containing foods be cooked in the presence of food containing weak acids such as chillies, lime and even tamarind and tomato as suggested by other investigators. These ingredients would not only enhance the percent retention of β-carotene but also enhance the taste and overall acceptability of the product.

Sensory evaluation of the coriander incorporated recipe *dhebra*

Score of each of the individual attributes for the shallow fried *dhebra* recipe ranged from 3.31 to 3.9 using the composite score card. Though the score for appearance was only 3.3 due to the dark green color of the leaves, the score for other attributes such as flavor (3.75), texture (3.9), after taste (3.75) and the overall acceptability (3.8) were very near to 4 indicating that the recipe was liked very much by the judges and it was rated as highly acceptable (Table 3). Hedonic test scores also indicated that *dhebra* prepared from fresh coriander leaves was highly acceptable as the score was approx. 8 out of 9 which means like very much (Table 4).

Retention of total and β- carotene content of the recipe

Dhebra which is made by shallow frying had 75.4% retention which was very high. This result is comparable with the result of Seshadri *et al.*,(1997) wherein the dhebra was incorporated with shade dried drumstick leaves and the total carotene retention was highest i.e. 73% compared to steaming-*muthia* (69%) and boling-dal soup (64%) indicating that shallow frying and steaming were better in retaining total carotenes (Table 5).

Table. 1: Moisture, total carotene and β-carotene content of 4 fresh carotene rich food analyzed:

Carotene rich foods	Moisture %	Mean ±SEM				
		Total carotene (TC)		β-carotene (BC)		BC as % TC
		FWµg/100g	DWµg/100g	FW µg/100g	DWµg/100g	
Mogri *(Raphananus caudatus)*	93.27± 0.755	2320.531 ± 140.09	316.10 ± 56.5	425.155 ± 12.93	69.24 ± 9.49	18.32
Green garlic *(Allium stativum)*	81 ± 0.861	6707.235 ± 272.78	346.24 ± 14.97	2376.971 ± 121.24	69.24 ± 9.49	35.43
Red chawli (*Amaranthus sp.)*	82.84 ± 0.985	9886.326 ± 138.264	562.22 ± 24.72	2135.298 ± 22.898	121.64 ± 5.66	21.59
Coriander*(Coriandrum sativum)*	84.55 ± 0.513	12079.733±844.872	877.11 ± 117.56	2921.797 ± 247.03	208.29 ± 23.37	24.18

Each value is mean of 6 values.

Table 2: β-carotene of selected carotene rich foods reported by various investigators.

	Speek et al.,	Esiong et al., 1990	Rodrequez et al., 1996	W santwisut et al., 1994	Yogesh et al., 1995	Reddy et al., 1995	Padmavati et al., 1991	Nambiar et al., 1998
	ıailand	ılesia	Brazil	N. Thailand	Nepal	India (Hyderabad)	India (Mumbai)	dia (Vadodara)
Amaranthus viridis	-	2947	1100	3498	-	-	-	-
Amaranthus uridis	-	-	-	-	-	700	-	-
Amaranthus gangeticus	1960	4646	-	-	-	8300	5291	2430
Coriander (coriandrum sativum)	1990	2745	4700	3408	1399	4800	7632	-

Table. 3: Effect of maceration using electric mixer grinder with different ingredients on total and β-carotene content of coriander leaves.

Treatment	Moisture	Total carotene		Retention	β-carotene		Retention
	%	FW (µg/100g)	DW (µg/100g)	%	FW (µg/100g)	DW (µg/100g)	%
Fresh coriander leaves * macerated	86.2	948.8	687.3	-	2815.02	204	-
	-	6761.37 ± 550.18	489.9 ± 39.9	71.2 ±5.7	2036.38 ** ± 27.35	147.56 ± 1.98	72.33 ± 0.32
Fresh coriander leaves *macerated using green chillies-5g	83.4	9400.25	566.28	-	3925.25	236.5	-
		12320.16 ±356.15	742.17 ± 21.45	131.06 ± 3.79	5880.75** ± 79.12	354.2 ± 4.74	149.81 ± 2.015
Fresh coriander * macerated with lemon juice-5g	86.2	10097.56	682.27	-	3245.59	219.3	98.2 ± .141
		5895.84 ± 175.13	398.36 ± 11.83	58.39 ± 1.73	3187.75** ± 4.58	215.38 30	
Fresh coriander leaves *macerated with green chillies-5g and lemon juice (5g)	86.1	9235.668	664.436	-	4180.76	300.72	-
		11665.29 ± 125.43	839.22 ± 9.0	126.31 ±1.357	7613.57** ± 12.89	547.74 ±.94	182.11 ±.311

Each value is a mean ± SEM of duplications. Significant at $p<0.01$.

Table. 4 : Attribute scores of *dhebra* using the composite score test.

Product	Attribute	Score (mean ± SEM)
Dhebra (Shallow fried Indian bread)	**Appearances**	3.312 ± .6
	Colour	3.25 ± .68
	Flavor	3.75 ± .68
	Taste	3.69 ± .6
	Texture	3.90 ± .68
	After taste	3.75 ± .93
	Overall	3.87 ± .62

Maximum scores 5 for each attributes.

Table. 5: Hedonic test score for *dhebra*.

Product	Score (mean + SEM)
Dhebra	7.94 ± .772

Table. 6 : Total carotene and β- carotene content of *dhebra* using 75g of fresh coriander leaves.

TC µg/100g (fresh)	TC µg/100g (cooked)	BC µg/100g (fresh)	BC µg/100g (cooked)	% retentionTC	BC
12079.733±844.87	9108.7±220.93	2921.797± 247.03	2165.08± 100.3	75.4	74.18 ±2.08

Each value is a mean ± SEM of 3 replicates.

Table. 7 : Nutritive value of the recipes.

Ingredients	Amount	Energy (kcal)	Protein (g)	Fats (g)	Calcium (mg)	Iron (mg)	B-car.(µg)	Vit.c (mg)
Wheat flour	75	255.7	9.07	1.27	36	3.67	-	-
Bajra	30	108.3	3.48	1.5	12.6	2.4		-
Coriander leaves	75	33	2.47	0.45	138	1.065	216.8	101.25
Green chillies	5	1.45	0.145	0.03	1.5	0.22	-	5.55
Lemon juice	10	5.7	0.1	.09	7	0.03	-	3.9
Curds	10	6	0.31	0.4	14.9	0.02		0.1
Garlic	5	7.2	0.315	-	1.5	0.06	-	0.65
Dry ginger	10	6.7	0.23	0.09	2	0.35	-	0.6
Ginjelly seeds	5	28.15	0.915	2.16	72.5	0.465	-	-
Oil	8	72	-	8	-	-	-	-
Jiggery	10	31.9	0.04	-	0.5	0.07	-	-
Total		*556.2*	*17.075*	*13.99*	*473.95*	*8.35*	*2165.8*	*112.05*
Chutney								
Corian leaves	50	22	1.65	0.3	92	0.71		67.5
Green chillies	5	1.45	0.145	0.03	1.5	.22	3854.69	5.55
Lemon juice	50	2.85	0.05	2.37	3.5	0.013		-
Ground nut	5	28.35	1.26	2	4.5	0.125	1.85	-
Sugar	5	19.9	-	-	0.6	0.008	-	-
Total		*74.56*	*3.105*	*2.37*	*102.1*	*1.076*	*3856.5*	*73.05*

Nutritive value of the recipe

Dhebra provided 556.2 kcal energy, 17.1 g protein, 13.99 g fats, 473.95 mg calcium, 8.35 mg iron, 2165.8 µg β-carotene and 112.05 mg vitamin C (Table 6).

DISCUSSION

The present study has shown that coriander leaves, red chawli and green garlic are good sources of β- carotene. Ingredients such as lemon juice and green chillies have an enhancing effect on the retention of beta carotene when minimal processing such as maceration is done in preparation of of carotene rich foods such as chutney. Coriander leaves when incorporated into a recipe namely *dhebra* which involves shallow frying retained 74.18% of β- carotene which is enough to meet the β-carotene requirements of the vulnerable population.

The study indicates that coriander should not just be used for garnishing. Owing to its distinct aroma due to its concentrated essential oils, freshness and nutritive value this coriander should be used abundantly in daily diets with minimal processing such as maceration and addition of weak acids and also be incorporated into common dishes.

Among many other factors, the chemical structures of carotenoids determine whether it has any availability as vitamin A activity, but most do not. The activity of β-carotene has been set at 1/6 of that of retinol but may be nearer to $1/4^{th}$ if the amount in a meal is small, and fall to 1/10 as the amount increases. The activity of all other pro Vitamin A carotenoids has been set at 1/12 of that of retinol (FAO/WHO consultation, 1998). All –trans isomers appear to have more activity than cis-isomers. The matrix within which a carotenoid is buried in a food appears to be of considerable importance. In green leaves carotenoids exist within chloroplasts as pigment-protein complexes, which require disruption of the cells for the carotenoid to be released. In other vegetables and fruits carotenoids are sometimes found in lipid droplets from which they may be readily released. Sweeney and Marsh (1971) reported that processing of fruits and vegetables induced isomerization of β- carotene resulting in an estimated 15% to 20% reduction in Vitamin A potency in green leafy vegetables and 30% to 35% in yellow vegetables. Cooking assists in the release, but if extensive may lead to oxidative destruction of the carotenoid. Dietary components may influences absorption. Fat is important for absorption as it is essential in the formation of micelles. Many studies have shown that leafy vegetables when cooked in closed pan retained more carotene than when cooked in open pan. Also, the β-carotene retention was maximum when the leafy vegetables were pressure cooked than those cooked in open and closed pan (Madhavapeddi et al, 1994).

Addition of oil while sauteting helps in better retention of β-carotene when compared to pressure cooking or cooking with or without lid (Madhavapeddi et al,1994). Amaranth, Koyyalykura, bacchali and spinach retained 60%,62%,75%,and 71%, β-carotene resp. Shallow frying of coriander *vadi, mithi muthia and colocasia patra* resulted in 8% 44%, and 62% loss in β-carotene resp. whereas deep frying of the same recipes resulted in 71%,79%, and 85% loss of β-carotene. Padmavati *et al.*,(1992) studied different green leafy vegetables when subjected to different methods of processing. It was observed that treatments like in salad preparations and macerating for the preparation of chutneys retained maximum β-carotene ie, 80.9% to 94% in case of minimum processing and 74.2% to 86.7% in case of maceration. Madhavapeddi *et al.*,(1994) when coriander and curry leaves were macerated in an electric mixer grinder, they retained maximum β-carotene ie,76% and minimum retention was observed when carrots were subjected to prolonged cooking i.e., 10% to 48% for the preparation of *halwas*.

A study by Nambiar (1998) observed that *dhebra* incorporated with radish leaves retained maximum total carotene i.e. 75%, followed by *muthia* (73%) and *handwa* (42%). These studies show that shallow frying retains maximum total carotene compared to steaming, boiling and baking. Seshadri (1997), reported that when dehydrated leaf powder was incorporated in *dhebra* (shallow-fried), *muthia* (steamed) and dhal soup (boiled with constant stirring), the steamed *muthia* in which drumstick

leaves were incorporated retained maximum β- Carotene i.e. 73% followed by shallow fried *dhebra* (69%) and dal soup (35%). Nambiar (1998) reported that radish leaves incorporated *dhebra* retained highest β- carotene i.e. 82% followed by *muthia* which retained 68%. Padmavati *et al.*,(1992) studied 3 recipes which were steamed and shallow fried and reported that maximum β-carotene retention was observed in coriander *vadi* (92.4%) followed by *methi muthia* (56.3%) and colocasia (37.9%).

Vegetables are a rich in macro and micro- nutrients other than β- carotene, have an added advantage over medicinal (synthetic) dozes for human population as they help in improving several other micronutrient deficiencies and inflammatory disorders due to their chemical composition (Nambiar et al, 2010, 2012).

Since the problem of providing good nutrition looms as one of the most important general public health problems, it is important for the nutritionist to evaluate the effect that methods of cooking have upon the retention of vitamin and how cooking procedures can be so modified as to retain these essential nutrients to the maximum without sacrifice of economy palatability and appearance. These results need to be disseminated in the community through various settings and approaches (Nambiar and Kosambia, 2005, Nambiar and Desai, 2012).

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