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Impact of domestic cooking on antioxidant activity of potato and carrot

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Abstract
Roots and tubers are widely cultivated all over the world and are good source of antioxidants. Antioxidants play a very important role in the body's defence system against free radicals which are formed in body continuously and are causative factors of various diseases. Most of the vegetables are consumed after being cooked or processed. Variety of effects like destruction, release and structural transformation of the phytochemicals take place during the cooking process. The total phenolics content (TPC) of potato and carrot were 25.23 and 19.14 mg GAE/100g on fresh weight basis, respectively. The total flavonoids content (TFC) of potato and carrot were 18.71 and 12.27 mg GAE/100g respectively. An overall increase in TPC and TFC content of cooked potato and carrot was observed. The DPPH activity of raw potato and carrot was16.60 and 6.02 mg TE/100g, respectively while FRAP activity was 61.50 and 36.43 mg TE/100g, respectively. A significant increase in FRAP and DPPH activity was observed in both the heat treatment in potato and carrot.

Keywords: Potato, Carrot, Cook, Antioxidants, DPPH, FRAP, Phenolics

Introduction
Antioxidants play a very important role in the body's defence system against Reactive Oxygen Species (ROS), which are the harmful by products generated during normal cell aerobic respiration (Gutteridge *et al*., 2000) [10]. Antioxidants are also quenchers of free radicals, one of the causative factors for the development and progression of degenerative diseases. Increasing intake of dietary antioxidants may help to maintain an adequate antioxidant status and, therefore, the normal physiological function of a living system and play an important role in preventing diseases. Phenolic compounds can act as antioxidants by interfering with oxidation processes through chain breaking reaction activities (primary oxidation) or through scavenging of free radicals (secondary oxidation) (Ndhlala *et al*., 2010; Augspole *et al*., 2014) [16, 2]. Roots and tubers are widely cultivated all over the world in tropical and subtropical areas. They provide a substantial part of the world's food supply and are also an important source of animal feed and processed products for human consumption and industrial use. Root vegetables form an integral part of Indian diet and some of these foods have been identified to be rich in antioxidants. Root and tuber crops are significant sources of a number of compounds, namely, saponins, phenolic compounds, glycoalkaloids, phytic acids, carotenoids, and ascorbic acid. They have several bioactivities, namely, antioxidant, immunomodulatory, antimicrobial, antidiabetic and hypocholesterolemic.

Potato is an important crop and it can supplement the food needs of the country in a substantial way as it produces more dry-matter food, has well balanced protein and produces more calories from unit area of land and time than other major food crops. It is a nutritious food containing practically all the essential dietary constituents (Pandey, 2007) [14]. Like cereals, carbohydrates are the major constituents of potato. Besides, it contains essential nutrients such as proteins and minerals like calcium, phosphorus and iron, and vitamins. The most common phenolics in potato are flavanols, cinnamic acid, *p*-coumaric acid, caffeic acid, chlorogenic acid, ferulic acid, and quinic acid. Since potatoes are consumed as a main vegetable in the developing countries, they form an important source of antioxidants (Brown, 2005; Marwaha *et al.*, 2007) [8, 14].

Carrots were first used for medical purposes and gradually used as food (Carlos and Dias, 2014) [9]. 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) [20]. Carrots are consumed in different ways, they can be eaten raw or cooked.

Most of the vegetables are consumed after being cooked or processed. Moreover, potatoes are always cooked before being eaten. Potato nutrients and bioactive components appear to be influenced by cooking methods. Variety of effects like destruction, release and structural transformation of the phytochemicals take place during the cooking process. Cooking can also lead to loss in essential vitamins and antioxidants, mostly water soluble and heat labile compounds. The extent of loss is dependent on the type of cooking treatment (Lin and Chang, 2005) [13]. Studies had also reported that cooking softens the cell walls which lead to increase in the extraction of carotenoids (Rodriguez-Amaya, 1999) [18]. However, there is no consistent information on the effects of thermal treatments on the properties of bioactive constituents. Thus, the main objective of the present study was to elucidate the effects of cooking on the bioactive components in potato and carrot tubers.

Materials and methods

Sample collection

Potato and carrot samples were collected from the local market of Hisar. Potato and carrot were washed with distilled water to remove dirt and dust. Then the tubers were sorted and cut into uniform pieces. Each vegetable batch was divided in three equal portions, one portion was retained as raw and remaining two were subjected to cooking treatments of boiling and pressure cooking.

Cooking methods

The vegetables were subjected to two cooking treatments (i.e., boiling and pressure cooking).Various experiments were carried out to standardised the time and water used for both cooking treatments without sticking of vegetables to pan. The best cooking time was determined by taking into consideration the surface appearance and tender texture felt by finger as well as by teeth. The vegetable weight, treatment time and amount of water used are given in Table 1.

Table 1: Cooking treatment with cooking time and water quantity used for vegetables.

Sr. No.	Roots and Tubers		Raw wt.(gm)	Water(ml)	Time(Minute)	Final wt.(gm)
1.	Potato	Boiling	20	22	12	21
		Pressure cooking	20	12	7	22
2.	Carrot	Boiling	30	30	13	32
		Pressure cooking	30	5	7	31

Sample extraction

Five gram of homogenized sample was extracted with 50 ml 80% methanol for all the vegetable for the determination of total phenolic content and total flavonoid content. The mixture was centrifuged at 6000 rpm for 15 min at room temperature. Extracted samples were stored at -20ºC.

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 (0.1 ml) was mixed with distilled water made volume up to 1.5ml with D/W. To this added 0.5ml of folin Ciocalteu reagent. Added 10ml of 7.5% Na_2CO_3 and incubated at 37 ^{0}C for 60 minutes. Absorbance measured at 760 nm in spectrophotometer. The total phenolic content was calculated using gallic acid as standard.

Determination of total flavonoid content

The amount of flavonoids content in methanolic extracts was determined by aluminium chloride colorimetric method (Zhishen *et al*., 1999) [24]. One ml of the extract was mixed with distilled water and made volume up to 5 ml with distilled water. After that 0.5ml of 5% $NaNO_2$ was added. After 5 minute, 0.6 ml of 10% $AlCl_3$ was added and mixed. After 6 minute, 2 ml of 1N NaOH was added and mixed. Then 2.1 ml D/W was added to make volume up to 10 ml. The absorbance of resulted pink colour was measured at 510 nm. The total flavonoid content was calculated using rutin as standard.

Determination of antioxidant activity using FRAP method

Total antioxidant capacity of the methanolic extracts was determined by using Ferric Reducing Antioxidant Power (FRAP) Assay (Benzie and Strain, 1996). An aliquot of 0.1 ml of the samples was taken in a test tube and made volume 0.3 ml with D/W. Added 1.8 ml of FRAP working reagent and incubated at 37^{0}C for 10 minutes. The absorbance of blue coloured complex was measured at 593 nm against blank. The FRAP content was calculated using trolox as standard.

Determination of antioxidant activity using DPPH method

The antioxidant activity of the extracts, on the basis of the scavenging activity of the stable DPPH free radical, was determined by the method followed by Brand-Williams *et al*. (1995) [7]. An aliquot of 0.1 ml of the samples was taken in a test tube and made volume 1 ml with methanol and then 3ml of DPPH reagent was added and vortexed then let to stand at 37^{0}C in the dark for 20 min. The absorbance of the resulting oxidized solution was measured at 517 nm against methanol as blank. The DPPH content was calculated using trolox as standard.

Statical analysis

Data were subjected to statistical analyses by using the SPSS (statistical package for social science) and given as mean ± Standard error. The data were analyzed by completely randomized design. Significance was accepted at $p \leq 0.05$.

Results and discussion

The effect of heat treatment on antioxidant activity of potato and carrot was shown in table 2. Folin Ciolcateu Reagent assay was adopted for the estimation of total phenolic conent. The total phenolic content (TPC) of potato and carrot were 25.23 and 19.14 mg GAE/100g on fresh weight basis, respectively. TPC content was increased on heat treatment except boiling of carrot in which it was decreased. An increase of 83% in TPC content was observed in boiling of potato. Our values were in agreement with Sreeramulu *et al*. (2010) [22], who reported a range of 22-169 mg/100g of TPC content in different roots and tubers. According to Karthiga and Jagnathan, (2013) [11], the TPC content of carrot and potato were 118 and 151 mg GAE/100g, respectively. Bembem and Sadana (2013) [3] reported TPC content of raw potato was 23.75 mg GAE/100g.

Table 2: Total phenol, total flavonoid content and antioxidant activity of raw and processed vegetables.

Sr. No.	Vegetables	Treatments	TPC (mg GAE/100g)	TFC (mg RE/100g)	FRAP (mg TE/100g)	DPPH (mg TE/100g)
1.	Potato	Raw	25.23±0.61^{a}	18.71±0.69^{a}	61.50±1.90^{a}	16.60±0.30^{a}
		Boiling	46.15±0.74^{c} (+83)	20.59±0.41^{a} (+10)	69.89±0.77^{b} (+13)	22.45±0.41^{b} (+35)
		Pressure cooking	34.18±0.92^{b} (+35)	26.83±0.82^{b} (+43)	154.38±0.95^{c} (+151)	44.93±0.83^{c} (+170)
2.	Carrot	Raw	19.14±0.11^{b}	12.27±0.42^{a}	36.43±0.41^{a}	6.02±0.03^{a}
		Boiling	16.55±0.29^{a} (-13)	13.60±0.29^{b} (+11)	39.52±0.63^{b} (+8)	9.69±0.07^{c} (+60)
		Pressure cooking	21.47±0.49^{c} (+12)	11.16±0.41^{a} (-9)	67.96±1.31^{c} (+86)	7.93±0.05^{b} (+31)

Values are mean ± SE of three independent determinations; Means with different superscripts in the same column of respective vegetable indicate significant difference ($p \leq 0.05$); Values in parenthesis indicate the percent variation from raw.

The total phenolic in different cultivars of carrots ranged from 10.5 mg/100g to 267.1 mg/100g with the highest values present in the purple colored roots (Leja *et al*., 2013) [12]. Venkatachalam *et al*. (2014) [23] and Bembem and sadana (2014) [4] reported 39.76 and 32.60 mg/100g TPC content of raw carrot, respectively. According to Bembem and Sadana (2014) [4] 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. The higher degree of softness was recorded by Ali *et al*. (2017) for boiled samples, which clarifies the maximum loss of phenolic compounds in boiling as compared to steamed and microwave samples of carrot. An increase in TPC content of potato was observed by Bembem and Sadana (2013) [3] for all the cooking methods. Recent study by Blessington *et al* (2010) showed an increase in most of the individual phenolic compounds by baking, frying and microwaving when compared to uncooked tuber samples. The total flavonoid content (TFC) of potato and carrot were 18.71 and 12.27 mg GAE/100g respectively. There was non-significant difference in TFC content on boiling of potato and pressure cooking of carrot. A significant ($p \leq 0.05$) increase was observed in TFC content on pressure cooking of potato (43%) and boiling of carrot (11%).

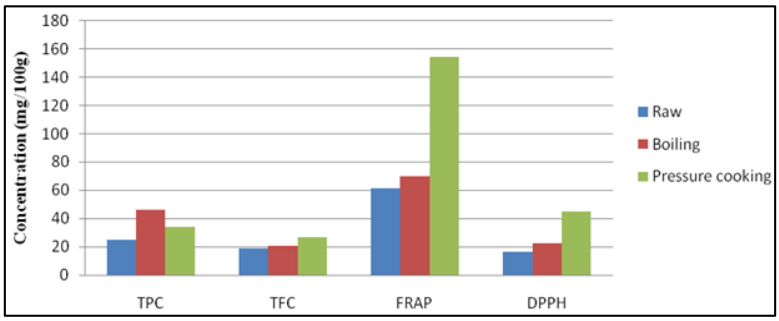

Fig. 1: Effect of cooking methods on total Phenols (TPC), total Flavonoids (TFC) and antioxidant activity of Potato

Bembem and sadana (2013) [3] reported TFC content of raw potato was 16.56 mg QE/100g and TFC of the vegetables cooked boiling, pressure cooking and microwaving were reduced variably from the TFC of raw potato sample by 9 to 13 percent. Bembem and sadana (2014) [4] reported TFC content of raw carrot was 5.70 mg QE/100g and TFC was found to decrease in all the carrot cooked by different cooking method except for carrot cooked by sautéing. While, reported a higher value of TFC raw carrot i.e. 40.76 mg QE/100g which was increased on heat treatments. Application of heat during cooking involves change in the structural integrity and cellular matrix of the vegetables and this causes both positive and negative effects on the phytochemical properties.

FRAP content of raw potato and carrot was 61.50 and 36.43 mg TE/100g, respectively. A significant ($p \leq 0.05$) increase was observed in FRAP activity of both potato and carrot on heat treatments shown in Fig.1 and Fig. 2. Venkatachalam *et al* (2014) [23] reported the FRAP content of raw carrot was 33.77 mg/100g. reported increasing trend of FRAP on heat treatment in carrot.

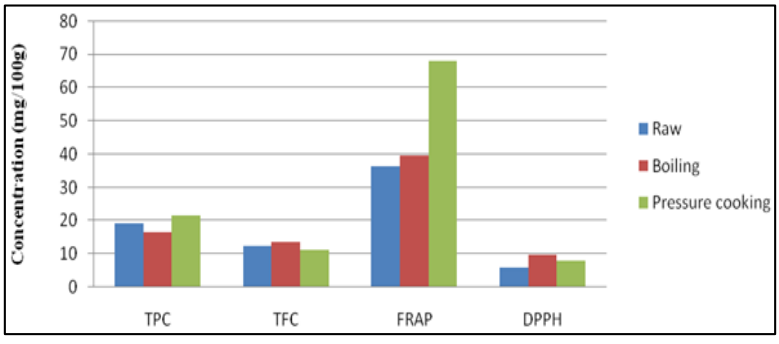

Fig. 2: Effect of cooking methods on total Phenols, total Flavonoids and antioxidant activity of Carrot

DPPH content of raw potato and carrot was 16.60 and 6.02 mg TE/100g, respectively. A significant increase was observed in both the heat treatment in potato and carrot, as shown in Fig.1 and Fig. 2. This study is in line with the study conducted by Bembem and Sadana (2013) [3] that reports that heat treatment increase the antioxidant activity of potato. Bembem and Sadana (2013) [3] determined the DPPH value of raw potato 16.13% and of sautéed potato 32.48%. Also determined the value of antioxidant activity in carrot (3.87%). An overall increase of TEAC, FRAP, and TRAP values was observed in all cooked vegetables, probably because of matrix softening and increased extractability of compounds, which could be partially converted into more antioxidant chemical species (Miglio *et al*., 2008) [15].

Conclusion

The result of this study clearly shows that cooking can make the phenolics and antioxidants of cooked vegetables quite different from that of uncooked form. This is probably due to variety of effects like destruction, release and transformation of the phytohemicals. In this study potato exhibited high antioxidant capacity. Cooking had the positive effect on antioxidant capacity of potato. But in carrot coking had the both positive and negative effect. Therefore, from the above discussed results, it could be concluded that cooking had both positive and negative effect on antioxidant capacities of vegetables.

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