

## Permeability of *Aloe vera* composite coatings and their effect on quality of peeled carrots

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**In this study, three different composite coatings having *Aloe vera* gel, viz. 5%, 10% and 15%, carboxymethyl cellulose, peanut oil and glycerol monostearate were prepared. The 15% composite coating had reduced O<sub>2</sub> and CO<sub>2</sub> permeability as well as water vapour transmission rate and higher viscosity. *A. vera* composite coating was applied on uniform healthy peeled carrots and they were packed in polyethylene bags. Storage was done at room and refrigerated temperature. During storage, surface microflora increased while total soluble solids, total sugars and total carotenoids decreased. The peeled carrots coated with 15% composite coating were best in quality at both room and refrigerated temperatures respectively.**

**Keywords:** *Aloe vera*, carrots, composite coatings, quality parameters.

CARROT (*Daucus carota*), belonging to the family Umbelliferae, is cultivated throughout the world for its edible fleshy roots. It possesses many medicinal properties. Carrots are the major source of carotenoid<sup>1</sup>. Demand for fresh, healthy and convenient food is continuously increasing, resulting into enormous growth in the minimally processed (MP) or ready-to-use (RTU) vegetables industry. But the market life of MP fruits and vegetables is limited by a series of problems related to cell disruption such as leakage of nutrients, enzymatic reactions, mould growth and lactic acid fermentation, loss of texture, development of off-flavours, off-odours and appearance defects. Likewise, when carrots are minimally processed, the product loses its turgidity and develops odours characteristic of anaerobic catabolism due to the high rate of respiration and microbiological deterioration during storage<sup>2</sup>, which reduces their consumer acceptability.

Therefore, it is necessary to develop methods to preserve MP commodities for longer storage. The most commonly used method is edible coating. Here, a thin layer of edible material is applied to the product surface, which protects perishable food products by retarding dehydration, suppressing respiration, improving textural quality, helping to retain volatile flavour compounds and reducing microbial growth. Edible coatings create a

modified atmosphere within the food product by controlling respiratory gas exchange. Such coatings may be of different compounds, viz. hydrocolloids (polysaccharides and proteins), hydrophobic compounds (lipids and waxes), or a combination of both (composite coatings)<sup>3</sup>. The use of composite coatings is beneficial to fresh produce, because each ingredient functions synergistically (lipids – good water barrier; hydrocolloids – good gas barrier) to provide a barrier for protection. The composite coatings adhere better to a large number of food surfaces due to both polar and non-polar compounds<sup>4</sup>. Thus, use of composite coatings represents a sound strategy to enhance the coating properties.

*Aloe vera*, family Liliaceae, is a tropical and subtropical plant that has been used for centuries for its medicinal and therapeutic properties. The leaves are the source of *A. vera* gel. Novel, edible coatings are developed to extend the shelf life of fruits and vegetables, using *A. vera* gel due to its moisturizing effect, antifungal and antibacterial properties<sup>5</sup>. *A. vera* gel coatings have been shown to prevent loss of moisture and firmness, check rate of respiration, maturation and oxidative browning, and lessen proliferation of microorganisms<sup>6</sup>. Less information is available on the use of *A. vera* in composite coatings of carrots and the available literature has been patented. Thus, in the present study we prepare *A. vera* composite coatings to assess the shelf life and quality of peeled carrots.

Uniform healthy carrots were sorted from local market and fresh *A. vera* leaves were procured from the Department of Medicinal Aromatic and Under-utilized Plants, Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar.

For gel preparation, upper epidermis was removed from *A. vera* leaves. Small cubes were cut from inner mucilaginous material. The cubes were heated for 10 min at 80°C. Grinding was done to obtain the gel.

Three *A. vera* composite coatings (AvCC) were prepared using 5%, 10% and 15% gel with carboxymethyl cellulose (CMC, 0.5%), peanut oil (5%) and glycerol monostearate (GMS, 2%; emulsifier). The mixture was homogenized in hot water for 30 sec at 4000 rpm. Water and glycerol were used as a solvent and plasticizer respectively, for preparation of coatings. All formulations were cooled at room temperature. The different coatings were applied on peeled carrots using a brush.

From the local market in Hisar, uniform healthy red carrots were sorted in January. They were subjected to various treatments, i.e. washing, peeling and coating with AvCC (5%, 10% and 15%). The peeled, uncoated carrots were used as control. Control and coated carrots were air-dried and packed in low density polyethylene (LDPE) (400 gauge) bags. The packs were stored under room and refrigerated conditions.

Six carrots were taken per pack weighing 500 ± 40 g. There were six replications per treatment. Samples were

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stored for 12 and 24 days at room ( $14 \pm 3^\circ\text{C}$ ,  $47\% \pm 8\%$ ) and refrigerated ( $5 \pm 2^\circ\text{C}$ ,  $55\% \pm 2\%$ ) conditions respectively. The various parameters were analysed every second and fourth day under room and refrigerated conditions respectively.

Three randomly selected carrots were evaluated for each variable under both storage conditions. Initial baseline values of each tested variable were based on zero day of the test period.

The coated and uncoated LDPE bags were flushed with  $\text{CO}_2$ . The bags were then sealed by vacuum packaging machine. Using a gas analyser (model 1902D, Quantak, USA), concentration of gas ( $\text{CO}_2$  and  $\text{O}_2$ ) after every 30 min was noted. Experiment was performed at room conditions ( $33^\circ\text{C} \pm 1$ ,  $20 \pm 5\%$  relative humidity (RH)). Gas permeability was measured using the following formula:

$$\text{Gas permeability} = Q \times X/A \times t \times \Delta P,$$

where  $Q$  is the quantity of permeant,  $X$  the thickness of the film,  $A$  the area,  $\Delta P$  the concentration difference and  $t$  is the time. The gas ( $\text{O}_2$  and  $\text{CO}_2$ ) transmission rate ( $\text{cm}^3 \text{cm}^{-2} \text{sec}^{-1} \text{Pa}^{-1}$ ) was assessed.

Water vapour transmission rate (WVTR;  $\text{g}/\text{m}^2 \cdot \text{d}$ ) was examined by static method using wide-open-mouth glass dish. Powdered  $\text{CaCl}_2$  (anhydrous) was kept and covered with cellophane film which were coated with different *A. vera* coating formulations (5%, 10% and 15% AvCC). Thickness of the coating was 0.06 mm as measured by gauge meter. Vacuum grease was used to make airtight. Vials closed with uncoated cellophane film act as control. Desiccators containing saturated  $\text{KNO}_3$  solution were used to maintain all the prepared vials. Desiccators were kept at  $38^\circ\text{C}$  in an incubator at 90% RH.

Viscometer (Rheology International, Shannon, Ireland) was used for measuring viscosity of different coatings and assessed in centipoises (mPa.s). The spindle number and spindle speed used were 3 and 50 respectively.

Hand refractometer (range 0–32%) was used to analyse total soluble solids (TSS) of samples at ambient conditions. TSS were read in percentage directly on the scale. Total sugars were determined by the method of

Hulme and Narian<sup>7</sup>. Total carotenoids were estimated by AOAC (Association of Official Analytical Chemists) method<sup>8</sup>. Surface microflora of coated and uncoated carrots during storage was evaluated for total plate count.

The data obtained were subjected to ANOVA (analysis of variance) and thus estimated according to two factorial completely randomized designs (CRD). The critical difference (CD) at 5% level was used to make a comparison among various treatments during storage. The software package OPSTAT ([www.hau.ernet.in](http://www.hau.ernet.in)) was used to statistically analyse the experimental results.

The coatings significantly affected the gas concentration inside the coated and uncoated LDPE bags. The permeability of gases was maximum in control compared to coatings. Among the coatings, 15% AvCC was found to have least permeability. Table 1 shows that as the concentration of *A. vera* in coating formulations increases, the  $\text{O}_2$  and  $\text{CO}_2$  permeability decreases.

Temperature and RH influence the gas permeability of edible coatings. The coatings showed minimum permeability that could be attributed to blocking of pores of the polymeric film (LDPE)<sup>6,9</sup>. The reduction in gas permeability of 15% AvCC could be due to higher concentration of glucomannans (polysaccharide found in *A. vera* gel) resulting in good gas barrier property.

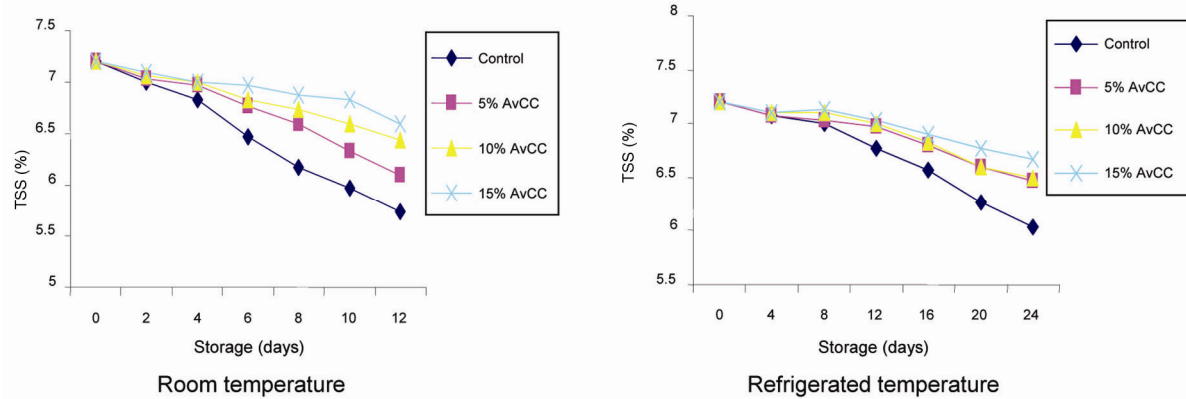
Control possessed highest WVTR (Table 1), which could be attributed to the moisturizing and hygroscopic behaviour of *A. vera* and also due to the presence of stearate that may have increased water vapour resistance<sup>10</sup>. This enables the formation of a barrier towards water diffusion, which helps in avoiding external transference of water vapour<sup>11,12</sup>. As concentration of *A. vera* gel increases in coating formulations, WVTR decreases. Thus, 15% AvCC shows least WVTR due to increased concentration of *A. vera* gel that may have resulted in better and effective moisturizing effect.

With the increase in concentration of *A. vera* gel in coating formulations, viscosity increases (Table 1). This may be due to the mucilaginous characteristics of *A. vera* gel<sup>11</sup>. Maximum viscosity was found in 15% AvCC and minimum in 5% AvCC, which helps in better spread ability of the coatings.

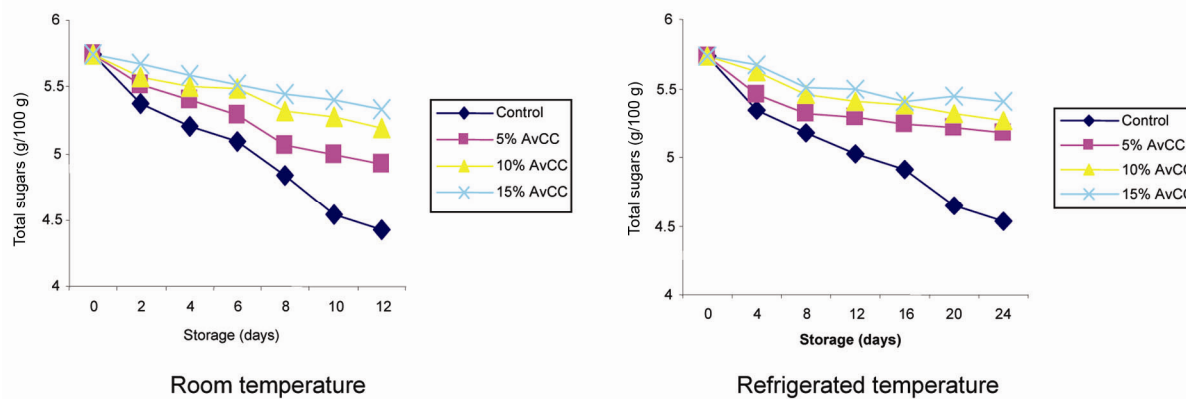
**Table 1.** Physical properties of *Aloe vera* composite coatings

Treatment	Gas permeability ( $\text{cm}^3 \text{cm}^{-2} \text{s}^{-1} \text{Pa}^{-1}$ )		Water vapour transmission rate ( $\text{g}/\text{m}^2 \cdot \text{day}$ )	Viscosity ( $\times 10^3$ mPa.s)
	$\text{O}_2$	$\text{CO}_2$		
Control	$11.11 \pm 0.06$	$37.94 \pm 0.32$	$117.3 \pm 17.13$	–
5% AvCC	$3.44 \pm 0.02$	$26.74 \pm 0.19$	$105.7 \pm 10.72$	$77.0 \pm 0.3$
10% AvCC	$3.09 \pm 0.02$	$18.74 \pm 0.09$	$87.0 \pm 11.16$	$118.6 \pm 0.3$
15% AvCC	$2.44 \pm 0.02$	$10.44 \pm 0.03$	$82.0 \pm 7.37$	$147.7 \pm 0.5$
CD at 5%	0.066	0.796	23.17	0.08

Values are mean  $\pm$  SD ( $n = 3$ ); Control for gas permeability – low density poly ethylene film; Control for water vapour transmission rate – Cellulose acetate film.



**Figure 1.** Effect of storage and *Aloe vera* composite coatings on total soluble solids (TSS) of peeled carrots.



**Figure 2.** Effect of storage and *Aloe vera* composite coatings on total sugars (g/100 g) of peeled carrots.

Significant decrease in TSS content was observed during storage under both conditions, viz. room and refrigerated (Figure 1). Loss of TSS could be due to utilization of sugars in respiration and other metabolic activities. A significant difference was observed in TSS content among the treatments. The uncoated peeled carrots showed higher loss in TSS which could be due to higher respiratory and metabolic activities due to peeling, resulting in injury to the commodity. Similar trend was observed in all the treatments under refrigerated temperature with values having lower magnitude due to reduced respiration and metabolic activities.

At room temperature, minimum TSS was observed in uncoated peeled carrots. In coated samples, maximum TSS was detected in 15% AvCC. Coated samples retained higher TSS due to AvCC which could have provided effective gas barrier. Maximum TSS in loquat coated with 3%  $\text{CaCl}_2$  compared to uncoated loquat could be attributed to higher concentration of  $\text{CaCl}_2$  (3%) forming a thin layer on fruit surface which retards deterioration, as observed by Akhtar *et al.*<sup>13</sup>

The storage had significant effect on total sugar content of peeled carrots (Figure 2). The decreased total sugar content at storage periods could be due to utiliza-

tion of sugars in respiration and other metabolic activities.

Significant difference was observed among the treatments in total sugars of peeled carrots. The uncoated peeled carrots showed higher loss in total sugars, which may be attributed to higher respiration and metabolic activities due to peeling. Among the coated samples, at room temperature, 15% AvCC showed maximum total sugars followed by 10% AvCC and 5% AvCC. Similar trend was observed in all the treatments under refrigerated temperature with values having lower magnitude due to reduced respiration and metabolic activities.

Minor effect of coating on sugar content has been examined by Howard and Dewi<sup>14</sup>. However, the coated samples had higher sugar retention than uncoated samples. High loss in glucose and fructose may be due to higher rate of respiration in uncoated carrots. Coating might have produced an internal modified atmosphere that has resulted in retardation of respiration rate and consumption of glucose and fructose in the coated samples.

Significant decrease in carotene content was observed during storage under room and refrigerated conditions (Figure 3). Possible reasons for this could be autoxidation

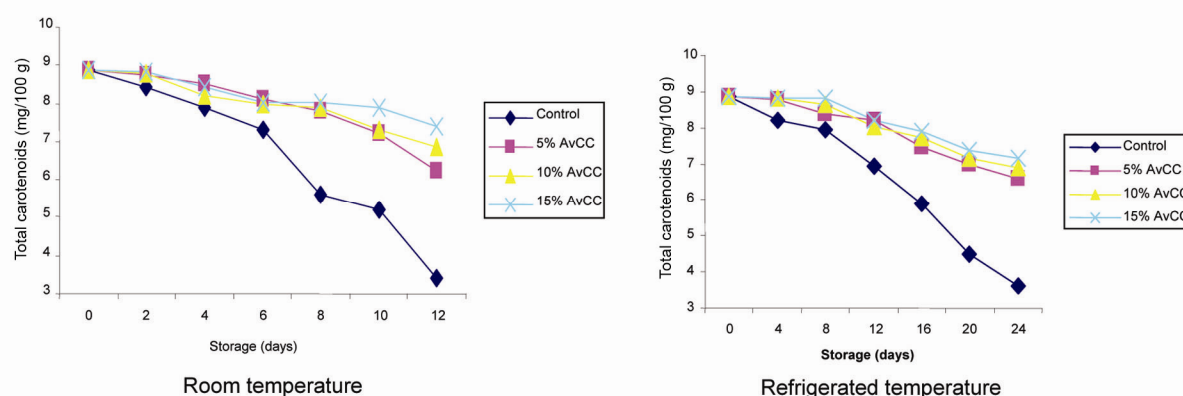


Figure 3. Effect of storage and *Aloe vera* composite coatings on total carotenoids (mg/100 g) of peeled carrots.

Table 2. Effect of storage and *Aloe vera* composite coatings on surface microflora of peeled carrots

Storage → Treatment ↓	Surface microflora (log cfu/g)		
	Zero day	Room temperature (12 days)	Refrigerated temperature (24 days)
Fresh peeled	3.68	7.38	7.24
Coated			
5% AvCC	NA	7.32	7.18
10% AvCC	NA	7.26	7.19
15% AvCC	NA	6.74	6.42

NA, Not analysed.

and enzymatic oxidation. Carotenoid content of peeled carrots differed significantly among the treatments. Maximum carotenoid content was observed in 15% AvCC at both room and refrigerated temperatures respectively. The carotenoid content was found to be least in uncoated peeled carrots at both room and refrigerated temperatures. The uncoated peeled carrots showed minimum carotenoid at room and refrigerated temperatures. This could be due to peeling of the carrot surface so that the phloem is exposed (where carotenoids are more concentrated) to light and air, and got autoxidized. Pilon *et al.*<sup>15</sup> also found a slight decrease in  $\beta$ -carotene of minimally processed carrot and green pepper throughout storage.

Coated samples retained higher carotenoid content compared to uncoated peeled carrots. This might be attributed to modified atmosphere produced by edible coatings, which acts as a barrier for O<sub>2</sub> and CO<sub>2</sub>. Thus, autoxidation potential of carotenes decreased<sup>16</sup>.

The data (Table 2) reveals that storage had significant effect on microbial count of peeled carrots. The surface microflora of peeled carrots increased progressively throughout the storage period at room and refrigerated conditions. Also, 15% AvCC showed least microbial count followed by 10% AvCC and 5% AvCC. This may be attributed to more effective *A. vera* gel concentration which has antibacterial as well as antifungal activity. The

other coatings were not significant enough to check the growth of microorganisms. The microfloral growth of unpeeled carrots was ten-fold more than the 15% AvCC.

Similar result was observed in all the treatments on, 24th day at refrigerated temperature. Similar trends have been reported by Martinez *et al.*<sup>12</sup>. They found reduction in microbial count of *A. vera* gel-coated sweet cherries, while uncoated sweet cherries showed increase in microbial count. Valverde *et al.*<sup>17</sup> reported that *A. vera* gel reduces microbial population in table grapes. According to Olivas and Barbosa-Cànovas<sup>18</sup>, MP fruits and vegetables provide appropriate environment for the growth of microorganisms, which may be due to more moisture and sugar content. Modified atmosphere will develop on coated products, resulting in change in the growth of bacteria.

In the present study, three coating formulations from three concentrations of *A. vera* gel were prepared and applied on peeled carrots. Coatings differed significantly in terms of O<sub>2</sub> and CO<sub>2</sub> permeability and WVTR. Minimum O<sub>2</sub> and CO<sub>2</sub> permeability and WVTR was recorded for 15% AvCC. Viscosity was maximum for 15% AvCC that showed improved spreadability on the surface of carrots during storage. TSS showed significant decrease at room and refrigerated conditions during storage. Also, 15% AvCC showed maximum TSS at both the storage conditions. The total carotenoids showed significant decrease

with increase in storage. Among the treatments, significant difference was also observed with 15% AvCC-treated carrots having minimum decrease compared to uncoated peeled carrots. The minimum microbial load was found in 15% AvCC-treated carrots (7.08 and 6.42 log cfu/g) at room and refrigerated conditions respectively.

Thus, the results showed that 15% AvCC treatment is better than 10% AvCC and 5% AvCC in enhancing the shelf life of peeled carrots. There were significant changes in TSS, total sugars, total carotenoids and microbial composition during storage, indicating that the peeled carrots coated with 15% AvCC could be kept wholesome till 12 and 24 days under room and refrigerated conditions respectively.

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## Effect of ultra graphite application on morphological and physico-chemical properties of red soil

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**We assess the effect of ultra graphite on red soil collected from Cauvery delta region, Tamil Nadu, India. Soil samples were collected from the top 15 cm depth from the experimental site using conventional soil tillage technology. We provide a detailed comparison of the morpho- and physico-chemical changes of red soil samples with and without ultra graphite. FTIR, SEM, EDAX and soil analysis data support the fact that ultra graphite application significantly influences soil carbon, soil physico-chemical properties and exchange capacity of coarse-textured red soil.**

**Keywords:** Morphological and physico-chemical properties, red soil, soil quality, ultra graphite.

RESTORATION of soil quality through soil organic carbon (SOC) management has remained the major concern for tropical soils<sup>1</sup>. Soil organic matter (SOM) plays an essential

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