NUTRITIONAL COMPOSITION AND SENSORY PROFILE OF MICROWAVE AND CONVENTIONALLY COOKED VEGETABLES

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ABSTRACT

Vegetables are either consumed in the raw or cooked form. While in the raw state, most of the nutrients are retained, whereas any degree of cooking generally results in partial loss of nutrients and considerable changes in its sensory characteristics. This study is aimed at comparing the effect of different cooking methods namely, conventional (boiling), pressure cooking, and microwave cooking on the nutritional and sensory parameters of selected vegetables. The results confirm that cooking time, or water uptake, was dependent on the type of vegetable rather than the cooking method. Moisture content of ladies finger was significantly decreased ($P \leq 0.01$*) after cooking. Proximate composition and minerals (namely, calcium, iron and phosphorus) did not vary to a significant extent due to different cooking methods. Pressure cooking caused a greater loss in ascorbic acid content of capsicum. Sensory analysis showed that color and appearance were the two attributes which were significantly impacted by varying cooking methods. Capsicum and carrot cooked in microwave oven scored higher for these attributes.*

INTRODUCTION

Vegetables are an integral part of human diet. Apart from being rich sources of vitamins and minerals, they are also being recognized for their antioxidant properties. Hence they are now characterized as functional foods for their preventive role against noncommunicable diseases. They provide a considerable amount of dietary fiber, which is proven to prevent colon cancer.

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They also contain certain nonnutrient compounds, such as quercetin, kaempferol etc., which have an antihypertensive, anti-inflammatory and anti-tumor activity (Peterson and Dwyer 1998). An intake of 400–500 g of vegetable and fruits per day in an adult diet is recommended by many countries world over (Truswell 1998; ICMR 1999). Vegetables are either consumed in raw or cooked form, while in the raw state, most of the nutrients are retained, and cooking by any method generally results in partial loss of nutrients. The sensory attributes of vegetables also differ depending upon the processing method adopted. To encourage consumption of vegetables, the sensory appeal has to be very high. While there are many studies in literature reporting about the nutrient retention or loss in vegetables cooked by conventional or pressure cooking method, information about microwave cooking of vegetables is relatively unknown. The present study was undertaken with an objective to analyze the nutritional composition and to evaluate sensory quality of microwave cooked vegetables and compare it with vegetables cooked by conventional, boiling and pressure cooking methods.

MATERIALS AND METHODS

Processing of Vegetables

Four commonly consumed fresh vegetables representing different pigments namely, Beetroot (*Beta vulgaris*), Carrot (*Daucus carota*), Capsicum (*Capsicum annum*) and Ladies finger (*Abelmoschus esculents*) were procured from a local market on the day of processing. They were cleaned and washed thoroughly under running water followed by distilled water and spread out on dry filter papers to remove the surface moisture. Beetroot, carrot and capsicum were then diced evenly and divided into four equal parts, of which one part (raw) served as the control and the other three parts were subjected to the three different cooking methods namely, (1) conventional cooking (boiling, covered), (2) pressure cooking (15 lbs) and (3) microwave cooking (covered, using high power only). Ladies finger was divided into three parts with one part serving as control and the other two were subjected to conventional and microwave cooking. Before either conventional or microwave cooking, the samples were shallow fried with oil in a pan to remove sliminess of the vegetable, 20 mL of oil was used for 600 g of vegetable.

Analysis of Nutritional Composition

The nutrients analyzed in raw and cooked vegetables were moisture by oven drying and weighing, protein (by Kjeldahl method), total ash, ether extract (using Soxhlet distillation apparatus), iron, phosphorus and β-carotene by colorimetric estimation, calcium and ascorbic acid by titrimetric procedures (Ranganna 1986) as well as total dietary fiber by enzymatic and gravimetric method (Asp *et al*. 1983). All the analyses were carried out in duplicate for two batches of vegetables procured separately at an interval of three months to limit biological variations. Double glass distilled water was used for all experiments. The chemicals required for analysis were from SD Fine Chemicals, and Qualigens Co. Ltd. Mumbai, India. Nutrient analysis results were analyzed statistically using ANOVA.

Sensory Attributes

The primary sensory attributes of cooked vegetables i.e. color, appearance, finger feel, mouth feel, aroma and taste were analyzed using a paired comparison test (Amerine *et al*. 1965). The panel members consisted of 20 postgraduate students of the Institution. The samples were coded and made into four different pairs. Each pair consisted of a vegetable cooked by two different methods except for one pair which consisted of vegetable cooked by same method. This was used as an in-built control to judge the performance of panelists. The panelists' data was edited based on their performance in the control pair. The panelists were asked to identify if any differences existed between the two samples in a pair and if so, quote the one which they preferred comparatively. The results were analyzed using a Binomial distribution table (Rao 1996).

For further evaluation of sensory quality, the samples were subjected to Quantitative Descriptive Analysis (QDA) (Zook and Wessman 1977). Based on the performance in the paired comparison test, 10 best panelists were selected for QDA. In this test, a line of 15 cm length is considered as a scale. The anchors were located at approximately 1.5 cm from each end. The scale spanned from left to right with increasing intensity. The judges evaluated the intensity of each attribute by placing a vertical line across the unstructured line. For this test, the characteristics of each vegetable were selected and documented on separate score cards. The sensory attributes used with their intensities for different vegetables are indicated in Table 1. Ten member panel was asked to judge the sample with utmost care. Scores of those which deviated in more than two attributes were exempted.

Instrumental Analysis of Color

Color of the cooked vegetables was also analyzed instrumentally using spectrophotometer. Beetroot, carrot and capsicum representing three different pigments cooked by three different methods were pureed using an electric

TABLE 1.
INTENSITY INDICATORS USED AS ANCHORS IN SCORE CARD FOR DESCRIPTIVE ANALYSIS OF DIFFERENT VEGETABLES

Sensory attributes	Beetroot	Carrot	Capsicum	Ladies finger
Color	Dull, bright	Dull, bright	Dull, bright	Dull, bright
Appearance	Shrunken, not shrunken	Not appealing, appealing	Mushy, firm	Not appealing, appealing
Appearance (A)	–	–	Peeled off, intact	Dry, moist
Appearance (B)	–	–	–	Disintegrated/ shrunken intact
Texture	Over/undercooked, well cooked	Over/undercooked, well cooked	Over/undercooked, well cooked	Tough, soft
Sliminess	–	–	–	High, low
Aroma	Low, high	Low, high	Low, high	Low, high
Taste	Low, high	Low, high	Low, high	Low, high
Overall quality	Poor, good	Poor, good	Poor, good	Poor, good

grinder and passed through a sieve to obtain a homogenous sample. These were compactly filled into quartz glass cuvettes and read using illuminant D65 in a Shimadzu UV 2100 spectrophotometer. The L*, a* and b* readings were recorded.

RESULTS AND DISCUSSION

Processing Conditions

The processing conditions of vegetables given in Table 2 indicated that pressure cooking of beetroot, carrot and capsicum required least amount of water followed by conventional cooking for carrot and capsicum. Ladies finger processed by only two methods required less water for microwave cooking. Least cooking time was taken by beetroot and ladies finger in the microwave whereas carrot and capsicum were cooked faster using the pressure cooker. The microwave method also had the lowest cooked weight for beetroot, carrot, and ladies finger. Although microwave ovens are very efficient for reheating, cooking may not offer any special advantage over time for all vegetables. The differences observed in cooking time or water uptake of vegetables could be due to their different cell structure since studies have shown that density of food material matters to a greater extent in microwave cooking (Lorenz 1976; Mudgett 1989).

TABLE 2.
PROCESSING CONDITIONS OF VEGETABLES (PER 600 g OF FRESH EDIBLE PORTION)

Vegetable	Cooking method	Water added (ml)	Time taken (min)	Cooked weight (g)
Beetroot	Conventional	110	25	559
	Pressure	75	25	608
	Microwave	90	20	549
Carrot	Conventional	160	28	580
	Pressure	120	14	590
	Microwave	170	21	531
Capsicum	Conventional	150	19	515
	Pressure	100	11	466
	Microwave	200	20	493
Ladies finger	Conventional	175	28	526
	Microwave	90	15	390

Although several manufacturer claim that microwave ovens require considerably lesser time to perform a given cooking task, when compared with conventional cooking. It is reported that time taken for cooking is roughly proportional to the quantity of food cooked (Annis 1980).

Nutrient Composition

The analyzed nutrient composition of vegetables is presented in Table 3. Moisture content of raw vegetables ranged from 86.8–93.2%. Cooking caused slight variation in the moisture content of beetroot, carrot and capsicum but these were nonsignificant. In ladies finger, there was significant loss of moisture ($P < 0.01$). This could be because of shallow frying done prior to cooking as a means to reduce the sliminess of the vegetable. The water content of the vegetable is altered during cooking. Water is absorbed when vegetables are cooked submerged in water (i.e, boiling water) and lost in cases of baking, frying or roasting. Moisture loss in these methods is due to the higher surface temperatures attained during cooking (Cross and Fung 1981). Schrumpf and Charley (1975) reported greater loss in microwave cooked carrots and broccoli compared to boiling. Although many studies reported greater moisture loss in microwave cooking, it greatly depends on the cooking conditions including whether the vegetable was prepared with or without water, covered or uncovered, and also on the power levels used as observed during the process of standardization.

The protein content of raw vegetable ranged from 0.99–1.68 g/100 g. The values obtained in this study were similar to those reported by Gopalan *et al.* (1996) and Souci *et al.* (1994). On cooking there were slight changes in the protein content, which were significant for beetroot and ladies finger and

TABLE 3.
NUTRITIONAL COMPOSITION OF VEGETABLES

Constituents	Raw	Cooking methods			F Ratio
		Conventional	Pressure	Microwave	
Moisture					
Beetroot	90.5 ± 1.02	88.8 ± 2.34	91.5 ± 0.78	88.2 ± 3.76	1.714ns
Carrot	86.8 ± 0.44	86.3 ± 0.55	87.3 ± 1.1	86.2 ± 1.45	1.108ns
Capsicum	93.2 ± 0.22	92.6 ± 0.44	92.9 ± 1.00	92.4 ± 0.68	4.545ns
Ladies finger	89.2^{a} ± 0.60	87.3^{b} ± 0.09	–	84.5^{c} ± 0.29	146.25**
Protein					
Beetroot	1.54^{a} ± 0.15 (16.21)	1.56^{a} ± 0.19 (13.93)	1.07^{b} ± 0.27 (12.95)	1.81^{c} ± 0.30 (16.16)	6.325*
Carrot	1.14 ± 0.09 (8.64)	1.08 ± 0.00 (7.88)	1.03 ± 0.05 (8.11)	0.99 ± 0.15 (7.17)	5.665ns
Capsicum	0.99 ± 0.05 (14.56)	1.03 ± 0.04 (13.92)	0.93 ± 0.15 (13.09)	1.15 ± 0.03 (15.13)	4.930ns
Ladies finger	1.68^{a} ± 0.17 (15.56)	1.39^{b} ± 0.07 (10.94)	–	1.78^{a} ± 0.12 (11.48)	10.801*
Ether extract					
Beetroot	0.06 ± 0.02 (0.63)	0.10 ± 0.02 (0.89)	0.07 ± 0.03 (0.82)	0.10 ± 0.03 (0.89)	1.577ns
Carrot	0.30 ± 0.04 (2.27)	0.32 ± 0.03 (2.42)	0.30 ± 0.06 (2.36)	0.35 ± 0.09 (2.54)	1.515ns
Capsicum	0.12 ± 0.01 (1.76)	0.20 ± 0.00 (2.70)	0.11 ± 0.09 (1.55)	0.12 ± 0.11 (1.58)	0.963ns
Ladies finger	0.19^{a} ± 0.00 (1.76)0	2.5^{b} ± 0.69 (19.68)	–	3.1^{b} ± 1.18 (20.00)	15.758***
Dietary fiber					
Beetroot	2.69 ± 0.45 (28.32)	3.05 ± 0.09 (27.23)	2.69 ± 0.03 (31.65)	3.39 ± 0.67 (30.27)	1.337ns
Carrot	3.14 ± 0.06 (23.80)	3.34 ± 0.33 (24.38)	2.60 ± 0.58 (20.47)	3.41 ± 0.21 (24.71)	2.154ns
Capsicum	2.00 ± 0.23 (29.41)	1.99 ± 0.22 (26.89)	2.70 ± 0.26 (30.56)	2.05 ± 0.04 (26.97)	0.711ns
Ladies finger	4.23^{a} ± 0.04 (39.17)	5.10^{b} ± 0.12 (40.16)	–	5.96^{b} ± 0.01 (38.45)	28.41*
Ascorbic acid					
Capsicum	47.58^{a} ± 5.73 (700)	19.82^{b} ± 4.89 (268)	16.67^{d} ± 2.68 (235)	21.9^{b} ± 4.57 (288)	38.135**
Ladies finger	6.88^{a} ± 0.72 (64)	1.88^{b} ± 0.72 (15)	–	1.63^{b} ± 0.43 (12)	115.03***
Total ash					
Beetroot	1.23^{a} ± 0.23 (12.95)	1.15^{a} ± 0.04 (11.27)	0.90^{b} ± 0.05 (10.59)	1.27^{a} ± 0.09 (11.34)	4.890*
Carrot	0.78 ± 0.04 (5.91)	0.81 ± 0.03 (6.14)	0.83 ± 0.02 (6.54)	0.84 ± 0.00 (6.09)	3.727ns

TABLE 3.
Continued

Constituents	Raw	Cooking methods			F Ratio
		Conventional	Pressure	Microwave	
Capsicum	0.41 ± 0.01 (6.03)	0.43 ± 0.03 (5.81)	0.41 ± 0.05 (5.77)	0.44 ± 0.06 (5.79)	0.567ns
Ladies finger	0.89[a] ± 0.07 (8.24)	0.94[ab] ± 0.01 (7.4)	–	0.40[b] ± 0.35 (9.03)	7.078*
Calcium (mg)					
Beetroot	5 ± 1.13 (53)	8 ± 1.76 (71)	7 ± 3.02 (82)	8 ± 1.24 (71)	1.110ns
Carrot	26 ± 2.75 (197)	25 ± 2.28 (189)	25 ± 1.67 (197)	23 ± 4.57 (167)	1.110ns
Capsicum	6 ± 0.77 (88)	7 ± 0.34 (95)	7 ± 1.45 (99)	7 ± 1.84 (92)	0.984ns
Ladies finger	78[a] ± 2.05 (722)	96[ab] ± 6.93 (728)	–	110[b] ± 7.48 (710)	28.848*
Phosphorus (mg)					
Beetroot	37 ± 8.23 (389)	35 ± 9.32 (313)	34 ± 6.84 (400)	38 ± 10.65 (339)	1.363ns
Carrot	48 ± 0.82 (364)	44 ± 4.04 (333)	42 ± 2.94 (331)	44 ± 7.23 (319)	1.363ns
Capsicum	23 ± 1.15 (338)	24 ± 0.50 (324)	22 ± 0.76 (310)	24 ± 1.83 (316)	1.714ns
Ladies finger	33[a] ± 3.51 (306)	41[ab] ± 8.99 (323)	–	50[b] ± 1.95 (323)	9.745*
Total iron (mg)					
Beetroot	0.68 ± 0.15 (7.16)	0.83 ± 0.29 (7.41)	0.69 ± 0.13 (8.12)	0.84 ± 0.30 (7.50)	0.484ns
Carrot	0.71 ± 0.10 (5.38)	0.70 ± 0.18 (5.30)	0.69 ± 0.00 (5.43)	0.71 ± 0.01 (5.14)	0.484ns
Capsicum	0.53 ± 0.08 (7.79)	0.55 ± 0.01 (7.43)	0.50 ± 0.01 (7.04)	0.58 ± 0.02 (7.63)	1.349ns
Ladies finger	0.85 ± 0.05 (7.87)	0.90 ± 0.16 (7.09)	–	0.86 ± 0.03 (7.55)	2.956ns

Values with different superscripts in the same row are significantly different.
Ascorbic acid was not estimated in beetroot and carrot due to interference of color.
Values in parenthesis indicate dry weights.
ns: not significant, * $P \leq 0.05$, ** $P \leq 0.01$, *** $P \leq 0.001$.

nonsignificant for carrot and capsicum. The significant differences observed in beetroot and ladies finger were also only due to moisture content and on dry weight basis (Table 3) and were not significant. The ether extractives in raw vegetables ranged from 0.06% in beetroot to 0.3% in carrot. Cooking made no differences to ether extractives. The difference seen in ladies finger was due to added fat. Dietary fiber content of vegetables ranged from 2.00–4.23% and there was no major changes observed on cooking. Svanberg and Nyman (1997) studied the influence of boiling and storage on dietary fiber content in eight different carrot cultivars and showed that the TDF was in the range of 252–291 g/kg dry matter. The differences between groups and cultivars were mainly due to differences in insoluble dietary fiber content. Boiling caused a decrease in total dietary fiber content.

Ascorbic acid was high in raw samples and was destroyed considerably in cooked samples. The losses in capsicum were highest in pressure cooking followed by conventional and microwave cooking. In ladies finger, 73 and 76% ascorbic acid was lost due to conventional and microwave cooking, respectively. The important factors that determine the ascorbic acid retention in cooked vegetables are cooking method, vegetable to water ratio and cooking time (Peckham 1974; Klein *et al*. 1981). Apart from these factors the loss also depends on the type of vegetable. It is shown that the typical loss is around 40% for root vegetables and 70% for leafy vegetables due to cooking (Selman 1994). The total ash content of vegetables did not vary much due to cooking except in pressure cooked beetroot which lost marginally significant amount due to leaching. Beetroot and capsicum had very low amount of calcium among the vegetables analyzed. However, none of them showed any difference on cooking. Ladies finger had a higher content of calcium in cooked vegetables in comparison with raw which could be due to moisture loss. No change on cooking was observed in phosphorus and iron content of vegetables.

Sensory Analysis

Cooked vegetables representing the different pigments namely, betanin in beetroot, carotene in carrot and chlorophyll in capsicum and ladies finger were analyzed for the sensory attributes both subjectively and objectively. Under the subjective test a two-tailed paired comparison test followed by quantitative descriptive analysis was conducted. The results of the paired comparison test are displayed in Table 4.

Preference scores (Table 4) show that significant differences due to cooking methods were only observed in two attributes: (1) color of carrot and capsicum and (2) in the texture of beetroot and capsicum. In the case of carrot and capsicum, the color of microwave cooked sample was preferred to a greater extent. Conventionally cooked carrot however, was much similar to the microwave cooked one. In beetroot, pressure cooked sample scored higher scores with respect to color, finger feel and mouth feel. Conventionally cooked and microwave cooked beetroot were almost similar. Ladies finger also showed a similar result with no significant difference between conventionally cooked and microwave cooked sample although the color of conventionally

TABLE 4.
DIFFERENCES AND PREFERENCES OF VEGETABLES COOKED BY DIFFERENT METHODS (PAIRED COMPARISON TEST)

Pairs	Color		Appearance		Finger feel		Mouth feel		Aroma		Taste	
	D	P	D	P	D	P	D	P	D	P	D	P
Beetroot												
Con × Pre	***	Ns	ns	ns	**	Pre	***	ns	ns	ns	ns	ns
Mic × Con	***	Ns	***	ns	Ns	ns	ns	ns	**	ns	ns	ns
Pre × Mic	***	Ns	**	ns	**	Pre	***	Pre	ns	ns	ns	ns
Carrot												
Con × Pre	***	Con	*	ns	Ns	ns	***	ns	ns	ns	ns	ns
Mic × Con	ns	Ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns
Pre × Mic	**	Mic	*	ns	Ns	ns	**	ns	ns	ns	ns	ns
Capsicum												
Con × Pre	***	Pre	***	ns	Ns	ns	**	Con	ns	ns	ns	ns
Mic × Con	***	M	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns
Pre × Mic	ns	Ns	ns	ns	Ns	M	*	ns	ns	ns	ns	ns
Ladies finger												
Con × Pre	ns	Ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns	ns

Con: Conventionally cooked, Pre: Pressure cooked, Mic: Microwave cooked.
P: Preference, D: Difference.
ns: not significant, * $P \leq 0.05$; ** $P \leq 0.01$, *** $P \leq 0.001$.

cooked ladies finger was preferred to a little larger extent. Aroma and taste were similar in all cooking methods.

Results of quantitative descriptive analysis (See Table 1 for descriptions used in the specific score cards) show that in beetroot the color and appearance of pressure cooked sample which was bright and not shrunken was liked the most. Microwave cooked sample looked comparatively less bright and shrunken and was liked the least. In carrot the conventionally cooked and microwave cooked samples were similar in all parameter. Color of these samples was considered to be brighter compared to the pressure cooked which, however, had more appealing appearance. The scores for the other attributes, however, were similar in carrot. Microwave cooked capsicum was marked to be brighter, firm and intact followed by the conventionally cooked sample. Color and appearance of pressure cooked capsicum was liked the least since they were relatively dull and less firm. The texture of conventionally cooked sample was liked the most while that of microwave cooked was marked relatively as undercooked and that of pressure cooked as overcooked. Color of conventionally cooked and microwave cooked ladies finger were similar with moderate brightness. Appearance of conventionally cooked ladies finger was considered to be more appealing with moistness and intact

TABLE 5.
INSTRUMENTAL COLOR MEASUREMENTS OF COOKED VEGETABLES

Cooking method	L*	a*	b*
Beetroot			
Conventional	6.96	11.91	−1.36
Pressure	8.72	11.66	−1.24
Microwave	5.13	12.19	−0.60
Carrot			
Conventional	36.92	32.19	34.73
Pressure	36.92	30.47	41.42
Microwave	36.73	33.82	38.15
Capsicum			
Conventional	31.72	0.859	25.68
Pressure	31.70	3.23	27.89
Microwave	32.74	0.72	28.23

structure. Texture of microwave cooked ladies finger was marked higher with less sliminess. On the whole, conventionally cooked ladies finger scored higher.

Instrumental analysis of color (Table 5) revealed that different cooking methods had the least influence on the color of carrots i.e., on carotene. The L* values that indicate lightness were almost similar in carrots cooked by the three methods ranging from 36.72 to 36.92. Pressure cooked carrot had the least a* value (30.47) which indicates loss in redness and showed a higher b* value (41.39) which shows an increase in the yellowness. Microwave and conventionally cooked carrots had similar values of a*. Chlorophyll, represented by capsicum, showed less difference in L* values (31.70 to 31.72) due to cooking methods. The a* values, however, varied to a large extent, only the microwave-cooked sample had a negative a* value (–0.72) indicating the presence of greenness. Pressure cooked capsicum had a higher positive a* value (3.23) indicating the loss of green color and appearance of brown color. Betanin represented by beetroot however varied to a large extent in L* (5.13 to 8.31) and b* values (–0.60 to −1.36) due to cooking methods. Pressure cooked beetroot with the highest L* value was the brightest and microwave cooked with low L* was darker. The a* values were similar in all the three samples. The b* values recorded in beetroot were negative indicating blueness which was highest in conventional sample followed by pressure cooked and then in microwave cooked sample. These values seem to be too low to be perceived by human eyes. On comparison of these results with that of QDA, it can be concluded that objective analysis of color can be adopted in cases where subjective analysis becomes a constraint. A similar study conducted by

Archana *et al.* (1995), also showed that a close correlation existed between the visually analyzed and instrumentally measured color.

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