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EFFECT OF COOKING METHODS ON THE NUTRITIONAL COMPOSITION AND ANTIOXIDANT ACTIVITY OF POTATO TUBERS

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ABSTRACT

The present study utilized different cooking methods to study their effect on the proximate composition, ascorbic acid (AA), Total Phenolic Content (TPC), Total Flavonoid Content (TFC), Total carotene and Antioxidant activity of potato tubers. Pressure cooking had more pronounced effect on the proximate composition. Raw potato had the highest ascorbic acid content of 17.91 mg/100g Fresh Weight (FW). Boiling (8.80mg/100g) had the most deleterious effect on the AA content. TPC and TFC were found to be less affected by cooking. TPC and TFC in raw samples were 23.75 mg/100g FW and 16.56 mg/100 g FW respectively. The TPC increased in all the cooking methods, with the maximum increase in sautéing (51.47 mg/100g FW). The total carotenoid content of uncooked potato was 0.18 mg/100g FW. Carotene content of the cooked samples ranged from 0.12 mg/100g FW to 0.19 mg/100 g FW. The DPPH activity of raw and processed sample ranged from16.13 percent in raw potato to 32.48 percent in sautéed potato. The study concluded that cooking increased the antioxidant activity of potato. The study suggests sautéing potato tubers would be an appropriate cooking method to preserve the nutritional qualities, as per the edible portion.

Keywords: Carotene, cooking, DPPH, flavonoids, phenolics, proximate.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the four major food crops of the world, the other three crops being rice, wheat and maize. It 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). 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. 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). Many studies have shown that potatoes exhibit antioxidant properties (Helmja *et al*, 2007; Hesam *et al*, 2011; Kaur and Kapoor, 2002; Rumbaoa *et al*, 2009). The antioxidant properties of fruits and vegetables have been associated with phytochemicals, vitamins and pro-vitamins such as ascorbic acid, tocopherols and carotenoids and a wide variety of phenolic substances (Cieslik, *et al* 2006; Loliger, 1991; Pourmorad *et al*, 2006). Major phenolics include chlorogenic acid and caffeic acid; values vary by genotype. Flavonoids are the most common group of plant polyphenols and provide much of the flavor and color to fruits and vegetables. Potatoes contain significant levels of a group of carotenoids called xanthophylls, most notably lutein and zeaxanthin (Blessington *et.al*, 2010). Carotenoids are found in all potatoes in the flesh (Brown *et al*, 2008). There is just a trace of either alpha- or beta-carotene, meaning potato is not a source of pro-vitamin A carotenes (Brown, 2005).

Most of the vegetables are consumed after being cooked or processed. In general, vegetables are prepared at home on the basis of convenience and taste preference rather than retention of nutrient and health-promoting compounds (Masrizal *et al*, 1997). Moreover, potatoes are always cooked before being eaten. Potato nutrients and bioactive components appear to be influenced by cooking methods. However, there is no consistent information on the effects of thermal treatments on the properties of its constituents. Thus, the main objective of the present study was to elucidate the effects of cooking on the nutritive and bioactive components in potato tubers.

MATERIALS AND METHODS

SAMPLE COLLECTION

Solanum tuberosum var. Kufri Pukhraj was collected from the Department of Vegetable Crops, Punjab Agricultural University, Punjab.

COOKING METHODS

The present study utilized five cooking methods (i.e., boiling, steaming, pressure cooking, microwaving and sautéing). Potato tubers were randomly selected washed with tap water, dried on paper towel. Potatoes were cut small cubes and mixed well. Two hundred gram of potato cubes was utilized for each cooking method; one portion was retained raw. The treatment time, amount of water and oil used are given in Table 1. Refined soybean oil was used for sautéing potato.

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

Treatments	Time	Water	Oil
Raw	-	-	-
Boiled	13	300	-
Steamed	15	-	-
Pressure cooked	5	150	-
Microwaved	5	10	-
Sautéed	8	-	10

PROXIMATE ANALYSIS

Ground samples of raw, blanched and cooked vegetables were analyzed for their proximate contents using the AOAC (2000) method. The moisture content was determined by air-oven drying at 105°C for 8 hrs, and the crude protein contents by microKjeldah method. The lipid content was determined using petroleum ether (bp. 60-80°C) in a soxhlet extraction apparatus and crude fiber content by dilute acid and alkali hydrolysis. Carbohydrate contents were calculated by difference of total contents from 100.

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.

EXTRACTION

Two 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 2200 rpm for 15 min at room temperature.

DETERMINATION OF TOTAL PHENOLICS

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) with some modifications. 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. Pure methanol was used to calibrate the spectrophotometer. Antioxidant activity was expressed as percentage inhibition of the DPPH radical.

RESULTS AND DISCUSSION

PROXIMATE COMPOSITION

Data in Table 2 show the effect of processing treatments on nutrient contents of potato. Cooking methods variably changed the moisture content. Boiling, steaming and pressure cooking increased the moisture content, by 3-6 percent, while microwaving and sautéing decreased the same by 8-10 percent. Cross *et al* (2009) reported that microwave cooking resulted in high moisture loss. Percent protein, fat, crude fibre, total ash and carbohydrate content decreased by boiling, steaming and pressure cooking. Conversely, the proximate nutrient composition increased by microwaving and sautéing potato. The increase in percent nutrient content might be because of the reduction in the moisture content by microwaving and sautéing potato cubes. Among all the cooking methods, pressure cooking showed pronounced reduction in crude protein (29 %), fat (9 %), crude fibre (28 %), total ash (24 %), and carbohydrate (20%). Similarly, Zia-ur-Rehman *et al* (2003) reported that pressure cooking showed a more pronounced effect on the reduction of dietary fibre components than ordinary and microwave cooking.

ASCORBIC ACID

The ascorbic acid content of raw and cooked potato is shown in Table 3. Raw potato had the highest ascorbic acid content of 17.91 mg/100g FW. This value is comparable

Table 2: Effect of processing treatments on proximate composition (g/100g FW)

Treatments	Raw	Boiled	Steamed	Pressure cooked	Microwaved	Sautéed	CD
Moisture (%)	76.52	79.16 (3)	78.56 (3)	81.46 (6)	70.45 (-8)	68.75 (-10)	0.55
Crude protein (%)	1.97	1.53 (-22)	1.62 (-18)	1.39 (-29)	2.36 (20)	2.36 (20)	0.19
Fat (%)	0.11	0.10 (-9)	0.11 (0)	0.10 (-9)	0.15 (36)	4.89 (4345)	0.37
Crude fibre (%)	0.50	0.40 (-20)	0.42 (-16)	0.36 (-28)	0.59 (18)	0.60 (20)	0.19
Total ash (%)	0.89	0.76 (-15)	0.78 (-12)	0.68 (-24)	1.08 (21)	0.94 (6)	0.55
Carbohydrate (%)	20.00	18.05 (-10)	18.50 (-8)	16.00 (-20)	25.25 (26)	22.40 (12)	0.41

*Significant at $p \leq 0.05$
Values in parenthesis indicate the percent variation.

to those reported by Burgos *et al* (2009). The AA content decreased significantly ($p \leq 0.05$) on cooking. However, cooking by boiling (8.80mg/100g) had the most deleterious effect on the AA content with 51 percent reduction; followed by pressure cooking (10.43 mg/100g), microwave cooking (11.68 mg/100g), steaming (12.58 mg/100g) and sautéing (12.79 mg/100g). Lee and Kader (2000) stated that ascorbic acid is easily oxidized, especially in aqueous solutions and losses are enhances by higher temperatures, physical damage and relative humidity. Furthermore, Burg and Fraile (1995) showed that the loss of vitamin C at the cooking time was mainly due to the enzymatic destruction. Prolonging of the residence time resulted in additional losses by thermal destruction. Low water content and the presence of air in the cooking atmosphere further increased the destruction rate.

Table 3: Ascorbic acid, total phenolics content and antioxidant activity of raw and processed potato (g/100g FW)

Compounds (mg/100g)	Raw	Boiled	Steamed	Pressure cooked	Micro waved	Sautéed	CD
AA	17.91	8.80 (-51)	12.58 (-30)	10.43 (-42)	11.68 (-35)	12.79 (-29)	0.46
TPC	23.75	26.38 (11)	30.12 (27)	32.72 (38)	32.54 (37)	51.47 (117)	0.26
TFC	16.56	14.48 (-13)	17.72 (7)	15.03 (-9)	14.94 (-10)	29.96 (81)	0.25
Total carotene	0.18	0.13 (-28)	0.12 (-33)	0.15 (-17)	0.18 (0)	0.19 (6)	0.14
DPPH %	16.13	25.75 (60)	31.63 (96)	27.70 (72)	29.75 (84)	32.48 (101)	0.14

*Significant at $p \leq 0.05$
Values in parenthesis indicate the percent variation.

TOTAL PHENOLIC CONTENT AND TOTAL FLAVONOID CONTENT

Folin Ciolcateu Reagent assay was adopted for the estimation of total phenolics and aluminum chloride colorimetric method was used for the estimation of total flvonoids in the present study. TPC and TFC were found to be less affected by cooking. TPC and TFC in raw samples were 23.75 mg/100g FW and 16.56 mg/100 g FW respectively (Table 3). The TPC increases in all the cooking methods, with the maximum increase in cooking by sautéing (117 %), followed by pressure cooking (38 %), microwaving (37 %), steaming (27 %) and boiling (11 %). Increase in the phenolic content upon cooking of vegetables was also reported. 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. On the contrary, Perla *et al* (2012) has reported a reduction in the total phenolic content of potatoes on cooking by boiling, microwaving and baking.

The 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, with the maximum reduction in boiling (13%). Steaming and sautéing potato increased the flavonoid content by 7 percent and 81 percent respectively. Increase in TFC on cooking by steaming was previously reported by Adefegha and Oboh (2011).

TOTAL CAROTENE CONTENT

Brown (2005) has reviewed that the carotenoid content of potatoes differs with the difference in their flesh colour and has indicated that potato is a poor source of beta carotene. The total carotene content of uncooked potato was 0.18 mg/100g FW (Table 3). Carotene content of the cooked samples ranged from 0.12 mg/100g FW in steamed potato to 0.19 mg/100 g FW in sautéed sample. Although present in small quantity, cooking significantly ($p \leq 0.05$) affect the carotenoid content of potato. Blessington *et al* (2010) reported that boiled samples were lower in carotenoid content than the other samples cooked by baking, microwaving and frying. Conversely, Granado *et al* (1992) found boiling did not alter the carotenoid profile of vegetables.

ANTIOXIDANT ACTIVITY

The DPPH free radical is considered to be a model of a stable lipophilic radical. Activity is measured as the relative decrease in absorbance at 517 nm as the reaction between DPPH and antioxidant progresses (Huang *et al,* 2004). The DPPH activity of raw and processed sample ranged from16.13% in raw potato to 32.48 % in sautéed potato (Table 3). This study showed all the cooking method employed, namely- boiling, steaming, pressure cooking, microwaving and sautéing method increases the antioxidant activity of potato. This study is in line with the study conducted by Blessington *et al* (2004) that reports that frying and microwaving increase the antioxidant activity of potato.

CONCLUSION

Pressure cooking had a more pronounced effect on the proximate composition. These finding suggest that the total phenolics, flavonoids, carotenoids and the antioxidant activities of the potato tubers were not reduced by sautéing. The losses for ascorbic acid were highest in boiling. Total phenolic content and antioxidant activities were increased by all the cooking methods. However, total flavonoid and total carotenoid retention were inconsistent with the cooking treatments. The study suggests sautéing potato tubers would be an appropriate cooking method to preserve the nutritional qualities, as per the edible portion.

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