Effect of Starch Coating on Shelf-Life and Biochemical Properties of Carrot (*Daucus carota)*

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ISSN : 2382-5359(Online), 1994-1412(Print)

DOI :
https://doi.org/10.3126/njst.v21i2.67169

Date of Submission: Nov 8, 2021

Date of Acceptance: Feb 12, 2022

ABSTRACT

A simple root vegetable (*Daucus carota*), often called as carrot, is usually conical or cylindrical in shape. It has a great medicinal value and different health benefits. The main objective of the study is to evaluate the effect of starch coating on shelf-life and biochemical properties of carrot. Total soluble solid (TSS) and titrable acidity (TA) was measured by hand refractometer method. The carrot treated with calcium chloride was more acidic 0.72 (±0.075) than distilled water 0.46 (±0.086) and starch 0.48 (±0.074) at 10 days after storage. Total soluble solid was found maximum at 10 days after storage (11.9 °Brix). As measured by spectrophotometer, carrot coated with starch had considerably high β-carotene content (21.78 mg/100 g) as compared to calcium chloride (17.39 mg/100 g) and distilled water (17.19 mg/100 g). Highest physiological weight loss was exhibited by calcium chloride as compared to distilled water and starch. Shelf-life of carrot was shorter in calcium chloride as compared to distilled water and starch; longest shelf-life was exhibited by starch coated carrot.

Keywords: β-carotene, physiological weight loss, shelf-life, titrable acidity, total soluble solid

1. Introduction

Carrot (*Daucus carota*) that belongs to family *Apiaceae* is a biennial herb grown for its edible root. It is an economically important horticultural crop that has become highly popular in recent decades due to increased awareness of its nutritional value (Arscott & Tanumihardjo 2010). Carrot is consumed fresh as well as cooked, either alone or with other vegetables, in the preparation of curries, soups, stews and pies. Fresh grated carrot is used in salad and tender roots are picked. Carrot root is healthy and highly nutritious because of enrichment with antioxidants, vitamins, dietary and mineral (Sharma *et al*. 2006; Mandal *et al*. 2017). It is also a good source of thiamine, vitamin A, and riboflavin (Thompson & Kelly 1957). Thus, it is associated with several health benefits. It is highly nutritious as it contains many important minerals, appreciable amounts of vitamins

B1, B2, B6, B12 and it is rich in β-carotene. β-carotene (Fig. 1) is a precursor of vitamin A and is reported to prevent cancer (Ong *et al* 1983). Carotenoids give yellow, orange, and red colors of the carrots, whereas anthocyanins (polyphenolic compounds) provide the purple color to carrots (Arscott & Tanumihardjo 2010). These pigments are health beneficial and provide protection from certain types of cancer and cardiovascular diseases (Semwal *et al*. 2016) and consumer interest in natural whole foods rich in these compounds, often referred to as functional foods, is growing (Hasler & Brown 2009). Carotenoids are a group of phytochemicals that comprises a family of over 700 compounds in nature and are responsible for the pigmentations in many fruits and vegetables (Britton *et al*. 2004). Carrots roots are rich in carotenoids which can be routinely separated and quantified in typical and dark orange carrots. The dominant forms of carotenoids are the provitamin A and carotenes (α and β-carotene) accounting for 13 to 40% and 45 to 80% of the carotenoids in orange carrots respectively (Simon & Wolff 1987). Several studies have reported that ripening can be slow down, color changes can be delayed, water loss and decay can be decrease and appearance can be improved by applying edible coating technology which is a simple and environmentally friendly technique (Park *et al*. 1994 (a,b); Baldwin, 2001; Rashidi *et al.* 2009). Edible coatings can be performed by using polysaccharides, proteins, lipids or a blend of these compounds (Rashidi *et al*., 2009). Their presence and abundance create the barrier properties of material such as water vapor, oxygen, carbon dioxide and lipid transfer in food systems (Guilbert *et al*. 1996). Starch and chitosan prolong storage life and control the decay of fruits by reducing the growth of many phytopathogenic bacteria and fungi because of its semi permeable film forming ability and biochemical properties (Jiang *et al*. 2001; Pokhrel *et al*. 2021). Edible films of starch are colorless, odorless, tasteless, nontoxic and biodegradable. They show very low permeability to oxygen at low relative humidity (Phan The *et al*. 2009) and are suggested for their uses in food product protection to improve quality and shelf life (Flores *et al*. 2007; Pokhrel 2015). This research was conducted to identify the effect of starch coating on shelf life and biochemical properties of Nepalese carrot.

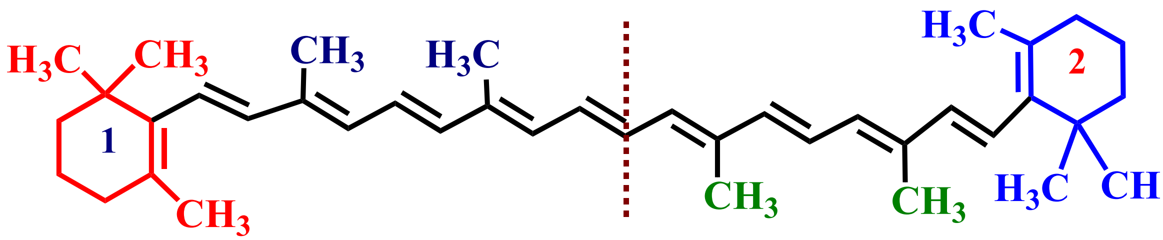

Fig. 1: Structure of β-carotene

2. Methodology

2.1 Plant Materials

Samples were brought from Mulpani Agricultural Organic Farm Kathmandu, Nepal. The cultivation conditions were same for all the species. The samples were washed in the cold water, sliced and stored for further analysis. Acetone (Parsol Chemical Pvt. Ltd. Mumbai, India), petroleum ether (B. Joshi Agrochem Pharma Mumbai, India), sodium sulphate (Lakshita Chemicals, Mumbai, India), β-carotene (Divis Nutraceuticals, Hyderabad, India), methanolic KOH (Paramount Acid and Chemicals Corporation, Mumbai, India), distilled water (Ultra Super TM, Marech Pvt. Ltd. Lalitpur, Nepal), calcium chloride (Shiv Shakti Chloride and Chemicals, Gujrat, India), and starch (Surya Agro Products Pvt. Ltd., Nepal)were provided by the National Horticulture Research Centre, Nepal Agricultural Research Council, Lalitpur, Nepal. Hand refractometer (Atago CO. Ltd.), and spectrophotometer and double-distilled water were used throughout the analysis.

2.2 Methodology

2.2.1 Titrable acidity

The samples paste was taken in a volumetric flask and its weight was measured. The volume was made up to 100 mL with distilled water. The sample was cut into small pieces and was taken in a volumetric flask. The sample fruit was weighed. About 20 g of the sample was put into the mixture and grinded. The juice was extracted with the help of cotton. The solution was filtered and 5mL of the sample wastaken in a beaker. The volume was made up to 100 mL with distilled water. The refractometer was cleaned with the help of distilled water and a few drops of sample juice were placed on the refractometer. The cover plate was lowered and the reading was noted. Finally, acidity of the sample was calculated (KC & Rai 2012).

2.2.2 Total Soluble Solid

The sample was taken in a volumetric flask and its weight was measured and the sample (20 g) was grinded. The juice was extracted with the help of cotton. Few drops of sample juice were placed in the refractometer. The cover plate was lowered and the reading was noted (KC & Rai 2012).

2.2.3 β-Carotene Extraction

First of all, 5 g sample and 62.5 mL acetone were taken in a mixture. The solution was blended/rotated for 5 min. Then the solution was filtered with the help of funnel. It was washed by acetone until the solution was colorless. The second step was separation. The filtrate solution was passed to the separatory funnel. 25 mL of petroleum ether and 10 mL of sodium sulphate (10%) were added in a separatory funnel. The funnel was shaken well, the lower phase was discarded to next separatory funnel to get the residual amount of β-carotene as the lower phase. 25 mL petroleum ether were added to the second funnel then it was shaken and lower phase was discarded. The upper layer was pooled with ether extract in the separatory funnel. Then 12.5 mL of acetone were added in it. The funnel was shaken well and lower phase was discarded. Again, 12.5 mL of methanolic KOH were added in the separatory funnel and shaken well. The lower layer was discarded and 80 mL of water were added in it. Then, the solution was shaken well and the lower layer was discarded. The extract solution was filtered through the Whatmann filter paper 1 and the volume was made up to 100 mL with petroleum ether in a volumetric flask. The absorbance of the sample was measured at 450 nm against β-carotene standard. For the standard solution, β-carotene (5 mg) was dissolved in 0.5 mL chloroform and the volume was made up to 50 mL by petroleum ether to give standard concentration of 0.0001 g/mL (or 0.1 mg/mL or 100 µg/mL). The standard concentration versus absorbance was plotted in the graph for the determination of slope value (KC & Rai 2012). Using the value obtained from the curve, the carotene in the sample was calculated by using equation (1),

$$\text{Carotene } (\mu g/g) = \frac{\text{concentration from the curve} \quad \text{final volume (mL)} \quad \text{dilution}}{\text{weight of sample} \quad \text{g}} \qquad (1)$$

2.2.4 Physiological Weight Loss (%)

Eighteen carrots in each treatment were labeled and the weight of each carrot was recorded with electronic digital balance in alternate day and mean was calculated (KC & Rai 2012). Physiological weight loss was determined by using equation (2).

$$\text{Weight loss } (\%) = \frac{\text{Initial weight} \quad \text{Final weight}}{\text{Initial weight}} \quad 100 \qquad (2)$$

2.2.5 Shelf Life

Shelf life was determined up to 50% acceptability of carrot (KC & Rai 2012).

3. Results and Discussion

3.1 Titrable Acidity (TA)

Fig. 2 shows that the titrable acidity of carrot increases during storage. Table 1 shows details about total acidity among the three treatments of carrot. Titratable acidity is directly related to the concentration of organic acids present in the carrot (Ghasemnezhad *et al*. 2010). TA of distilled water ranged from 0.35 (±0.0354) to 0.46 (±0.086). Similarly, that of calcium chloride ranged from 0.22 (± 0.0009) to 0.72 (± 0.075) and starch from 0.18 (± 0.013) to 0.48 (± 0.074) at various days after storage. From this result it was found that carrot treated with calcium chloride was more acidic followed by the carrot treated with starch and distilled water at 10 days after storage. However, Mandal *et al*. (2017) reported that chitosan (2%) coated with carrot remained with higher titrable acidity 0.22 at 5 days after storage (DAS) and 0.45 at 10 DAS.

Table 1: Titrable acidity of carrot at various days after storage (DAS) as affected by distilled water, calcium

chloride, and starch treatment.

Treatments	2 DAS	4 DAS	6 DAS	8 DAS	10 DAS
Distilled Water	0.35 (±0.0354)	0.25 (±0.00016)	0.19 (±0.0002)	0.35 (±0.018)	0.46 (±0.086)
Starch	0.18 (±0.013)	0.26 (±0.0002)	0.27 (±0.007)	0.47 (±0.046)	0.48 (±0.074)
Calcium Chloride	0.22 (±0.0009)	0.36 (±0.037)	0.33 (±0.021)	0.4 (±0.046)	0.72 (±0.075)

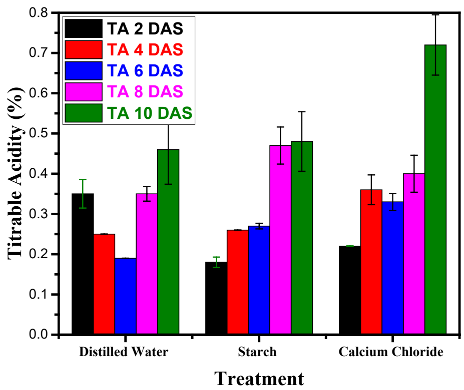

Fig. 2: Titrable acidity of carrot at various days after storage (DAS) as affected by distilled water, calcium chloride, and starch treatment.

3.2 Total Soluble Solid (TSS)

A significant variation in total soluble solid (TSS) content was noted in different treatments of carrot (Table 2). Carrot treated with calcium chloride showed TSS value (3.36, 3.23, 5.93, and 8.16 and 11.90 °Brix) at 2, 4, 6, 8 and 10 DAS respectively. Total soluble content (TSS) was found to increase with the storage time and its highest value was found 11.90 °Brix in carrot treated with calcium chloride after 10 days. These results are in agreement with the results reported by Niari *et al*. (2013) and Rashidi *et al*. (2009) that TSS was significantly increased by increasing storage period with edible coatings.

Table 2: Total soluble solid (TSS) of carrot at various days after storage (DAS) as affected by distilled water, calcium chloride and starch treatment.

Treatments	2 DAS	4 DAS	6 DAS	8 DAS	10 DAS
Distilled water	7.16 (±0.094)	6.63 (0.126)	9.86 (±0.044)	8.43 (±0.094)	9.06 (±0.368)
Starch	4.20 (±0.077)	6.83 (±0.170)	7.73 (±0.094)	11.23 (±0.593)	9.90 (±0.293)
Calcium chloride	3.36 (±0.043)	3.23 (±0.044)	5.93 (±0.046)	8.16 (±0.262)	11.90 (±0.354)

3.3 β-Carotene

The absorption peaks shown by the carrot extract (see Table 3 for absorption peak values) as measured in absorption spectrophotometer were found to occur at the same wavelength with a maximum absorption peak (λ_{max}) at 450 nm as in absorption curve of β-carotene reported by John Scott 2001 (Karnjanawipagul *et al*. 2010; Suryana *et al*. 2013). Therefore, the sample extracted from carrot was valid as β-carotene. There was a marked decrease in the β-carotene content of the treatment at various DAS. The decrease in carotenoids is possibly due to the reduced ethylene emission rates and slows down the ripening process for the Aloe-coated tomato fruits (Chrysargyris *et al*. 2016). It was observed that at 4 DAS, it was ranged between 339.7 and 279.45 mg/100 g where as it ranged between 150.44 and 174.14 mg/100 g at 8 DAS and further reduced and ranged between 17.19 and 21.78 mg/100 g at 12 DAS which can be illustrated in Table 3. Carrot treated with starch had considerably high β-carotene content (21.78 mg/100 g) at 12 DAS, compared to other treatments. Similarly, Mandal *et al.* (2017) reported that carrot coated with chitosan 2% and carboxymethyl cellulose 2% had considerably high β-carotene content during the storage period.

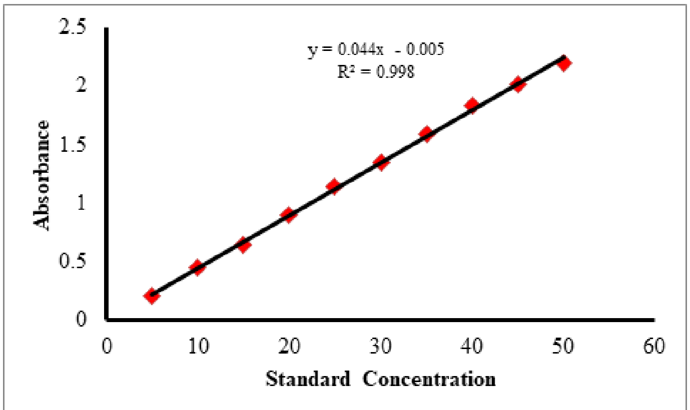

Fig. 3: Absorbance of the sample against β-carotene standard at 4 days after storage

Table 3: Determination of β-carotene from solvent partition method.

4 Days after storage				
Treatments	**Wt. of sample (g)**	**Absorbance (450 nm)**	**Concentration (y= 0.0055x-0.0167)**	**Amount (mg/100 gm)**
Distilled water	5	0.9175	169.8545455	339.709091
Calcium chloride	5	0.8003	148.5454545	297.090909
Starch	5	0.7518	139.7272727	279.454545
8 Days after storage				
Treatments	**Wt. of sample (g)**	**Absorbance (450 nm)**	**Concentration (y= 0.0055x-0.0167)**	**Amount (mg/100 gm)**
Distilled water	5	0.6497	75.22352941	150.447059
Calcium chloride	5	0.7298	84.64705882	169.294118
Starch	5	0.7504	87.07058824	174.141176
12Days after storage				
Treatments	**Wt. of sample (g)**	**Absorbance (450 nm)**	**Concentration (y= 0.0055x-0.0167)**	**Amount (mg/100 gm)**
Distilled water	5	0.4525	8.599534342	17.1990687
Calcium chloride	5	0.4611	8.699630757	17.3993015
Starch	5	0.6493	10.89057043	21.7811409

3.4 Physiological Weight Loss

The physiological weight loss of carrots treated with calcium chloride, starch and distilled water determined at alternate days (Fig. 4) and the dehydration condition of the carrot samples were the same as all the samples taken were fresh cut. At 2 days of storage, the weight loss of carrot samples treated with distilled water, starch and calcium chloride was 2.16 (±0.18), 2.26 (±0.30) and 1.79 (±0.15) percentage respectively. As compared to 2 DAS and 14 DAS the weight loss of calcium chloride treated carrot was increased from 1.79 (±0.15) to 2.83 (±0.16). However, the weight loss of carrot treated with distilled water was decreased from 2.16 (±0.18) to 1.29 (±0.06) and that of starch coated carrot decreased from 2.62 (±0.30) to 1.24 (±0.10). From the result, it was found that the highest loss was exhibited by carrot treated with calcium chloridefollowed by the carrot sample treated with distilled water and the least weight loss was shown by starch coated samples. Arnon *et al*. (2014) reported that carrots treated with chitosan and carboxymethyl cellulose had low physiological weight loss during storage.

3.5 Shelf-Life

For shelf-life study carrots were kept until 50% acceptability. Among the three treatments, the shelf-life was the shortest in the carrot sample coated with calcium chloride (17 days) followed by the sample coated with distilled water (23 days) and the longest shelf-life was shown by starch coated carrots (27 days). The longest shelf-life in starch was associated with bigger fruit size, a greater number of locules per fruit and lower weight loss. However, Mandal *et al.* (2017) reported that carrot treated with chitosan 2% and carboxymethyl cellulose had maximum shelf-life (25.5 days) followed by treatment with chitosan 1% and carboxymethyl cellulose (shelf-life 21.25 days) and chitosan 2% (shelf-life 20.25) days.

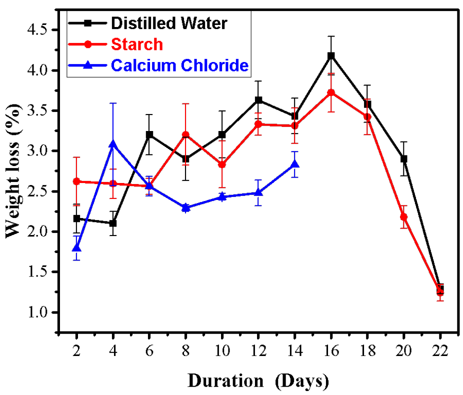

Fig. 4: Physiological weight loss (%) of carrots at various days after storage

4. Conclusion

On the basis of above findings, it can be concluded that there is increase in the titrable acidity (TA) and total soluble solid (TSS) with the storage time as observed in calcium chloride treated carrot at 10 DAS, whereas the β-carotene value was found to decrease with the storage time in all as observed in all carrots treated with distilled water, starch and calcium chloride. There was not much difference in TSS and titrable acidity among the treatments. β-carotene content was found to decrease with the storage duration of the carrots whereas highest physiological weight loss was exhibited by calcium chloride treated carrot followed by the samples treated with distilled water and the lowest decrease in β-carotene content was shown by starch coated carrot. Shelf-life was found longest viz. 27 days by starch coated carrots. Thus, this study reveals that starch coating is highly effective for increasing the postharvest shelf-life of carrot.

The results exclude the quantitative analysis of the thickness of coating; it has to be further confirmed by means of analytical and gravimetric tools. The β carotene content in various DAS could be affected by atmospheric humidity, temperature, method of carotene extraction etc. The optimized conditions and sources of experimental errors have not been studied; and this is the limitation of the research, and can be quantified by a future perspective study.

Acknowledgements

We are highly thankful to University Grant Commission (UGC), Sanothimi, Bhaktapur, Nepal for providing research funds (SRDIG-79/80-01) for First Author (S.P.). The authors are grateful to Department of Chemistry, Tri-Chandra Multiple Campus, Tribhuvan University, Kathmandu, Nepal for providing laboratory facilities to conduct experimental work. National Horticulture Research Centre, Nepal Agricultural Research Council (NARC), Lalitpur, Nepal is also gratifying for the research collaboration.

References

Arnon, H., Y. Zaitsev, R. Porat, and E. Poverenov, 2014. Effects of carboxymethyl cellulose and chitosan bilayer edible coating on postharvest quality of citrus fruit, Journal of Postharvest Biology and Technology 87:21-26
DOI: 10.1016/j.postharvbio.2013.08.007

Arscott, S. A., and S. A. Tanumihardjo, 2010. Carrots of many colors provide basic nutrition and bioavailable phytochemicals acting as a functional food. Comprehensive Reviews in Food Science and Food Safety 9(2):223-239.
DOI:10.1111/j.1541-4337.2009.00103.x

Britton, G., S. Liaaen-Jenson, and H. A. Pfander, 2004. Carotenoids Handbook. Journal of Switzerland 134:1081-1083.
DOI: 10.1007/978-3-0348-7836-4

Chrysargyris, A., A. Nikou, and N. Tzortzakis, 2016. Effectiveness of Aloe vera gel coating for maintaining tomato fruit quality, New Zealand Journal of Crop and Horticultural Science, 44(3):203-217.

DOI: 10.1080/01140671.2016.1181661

Flores, S., A. S. Haedo, C. Campos, and L. Gerschenson, 2007. Antimicrobial performance of potassium sorbate supported in tabioca starch edible films. European Food Research Technology 225:375-384.
DOI: 10.1007/s00217-006-0427-5

Ghasemnezhad, M., M. Shiri, and M. Sanavi, 2010. Effect of chitosan coatings on some quality indices of apricot (*Prunus armeniaca* L.) during cold storage. Caspian Journal of Environmental Sciences 8(1):25-33.

Guilbert, S., N. Gontard, and L. G. M. Gorris, 1996. Prolongation of the shelf-life of perishable food products using biodegradable films and coatings. Lebensmittel-Wissenschaft & Technologie 29:10-17.
DOI: 10.1006/fstl.1996.0002

Hasler, C. M., and A. C. Brown, 2009. Position of the functional foods.Journal of American Dietetic Association109:735-746.
DOI: 10.1016/j.jada.2009.02.023 PMID:19338113

Jiang, Y., and Y. Li, 2001. Effects of chitosan coating on postharvest life and quality of longan fruit. Food Chemistry 73:139-143.
DOI: 10.1016/S0308-8146(00)00246-6

KC, B. J., and B. K. Rai, 2012. Determination of β-carotene by solvent partition method. Journal of Basic Food Analysis Handbook.

Mandal, D., V. Ngohla, Veronica, T. Hazarika Kumar, and A. Shukla Chandra, 2017. Influence of 6-Benzylaminopurine, chitosan and carboxy methyl cellulose on quality and shelf life of fresh cut carrot (*Daucus D. carota*) shreds under refrigerated storage. International Journal of Bio-research and Stress Management 8:69-74.
DOI: 10.23910/IJBSM/2017.8.1.1739b

Nairi, S. M., M. H. Bahrt, and M. Rashidi, 2013. Effects of coating methods and storage periods on some quality characteristics of carrots during ambient storage. Journal of World Applied Science 21:1025-1031.

Ong, D. E., F. Chytil, and E. D. Aurbach, 1983. Vitamins and hormones. Journal of New York Academic Press 13:105-112.
DOI: 10.1016/S0083-6729(08)60433-1
PMID:6324478

Phan The, D., F. Debeaufort, A. Voilley, and D. Luu, 2009. Biopolymer interactions affect the functional properties of edible films based on agar, cassava starch and arabinoxylan blends. Journal of Food Engineering 90:548-558. DOI: 10.1016/j.jfoodeng.2008.07.023

Park, H. J., M. S. Chinnan, and R. L. Shewfelt, 1994a. Edible coating effects on storage life and quality of tomatoes. Journal of Food Science 59:568-570.
DOI: 10.1111/j.1365-2621.1994.tb05563.x

Park, H. J., M. S. Chinnan, and R. L. Shewfelt, 1994b. Edible corn-zein film coatings to extend storage life of tomatoes. Journal of Food Processing and Preservation 18:317-331.
DOI:10.1111/j.1745-4549.1994.tb00255.x

Baldwin, E. A., 2001. New coating formulations for the conservation of tropical fruits, http://technofruits2001.cirad.fr 10/08/2002.

Karnjanawipagul, P., W. Nittayanuntawech, P. Rojsanga, and L. Suntornsuk, 2010. Analysis of β-carotene in carrot by spectrophotometry, Mahidol University Journal of Pharmaceutical Sciences 37:8-16.

Pokhrel, S., 2015. A review on introduction and applications of starch and its biodegradable polymers. International Journal of Environment 4(4):114-125.DOI: 10.3126/ije.v4i4.14108

Pokhrel, S., S. Shah, and H. S. Adhikari, 2021. Synthesis and characterization of chitosan from prawn shells and study of its effects on weight loss of *Myrica esculenta* fruits. Asian Journal of Chemistry 33(2):299-306.
DOI: 10.14233/ajchem.2021.22980

Rashidi, M., M. H. Bahri, and S. Abbassi, 2009. Effects of relative humidity, coating methods and storage periods on some qualitative characteristics of carrot during cold storage. American-Eurasian Journal of Agricultural & Environmental 5:359-367.

Semwal, S., N. Chaudhary, and S. Karoulia, 2016. Addition of carrot pomace to increase the nutritional and rheological properties of traditional cake. International Journal of Scientific Research 5:1412-1416.DOI: 10.21275/v5i5.NOV163676

Sharma, H. K., J. Kaur, B. C. Singh, and A. A. Shilandi, 2006. Optimization of pretreatment conditions of carrots to maximize juice recovery by response surface methodology.Journal of Engineering Science and Technology 1:158-165.

Simon, P. W., and X. Y. Wolff, 1987. Carotene in typical and dark orange carrots. Journal of Agriculture and Food Chemistry 35:1077-1122.
DOI: 10.1021/jf00078a038

Scott, K. J., 2001. Detection and measurement of carotenoids by UV/VIS spectrophotometry. Current Protocols in Food Analytical Chemistry, 1:F2-2.
DOI: 10.1002/0471142913.faf0202s00

Suryana, R., Khoiruddin, and A. Supriyanto, 2013. Beta-carotene Dye of *Daucus carota* as Sensitizer on Dye-Sensitized Solar Cell, Materials Science Forum 737, 15-19.
DOI: 10.4028/www.scientific.net/MSF.737.15

Thompson, H. C., and W. C. Kelly, 1957. Vegetable crops edition. Journal of Macgrow Hill Book 65:405-430.