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Effects of Coating Methods and Storage Periods on Quality of Ambient Stored Carrot

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Abstract: This study was conducted on the effects of coating methods (CM) and storage periods (SP) on Nantes carrot during ambient storage at temperature of 25°C and 65% relative humidity. Four CM [carboxy methyl cellulose + cellophane film (CMC + CF), carboxy methyl cellulose (CMC), cellophane film (CF) and no-coating (NC)] and five SP (0, 4, 8, 11 and 14 days) were investigated for some qualitative characteristics including water content, total soluble solids (TSS), reducing sugars and firmness. The statistical results of the study indicated that CM and SP significantly ($P \leq 0.01$) affected all traits. Interaction of CM × SP for all traits was also significant. The statistical results of the study indicated that CMC + CF for water content and reducing sugars and CF for firmness were the best CM. In addition, water content, reducing sugars and firmness decreased by increasing the SP, whereas TSS increased by an increase in SP.

Key words: Carrot · Ambient storage · Coating methods · Storage periods · Quality · Iran

INTRODUCTION

Carrot (*Daucus carota* L.) belongs to the family Umbelliferae. The carrot is believed to have originated in Asia and now under cultivation in many countries. The carrot is an important vegetable because of its large yield per unit area throughout the world and its increasing importance as human food. It is orange-yellow in color, which adds attractiveness to foods on a plate and makes it rich in carotene, a precursor of vitamin A. it contains appreciable quantities of nutrients such as protein, carbohydrate, fiber, vitamin A, Potassium, Sodium, thiamine and riboflavin and is also high in sugar. Its use increases resistance against the blood and eye diseases. It is eaten raw as well as cooked in curries and is used for pickles and sweetmeats [1-3].

Methods that are being used to preserve whole fruits and vegetables during storage and marketing are generally based on refrigeration with or without control of composition of the atmosphere [4, 5]. However, temperature, atmosphere, relative humidity and sanitation must be regulated to maintain quality of them [6, 7]. In this direction, several methods that have been used are refrigeration, controlled atmosphere packaging, modified atmosphere packaging and chemical preservatives [8-10]. The most prevalent method is rapid cooling at a low temperature with high relative humidity [11]. However, low temperature storage is not economically feasible in most developing countries [5, 12].

Fungicides control postharvest decay of whole fruits, but they leave residues that are potential risks to humans and the environment [12]. In addition, many consumers are suspicious of chemicals in their foods, especially in fruits and vegetables [9]. Sulfites were effective chemical preservative as they were both inhibitors of enzymatic browning and antimicrobial. But their use has been banned due to adverse reaction in consumers [9, 13]. Moreover, chemical preservatives affect the flavor of fruits and vegetables [14].

Plastic films are also effective in reducing desiccation (moisture loss), but are subject to microbial growth and disposal problems [10, 15]. It takes many years of research to develop a material that would coat fruit so that an internal modified atmosphere would develop [16, 17]. Studies have shown that ripening can be retarded, color changes can be delayed, water loss and decay can be reduced and appearance can be improved by using a simple and environmentally friendly technology, edible

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coating [16-18]. The concept of edible films as protective films has been used since the 1800s [19]. The first edible coating used was wax in China [20]. Extensive research in this area has paved the way for different effective edible films and coatings.

The use of edible films and coatings is extended for a wide range of food products including fresh fruits and vegetables. The reasons for their use are: they extend product shelf life [16, 17], control oxidation and respiration reactions [21, 22], add to texture and sensory characteristics and are environmentally friendly [19]. Krochta [23] indicated that the present commercial edible coatings are solvent based (ethanol) and the food industry should replace these solvent-based coatings with water-based coatings to ensure worker and environmental safety.

Coatings are applied and formed directly on the surface of the food product, whereas films are structures, which are applied after being formed separately. Because they may be consumed, the material used for the preparation of edible films and coatings should be approved by Food and Drug Administration (FDA) and must conform to the regulations that apply to the food product concerned [19]. The purpose of edible films or coatings is to inhibit migration of moisture, oxygen, carbon dioxide, or any other solute materials, serve as a carrier for food additives like antioxidants or antimicrobials and reduce the decay without affecting quality of the food. Specific requirements for edible films and coatings are: 1. The coating should be water-resistant so as to remain intact and to cover all parts of a product adequately when applied; 2. It should not deplete oxygen or build up excessive carbon dioxide. A minimum of 1-3% oxygen is required around a commodity to avoid a shift from aerobic to anaerobic respiration; 3. It should reduce water vapor permeability; 4. It should improve appearance, maintain structural integrity, improve mechanical handling properties, carry active agents (antioxidants, etc.) and retain volatile flavor compounds [24].

Edible coatings are thin layers of edible material applied to the product surface in addition to or as a replacement for natural protective waxy coatings and provide a barrier to moisture, oxygen and solute movement for the food [5, 15, 19, 25-27]. They are applied directly on the food surface by dipping, spraying or brushing to create a modified atmosphere [19, 27, 28]. An ideal coating is defined as one that can extend storage life of fresh fruit without causing anaerobiosis and reduces decay without affecting the quality of the fruit [29]. Previously, edible coatings have been used to reduce water loss, but recent developments of formulated edible coatings with a wider range of permeability characteristics has extended the potential for fresh produce application [30]. Also, the effect of coatings on fruits and vegetables depends greatly on temperature, alkalinity, thickness and type of coating and the variety of and condition of fruits [16, 17]. The functional characteristics required for the coating depend on the product matrix (low to high moisture content) and deterioration process to which the product is subject [19].

Edible coatings may be composed of polysaccharides, proteins, lipids or a blend of these compounds [16, 17, 19, 24, 31, 32]. Their presence and abundance determine the barrier properties of material with regard to water vapor, oxygen, carbon dioxide and lipid transfer in food systems [19]. However, none of the three constituents can provide the needed protection by themselves and so are usually used in a combination for best results [19, 21, 22].

Some of the polysaccharides that have been used in coating formulations are starch and pectin [18], cellulose [18, 32, 33], chitosan [11, 12, 18, 34-37] and alginate [18, 33]. These films are excellent oxygen, aroma and oil barriers and provide strength and structural integrity; but are not effective moisture barriers due to their hydrophilic nature [23, 38]. The oxygen barrier properties are due to their tightly packed, ordered hydrogen bonded network structure and low solubility [39]. These coatings may retard ripening and increase shelf life of coated produce, without creating severe anaerobic conditions [24, 40].

In this paper, the effect coating methods (CM) and storage periods (SP) on some qualitative characteristics of Nantes carrot including water content, total soluble solids (TSS), reducing sugars and firmness during ambient storage at temperature of 25°C and 65% relative humidity is reported.

MATERIALS AND METHODS

Plant Materials: Carrots (*Daucus carota* L. cv. Nantes) were purchased from a local market in Karaj, Iran. They were visually inspected for freedom of defects and blemishes. Carrots were then washed with tap water and treated for the prevention of development of decay by dipping for 20 min at 20°C in 0.5 g L^{-1} aqueous solution of iprodione and then air dried for approximately 1 h.

CMC Application: Carrots were placed in 30-liter plastic boxes and soaked for 5 min at 20°C in 20 g L^{-1} aqueous solution of CMC. They were then removed from the plastic boxes and then air dried for approximately 1 h.

Water Content: The water content of carrots was determined using the following formula:

Water content (%) = 100 × (M_1-M_2)/M_1

Where:

M_1 = Mass of sample before drying (g)
M_2 = Mass of sample after drying (g)

Total Soluble Solids (TSS): The TSS of carrots was measured using an ATC-1E hand-held refractometer (ATAGO, Japan) at temperature of 20°C.

Reducing Sugars: The reducing sugars of carrots were determined using Fehling method. This method can be used as a basis for the analysis of reducing sugars. Fehling's solution contains Cu^{2+} ions that can be reduced by some sugars to Cu^{+} ions. As the Fehling's solution is added the blue Cu^{2+} ions will be reduced to Cu^{+}ions. These will precipitate out of solution as red Cu^{+} ions. The resulting solution will be colorless. A titration can be carried out to determine an equivalent amount of the sugar to the Fehling's solution. The end point would be when the blue color has just disappeared. This reaction can be used for the quantitative analysis of reducing sugars [41].

Firmness: The firmness of carrots was analyzed using a Hounsfield texture analyzer (Hounsfield Corp. UK). The test used was a shear or cut test on the 50 g carrot pieces closely placed into a 6×6×6 cm test box with 8 chisel knife blades. The variations in carrots size and geometry were minimized by testing the pieces of same thickness from the carrots. The test mode used for the texture analysis was "Force in Compression". A 5000 N load cell, test speed of 100 mm min^{-1} and post-test speed 600 mm min^{-1} were used. The "Trigger Type" was set to "Button" and distance to be traveled was set to 68 mm. Based on the average firmness of carrots in 0 days (3200 N); the range of the cutting force was set to 2000-3400 N and the maximum cutting force measured during each test was considered as stiffness.

Statistical Analysis: The experiment had factorial structure with four CM [carboxy methyl cellulose + cellophane film (CMC + CF), carboxy methyl cellulose (CMC), cellophane film (CF) and no-coating (NC)] and five SP (0, 4, 8, 11 and 14 days) at temperature of 25°C and 65% relative humidity. The experiment had a complete random design for each factor combination with three replications. The effects of the factors on each qualitative characteristic were determined by analysis of variance using SPSS 12.0 (Version, 2003). Also, Duncan's Multiple Range Test (DMRT) at 1% probability ($P \leq 0.01$) was performed to compare the means of different treatments.

RESULTS AND DISCUSSION

Effect on Water Content: CM and SP significantly affected water content (Table 1). The highest water content of 84.95% was observed in the first CM (CMC + CF) and lowest (81.75%) in the fourth CM (NC) and CM affected water content in the order of CMC + CF > CF > CMC > NC (Table 2). Moreover, the highest water content of 87.80% was observed in 0 days and lowest (79.69%) in 14 days SP and water content decreased with increased SP (Table 2). Furthermore, interaction of CM × SP showed significant effect on water content (Table 1). The study of CM and SP combinations on water content showed that in each CM, water content had the highest value in 0 days and lowest value in 14 days SP. The maximum mean value for water content was observed in 0 days of each CM and minimum mean value for water content was observed in 14 days SP and the fourth CM (NC). Also, in each SP, CM affected water content in the same order as mentioned before (Table 3). These results are in agreement with those of Avena-Bustillos *et al.* [26] and Mahmoud and Savello [31] who concluded that coatings and/or films significantly conserved water content. These results are also in line with the results reported by Smith and Stow [4], Baldwin *et al.* [9], El Ghaouth *et al.* [29] and Rashidi *et al.* [42] that water content significantly decreased with increased SP.

Effect on TSS: The effect of CM and SP on TSS was found significant (Table 1). The highest TSS of 10.5% was observed in the fourth CM (NC) and lowest (9.03%) in the first CM (CMC + CF) and CM affected TSS in the order of NC > CMC > CF > CMC + CF (Table 2). Moreover, the highest TSS of 11.0% was observed in 14 days SP and lowest (8.63%) in 0 days and TSS increased with

Table 1: Analysis of variance for several carrot quality characteristics

		Mean square			
Source of variation	Df	Water content	TSS	Reducing sugars	Firmness
CM	3	26.46 **	5.393 **	1.105 **	129544 **
SP	4	125.0 **	10.64 **	3.217 **	355513 **
CM × SP	12	3.098 **	0.700 **	0.201 **	16557.1 **
Error	38	0.406	0.001	0.006	268.582
C.V. (%)	---	0.76	0.36	1.00	0.55

** = Significant at 0.01 probability level

Table 2: Means comparison for different carrot quality characteristics for different studied treatments using DMRT at 1% probability

Treatment		Water content (%)	TSS (%)	Reducing sugars (%)	Firmness (N)
CM	CMC + CF	84.95 a	9.03 d	7.99 a	3022 b
	CMC	83.62 b	10.0 b	7.88 b	2944 c
	CF	83.81 b	9.81 c	7.50 c	3076 a
	NC	81.75 c	10.5 a	7.44 c	2863 d
SP	0 days	87.80 a	8.63 e	8.26 a	3200 a
	4 days	85.49 b	9.17 d	8.07 b	3086 b
	8 days	83.34 c	9.92 c	7.80 c	2963 c
	11 days	81.34 d	10.5 b	7.41 d	2864 d
	14 days	79.69 e	11.0 a	6.97 e	2767 e

Means in the same column with different letters differ significantly at 0.01 probability level according to DMRT

Table 3: Means comparison for different carrot quality characteristics of coating method (CM) and storage period (SP) combinations using DMRT at 1% probability

CM ×	SP	Water content (%)	TSS (%)	Reducing sugars (%)	Firmness (N)
CMC + CF	0 days	87.80 a	8.63 n	8.26 a	3200 a
	4 days	86.25 b	8.83 m	8.17 ab	3108 bc
	8 days	84.82 bcd	9.10 l	8.03 bcd	3015 e
	11 days	83.49 de	9.17 l	7.86 d	2934 gh
	14 days	82.41 ef	9.40 j	7.64 e	2852 i
CMC	0 days	87.80 a	8.63 n	8.26 a	3200 a
	4 days	85.51 bc	9.27 k	8.13 abc	3063 e
	8 days	83.44 de	10.2 h	7.95 cd	2912 h
	11 days	81.50 fg	10.8 e	7.62 e	2830 i
	14 days	79.85 hi	11.2 c	7.42 f	2714 j
CF	0 days	87.80 a	8.63 n	8.26 a	3200 a
	4 days	85.64 bc	9.13 l	8.01 bcd	3135 b
	8 days	83.58 de	9.80 i	7.63 e	3072 cd
	11 days	81.93 f	10.5 g	7.13 g	3004 ef
	14 days	80.12 gh	11.0 d	6.48 h	2968 fg
NC	0 days	87.80 a	8.63 n	8.26 a	3200 a
	4 days	84.58 cd	9.47 j	7.98 cd	3037 de
	8 days	81.52 fg	10.6 f	7.58 ef	2854 i
	11 days	78.46 i	11.4 b	7.05 g	2688 j
	14 days	76.38 j	12.2 a	6.35 h	2535 k

Means in the same column with different letters differ significantly at 0.01 probability level according to DMRT increased SP (Table 2). Furthermore, interaction of CM × SP showed significant effect on TSS (Table 1). Mean comparison of CM × SP combinations on TSS revealed that in each CM, TSS had the highest value in 14 days SP and lowest value in 0 days. The maximum mean value for TSS was observed in 14 days SP and the fourth CM (NC) and minimum mean value for TSS was observed in 0 days of each CM. Also, in each SP, CM affected TSS in the same order as mentioned before (Table 3). These results are in agreement with those of Smith and Stow [4] who concluded that coatings and/or films significantly affected TSS. These results are also in line with the results reported by Park *et al.* [16, 17], Rashidi *et al.* [42] and Hussain *et al.* [43] that TSS significantly increased by increasing SP.

Effect on Reducing Sugars: The effect of CM and SP on reducing sugars was also found significant (Table 1). The highest reducing sugars of 7.99% was observed in the first CM (CMC + CF) and lowest (7.44%) in the fourth CM (NC) and CM affected reducing sugars in the order of CMC + CF > CMC > CF > NC (Table 2). Moreover, the highest reducing sugars of 8.26% was observed in 0 days and lowest (6.97%) in 14 days SP and reducing sugars decreased with increased SP (Table 2). Furthermore, interaction of CM × SP showed significant effect on reducing sugars (Table 1). The study of CM and SP combinations on reducing sugars showed that in each CM, reducing sugars had the highest value in 0 days and lowest value in 14 days SP. The maximum mean value for reducing sugars was observed in 0 days of each CM and minimum mean value for reducing sugars was observed in 14 days SP and the fourth CM (NC). Also, in each SP, CM affected reducing sugars in the same order as mentioned before (Table 3). These results are in agreement with those of Ahmad and Khan [8], El Ghaouth *et al.* [11], Li and Yu [12] and McHugh and Senesi [27] who concluded that coatings and/or films significantly affected reducing sugars. These results are also in line with the results reported by Rashidi *et al.* [42], Suojala [44] and Forney *et al.* [45] that reducing sugars significantly decreased with increased SP.

Effect on Firmness: CM and SP significantly affected firmness (Table 1). The highest firmness of 3076 N was observed in the third CM (CF) and lowest (2862%) in the fourth CM (NC) and CM affected firmness in the order of CF > CMC + CF > CMC > NC (Table 2). Moreover, the highest firmness of 3200 N was observed in 0 days and lowest (2767 N) in 14 days SP and firmness decreased with increased SP (Table 2). Furthermore, interaction of CM × SP showed significant effect on firmness (Table 1). Mean comparison of CM × SP combinations on firmness revealed that in each CM, firmness had the highest value in 0 days and lowest value in 14 days SP. The maximum mean value for firmness was observed in 0 days of each CM and minimum mean value for firmness content was observed in 14 days SP and the fourth CM (NC). Also, in each SP, CM affected firmness in the same order as mentioned before (Table 3). These results are in line with the results reported by Lerdthanangkul and Krochta [15] who concluded that coatings and/or films significantly affected firmness. These results are also in line with the results reported by Mostofi and Toivonen [7] that firmness significantly decreased by increasing SP.

CONCLUSIONS

Coating methods (CM) and storage periods (SP) significantly ($P \leq 0.01$) affected water content, total soluble solids (TSS), reducing sugars and firmness of Nantes carrot during ambient storage at temperature of 25°C and 65% relative humidity. Results of the study indicated that carboxy methyl cellulous + cellophane film (CMC + CF) for water content and reducing sugars and cellophane film (CF) for firmness were the best CM. In addition, water content, reducing sugars and firmness decreased by increasing the SP, whereas TSS increased by an increase in SP.

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REFERENCES

1. Ahmad, B., M.A. Chaudhry and S. Hassan, 1994. Cost of producing major crops in Punjab, Department of farm Management, University of Agriculture, Faisalabad, Pakistan.
2. Ahmad, B., S. Hassan and K. Bakhsh, 2005. Factors affecting yield and profitability of carrot in two districts of Punjab. Int. J. Agric. Biol., 7: 794-798.
3. Hassan, I., K. Bakhsh, M.H. Salik, M. Khalil and N. Ahmad, 2005. Determination of factors contributing towards the yield of carrot in Faisalabad (Pakistan). Int. J. Agric. Biol., 7: 323-324.

4. Smith, S.M. and J.R. Stow, 1984. The potential of a sucrose ester coating material for improving the storage and shelf-life qualities of Cox's Orange Pippin apples. Ann. Appl. Biol., 104: 383-391.
5. Smith, S.M., J. Geeson and J.R. Stow, 1987. Production of modified atmospheres in deciduous fruits by the use of films ad coatings. Hort. Sci., 22: 772-776.
6. Watada, A.E., N.P. Ko and D.A. Minott, 1996. Factors affecting quality of fresh-cut horticultural products. Postharvest Biol. Technol., 9: 115-125.
7. Mostofi, Y. and P.M.A. Toivonen, 2006. Effects of storage conditions and 1-methylcyclopropene on some qualitative characteristics of tomato fruits. Int. J. Agric. Biol., 8: 93-96.
8. Ahmad, M. and I. Khan, 1987. Effects of waxing and cellophane lining on chemical quality indices of citrus fruits. Plant Food Human Nutr., 37: 47-57.
9. Baldwin, E.A., M.O. Nisperos-Carriedo, X. Chen and R.D. Hagenmaier, 1996. Improving storage life of cut apple and potato with edible coating. Postharvest Biol. Technol., 9: 151-163.
10. Zhang, D. and P.C. Quantick, 1997. Effects of chitosan coating on enzymatic browning and decay during postharvest storage of litchi (Litchi chinensis Sonn.) fruit. Postharvest Biol. Technol., 12: 195-202.
11. El-Ghaouth, A., J. Arul, R. Ponnampalam and M. Boulet, 1991. Chitosan coating effect on storability and quality of fresh strawberries. J. Food Sci., 56: 1618-1620.
12. Li, H. and T. Yu, 2000. Effect of chitosan on incidence of brown rot, quality and physiological attributes of postharvest peach fruit. J. Sci. Food Agric., 81: 269-274.
13. Kim, D.M., N.L. Smith and C.Y. Lee, 1993. Quality of minimally processed apple slices from selected cultivars. J. Food Sci., 58: 1115-1117.
14. Rocha, A.M.C.N., C.M. Brochado and A.M.M.B. Morais, 1998. Influence of chemical treatment on quality of cut apple (cv. Jonagored). J. Food Qual., 21: 13-28.
15. Lerdthanangkul, S. and J.M. Krochta, 1996. Edible coating effects on post harvest quality of green bell peppers. J. Food Sci., 61: 176-179.
16. Park, H.J., M.S. Chinnan and R.L. Shewfelt, 1994. Edible coating effects on storage life and quality of tomatoes. J. Food Sci., 59: 568-570.
17. Park, H.J., M.S. Chinnan and R.L. Shewfelt, 1994. Edible corn-zein film coatings to extend storage life of tomatoes. J. Food Proc. Preserv., 18: 317-331.
18. Baldwin, E.A., 2001. New coating formulations for the conservation of tropical fruits, http:// techn of ruits 2001. cirad.fr 10/08/2002.
19. 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 Technol., 29: 10-17.
20. Park, H.J., 1999. Development of advanced edible coatings for fruits. Trends Food Sci. Technol., 10: 254-260.
21. McHugh, T.H. and J.M. Krochta, 1994. Milk protein based edible films and coatings. Food Technol., 48: 97-103.
22. McHugh, T.H. and J.M. Krochta, 1994. Sorbitol vs glycerol plasticized whey protein edible films: Integrated oxygen permeability and tensile property evaluation. J. Agric. Food Chem., 42: 41-45.
23. Krochta, J.M., 2001. FAQ about edible films and coatings, http://www.dairybiz.com/feature.htm 05/07/2002.
24. Arvanitoyannis, I. and L.G.M. Gorris, 1999. Edible and biodegradable polymeric materials for food packaging or coating in processing foods: Quality optimization and process assessment. CRC Press, Boca Raton, FL. pp: 357-371.
25. Nisperos-Carriedo, M.O., E.A. Baldwin and P.E. Shaw, 1992. Development of an edible coating for extending postharvest life of selected fruits and vegetables. Proceed. Annu. Meeting Florida State Hort. Soc., 104: 122-125.
26. Avena-Bustillos, R.J., J.M. Krochta and M.E. Saltveit, 1997. Water vapor resistance of red delicious apples and celery sticks coated with edible caseinate-acetylated monoglyceride films. J. Food Sci., 62: 351-354.
27. McHugh, T.H. and E. Senesi, 2000. Apple wraps: A novel method to improve the quality and extend the shelf life of fresh-cut apples. J. Food Sci., 65: 480-485.
28. Krochta, J.M. and C.D. Mulder-Johnston, 1997. Edible and biodegradable polymer films: Challenges and Opportunities. Food Technol., 51: 61-74.
29. El-Ghaouth, A., J. Arul, R. Ponnampalam and M. Boulet, 1992. Chitosan coating to extend the storage life of tomatoes. Hort. Sci., 27: 1016-1018.
30. Avena-Bustillos, R.J., L.A. Cisneros-Zevallos, J.M. Krochta and M.E. Saltveit, 1994. Application of casein-lipid edible film emulsions to reduce white blush on minimally processed carrots. Postharvest Biol. Technol., 4: 319-329.

31. Mahmoud, R. and P.A. Savello, 1992. Mechanical properties of and water vapor transferability through whey protein films. J. Dairy Sci., 75: 942-946.
32. Li, P. and M.M. Barth, 1998. Impact of edible coatings on nutritional and physiological changes in lightly processed carrots. Postharvest Biol. Technol., 14: 51-60.
33. Tien, C.L., M. Letendre, P. Ispas-Szabo, M.A. Mateescu, G.D. Patterson, H.L. Yu and M. Lacroix, 2000. Development of biodegradable films from whey proteins by cross-linking and entrapment in cellulose. J. Agric. Food Chem., 48: 5566-5575.
34. El-Ghaouth, A., J. Arul, J. Grenier and A. Asselin, 1992. Antifungal activity of chitosan on two postharvest pathogens of strawberry fruits. Phytopathology, 82: 398-402.
35. Cheah, L.H., B.B.C. Page and R. Shepherd, 1997. Chitosan coating for inhibition of sclerotinia rot of carrots. New Zealand J. Crop Hort. Sci., 25: 89-92.
36. Zhang, D. and P.C. Quantick, 1998. Antifungal effects of chitosan coating on fresh strawberries and raspberries during storage. J. Hort. Sci. Biotechnol., 73: 763-767.
37. Jiang, Y. and Y. Li, 2001. Effects of chitosan on postharvest life and quality of longan fruit. Food Chem., 73: 139-143.
38. Kester, J.J. and O.R. Fennema, 1986. Edible films and coatings. A review. Food Technol., 40: 47-59.
39. Banker, G.S., 1966. Film coating theory and practice. J. Pharmaceut. Sci., 55: 81-89.
40. Baldwin, E.A., M.O. Nisperos-Carriedo and R.A. Baker, 1995. Use of edible coatings to preserve quality of lightly (and slightly) processed products. Crit. Rev. Food Sci. Nutr., 35: 509-552.
41. Mendham, J., R.C. Denney, J.D. Barnes and M. Thomas, 2000. Vogel's Textbook of Quantitative Chemical Analysis, Pearson Education Ltd, England.
42. 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 J. Agric. & Environ. Sci., 5(3): 359-367.
43. Hussain, I.,S.N. Gilani, M.R. Khan, M.T. Khan and I. Shakir, 2005. Varietal suitability and storage stability of mango squash. Int. J. Agric. Biol., 7: 1038-1039.
44. Suojala, T., 2000. Variation in sugar content and composition of carrot storage roots at harvest and during storage. Sci. Hort., 85: 1-19.
45. Forney, C.F., J. Song, P.D. Hildebrand, L. Fan and K.B. McRae, 2007. Interactive effect of ozone and 1-methylcyclopropene on decay resistance and quality of stored carrots. Postharvest Biol. Technol., 45: 341-348.