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Impact of Alginate Coating on Shelf life and Quality of Carrot (*Daucus carota* L.) during Storage

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Carrot (*Daucus carota* L.) has been widely consumed as readyto-eat salad. Its orange color is attractive on the plate, and makes it rich in carotene. Carrot is highly perishable during post-harvest due to numberous physiological damages that limit its long-term storage. The effect of different sodium alginate coating (1.0%, 1.5%, 2.0%, 2.5%, 3.0%) on the quality and shelf life of carrot during 28 days of storage at 28±2^{o}C was investigated. The coacted and uncoated (as control) carrot tubers were periodically sampled for various quality attributes like weight loss, firmness and carotenoid content. Our results indicated that carrot tubers coated by 2.5% alginate had the lowest weight loss, maintained the highest firmness and beta-carotene content with shelf life lasted up to 28 days compared to the uncoated ones only lasted to 21 days. Alginate coating was highly effective to extend stability of carrot tubers during distribution

Keywords: Carrot tuber, sodium alginate, coating, weight loss, firmness, carotenoid, shelf life, quality

INTRODUCTION

Edible coating is biodegradable, environmentally friendly, economic, consumer compatible method of food preservation (Anuradha Saha et al., 2014). Edible coating is used as a thin layer on the surface of fruits and vegetables (Gonzalez-Aguilar et al., 2010). It provides a selective barrier to oxygen, carbon dioxide and moisture, improve textural and mechanical characteristics, limit flavour loss and carry food additives (Tapia et al., 2008). Edible coating also improved the aesthetic appearance by minimizing the development of physical damage, hiding scars, and improving surface shine (Ncama et al., 2018; Murmu et al., 2018). Storage losses normally happened due to sprouting, evaporation of water from tubers, changes in chemical component, outbreak of diseases and damage by extreme temperature.

Sodium alginate derived from marine algae with a linear polymer consist of 1,4-linked-β-D-mannuronic and α-L-guluronic acid (Azarakhsh et al., 2012). It is a biopolymer with its unique characteristics to improve emulsion durability, create suspension and increase the thickness of the film (Khanedan N. et al., 2011). It can be renovated and utilized as disintegrable nourishment packing film. It has a durable intensity as a suitable material coating to maintain aroma, flavor, taste and color, as well as enhance nourishment product quality (Rhim, 2004). It's utilized as a thickening agent, stabilizer, emulsifier, chelating agent, encapsulation, swelling, suspending agent, gel forming, edible film, and membrane (Hay et al., 2013; Kim et al., 2000).

Carrot (*Daucus carota* L.) belongs to the family *Umbelliferae*. It's highly appreciated due to a large amount of nutrients such as proteins, carbohydrates, fiber, potassium, sodium, thiamine, riboflavin, and sugar. So it's beneficial for blood and eye (Rashidi et al., 2005). The application of edible coatings for carrot has been popularly explored in order to better keep its fresh-like properties (Fernando Villafañe, 2017). Carrot distribution is limited by its rapid perishability during preservation owing to different physiological modifications that decrease its stability (Emmambux et al., 2003; Ragaert et al., 2007). Alginate coating loaded with silver-montmorillonite nanoparticles on the stability of fresh-cut carrots packaged in oriented polypropylene packages of different thicknesses was evaluated (Costa et al., 2012).

The aim of our study was to optimize the alginate edible coating formulations for carrot tubers based on weight loss, firmness and beta-carotene.

MATERIALS AND METHODS

2.1 Material

Carrot tubers were collected from My Xuyen district, Soc Trang province, Vietnam. After collecting, they must be kept in dry cool place and quickly conveyed to laboratory for experiments. They were subjected to washing to remove dirt and foreign matter, sanitizing by peracetic acid 20 ppm. They were left to drain excess water. Apart from carrot tuber, we also used other materials: peracetic acid as sanitizing agent, sodium alginate as polysaccharide-based edible coating, glycerol as plasticizer, calcium chloride as gel forming and cross-linking.

2.2 Researching method

Sodium alginate powder (1.0, 1.5, 2.0, 2.5, 2.5 g) was dissolved in 100 mL of distilled water by heating the mixtures using the stirring hot plate (70°C) until the solutions became clear and then 0.05% glycerol as plasticizer was added to the solutions. For cross-linking of polymers a 1.0% (w/v) calcium chloride solution was used (Montero-Calderon et al., 2008). Carrot tubers were dipped in glycerol 0.05% + sodium alginate solutions (1.0, 1.5, 2.0, 2.5, 3.0%) then drained to drip off. Then the coated samples were dipped in calcium chlorid 1.0% for 3 minutes. The coated carrot tubers were kept at 28±2ºC on dedicated trays for 28 days. The uncoated carrot tubers as control were preserved in the same condition. In 7 day-interval, samples were taken to evaluate weight loss (%), firmness (N) and beta-carotene (mg/kg)

2.3 Physico-chemical and statistical analysis

The initial weight of carrot tuber was taken before coating and then at the end of each storage period (7th day). The difference between the initial and final weight of carrot tuber was calculated as weight loss (%) at each storage interval. Firmness (N) was calculated by texture analyzer. Beta-carotene (mg/kg) content was determined by HPLC-DAD method. The experiments were run in triplicate with three different lots of samples. Statistical analysis was performed by the Statgraphics Centurion XVI.

RESULTS

Glycerol lead to stronger and more elastic alginate-based film (Parris et al., 1995). Crosslinking with calcium chloride generated stronger alginate gel (Gennadios et al., 1997). Alginate is an acidic anionic polysaccharide and able to form covalent bonds and charge-charge electrostatic complexes with protein (Shih et al., 1994). Alginate coating reduced the respiration of fruits and vegetables due to their selective permeabilities to the O_2 and CO_2 gas, therefore shelf life extension could be observed (Tugce Senturk Parreidt et al., 2018). In our research, the influence of different alginate concentrations (1.0%, 1.5%, 2.0%, 2.5%, 3.0%) on the quality and shelf life of carrot during 28 days of storage at 28±2ºC was examined. Our results revealed that 2.5% alginate coating for carrot tubers kept weight loss in minimal level while keeping firmness and beta-carotene in maximum (table 1, 2, 3). Shelf life of alginate-coated carrot could extend to 28 days at ambient condition. Our results could be explained via some other findings. In raw, untreated fruits and vegetables, epidermal cell layer and cuticles reduce weight loss. Edible coating created an additional extra barrier layer on the stomata and decrease transpiration (Díaz-Mula et al., 2012). Chiabrando and Giacalone (2017) showed that alginate coating promoted firmness of blueberry. Moraes, et al. (2012) proved that alginate coated pears had a higher tensile strength, elongation, and elasticity; on the other hand, they had a lower water loss, pH increase, metabolic activities with maintained firmness and green color. Alginate-coated cherries could be stored with optimal quality and enhanced antioxidant activity up to 16 days at 2 °C plus 2 days at 20 °C (Huertas M. Díaz-Mula et al., 2012). Carotenoid of guava fruit coated by alginate were remarkably changed (M. E. Othman et al., 2017).

Table 1: Weight loss (%) of uncoated and coated carrot tuber by storage

Storage (days)	Alginate concentration					
	Control	1.0	1.5	2.0	**2.5**	3.0
0	0	0	0	0	0	0
7	2.47±0.00[a]	1.39±0.03[b]	1.21±0.01[bc]	1.13±0.02[c]	1.01±0.00[cd]	0.94±0.01[d]
14	7.35±0.01[a]	2.01±0.02[b]	1.86±0.02[bc]	1.65±0.03[c]	1.47±0.00[cd]	1.35±0.02[d]
21	10.78±0.03[a]	3.59±0.01[b]	3.18±0.00[bc]	3.01±0.01[c]	2.83±0.02[cd]	2.57±0.00[d]
28	14.29±0.02[a]	5.27±0.00[b]	5.04±0.01[bc]	4.85±0.02[c]	4.61±0.01[cd]	4.39±0.03[d]

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 2: Firmness (N) of uncoated and coated carrot tuber by storage

Storage (days)	Alginate concentration					
	Control	1.0	1.5	2.0	**2.5**	3.0
0	6.58±0.01[a]	6.58±0.01[a]	6.58±0.01[a]	6.58±0.01[a]	6.58±0.01[a]	6.58±0.01[a]
7	4.15±0.02[c]	4.54±0.00[bc]	4.95±0.00[b]	5.27±0.03[ab]	5.96±0.03[a]	6.00±0.02[a]
14	3.06±0.03[d]	3.98±0.01[c]	4.33±0.01[bc]	4.96±0.00[b]	5.38±0.01[ab]	5.67±0.00[a]
21	2.31±0.00[d]	3.45±0.03[c]	3.76±0.00[bc]	3.92±0.02[b]	4.53±0.02[ab]	4.91±0.03[a]
28	1.27±0.01[d]	3.21±0.02[c]	3.53±0.01[bc]	3.76±0.03[b]	3.99±0.00[ab]	4.25±0.01[a]

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 3: Beta-carotene (mg/kg) of uncoated and coated carrot tuber by storage

Storage (days)	Alginate concentration					
	Control	1.0	1.5	2.0	**2.5**	3.0
0	86.23±0.02[a]	86.23±0.03[a]	86.23±0.00[a]	86.23±0.02[a]	86.23±0.02[a]	86.23±0.02[a]
7	51.74±0.01[d]	80.35±0.00[c]	80.71±0.03[bc]	81.01±0.00[b]	81.56±0.01[ab]	81.69±0.00[a]
14	39.65±0.00[d]	75.24±0.01[c]	76.19±0.03[bc]	77.05±0.01[b]	78.34±0.02[ab]	78.82±0.01[a]
21	30.11±0.01[c]	70.76±0.02[b]	71.34±0.01[ab]	71.79±0.03[ab]	72.67±0.00[a]	72.70±0.03[a]
28	21.69±0.03[d]	64.91±0.00[c]	65.87±0.02[bc]	67.43±0.00[b]	68.59±0.03[ab]	69.25±0.02[a]

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

CONCLUSION

Alginate is a polysaccharide widely exploited in edible coating with important properties such as resistance to gas exchange and mechanical damage, the capacity to retard lipid oxidation, and the ability to improve the flavor, texture and adhesion. It overcomes many obstacles involved in the marketing of foods. In this research, we have successfully applied the alginate coating 2.5% to maintain quality and extend shelf life to carrot tuber for 28 days at ambient temperature..

CONFLICT OF INTEREST

The author declared that present study was performed in absence of any conflict of interest.

AUTHOR CONTRIBUTIONS

This a single author publication.

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