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Effect of carnauba wax coating on the quality and shelf life of carrot (*Daucus carota* L.)

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Abstract

Carrot is one of the most important vegetables grown in India, used as a fresh vegetable all the year for salad purposes as well as for extraction of juice, canning and as supplement for infant baby food. It is an economically important vegetable worldwide and is the richest source of carotenoids in the human diet. The purpose of applying carnauba wax to carrots includes delayed reduction in colour, flavour, moisture and firmness thus maintaining freshness in carrots for longer period. The carnauba wax diluted to 5.3% wax level exhibited maximum flavour and body and texture sensory score after 20-25 days of storage at room temperature and 50 days at refrigerated storage, respectively. The carnauba wax diluted to 4.8% wax level exhibited maximum red colour (a-value) response at room temperature and at low temperature but there is very little difference between red colour (a-value) of 4.8% and 2.3% wax level. The hardness value in terms of force (gm) in carnauba wax treated carrots increased during storage at room temperature (26-32^{o}C) and at low temperature (10^{0}C). The carnauba wax diluted to 5.3% wax level exhibited minimum (3.24%) and maximum PLW (3.82%) after 50 days of refrigerated and 35 days of room temperature storage, respectively.

Keywords: Carrot, carnauba wax, storage, texture, PLW

Introduction

Carrot (*Daucus carota* L.) is one of the most important vegetables grown in India. It is used as a fresh vegetable all year long as well as for juice production, dessert, canning and baby food. It is an economically important vegetable worldwide and is the largest source of carotenoids in the human diet. Carrots are best known for the richest supply of carotenoid, â-carotene. Carrot also provides other health promoting attributes such as prevention of cardiovascular diseases and other health-supporting nutrients. Edible coatings provide semipermeable barrier against oxygen, carbon dioxide, moisture and solute movements thereby reducing respiration, water loss and oxidation reaction. Proteins, lipids and polysaccharides are the main constituents of edible films and coatings. However, among the edible films, carnauba wax is an important edible and natural polymer coating material under the lipid group, which is recovered from the underside of the leaves of a Brazilian palm tree (*Coperni cacerifera*) and is mainly used to reduce water loss and gloss. Carnauba wax is widely used as glazing agent for confectionary products including chocolate, snacks, nuts, coffee beans and dietary supplements (European Parliament and Council Directive 1995). The present investigation has been carried to evaluate the different carnauba wax diluted emulsion on sensory and physico-chemical properties during refrigerated and room temperature storage.

Materials and Methods

The study was conducted at Indian Institute of Vegetable Research, Varanasi. Freshly harvested carrots from local farmer's field were immediately brought to laboratory and washed thoroughly to clean the adhering soil from carrot roots. Carnauba wax stable emulsion was made with varying levels (7.5-10.0%) of oleic acid and addition of hot water (80-100^{o}C). The emulsion contained 7.7% wax level in carnauba wax emulsion. Carnauba wax emulsion was diluted with hot water (20-100%) to dilute make the wax level from 4.4 to 6.7%. Washed and surface air dried carrots were dipped in different diluted carnauba wax emulsion for 1 min and subsequently surface air dried for 15-20 min at room temperature. All the carnauba wax dipped carrots after drying in air were packaged in polypropylene pouches (15cm Î 13cm) of thickness 14.5 gauge and sealed with hand sealer. All the packaged carrots were stored at room temperature (26-32^{o}C) and refrigerated condition (10^{o}C). The observations of storage characteristics were recorded

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after every 5 days interval. Physiological loss in weight was calculated using the formula (A-B)/AX100, where A is weight just before storage and B is the weight after storage.

Sensory evaluation: A panel of 10 trained judges was set up to evaluate carnauba wax coated carrot for overall acceptability with regards to flavor, color and appearance and body and texture on 9-point hedonic scale as per the method (Lawless and Haymann 1988).

Physico-chemical analysis: The physico-chemical parameters such as moisture content were analyzed initially and at the interval of 5 days of refrigerated storage at 10±1 °C and room temperature using standard analytical method (Ranganna, 1997). Total carotenoids were extracted and partitioned in acetone and petroleum ether, respectively and estimated using a spectrophotometer as per the method of Gross (1991).

Texture profile analysis: Texture profile analysis (hardness) of carnauba wax coated samples was studied using TA-XT2i (Stable Micro System, UK) Texture Analyzer fitted with a 50 kg load cell using Needle probe stainless steel P/2N having pre-test speed of 2 mm/sec, test speed of 1mm/sec and post test speed of 2 mm/ sec.

Color measurement: Colour attributes (L*, a*, b*) of fruit surface were measured using colour meter (Colour-Tec PCM, USA). Measurement was done in triplicate.

Statistical analysis: The data generated during the study was analyzed using Design expert version 7.0 which was analyzed using Systat Version 7.0 SPSS Inch., USA to draw meaningful inferences.

Result and Discussion

Changes in mean flavour score of carnauba wax coated carrot during storage: The flavour score in carnauba wax treated carrots decreased during storage at room temperature (26-32°C) and at low temperature (10°C). The carnauba wax treated carrots with wax level of 5.3% had exhibited maximum flavour score of 7.0 after 50 days of storage at low temperature (10°C) while the carnauba wax treated carrots with wax level at 5.3% spoiled after 35 days of storage at room temperature (Table 1). Control carrots without wax coating had the acceptable flavour score of 7.0 after 10 days and 35 days of storage at room and at refrigerated storage temperature, respectively. It is evident from Table 1 that maximum flavour score was obtained for wax dilution at 5.3% while the flavour score was

Table 1: Change in mean flavour score of carnauba wax coated carrot during storage

		Days										
Sample	**Temp °C**	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Control		8.5	8.0	7.0	6.0	5.0	S	S	S	S	S	S
6.7%		8.5	8.5	7.5	7.0	6.0	5.5	S	S	S	S	S
5.9%	**26-32**	8.5	8.5	8.0	7.0	7.0	6.0	5.0	S	S	S	S
5.3%		**8.5**	**8.5**	**8.0**	**7.5**	**6.5**	**6.0**	**5.5**	**5.0**	**S**	**S**	**S**
4.8%		8.5	8.0	7.5	7.0	6.0	5.0	S	S	S	S	S
Control		8.5	8.5	8.5	8.5	8.5	8.0	7.5	7.0	6.0	S	S
6.7%		8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0	7.0	6.5	5.5
5.9%	**10**	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.0	7.5	7.5	6.5
5.3		**8.5**	**8.5**	**8.5**	**8.5**	**8.5**	**8.5**	**8.5**	**8.0**	**7.5**	**7.0**	**7.0**
4.8%		8.5	8.5	8.5	8.5	8.5	8.0	8.0	7.5	6.5	5.5	5.0

$P<0.001$, CD :$I_{0.27}$, $D_{0.27}$, $IxD_{0.29}$ (room temperature); $P<0.001$, CD :$I_{0.16}$, $D_{0.16}$, $IxD_{0.21}$(low temperature)

Table 2: Change in mean body and texture score of carnauba wax coated carrot during storage

		Days										
Sample	**Temp °C**	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Control		8.5	7.5	6.5	6.0	5.0	S	S	S	S	S	S
6.7%		8.5	7.5	7.0	6.5	6.0	5.0	S	S	S	S	S
5.9%	**26-32**	8.5	8.0	7.5	7.0	7.0	6.0	5.0	S	S	S	S
5.3%		**8.5**	**8.0**	**8.0**	**8.0**	**7.5**	**7.5**	**6.0**	**5.0**	**S**	**S**	**S**
4.8%		8.5	7.0	6.5	6.0	5.5	5.0	S	S	S	S	S
Control		8.5	8.5	8.5	8.5	8.0	8.0	7.5	7.0	6.0	S	S
6.7%		8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0	7.0	6.5	5.5
5.9%	**10**	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.0	7.5	7.0	6.5
5.3%		**8.5**	**8.5**	**8.5**	**8.5**	**8.5**	**8.5**	**8.5**	**8.0**	**7.5**	**7.0**	**7.0**
4.8%		8.5	8.5	8.5	8.5	8.5	8.5	8.5	7.5	6.5	5.5	5.0

$P<0.001$, CD :$I_{0.27}$, $D_{0.27}$, $IxD_{0.29}$ (room temperature); $P<0.001$, CD :$I_{0.80}$, $D_{0.81}$, $IxD_{1.03}$(low temperature)

minimum for carnauba wax treated carrot with wax dilution of 4.8% as wax level. Ben-Yehoshua (1987) also mentioned that edible coating and films could retain the volatile flavors in vegetables for longer time. The analysis of variance studies showed that storage periods, carnauba wax dilutions and interaction of storage period and dilution had significant ($P<0.001$, CD:$I_{0.27}$, $D_{0.27}$, $IxD_{0.29}$) at room temperature and $P<0.001$, CD :$I_{0.16}$, $D_{0.16}$, $IxD_{0.21}$ at low temperature) changes of flavour score of carnauba wax coated carrot during storage for 50 days (Table 1).

Changes in mean body and texture score of carnauba wax coated carrot during storage: The body and texture sensory score in carnauba wax treated carrots decreased during storage at room temperature (26-32°C) and at low temperature (10°C). The carnauba wax diluted to 5.3% wax level exhibited maximum body and texture score at room temperature and at low temperature (Table 2). The carnauba wax treated carrots with wax level of 5.3% had the maximum (7.0) body and texture score after 50 days of storage at low temperature (10°C) while the carnauba wax treated carrots with wax level of 5.3% spoiled after 35 days of storage at room temperature (Table 2). Control carrots without wax coating had body and texture sensory score of 7.5 after 5 days and 30 days of room temperature and refrigerated storage, respectively. It is evident from Table 2 that maximum body and texture score was obtained after wax dilution of 5.3% followed by 5.9% and 6.7% while the body and texture score was minimum for carnauba wax treated carrot with wax dilution of 4.8% during room temperature and refrigerated storage temperature. The analysis of variance studies had shown that storage periods, carnauba wax dilution and interaction of storage period and dilution had significant ($P<0.001$, CD :$I_{0.27}$, $D_{0.27}$, $IxD_{0.29}$ at room temperature and $P<0.001$, CD :$I_{0.80}$, $D_{0.81}$, $IxD_{1.03}$ at low temperature) changes of body and texture score of carnauba wax coated carrot during storage for 50 days (Table 2).

Changes in mean red colour (a-value) of carnauba wax coated carrot during storage: The red colour (a-value) in carnauba wax treated carrots was not changed during storage at room temperature (26-32°C) and at low temperature (10°C). The red colour (a-value) in carrot samples increased with decrease the level of wax dilution (Table 3). The carnauba wax diluted to 4.8% wax level exhibited maximum red colour (a-value) development at room temperature and at low temperature but there is very little difference between red colour (a-value) change of 4.8% and 5.3 % wax level (Table 3).

Table 3: Change in mean red colour (a-value) of carnauba wax coated carrot during storage

		Days										
Sample	**Temp °C**	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Control		18.19	17.50	17.00	16.81	16.50	S	S	S	S	S	S
6.7%		18.19	17.71	17.40	17.11	17.00	16.75	S	S	S	S	S
5.9%	**26-32**	18.19	17.64	17.13	16.90	16.87	16.53	16.74	S	S	S	S
5.3%		**18.19**	**17.82**	**17.55**	**17.27**	**17.05**	**16.89**	**16.94**	**16.70**	**S**	**S**	**S**
4.8%		**18.19**	**17.95**	**17.62**	**17.50**	**17.30**	**17.01**	S	S	S	S	S
Control		18.19	17.50	17.27	17.01	16.88	16.53	16.31	15.97	15.64	S	S
6.7%		18.19	17.77	17.52	17.42	17.31	17.22	17.12	17.07	16.76	16.53	16.40
5.9%	**10**	18.19	17.70	17.49	17.36	17.21	17.11	17.00	16.92	16.61	16.44	16.23
5.3%		**18.19**	**17.95**	**17.81**	**17.71**	**17.63**	**17.44**	**17.37**	**17.11**	**17.07**	**16.88**	**16.73**
4.8%		**18.19**	**18.09**	**17.99**	**17.87**	**17.77**	**17.64**	**17.53**	**17.41**	**17.28**	**17.12**	**17.02**

$P<0.001$, CD :$I_{0.12}$, $D_{0.12}$, $IxD_{0.13}$(room temperature); $P<0.001$, $CD_{4.16}$(low temperature)

Table 4: Change in mean hardness (gm) of carnauba wax coated carrot during storage

		Days										
Sample	**Temp °C**	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Control		1228.9	994.5	953.6	917.8	856.1	S	S	S	S	S	S
6.7%		1228.9	1170.8	1000.6	981.9	932.9	880.7	S	S	S	S	S
5.9%	**26-32**	1228.9	1186.9	1072.3	1063.0	954.6	918.2	891.3	S	S	S	S
5.3%		**1228.9**	**1201.1**	**1198.5**	**1099.1**	**987.8**	**942.7**	**921.5**	**909.0**	**S**	**S**	**S**
4.8%		1228.9	1007.2	986.3	953.1	902.3	865.4	S	S	S	S	S
Control		1228.9	1140.6	1100.8	1075.4	991.7	952.8	948.9	910.7	885.5	S	S
6.7%		1228.9	1190.8	1167.6	1150.9	1132.8	1121.4	1055.9	1012.6	1003.7	993.5	980.0
5.9%	**10**	1228.9	1200.4	1185.7	1173.8	1164.2	1137.3	1110.9	1100.4	1084.4	1054.7	1044.5
5.3		**1228.9**	**1210.7**	**1200.9**	**1196.3**	**1181.1**	**1174.4**	**1169.2**	**1160.0**	**1147.7**	**1122.5**	**1107.6**
4.8%		1228.9	1170.3	1143.3	1124.4	1117.9	1080.1	1001.3	989.1	975.7	957.9	923.4

$P<0.001$, CD :$I_{5.21}$, $D_{5.21}$, $IxD_{5.63}$(room temperature); $P<0.001$, CD :$I_{1.36}$, $D_{1.38}$, $IxD_{1.75}$(low temperature)

The carnauba wax treated carrots with wax level of 5.3% had the red colour (a-value) of 16.73 after 50 days of storage at low temperature (10°C) while the carnauba wax treated carrots with wax level of 5.3% were spoiled after 35 days of storage at room temperature (Table 3). It is evident from Table 3 that maximum red colour (a-value) was obtained for wax dilution of 4.8% while the red colour (a-value) was minimum for carnauba wax treated carrot with wax dilution of 6.7% as wax level. The analysis of variance studies had shown that storage periods, carnauba wax dilutions and interaction of storage period and dilution had significant ($P<0.001$, CD:$I_{0.12}$, $D_{0.12}$, $IxD_{0.13}$ at room temperature and $P<0.001$, CD:$D_{4.16}$ at low temperature) changes of red colour (a-value) of carnauba wax coated carrot during storage for 50 days (Table 3).

Changes in mean hardness of carnauba wax coated carrot during storage: The hardness in carnauba wax treated carrots decreased during storage at room temperature (26-32°C) and at low temperature (10°C) due to softening of tissues (Table 4). El-Anany et al, 2009 also reported that hardness in apple decreased with increasing the storage period in treated and untreated apple samples. Apple coated with edible wax such as jojoba wax, paraffin oil, soybean gum, glycerol and arabic gum retain the highest hardness as compared to uncoated apple samples during storage. The carnauba wax diluted to 5.3% wax level exhibited maximum hardness at room temperature and at low temperature (Table 4). The carnauba wax treated carrots with wax level of 5.3% had the hardness of 1107.6 gm after storage for 50 days at low temperature (10°C) while the carnauba wax treated carrots with wax level of 5.3% had hardness value of 909 gm after 35 days of storage at room temperature and which was sensory spoiled (Table 4). Control carrot without wax coating had the hardness values of 856.1 and 885.5gm after 20 and 40 days of storage at room temperature and at low temperature, respectively. It is evident from Table 4 that maximum hardness was obtained for wax dilution of 5.3% while the minimum hardness was obtained with carnauba wax dilution of 4.8%. The analysis of variance studies had shown that storage periods, carnauba wax dilutions and interaction of storage period and dilution had significant ($P<0.001$, CD:$I_{5.21}$, $D_{5.21}$, $IxD_{5.63}$ at room temperature and $P<0.001$, CD:$I_{1.36}$, $D_{1.38}$, $IxD_{1.75}$ at low temperature) changes of hardness (gm) of carnauba wax coated carrot during storage for 50 days (Table 4).

Changes in mean physiological loss in weight (PLW) of carnauba wax coated carrot during storage: The PLW in carnauba wax treated carrots increased during storage at room temperature (26-32°C) and at low

Table 5: Change in mean physiological loss in weight (PLW, %) of carnauba wax coated carrot during storage

		Days										
Sample	**Temp °C**	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Control		0.00	0.93	2.06	3.94	5.13	S	S	S	S	S	S
6.7%		0.00	0.79	1.64	2.70	3.71	4.04	S	S	S	S	S
5.9%	**26-32**	0.00	0.54	1.10	1.70	2.60	3.26	3.80	S	S	S	S
5.3%		**0.00**	**0.42**	**0.98**	**1.51**	**2.21**	**2.92**	**3.41**	**3.82**	**S**	**S**	**S**
4.8%		0.00	0.88	1.70	2.87	3.86	4.20	S	S	S	S	S
Control		0.00	0.82	1.33	1.89	2.39	2.80	3.37	3.75	4.22	S	S
6.7%		0.00	0.60	1.00	1.43	1.90	2.27	2.30	3.00	3.46	3.90	4.30
5.9%	**10**	0.00	0.41	0.71	1.07	1.34	1.67	2.00	2.37	2.70	3.11	3.46
5.3		**0.00**	**0.39**	**0.59**	**0.90**	**1.20**	**1.56**	**1.86**	**2.17**	**2.40**	**2.89**	**3.24**
4.8%		0.00	0.72	1.16	1.60	2.01	2.46	2.88	3.30	3.67	4.19	4.60

$P<0.001$, CD :$I_{0.14}$, $D_{0.14}$, $IxD_{0.15}$(room temperature); $P<0.001$, CD :$I_{0.10}$, $D_{0.10}$, $IxD_{0.12}$(low temperature)

Table 6: Change in mean moisture (%) of carnauba wax coated carrot during storage

		Days										
Sample	**Temp °C**	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Control		89.67	88.09	87.01	86.00	85.12	S	S	S	S	S	S
6.7%		89.67	88.52	87.69	86.75	85.91	85.36	S	S	S	S	S
5.9%	**26-32**	89.67	88.91	88.13	87.29	86.69	85.75	85.16	S	S	S	S
5.3%		**89.67**	**89.27**	**88.65**	**87.78**	**86.99**	**86.04**	**85.65**	**85.30**	**S**	**S**	**S**
4.8%		89.67	88.36	87.47	86.57	85.70	85.26	S	S	S	S	S
Control		89.67	89.27	88.88	88.49	88.09	87.70	87.30	86.89	86.50	S	S
6.7%		89.67	89.37	89.07	88.77	88.47	88.25	87.94	87.65	87.36	87.05	86.76
5.9%	**10**	89.67	89.45	89.26	89.02	88.84	88.61	88.36	88.13	87.94	87.74	87.54
5.3%		**89.67**	**89.58**	**89.46**	**89.33**	**89.23**	**89.11**	**89.00**	**88.92**	**88.83**	**88.70**	**88.60**
4.8%		89.67	89.34	89.05	88.73	88.34	88.23	87.94	87.62	87.34	87.00	86.55

$P<0.001$, CD :$I_{0.12}$, $D_{0.12}$, $IxD_{0.13}$(room temperature); $P<0.001$, CD :$I_{0.68}$, $D_{0.69}$, $IxD_{0.87}$(low temperature)

temperature (10°C). The carnauba wax diluted to 5.3% wax level exhibited minimum PLW at room temperature and at low temperature (Table 5). The carnauba wax treated carrots with wax level of 5.3% had PLW of 3.24% after 50 days of storage at low temperature (10°C) while the carnauba wax treated carrots with wax level of 5.3% spoiled after 35 days of storage at room temperature (Table 5). Control carrots without wax coating had maximum PLW of 5.13 and 4.22% after 20 and 40 days of storage at room temperature and at low temperature, respectively. It is evident from Table 5 that minimum PLW (%) was obtained for wax dilution of 5.2%. El-Anamy et al., 2009 also supported our results and reported that edible coating through jojoba wax, paraffin oil, soybean gum, glycerol and arabic gum caused significant ($P<0.05$) reduction in weight loss as compared to fully controlled apple samples. The analysis of variance studies had shown that storage periods, carnauba wax dilutions and interaction of storage period and dilution had significant ($P<0.001$, CD:$I_{0.14}$, $D_{0.14}$, $IxD_{0.15}$ at room temperature and $P<0.001$, CD:$I_{0.10}$, $D_{0.10}$, $IxD_{0.12}$ at low temperature) changes of PLW (%) of carnauba wax coated carrot during storage for 50 days (Table 5).

Changes in mean moisture content in carnauba wax coated carrot during storage: The changes in mean moisture content in carnauba wax treated carrot are presented in Table 6. The moisture content in carnauba wax treated carrots decreased during storage at room temperature (26-32°C) and at low temperature (10°C). The carnauba wax diluted to 5.3% exhibited maximum retention of moisture content at room temperature and at low temperature (Table 6). The carnauba wax treated carrots with wax level of 5.3% had the moisture content of 88.6% after storage for 50 days at low temperature (10°C) while the carnauba wax treated carrots with wax level of 5.3% were spoiled after 35 days of storage at room temperature (Table 6). Control carrots without wax coating had the moisture content of 85.12% and 86.50% after 20 and 40 days of storage at room temperature and at low temperature, respectively. It is evident from Table 6 that maximum moisture content was obtained at 5.3% level of dilution while the minimum moisture content was found in carnauba wax treated carrot with dilution of 4.8%. Chien et al., 2005 reported that higher loss in uncoated fruits can be attributed due to higher rate of respiration and transpiration during storage. The analysis of variance studies had shown that periods, carnauba wax dilutions and interaction of storage period and dilution had significant ($P<0.001$, CD:$I_{0.12}$, $D_{0.12}$, $IxD_{0.13}$ at room temperature and $P<0.001$, CD:$I_{0.68}$, $D_{0.68}$, $IxD_{0.87}$ at low temperature) changes of moisture content (%) of carnauba wax coated carrot during storage for 50 days (Table 6).

Changes in mean â- carotene of carnauba wax coated carrot during storage: The â- carotene content in carnauba wax treated carrots decreased during storage at room temperature (26-32°C) and at low temperature (10°C). The carnauba wax diluted to 5.3% wax level exhibited maximum â-carotene content at room temperature and at low temperature (Table 7) but there has been little differences in all carnauba wax treated carrot samples during storage The carnauba wax treated carrots with wax level of 5.3% had the â-carotene 6.31 mg/100g after storage for 50 days at refrigerated storage temperature (10°C) while the carnauba wax treated carrots with wax level of 5.3% were spoiled after 35 days of storage at room temperature (Table 7). Control carrots without wax coating had the â-carotene of 5.67 and 6.01 mg/100g after 20 and 40 days of storage at room temperature and at low temperature, respectively. It is evident from Table 7 that maximum â-carotene (mg/100g) was obtained for wax dilution of 5.3% followed by 5.9% and 6.7% while the â-carotene (mg/100g) content was minimum in carnauba wax treated carrot with wax dilution of 4.8% as wax level. The analysis of variance studies had shown that storage periods, carnauba wax dilutions and interaction of

Table 7: Change in mean â- carotene (mg/100g) of carnauba wax coated carrot during storage

		Days										
Sample	**Temp °C**	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Control		8.01	7.41	6.86	6.43	5.67	S	S	S	S	S	S
6.7%		8.01	7.61	7.02	6.69	6.27	5.99	S	S	S	S	S
5.9%	**26-32**	8.01	7.73	7.19	6.90	6.76	6.31	6.09	S	S	S	S
5.3%		**8.01**	**7.95**	**7.52**	**7.21**	**7.08**	**6.88**	**6.72**	**6.44**	**S**	**S**	**S**
4.8%		8.01	7.54	7.0	6.52	6.11	5.78	S	S	S	S	S
Control		8.01	7.66	7.44	7.21	6.91	6.50	6.32	6.10	6.01	S	S
6.7%		8.01	7.87	7.63	7.60	7.21	7.08	6.88	6.74	6.42	6.18	6.01
5.9%	**10**	8.01	7.91	7.78	7.70	7.47	7.20	7.02	6.84	6.50	6.37	6.12
5.3		**8.01**	**7.99**	**7.81**	**7.73**	**7.50**	**7.32**	**7.13**	**6.97**	**6.72**	**6.51**	**6.31**
4.8%		8.01	7.80	7.61	7.55	7.13	6.98	6.78	6.57	6.32	6.03	5.87

$P<0.001$, CD :$I_{0.19}$, $D_{0.19}$, $IxD_{0.21}$(room temperature); $P<0.001$, CD :$I_{0.03}$, $D_{0.03}$, $IxD_{0.04}$(low temperature)

storage period and dilution had significant ($P<0.001$, CD:$I_{0.19}$, $D_{0.19}$, $IxD_{0.21}$ at room temperature and $P<0.001$, CD:$I_{0.03}$, $D_{0.03}$, $IxD_{0.04}$ at low temperature) changes of â-carotene (mg/100g) of carnauba wax coated carrot during storage for 50 days (Table 7).

सारांश

गाजर एक महत्वपूर्ण सब्जी है जिसे सलाद के अलावा जूस, पाउडर एवं हलुवा के रूप में उपयोग करते हैं। आर्थिक दृष्टिकोण से संसार की सबसे महत्वपूर्ण सब्जी मानी जाती है एवं मानव आहार में कोरोटीन की धनी भी है। गाजर में कोनोआवैक्स के प्रयोग का उददेश्य रंग, सुगंध, नमी एवं कसावट कमी को बचाना जिससे गाजर में लम्बे समय तक ताजापन बना रहे। कारनौबा को 5.3 प्रतिशत के स्तर पर तनु करण कर 20–25 दिनों तक सामान्य तापक्रम पर भण्डारण एवं 50 दिनों तक रेफ्रीजेरेटेड दशा में रखने पर अधिकतम सुंगन्ध को प्रदर्शित किया। कारनौबा वैक्स के 4.8 प्रतिशत स्तर तक तनुकरण से अधिकतम लाल रंग (ए वैल्यू) सामान्य तापक्रम एवं कम तापक्रम पर पाया गया लेकिन लाल रंग में मात्र 4.8 प्रतिशत तथा 2.3 प्रतिशत वैक्स स्तर पर पाया गया। कारनौबा वैक्स शोधित गाजर का बल (ग्राम) कोशिका सावर मूल्य सामान्य तापक्रम कोशिका सावर मूल्य सामान्य तापक्रम (26–32 सेन्टीग्रेड) पर बड़ा पाया गया। कारनौबा वैक्स का 5.3 प्रतिशत तनुकरण स्तर से 3.24 प्रतिशत एवं अधिकतम पी.एल.डब्लू (3.82 प्रतिशत) 50 दिनों तक प्रशीतन से तथा 35 दिनों तक सामान्य तापक्रम के भण्डारण पर पाया गया।

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