

## Investigating the Changes in $\beta$ -Carotene concentrations of Carrot and Sweet Corn Using Different Methods of Heat Treatments

M. Yahyaei <sup>a\*</sup>, A. Ghavami <sup>b</sup>, M. Gharachorloo <sup>c</sup>, K. Larijani <sup>d</sup>, S. Z. Mazhari <sup>e</sup>

<sup>a</sup> M. Sc. Research Student of Food Science and Technology, Science and Research Branch, Islamic Azad University, Tehran, Iran.

<sup>b</sup> Senior Lecturer in Food Science & Nutrition, School of Human Sciences, Faculty of Life Sciences, Metropolitan University, London.

<sup>c</sup> Assistant Professor of the College of Food Science and Technology, Science and Research Branch, Islamic Azad University, Tehran, Iran.

<sup>d</sup> Assistant Professor of Chemistry Department, Science and Research Branch, Islamic Azad University, Tehran, Iran.

<sup>e</sup> Associate Professor of Nutrition Department, Science and Research Branch, Islamic Azad University, Tehran, Iran.

Received: 10 November 2013

Accepted: 12 April 2014

**ABSTRACT:** Carotenoids are red, orange and yellow pigments, which are widely distributed in fruit and vegetables. The aim of this research is to investigate the effect of conventional, high pressure and microwave cooking on the concentrations of  $\beta$ -carotene in carrot and sweet corn. Raw carrots were washed, peeled and diced to a uniform size and then frozen at  $-70^{\circ}\text{C}$ . Sweet corn was also provided in a similar ready to serve condition and stored at  $-70^{\circ}\text{C}$ .  $\beta$ -carotene contents in the vegetables were quantified after extraction and injection onto the High Performance Liquid Chromatography column and measured on the UV-Visible detector. The results indicated the conventional cooking of carrots and microwave cooking of corn for 10 minutes were taken as the ideal cooking procedure to retain this vital important micronutrient. Also microwave cooking for 20 minutes had the highest loss of  $\beta$ -carotene in both carrot (53.76%) and corn (83.03%) as compared to other methods of cooking.

**Keywords:**  $\beta$ -carotene, Carrot, Cooking, High Performance Liquid Chromatography, Sweet Corn.

### Introduction

Fruits and vegetables are rich sources of antioxidants and pigments such as carotenoids and phenolic compounds. Antioxidants provide a defensive role in the protection of the body and reduce the risk of some diseases namely diabetes, alzheimer's and cancer (Zhang and Hamauzu, 2004).

In green vegetables  $\beta$ -carotene are incorporated into carotenoid-protein complexes within the chloroplasts. These so-called carotenoproteins have an inhibitory effect on the extractability of  $\beta$ -carotene from the vegetable matrix. Cooking led to a

softening of the plant tissue and the denaturation of proteins, therefore the carotenoids are released from the plant matrices (Bernhardt and Schlich, 2006). Heating and cooking of food is a traditional habit to improve the organoleptic properties of foods. However, this will also cause nutrient loss and the reduction in the quantity of vitamins within the food. These effects will depend on the length, the degree and type of processing methods, for example: conventional, high pressure and microwave cooking (Sant'Ana *et al.*, 1998; Pearson, 1973). The latter of which is gaining popularity due to the energy and

\*Corresponding Author: [yahyaei\\_mah30ma@yahoo.com](mailto:yahyaei_mah30ma@yahoo.com)

time saving benefits (Kumar and Aalbersberg, 2006; Lemmens *et al.*, 2009).

In addition, other factors such as the type of heat treatment, presence of oxygen, moisture, light and pH will affect the stability of carotenoids and their retention (Leskova' *et al.*, 2006).

Nunn *et al.* (2006) investigated the retention of carotenoids as well as their organoleptic properties of broccoli, carrots, green beans and sweet potatoes by different methods of induction boiling, conventional boiling and steam generation by the application of microwave. The results of this study confirmed that the loss of  $\beta$  and  $\alpha$  carotenes in green beans and carrots were similar by the three methods applied, but the concentration of  $\beta$ -carotene in broccoli and sweet potatoes prepared by generated steam by microwave was reduced significantly as compared to other methods. In contrast, Zhang and Hamazu (2004) measured the losses of micronutrients such as ascorbic acid, carotenoids and some phenolic compounds in broccoli by conventional and microwave cooking and identified that there were significant differences between the two types of cooking method.

Bernhardt and Schlich (2006) investigated the influence of different domestic cooking methods on the all-trans and cis- $\beta$ -carotene content, and the  $\alpha$ -tocopherol content in fresh and frozen broccoli and red sweet pepper. With regard to the frozen broccoli, no significant change occurred, however the different cooking regimes to the fresh red pepper led to significant losses in all-trans- $\beta$ -carotene content. In frozen red pepper boiling and microwave cooking lead to significant losses of all-trans- $\beta$ -carotene. In summary it is shown that cooking has significant effect on the  $\beta$ -carotene content in fresh and frozen red peppers.

The aim of this research was to investigate the effect of conventional, microwave and high pressure cooking on the

$\beta$ -carotene concentration of locally purchased carrots and sweet corn of this micronutrient which might be important as a view of nutrient deficiency.

## Materials and Methods

### - Chemicals and solvents

Chemicals and solvents were obtained from Merck Chemical Company.

$\beta$ -carotene standard (C9750, Type I, synthetic,  $\geq 93\%$ (UV), powder) was purchased from Sigma Chemical Company.

### - Samples

Raw carrots and sweet corn were purchased from the open market in Tehran. Carrots were washed, peeled, cut into a uniform size and then frozen at  $-70^{\circ}\text{C}$ . Sweet corn was also provided in a similar ready to serve condition and stored at  $-70^{\circ}\text{C}$ .

### - Cooking Treatments

Three different cooking treatments were employed:

Conventional cooking: 50 g of corn or diced carrots were added separately to a glass beaker containing 200 ml of hot distilled water ( $92-95^{\circ}\text{C}$ ) and cooked in an oven for periods of 10 and 20 minutes.

Microwave cooking: 50 g of the samples were added to a glass beaker containing 200 ml of hot distilled water ( $92-95^{\circ}\text{C}$ ) and cooked in a microwave oven at 1000 W for 10 and 20 minutes.

High pressure cooking: 50 g of the samples were added to a glass beaker containing 200 ml of hot distilled water ( $92-95^{\circ}\text{C}$ ) and was carried out at  $121^{\circ}\text{C}$  for 10 and 20 minutes at 1.2 - 1.4 atmospheric pressure.

### - Extraction and $\beta$ -carotene measurement

The raw and cooked samples were homogenized in a blender. 10 g of homogenized sample was mixed thoroughly with 1 g magnesium carbonate, 50 ml methanol and tetrahydrofuran (1:1 v/v) and

then the suspension was filtered through a sintered glass funnel by the aid of vacuum pump. The filtrate was poured into a separating funnel and then 50 ml petroleum ether and 50 ml sodium chloride (10%) were added. The upper layer was removed and the solvent evaporated at 35°C by rotary evaporator. The residue was dissolved in dichloromethane and kept until required (Ghavami *et al.*, 2012; Hart and Scott, 1995).

High Performance Liquid Chromatography model KNAUER-2500 equipped with UV-Visible detector (450nm) and C18 column (250×4.6mm) was employed. The mobile phase consisted of Tetrahydrofuran-Methanol (30:70 %v/v) with a flow rate of 1.5 ml/min was employed (Ghavami *et al.*, 2012; Hart and Scott, 1995).

- Statistical Analysis

Statistical Analysis were carried out by SPSS statistics version 17 in triplicated order by the Duncan Test at 5% probability.

**Results and Discussion**

The β-carotene content in raw and cooked carrots and sweet corn are shown in Tables 1 and 2. Figure 1 indicates the percentage loss of β-carotene in the samples during various cooking procedures.

There are significant differences in the β-carotene concentrations of the carrots between the three different cooking methods (table 1), also according to table 2, there are

significant differences in the β-carotene concentrations of the sweet corn between the three different cooking methods.

Some researchers have investigated the β-carotene concentrations of raw carrots and reported the following quantities of β-carotene; 1830-14700 μg/100g (Su *et al.*, 2002), 2768 μg/100 g (Nunn *et al.*, 2006), 2200 μg/100g (Singh *et al.*, 2001) and 8870 μg/100g (Lemmens *et al.*, 2009). In this research, the quantities of 1231.19±6.24 μg/100g were determined. The concentrations of β-carotene in carrots and sweet corn varies according to the variety of plants, soil and method of cultivation, extraction procedure, time and length of storage. The retention of β-carotene in carrots regarding the conventional cooking for 10 and 20 minutes was better as compared to the microwave and high pressure cooking methods. The losses might be due to the effect of heat on β-carotene, the length of treatment or leaching of β-carotene into the water and oxidation. Although cooking of carrots for 10 minutes by any of the methods mentioned caused a considerable losses in β-carotene content but the severity was less if the samples were cooked for a longer period of time. However, it should be noted that cooking of carrots by the conventional method retained β-carotene content better as compared to high pressure cooking, which in turn retained some β-carotene content. The loss of β-carotene content in carrot after 20 minutes of microwave cooking accounted for 53%.

Table 1. The effect of different cooking methods on β-carotene content of carrot

Cooking methods	β-carotene(μg/100g)		
	0	10	20
Conventional	1231.19 <sup>a</sup> ±6.24	1038.27 <sup>b</sup> ±1.4	876.91 <sup>c</sup> ±11.43
Pressure cooking	1231.19 <sup>a</sup> ±6.24	768.67 <sup>d</sup> ±0.62	756.93 <sup>d</sup> ±10.07
Microwave	1231.19 <sup>a</sup> ±6.24	988.09 <sup>e</sup> ±20.82	569.21 <sup>f</sup> ±1.13

Data are means of three duplicate experiments ± SD. Similar alphabets have no significant difference (p<0.05).

Table 2. The effect of different cooking methods on  $\beta$ -carotene content of sweet corn

Cooking methods	$\beta$ -carotene( $\mu\text{g}/100\text{g}$ )		
	Cooking time (min)		
	0	10	20
Conventional	49.30 <sup>a</sup> $\pm$ 0.51	39.47 <sup>b</sup> $\pm$ 0.08	38.72 <sup>b</sup> $\pm$ 0.35
Pressure cooking	49.30 <sup>a</sup> $\pm$ 0.51	35.02 <sup>c</sup> $\pm$ 0.32	32.05 <sup>d</sup> $\pm$ 0.52
Microwave	49.30 <sup>a</sup> $\pm$ 0.51	44.11 <sup>e</sup> $\pm$ 0.71	8.33 <sup>f</sup> $\pm$ 0.22

Data are means of three duplicate experiments  $\pm$  SD.  
 Similar alphabets have no significant difference ( $p < 0.05$ ).

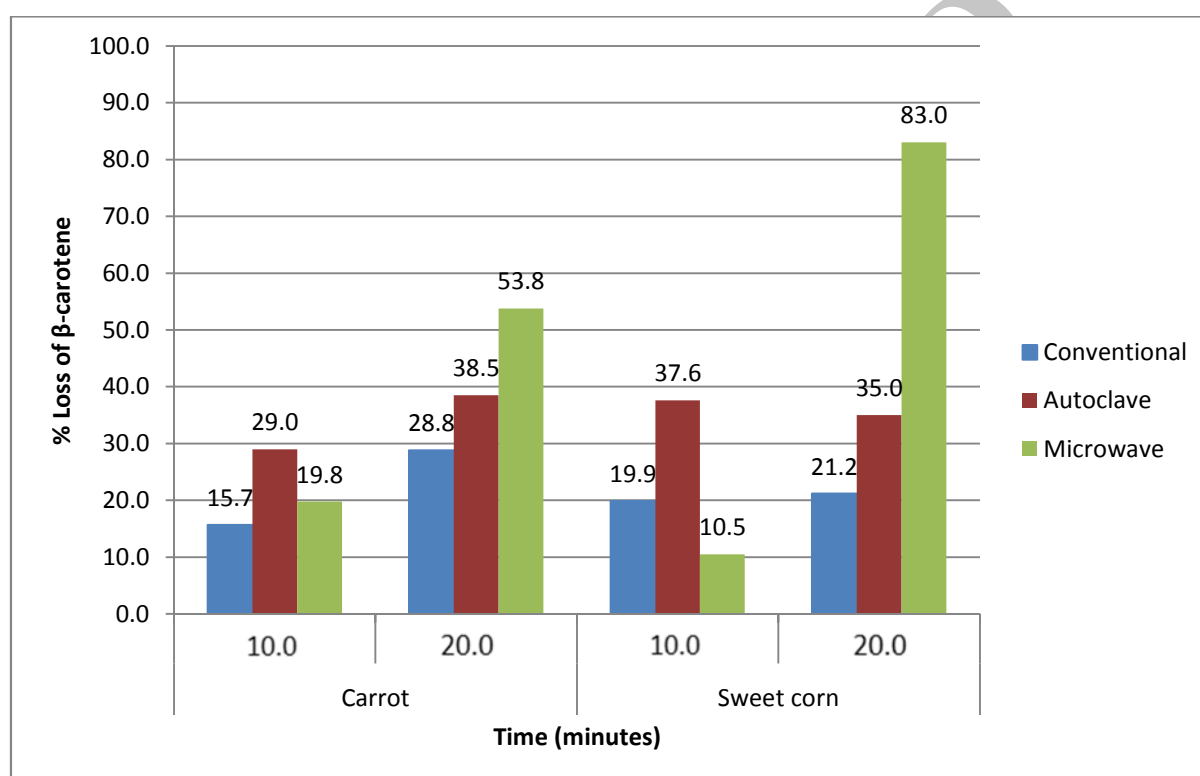


Fig. 1. % Loss of  $\beta$ -carotene in carrot and sweet corn from different cooking methods

Apart from the carotenoid losses, the sensory properties and acceptability of the food products cooked by different methods are important factors to consider, namely the texture and hardness (Venkatesh and Raghavan, 2004; Hill, 1998).

Sweet corn is not a rich source of  $\beta$ -carotene as compared to carrot and the loss of this vital and important micronutrient by various cooking methods and procedures

follows similar pattern to carrot.

### Conclusion

Carrot is a rich source of  $\beta$ -carotene, a vitamin A precursor, and is an essential micronutrient required by the body. The lack and deficiency of this micronutrient might cause severe body disorders and problems. Various cooking and heating applications have caused losses of this vital compound in

both sweet corn and carrot. In this study it was observed that when microwave apparatus was applied for 20 minutes, the color of water used as media became deeper as compared to other methods of heat treatment, meaning higher extraction of  $\beta$ -carotene and more transfer of this compound to the cooking water. It might be concluded that due to the nature of the food and the source of application shorter period of cooking is required by microwave to achieve good quality in term of texture, organoleptic characteristics and nutritional properties as compared to the conventional and high pressure cooking.

### References

- Bernhardt, S. & Schlich, E. (2006). Impact of different cooking methods on food quality: Retention of lipophilic vitamins in fresh and frozen vegetables. *Journal of Food Engineering* 77(2): 327–333.
- Ghavami, A., Coward, W. A. & Bluck, L. J. C. (2012). The effect of food preparation on the bioavailability of carotenoids from carrots using intrinsic labelling. *British Journal of Nutrition* 107, 1350-1366.
- Hart, D. J. & Scott, K. J. (1995). Development and evaluation of an HPLC method for the analysis of carotenoids in foods, and the measurement of the carotenoid content of vegetables and fruits commonly consumed in the UK. *Food Chemistry* 54(1): 101-111.
- Hill, A. (1998). Microwave ovens. *The International Life Sciences Institute Europe Microwave Oven Task Force*.
- Kumar, S. & Aalbersberg, B. (2006). Nutrient retention in foods after earth-oven cooking compared to other forms of domestic cooking: 2. Vitamins. *Journal of Food Composition and Analysis* 19(4): 311–320.
- Lemmens, L., Tibäck, E., Svelander, C., Smout, C., Ahrné, L., Langton, M., Alminger, M., Loey, A. V. & Hendrickx, M. (2009). Thermal pretreatments of carrot pieces using different heating techniques: Effect on quality related aspects. *Innovative Food Science and Emerging Technologies* 10(4): 522–529.
- Lesřkova, E., Kubiřkova, J., Kovařikova, E., Kosřicka, M., Porubská, J. & Holcřřkova, K. (2006). Vitamin losses: Retention during heat treatment and continual changes expressed by mathematical models. *Journal of Food Composition and Analysis* 19(4): 252–276.
- Nunn, M. D., Giraud, D. W., Parkhurst, A. M., Hamouz, F. L. & Driskell, J. A. (2006). Effects of cooking methods on sensory qualities and carotenoid retention in selected vegetables. *Journal of the Food Quality* 29(5): 445-457.
- Pearson, D. (1973). *Laboratory Techniques in Food Analysis*. Fric, Fifst Published.
- Sant'Ana, H. M. P., Stringheta, P. C., Brandao, S. C. C. & Azeredo, R. M. C. D. (1998). Carotenoid retention and vitamin A value in carrot (*Daucus carota* L.) prepared by food service. *Food Chemistry* 61(1-2): 145-151.
- Singh, G., Kawatra, A. & Sehgal, S. (2001). Nutritional composition of selected green leafy vegetables, herbs and carrots. *Plant Foods for Human Nutrition* 56(4): 359–364.
- Su, Q., Rowley, K. G. & Balazsa, N. D. H. (2002). Carotenoids: separation methods applicable to biological samples. *Journal of Chromatography* 781(1-2): 393–418.
- Venkatesh, M. S. & Raghavan, G. S. V. (2004). An overview of microwave processing and dielectric properties of agri-food materials. *Biosystems Engineering* 88(1): 1–18.

Zhang, D. & Hamazu, Y. (2004). Phenolics, ascorbic acid, carotenoids and antioxidant activity of broccoli and their changes during conventional and microwave cooking. *Food Chemistry* 88(4): 503–509.

Archive of SID