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Effect of Pre - treatments and Packaging on Shelf life of Minimally Processed Carrots

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This study was undertaken to investigate the effect of pre- treatments, packaging and cold storage on shelf life of minimally processed carrots. Carrots were prepared by manual peeling, cutting, slicing and shredding and pre -treated in 1% citric acid, ascorbic acid, potassium meta bisulphite, egg albumin and 0.5% potassium sorbate solutions for 30 sec. prior to packaging. Pre-treated carrot pieces were surface dried in atmospheric air and packed with a proportion of gases (5% oxygen, 15% carbon dioxide and 80% nitrogen) stored at 10°C. During storage, the chemical constituents and shelflife were analyzed. The results indicated that the whole peeled carrot without any pre - treatment had exhibited changes in the chemical constituents compared to other minimally processed carrots up to 45 days at 10°C.

Key words: Minimal Processing, Carrot, Quality

Fresh cut vegetables are widely prepared and handled to maintain fresh quality while providing convenience to the consumer. Minimal processing of fruits and vegetables includes washing, cutting, and treatments with sanitizing agents, packaging and storage under refrigerated conditions. Minimally processed carrots consumed as ready to eat snacks or salad vegetables have become increasingly popular (Amanatidou *et al*., 2000; Barry - Ryan *et al*., 2000). Hagenmaier and Baker (1998) rinsed carrot with chlorinated water, removed the ends, cut into sections, shredded them (cross section 2.8 x 2.8 cm) and packaged. The resultant products were often less stable due to the enzymatic activity of the cut cell walls and due to the potential bacteriological contamination. Various post – harvest treatment methods are employed to increase the biological stability and to extend the shelf life. In all, low temperature and packaging is most important. The most studied and used method of packaging for prepared raw fruits and vegetables is modified atmospheric packaging. Storage of minimally processed carrots in one to two per cent carbon dioxide at 2°C for six months was reported to have been successful (Platenius, 1984). The choice of refrigeration temperature is of critical importance in maintaining the quality of the packed product. The shelf life can be predicted either by controlling the driving agents (growth of microbial population, enzymatic activities, concentration of reactive compounds) or monitoring their effects, in terms of changes in texture, pH, nutritional value or flavour (Riva, Fessas and Schiraldi, 2001). Based on these principles, this study was undertaken to assess the effects of pre - treatment on the quality and shelf life of minimally processed carrots under refrigerated storage conditions.

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Materials and Methods

Methods

The carrots were first washed with tap water and wiped with muslin cloth to dry. After surface drying they were cut on both ends, peeled and prepared as whole, sticks, slices and shreds. The different shapes of the prepared carrots were classified as vegetable types (T_1-T_4).

Pre -treatments

Carrot samples of each 50 g were pre -treated by soaking them in 1.0 % citric acid (C_2), ascorbic acid (C_3), potassium meta bisulphite (C_4), egg albumin (C_5) and 0.5 % potassium sorbate (C_6) solutions separately for 30 seconds and air dried prior to packaging. Control samples (without pre - treatments) were also prepared (C_1).

Packaging

The minimally processed carrots were packed into PET bottles (500 g) in which the gas composition was initially flushed with a standardized gas composition (5.0% oxygen, 15.0% carbon dioxide and 80% nitrogen) in order to reduce the product's respiration rate. Carrots were stored at mild refrigeration temperature maintained at 10°C and 85 per cent relative humidity .

Storage studies

The moisture content was determined by drying in hot air oven at 70°C for 24h (Ranganna, 1995). Chemical analyses for acidity and beta carotene were done at periodical intervals (once in 15 days).

Acidity was determined by potentiometric titration with 0.1 N NaOH up to pH 8.1 using 10 ml of macerate diluted with 100 ml of distilled water (Ranganna, 1995). Determination of β-carotene content was done based on Ranganna procedure (1995), which consists of an extraction, followed by pigment separation by column chromatography and reading in a spectrophotometer. The results were expressed in micrograms of β-carotene per 100 g of sample.

Shelf-life study

Untreated and treated minimally processed carrots were packed in bottles and stored at 10 °C. The shelf-life study consisted of three storage periods 15, 30 and 45 days *viz.,* d_1, d_2, and d_3, three samples per treatment (treated and untreated) were taken at 15 days intervals for sensory quality, chemical and microbiological analyses. The end of shelf-life experiment was arrived when the population of microorganisms reached an unacceptable level or when the sensory panel rejected the samples.

Statistical analysis

The experiments were conducted using a completely randomized factorial design (3x4) with four vegetable preparations; three storage periods and six pre-treatments. The data obtained were analysed based on Factorial Completely Randomized Design (*Gomez* and *Gomez* 1984).

Results and Discussion

Moisture

From Table 1 it was observed that there was a slight reduction in moisture content during storage. Initially the moisture content was 86.3 per cent. Gradually it reduced to 78.5 per cent for whole carrot (T_1) in control, whereas in the treatments, the reduction was 74.8 to 84.3 per cent in C_2 to C_7 during 15 days of storage (d_1). Statistical analysis of the data revealed that there was a significant difference in the vegetable preparation. Among the vegetable preparation (T), "whole" was highly significant followed by T_2, T_3, T_4 in retention the moisture content. Moisture loss was primarily due to transpiration and respiration. Transpiration loss was due to differences in vapour pressure of water in the atmosphere and the vegetable surface. Moisture changes indicated the difference between pre - treatments, vegetable preparation and storage days. Anaerobic atmosphere and optimum packaging film lead to low condensation preventing moisture loss during storage. The lower the respiration rates the longer the storage life.

Table 1. Changes in the mean moisture content (%) of carrot during storage

Carrot type (T) / storage days (d)		Moisture content (%)	Control	GC	GC+ citric acid	GC + ascorbic acid	GC + potassium metabisulphite	GC + potassium sorbate	GC + egg albumin
			C_1	C_2	C_3	C_4	C_5	C_6	C_7
Initial		86.39							
Whole (T_1)									
15	d_1	78.55	84.32	83.71	83.58	81.87	81.35	74.89	
30	d_2	-	79.81	78.11	77.46	74.94	74.87	74.34	
45	d_3	-	78.02	77.56	76.52	-	-	-	
Sticks (T_2)									
15	d_1	73.90	81.81	80.71	80.43	78.67	76.12	75.68	
30	d_2	-	78.83	76.31	75.11	72.57	70.97	69.48	
45	d_3	-	72.04	69.10	68.64	-	-	-	
Slice (T_3)									
15	d_1	71.69	80.11	78.84	78.48	73.33	73.34	73.13	
30	d_2	-	76.75	75.86	74.87	71.12	70.42	68.41	
45	d_3	-	71.97	69.04	68.48	-	-	-	
Shreds (T_4)									
15	d_1	69.47	79.43	75.01	74.95	72.91	69.84	69.74	
30	d_2	-	77.61	72.58	72.47	70.95	69.03	67.27	
45	d_3	-	71.30	68.62	68.60	-	-	-	

	SED	CD (0.05)	CD (0.01)
T	0.00523	0.01032	0.01362**
d	0.00453	0.00894	0.01180**
C	0.00691	0.01365	0.01802**
Td	0.00905	0.01787	0.02359**
dC	0.01198	0.02365	0.03121**
TC	0.01383	0.02730	0.03604**
TdC	0.02395	0.04729	0.06242**

Acidity

During storage, the acidity content of carrot increased as shown in Table 2. The initial acidity was 0.25 per cent. After 45 days (d_3) the acidity

Table 2. Changes in the mean acidity (g/100g) of carrot during storage

Carrot type (T) / storage days (d)		Acidity (%)	Control	GC	GC+ citric acid	GC + ascorbic acid	GC + potassium metabisulphite	GC + potassium sorbate	GC + egg albumin
			C_1	C_2	C_3	C_4	C_5	C_6	C_7
Initial		0.25							
Whole (T_1)									
15	d_1	0.32	0.26	0.28	0.27	0.29	0.29	0.30	
30	d_2	-	0.38	0.40	0.38	0.38	0.41	0.40	
45	d_3	-	0.39	0.41	0.41	-	-	-	
Stick (T_2)									
15	d_1	0.32	0.27	0.28	0.27	0.29	0.30	0.30	
30	d_2	-	0.39	0.40	0.38	0.39	0.41	0.40	
45	d_3	-	0.39	0.41	0.41	-	-	-	
Slice (T_3)									
15	d_1	0.32	0.28	0.29	0.27	0.29	0.30	0.31	
30	d_2	-	0.39	0.41	0.38	0.38	0.41	0.40	
45	d_3	-	0.40	0.41	0.41	-	-	-	
Shreds (T_4)									
15	d_1	0.32	0.28	0.29	0.28	0.30	0.30	0.30	
30	d_2	-	0.40	0.41	0.39	0.39	0.41	0.42	
45	d_3	-	0.40	0.42	0.42	-	-	-	

	SED	CD (0.05)	CD (0.01)
T	0.00025	0.00050	0.00066**
d	0.00022	0.00043	0.00057**
C	0.00034	0.00066	0.00088**
Td	0.00044	0.00087	0.00115**
dC	0.00058	0.00115	0.00152**
TC	0.00067	0.00133	0.00175**
TdC	0.00116	0.00230	0.00303**

increased to 0.39, 0.41 and 0.41 per cent in C_2, C_3 and C_4 samples, respectively and the samples C_5 and C_6 were found to be spoiled. Statistical analysis of the data revealed that there was a highly significant difference in treatments (C), vegetable type (T) and days of storage (d) and their interactions. In the vegetable type, the minimum increase was found in T_1 (whole) whereas the maximum was found in T_4 (shredded). Among the treatments citric acid (C_3) was the best followed by C_4, C_6, C_7, C_5, C_1 and C_6 . However, the treatments were on par with each other. Kakiomenio *et al*. (1996) studied the sensory alterations in minimally processed carrots and demonstrated that there was an increase in its organic acids, resulting in a reduction in the values of texture, characterized by softening of the tissues during storage. In the present study shredded carrots showed increase in acid content.

Beta - Carotene

The initial β-carotene content was 849.5 mg/100 g. Table 3 shows that there was reduction in the β - carotene content during storage. Statistical analysis of the data revealed that the vegetable type (T), storage days (d) and treatments (C) significantly affected β- carotene, whereas interactions yielded no significant influence between storage days vs. treatments (d vs C) and storage days vs. treatments vs. vegetable type (d vs C vs T). Stick (T_2) and sliced (T_3) samples were similar as there was a significant difference with the shredded carrots (T_4). Overall, treatment C_2 had the higher â-carotene retention, followed by C_3, C_4, C_5, C_6, and C_1. Similar losses were observed when data were expressed as fresh weight by Howard and Dewi (1996). The largest decline in carotene content occurred within three days after processing. In the present study, similar results were obtained where β -carotene loss was minimum in whole (T_1) compared to T_2, T_3 and T_4. Although the above described changes indicate that carrot sticks underwent degradation, variation was observed on carotenoid concentration at 10 °C, in agreement with the observations made by Carlin *et al*., (1990). At 4 °C α- and β-carotene concentration showed a 9% and 13% increase after 3 days of storage and decreased. The initial carotenoid increase could be ascribed to carotenoid synthesis in response to post harvest stress conditions. By comparison, it has been found that carotenoids increased more in post-harvest ripened tomatoes than in vine-ripened tomatoes (Giovanelli *et al*., 1999). The irregular trend of variation of carotenoid concentration makes it unpredictable. In any case, data showed that degradation did not occur during storage at 4 and 10°C. This result is particularly interesting due to the dietary importance of carrot as a source of vitamin A precursor. However, some authors observed that α- and β-carotene concentration decreased in minimally-processed carrots stored at 1 and 2°C (Howard and Dewi 1996 and Li and Barth, 1998). Degradation of carotenes

Table 3. Changes in the mean carotene content (mg/100 g) of carrot during storage

Carrot type (T) / storage days (d)			Control	GC	GC+ citric acid	GC + ascorbic acid	GC + potassium metabisulphite	GC + potassium sorbate	GC + egg albumin
			C_1	C_2	C_3	C_4	C_5	C_6	C_7
Initial			849.50						
Whole (T_1)									
	15	d_1	725.33	761.00	732.33	702.33	693.00	691.33	686.66
	30	d_2	-	761.00	718.66	652.33	612.66	610.00	607.33
	45	d_3	-	760.00	690.00	644.66	-	-	-
Sticks (T_2)									
	15	d_1	717.33	757.33	725.33	699.66	694.00	686.66	681.33
	30	d_2	-	754.00	696.66	652.66	619.66	610.00	606.00
	45	d_3	-	748.00	682.33	648.00	-	-	-
Slice (T_3)									
	15	d_1	714.00	750.00	716.00	694.00	696.33	683.33	675.00
	30	d_2	-	743.00	695.00	654.66	636.33	618.33	606.66
	45	d_3	-	742.66	690.00	632.33	-	-	-
Shreds (T_4)									
	15	d_1	712.00	749.00	714.00	687.33	688.66	677.00	665.66
	30	d_2	-	744.66	689.00	644.66	608.00	605.00	605.66
	45	d_3	-	744.00	678.00	636.00	-	-	-

	SED	CD (0.05)	CD (0.01)
T	1.49609	2.95383	3.89875**
d	1.29565	2.55809	3.37641**
C	1.97914	3.90755	5.15756**
Td	2.59130	NS	NS
dC	3.42797	6.76807	8.93315**
TC	3.95828	7.81510*	NS
TdC	6.85595	NS	NS

might have probably been initiated by peeling and further accumulation due to cutting and shredding. This process also increased the exposed surface area of the carrots to oxidative degradation. Biotic stress such as wounding stimulates enzymes involved in deposition of wound barriers and membrane repair. Lipoxygenase catalyzes the co-oxidation of pigments, can bleach carotenoids. Peel removal may also have resulted in greater exposure of carotenoids to oxygen. In the study, packaging reduced the oxygen content and therefore the loss of ß carotene was minimized.

Conclusion

From the study, it is concluded that minimally processed carrots could be stored at 10°C with minimum changes in the chemical and nutritional parameters. Whole carrot was the best in all characteristics compared to others like sticks, slices and shreds. Whole vegetable retained the maximum chemical constituents compared to other minimally processed carrots. Soaking solutions like citric acid and ascorbic acid were suitable for preserving carrots with out loss to the original characteristics as compared to potassium meta bisulphite, potassium sorbate and egg albumin. During storage, there was an increase in acidity, total soluble solids, reducing sugar and decrease in moisture and β carotene in all the preparation. No change in the mineral content was observed during storage. The products prepared from stored carrots retained maximum consumer acceptability scores. The shelf life of carrots was found to be good up to 45 days at 10°C (refrigeration temperature), without chilling injury.

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