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Postharvest Shelf-life Extension of Carrot (*Daucus carota* L.) cv. New Kuroda using different surface Coatings

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ABSTRACT: Vegetables aesthetic qualities are frequently enhanced by the application of different surface coatings. In this work, different edible and chemical based coatings were evaluated for postharvest shelf-life extension of Carrot (*Daucus carota* L.) cv. New Kuroda during storage at ambient temperature (26 ± 2 °C, RH 68 ± 4%) for 7 days. Untreated samples were used as the controls. Results suggested that the coating treatment T_4 (*Aloe vera* gel 40%) enhanced product quality by preventing physiological loss in weight (10.29 %), per cent of decay (29.13%), maintaining better values for firmness (7.10 kg/cm^2), beta carotene (2.93 mg/100g) and ascorbic acid (2.70 mg/100g). While, the treatment T_6(30% honey) recorded the highest values in TSS(12.58^0) and total sugars (4.83 %).From the sensory point of view, all the coated samples were appreciated for quality attributes about 6 to 7 days, whereas all the other fresh carrots were refused after only 2 days.

Keywords: Carrot, edible and chemical coatings, storage life.

INTRODUCTION

Carrot (*Daucus carota* L.) is a cool-season vegetable, which is an important root crop grown throughout the world. It belongs to the family Apiaceae previously known as Umbelliferae, with chromosome number 2n=2x=18. In India, the total growing area of carrot is 112 thousand ha with a production rate of 2042 thousand MT in 2019-2020 (NHB, 2019-2020). Haryana is the largest state with a production of 3.72 lakh tones contributing 27.8 percent of total production. Odisha ranks 22nd in production with 1.27 thousand tones and is considered a very important root crop of the state. Carrot is an annual for root production and biennial for seed production. It has quadripinnate leaves and a hollow, upright, extremely short stem. It possesses a primary tap-root that, unlike the secondary roots, grows tuberous with absorbent hairs. It consists of a central cylinder called core that is more or less fibrous and a tender outside part called cortex that is darker in colour than the inner core.

Carrots were first cultivated for medical purposes. They were used to treat stomach ulcers, abscesses, bladder, liver, and renal disorders, among other ailments. Carotenoids, vitamins, dietary fiber, minerals, and antioxidants are abundant in the carrot storage root. On average, a fresh carrot comprises 86 percent moisture, 10.6 percent carbs, 0.9 percent protein, 0.18 percent fat, 1.2 percent crude fiber, and 1.1 percent minerals. Temperate carrots have more carotene than Asiatic carrots and are high in thiamine and riboflavin and Asiatic carrots are rich in riboflavin. The presence of glutamic acid gives carrots their taste. It is consumed both raw and cooked. It is used in pickles, desserts, and curries, etc. Processing markets include baby food production, frozen and canned products. A specific form of beverage called kanji is made from black carrots and served as an appetizer.

Several chemical changes occur in carrots during storage *i.e.*, in the process of becoming simple sugars from polysaccharides and reducing sugars from sucrose, foods release off flavours and undergo sensory, structural, and colour changes. Hence, there is a need to treat the carrots with physical and chemical methods to inhibit the biochemical changes and microbial attacks without losing the quality. Edible coatings are being considered a safer alternative for extending the shelf life of fruits and vegetables and improving their appearance Blancas-Benitez *et al*. (2022). They maintain the product's firmness while also preventing respiration and weight loss. The use of *Aloe vera* gel and honey, which are safe and environmentally friendly postharvest treatments, has received a lot of attention in recent years. *Aloe vera* gel is a plant-based edible coating that is found to be appropriate in maintaining the quality of the commodity. Honey as an edible coating hinders the growth of pathogens and it also has antioxidant properties. $CaCl_2$ shows great outcomes by preserving firmness, texture, physiological loss of weight, soluble solid content and titratable acidity while also slowing ripening and color loss during storage (Farina *et al.,* 2020; Lara *et al*., 2004). Hydrogen peroxide (H_2O_2) was effective in controlling decay and kept the quality of fruits (Isaac and Maalekuu 2013). Therefore, it has been suggested that the current study examine the impact of various postharvest practises on the quality and storage of Carrot cv. New Kuroda under ambient settings.

MATERIALSANDMETHODS

The present investigation entitled "Postharvest shelf-life extension of Carrot (*Daucus carota* L.) cv. New Kuroda using different surface coatings" was carried out in the year 2021-22 at Horticulture Lab, M.S.S.S.O.A., CUTM, Paralakhemundi, Odisha. Carrot cv. New Kuroda roots harvested at mature stage were taken out. They were then trimmed and washed with clean tap water to remove any dirt and dipped in different coatings according to the treatments listed below in order to study their storage life. Ten roots, three replications, and ambient storage were used for each treatment.

Treatment combinations = T_1- H_2O_2 1% dipping for 1 minute, T_2- H_2O_2 2% dipping for 1 minute, T_3- Aloe vera 20% juice dipping for 1 minute, T_4- Aloe vera 40% juice dipping for 1 minute, T_5- Honey 10% dipping for 1 minute, T_6- Honey 30% dipping for 1 minute, T_7- $CaCl_2$ (3%) dipping for 5 minutes, T_8- $CaCl_2$ (6%) dipping for 5 minutes, T_9- Control (Distilled water).

Percent of Physiological loss in weight (PLW). Based on the discrepancy between the root's original weight and ultimate weight, physiological weight loss was estimated. The results were then expressed in percentages using the following formula.

$$\%\ \text{PLW} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

Firmness (kg/cm²). The firmness of the Carrot roots was evaluated by using penetrometer (kg/cm^2).

TSS (°Brix). The amount of total soluble solids was calculated using an ERMA Hand Refractometer, and the results were represented in degrees Brix.

Total sugars (mg/100 g). Total sugars are determined by Lane and Eynon method (Ranganna, 1986). A quantity of 50 ml lead-free filtrate was taken in a 100 ml volumetric flask and 5 ml of concentrated HCl was added to it. Total sugars were then estimated by taking this solution into a burette and titrating it against standard Fehling's solution mixture of A and B (1:1) using methylene blue as an indicator to a brick red colour as an end point (10 ml Fehling's solution = 0.052 glucose).

β-carotene (mg). β-carotenecontent of carrot was estimated by using the methodology of Srivastava and Sanjeevkumar (2002). The optical density was recorded at 452 nm using petroleum ether as blank.

$$\beta\text{ - Carotene (mg/100g)} = \frac{\text{O.D. of sample} \times 13.9 \times 10^4 \times 100}{\text{Weight of sample} \times 560 \times 1000}$$

Ascorbic Acid (mg/100 g). Using the formula provided by Ranganna (1986), the dye factor, or mg of ascorbic acid per ml of dye, was calculated.

$$\text{Ascorbic acid} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Aliquot of extraction taken for estimation} \times \text{volume of sample taken for estimation}}$$

Percentage of Decay (%). Carrot cultivars treated with various edible and chemical coatings were stored at room temperature and monitored daily for signs of decay which included fungal mycelia growth, flaccidity and necrotic spots.

Shelf life (days). Shelf life of roots was assessed in days based on visual parameters. The number of days was computed from the day of the harvest till the root remains in fresh condition and acceptable to the consumer.

Organoleptic evaluation. Sensory profile is developed for carrot including attributes of Taste, Colour, Texture, Appearance and Overall acceptability in 3 replications by the assessors with the help of 9- point Hedonic scale (Amerine *et al*., 1965). Sensory descriptive analysis was performed by a sensory panel of five aged between 25 to 45 years old.

RESULTS AND DISCUSSION

Percent of Physiological loss weight (PLW): The data pertaining to the influence of postharvest treatments on percent of physiological loss weight is presented in the Table 1. There was a gradual increase in percent of physiological loss of weight in carrots as the storage period progressed. The minimum percentage of physiological weight loss is observed in treatment T_4 (*Aloe vera* 40% juice dipping for 1 minute) which is 10.29% followed by the treatment T_8 ($CaCl_2$ (6%) dipping for 5 minutes) and T_6 (Honey 30% dipping for 1 minute) with values 10.50% and 11.06% respectively. Whereas the maximum percentage of weight loss was recorded in the treatment T_9 (13.80%) which is treated with distilled water. The reason for minimum PLW in treatment 4 might be due to 40% *Aloe vera* gel that can control water vapour and other gases such as oxygen and carbon dioxide permeability from the root to the exterior. Using *Aloe vera* 40% can deaccelerate the degradation process. It also helps in delaying the root transpiration and decreasing weight loss during storage hence this enhances shelf life. Similar findings were recorded by Ozturk *et al.,* (2019); Ali *et al*., (2019); Shah and Hashmi (2020); Farina *et al*., (2020); Pietrosanto *et al*. (2022).

Losing weight is a crucial indicator of post-harvest activities. The primary cause of it is the water loss caused by metabolic processes like respiration and transpiration. Guard cells and stomata on the epidermis often regulate moisture loss and gas exchange from the fruits. The *Aloe vera* coating aids in further lowering this by creating a film on the skin's surface that serves as an extra barrier to moisture loss. This barrier also slows down the fruit's ability to absorb oxygen, which in turn slows down respiration and the weight loss from the fruit's surface that goes along with it. The effects of these coatings as a semi-permeable barrier against oxygen, carbon dioxide, moisture, and solute movement, consequently reducing respiration, water loss, and oxidation reaction rates, were likely the cause of the coated carrots' reduced weight loss (Baldwin *et al*., 1999). Lower water loss through transpiration, weight loss from respiration, ethylene generation, and consequently reduced activation of cell wall hydrolases are the causes of the extended quality of Aloe vera-coated fruits. Since covered fruits receive less oxygen, which is needed to produce ethylene, the fruits take longer to ripen.

Firmness: The maximum firmness was observed in treatment T_4 (Aloe vera 40% juice dipping for 1 minute) with a value of 7.10 (Table 1). Because there was less breakdown of insoluble protopectins into pectin acid and pectin, the firmness of coated fruits was preserved. It was shown that during fruit ripening, pectin esterase and polygalacturonase activities increase together with the depolymerization or shortening of chain length of pectin compounds (Yaman and Bayoindirli 2002). As a result, these enzymes' activity is decreased by low oxygen and high carbon dioxide levels, allowing for the preservation of firmness during storage Salunkhe *et al*. (1991); Pietrosanto *et al*. (2022).

Percentage of decay (%): The minimum percentage of decay in carrots was observed in treatment T_4 (Aloe vera 40% juice dipping for 1 minute) (29.13%). However, treatment T_2 (H_2O_2 2% dipping for 1 minute) and treatment T_8 ($CaCl_2$ (6%) dipping for 5 minutes) with values of 35.19% and 37.24% respectively which are next to the treatment T_4. Whereas, treatment T_9 Control (Distilled water) recorded a maximum percentage of decay with a value of 51.67%. *Aloe vera* coating plays an important role in the retention of quality by lowering the gas permeability which inhibits the respiratory rate and retard overall metabolic activity. And also, some individual components found in *A. vera* gel, such as saponins, acemannan and anthraquinones derivatives, are known to have antibiotic activity and could be responsible for its antibacterial activity. Similar results are in conformity with findings of Hassanpour (2015); Shah and Hashmi (2020); Castillo *et al.,* (2010). As well as H_2O_2 plays an important role in sanitizing the pathogenic organisms from causing decay. It prevents moisture loss in wider opens and respiration activities as well as strengthens the cell of the root by preventing the invasion of the cell wall by disease-causing spores. Hence, prevents decay. These results are in conformity with the findings of Isaac and Maalekuu (2013); Forney *et al*., (1991).

Beta carotene (mg/100g): The presence of high concentration of antioxidants, carotenoids, especially β-carotene, may account for the biological and medicinal properties of carrots but the loss of β-carotene during processing and storage is well-established (Singh *et al.,* 2013). During storage, a number of degradation events have an impact on the colour, nutrient content, texture, and flavour of vegetables. The flavour and nutritional content of carrots are also impacted by -carotene degradation, in addition to the colour of the vegetable. To produce a product that consumers will be satisfied with, the stability of -carotene throughout carrot storage is a crucial goal.

Therefore, it is necessary to develop methods to preserve the quality of carrots (β-carotene) for longer storage. The most commonly used method is edible coating (a thin layer of edible material is applied to the product surface, which protects perishable food products by retarding dehydration, suppressing respiration, improving textural quality, helping to retain volatile flavour compounds and reducing microbial growth). Edible coatings create a modified atmosphere within the food product by controlling respiratory gas exchange. Such coatings may be of different compounds, *viz.* hydrocolloids (polysaccharides and proteins), hydrophobic compounds (lipids and waxes), or a combination of both (composite coatings) Olivas *et al.* (2008).

Minimal significant difference observed among the treatments except treatment T_9. However, the maximum value for beta carotene was observed in treatment T_4 (Aloe vera 40% juice dipping for 1 minute) with a value of 2.98 mg.While the minimum beta carotene was recorded in the treatment T_9 which is control (2.39 mg).Carrots are the most common and popular vegetable which are good source of natural antioxidants, especially carotenoids which are a group of fat-soluble pigments characterized by a linear, long-chain polyene structure (Zhang *et al.,* 2004). *Aloe vera* gel coated samples retained higher carotenoid content compared to uncoated carrots might be attributed to modified atmosphere produced by edible coatings, which acts as a barrier for O_2 and CO_2. Thus, autoxidation potential of carotenes decreased (Li and Barth 1998).

Ascorbic acid (mg/ 100g): There is not much significant difference between the treatments. However, the maximum ascorbic acid content was recorded in treatment T_4 (*Aloe vera* 40% juice dipping for 1 minute) with a value of 2.70 mg followed by treatment T_2 (H_2O_2 2% dipping for 1 minute) and T_3 (*Aloe vera* 20% juice dipping for 1 minute) with values 2.55 mg and 2.50 mg respectively. Whereas, minimum ascorbic acid was recorded in treatment T_9 which is control (2.20 mg).The ascorbic acid content decrease during storage due to its oxidative breakdown (Mditshwa *et al.,* 2017). *Aloe vera* coatings reduce the decline of ascorbic acid content by hindering its oxidation during post-harvest storage (Khaliq *et al.,* 2019). During oxidation, *Aloe vera* gel appears to be converted to dehydroascorbic acid and then degraded into 2,3-diketo-gluconic acid (Deutsch 2000). Similar observations are recorded by Ali *et al.,* (2019); Nasution *et al.* (2015).

TSS (Brix): The highest value for TSS was recorded in treatment T_6 (Honey 30% dipping for 1 minute) with a value of 12.58 followed by treatment T_4 (*Aloe vera* 40% juice dipping for 1 minute) and T_5 (Honey10%

juice dipping for 1 minute) with values of 12.36 and 12.27 respectively. Whereas, minimum ascorbic acid was recorded in treatment T_9 which is control (9.26). The fact that TSS gradually increased up to the trial's conclusion shows that the *Aloe vera* gel treatments reduced the rate at which carrots respired during storage. Similar findings that suggested a connection between TSS and respiration rate have already been published. TSS stands for carbohydrate content, and a rise in TSS can be a sign of deteriorating cell walls. The hydrolysis of starch into sugar may have caused the first rise in TSS, and the following drops in TSS may have been caused by the conversion of sugars into organic acids and a slower rate of respiration (Javed *et al*., 2017). Additionally, it has been suggested that the occurrence of the hydrolysis of carbs into sugar may be caused by a decreased TSS (Gohlani and Bisen 2012). When compared to uncoated samples, *Aloe vera* gel and honey acted effectively as edible coatings, slowing down the biochemical changes during storage, as noted in Kuwar *et al.* (2015); Eman *et al*. (2015); Roy *et al.* (2015); Viswanath *et al.* (2018).

Total sugars (mg/100g): The data pertaining to the total sugars revealed that the highest total sugar was observed in the treatment T_6 (Honey 30% dipping for 1 minute) (4.83) followed by T_4 (Aloe vera 40% juice dipping for 1 minute) and T_2 (H_2O_2 2% dipping for 1 minute) with values 4.78 and 4.68 respectively. Whereas the lowest value was recorded in the treatment T_8 (control) with a value 4.57.Regardless of the treatments, the total sugar level of carrots grew over the course of storage, while in carrots treated with aloe vera gel, it nearly remained constant. With fruit ripening and senescence, sugar content rises. Similar to how sugar levels may rise as a result of starch conversion. A coating prevents fruit from ripening, ageing, and turning into sugars (Ullah *et al.*, 2017). Our results are in accordance with previous findings of Roy *et al.*, (2015) in Cashew, Viswanath *et al.* (2018) in pomegranate.

Shelf life: It is apparent from the data that the shelf life was performed highest in T_4 (Aloe vera 40% juice dipping for 1 minute) with 7.87 days followed by the treatments T_2 (H_2O_2 2% dipping for 1 minute) and T_8 ($CaCl_2$ (6%) dipping for 5 minutes) with values of 7.73 and 7.67 days respectively. while the minimum shelf life was recorded in the treatment T_9 (control) with 4.33 days.

A protective layer that also regulates the permeability of oxygen and carbon dioxide is a coating. Aloe vera 40 % gel minimised water loss and decay percentage in carrot and thereby increased shelf life. To extend the shelf life of postharvest vegetable such as carrot, *Aloe vera* gel-based coating is a relatively convenient and considered safe. The antimicrobial efficacy of *Aloe vera* gel coating tends to reduce microbial load thereby limiting spoilage. Similar findings were also observed in experiments conducted by Parven *et al.* (2020); Sharmin *et al.* (2016).

Organoleptic evaluation: The data related to the influence of postharvest treatments on organoleptic evaluation are presented in Fig. 1.

Taste. The study revealed that better taste was recorded in treatment T_6 (Honey 30% dipping for 1 minute) (5.57) which was followed by treatment T_4 (*Aloe vera* 40% juice dipping for 1 minute) (5.51) and treatment T_2 (H_2O_2 2% dipping for 1 minute) (5.39). The poor taste was recorded in treatment T_9 (Distilled water) (3.58).

Colour. The study revealed that a better colour was noticed in T_4 (*Aloe vera* 40% juice dipping for 1 minute) (5.62) followed by T_2 (H_2O_2 2% dipping for 1 minute) with a value of 5.56 and T_6 (Honey 30% dipping for 1 minute) with a value of 5.54. The lowest colour was recorded in treatment T_9 (Distilled water) i.e., 4.80.

Texture. Good texture was recorded in treatment T_4 (*Aloe vera* 40% juice dipping for 1 minute) (4.77) followed by treatment T_8 ($CaCl_2$ (6%) dipping for 1 minute) (4.75) and treatment T_2 (H_2O_2 2% dipping for 1 minute) (4.50). The lowest texture was recorded in treatment T_9 (distilled water (3.56).

Appearance. The highest acceptability for appearance was recorded in treatment T_4 (*Aloe vera* 40% juice dipping for 1 minute) (5.68) followed by treatment 2 (H_2O_2 2% dipping for 1 minute) (5.64) and treatment T_8 ($CaCl_2$ (6%) dipping for 1 minute) (5.55). The lowest acceptability for appearance was recorded by treatment T_9(distilled water) (3.97).

Table 1: Effect of chemical dips and edible coatings on quality improvement of carrot cv. New Kuroda.

Treatments	Combinations	%PLW	Firmness(Kg/cm^2)		% of decay	Shelf life
			0th day	7th day		
T_1	H_2O_2 1% dipping for 1 minute	13.76	9.20	5.56	42.26	7.50
T_2	H_2O_2 2% dipping for 1 minute	12.98	9.33	5.92	35.19	7.73
T_3	*Aloe vera* 20% juice dipping for 1 min	11.45	9.47	6.56	40.25	7.53
T_4	*Aloe vera* 40% juice dipping for 1 min	10.29	9.57	7.10	29.13	7.87
T_5	Honey 10% dipping for 1 minute	13.35	9.27	5.81	45.67	7.40
T_6	Honey 30% dipping for 1 minute	11.06	9.40	6.22	38.03	7.60
T_7	$CaCl_2$ (3%) dipping for 5 minutes	11.68	9.33	6.16	43.15	7.47
T_8	$CaCl_2$ (6%) dipping for 5 minutes	10.50	9.50	6.81	37.24	7.67
T_9	Control (Distilled water)	13.80	9.47	3.01	51.67	4.33
	SE(m)	0.26	0.19	0.19	0.81	0.15
	C.D.	0.79	N/A	0.57	2.44	0.44

Table 2: Effect of chemical dips and edible coatings on quality improvement of carrot cv. New Kuroda.

Treatments	Combination	β-carotene(mg/100g)		Ascorbic acid(mg/100g)		TSS(^{0}Brix)		Total sugar (%)	
		0 day	7th day	0 day	7th day	0 day	7th day	0 day	7th day
T_1	H_2O_2 1% dipping for 1 minute	3.46	2.47	3.55	2.48	11.61	11.16	4.53	4.63
T_2	H_2O_2 2% dipping for 1 minute	3.55	2.79	3.53	2.55	11.46	12.23	4.50	4.68
T_3	*A. vera* 20% juice dipping for 1 minute	3.52	2.60	3.52	2.50	11.53	12.01	4.48	4.64
T_4	*A. vera* 40% juice dipping for 1 minute	3.45	2.98	3.40	2.70	11.52	12.36	4.56	4.78
T_5	Honey 10% dipping for 1 minute	3.58	2.46	3.54	2.49	11.49	12.27	4.52	4.65
T_6	Honey 30% dipping for 1 minute	3.53	2.62	3.61	2.45	11.62	12.58	4.58	4.83
T_7	$CaCl_2$ (3%) dipping for 5 minutes	3.57	2.47	3.57	2.39	11.65	11.12	4.54	4.62
T_8	$CaCl_2$ (6%) dipping for 5 minutes	3.49	2.52	3.55	2.47	11.52	10.15	4.50	4.64
T_9	Control (Distilled water)	3.54	2.39	3.45	2.20	11.62	9.26	4.52	4.57
	SE(m)	0.07	0.06	0.06	0.05	0.09	0.16	0.02	0.03
	C.D.	N/A	0.19	N/A	0.15	N/A	0.48	0.05	0.08

Overall acceptability (9-point hedonic scale). Overall acceptability was good in treatment T_4 (*Aloe vera* 40% juice dipping for 1 minute) (5.67) followed by treatment 2 (H_2O_2 2% dipping for 1 minute) (5.51) and treatment 8 ($CaCl_2$ (6%) dipping for 1 minute) (5.45). The poor overall acceptability was recorded in treatment T_9 (distilled water) (3.53). Similar results are in consonance with the findings of Lara *et al*. (2004), Bayoumi (2007); Hazrati *et al*. (2017).

CONCLUSION

Postharvest treatments significantly delays in respiration rate and maintains firmness when treated with *Aloe vera*, H_2O_2, $CaCl_2$ and honey solution, it lowers the decay percentage during the storage. So, we can recommend the use of *Aloe vera*, H_2O_2, $CaCl_2$ and honey solution as edible coating to maintain the quality attributes during storage which shows great potential for preserving. This coating provides a barrier to reduce weight loss, preserve pH, maintains TSS and shelf life as well as quality of carrots. *A. vera* gel has an impact on the product's quality and the quantity of bioactive substances it contains. Edible coverings made of *Aloe vera* have been demonstrated to delay oxidative browning and microbe growth, control respiration rate and maturation and prevent moisture and firmness loss. Post-harvest losses can be reduced with effective post-harvest procedures.

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Conflict of Interest. None.

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