



# Effect of Type and Permeability Behaviour of Packaging Material on the Quality Characteristics of Dried Carrot Roundels during Storage

Pradeep Kumar<sup>1\*</sup>, N. S. Thakur<sup>1</sup>, K. D. Sharma<sup>1</sup>, Hamid<sup>1</sup>  
and Abhimanyu Thakur<sup>1</sup>

<sup>1</sup>Department of Food Science and Technology, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP 173230, India.

## Authors' contributions

*This work was carried out in collaboration among all authors. Author PK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors NST, Hamid and AT managed the analyses of the study. Author KDS managed the literature searches. All authors read and approved the final manuscript.*

## Article Information

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## ABSTRACT

Carrot (*Daucus carota* L) is a carotenoids rich vegetable which is mainly consumed raw, converted to various products and cooked vegetable dishes. Present studies were carried out to study the changes observed in quality characteristics of dried carrot roundels during storage. Steam blanching and KMS dipping of carrot roundels followed by mechanical cabinet drying was found to be the best pretreatment for drying of carrot roundels as discussed earlier. These dried carrot roundels were further packed and stored under refrigerated (4-7°C) and ambient (11.6-26.2°C) storage conditions for 12 months. The dried carrot roundels packed in aluminium laminated pouches and stored under refrigerated conditions showed minimum increase in physico-chemical characteristics like moisture content (11.03%), water activity (0.310), pH (6.04), reducing sugars (21.00%), total sugars (35.36%) and retained highest amounts of titratable acidity (0.73%), carotenoids (29.40mg/100g), total phenols (87.50mg/100g), crude fibres (4.16%), rehydration ratio (7.81), antioxidant activity (52.68%)

\*Corresponding author: E-mail: [pradeep6751@gmail.com](mailto:pradeep6751@gmail.com);

and SO<sub>2</sub> content (174.75 ppm), respectively. The sensory characteristics scores like colour (8.05), texture (7.48), taste (6.88) and overall acceptability (7.54), respectively were also retained highest in the aluminium laminated pouch under refrigerated storage condition.

**Keywords:** Carrot (*Daucus carota* L.); roundels; carotenoids; aluminium laminated pouch; polyethylene pouch.

## 1. INTRODUCTION

Carrot (*Daucus carota* L.) is a root vegetable cultivated throughout the world for its fleshy edible roots. Primary centre of origin of carrot was Afghanistan from where it was distributed to Asia, Europe, North Africa and the Mediterranean region [1]. In India, the carrot is said to have been introduced from Persia. Major carrot producing states in India are Haryana, Andhra Pradesh, Uttar Pradesh, Assam, Karnataka, Punjab and Tamil Nadu. Carrot contains higher amount of carotenoids both  $\alpha$  and  $\beta$  carotene and vitamins such as B<sub>1</sub>, B<sub>2</sub>, B<sub>6</sub>, B<sub>12</sub>, dietary fibers and minerals like calcium, potassium and phosphorus [2,3]. The presence of handsome amount of the vitamins, bioactive compound including phenols and minerals have led this vegetable to rank it among top ten fruits and vegetables [4]. The consumption of fresh as well as processed products of carrot has increased steadily due to their recognition as an important functional food having antioxidant and anticancer activities [5,6]. The antioxidants like phenolics, carotenoids and polyacetylenes having various health benefits have been found in appreciable amount in carrot [7]. Carrot being perishable and seasonal, it is not possible to make it readily available throughout the year. Drying of carrot during the main growing season and its storage is one of the important alternatives of its preservation. Various value added products like juice, drink, candy, preserve, soups, stews, curries, pies, *halwa*, ice-cream and cooked vegetable dishes have also been prepared from fresh carrot keeping in mind its nutritional importance [8], but not much efforts have been made for drying and storage of different forms of carrot so that it can be made available throughout the year. Therefore the present investigations were aimed to study the quality characteristics changes in dried roundels of carrot during storage so as to utilize it as food item.

The objective was to study the effect of type and permeability behaviour of packaging material on quality characteristics of dried carrot roundels during storage.

## 2. MATERIALS AND METHODS

### 2.1 Procurement and Preparation of Raw Material

Carrot roots of uniform shape, size, colour and maturity were procured from local market of district Solan. Carrot roots were washed, peeled, cut into one cm thick roundels and were further steam blanched and pretreated with KMS dipping [9]. These pretreated forms of carrot were then dried in mechanical cabinet drier at standardized temperature of 60±2°C [10]. The best dried carrot roundels were further packed in different packaging materials viz. ALP (aluminium laminated pouch) T<sub>2</sub> (99.8 gsm) and PEP (polyethylene pouch) T<sub>1</sub> (93.9 gsm). These packed dried carrot roundels were stored under ambient (11.6-26.2 °C) and refrigerated (4-7 °C) temperature conditions upto a period of 12 months for storage studies. The observations for different quality parameters were recorded at 0, 3, 6, 9 and 12 months interval of storage.

### 2.2 Physico-chemical and Sensory Analysis

Among various chemical characteristics of dried carrot roundels observed during storage moisture content was estimated by drying the weighed samples to a constant weight in a hot air oven at 70±1°C. Loss in weight of dried carrot roundels after drying representing the moisture content and was expressed as per cent (W/W). Water activity of the dried carrot roundels was estimated by computer based digital water activity meter (HW3 model, Rotronic International, Switzerland). The titratable acidity, sugars, carotenoids, sulphur dioxide, ash content and rehydration ratio were determined by the method given by [11]. The pH of dried carrot roundels was determined by using a digital pH meter (CRISON Instrument, Ltd, Spain). Crude fibres content was estimated by the method given by [12]. The total phenol content was determined by the Folin-Ciocalteu procedure given by Singleton and [13]. Antioxidant activity was measured as per the method of [14].

Sensory analysis of dried carrot roundels during storage was carried out by using 9 point hedonic scale as described by the [15].

### 2.3 Statistical Analysis

The data pertaining to the sensory evaluation of dried carrot roundels replicated three times were analyzed by Randomized Block Design (RBD) as described by [16]. Whereas the data pertaining to the physico-chemical characteristics was replicated three times and analysed using Completely Randomized Design (CRD) [17].

## 3. RESULTS AND DISCUSSION

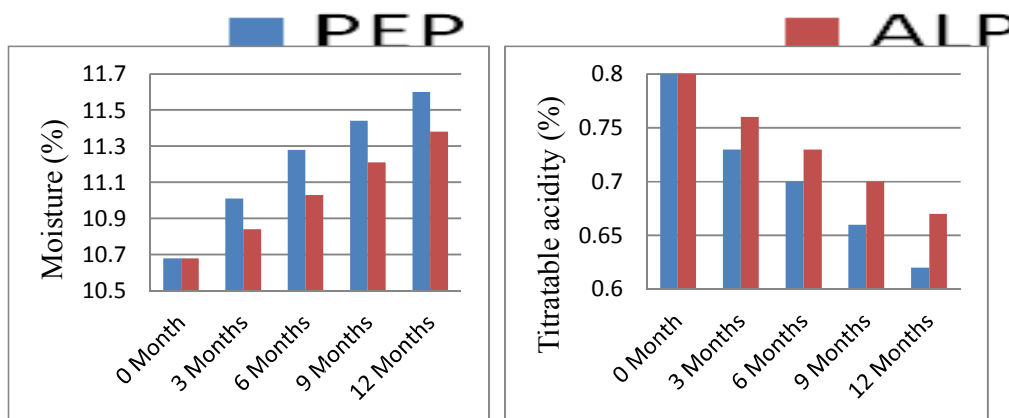
Results in Fig. 1 (a, c, and d) and Table 1 indicates that there was a general increase in moisture, pH, total sugars and water activity was recorded during 12 months storage of roundels, whereas, data presented in Fig. 1 (b, e, f, g and h) and Tables 2 and 3 reveals that titratable acidity, total phenols, crude fibres, rehydration ratio, SO<sub>2</sub>, carotenoids and antioxidant activity, decreased with the advancement of storage period. The moisture content of the roundels increased significantly from 10.68 to 11.49 per cent during storage. The above results are in conformity with the earlier reported results [18, 19] which have observed increase in moisture content of dried carrot slices during storage packed in ALP under ambient storage conditions, which might be due to the absorption of moisture from its surroundings as a result of its hygroscopic nature. Other reason of increase in the moisture content during storage might be because of the release/formation of water during non-enzymatic browning reactions in the product [18,19,20]. However, the water activity of the roundels increased significantly from 0.278 to 0.352 during storage. Similarly Increase of water activity in dried carrot slices packed in ALP under ambient temperature storage conditions have also been reported [19], which might be due to the absorption of moisture by carrot roundels. There was a gradual decrease in titratable acidity of the roundels from 0.80 to 0.65 per cent was observed during storage, might be due to the participation of acids in the conversion of non reducing sugars to reducing sugars and also in non enzymatic browning reactions [21]. A similar result of decrease in titratable acidity in carrot pomace powder and carrot slices has been reported [22,19]. The pH content of the roundels increased significantly from 5.88 to 6.25 during storage, which might be due to the decrease in

its acid content as a result of copolymerization of acids with sugars and amino acids in the non-enzymatic browning reactions. Increase in the pH during storage has also been observed in horse chestnut flour. Significant increase in the reducing sugars of the roundels from 20.70 to 21.39 per cent was observed during storage [23]. The total sugars of the roundels shows that it increased significantly from 34.80 to 35.98 per cent during storage, which might be attributed to the hydrolysis of polysaccharides and their subsequent conversion to reducing sugars. The carotenoids of the dried carrot roundels decreased significantly from 30.10 to 28.76 mg/100g during storage. The decrease in carotenoids content of dried carrot slices during storage have also been observed, which might be due to their susceptible nature towards oxidative losses caused by air, temperature and light [19]. A significant decrease in total phenols of the roundels from 97.50 to 75.75mg/100g was observed during storage, which might be attributed to their oxidation as a result of decreased residual SO<sub>2</sub> during storage which lead to the participation of total phenols in browning reactions as has clearly been reported [24]. The crude fibres of the dried carrot roundels show that it decreased from 4.40 to 3.90 per cent during storage. Non-significant decrease in crude fibres of dried chilgoza nut during storage [25]. The rehydration ratio of the roundels decreased significantly from 8.00 to 7.60 during storage period of twelve months, which might be due to the changes in macromolecular components including cellulose, pectin and hemicelluloses content [19]. Decrease in rehydration ratio of carrot slices and pomace powder during storage [22]. Other reason of decrease of rehydration ratio could be attributed to the reduction in water binding sites due to chemical and structural changes in major components of the product [19]. A significant decrease in antioxidant activity of the dried carrot roundels from 53.30 to 52.05 per cent was observed during storage, might be due to the loss of various chemical characteristics like carotenoids, total phenols and ascorbic acid in dried carrot roundels and other reason could be the non-enzymatic browning reactions. Decrease in antioxidant activity of bael powder during storage [26]. The SO<sub>2</sub> of the roundels decreased significantly from 181.25 to 167.81 ppm during storage, which might be due to its escape from the packaging material or its involvement in the various chemical reactions. These results for decrease in residual SO<sub>2</sub> are in accordance with those reported earlier in dried carrot slices [19].

The colour score of the dried carrot roundels decreased significantly from 8.40 to 7.58 during storage. A significant decrease in the texture score of the roundels from 8.00 to 6.95 was observed during storage. The taste score of the roundels decreased significantly from 7.30 to 6.40 during storage. A significant decrease in the overall acceptability score of the dried carrot roundels from 8.00 to 7.03 was observed during storage period of twelve months. Decrease in sensory characteristics score of dried carrot roundels observed during storage might be due to reduction in colour intensity which could be as a result of degradation of carotenoids of dried carrot roundels which might have also lead to the occurrence of non enzymatic browning and oxidation reactions. Changes in various chemical characteristics of the dried carrot roundels might have lead the judges to award the lower sensory characteristics scores to the product. Distortion/disruption of texture of the product could also have contributed towards the poor scores of the product during storage. Earlier similar trend for decrease in sensory

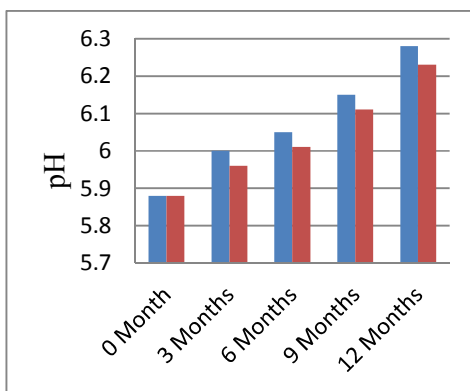
characteristics score have also been observed in carrot slices [27].

While comparing different packaging material, maximum retention of titratable acidity, carotenoids, total phenols, rehydration ratio, antioxidant activity and SO<sub>2</sub> were recorded in ALP (T<sub>2</sub>) under refrigerated temperature condition, however, the minimum were recorded in Polyethylene pouch (T<sub>1</sub>) during storage period of 12 months under ambient temperature conditions. Among the different packaging material, minimum increase in water activity, moisture and reducing sugars and total sugars of the dried carrot roundels were recorded in ALP (T<sub>2</sub>) under refrigerated temperature condition, however, maximum were recorded in Polyethylene pouch (T<sub>1</sub>) under ambient temperature conditions during storage period of 12 months. Results pertaining to changes in sensory scores (colour, taste, aroma, texture & overall acceptability) of the dried carrot roundels during storage are presented in.

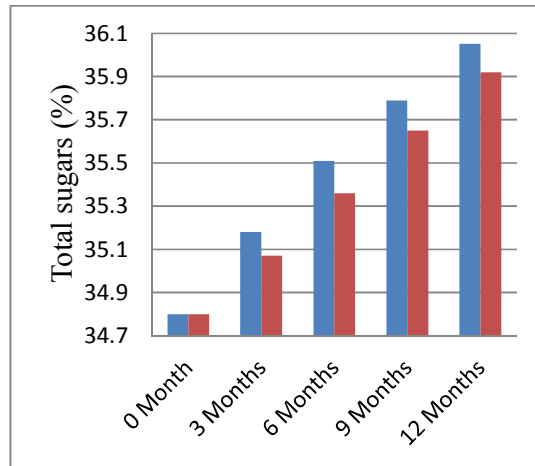


a. Moisture (%)

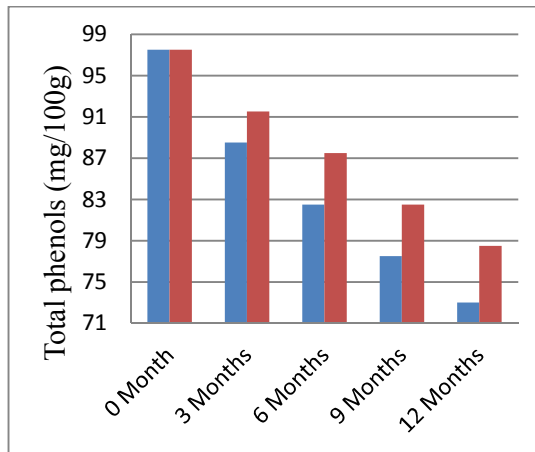
b. Titratable acidity (%)



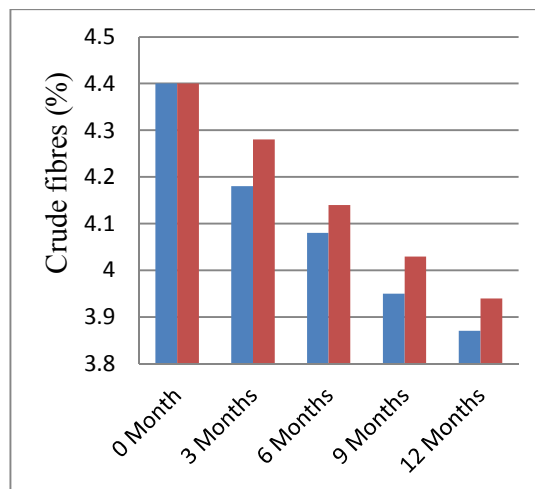
c. pH



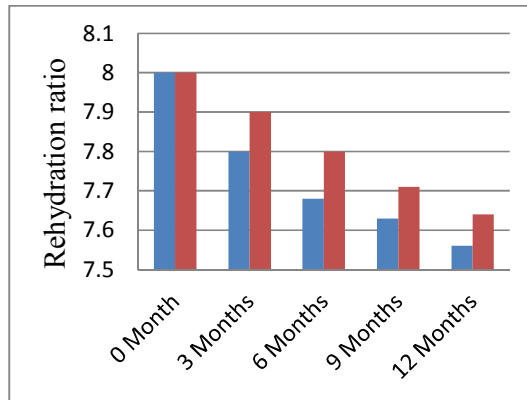
d. Total sugars (%)



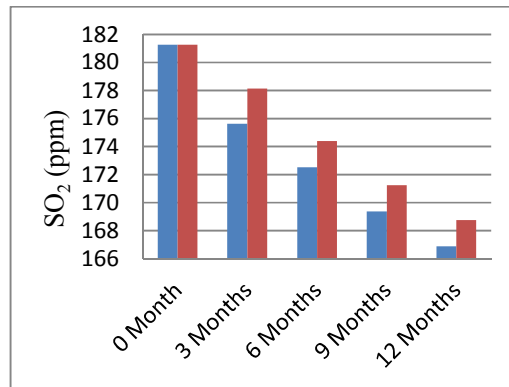
e. Total phenols (mg/100g)



f. Crude fibres (%)



g. Rehydration ratio



h. SO<sub>2</sub> (ppm)

Fig. 1. Effect of packaging material on physico-chemical characteristics of dried carrot roundels during storage

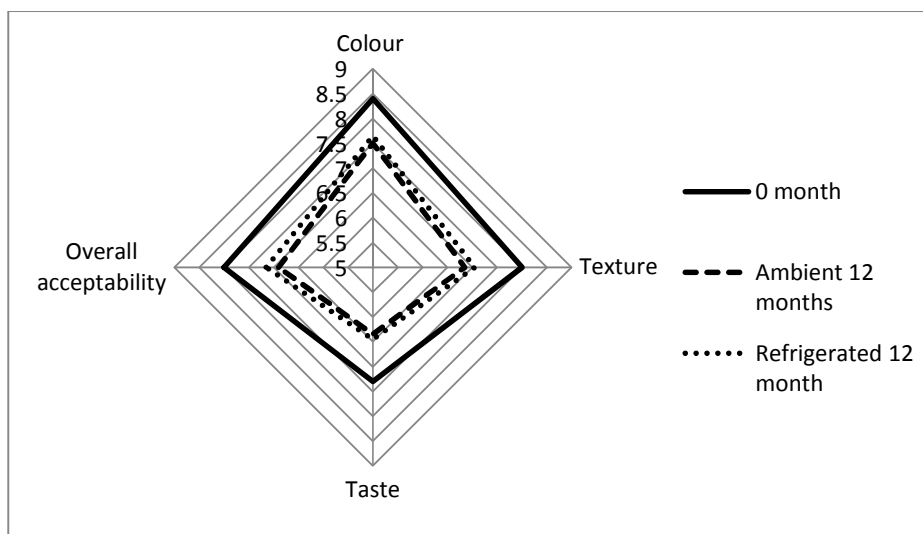


Fig. 2. Effect of packaging material on sensory characteristics of dried carrot roundels during storage

**Table 1. Effect of packaging material on the water activity of dried carrot roundels during storage**

V	Ambient storage (Months)					Mean	Refrigerated storage (Months)					Mean
	S/T	0	3	6	9		12	0	3	6	9	
T <sub>1</sub>	0.278	0.313	0.335	0.359	0.375	0.332	0.278	0.294	0.317	0.333	0.35	0.315
T <sub>2</sub>	0.278	0.298	0.321	0.343	0.351	0.318	0.278	0.283	0.303	0.319	0.328	0.302
<b>Mean</b>	0.278	0.306	0.328	0.351	0.363		0.278	0.289	0.310	0.326	0.341	
<b>Mean (V)</b>	0.325						0.309					
<b>T x S interaction table</b>							<b>CD<sub>(0.05)</sub></b>					
T	0	3	6	9	12	<b>Mean (T)</b>	Storage period (S)					0.002
T <sub>1</sub>	0.278	0.304	0.326	0.346	0.364	0.324	Storage conditions (V)					0.002
T <sub>2</sub>	0.278	0.291	0.312	0.331	0.340	0.310	Packaging material (T)					0.002
							S×V					0.004
							T×V					NS
<b>Mean (S)</b>	0.278	0.297	0.319	0.339	0.352		T×S					0.004
							T×S×V					NS

T<sub>1</sub>: Polyethylene pouch (PEP), T<sub>2</sub>: Aluminium laminated pouch (ALP)

**Table 2. Effect of packaging material on carotenoids (mg/100g) of dried carrot roundels during storage**

V	Ambient storage (Months)					Mean	Refrigerated storage (Months)					Mean
	S/T	0	3	6	9		12	0	3	6	9	
T <sub>1</sub>	30.10	29.13	28.85	28.61	28.35	29.01	30.10	29.65	29.36	29.11	28.95	29.43
T <sub>2</sub>	30.10	29.38	29.13	28.86	28.63	29.22	30.10	29.79	29.55	29.33	29.12	29.58
<b>Mean</b>	30.10	29.26	28.99	28.74	28.49		30.10	29.72	29.46	29.22	29.04	
<b>Mean (V)</b>	29.11						29.51					
<b>T x S interaction table</b>							<b>CD<sub>(0.05)</sub></b>					
T	0	3	6	9	12	<b>Mean (T)</b>	Storage period (S)					0.27
T <sub>1</sub>	30.10	29.39	29.11	28.86	28.65	29.22	Storage conditions (V)					0.17
T <sub>2</sub>	30.10	29.59	29.34	29.10	28.88	29.40	Packaging material (T)					0.17
							S×V					NS
							T×V					NS
<b>Mean (S)</b>	30.10	29.49	29.22	28.98	28.76		T×S					NS
							T×S×V					NS

T<sub>1</sub>: Polyethylene pouch (PEP), T<sub>2</sub>: Aluminium laminated pouch (ALP)

**Table 3. Effect of packaging material on the antioxidant activity (%) of dried carrot roundels during storage**

V	Ambient storage (Months)					Mean	Refrigerated storage (Months)					Mean		
	S/T	0	3	6	9		12	0	3	6	9		12	
T <sub>1</sub>		53.30	52.45	52.13	51.94	51.68	52.30	53.30	52.91	52.73	52.52	52.23	52.74	
T <sub>2</sub>		53.30	52.69	52.36	52.09	51.87	52.46	53.30	53.11	52.96	52.71	52.40	52.90	
<b>Mean</b>		53.30	52.57	52.25	52.02	51.78		53.30	53.01	52.85	52.62	52.32		
<b>Mean (V)</b>		52.38							52.82					
<b>T x S interaction table</b>							<b>CD<sub>(0.05)</sub></b>							
T	0	3	6	9	12	Mean (T)	Storage period (S)						0.25	
T <sub>1</sub>	53.30	52.68	52.43	52.23	51.96	52.52	Storage conditions (V)						0.16	
T <sub>2</sub>	53.30	52.90	52.66	52.40	52.14	52.68	Packaging material (T)						0.16	
							S×V						NS	
							T×V						NS	
<b>Mean (S)</b>	53.30	52.79	52.55	52.32	52.05		T×S						NS	
							T×S×V						NS	

T<sub>1</sub>: Polyethylene pouch (PEP), T<sub>2</sub>: Aluminium laminated pouch (ALP)



#### 4. CONCLUSION

It was concluded that the dried carrot roundels packed in aluminium laminated pouches and stored under refrigerated conditions showed minimum increase in physico-chemical characteristics like moisture content, water activity, pH, reducing sugars, total sugars and retained highest amounts of titratable acidity, carotenoids, total phenols, crude fibres, rehydration ratio and antioxidant activity, respectively. The sensory characteristics scores like colour (8.05), texture (7.48), taste (6.88) and overall acceptability (7.54), respectively were also retained highest in the aluminium laminated pouch under refrigerated storage condition. So dried roundels packed in aluminium laminated pouch can be stored safely for a period of 12 months under refrigerated condition without much changes in its overall quality. These dried carrot roundels can further be used for development of good quality nutritious instant products throughout the year.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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