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Full Length Article

Effect of different cooking methods on the antioxidant components of Carrot

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ABSTRACT

Effect of different cooking methods on the proximate composition, vitamin C, total phenolic content (TPC), total flavonoid content (TFC), total carotenoid and ß-carotene content and antioxidant activity of carrot were studied. Moisture content of the raw and cooked carrot ranged from 81.6 to 89.4 percent. There was no significant ($p \leq 0.05$) difference in the percent protein content of cooked and uncooked carrot. Percent crude fibre and total ash differ significantly ($p \leq 0.05$) for the cooked samples from the raw. Vitamin C content decreased in all the carrot samples cooked by different cooking methods. Cooking carrot by sautéing had the maximum increase for both total and ß- carotene content. There was a significant ($p \leq 0.05$) increase in the TPC of carrot cooked by different cooking method, but the TFC was found to decrease in the cooked carrots. All the extracts from the differently cooked carrots were found to possess DPPH-radical scavenging activity.

Key words: Antioxidant, carotenoid, carrot, cooking, phenolic, proximate

INTRODUCTION

The protection that fruits and vegetables provide against diseases has been attributed to the various antioxidants contained in them (Carlsen *et al.*, 2010; Song *et al.*, 2010). Their contributory factors are due to the presence of vitamins and pro-vitamins such as ascorbic acid, tocopherols and carotenoids and in addition to that they are also rich in a wide variety of phenolic substances (Cieslik, *et al.,* 2006; Pourmorad *et al.*, 2006).

Carrot is one of the important root vegetables rich in bioactive compounds like carotenoids and dietary fibres with appreciable levels of several other functional components including phenolics, having significant health promoting properties (Sharma *et al.*, 2012). The role of carrot carotenoids as the precursors of vitamin A as well as excellent antioxidants has been commonly known. Phenolic compounds and their antioxidant capacity in carrot cultivars have been also investigated by Zhang and Hamauzu (2004).

Carrots can be eaten in a variety of ways. Only 3% of the β-carotene in raw carrots is released during digestion: this can be improved to 39% by pulping, cooking and adding cooking oil (Hedren *et al.*, 2002). Alternatively, they may be chopped and boiled, fried or steamed, and cooked in soups and stews. However, little is known about the effect of different cooking methods on the antioxidant constituents in carrot. Therefore the objective of this study was to evaluate their antioxidant constituents as influenced by different cooking methods so as to understand the best way to preserve the nutrients during processing.

MATERIALS AND METHODS

Plant materials and sample preparation

Fresh carrot (*Daucus carota* var. PC 34) was procured from Department of Vegetable Crops, Punjab Agricultural University, Punjab. Carrots were washed with tap water, pat dried with paper towel and the inedible parts were removed. The edible portions were cut into small cubes (0.5 cm), mixed well and divided into six equal portions. One portion was retained raw, others were cooked in five different methods (i.e., boiling, steaming, pressure cooking, microwaving and sautéing). Two hundred gram of carrot cubes was utilized for each cooking method. The treatment time, amount of water and oil used are given in Table 1. Refined soybean oil was used for sautéing carrot cubes.

Table 1: Treatment time (in min), amount of water and oil used (in ml)

Treatments	Time	Water	Oil
Raw	-	-	-
Boiling	9	300	-
Steaming	10	-	-
Pressure cooking	5	150	-
Microwave cooking	5	10	-
Sautéing	8	-	10

Determination of ascorbic acid

The carrot samples were estimated for their ascorbic acid content by the Association of Vitamin Chemists (AOVC, 1996) method. The blue colour produced by the reduction of 2,6-dichlorophenyl indophenols dye by ascorbic acid is estimated colorimetrically.

Determination of carotenoid contents

Total Carotenoid and ß-carotene contents were determined according to the method of Ranganna, (2002).

Two gram sample was taken in a pestel and mortar, grinded using acetone. Extraction was repeated for 2-3 times until the extract becomes colourless. The extracts were pooled and filtered. The filtrate was transferred to a separating funnel and added 10-15 ml of petroleum ether. The pigments got transferred into the petroleum ether phase by diluting the acetone with water containing 5% sodium sulphate. Petroleum ether extracts were pooled and volume was made up to 25 ml with 3% acetone in petroleum ether. Absorbance at 452 nm was measured spectrophotometrically for total carotenoid content. For determination of ß-carotene content, the extract was passed through a column containing activated alumina. ß-carotene band formed in the column was eluted and made up the volume with 3% acetone in petroleum ether. Then the absorbance was measured spectrophotometrically.

Preparation of extract

Two gram of homogenized sample was extracted with 50 ml 80% methanol for all the carrot samples for the determination of total phenolic content and total flavonoid content. The mixture was centrifuged at 2200 rpm for 15 min at room temperature and the supernatant decanted into polypropylene tubes. The clear extracts were analyzed for the determination of phenolic content, flavonoid content and antioxidant activity.

Determination of total phenolic content

The total phenol content of the extract was determined using the method reported by Singleton and Rossi (1965). A sample of methanolic extract (0.2 ml) was mixed with 1 ml of Folin–Ciocalteau reagent (ten fold dilutions). The mixture was allowed to stand for 5 min at room temperature before adding 0.80 ml of 20% Na_2CO_3 and then mixed gently. The reaction mixture was incubated for 40 min and the absorbance measured at 760 nm in spectrophotometer. The total phenolic content was calculated using gallic acid as standard.

Determination of total flavonoid content

The total flavonoid content was measured using the Aluminium chloride colorimetric method modified from the procedure reported by Woisky and Salatino (1998). Two ml of the extract was mixed with 100µl of 10 percent $AlCl_3$, 100µl of 1 mol per litre potassium acetate and 2.8 ml water and allowed to incubate at room temperature for 30 min. Thereafter, the absorbance of the reaction mixture was subsequently measured at 415 nm.

Determination of antioxidant activity using DPPH method

Total antioxidant activity was determined by the 2,2,-di- phenyl-2-picryl-hydrazyl (DPPH) method of Liang Yu (2008). An aliquot of 0.1 ml of the samples was taken in a test tube and then 2.9 ml of 0.01mM DPPH reagent was added and vortexed and let to stand at room temperature in the dark for 30 min.

The decrease in absorbance at 517nm was measured. Antioxidant activity (AA) was expressed as percentage inhibition of the DPPH radical.

RESULTS AND DISCUSSION

Antioxidant components

Concentration of vitamin C in raw carrot was 3.2 mg/ 100 g FW, confirming that carrots are not a good source of this vitamin. Vitamin C is very susceptible to chemical and enzymatic oxidation during the processing, cooking and storage of produce. Cooking is often responsible for the greatest loss of vitamin C, and the extent of the loss depends upon variations in cooking methods and periods. As expected ascorbic acid decreased in all the carrot samples cooked by different cooking methods (Table 2). However the highest reduction was found in pressure cooked (42.4 %), followed by boiling (33.1 %), steaming (29.5 %), microwave cooking (18.2 %) and the least in sautéed (17.2 %) carrot. The highest vitamin C losses occurred in the water-blanched samples (Lee and Kader, 2000). Loss of vitamin C is caused by leaching in surrounding water and thermal breakdown.

In the present study, uncooked carrot contains 12.3 mg total carotenoids and 5.69 mg ß-carotene per 100 g of the edible part (Table 2). ß-carotene is the predominant carotenoid in carrots (Nicolle *et al.*, 2004). Kalt (2005) reviewed that ß-carotene makes up about 45 - 80 percent of the total carotene. Baranski *et al.,* (2012) reported that the total carotenoid content was related to root colour and ranged from 0 to 40 mg per 100 g fresh weight. The effect of cooking on carotenoids in carrot is shown in Table 2. All the cooking method caused significant ($p \leq 0.05$) increase in total carotenoids. Processing can lead to a dissociation of antioxidants from plant matrix components, increasing the carotenoid antioxidants (Kalt, 2005). The carrots cooked by different cooking methods: boiling, steaming, pressure cooking, microwave cooking and sautéing increased the total Carotenoids by 12.0, 11.3, 16.1, 17.3 and 61.1 percent respectively, while the increased in ß-carotene were 13.6, 7.7, 10.0, 12.3 and 28.1 percent respectively. Cooking carrot by sautéing had the maximum increase for both total carotene and ß- carotene content, which might be due to the low moisture content in sautéed carrot leading to higher nutrient concentration. Howard *et al.,* (1999) reported an increase in trans ß-carotene concentration in steam blanched and microwave cooked carrots. Similarly, Miglio *et al.,* (2008) reported an increased in total carotenoids and ß-carotene content of boiled carrots compared to raw carrots. Conversely, Borowska *et al.,* (2003) found that the content of *trans* α- and β-carotene in carrots decreased significantly ($p \leq 0.05$) when carrot cubes were subjected to heat treatment by putting in water with or without citric acid, or in a convection-type steam furnace, compared with the control sample.

Methanolic extracts of carrots were found to have 32.60, 35.97, 36.91, 35.89, 37.18 and 37.34 mg GAE/100g FW in raw, boiled, steamed, pressure cooked, microwave cooked and sautéed carrot (Table 2). The TPC for raw carrot are in line with the values reported by Chu *et al.,* (2002) and Leja *et al.,* (2013) that the content of phenolic compounds in the accessions of carrot to vary from 19.8 to 342.2mg/100g FW. There was a significant ($p \leq 0.05$) increase in the TPC of carrots cooked by different cooking method, with the highest increase in sautéed and microwave cooked carrots. Andlauer *et al.,* (2003) in their study found that cooking of zucchini, beans and carrots with smaller amounts of water resulted in significant higher content of phenolic phytochemicals in the vegetables compared to cooking with larger water volumes. Food processing, like cutting of the vegetable tissue and exposure to higher temperatures, can lead to cellular disruption and dissociation of some phenolic compounds from cellular structures such as lignin and polysaccharides (Bernhart and Schlich, 2005), causing them to be more extractable and readily detected (Cohen *et al.*, 2001). However, the TFC was found to decrease in all the carrot cooked by different cooking method except for carrot cooked by sautéing (Table 2). Faller and Fialho (2009) observed that sautéing lead to a 7–25% gain in quercetin concentration, whereas boiling leads to an 18% decrease in the concentration of this flavonol.

All the extracts from the differently cooked carrots were found to possess DPPH-scavenging activity (Table 2). DPPH radical scavenging activity was found to increase by all the cooking methods. It was the highest in microwave cooked (13.75 %) carrot, followed by pressure cooking (13.35 %), sautéing (13.20 %), steaming (17.4 %), boiling (13.0 %) and the least in raw carrot (11.20 %).

In contrast to the result found in the present study Faller and Fialho (2009) reported that the radical scavenging activity of carrot decreased after cooking, independently of the procedure, while the Radical scavenging activity increases after cooking for potato, broccoli and white cabbage. This study is supported by the by the study conducted by Yagamuchi *et al.,* (2001) and Turkmen *et al.,* (2005) which showed that cooking by different methods namely- boiling, microwave cooking and steaming enhanced antioxidant activity in some vegetables.

Table 2: Effect of cooking on the antioxidant constituents of carrot

	Raw	Boiling	Steaming	Pressure cooking	Microwave cooking	Sautéing
Vitamin C (mg/100g)	3.02[a]	2.02[c] (-33.1)	2.13[d] (-29.5)	1.74[e] (-42.4)	2.47[b] (-18.2)	2.50[b] (-17.2)
Total carotenoid (mg/100g)	12.13[a]	13.59[b] (12.0)	13.50[b] (11.3)	14.08[c] (16.1)	14.23[c] (17.3)	19.54[d] (61.1)
ß- carotene (mg/100g)	5.69[a]	6.35[b] (13.6)	6.02[ab] (7.7)	6.15[ab] (10.0)	6.28[b] (12.3)	7.16[c] (28.1)
TPC mg GAE/100g	32.60[a]	35.97[b] (10.3)	36.91[c] (13.2)	35.89[d] (10.1)	37.18[e] (14.1)	37.34[f] (14.5)
TFC mg QE/100g	5.70[a]	5.34[b] (-6.3)	5.21[c] (-8.6)	4.82[d] (-15.4)	4.50[e] (-21.1)	7.42[f] (30.2)
DPPH %	11.20[a]	13.00[b] (16.1)	13.15[b] (17.4)	13.35[b] (19.2)	13.75[b] (22.8)	13.20[b] (17.9)

Means in rows followed by different letters differ significantly ($p \leq 0.05$)
Percent variation from raw values are given in parenthesis.

CONCLUSION

The vitamin C content and the total flavonoid content of carrot decreased by all the cooking methods employed except for TFC in sautéed carrot. However, the proximate composition and other antioxidant components were found to increase by cooking irrespective of the cooking method used. Overall, sautéing and microwave cooking were identified the optimum method of cooking carrot, which resulted in highest retention and an increased in the antioxidant constituents.

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