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Impression of Instinctive Cookery Methods along with Altered Processing Time on the Potential Antioxidants, Color, Texture, Vitamin C and β-Carotene of Selected Vegetables

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Abstract

In the current millennium, consumers are becoming more conscious about their dietary patterns with special concern to nutrient retention during cooking methods. There is a need to assess the most convenient and nutritionally better thermal cooking method which causes the least nutrient abuse. The current study investigated the consequence of three cookery methods viz. conventional boiling, steaming and microwave cooking on the physical parameters, β-carotene, vitamin C, total phenolic contents (TPC), total flavonoid contents (TFC) and antioxidant activity (DPPH%) of the particular vegetables. Results revealed that both cooking methods and length of time exerted positive and negative influence on nutritional composition of vegetables. *L**, *a** and *b** values decreased in all samples. In texture analysis, highest force N (Newton) determined in control and microwave cooked samples followed by steaming and boiled samples. Cooking of vegetable by microwaving had the maximum retention for vitamin C, TPC and DPPH% after control. While, ß-carotene contents increased in microwave cooking than control. Total flavonoid contents were tending to a decreasing trend in all cooking methods but highest contents were retained in boiling cooking. Amongst the three cookery methods adopted, microwave cooking method emerged as the most appropriate method in terms of retention of nutrients in vegetables.

Keywords: Carrot; Cabbage; Cooking; Boiling; Steaming; Microwave

Introduction

In current era, there is a mounting trend towards the assessment of beneficial phytochemicals and efficient ingredients from natural dietetic sources like fruits and vegetables [1,2]. Fresh vegetables contain nutritional constituents including phytochemicals, vitamins and minerals. However, these are extremely perishable [3]. Numerous epidemiological investigation has showed the defensive impacts of vegetable utilization against the danger of several age-related illnesses like tumor, cardiovascular diseases, cataract and muscular disintegration [4,5]. Carrot and Cabbage are usually consumed after adopting the cooking procedures such like boiling, steaming and microwave before use. These vegetables are consisting of various bioactive components like phytochemicals, carotenoids, vitamin C and minerals. In this way, these compounds prevent the people from certain diseases like hypertension, stroke and heart disorders [6]. The role of carrot carotenoids as the precursors of vitamin A and excellent antioxidants source has been generally known [7,8]. Cabbage is a cruciferous green leafy vegetable, which contains high amounts of fibre, vitamins, and minerals [9,10]. Cabbage also attains beneficial phytochemicals and carotenoid contents in significant amounts [11].

The nutritional profile of vegetables is highly dependent on handling and processing techniques. Even minor thermal treatments, like blanching exert detrimental effects on functional constituents [12]. Cookery methods initiate substantial alteration in natural composition, manipulation in chemical concentration and bio-accessibility of bioactive component in vegetables. Alternatively, impacts of both aspects, positive and negative have been accounted which are dependent upon changes in process conditions, morphological parameters and dietary properties of vegetables [13]. Defective cooking methods expressively affect the physical parameters, ß-carotene, vitamin C, TPC, TFC and DPPH% of vegetables. Such cooking methods alter the antioxidant and anti-nutrient components [14]. While, the degree of alteration largely depends upon length of time and adopted cooking methods [15]. Cookery methods can also lead to interruption of the food matrix, growing the bio-accessibility of many phytochemicals and therefore improve the nutritional quality of vegetables [16].

After processing, vegetables quality was gradually lowered as the result of nutrient loss. The result of these changes shows poor acceptability [17]. Hence, the influence of different cooking methods on qualitative and quantitative values of nutrients should be investigated. Therefore, current study was planned to inspect the values of nutritionally active components and physical characteristics of carrot and cabbage before and after boiling, steaming and microwave cooking protocols.

Material and Methods

Research was conducted in National Institute of Food Science and Technology, University of Agriculture Faisalabad.

Chemicals

All chemicals used were of analytical grade supplied by Merck and Sigma. All the measurements were done in triplicates.

Procurement of raw material

The vegetables cabbage and carrot were purchased from the local market of Faisalabad, Pakistan.

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Preparation of raw material

The vegetables were subjected to washing, peeling and dicing prior to subjecting for cooking process.

Cooking methods

Conventional boiling, microwave and steam cooking methods were adopted to cook the vegetable [12]. In all cooking methods, 500 g of each vegetable was taken. In conventional cooking method, vegetables were subjected to boiling in sufficient volume of water. While in steam cooking, vegetables were subjected to a domestic steamer. After cooking, vegetables were drained using a strainer. For microwave cooking, vegetables samples were subjected to a microwave oven (Panasonic 600 W power) in which no added water was used. All vegetable samples were cooked for both 10 min and 15 min separately. The cooked material was packed in polythene zip bags and stored at (-42°C) for further analysis

Treatments

Raw vegetables were taken as T_o showing no cooking treatment employed, T_1 and T_2 showed vegetables subjected to boiling for 10 and 15 minutes, T_3 and T_4 showed vegetable subjected to steaming for 10 and 15 minutes while T_5 and T_6 showed vegetables subjected to microwave cooking for 10 and 15 minutes.

Physicochemical Analysis

Color analysis

The color measurements of cooked vegetables were determined using ColorTec-PCM™ spectrophotometer (Accuracy Microsensors, Inc. Pittsford, New York, USA) method [17]. The color was expressed in terms of L*, a* and b*.

Texture analysis

Textural analyses of all the samples were determined using the texture analyzer (TA-XT2, Stable Microsystems, Surrey, UK) method [18].

Determination of ascorbic acid

Vegetables samples were assessed for evaluating the ascorbic acid content by the method of Association of Vitamin Chemists [19]. The blue color created by the reduction of 2,6-dichlorophenyl indophenols dye by ascorbic acid was recorded calorimetrically.

Determination of ß-carotene

Beta-carotene contents were analyzed by the spectrophotometer method [20]. In this method, 500-gram sample was taken in a pestle and mortar, grinded using acetone. Extraction procedure was repeated for 2-3 times. The extract was collected and subjected to filtration process. The filtrate was shifted to separating funnel and mixed with 10-15 mL of petroleum ether. The pigments were shifted into the petroleum ether phase. The staying period was given to separate the extract thoroughly. After staying time the bottom layer was drained off while top layer extract was collected into a 250 mL conical flask. The absorbance of the extract was estimated at 452nm by spectrophotometer.

Preparation of extract

Extract was prepared by mixing the 5 grams of each sample into 50 mL 80% methanol by using ultrasonic bath for 20 minutes. An aliquot (2 mL) of the extracts was ultracentrifugated for 15 minutes at 2200 rpm at room temperature. The clear extract solution was analyzed for the estimation of TPC, TFC and antioxidant activity.

Determination of total phenolic contents

The TPC of sample extract was estimated by using Folin-Ciocalteu's reagent method [21]. In this method, 1 mL of extract was mixed with 9 mL of distilled water. Latterly, 1 mL of Folin-Ciocalteu's phenol reagent was incorporated with extract. After time interval of 5 min, 10 mL of 7% Na_2CO_3 was incorporated. Final volume was made up to 25 mL with the incorporation of 4 mL of distilled water. After 90 min of incubation period at room temperature, the absorbance was recorded at 750 nm by using spectrophotometer. The total phenolics were stated as mg of gallic acid equivalents (GAE)/g fresh matter of vegetable (mg/g sample).

Determination of total flavonoids contents

The TFC of vegetables extract was estimated according to the aluminium chloride colorimetric method [22]. In this method, 1 mL of extract was added in 4 mL of distilled water and incorporated with 0.3 mL 5% $NaNO_2$. 0.3 mL of 10% $AlCl_3$ was mixed after time interval of 5 min. This mixture was agitated thoroughly with 2 mL of 1 M NaOH for 6 min. After it final volume of mixture was made up to 10 mL by distilled water incorporation. At wavelength of 510 nm, the reaction mixture absorbance was recorded. The findings were stated as mg of quercitin equivalent (QE)/g fresh matter of vegetable.

Determination of antioxidant activity (DPPH%)

The antioxidant activity of extract was estimated by adopting the spectrophotometer method [23]. In this method, 200 µL of extracts and 0.8 mL methanol was incorporated in 2 mL of 0.1 mM DPPH methanol solution. Then, final mixture was agitated systematically and placed in the dark place for 60 min at room temperature. The control was prepared by the incorporation of 2 mL of DPPH with 1 mL of methanol. Finally, absorbance was estimated at 517 nm. Percent inhibition was calculated by using the following formula;

Reduction in absorbance (%) = [Abs control - Abs sample / Abs control] × 100

Statistical Analysis

Statistical analysis was carried out by using two factor factorials under completely randomized Design (CRD) to determine the level of significance [24].

Results and Discussion

Color

Statistical results regarding color values of vegetables are presented in Table 1. Highest *L** (lightness), *a** (red color) and *b** (yellow color) values were noticed in T_5 after T_o followed by T_6, T_3 and T_4. Lowest values were recorded in T_2 and T_1. The decreasing trend of *L* a** and *b** value in boiling cooking was observed due to the fact of degradation of chlorophyll pigments mainly in cabbage and carotenoid contents in carrot. The deteriorated effect of heat along with leach down effect of boiling cooking was the major reason of color lessening. α- and β- carotene contents collectively resolute the final color of cooked vegetables. However, such carotene compounds were identified as moderately heat sensitive. So, these compounds isomerize into numerous cis-isomers during cooking. The reduction in *L**, *a**, *b** values observed in all treated vegetables which may be related to α- and β- carotene decrease and their isomerization [25]. Heat induces

Treatment	*L**-value	*a**-value	*b**-value	Texture (N)
		Carrot		
T_0	57.50 ± 1.75[a]	33.57 ± 1.06[a]	42.41 ± 1.76[a]	151.82 ± 2.16[a]
T_1	42.59 ± 1.17[ef]	13.63 ± 1.11[de]	29.64 ± 1.27[c]	122.48 ± 2.02[e]
T_2	40.16 ± 1.47[f]	11.92 ± 1.04[e]	24.81 ± 1.51[d]	117.82 ± 2.26[f]
T_3	48.50 ± 1.38[cd]	17.05 ± 1.11[d]	36.41 ± 1.20[b]	132.48 ± 2.02[d]
T_4	45.83 ± 1.52[de]	14.67 ± 1.45[de]	32.19 ± 1.45[c]	126.15 ± 2.72[e]
T_5	54.50 ± 1.75[ab]	26.17 ± 1.38[b]	41.81 ± 1.01[a]	142.82 ± 2.49[c]
T_6	51.84 ± 1.62[bc]	22.28 ± 1.72[c]	38.55 ± 1.37[ab]	147.48 ± 2.74[b]
		Cabbage		
T_0	52.82 ± 1.55[a]	-6.59 ± 0.06[b]	8.69 ± 0.43[a]	105.82 ± 2.50[b]
T_1	35.47 ± 1.23[e]	-1.64 ± 0.60[a]	5.36 ± 0.81d[e]	67.48 ± 2.74[f]
T_2	31.51 ± 1.11[f]	-1.53 ± 0.55[a]	4.86 ± 0.60[e]	62.41 ± 3.00[c]
T_3	41.83 ± 1.21[cd]	-5.93 ± 0.53[b]	6.69 ± 0.51[bcd]	77.43 ± 2.01[d]
T_4	39.68 ± 1.25[d]	-5.73 ± 0.57[b]	6.09 ± 0.95[cde]	69.67 ± 0.78[ab]
T_5	45.67 ± 1.08[b]	-6.53 ± 0.97[b]	8.23 ± 0.39[ab]	93.15 ± 2.02[f]
T_6	43.28 ± 1.04[bc]	-6.13 ± 0.50[b]	7.90 ± 0.62[abc]	97.27 ± 2.74[f]

Values carrying same letters are non-significantly different with each other.
T_o= Vegetable without any cooking technique, T1= Vegetable subjected to boiling for 10 minutes, T2 = Vegetable subjected to boiling for 15 minutes, T3 = Vegetable subjected to steaming for 10 minutes, T4 = Vegetable subjected to steaming for 15 minutes, T5 = Vegetable subjected to microwaving for 10 minutes, T6 = Vegetable subjected to microwaving for 15 minutes.

Table 1: Effects of different cooking methods on the physical characteristics of vegetables.

modifications on carotenoid pigment which results in color variation in vegetables. The results were parallel with the findings of Miglio [13], Nwanekezi [26] who noticed pronounced L*, a*, b* values in vegetables during different cooking methods.

Texture

Different thermal cooking methods influence the texture attributes of vegetables. Firmness of cooked samples significantly decreased relative to the control sample. The statistical results are presented in Table 1. Highest shear force N (Newton) was taken by T_6 after T_o followed by T_5, T_3 and T_4. While the Lowest shear force was gained by T_2 and T_1. Cooking of vegetables triggered a decrease in the force required to shred the vegetable. Heat effect of cooking represents the decrease of softness and consequently softening of the vegetable internal and external structures. The findings of this study were covenant with Miglio [13], Maria [18] who studied the effect of microwaving and conventional cooking methods on nutrient profile and textural analysis of different vegetables (Table 1).

ß-Carotene content

Statistical values regarding ß-Carotene content are presented in Table 2. Highest β-carotene content was observed in T_6 followed by T_5, T_o, T_1 and T_2. Lowest β-carotene contents were determined in T_4 and T_3. Steaming caused major losses due to the oxidation of conjugate double bonds in β-carotene along with higher temperatures degradation. It was observed that heating triggered the both coloring pigment deprivation and an extractability upturn due to the breakdown of protein-carotenoid complexes: in the skin the first outcome prevailed as of the thinness of soft tissue, which permitted easy and fast heat transmission and results in extreme water leaching [27]. Results of beta carotenoid contents during the study of different cooking treatment in different vegetables were in similarity with the findings of some previous studies [13,20,28,29].

Vitamin C

Different cooking methods showed significant variation on vitamin C contents of vegetables. Statistical values of all treatments are presented in Table 2. The highest vitamin C contents were recorded in T_5 after T_o followed by T_6, T_3 and T_4. Unlike to that, maximum loss of vitamin C content was seen in T_2 and T_1. Consequently, microwaving did not far destroy the vitamin C as compared to boiling and steaming [30]. Boiling largely decreased the vitamin C content when vegetable was subjected for 15 minutes. In boiling cooking, decreasing trend of vitamin C occurred due to the oxidation of vitamin C in the presence of molecular oxygen initiated by inherent enzymes (vitamin C oxidase and peroxidase). The findings of this study regarding vitamin C concentrations were similar with Lee SK [31] who determined the ascorbic acid contents decreased in vegetables from 3.02 mg/100 g to 2.47 mg/100 g during different cooking methods. Lower content of vitamin C during cooking were also determined [20,28] (Table 2).

Total phenolic content

It is obvious from the results that the total phenolic contents were highly significantly affected due to the differences in cooking methods and different cooking time length. Statistical values regarding total phenolic content of vegetables are presented in Table 3. This indicated that the maximum TPC were recorded in T_6 after T_o followed by T_5, T_3 and T_4. The lowest TPC were observed in T_1 and T_2 in both vegetables. The total phenolic contents were effect significantly by the cooking methods and water contents. Low moisture contact results in lowest losses of total phenolic contents. Application of thermal treatment regulates firmness and break down of cellular structures with consequential discharge of these components into the hot water. The higher degree of softness was recorded for boiled samples, which clarifies the maximum loss of phenolic compounds in boiling as compared to steamed and microwave samples. The results were in conformity with the findings of Miglio [13] who observed that the TPC decreased in vegetables during different cooking methods. Changes of TPC during different cooking methods were also in conformity with the research findings of Hunter [30] and Ismail [32] showed that TPC decreased during different cooking methods. Our results of this study were also in matching with the conclusions of Sahlin [33].

Total flavonoid content

Cooking had both positive and negative influence on TFC depending on the kind of vegetables [34,35]. Statistical values regarding

Treatment	β – Carotene (mg/100g)	Vitamin C (mg/100g)	β-Carotene (mg/100g)	Vitamin C (mg/100g)
	Carrot		Cabbage	
T_0	55.36 ± 2.88^{bc}	30.56 ± 1.31^{a}	1.63 ± 0.02^{b}	18.11 ± 1.88^{a}
T_1	53.58 ± 2.05^{c}	19.14 ± 0.22^{d}	1.57 ± 0.01^{c}	12.02 ± 1.42^{de}
T_2	51.66 ± 2.07^{c}	18.18 ± 0.27^{d}	1.54 ± 0.01^{cd}	10.60 ± 1.87^{e}
T_3	47.56 ± 2.17^{d}	26.11 ± 1.27^{bc}	0.52 ± 0.03^{de}	14.44 ± 1.34^{bc}
T_4	45.56 ± 2.78^{d}	24.26 ± 1.52^{c}	0.49 ± 0.01^{e}	13.11 ± 1.27^{cd}
T_5	57.83 ± 1.63^{ab}	29.21 ± 0.33^{ab}	1.67 ± 0.03^{a}	17.44 ± 0.37^{ab}
T_6	59.42 ± 1.06^{a}	28.17 ± 1.90^{b}	1.69 ± 0.01^{a}	16.11 ± 0.51^{ab}

Values carrying same letters are non-significantly different with each other.
T_o= Vegetable without any cooking technique, T_1= Vegetable subjected to boiling for 10 minutes, T_2 = Vegetable subjected to boiling for 15 minutes, T_3 = Vegetable subjected to steaming for 10 minutes, T_4 = Vegetable subjected to steaming for 15 minutes, T_5 = Vegetable subjected to microwaving for 10 minutes, T_6 = Vegetable subjected to microwaving for 15 minutes.

Table 2: Effects of different cooking methods on the β – Carotene and Vitamin C contents of vegetables.

Treatment	TPC (mg GAE/100 g)	TPC (mg GAE/150 g)	TFC (mg QE/100g) DPPH%
	Carrot		
T_0	13.55 ± 1.84a	5.79 ± 0.15a	73.67 ± 2.14a
T_1	8.21 ± 1.03^{d}	5.40 ± 0.21^{b}	62.35 ± 2.57^{c}
T_2	7.96 ± 0.81^{d}	5.04 ± 0.10^{c}	56.42 ± 2.91^{d}
T_3	10.55 ± 1.28^{bc}	5.32 ± 0.10^{b}	69.15 ± 0.56^{b}
T_4	9.21 ± 1.06^{cd}	4.94 ± 0.04^{c}	64.82 ± 2.24^{c}
T_5	11.88 ± 1.01^{ab}	4.01 ± 0.02^{d}	70.16 ± 1.07^{b}
T_6	12.1 ± 1.06^{ab}	3.97 ± 0.04^{d}	72.01 ± 1.02^{ab}
	Cabbage		
T_0	16.70 ± 1.11^{a}	10.91 ± 0.49^{a}	64.10 ± 1.80^{a}
T_1	9.36 ± 0.52^{de}	9.29 ± 0.15^{b}	47.95 ± 1.92^{e}
T_2	8.03 ± 0.11^{e}	8.18 ± 0.11^{c}	44.10 ± 1.57^{f}
T_3	11.36 ± 1.04^{cd}	8.42 ± 0.20^{c}	55.67 ± 1.23^{c}
T_4	10.41 ± 0.58^{de}	7.37 ± 0.04^{d}	52.89 ± 1.00^{d}
T_5	13.04 ± 1.81^{ab}	6.77 ± 0.18^{e}	58.25 ± 1.41^{c}
T_6	15.63 ± 1.14^{bc}	6.34 ± 0.19^{e}	61.30 ± 1.80^{b}

Values carrying same letters are non-significantly different with each other.
T_o= Vegetable without any cooking technique, T_1= Vegetable subjected to boiling for 10 minutes, T_2 = Vegetable subjected to boiling for 15 minutes, T_3 = Vegetable subjected to steaming for 10 minutes, T_4 = Vegetable subjected to steaming for 15 minutes, T_5 = Vegetable subjected to microwaving for 10 minutes, T_6 = Vegetable subjected to microwaving for 15 minutes.

Table 3: Effects of different cooking methods on the TPC, TFC and DPPH% of vegetables.

total flavonoid content of both vegetables are presented in Table 3. This indicated that the highest total flavonoid contents were recorded in T_1 after T_o followed by T_3, T_2, T_4, and T_5. While the lowest total flavonoid contents were identified in T_6. Decreasing trend of TFC in all cooking methods was due to the fact of food processing, like cutting action of the vegetable tissues and influence of employed temperatures. This can lead to cellular destruction and separation of some flavonoids compounds from cellular assemblies such as lignin and causing them to be highly extractable and freely identified [36]. The TFC was found to decrease highly in microwave cooking due to the application of dry heat, which leads to the maximum moisture reduction along with oxidation of volatile compounds in the presence of light and oxygen. Commonly, thermal actions have damaging influence on the flavonoid and phenolic compounds as they are extremely heat sensitive compounds [32]. The results were parallel with the findings of Khwairakpam B [20] who observed that the total flavonoid contents decreased in vegetables from 5.7 to 4.5mg QE/100g during different cooking methods.

Antioxidant activity (DPPH%)

Statistical values regarding antioxidant activity (DPPH%) of both vegetables are described in Table 3. This indicated that the maximum antioxidant activity (DPPH%) was observed in T_6 after T_o followed by T_5, T_3, T_4 and T_1. While the lowest antioxidant activity (DPPH%) was observed in T_2. The decreasing trend of antioxidant activity (DPPH%) was due to the fact of reduction and extractability of total phenolic compounds in cooking methods. No association was establish between TPC and antioxidant activity (DPPH%) in the study by Kahkonen MJ [37] on some vegetable extracts having phenolic contents. While the current study showed a strong correlation between phenolic contents and DPPH radical scavenging activity. antioxidant activity (DPPH%) was found to decrease by cooking irrespective of the leach down of high extent of total phenolic contents caused by thermal damage of cellular and sub-cellular compartment walls and radical exclusion by heat and chemical reaction. Overall microwave cooking was identified as an optimum method of cooking which resulted in highest DPPH% inhibition. The results were in accordance with the findings of Khwairakpam [20] who observed that the antioxidant activity increased from 11.20% to 13.75% during microwave cooking method. Changes of antioxidant activity during different cooking treatments were also in conformity with the findings of Faller ALK [38-40] (Table 3).

Conclusion

Certain nutrients are lost during processing of vegetables. Vegetables were cooked by boiling, steaming and microwave cooking methods. Physical characteristics of cooked vegetables were highly affected by all adopted cooking methods. Vitamin C, beta carotene, TPC, TFC and antioxidants activity (DPPH%) significantly decreased by thermal action of applied cooking methods along with longer time of cooking. Short time length of cooking significantly reduced the nutrient loss. Overall, microwave cooking method was recognized the optimum cooking method which resulted in highest retention of vegetables constituents. Consequently, it is suggested that cook the vegetables for short time up to just softening the tissue to improve their digestibility and reserve maximum nutritional profile.

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Research

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