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Influence of 6-Benzylaminopurine, Chitosan and Carboxy Methyl Cellulose on Quality and Shelf Life of Fresh Cut Carrot (*Daucus carota* L.) Shreds under Refrigerated Storage

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Abstract

Carrots are very popular root vegetable, highly preferred for its richness in antioxidant, vitamin-A and dietary fibre. Fresh cut carrots have gained popularity in recent time to cope with the need of ready to use fresh vegetable demand of urban cities and super markets. But storage of fresh cut carrots are difficult task as it loses moisture rapidly and become shrivelled and thus become susceptible to post-harvest decay which causes short shelf life. Present study was undertaken to evaluate the influence of 6-Benzylaminopurine (6-BAP), Chitosan and Carboxy Methyl Cellulose (CMC) on quality and shelf life of fresh cut carrot shreds under refrigerated condition. Eight post-harvest treatments viz. fruit dipping in 6-BAP at 100 ppm, 200 ppm, 300 ppm; fruit dipping in Chitosan at 1%, 2% and in Chitosan 1% along with CMC 2%, Chitosan 2% along with CMC 2% and control (treated with water) with six replications were used and statistical analysis was done by following complete randomized design. The results of the research showed that carrot shreds bilayer coated with chitosan 2% and carboxy methyl cellulose 2% had minimum percentage of physiological weight loss (8.56%) with high TSS:acid ratio (26.97), ascorbic acid (6.12 mg 100 g^{-1}) and carotene (7.25 mg g^{-1}) content at 15 DAS. Moreover, there was no decay in stored carrot shreds and showed maximum shelf life (25.25 days) under this treatment. However, carrot shreds bilayer coated with chitosan 1% and CMC 2% also had high shelf life (21.25 days).

Keywords: Storage, 6-BAP, chitosan, CMC, shelf life, carrot

1. Introduction

Carrots (*Daucus carota* L.) are one of the most important root vegetables as it preferred throughout the world for its ample culinary uses, enriched healthy composition, such as antioxidants, dietary fibre and mineral. Carrots are consumed fresh as well as cooked, either alone or with other vegetables, in the preparation of curies, soups, stews and pies. Fresh grated carrots are used in salads and tender roots are pickled (Sharma et al., 2006). Carrots are also good source of vitamin-A, thiamine and riboflavin (Thompson and Kelly, 1957) and thus have several health benefits associated with it. The consumption of fresh cut carrots has gained popularity in recent years, particularly baby carrots which is one of the most popular products. Fresh cut carrots could be found on the market in the following forms: whole peeled, sticks and sliced, shredded, grated and diced. Baby carrots are prepared by peeling the outer layer of the carrot roots and are found susceptible to a variety of physiological changes which reduce their quality (Li & Barth, 1998). Cut or grated carrot is one of the most widely used products in ready-to-eat salads; however, the main problems limiting its shelf-life are surface white blush discoloration and microbial spoilage (Emmambux and Minnaar, 2003). It is well known that the quality of minimally processed products can be maintained by cold storage and controlled storage as a way to minimised the wound –induced reactions, diseases, increases tissue susceptibility to chemical and physical damage (Eshel et al., 2009). Post-harvest moisture loss causes carrots to become shrivelled (Hurschka, 1977), lose their bright orange appearance, and become susceptible to post-harvest decay (Van den Berg and Lentz, 1966; 1973). Post-harvest treatment with 6-BAP resulted marked influence on antioxidant activity, quality and shelf life of vegetables like cauliflower (Siddiqui et al., 2011) and broccoli (shew Felt et al., 1982). Chitosan is a linear polysaccharide consisting of β-(1→4)-linked 2-amino-2- deoxy-D-glucose residues, originating from deacetylated derivative of chitin, which is the second most abundant polysaccharide in nature after cellulose (Jianglian and Shaoying, 2013). It was non-toxic, biodegradable, biofunctional, and biocompatible. Chitosan has strong antimicrobial and antifungal activities that could effectively control fruit decay (Aider, 2010). It could easily form coating on fruit and vegetable, and the respiration rate of fruit and vegetable was reduced by adjusting the

permeability of carbon dioxide and oxygen (Elsabee and Abdou, 2013). Tamer and Copur (2010) reported Chitosan and methyl cellulose films provided inhibitory effect against E.coli and S. cerevisiae in storage of fresh cut cantaloupe and pineapple and increased their storability. Charles et al (2013) reported that cucumber, when coated with CMC and corn starch showed extension in shelf life. Therefore, the present study has been taken by to evaluate the influence of 6-BAP, Chitosan and CMC on quality and shelf life of fresh cut carrot shreds under refrigerated storage.

2. Materials and Methods

2.1. Location of experiment

The experiment was carried out during March−April, 2016, at Research Laboratory, Department of Horticulture, Aromatic & Medicinal Plants, Mizoram University; with freshly harvested carrot roots obtained from a local carrot grower of Tanhril village, Aizawl district of Mizoram. Roots cultivated under open field condition were selected as samples with specific maturity indices i.e. fully mature but tender.

2.2. Treatments

Eight post-harvest treatments viz. fruit dipping in 6-Benzylaminopurine (6-BAP) at 100 ppm, 200 ppm, 300 ppm; fruit dipping in Chitosan at 1%, 2% and in Chitosan 1% along with CMC 2%, Chitosan 2% along with CMC 2% and control (treated with water) with six replications were used and statistical analysis was done by following complete randomized design (Gomez and Gomez, 1984). Comparison of treatment means were made with the help of Critical Differences. Duncan Multiple Range Test (DMRT) was used to group the treatment means on the basis of C.D. (Duncan, 1955). The values were marked with English alphabets. The alphabet 'a' denoted the minimum value and subsequent higher values in increasing order were marked alphabetically. The values marked with same alphabet (s) indicated that they were statistically at par. Fresh cut carrot shreds of 200 g stored in poly ethylene trays under each replication. The entire experiment was conducted at refrigerated condition (4–5 °C with 65−80% relative humidity).

2.3. Determination of weight loss

Carrot shreds for each treatment kept in poly ethylene trays were tagged and weighed at 5 days interval using a digital electronic balance. The percentage weight loss was calculated by the following equation:-

$$\text{Wt. loss at } n^{th} \text{ day (\%)} = \frac{\text{Weight lose (0 day-}n^{th}\text{ day)}}{\text{Weight at 0 day}} \times 100$$

2.4. Biochemical parameters

Carrot shreds were prepared for analysis by macerating with mortar and pestle and strained with clean muslin cloth. Analyses were carried out immediately for total soluble solids (TSS), total sugar, reducing sugar, titratable acidity, TSS: acid ratio and ascorbic acid content. The total soluble solids of the shredded carrots were determined with the help of hand refractometer calibrated in °Brix at 20 °C with necessary correction factor. Determination of total sugar and reducing sugar content of samples was performed by standard procedure of A.O.A.C. (1990) using Fehling's A and Fehling's B reagents with methylene blue as an indicator through copper reduction method. Total titrable acidity was determined by titrating the shredded carrot extracted against N/10 NaOH (sodium hydroxide) using phenolphthalein as indicator and expressed in percentage (A.O.A.C., 1990). TSS: acid ratio under each treatment was calculated by dividing TSS value by titratable acidity content of the sample. 2, 6 dichlorophenol indophenols dye titration method was used to estimate the ascorbic acid content (A.O.A.C., 1990; Ranganna, 1977) and expressed as mg 100 g^{-1} of carrot. Carotene content of the sample was determined by using acetone, hexane and magnesium carbonate following the standard procedure given by Sadasivam and Manickam (1997). Determination was done by calculating carotene (mg 100 g^{-1}) in the sample using standard curve prepared with different concentration of β-carotene standard and measuring absorbance at 436 nm wave length using a digital spectrophotometer. Final value of carotene content was converted into mg g^{-1} unit.

2.5. Percentage of decay

The decay or rotting of the stored carrot shreds were determined by their visual observations. Decay percentage of shredded carrot was calculated as the number of poly trays of decayed root shreds divided by initial number of all poly trays.

2.6. Shelf life of shredded carrot

Optimum shelf life (days) of shredded carrot roots under different treatment in refrigerated condition were evaluated depending on the visual observation of root decay, physico – chemical parameters and counting the days from harvest to the day with maximum edible and marketable quality (Pila et al., 2010; Moneruzzaman et al., 2009; Mandal et al., 2015) .

3. Results and Discussion

3.1. Physiological weight loss

Percentage weight loss increased with duration of storage because of enhanced respiration and loss of water due to transpiration and dehydration. Generally weight loss of tomato fruits increased progressively during their storage and this kind of weight loss continued till the fruit obtained fully ripened stage (Pila et al., 2010). At 15 DAS, except the shredded carrot double coated with Chitosan 1%+CMC 2% (9.63%), Chitosan 2%+CMC 2% (8.56%) and coated with Chitosan at 2% (9.82%), rest of the treatments resulted >11% of weight loss (Table 1). Carrots shreds at control stored the maximum weight loss (20.16%). Arnon et al. (2014) reported low physiological weight loss when bilayer edible coated with

Table 1: Effect of selected post-harvest treatments on percentage weight loss, decay and shelf life of shredded carrot under refrigerated storage

Treatments	Percentage of wt. Loss (%)			Decay (%)	Shelf life (Days)
	5 DAS	10 DAS	15 DAS	15 DAS	
BAP 100 ppm	6.75^{d}	14.56^{e}	18.56^{de}	50	16.50
BAP 200 ppm	5.29^{c}	12.75^{d}	16.78^{cd}	50	17.00
BAP 300 ppm	5.04^{c}	11.28^{c}	14.93^{c}	25	17.50
Chitosan 1%	2.16^{b}	3.46^{b}	11.57^{b}	25	18.75
Chitosan 2%	0.52^{a}	2.54^{ab}	9.82^{ab}	0	20.25
Chitosan 1%+CMC 2%	0.00^{a}	1.85a	9.63^{ab}	0	21.25
Chitosan 2%+CMC 2%	0.00^{a}	1.67a	8.56^{a}	0	25.25
Control	8.75^{e}	16.67^{f}	20.16^{e}	50	16.25
SEm±	0.2885	0.3851	0.8566	-	-
CD (*p*=0.5)	0.8406	1.1219	2.4955	-	-

Chitosan and CMC in case of mandarin fruits.

3.2. Total soluble solids (TSS)

Carrot shreds treated with Chitosan (1.2%) and double coated with Chitosan 1%+CMC 2% and Chitosan 2%+CMC 2% showed steady increase in TSS content, whereas, carrot shreds treated with BAP (100–300 ppm) and control had accumulation of TSS up to Chitosan 1%+CMC 2% o 10 DAS, afterward declined. TSS content was found maximum in shredded carrots at control at 5 DAS (8.38 °Brix) and 10 DAS (9.19 °Brix), which however sharply reduced (6.75 °Brix) at 15 DAS (Table 2). On the contrary, fresh cut carrot shreds treated with Chitosan 2%+CMC 2% showed low TSS (7.44 and 8.31 °Brix) at 5 and 10 DAS, respectively, but at 15 DAS it was found maximum (9.44 °Brix) under this treatment. Niari et al. (2013) reported that Nantes carrot gained TSS while stored with edible coating. Smith and Stow (1984) reported that coating and exogenous protective film as marked influence on TSS content.

3.3. *Titrable acidity*

Titrable acidity of fresh cut carrot shreds increased during refrigerated storage. It was observed that different coatings treatments either with only Chitosan (1–2%) or in combination with CMC (2%) had higher accumulation of acidity (ranged between 0.35%–0.45%) at 15 DAS compared with water based treatments; BAP (100–300 ppm) or at Control (0.32%). It was found that carrot shreds coated with Chitosan (1–2%) or double coated with Chitosan (1–2%)+CMC (2%) had constant high acidity (0.19–0.22% at 5 DAS; 0.32–0.36% at 10 DAS and 0.35–0.45% at 15 DAS) during the storage period (Table 2). Ghaouth et al. (1991) reported that chitosan coated strawberry fruits remained with higher titrable acity of the fruit during storage.

Table 2: Effect of selected post-harvest treatments on Total Soluble Solids (TSS), titrable acidity and TSS:acid ratio of shredded carrot under refrigerated storage

Treatments	TSS (°Brix)			Titrable acidity (%)			TSS: Acid ratio		
	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS
BAP 100 ppm	8.31^{d}	9.06^{c}	6.88^{ab}	0.15^{ab}	0.34^{ab}	0.28^{a}	55.40^{d}	26.65^{b}	24.57^{bc}
BAP 200 ppm	8.13^{cd}	8.88^{bc}	7.25^{ab}	0.15^{ab}	0.27^{a}	0.32^{ab}	54.20^{cd}	32.89^{c}	22.66^{ab}
BAP 300 ppm	8.06^{bcd}	8.94^{bc}	7.44^{b}	0.16^{b}	0.35^{b}	0.35^{bc}	50.38^{c}	25.54^{b}	21.26^{a}
Chitosan 1%	7.50^{abc}	8.06^{a}	8.24^{c}	0.19^{c}	0.36^{b}	0.38^{c}	39.47^{b}	22.39^{a}	21.68^{a}
Chitosan 2%	7.44^{ab}	7.94^{a}	9.13^{d}	0.22^{d}	0.32^{ab}	0.45^{d}	33.82^{a}	24.81^{ab}	20.29^{a}
Chitosan 1%+CMC 2%	7.31^{a}	8.63^{abc}	9.31^{d}	0.18^{c}	0.34^{ab}	0.38^{c}	40.61^{b}	25.38^{b}	24.50^{bc}
Chitosan 2%+CMC 2%	7.44^{ab}	8.31^{ab}	9.44^{d}	0.19^{c}	0.32^{ab}	0.35^{bc}	39.16^{b}	25.97^{b}	26.97^{c}
Control	8.38d	9.19^{c}	6.75^{a}	0.13^{a}	0.29^{ab}	0.32^{ab}	64.46^{e}	31.69^{c}	21.09^{a}
SEm±	0.2123	0.2201	0.2161	0.0066	0.0233	0.0171	1.6277	0.8303	0.8841
CD (*p*=0.5)	0.6184	0.6412	0.6297	0.0193	0.0678*	0.0498	4.7418	2.4188	2.5755

3.4. TSS: acid ratio, total sugar and reducing sugar

Refrigerated storage of the fresh cut carrot had marked reduction in TSS:acid ratio. It was found that TSS:acid ratio was ranged between 33.82 and 64.46 at 5 DAS; which reduced and ranged between 22.39 and 32.89 at 10 DAS; and further reduced and ranged between 20.29 and 26.97 at 15 DAS. After 15 days of refrigerated storage, carrot shreds coated with Chitosan 2%+CMC 2% had comparatively higher TSS:acid ratio (26.97) than others. Moreover, at 15 DAS, carrot treated with BAP 100 ppm showed minimum total sugar ((5.14%), whereas, treatment with Chitosan 2%+CMC 2% had maximum total sugar (8.06%) content. Pushkala et al. (2013) reported that fresh cut radish shreds got increased in soluble solids content

while stored after coating with Chitosan. Refrigerated storage of fresh cut carrot caused consistent drop in reducing sugar content and ascorbic acid content. It was recorded that at 5 DAS, reducing sugar ranged between 5.07% and 6.32%, which reduced and ranged between 4.23 and 5.26% at 10 DAS; and further reduced and finally ranged between 3.58 and 5.06% at 15 DAS. Treatment with Chitosan 1%+CMC 2% (4.86%) and Chitosan 2%+CMC 2% (5.06%) had high reducing sugar even at 15 DAS (Table 3).

3.5. Ascorbic acid content

On the other hand, ascorbic acid content of the shredded carrots ranged between 5.08-7.78 mg 100 g^{-1} at 5 DAS, 4.78-6.51 mg 100 g^{-1} at 10 DAS and 4.34-6.12 mg 100 g^{-1} at 15 DAS, across the Post-harvest treatments under study (Table 3). Though, ascorbic acid content decresed through the period of storage however, treatment with Chitosan 1%+CMC 2% (5.87 mg 100 g^{-1}) and Chitosan 2%+CMC 2% (6.12 mg 100 g^{-1}) caused

Table 3: Effect of selected post-harvest treatments on total sugar, reducing sugar and ascorbic acid content of shredded carrot under refrigerated

Treatments	Total sugar (%)			Reducing sugar (%)			Ascorbic acid (mg 100 g^{-1})		
	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS	5 DAS	10 DAS	15 DAS
BAP 100 ppm	7.31^{b}	7.35^{bc}	5.14^{a}	5.48^{c}	4.23^{a}	3.58^{a}	5.08^{a}	4.78^{a}	4.41^{a}
BAP 200 ppm	7.23^{b}	7.32^{b}	6.18^{c}	5.42^{bc}	4.37^{ab}	3.76^{ab}	5.28^{a}	4.85^{a}	4.52^{a}
BAP 300 ppm	7.12^{b}	7.34^{bc}	6.29^{c}	5.75^{d}	4.65^{cd}	3.93b^{cd}	5.62^{b}	4.92^{a}	4.64^{a}
Chitosan 1%	6.32^{a}	6.92^{a}	7.32^{d}	5.13^{a}	4.55^{bc}	3.89^{bc}	6.51^{c}	5.26^{a}	5.07^{b}
Chitosan 2%	6.18^{a}	6.85^{a}	7.58^{e}	5.07^{a}	4.78^{de}	4.08^{cd}	6.82^{d}	5.85^{b}	5.43^{c}
Chitosan 1%+CMC 2%	6.15^{a}	7.51^{c}	7.84^{f}	5.24^{ab}	4.95^{ef}	4.86^{e}	7.25^{e}	6.25^{bc}	5.87^{d}
Chitosan 2%+CMC 2%	6.23^{a}	7.45^{bc}	8.06^{g}	5.41^{bc}	5.26^{g}	5.06^{e}	7.78^{f}	6.51^{c}	6.12^{d}
Control	7.54^{b}	7.85d	5.35^{b}	6.32^{e}	5.08^{fg}	4.18^{d}	5.24^{a}	4.78^{a}	4.34^{a}
SEm±	0.2040	0.0541	0.0517	0.0741	0.0664	0.0869	0.0862	0.1580	0.1133
CD (p=0.05)	0.5942	0.1575	0.1505	0.2160	0.1935	0.2531	0.2511	0.4602	0.3300

slow reduction rate. Preservation of ascorbic acid content during storage is a difficult task since it undergoes oxidation (Cantwell et al., 2009). A decrease of ascorbic acid content of fruits indicate senescence (Sammi and Masud, 2007).

3.6. β-carotene content

β-carotene content of the carrot shreds at refrigerated storage markedly decreased. It was observed that at 5 DAS, it ranged between 5.48 and 8.62 mg g^{-1}, where as it ranged between 3.86 and 7.54 at 10 DAS and further reduced and rnaged between 1.24 and 7.25 mg g^{-1} at 15 DAS (Figure 1). Carrot shreds double coated with Chitosan 2%+CMC 2% had considerably high β-carotene content (7.25 mg g^{-1}) at 15 DAS, compared to other treatments. Karande et al. (2014) reported that minimally processed carrot got reduction in β-carotene content during modified atmosphere storage.

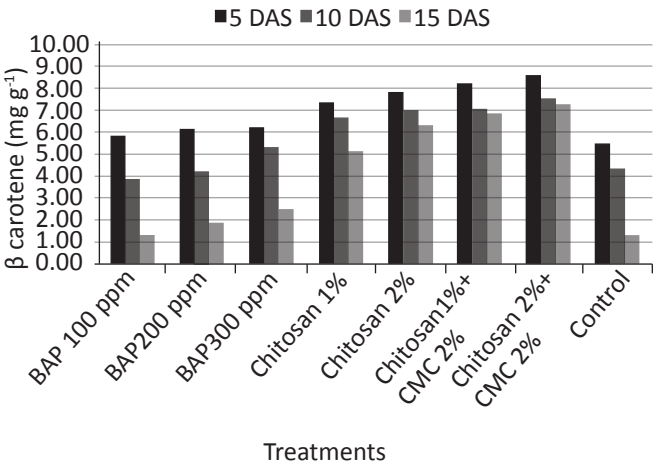

Figure 1: Effect of post-harvest treatments on β-carotene content of stored carrot shreds

3.7. Decay percentage and shelf life

After 15 days of refrigerated storage, carrot shreds treated with BAP 100-200 ppm and at control showed 50% decay, whereas, coated with either Chitosan 2% or double coated with Chitosan (1–2%)+CMC (2%) showed no decay. Shelf life study revealed that carrot shreds treated with Chitosan 2%+CMC 2% had maximum shelf life (25.25 days) followed by treatment with Chitosan 1%+CMC 2% (21.25 days) compared with control (16.25 days). Maftoonazad et al. (2008) reported that sodium alginate and CMC coating increased shelf life in peaches. Arnon et al. (2014) reported that bilayer edible coating has marked influence on storability of citrus fruits. Rabea et al. (2003) opinioned that chitosan has antimicrobial effect.

4. Conclusion

Bilayer coating with Chitosan 2%+CMC 2% may be the effective post-harvest treatment to extend shelf life while maintaining

the physico-chemical attributes of fresh cut carrot shred under refrigerated storage.

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