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RESEARCH NOTE

The Impact of Thermal Processing Methods on The β-carotene Content of Some Commonly Consumed Vegetables

Neerja Singla*, Priya Singla and Navjot Kaur

Punjab Agricultural University, Ludhiana, Punjab, India

*Corresponding author: singlaneerja@pau.edu

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Abstract

The vegetables namely mustard leaves, spinach, *bathua*, radish leaves, amaranthus, carrots and pumpkin were analyzed for their β-carotene content in the raw and in the cooked form using traditional cooking methods. Spinach, Amaranthus, mustard leaves, fenugreek leaves, carrots and pumpkin had β-carotene content as 5.80, 4.28, 5.85, 2.75, 5.21 and 0.89 mg/100g, respectively on fresh weight basis whereas in the pressure cooked form, the β-carotene content of the above said vegetables was 4.84, 3.62, 5.42, 2.23, 4.14 and 0.68 mg/100g, respectively. Cooking resulted in 7.2-24.3 % losses being minimum in mustard and maximum in pumpkin. The *bathua* leaves, fenugreek leaves, radish leaves and maize flour had β-carotene as 2.49, 2.75, 3.98 and 0.09 mg/100g, respectively on fresh weight basis. The β-carotene content of commonly consumed vegetables decreased significantly ($p<0.01$) on pressure cooking. The vegetables cooked in the form of traditional Punjabi recipes i.e. mustard *saag* had β-carotene 32 mg/100 g, spinach + *paneer* vegetable had 47.3 mg/100 g, whereas potato fenugreek and carrot, potato+ peas had β-carotene as 0.39 and 37.6 mg/100g, respectively. The increase in the β-carotene content of cooked vegetables using traditional methods might be due to the addition of other ingredients like *bathua* leaves, maize flour, tomatoes, *paneer*, potatoes and peas etc. Thus, these traditional recipes could be a potential the contributor to daily requirement of β-carotene and should be made use of.

Keywords: Amaranthus, β-carotene, *bathua* leaves, fenugreek, *saag*, processing methods

Carotenoids are the phytonutrients that impart a distinctive yellow, orange, and red colour to various fruits and vegetables. *β-carotene* is important not only for the colour that it imparts to the food stuffs, but also because of the myriad of associated health benefits. It has a potent antioxidant capacity and offers an array of health benefits such as lowering the risk of heart diseases and certain types of cancers, enhancing the immune system and protection from age-related macular degeneration - the leading cause of irreversible blindness among the adults. Incorporation of *β-carotene* in various food systems is limited by its poor water solubility and instability in the presence of light, heat, and oxygen (Gul *et al.* 2015). β-carotene has been found in most of the yellow, orange, dark green leafy vegetables and fruits such as kale, pumpkin, spinach, papaya, apricots, and peaches. Green leafy vegetables are a store house of vitamins such as β-carotene, ascorbic acid, folic acid and riboflavin as well as minerals such as iron, calcium and phosphorus (Carvalho *et al.* 2014).

Fresh vegetable produce is abundant during the winter season in Punjab. It is an important source of vitamins and minerals in the Punjabi diet, but the availability of ascorbic acid and β-carotene from the vegetables is altered to varying degrees when they are subjected to traditional household processing methods (Gupta and Bains, 2006). Vegetables are prepared at home on the basis of convenience and taste preference rather than nutrient losses. Researchers have reported that 5 to 78% of the β-carotene degraded when vegetables were prepared using different cooking methods (Vimala *et al*. 2011). Considerable quantities of carotenoids needed by individuals may be lost during

Table 1: Traditional Punjabi methods used for cooking of vegetables

Product	Ingredients	Amount(g)	Methods
Mustard *Saag*	Mustard leaves *Bathua* leaves Maize flour Onion Ginger Garlic refined oil	400 500 49 15 10 5 5	Mustard and *bathua* leaves were pressure cooked in the required quantity of water for about 30-35 min till done and mashed in an electric blender to a fine consistency then cooked further by adding of maize flour at short intervals till the required consistency was achieved. Onions ginger and of garlic were fried in a separate pan in refined oil. This mixture was added to the mustard *saag* before serving.
Carrot-peas vegetable	Carrots Potatoes Peas Refined oil	300 100 25 10	Carrots, potatoes and peas were pressure cooked for about 5 minutes using refined oil. Salt, chillies and condiments and spices were added to taste
Palak paneer	Spinach leaves Onions Ginger Garlic Refined oil *Paneer*	400 15 10 5 5 25	Spinach leaves were pressure cooked using required quantity of water for about 15-20 minutes, mashed in electric blender and excessive water was further evaporated. Onions, ginger and garlic (chopped finely) were fried in refined oil in a separate pan and salt, chillies and spices were added to taste. This mixture along with *paneer* (cut into small pieces) was added to the spinach mixture.
Pumpkin vegetable	Onions Tomatoes Refined flour Pumpkin	15 15 10 200	Onions and tomatoes were fried in refined oil in a pressure cooker and chopped pumpkin was added to it, mixed well and pressure cooked for about 5 mins. Salt, chillies and spices were added to taste.

household cooking of vegetables. Thus, information on the possible losses of carotenoids from vegetables, during traditional cooking methods, is of major importance (Gayathri *et al*. 2004). Various household cooking methods viz. open pan cooking and pressures cooking etc. have been reported to have a different effect on the retention of carotene of leafy vegetables. The consumption of green leafy vegetables in common Punjabi diets is quite high especially in winters in the form of *Sarson ka Saag*, *Palak Paneer* and Carrot-peas-potato vegetable etc. So, the present investigation was undertaken to study the β-carotene of vegetables commonly consumed in Punjab and to study the effect of commonly used traditional Punjabi methods of cooking, on the β-carotene content of the vegetables.

Materials and Methods

The raw samples of vegetables namely mustard leaves (*Brassica campestris*), spinach (*Spinacia oleracea*), *bathua* (*Chenopodium album*), fenugreek leaves (*Trigonella foenum graecum*), radish leaves (*Raphanus sativus*), amaranthus (*Amaranthus paniculatus*), carrots (*Daucus carota*), tomatoes (*Solanum lycopersicum*) and pumpkin (*Cucurbita maxima*) were procured from the local market of Ludhiana city and cleaned of any extraneous material.

Cooking of samples

To determine losses of β-carotene in various vegetables by pressure cooking, 100 g of each vegetable were pressure cooked with 25-50 ml of water, just enough to make them soft and mashy. The respective weight of all the cooked foods was noted down for further analysis.

Table 2: β-carotene content of raw commonly consumed vegetables (mg/100 g) *

Vegetable	Raw (Mean±SE)
Spinach	5.80±0.03 [a]
Amaranthus	4.28±0.05 [c]
Mustard *saag***	5.85***±0.05 [a]
Bathua leaves	2.49±0.06 [e]
Maize flour	0.09±0.01 [h]
Fenugreek leaves	2.75±0.05 [e]
Radish leaves	3.98±0.07 [d]
Carrots	5.21±0.1 [b]
Pumpkin	0.89±0.06 [f]
Tomato	0.32±0.02 [g]
Overall Mean (Mean±SE)	3.17±0.01

DMRT test has been applied
Figures followed with different superscripts are significantly different (P<0.05)
* Values are per 100 g on fresh weight basis
** Mustard leaves (100g) were cooked along with *bathua* (15g) and maize flour (10g) and % loss has been calculated taking into consideration the β-carotene content of raw ingredients.
*** Raw mustard leaves only.

Prior to cooking, all the vegetables were cleaned, freed of extraneous matter and inedible portion, washed thoroughly with water and chopped finely. Punjabi methods were used for cooking of vegetables (Table 1). β-carotene of the raw, pressure cooked and Punjabi recipes were estimated using method of AOAC (1980).

Statistical Analysis

The data were analyzed statistically by using various statistical tools such as mean and standard error. Analysis of variance [Data analysis by using Statistical Package for Social Sciences (SPSS) Software)] was also applied to assess the difference in β-carotene content of various commonly consumed vegetables. To test the level of difference in raw and cooked vegetables, independent t-test was applied.

Results and Discussion

As is evident from the Table 2, mustard and spinach leaves were found to contain the highest

Table 3: Effect of pressure cooking on β-carotene content of commonly consumed vegetables (mg/100 g) *

Vegetable	Raw (Mean±SE)	Cooked Mean±SE)	% loss in B-carotene content	t-value
Spinach	5.80±0.03	4.84±0.02 [b]	16.5	28.24*
Amaranthus	4.28±0.05	3.62±0.05 [d]	15.4	4.00*
Mustard *saag***	5.85***±0.05	5.42±0.01 [a]	7.2	8.85*
Fenugreek leaves	2.75±0.05	2.23±0.01 [e]	18.9	9.56*
Carrots	5.21±0.1	4.14±0.02 [c]	20.5	13.71*
Pumpkin	0.89±0.06	0.68±0.01 [f]	24.3	3.48*
Overall Mean (Mean±SE)	3.50±0.01	3.50±0.01	17.1	

DMRT test has been applied
Figures followed with different superscripts are significantly different (P<0.05)
* Significant at 1% level
* Values are per 100 g on fresh weight basis
** Mustard leaves (100g) were cooked along with *bathua* (15g) and maize flour (10g) and % loss has been calculated taking into consideration the β-carotene content of raw ingredients.

amount of β-carotene i.e. 5.85 and 5.80 mg/100g, respectively. *Bathua*, fenugreek, radish and amaranths leaves were found to have β-carotene as 2.49, 2.75, 3.98 and 4.28 mg/100 g, respectively. Carrots had a carotene content of 5.21 mg/100 g, whereas pumpkin and tomato were found to have β-carotene as 0.89 and 0.32mg/100 g, respectively. The per cent losses in β-carotene after cooking of mustard leaves, amaranths, spinach, fenugreek leaves, carrots and pumpkin were found to be 7.2, 15.4, 16.5, 18.9, 20.5 and 24.3, respectively (Table 3). The vegetables namely pumpkin, ridge gourd, green chillies, tomato, green peas, field beans and French beans are not only inexpensive but are better sources of β-carotene ranging from 20–120 mg/100 g (Kandlakunta *et al.* 2008). β-carotene content in carrots and pumpkin was 6.4 and 3.17 mg/100g (Javeria *et al.* 2013) which were lower as compared to those found in present study. Raw pumpkin contained 172.20 μg/g, whereas that cooked in boiling water had 184.80 μg/g and the steamed samples contained 202.00 μg/g of β-carotene (Carvalho *et al.* 2014).

Table 4: β-carotene content of some vegetables cooked using traditional Punjabi methods.

Vegetable	β- carotene(mg/100g) (Mean±SE)
Mustard *saag*	32±18.5 [c]
Spinach – *paneer*	47.3±27.3 [a]
Potato fenugreek	0.39±0.22 [d]
Carrot- potato-peas	37.6±21.7 [b]
Overall Mean (Mean±SE)	29.32±10.14

DMRT test has been applied
Figures followed with different superscripts are significantly different (P<0.05)

The β-carotene content of traditional Punjabi recipes, fenugreek potato and carrot potato peas were 0.39 and 37.6 mg/100 g on dry matter basis, respectively, whereas, the corresponding values for *palak paneer* and mustard *saag* was 47.3 and 32.0 mg/100 g, respectively (Table 3). The cooked pumpkin vegetable had a carotene content of 4.6 mg/100 g. The increase in the β-carotene content of cooked vegetables using traditional Punjabi methods might be due to addition to other ingredients like *bathua* leaves, maize flour, tomatoes, potatoes and peas etc. Overall loss of β-carotene during the 10 days of storage period was not statistically significant between the processed and unprocessed vegetables and the packaging systems (Hussein *et al.* 2000). β-carotene content in eleven most frequently consumed cooked vegetable preparations in Punjab namely potato beans, potato brinjal, brinjal *bhatha*, potato capsicum, okra, bottle gourd, ridge gourd, summer squash, pumpkin, colocasia and bitter gourd ranged between 0.8 to 98.7 μg/100g, respectively on fresh weight basis (Singh *et al.* 2014).

Conclusion

β-carotene content of commonly consumed vegetables ranged between 0.3 to 5.85 mg/100g, being lowest in tomato and highest in mustard *saag*. The values in the raw vegetables varied significantly ($p<0.05$) except for between spinach and mustard *saag* and *bathua* and fenugreek leaves. Pressure cooking of the vegetables resulted in a significant loss of β-carotene content. The traditional Punjabi recipes used for cooking of the vegetables resulted in a significant ($p<0.05$) increase in β-carotene content because of the addition of other carotene rich sources. It is concluded that the commonly consumed winter vegetables in Punjab are good source of β-carotene and should be included in daily diet in order to meet the requirements of β-carotene which is a good precursor of vitamin A.

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