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Effect of pre storage treatments on the shelf-life of fresh cut carrots

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SUMMARY :

Fresh carrots collected from the local market were used for the study. Freshly collected carrots were washed, surface sanitized using the standardized 30 ppm sodium hypo chlorite solution, outer skin scraped, washed and shreds were prepared and these shreds were air dried and kept in aluminiumtrays wrapped with cling film under refrigerated storage for taking observations. The physical, physiological and chemical quality parameters were analyzed and based on the microbial analysis it was found that 2 per cent calcium ascorbate as the best effective chemical treatment for shredded carrots.

KEY WORDS : Pre storage treatments, Fresh cut vegetables, Carrot, Nutritional quality, Shelf-life

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Fruits and vegetables are well known sources of useful nutrients in the form of vitamins, minerals, dietary fibre and other phytonutrients including flavonoids, carotenoids and phenolic compounds that may lower the risk of cancer, heart disease and others illnesses (Kader, 2002). Intensification of human life activities and development of advanced systems in food processing have led the producers and consumers to new offers and demands in recent years. Lifestyle of people has been changing and the new consumer's profile is ''rich in cash and poor in time'' and eating habits are diverse in different parts of the world; however, some aspects in the production and consumption of food are universal, such as the consumption of ready-to-eat products such as pre-cooked and minimally processed foods. This increase is due in part to two key trends: a growing focus on health, which includes the consumption of fresh vegetables, and the increased preference for convenience which means the consumers want healthy products for their meals, available at a good value, convenient, safe, and with good quality. Consumer trends are changing, and high quality foods with fresh like attributes are demanded (Alzamora *et al*., 2005). Fresh-cut products are fruit or vegetables that have been trimmed and/or peeled and/or cut into 100 per cent usable product that is bagged or prepackaged to offer consumers high nutrition, convenience, and flavor while still maintaining its freshness (IFPA, 2004). Minimally processed fruits and vegetables consist of raw fresh cut produce, which have undergone a minimal processing such as peeling, slicing or shredding to make them ready-to-use. Chemical treatments are used in fresh cut vegetables for controlling decay, reducing browning and retaining firmness.

EXPERIMENTAL METHODS

Fresh carrots of good quality were uniformly processed from FSRS, Sadananthapuram, washed in tap water followed by distilled water and then subjected to surface sanitization using 30 ppm sodium hypo chlorite solution (Chandran, 2013).

After sanitization period of ten minutes, solution was drained, outer skin of carrot scraped, washed in distilled water and made into shredded pieces and fifty grams of shreds were completely immersed in following chemical treatments for 10 min.

T_1 - 0.1% KMS and 0.1% ascorbic acid
T_2 - 0.1% KMS and 0.1% citric acid
T_3 - 0.1% Sodium benzoate and 0.1% ascorbic acid
T_4 - 0.1% Sodium benzoate and 0.1% citric acid
T_5 - Calcium chloride (1%)
T_6 - Calcium ascorbate (1%)
T_7 - Sodium chloride (2%)
T_8 - Acetic acid (0.1%)
T_9 - Control (without any treatment).

The solution was drained and shreds were air dried, kept in aluminium trays wrapped with cling film and stored under refrigerated condition for finding the effective treatment for increasing the shelf-life of shredded carrots. The physical, physiological and chemical quality parameters were analyzed.

The treated carrot shreds were steamed for 60 seconds and physical parameters like colour, texture, appearance, flavor and taste of the steamed carrot shreds were examined on the first and third day of storage by conducting a sensory evaluation trial performed by a 30 member semi - trained panel using a nine point hedonic scale.

Like extremely	-	9
Like very much	-	8
Like moderately	-	7
Like slightly	-	6
Neither like nor dislike	-	5
Dislike slightly	-	4
Dislike moderately	-	3
Dislike very much	-	2
Dislike extremely	-	1

The scores given by 30 judges in the panel were converted into mean rank values and statistically analyzed using the non-parametric anova (Kruskall Wallis test).

Physiological parameters like physiological loss in weight, transpiration loss, per cent leakage were recorded continuously for a period of five days and the average worked out using standard techniques.

Physiological loss in weight (PLW) was determined on initial weight basis by weighing the carrot shreds on the day of observation, using a laboratory level weighing balance having 0.01g accuracy and expressed as percentage. Weight of water molecules adhering on the cling film used for wrapping and inside the aluminium foil tray was recorded and expressed as transpiration loss in g/100g of the sample. Absorbance of carrot shreds was recorded at 273nm by dipping in distilled water for 3 hours and later heating in water bath at 100^0C for 20 minutes. The ratio of initial and final absorbance values gives the per cent leakage.

Chemical parameters like starch, vitain C, carotenoids (Saini *et al*., 2001) and total phenol (Sadasivam and Manikam, 1992) of treated carrot shreds were recorded continuously for a period of five days and average was worked out using standard techniques.

As none of the treatments showed superior performance for all the quality parameters evaluated, comparatively more important chemical and physiological parameters were given more weightage and selection index was calculated by conducting discriminal function test. The four pre-treatments having superior selection index were selected for further microbial analysis.

Whole carrots were surface sanitized using 30 ppm sodium hypo chlorite, shreds prepared, treated with top four pretreatments selected from previous experiments and microbial count on one gram treated carrot sample was calculated once in two days for five days using serial dilution spread plate technique. Based on the efficiency in controlling microbial population best effective pre storage treatment for increasing the shelf-life of shredded/fresh cut carrots was selected.

EXPERIMENTAL FINDINGS AND ANALYSIS

The findings of the present study as well as relevant discussion have been presented under following heads :

Physical and physiological parameters :

Different treatments are used to control undesirable changes *viz.*, physiological and physical changes that adversely affect quality of minimally processed products (Gonzalez *et al.*, 2010). Minimally processed products have high rate of respiration, which generally leads to ageing of products by using reserve energy during oxidative – reduction process. Higher the rate of respiration, shorter will be the shelf-life of product. Refrigeration, chemical or bio preservatives, additives, reduction of water activity, disinfectants or dipping in chemical solutions are used to maintain quality and thereby to extend shelf-life of minimally processed products. Effect of different pre-storage treatments on physical and physiological quality parameters of shredded carrot is shown in Table 1 and 2.

Physiological weight loss is a phenomenon related with shelf-life of vegetables whether whole or fresh cut, accelerated weight loss being directly related with transpiration of fresh cut products. Fresh cut products are highly susceptible to weight loss because internal tissues are exposed and there in lack of skin or cuticle (Ayala *et al.*, 2008). Any fresh cut vegetable with least transpiration rate, per cent leakage and physiological weight loss maintains its turgidity, freshness and quality.

Carrot shreds treated with calcium compounds like calcium chloride (1.52%) and calcium ascorbate (1.46%) recorded the least PLW and transpiration rate (0.12g/100g and 0.13g/100g), respectively resulting in highest acceptability for physical

parameters like appearance (54.29 and 53.57), colour (52.14 and 56.36) and texture (56.50), respectively. Per cent leakage is negatively correlated with the integrity of cell membrane.Per cent leakage was least in shredded samples treated with calcium compounds. This was supported by the highest mean rank values for the textural quality of shredded carrots. The result is in accordance with the findings of Kang *et al.* (2002) who had reported that loss in moisture results in reduction of fresh weight accompanied by loss of freshness, appearance and texture in cabbage. Tirmazi and Wills (1981) showed reduction in respiratory activity of shredded cabbage by calcium infusion, which can be attributed to inactivation of enzyme catalytic mechanism. Dong *et al.* (2000) reported that calcium lactate solution resulted in textural improvement similar to calcium chloride and had better flavour in cantaloupe melon. Luna-Guzman and Barrett (2000) compared the effect of calcium chloride and calcium lactate dips in fresh-cut cantaloupe firmness evaluation.

Preservative action of KMS is improved in acidic medium and hence the combination treatment of KMS + citric or ascorbic acid was effective in reducing the physiological loss in weight of shredded carrot, there by maintaining quality, freshness and appearance of the produce. But bleaching action of KMS makes it unsuitable as an effective pre storage treatment for coloured vegetables. Earlier studies proved that the combination treatment of KMS + ascorbic acid resulted in least physiological loss in weight in fresh cut papaya pieces (Amith, 2012) and KMS in combination with citric acid was effective in prolonging shelf-life of fresh cut vegetables under ambient conditions (Varghese, 2006).

Combination treatment of sodium benzoate + citric or ascorbic acid was equally effective in reducing the physiological weight loss in carrot. Two per cent sodium chloride was another chemical which was effective in retarding the physiological weight loss of shredded carrot and hence carrot shreds treated with this chemical scored better mean rank value for physical parameters like appearance, texture and colour during sensory evaluation.

The untreated samples and the samples treated with 0.1 per cent acetic acid showed poor performance in all the physiological parameters tested and hence had poor sensory scores for the physical parameters too.

Chemical parameters :

Effect of different pre-storage treatments on chemical quality parameters of shredded carrot is shown in Table 3.

Table 1 : Effect of pre storage treatments on physical quality parameters of shredded carrot

Pre storage treatments	Mean rank values					
	Appearance	Colour	Flavour	Texture	Taste	Overall acceptability
0.1% KMS + 0.1% ascorbic acid	31.64	30.57	34.07	29.21	37.29	28.64
0.1% KMS + 0.1% citric acid	20.36	25.57	34.07	29.21	36.28	30.29
0.1% sodium benzoate + 0.1% ascorbic acid	22.57	30.86	31.14	29.21	36.21	31.07
0.1% sodium benzoate + 0.1% citric acid	36.14	28.07	31.14	31.57	31.36	30.14
Calcium chloride (1%)	54.29	52.14	53.43	56.50	45.71	56.14
Calcium ascorbate (1%)	53.57	56.36	48.64	56.50	44.07	55.14
Sodium chloride (2%)	45.86	37.86	26.07	35.93	38.21	34.29
Acetic acid (0.1%)	5.43	11.57	8.43	6.36	7.07	5.86
Control (without any treatment)	18.14	15.0	17.21	13.5	11.79	16.43
CV	19.20					

Table 2 : Effect of pre storage treatments on physiological parameters of shredded carrot

Pre storage treatments	Physiological loss in weight (%)	Transpiration loss (g/100g)	Per cent leakage
0.1% KMS + 0.1% ascorbic acid	1.67	0.17	94.35
0.1% KMS + 0.1% citric acid	1.80	0.14	94.77
0.1% Sodium benzoate + 0.1% ascorbic acid	1.72	0.13	92.47
0.1% Sodium benzoate + 0.1% citric acid	1.93	0.21	95.52
Calcium chloride (1%)	1.52	0.12	89.54
Calcium ascorbate (1%)	1.46	0.13	89.49
Sodium chloride (2%)	1.60	0.15	91.54
Acetic acid (0.1%)	1.94	0.19	94.77
Control (without any treatment)	2.00	0.21	95.52
CD (P=0.05)	0.28	0.01	0.52

Treatment with both calcium compounds had resulted in increased vitamin C content in fresh cut carrot. Combination treatment of preservatives and acidulants were also effective in increasing the vitamin C content. The maximum retention of ascorbic acid in the shreds might be due to less enzymatic oxidation of L- ascorbic acid to de hydro ascorbic acid due to the influence of anti – browning chemicals (Joshi and Nath, 2002). Suryawanshi (2008) reported a higher ascorbic acid retention in potato slices and cubes treated with 0.5 per cent ascorbic acid + 0.2% KMS + 2% NaCl.

Carrot shreds treated with 0.1% KMS + 0.1% ascorbic acid recorded least Vitamin C. The lower content of Vitamin C might be due to the oxidative reduction of vitamin C in presence of molecular oxygen by ascorbic acid oxidase enzyme (Suryawanshi, 2008). Similar result was also observed by Behra *et al.* (2004) in capsicum.

Starch content was similar in the case of both treated and untreated carrot shreds. Suryawanshi (2008) reported minimum starch level in potato slices without any chemical which might be due to the higher conversion of starch into sugar due to the higher enzyme activity. This lower starch content in untreated and acetic acid treated beetroot and cabbage resulted in lower mean rank value for texture during sensory scoring.

Total carotenoid content showed no significant difference between the pre storage treatments for carrot shreds. However maximum carotenoid was shown by the calcium compounds like calcium chloride and calcium ascorbate treated shredded carrots. Higher carotenoid content in calcium treated carrot shreds had better firmness, there by scored highest mean rank values for physical quality parameters like appearance and colour.

Any fresh cut vegetable should have low phenol content to avoid enzymatic browning. Visual quality loss is the main factor limiting shelf-life of fresh cut produce. Total phenol content was least observed in the shreds treated with calcium compounds like calcium chloride and calcium ascorbate. The lower phenol content indicate least enzymatic browning and hence scoring superior performance in physical parameters like appearance and colour.

Untreated samples recorded the highest phenol content in shredded carrot. High phenol content is due to higher enzymatic browning and hence they scored poor mean rank values in physical parameters and thereby with least overall acceptability.

When the effect of different pre-storage effects was tested, none of the treatments showed uniform superior performance for all the quality parameters tested. Hence for selecting the best pre storage treatments comparatively more important

Table 3 : Effect of pre-storage treatments on chemical quality parameters of shredded carrot

Pre storage treatments	Starch (%)	Vit. C (mg/100g)	Carotenoids (µg/100g)	Total phenol (mg/100g)
0.1% KMS + 0.1% ascorbic acid	9.22	2.30	1000.00	50.29
0.1% KMS + 0.1% citric acid	9.25	2.43	1040.00	45.18
0.1% Sodium benzoate + 0.1% ascorbic acid	9.20	2.28	1040.00	49.06
0.1% Sodium benzoate + 0.1% citric acid	9.22	2.48	1030.00	45.32
Calcium chloride (1%)	9.33	2.55	1080.00	40.31
Calcium ascorbate (1%)	9.32	2.56	1110.00	40.63
Sodium chloride (2%)	9.22	2.40	1070.00	42.05
Acetic acid (0.1%)	9.09	2.24	990.00	51.08
Control (without any treatment)	8.94	2.10	960.00	56.18
CD (P=0.05)	NS	0.21	NS	0.49

NS= Non-significant

Table 4 : Selection index

Pre storage treatments	Carrot
0.1% KMS + 0.1% ascorbic acid	161.95(3)
0.1% KMS + 0.1% citric acid	151.38
0.1% Sodium benzoate + 0.1% ascorbic acid	126.50
0.1% Sodium benzoate + 0.1% citric acid	168.47(1)
Calcium chloride (1%)	162.29 (2)
Calcium ascorbate (1%)	153.20 (4)
Sodium chloride (2%)	132.31
Acetic acid (0.1%)	127.26
Control (without any treatment)	109.16

Values in parenthesis shows the rank of different pre storage treatments

physiological (loss in weight, per cent leakage) and chemical parameters (vitamin C, total carotenoids, total phenol) which decide the quality of any fresh cut vegetables, have given more weightage and discriminal function test was conducted, based on which selection index was determined. The selection index calculated was shown in the Table 4.

As none of the pre-treatments tried showed superior performance for all the quality parameters evaluated, four pre-treatments having top rank were selected for carrot shreds based on a selection index obtained by conducting discriminal function test. Carrot shreds treated with a good pre- storage treatment chemical should have low PLW, per cent leakage and phenol content, and at the same time; it should retain increased vitamin C and carotenoid content. Hence these characters were considered for calculation of selection index.

The top four pre storage treatments having high selection index were selected for conducting microbial analysis.

- Sodium benzoate + citric acid
- Calcium chloride
- KMS + ascorbic acid
- Calcium ascorbate.

Enumeration of microbial load :

Carrot shreds were surface sanitized using standardized 30 ppm sodium hypochlorite solution and pretreated with the top four selected pre-storage treatments and subjected to microbial analysis. Effect of bacterial count on fresh cut carrots treated with selected pre -storage treatments were shown in Table 5.

Table 5 : Microbial count on fresh cut carrots treated with selected pre-storage treatments

Pre storage treatments	Bacterial count × 10^4cfu/g
0.1% KMS + 0.1% ascorbic acid	2.48
0.1% sodium benzoate + 0.1% citric acid	2.42
Calcium chloride (1%)	2.48
Calcium ascorbate (1%)	2.40
CD (0.05)	0.081

Ayala *et al*. (2010) and Toivonen *et al*. (2002) reported that increase in microbial population on minimally processed products is associated to damaged tissues and broken cells. Varghese (2006) reported that increased handling of the product provides greater opportunity for contamination by pathogenic organisms.

Bacterial load was least (2.40 x10^4cfu) in shredded carrot treated with 1 per cent calcium ascorbate which was at par with all the other samples except the samples treated with 1 per cent calcium chloride (2.50 x 10^4cfu). Considering the physical parameters, calcium ascorbate was selected as the best pre - storage treatment for shredded carrot.

In general, the pretreatment having capacity to maintain physical, physiological and chemical quality parameters and to reduce the microbial population of shredded vegetable, stored under refrigerated condition, was selected as the efficient pre-storage treatment. Accordingly one per cent calcium ascorbate was selected as the best effective pre storage treatment for increasing the shelf-life of fresh cut carrot under refrigerated storage.

Conclusion :

Protocol for preparation of any fresh cut vegetable includes surface sanitization of whole vegetable, preliminary preparations like removal of inedible portions and cutting into pieces of required sizes, pre- treatment of cut pieces, air drying, packaging and storage. Hence, the investigation was carried out as different continuous experiments incorporating all these steps. Good quality carrots were collected from the local market for the study. These carrots were surface sanitized with already standardized 30ppm sodium hypochlorite solution which was effective in reducing microbial population. Investigation on the effect of different pre storage treatments revealed the superiority of calcium treatments in maintaining the freshness and quality of the fresh cut carrots. Shredded carrots treated with one per cent calcium chloride and calcium ascorbate showed least physiological weight loss, transpiration loss and hence had highest water potential. Per cent leakage was also least in shredded carrots treated with calcium compounds resulting in better texture. As none of the pre - treatments showed superior performance for all the chemical quality parameters evaluated, the top four pre storage treatments were selected based on discriminal function test and subjected to microbial analysis. Considering the efficiency in reducing the microbial load and other physical parameters, calcium ascorbate was selected as the effective pre storage treatment for extending the shelf-life of fresh cut carrot.

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