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Shelf Life Extension of Fresh Cut Carrot by the Application of Cinnamon Extract Infused Edible Coating

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ABSTRACT

The consumer demand for fresh cut fruits and vegetables is increasing rapidly owing to fast paced life style changes. The main problem with fresh cut fruits and vegetables is deterioration in term of color, taste, firmness etc. To solve these issues, researcher and processors have been using edible coatings to maintain quality of fresh cut commodities. **Objective:** To assess the potential effects of cinnamon extract infused edible coating formulated for shelf life extension of fresh cut carrots. **Methods:** Cinnamon extract was added as an antioxidant, aimed to aid in shelf life extension of fresh cut carrots. Cinnamon extract was obtained in an aqueous medium. The treatments were stored at 5oC for 21 days for shelf life study. The treatments were assessed for weight loss%, %acidity, TSS, firmness, color and ascorbic acid content at 7 days. **Results:** Coated treatments had better quality after storage period in term of wt. loss %, firmness and color, as compared to non-coated control treatments. **Conclusions:** Result suggests that edible coating enhanced with antioxidants have the potential to extend shelf life of fresh cut fruits and vegetables.

INTRODUCTION

Elevated household income, bustling urban lifestyle, and the expansion of cold chain facilities have collectively contributed to a surge in the demand for convenience foods, such as minimally processed or fresh-cut fruits and vegetables. Fresh-cut products are defined as items that have been prepared and are ready for cooking or consumption while still retaining the fresh attributes of raw produce. The vulnerability of fresh-cut vegetables to deterioration arises from factors such as browning, dehydration, microbial invasion, and the decline in nutritional value, primarily stemming from tissue damage during preparation. Furthermore, rapid respiration, increased enzyme activities, and the consequent microbial growth worsen the deterioration of fresh-cut vegetables [1]. Carrot, scientifically known as *Daucas carota L.*, is a widely consumed taproot vegetable either in its raw state or when cooked. The vegetable is notably abundant in β-carotene, a precursor of vitamin A, as well as various minerals and phenolic antioxidants [2]. The quality of fresh-cut carrots deteriorates primarily due to alterations in color, texture, smell, and biochemical attributes [3]. Research conducted by highlighted the utilization of hygroscopic salts like calcium lactate or calcium chloride to maintain the freshness of fresh-cut carrots [4].

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Additionally, some studies, such as those by have proposed the use of edible coatings. However, concerns have been raised regarding the safety of chemical additives, prompting consumers and researchers to seek natural alternatives for the preservation and enhancement of food quality [5-7]. The utilization of edible coatings has been documented as a means to mitigate the adverse impacts of minimal processing. Edible coating has emerged as a promising technique for the preservation of food and is characterized as "thin layers of materials that envelop food surfaces, can be consumed, and are regarded as integral components of the overall food item" [8]. The fundamental purpose of these coatings is to establish a partially permeable shield against oxygen, carbon dioxide, and moisture losses, thereby eliciting a comparable effect to storage in a modified atmosphere. Additionally, these edible coatings furnish supplementary nutrients, enhance quality, and are acknowledged as sensory enhancers. Food-grade solvents, fillers, and binding agents are the main ingredients of edible coatings. The incorporation of polysaccharide, protein, lipids, bioactive, and composite-based elements into an edible coating matrix helps to improve the minimally processed food's quality and mitigate significant post-harvest losses of highly perishable commodities[9].

Consequently, this study was conducted to establish a cost-effective and straightforward pretreatment method to enhance the shelf life of fresh-cut carrots, as well as to assess the variations in physical, biochemical, and sensory characteristics throughout the storage period of the coated fresh cut carrots.

METHODS

In this research experiment, carrot samples were evaluated to study the effect of designed treatments throughout the storage period. The tests were carried out in laboratories of Post-Harvest Research Centre, Ayub Agricultural Research Institute, Faisalabad. For this purpose, carrots were collected from field at the time of maturity and immediately transported to the laboratory. The carrots were washed and cut into uniform pieces having approximately 8 ± 2 mm thickness and 40 ± 10 mm length. Cinnamon aqueous extract was prepared using method described by with some modifications [10]. 250-gram cinnamon was added in 1 litre distilled water and heated at 70oC for 40 minutes. Afterwards it was filtered and stored in glass bottle for further use. Then the samples were dipped in coating solutions for 5 minutes prepared according to the treatment plan. Coating solutions were prepared with varying concentrations of cinnamon extract i.e. 0.5%, 1.0%, 1.5%, 2.0% while concentrations of pectin (2%) and glycerol (1%) remained unchanged in all treatments. After dipping, carrots were air dried at room temperature for 10 hours and then sealed in air tight zipper bags and stored at 5° C for 21 days. The tests for firmness, acidity, Total Soluble Solids (TSS), colour and ascorbic acid (mg/100ml) were done after 7 days' interval. All the tests were performed in triplicates. The firmness of carrot pieces was measured using a penetrometer with plunger size of 3mm. After placing the carrot piece on a hard surface, force was applied which caused the plunger to penetrate through the carrot's surface. This force was measured as carrot firmness in kg/cm2 [10]. The acidity was determined by following titration method of [11]. Carrot juice was prepared and 10ml of the sample juice was mixed with 100ml distilled water. This solution was titrated against 0.1M NaOH with 1% phenolphthalein as an indicator. Light pink colour appeared indicating the end point which lasted for almost 10 seconds. Carrot juice was prepared and total soluble solids in the juice were determined through digital refractometer (HI 96801). TSS values were measured in Brixo [12]. The ascorbic acid content in fresh-cut carrot slices was determined by using 2,6-dichlorophenol indophenol dye following the method used in the study [13, 14]. In short, a 4% oxalic acid solution was used to extract ascorbic acid from carrot juice which was then titrated against the dye until a light pink colour was achieved. The volume of dye used was noted down. The ascorbic acid content was calculated in mg per 100g of the sample by using the following formula:

$$\text{Dye Factor} = \frac{0.05}{\text{Titre}}$$

$$\text{Vitamin C (mg/100g)} = \frac{\text{dye factor} \times \text{titre} \times \text{volume of sample made}}{\text{Weight of sample} \times \text{volume of extract taken}} \times 100$$

RESULTS

Mean acidity values of fresh-cut carrot were statistically significant ($p < 0.05$) as indicated in table 1. An increase in acidity was observed in all treatments throughout the storage. The lowest acidity was reported at 0 day (0.71%) whereas the highest acidity was observed at 21 days of storage (1.76%) in T1 (Table 1).

Table 1: Acidity of Fresh Cut Carrot

Treatments	Days of Storage (Mean ± SD)			
	0	7	14	21
T_o	0.71 ± 0.01^l	0.98 ± 0.01^j	1.43 ± 0.01^d	1.70 ± 0.02^b
T_1	0.71 ± 0.01^l	0.88 ± 0.01^k	1.09 ± 0.01^i	1.76 ± 0.01^a
T_2	0.71 ± 0.02^l	1.12 ± 0.02^h	1.15 ± 0.01^g	1.36 ± 0.02^e
T_3	0.71 ± 0.02^l	1.35 ± 0.01^e	1.41 ± 0.01^d	1.54 ± 0.01^c
T_4	0.71 ± 0.01^l	1.14 ± 0.01^{gh}	1.24 ± 0.01^f	1.52 ± 0.02^c

T_o=0.5% Cinnamon extract, T_1= 1% Cinnamon extract, T_2= 1.5% Cinnamon Extract, T_3= 2% Cinnamon Extract, T_4= 2.5% Cinnamon Extract

Table 2 showed the changes in TSS of fresh cut carrot during storage. TSS increased in all treatments with minimum value of 7.33 at 0 day and maximum value of 11.03 at 21 days in To (Control) (Table 2).

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Table 2: TSS of Fresh Cut Carrot

Treatments	Days of Storage (Mean ± SD)			
	0	7	14	21
T_0	7.33 ± 0.32^{h}	9.9 ± 0.06^{b}	10.8 ± 0.06^{a}	11.03 ± 0.15^{a}
T_1	7.33 ± 0.20^{h}	9.77 ± 0.10^{bc}	9.93 ± 0.10^{b}	10.73 ± 0.32^{a}
T_2	7.33 ± 0.17^{h}	9.13 ± 0.06^{e}	9.43 ± 0.32^{cde}	9.8 ± 0.10^{b}
T_3	7.33 ± 0.21^{h}	8.77 ± 0.32^{f}	9.33 ± 0.12^{de}	9.67 ± 0.23^{bcd}
T_4	7.33 ± 0.32^{h}	8.1 ± 0.06^{g}	9.23 ± 0.12^{e}	9.4 ± 0.35^{de}

T_0=0.5% Cinnamon extract, T_1= 1% Cinnamon extract, T_2= 1.5% Cinnamon Extract, T_3= 2% Cinnamon Extract, T_4= 2.5% Cinnamon Extract

Color values in terms of L*, a* and b* of fresh cut carrots are given in table 3, 4 and 5. As evident from the table, L* values increased in all treatments for up to 14 days followed by a decrease towards the end of storage. a* and b* values were non-significant for all treatments during storage. Minimum L* value was 34.27 observed at 0 day whereas the maximum L* value was observed in T3 (44.69) at 14 days of storage. In case of a* values, the maximum value was observed at 0 day (32.59) while the minimum value of 19.28 was observed at 7 days in To (Table 3).

Table 3: Color (L*) of Fresh Cut Carrot

Treatments	Days of Storage (Mean ± SD)			
	0	7	14	21
T_0	34.27 ± 1.91^{f}	43.02 ± 1.91^{cde}	50.46 ± 0.95^{a}	48.81 ± 2.95^{ab}
T_1	34.27 ± 1.87^{f}	42.02 ± 1.42^{cde}	44.06 ± 3.12^{bcd}	42.02 ± 6.74^{cde}
T_2	34.27 ± 2.06^{f}	38.47 ± 2.91^{def}	39.90 ± 3.08^{cde}	41.63 ± 4.87^{cde}
T_3	34.27 ± 1.12^{f}	37.29 ± 1.91^{ef}	44.69 ± 6.1^{bc}	39.76 ± 5.06^{cdef}
T_4	34.27 ± 1.91^{f}	38.85 ± 1.12^{def}	40.47 ± 1.91^{cde}	38.59 ± 2.84^{def}

T_0=0.5% Cinnamon extract, T_1= 1% Cinnamon extract, T_2= 1.5% Cinnamon Extract, T_3= 2% Cinnamon Extract, T_4= 2.5% Cinnamon Extract

Table 4 showed the color (a*) of fresh cut carrots treated with various cinnamon extract concentrations over different storage times. Initially, all treatments had the same a* value of 32.59. Over 21 days, T0 (0.5% extract) showed a notable decline in color, dropping to 27.38. T1 (1% extract) maintained relatively stable color with a slight decrease to 26.21. T2 (1.5% extract) and T3 (2% extract) had moderate reductions, ending at 28.56 and 29.51, respectively. T4 (2.5% extract) experienced the most significant color loss, falling to 24.41. This indicates that higher cinnamon extract concentrations may not be as effective in preserving color stability over time (Table 4).

Table 4: Color (a*) of Fresh Cut Carrot

Treatments	Days of Storage (Mean ± SD)			
	0	7	14	21
T_0	32.59 ± 1.75^{a}	19.28 ± 4.62^{f}	21.7 ± 4.29^{ef}	27.38 ± 1.75^{abcd}
T_1	32.59 ± 3.26^{a}	32.15 ± 5.42^{ab}	30.8 ± 1.64^{abc}	26.21 ± 0.5^{cde}
T_2	32.59 ± 3.77^{a}	24.79 ± 1.75^{def}	29.68 ± 1.75^{abcd}	28.56 ± 2.55^{abcd}
T_3	32.59 ± 2.85^{a}	27.22 ± 3.02^{abcde}	31.36 ± 7.04^{abc}	29.51 ± 2.12^{abcd}
T_4	32.59 ± 1.75^{a}	26.88 ± 0.73^{bcde}	28.13 ± 5.47^{abcd}	24.41 ± 2.89^{def}

T_0=0.5% Cinnamon extract, T_1= 1% Cinnamon extract, T_2= 1.5% Cinnamon Extract, T_3= 2% Cinnamon Extract, T_4= 2.5% Cinnamon Extract

Table 5 presented the color (b*) values of fresh cut carrots treated with different concentrations of cinnamon extract over a 21-day storage period. At day 0, all treatments had the same b* value of 20.89. Over time, T1 (1% extract) initially showed an increase in b* value to 24.27, but decreased to 21.10 by day 21. T2 (1.5% extract) decreased to 18.58 on day 7 but recovered slightly to 22.60 by day 21. T3 (2% extract) increased to 24.01 by day 14 and remained relatively high at 23.60 on day 21. T4 (2.5% extract) initially rose to 23.14 but dropped to 19.32 by day 21. This suggests that cinnamon extract concentration affects the b* value, with higher concentrations initially showing better color retention but eventually declining (Table 5).

Table 5: Color (b*) of Fresh Cut Carrot

Treatments	Days of Storage (Mean ± SD)			
	0	7	14	21
T_0	20.89 ± 0.93^{bcde}	20.61 ± 3.72^{cde}	21.39 ± 2.00^{abcde}	22.66 ± 3.13^{abc}
T_1	20.89 ± 2.24^{bcde}	24.27 ± 1.85^{a}	23.72 ± 1.90^{abc}	21.10 ± 0.93^{abcde}
T_2	20.89 ± 2.60^{bcde}	18.58 ± 0.87^{e}	22.28 ± 0.93^{abcd}	22.60 ± 0.71^{abc}
T_3	20.89 ± 2.39^{bcde}	21.36 ± 0.93^{abcde}	24.01 ± 0.47^{ab}	23.60 ± 3.49^{abc}
T_4	20.89 ± 0.93^{bcde}	23.14 ± 1.62^{abc}	20.83 ± 1.75^{bcde}	19.32 ± 1.66^{de}

T_0=0.5% Cinnamon extract, T_1= 1% Cinnamon extract, T_2= 1.5% Cinnamon Extract, T_3= 2% Cinnamon Extract, T_4= 2.5% Cinnamon Extract

Table 6 showed the changes in firmness of fresh cut carrot during storage. A decrease in firmness was observed in all treatments with maximum value at 0 day (1.77) in T4 (2.5% Cinnamon extract) whereas minimum value (1.19) was observed at 21 days of storage in To (control) (Table 6).

Table 6: Firmness of Fresh Cut Carrot

Treatments	Days of Storage (Mean ± SD)			
	0	7	14	21
T_0	1.74 ± 0.03^{ab}	1.61 ± 0.02^{d}	1.33 ± 0.04^{f}	1.19 ± 0.08^{g}
T_1	1.76 ± 0.02^{a}	1.68 ± 0.02^{c}	1.49 ± 0.03^{e}	1.30 ± 0.03^{f}
T_2	1.76 ± 0.03^{a}	1.68 ± 0.03^{bc}	1.48 ± 0.04^{e}	1.27 ± 0.03^{f}
T_3	1.75 ± 0.02^{a}	1.67 ± 0.06^{cd}	1.45 ± 0.01^{e}	1.28 ± 0.05^{f}
T_4	1.77 ± 0.02^{a}	1.68 ± 0.02^{c}	1.45 ± 0.06^{e}	1.29 ± 0.08^{f}

T_0=0.5% Cinnamon extract, T_1= 1% Cinnamon extract, T_2= 1.5% Cinnamon Extract, T_3= 2% Cinnamon Extract, T_4= 2.5% Cinnamon Extract

The vitamin C content of fresh cut carrot during storage is given in table 7. As the table indicates, a decrease in vitamin C content was observed in all treatments of fresh cut carrot. The highest (14.40%) and the lowest (7.84%) vitamin C content was observed in To (Control) at 0 and 21 days of storage respectively (Table 7).

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Table 7: Vitamin C Content of Fresh Cut Carrot

Treatments	Days of Storage (Mean ± SD)			
	0	7	14	21
T_o	14.40 ± 0.04^{a}	12.69 ± 0.12^{e}	11.99 ± 0.05^{f}	7.84 ± 0.22^{i}
T_1	14.23 ± 0.35^{ab}	13.87 ± 0.09^{bcd}	11.1 ± 0.6^{g}	9.71 ± 0.1^{h}
T_2	14.14 ± 0.11^{abc}	13.75 ± 0.35^{cd}	11.04 ± 0.14^{g}	10.04 ± 0.44^{h}
T_3	14.14 ± 0.45^{abc}	13.58 ± 0.12^{d}	11.02 ± 0.46^{g}	9.99 ± 0.04^{h}
T_4	14.13 ± 0.18^{abc}	13.58 ± 0.12^{d}	11.03 ± 0.02^{g}	10.85 ± 0.08^{g}

T_o=0.5% Cinnamon extract, T_1= 1% Cinnamon extract, T_2= 1.5% Cinnamon Extract, T_3= 2% Cinnamon Extract, T_4= 2.5% Cinnamon Extract

Table 8 indicated the weight loss % of fresh cut storage during storage for 21 days. An Increase in weight loss % of all samples was observed as indicated in the table 8.

Table 8: Weight Loss % of Fresh Cut Carrot

Treatments	Days of Storage (Mean ± SD)			
	0	7	14	21
T_o	0.00 ± 0.00^{j}	19.77 ± 0.21^{d}	28.36 ± 0.04^{b}	32.00 ± 0.02^{a}
T_1	0.00 ± 0.00^{j}	15.31 ± 0.72^{ef}	24.08 ± 0.02^{c}	27.39 ± 0.00^{b}
T_2	0.00 ± 0.00^{j}	13.88 ± 0.32^{f}	16.27 ± 0.00^{e}	18.40 ± 0.07^{d}
T_3	0.00 ± 0.00^{j}	4.76 ± 0.00^{i}	6.56 ± 0.02^{h}	8.93 ± 0.22^{g}
T_4	0.00 ± 0.00^{j}	0.80 ± 0.03^{j}	3.39 ± 0.02^{i}	4.43 ± 0.03^{i}

T_o=0.5% Cinnamon extract, T_1= 1% Cinnamon extract, T_2= 1.5% Cinnamon Extract, T_3= 2% Cinnamon Extract, T_4= 2.5% Cinnamon Extract

DISCUSSION

TSS increased in all treatments with minimum value of 7.33 at 0 day and maximum value of 11.03 at 21 days in To (Control). In case of b* values, the maximum value (24.27) was observed at 7 days in T_1 whereas the minimum value (18.58) was observed at 7 days in T_2. Carrot color pigment variations are caused by minimal processing methods and storage duration, which affect carotenoid pigment [15, 16]. Decrease in firmness maybe attributed to degradation of insoluble protopectin to more soluble pectin and pectic acids in fruits and vegetables [17]. A decrease in vitamin C content was observed in all treatments of fresh cut carrot. The highest (14.40%) and the lowest (7.84%) vitamin C content was observed in T_o (Control) at 0 and 21 days of storage respectively. Similar decrease in vitamin C content was also reported by in fresh-cut carrot disks during 8 days of storage at 4°C [18]. Maximum weight loss was observed in T_o at 21 days (32.00%) whereas minimum weight loss was observed in T_4 (0.80%) at 7 days of storage. Similarly, an increase in weight loss % of fresh-cut carrots was also reported by Wang after treatment with carrot puree edible films followed by storage at 5°C for 12 days. The weight loss serves as an indicator for the transpiration-induced dehydration of vegetables and involves the transfer of water from the cell to the surrounding atmosphere. As such, it may be used to assess the effectiveness of coating treatments for the preservation of fresh-cut carrots [19]. In this research study, fresh-cut carrots coated with varying percentages of cinnamon extract were analyzed for several quality parameters over 0, 7, 14, and 21 days of storage. Acidity levels showed a gradual increase over time in all samples, with higher cinnamon extract concentrations resulting in a slower rate of increase indicating better preservation [14]. The oxidation of reducing sugars may cause an increase in acidity during storage, and the breakdown of polysaccharides and pectic substances [16]. Total Soluble Solids (TSS) remained relatively stable in carrots coated with higher percentages of cinnamon extract, suggesting that the extract helps maintain the carrots' natural sugars. Moisture loss and rising soluble solid concentrations are the primary causes of the rise in TSS. Furthermore, it is linked to the respiration and fruit-ripening processes that break down complex carbohydrates into soluble solids. The enzymes amylases, starch phosphorylase, and 1, 6-glucosidase catalyze the fast breakdown of starch into sugars including sucrose, glucose, and fructose [15]. Weight loss was significantly lower in samples with higher cinnamon extract percentages, likely due to the antimicrobial and moisture-retentive properties of cinnamon. These results are in agreement with the findings of Kowalczyk and colleagues who also reported an increase in weight loss % of different carrot cultivars treated with different chemicals during 12 days of storage at room temperature. Firmness was better retained in coated samples, especially those with higher cinnamon concentrations, suggesting the structural advantages offered by the extract [20]. The decrease in firmness of fresh-cut carrots was also reported by [17] during storage at 5°C in perforated polyethylene packaging [17]. Non-significant differences were observed in a* and b* values and an increase in L* values of fresh-cut carrots was seen when treated with edible coatings and stored for 21 days at 5°C. In a separate study, reported an increase in the whiteness index of fresh-cut carrots stored for 10 days at 5°C after exposure to abiotic stresses such as heat shock and UV-C irradiation [21]. An efficient preservative method for extending the shelf life of thinly sliced carrots is alginate-based coating enhanced with α-tocopherol acetate, an antioxidant [22].

CONCLUSIONS

This research experiment investigated the potential of edible coating enriched with cinnamon extract to enhance the shelf life of fresh-cut carrots. The results showed the effectiveness of the coating in alleviating quality deterioration during storage period of 21 days at. Fresh-cut carrots coated with pectin and cinnamon extract exhibited significantly lower weight loss, better retention of firmness and better color retention compared to non-coated treatment group. The results indicate that the edible coating acted as a physical barrier, reducing moisture loss and maintaining firmness and other quality parameters. The presence of cinnamon extract, a natural antioxidant, may have contributed to these positive effects by delaying oxidative degradation processes. The findings of this study

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align with previous studies, highlighting the potential of edible coatings enhanced with antioxidants in extending the shelf life of fresh-cut commodities.

Authors Contribution

Conceptualization: HN, MHR, ZY
Methodology: HN, MHR, SM
Formal analysis: HN, HUN, MHR, SM, ZI
Writing, review and editing: HN, RZ, SR, AM, BS

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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REFERENCES

[1] Jain S, Nidhi N, Ausari PK, Das P, Singh A, Kumar L *et al.* A Comprehensive Review on Nature and Causes of Deterioration in Fruits and Vegetables. International Journal of Environment and Climate Change. 2023 Sep; 13(10): 3548-58. doi: 10.9734/ijecc/2023/v13i103025.

[2] Boadi NO, Badu M, Kortei NK, Saah SA, Annor B, Mensah MB *et al.* Nutritional composition and antioxidant properties of three varieties of carrot (*Daucus carota*). Scientific African. 2021 Jul; 12: e00801. doi: 10.1016/j.sciaf.2021.e00801.

[3] Condurso C, Cincotta F, Tripodi G, Merlino M, Giarratana F, Verzera A. A new approach for the shelf-life definition of minimally processed carrots. Postharvest Biology and Technology. 2020 May; 163: 111138. doi: 10.1016/j.postharvbio.2020.111138.

[4] Zhang J, Zuo X, Li Y, Ru X, You W, Xu F *et al.* Calcium chloride treatment maintains quality and enhances antioxidant capacity of fresh-cut carrots through modulating DcCMLs-DcCAMTA3-mediated phenylpropanoid pathway. Postharvest Biology and Technology. 2024 Mar; 209: 112714. doi: 10.1016/j.postharvbio.2023.112714.

[5] Leon A, Logegaray V, Casajús V, Perini M, Lourenco AB, Salinas C *et al.* Effect of Aloe vera gel coating on organoleptic and nutritional quality of minimally processed carrot. Food Science and Technology International. 2023 Sep: 10820132231199509. doi: 10.1177/10820132231199509.

[6] Salehi F. Edible coating of fruits and vegetables using natural gums: A review. International Journal of Fruit Science. 2020 Sep; 20(2): S570-89. doi: 10.1080/15538362.2020.1746730.

[7] Valliath AS, Johar V, Mondal R, Tejaswi S, Das P, Saha I. Application of natural preservatives and sweeteners in fruit products to reduce health risks-a review. Environment Conservation Journal. 2023 Nov; 24(4): 344-54. doi: 10.36953/ECJ.22892594.

[8] Rajial H and Varma S. Edible Coatings: A Novel Approach to Extending the Shelf Life of Fruits and Vegetables. Journal of Advances in Biology & Biotechnology. 2024 Jun; 27(7): 25-37. doi: 10.9734/jabb/2024/v27i7963.

[9] Yaashikaa PR, Kamalesh R, Kumar PS, Saravanan A, Vijayasri K, Rangasamy G. Recent Advances in Edible Coatings and Their Application in Food Packaging. Food Research International. 2023 Nov; 173: 113366. doi: 10.1016/j.foodres.2023.113366.

[10] Ergönül B. Determination of the effects of refrigerated storage and packaging method on the instrumental textural attributes of fresh-cut carrot slices. Quality Assurance and Safety of Crops & Foods. 2013 Jun; 5(2): 141-3. doi: 10.3920/QAS2012.0112.

[11] Hwang CC, Chien HI, Lee YC, Lin CS, Hsiao YT, Kuo CH *et al.* Effect of high-pressure processing on the qualities of carrot juice during cold storage. Foods. 2023 Aug; 12(16): 3107. doi: 10.3390/foods12163107.

[12] Khalil AA, Khan AA, Khalid A, Abid Z, Proestos C, Bhat ZF *et al.* Comparing the antioxidant properties and volatile compounds of carrot-orange juice blend processed through varied chemical, pasteurization and ultrasound conditions. Ultrasonics Sonochemistry. 2023 Aug; 98: 106534. doi: 10.1016/j.ultsonch.2023.106534.

[13] Piscopo A, Zappia A, Princi MP, De Bruno A, Araniti F, Antonio L *et al.* Quality of shredded carrots minimally processed by different dipping solutions. Journal of Food Science and Technology. 2019 May; 56: 2584-93. doi: 10.1007/s13197-019-03741-6.

[14] Rashidi M and Bahri MH. Interactive effects of coating method and storage period on quality of carrot (cv. Nantes) during ambient storage. ARPN Journal of Agricultural and Biological Science. 2009 Nov; 4(3): 29-35.

[15] Gonçalves EM, Pinheiro J, Abreu M, Brandão TR, Silva CL. Carrot (Daucus carota L.) peroxidase inactivation, phenolic content and physical changes kinetics due to blanching. Journal of Food Engineering. 2010 Apr; 97(4): 574-81. doi: 10.1016/j.jfoodeng.2009.12.005.

[16] Alegria C, Pinheiro J, Duthoit M, Gonçalves EM, Moldão-Martins M, Abreu M. Fresh-cut carrot (cv. Nantes) quality as affected by abiotic stress (heat shock and UV-C irradiation) pre-treatments. LWT-Food Science and Technology. 2012 Oct; 48(2): 197-203. doi: 10.1016/j.lwt.2012.03.013.

DOI: https://doi.org/10.54393/df.v5i2.138

[17] Dam MS, Nguyen LL, Zsom T, Hitka G, Zeke IC, Friedrich L. Effect of perforation packaging on quality of fresh-cut carrot during storage. Progress in Agricultural Engineering Sciences. 2020 Nov; 16(S1): 11-8. doi: 10.1556/446.2020.10002.

[18] Kenny O and O'Beirne D. Antioxidant phytochemicals in fresh-cut carrot disks as affected by peeling method. Postharvest Biology and Technology. 2010 Dec; 58(3): 247-53. doi: 10.1016/j.postharvbio.2010.07.012.

[19] Wang X, Kong D, Ma Z, Zhao R. Effect of carrot puree edible films on quality preservation of fresh-cut carrots. Irish Journal of Agricultural and Food Research. 2015 Jan; 54(1): 64-71. doi: 10.1515/ijafr-2015-0007.

[20] Kowalczyk D, Skrzypek T, Łupina K. Effect of carboxymethyl cellulose/candelilla wax edible coating incorporated with ascorbic acid on the physicochemical and sensory qualities of prepackaged minimally processed carrots (*Daucus carota L.*) during cold storage. Journal of Food Processing and Preservation. 2020 Sep; 44(9): e14713. doi: 10.1111/jfpp.14713.

[21] Nasrin TA, Yasmin L, Arfin MS, Molla MM, Nizam-Uddin M. Effect of hot water treatment with organic additives in fresh cut carrot. Journal of Agricultural Science and Food Technology. 2021 Jan; 7(1): 1-9. doi: 10.36630/jasft_20028.

[22] Keshari D, Tripathi AD, Agarwal A, Rai S, Srivastava SK, Kumar P. Effect of α-dl tocopherol acetate (antioxidant) enriched edible coating on the physicochemical, functional properties and shelf life of minimally processed carrots (*Daucus carota subsp. sativus*). Future Foods. 2022 Jun; 5: 100116. doi: 10.1016/j.fufo.2022.100116..