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RESEARCH ARTICLE

Effect of Various Packaging Materials on Sensory Quality of Herbal Edible Coated Pears

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ABSTRACT

The effect of packaging materials was studied on the quality of herbal edible coated pears by organoleptic evaluation at ambient and low temperature, the coated fruits were packed in jute bags, cloth bags, brown paper bags, HDPE (150 gauge or 38 micron) and LDPE (200 gauge or 50 micron). The coated and packaged fruits were stored at ambient temperature whereas coated fruits packed in HDPE and LDPE bags were stored at low temperature. The effect of packaging materials on herbal edible coated pear fruits was evaluated by sensory evaluation in terms of appearance/color, texture, taste and after taste. On the basis of sensory score, the jute bag was reported the best packaging material for packed coated pear at ambient temperature (31±2°C) during storage, however, HDPE was best packaging material at low temperature for coated pear. On the other hand, the best sensory score was revealed in beeswax herbal edible coated packed pears as compared to uncoated at both temperatures i.e. 31±2°C and 4°C. The packed coated fruits were having good quality and longer shelf life than uncoated samples during storage.

Keywords: Fruits & vegetables, Herbal edible coating, Tulsi (*Ocimum sanctum*), Packaging materials and Sensory attributes.

INTRODUCTION

The consumers are giving the preference to fresh fruits and vegetables for their nutritional components in their daily diet. Therefore, the demand of fresh produce is increasing day by day [2]. Pears are rich source of nutrients and healthy bioactive compounds such as carotenoids (flavonols, anthocyanins, kaemferol and isorhamnetin) and phenolic compounds [5]. After harvesting fresh fruits & vegetables cannot replenish carbohydrates or water, the fresh commodities use the stored sugar or starch in the respiration process and stop when reserve food becomes

finished. As a result, aging begins and responsible for the death and decaying of fresh fruits and vegetables [1]. Horticulture produce are highly perishable and because of this rapid deterioration are found during various processes after harvesting from the field therefore fresh produces are to be handled with much care to minimize the post-harvest losses. Pear (*Pyrus pyrifolia ver. Gola*) is climacteric fruit. In the ripening process, some changes are observed in color, firmness, acidity, sugar content, and aroma development [2]. These nutritional properties of the fresh fruits and vegetables are increasing the demand for fresh fruits and vegetables in the market. Recent studies have been reported to prolong the shelf life of pears using edible coatings that are used to improve the handling characteristics of the fruits and vegetables, reporting the ability of this technological strategy to retard changes in oxygen, aromas, moisture and solute transport [2, 6]. Edible coatings are thin layers of material applied to the surface of the fruit and vegetable as an addition to or replacement for the natural protective waxy coating. Traditionally, edible coatings have been used to reduce water loss, but the recent development of formulated edible coatings with a wider range of permeability characteristics has extended the potential application to fresh produce 4. Therefore there is a growing interest in the use of degradable coatings from polysaccharide, protein, and lipid biopolymers. Edible coatings are preferred to enhance the storage or shelf life of fresh produces not only to have good barrier functionalities to gas and water vapour but also to have good sensory properties such as transparency and blend flavour [7]. Nowadays the edible coatings are one of the most useful innovative techniques of preservation which is used in post-harvest industry for increasing the shelf life and quality of horticulture produces [8]. The herbal edible coating is a novel technique for the post-harvest industry, which plays a significant role to minimize the post-harvest losses of fresh fruits and vegetables by extending the storage life. The researchers are highly focused on edible coating due to its demand and importance in post-harvest industry. Herbal edible coatings are made by incorporating aqueous herbal extract in edible coatings. The function of the edible coating can be improved by including herbs such as neem, mint, aloe vera, tulsi, basil, mentha, which act as antioxidants, antimicrobials, colorants, flavors, fortifying nutrients, and spices in edible coating formulation [9]. The herbal edible coatings enhance the shelf life of fresh fruits and vegetables several folds at ambient as well as low temperature. But not many studies have been conducted to study the effect of various packaging material on the herbal edible coated fruits and vegetables [4]. Hence the main objective of this study was to find out the effect of different packaging material on the sensory attributes of herbal edible coated fruits and vegetables so that a suitable packaging material may be recommended for the herbal edible coated fruits and vegetables.

MATERIALS AND METHODS

Raw Materials

The fruits were selected at green–mature stage from Haridwar, Uttarakhand and transported to the Jayoti Vidyapeeth Women's University, Jaipur, Rajasthan. The fresh pears were selected fresh, mature, clean, uniform in shape and size. The selected pears were divided into two groups on the basis of temperature and coating types demonstrated in Table 1a and 1b. TC_1 and TC_2 was uncoated pear at ambient temperature (31±2°C and 70±8% RH) and low temperature (4°C). Each group was containing 10 pears. Pears were washed with water for 5-7 min and air dried at ambient temperature before applying the herbal edible coating. All parameters performed in the department of food and biotechnology at Jayoti Vidyapeeth Women's University.

Packaging Materials

The packaging materials were procured from Jaipur market. The packaging materials used for packaging the herbal edible coated fruits were jute bags, cloth bags, brown paper bags, HDPE (150 gauge or 38 micron) and LDPE (200 gauge or 50 micron).

Development of Herbal Edible Coatings

The aqueous tulsi leaves extract (TLE) was prepared by using Soxhlet apparatus at 78°C, distilled water used as a solvent. The tulsi leaves extract was evaporated and air dried at ambient temperature. The Herbal edible coatings were prepared from tulsi leaves extract (TLE). Herbal edible coatings were prepared by incorporation of aqueous

tulsi leaves extract (Aq-TLE) in four edible coatings separately i.e. chitosan, alginate, cornstarch and beeswax. The addition of Aq-TLE was the same quantity in all herbal edible coatings. The percentage of Aq-TLE was decided after the preliminary study of herbal edible coating applied to fruits. For coating preparation, chitosan, alginate, cornstarch and beeswax were used as a base material in the herbal edible coatings. The chitosan herbal edible coating was prepared by the dissolving the chitosan (1g) in 0.5% acetic acid solution by continuous stirring for 20 min at room temperature then filtered the chitosan coating solution and Aq-TLE (aqueous tulsi leaves extract) and glycerol was added and mixed and stored at room temperature (25-30°C). The alginate herbal edible coating was prepared by dissolving the alginate (2.5 g) in distilled water at 70°C for 10-15 minutes with continuous stirring. Alginate solution was cooled at room temperature (25-30°C) and filtered. Then Aq-TLE (aqueous tulsi leaves extract), glycerol and tween 80 were added in the filtered edible coating. In this coating, the glycerol was used as a plasticizer and tween 80 as a surfactant. The prepared edible coating solution was stored in the refrigerator. Cornstarch herbal edible coating solution was prepared by dissolving 2.5% (w/v) cornstarch and 1.5 g dried tulsi leaves extract (Aq.) in distilled water with agitation for 15 minutes at 90ºC. The pH value was adjusted to 5.6 with 50% (w/v) citric acid solution. Glycerol was added as a plasticizer (2ml/L solution). The beeswax herbal edible coating was prepared by the beeswax (6 g), soy lecithin (10 g) added as an emulsifying agent and aqueous tulsi leaves extract (1.5 g). Beeswax melted at 55-60 °C and mixed with aqueous tulsi leaves extract and 10% soy lecithin solution for 15-20 min with continuous stirring and cool at ambient temperature. Treatments details are given below.

Application of herbal edible coating: The herbal edible coating applied on pears by spraying method and then the residual coating solution was allowed to drip off for a minute. When the pears get dried completely after coating, they were stored at ambient temperature (31±1°C) and low temperature (4°C) for physiochemical analysis.

Sensory Evaluation: The sensory evaluation was performed by using 9 point Hedonic scale, by semi-trained panel members having 10 or 12 panel members. The panel members were provides a 9 point hedonic scale questionnaire to test appearance color, taste, texture, flavor, after taste and overall acceptability of coated pear and control. They were scored on a scale of 1-9 (1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5= neither like nor dislike, 6= like slightly, 7= like moderately, 8 = like very much and 9= like extremely).

Statistical Analysis: The mean and standard deviation was determined for the statistical analyses of the data using MS Excel 2007.

RESULTS AND DISCUSSION

Appearance/Color

The effect of packaging material on appearance/color of coated pears is shown in Figure 1 & 2 and data is presented in Table 2a, 2b and 3. Coated pears packed in various packaging materials; the sensory scores for color decreased progressively throughout the storage time at ambient and low temperature and did not show any significant change. The sensory score of appearance for packed coated pears at 0^{th} day of storage was 9.0. On 50^{th} day of storage, the sensory score of appearance for packed coated pears was 6.4 (T_1), 5.8 (T_2), 6.0 (T_3), 5.8 (T_4), 5.5 (T_5), 6.2 (T_6), 5.2 (T_7), 5.2 (T_8), 5.7 (T_9), 5.4 (T_{10}), 6.0 (T_{11}), 5.4 (T_{12}), 5.9 (T_{13}), 6.5 (T_{14}), 5.7 (T_{15}), 6.8 (T_{16}), 5.7 (T_{17}), 5.8 (T_{18}), 6.2 (T_{19}) and 6.3 (T_{20}). These samples were stored at ambient temperature (31±2°C). However, the sensory score of appearance for packed coated pears at low temperature on 75^{th} day was 5.8 (T_{21}), 5.6 (T_{22}), 5.5 (T_{23}), 5.3 (T_{24}), 5.8 (T_{25}), 5.7 (T_{26}), 6.5 (T_{27}) and 5.7 (T_{28}). On the basis of present investigation, the coated pears packed in jute bag found highest appearance score in all samples as compared to other packaging materials at ambient temperature (31±2°C) on 50^{th} day. The maximum sensory score of appearance was reported in HDPE packed coated pears at low temperature on 75^{th} day, however the uncoated pears were not acceptable for evaluation of appearance at that time on low temperature (4°C) as well as ambient temperature (31±2°C). Further, the uncoated pears were discarded on 30^{th} day and 45^{th} day at ambient and low temperature respectively. The highest sensory score of appearance was recorded in packed pear fruits as

compared to uncoated. The coated pears packaged in various packaging materials revealed better appearance or color during storage at ambient temperature as compared to uncoated samples which were stored at same temperature and storage time. The packaging material provides suitable environment for gaseous exchange, decrease the rate of transpiration and moisture loss therefore shelf life of fruits is increased. Bhattarai and Shah [10] observed that the effect of packaging materials on mandarin, the five treatments viz. plastic, newspaper wrapping, jute wrapping and no packaging materials (control) were used and found that the shelf life of all packaged fruits was increased as compared -to control. Moreover, the Taduri *et al*.[11] found the fruits packed in perforated LDPE had better colour development as compared to control fruits and it maintained the better quality after two weeks of storage as compared to other treatments. Similarly, Kaur *et al*. [12] revealed the sensory score was gradually decreased during storage. The fruits was packed in CFB boxes with HDPE liners maintained the higher sensory score (7.8).

Texture

The effect of packaging material on the texture of coated pears demonstrated in Table 2a, 2b and 3. For coated pears packed in various packaging materials, the sensory scores for texture decreased progressively throughout the storage time at ambient temperature and did not show any significant change. The sensory score of texture for packed coated pears at 0th day of storage was 8.8.On 50th day of storage, the sensory score of texture for packed coated pears was 6.3 (T_1), 5.6 (T_2), 6.2 (T_3), 5.9 (T_4), 5.5 (T_5), 5.9 (T_6), 5.3 (T_7), 5.4 (T_8), 5.7 (T_9), 5.4 (T_{10}), 6.4 (T_{11}), 6.2 (T_{12}), 5.4 (T_{13}), 6.1 (T_{14}), 5.5 (T_{15}), 6.5 (T_{16}), 5.8 (T_{17}), 6.0 (T_{18}), 6.5 (T_{19}) and 6.4 (T_{20}). These samples were stored at ambient temperature (31±2℃). However, the sensory score of texture for packed coated pears at low temperature on 75th day was 5.9 (T_{21}), 5.5 (T_{22}), 5.7 (T_{23}), 5.4 (T_{24}), 6.1 (T_{25}), 5.5 (T_{26}), 6.5 (T_{27}) and 6.4 (T_{28}). The sensory score of texture for coated pears packed in jute bag was better as compared to other packaging materials at ambient temperature (31±2℃) on 50th day. The maximum sensory score of texture was reported in HDPE packed coated pears at low temperature on 75th day, however the uncoated pears were not acceptable for evaluation of texture at that time on low temperature (4℃) as well as ambient temperature (31±2℃). Further, the uncoated pears were discarded on 30th day and 45th day at ambient and low temperature respectively. The highest sensory score of texture was recorded in packed fruits and vegetables as compared to uncoated. The coated fruits and vegetables packaged in various packaging materials revealed better texture during storage at ambient temperature as compared to uncoated samples which were stored at same temperature and storage time. Similarly, Kaur et al.[12] revealed that the sensory score for was gradually decreased during storage. The fruits was packed in CFB boxes with HDPE liners maintained the texture of fruits on 75th day of storage. Taduri et al.[11] found that the fruits packed in perforated LDPE had more firmness as compared to control fruits and maintained the better quality after two weeks of storage as compared to other treatments. Prasad et al. 13 concluded that the Cool chamber+Brown paper and Cool chamber+Tissue paper were improved the quality of banana fruits alongwith the nutritional and storage properties and these treatments were also found to be good for 3 days of storage both at ambient and cool chamber conditions respectively.

Taste

The effect of packaging material on the taste of coated pears demonstrated in Table 2a, 2b and 3. For coated pears packed in various packaging materials, the sensory scores for taste decreased progressively throughout the storage time at ambient temperature and did not show any significant ($p>0.05$) change. The sensory score of after taste for packed coated pears at 0th day of storage was 8.7. On 50th day of storage, the sensory score of after taste for packed coated pears was 6.8 (T_1), 5.6 (T_2), 5.2 (T_3), 6.5 (T_4), 5.7 (T_5), 6.5 (T_6), 5.5 (T_7), 5.5 (T_8), 6.3 (T_9), 5.8 (T_{10}), 6.5 (T_{11}), 5.6 (T_{12}), 5.8 (T_{13}), 6.3 (T_{14}), 5.8 (T_{15}), 6.5 (T_{16}), 5.7 (T_{17}), 5.6 (T_{18}), 5.7 (T_{19}) and 5.4 (T_{20}). These samples were stored at ambient temperature (31±2□). However, the sensory score of after taste for packed coated pears at low temperature on 75th day was 5.8 (T_{21}), 5.2 (T_{22}), 5.7 (T_{23}), 5.1 (T_{24}), 5.6 (T_{25}), 6.4 (T_{26}), 6.1 (T_{27}) and 5.9 (T_{28}). The coated pears packed in jute bag were found the highest score for after taste as compared to other packaging materials at ambient temperature (31±2**°**C) on 50th day. The maximum sensory score of after taste was reported in HDPE packed coated pears at low temperature on 75th day, however the uncoated pears were not acceptable for evaluation of after taste at that time on low temperature (4°C) as well as ambient temperature (31±2°C). Further, the uncoated pears were discarded on 30th

day and 45th day at ambient and low temperature respectively. The highest sensory score of after taste was recorded in packed pears as compared to uncoated. The coated pears packaged in various packaging materials revealed better after taste during storage at ambient temperature as compared to uncoated samples. The sensory score of after taste for packed fruits and vegetables were observed better as compared to uncoated samples stored at ambient and low temperature both. Taduri *et al*.[11] also found that the fruits packed in perforated LDPE had better flavour and after taste as compared to control fruits and maintained the better quality after two weeks of storage as compared to other treatments [11].

After Taste

The effect of packaging material on the after taste of coated pears fruits demonstrated in Table 2a, 2b and 3. For coated fruits packed in various packaging materials, the sensory scores for after taste decreased progressively throughout the storage time at ambient temperature. After taste score of packed coated pears was significantly decreased ($p<0.05$). The sensory score of after taste for packed coated pears at 0th day of storage was 6.5 (T_1), 5.5 (T_2), 5.6 (T_3), 5.4 (T_4), 5.9 (T_5), 6.5 (T_6), 5.0 (T_7), 6.3 (T_8), 5.9 (T_9), 5.5 (T_{10}), 6.4 (T_{11}), 5.5 (T_{12}), 6.1 (T_{13}), 5.7 (T_{14}), 5.4 (T_{15}), 6.3 (T_{16}), 5.7 (T_{17}), 5.8 (T_{18}), 6.1 (T_{19}) and 5.5 (T_{20}). These samples were stored at ambient temperature (31±2°C). However, the sensory score of after taste for packed coated pears at low temperature on 75th day was 6.2 (T_{21}), 5.1 (T_{22}), 6.0 (T_{23}), 5.9 (T_{24}), 6.3 (T_{25}), 5.7 (T_{26}), 6.3 (T_{27}) and 6.0 (T_{28}). The coated pears packed in jute bag were found the highest score for after taste as compared to other packaging materials at ambient temperature (31±2°C) on 50th day. The maximum sensory score of after taste was reported in HDPE packed coated pears at low temperature on 75th day, however the uncoated pears were not acceptable for evaluation of after taste at that time on low temperature (4°C) as well as ambient temperature (31±2°C). Further, the uncoated pears were discarded on 30th day and 45th day at ambient and low temperature respectively. The highest sensory score of after taste was recorded in packed pears as compared to uncoated. The coated pears packaged in various packaging materials revealed better after taste during storage at ambient temperature as compared to uncoated samples. The sensory score of after taste for packed fruits were observed better as compared to uncoated samples stored at ambient and low temperature both. Taduri *et al*. [11] also found that the fruits packed in perforated LDPE had better flavour and after taste as compared to control fruits and maintained the better quality after two weeks of storage as compared to other treatments.

Overall Acceptability

The effect of packaging material on the overall acceptability of coated pears demonstrated in Table 2a, 2b and 3. For coated pears packed in various packaging materials, the sensory scores for overall acceptability decreased progressively throughout the storage time at ambient temperature and show significant change during storage at both temperatures. The sensory score of overall acceptability for packed coated pears at 0th day of storage was 8.6. On 50th day of storage, the sensory score of overall acceptability for packed coated pears was 6.1 (T_1), 5.5 (T_2), 5.7 (T_3), 5.7 (T_4), 5.4 (T_5), 6.1 (T_6), 5.4 (T_7), 5.0 (T_8), 6.0 (T_9), 5.6 (T_{10}), 6.0 (T_{11}), 5.5 (T_{12}), 5.1 (T_{13}), 5.4 (T_{14}), 5.9 (T_{15}), 6.5 (T_{16}), 5.9 (T_{17}), 5.4 (T_{18}), 6.3 (T_{19}) and 5.8 (T_{20}). These samples were stored at ambient temperature (31±2°C). However, the sensory score of overall acceptability for packed coated pears at low temperature on 75th day was 5.5 (T_{21}), 6.0 (T_{22}), 5.6 (T_{23}), 5.8 (T_{24}), 5.5 (T_{25}), 6.2 (T_{26}), 6.0 (T_{27}) and 7.3 (T_{28}). The sensory score of overall acceptability for coated pears packed in jute bag was better as compared to other packaging materials at ambient temperature (31±2°C) on 50th day. The maximum sensory score of overall acceptability was reported in LDPE packed coated pears at low temperature on 75th day, however the uncoated pears were not acceptable for evaluation of overall acceptability at that time on low temperature (4°C) as well as ambient temperature (31±2°C). Further, the uncoated pears were discarded on 30th day and 45th day at ambient and low temperature respectively. The highest sensory score of overall acceptability was recorded in packed pears as compared to uncoated. The coated fruits and vegetables packaged in various packaging materials revealed better overall acceptability during storage at ambient temperature as compared to uncoated samples which were stored at same temperature and time. The sensory score of overall acceptability for packed fruits and vegetables were observed better as compared to uncoated samples stored at ambient and low temperature both. Similarly, Kaur *et al*.[12] revealed that the sensory score was gradually decreased during storage. The fruits was packed in CFB boxes with HDPE liners maintained the higher sensory score. Taduri *et al*. [11] found that the fruits

packed in perforated LDPE had better colour development as compared to control fruits and maintained the better quality after two weeks of storage as compared to other treatments. Singh *et al*. [14] also reported that the kinnow fruits packaged with cling film (at 15 micron + wax at 10%) was found better quality on 25th day of storage at ambient temperature as compared with other packaging treatments including LDPE (25 micron), HDPE (15 micron), Polypropylene (25 micron), Shrink film (15 micron) and control (open).

CONCLUSION

The results concluded in the present study that the jute bag was best packaging material for pear with herbal edible coatings (cornstarch and beeswax) at ambient temperature. But the HDPE was best packaging material for pear at low temperature. According to sensory score of packaged coated pears, the best packaging material for all coated pears was jute bag at ambient temperature during storage however HDPE was best packaging material at low temperature for pear. There is a need to find alternative post harvest technology for reducing post harvest losses, thus enhancing the shelf life and maintaining the quality of fresh produces at low cost. The results revealed that the herbal edible coating is a good alternative to enhance the shelf life of the fresh produce.

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Table 1a: Coated pears packed in different packaging materials stored at ambient temperature (31±2°C).

TC_1	Uncoated
CH-HEC	
T_1	CS-HEC coated pears packed in jute bag
T_2	CS-HEC coated pears packed in cloth bag
T_3	CS-HEC coated pears packed in brown paper bag
T_4	CS-HEC coated pears packed in HDPE bag
T_5	CS-HEC coated pears packed in LDPE bag
AL-HEC	
T_6	AL-HEC coated pears packed in jute bag
T_7	AL -HEC coated pears packed in cloth bag
T_8	AL -HEC coated pears packed in brown paper bag
T_9	AL -HEC coated pears packed in HDPE bag
T_{10}	AL -HEC coated pears packed in LDPE bag
CS-HEC	
T_{11}	CS-HEC coated pears packed in jute bag
T_{12}	CS -HEC coated pears packed in cloth bag
T_{13}	CS -HEC coated pears packed in brown paper bag
T_{14}	CS -HEC coated pears packed in HDPE bag
T_{15}	CS -HEC coated pears packed in LDPE bag
BW-HEC	
T_{16}	BW-HEC coated pears packed in jute bag
T_{17}	BW-HEC coated pears packed in cloth bag
T_{18}	BW-HEC coated pears packed in brown paper bag
T_{19}	BW-HEC coated pears packed in HDPE bag
T_{20}	BW-HEC coated pears packed in LDPE bag

Table 1b: Coated pears packed in different packaging materials stored at low temperature (4°C).

TC_2	Uncoated
T_{21}	CH-HEC coated pears packed in HDPE bag
T_{22}	CH-HEC coated pears packed in LDPE bag
T_{23}	AL-HEC coated pears packed in HDPE bag
T_{24}	AL-HEC coated pears fruits packed in LDPE bag
T_{25}	CS-HEC coated pears packed in HDPE bag
T_{26}	CS-HEC coated pears packed in LDPE bag
T_{27}	BW-HEC coated pears packed in HDPE bag
T_{28}	BW-HEC coated pears fruits packed in LDPE bag

Table 2a: Sensory evaluation of packaged coated fruits and vegetables at ambient temperature (31±2°C).

Quality Attributes	Storage Time (Days)	Uncoated (TC_1)	Treatments											
			CH-HEC			AL-HEC			CS-HEC			BW-HEC		
			T_1	T_2	T_3	T_6	T_7	T_8	T_{11}	T_{12}	T_{13}	T_{16}	T_{17}	T_{18}
Appearance/ Color	0th	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00
	15th	7.6±0.29	8.2±0.29	7.8±1.25	8.0±1.00	7.8±0.76	7.5±0.87	7.1±0.00	8.0±0.50	7.1±0.00	7.4±0.58	8.4±0.58	7.6±0.15	7.5±1.04
	30th	5.2±0.58	7.6±0.15	7.3±1.15	7.1±0.00	7.2±1.04	7.0±0.29	6.5±1.00	7.3±0.58	6.5±0.58	6.8±0.29	7.8±0.76	6.7±1.57	7.1±0.00
	45th	-	7.0±2.75	6.8±2.08	6.5±1.00	6.8±0.29	6.2±0.30	6.3±1.44	6.5±0.58	6.0±0.50	6.2±0.30	7.1±0.29	6.5±1.00	6.7±1.57
	50th	-	**6.4±0.29**	**5.8±0.10**	**6.0±0.87**	**6.2±1.26**	**5.2±0.58**	**5.2±0.00**	**6.0±0.50**	**5.4±2.22**	**5.9±1.05**	**6.8±0.29**	**5.7±1.00**	**5.8±0.29**
Texture	0th	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29
	15th	7.4±0.29	8.0±0.50	6.8±2.08	6.9±0.29	7.2±0.77	6.7±1.57	7.1±0.00	7.1±0.50	7.8±0.76	6.6±0.47	7.8±1.04	6.7±1.57	6.8±0.29
	30th	5.0±0.21	7.0±2.75	6.7±1.39	6.6±0.47	7.0±0.53	6.4±0.29	6.5±1.00	6.9±0.29	7.0±0.50	6.5±0.00	7.1±0.00	6.4±0.29	6.2±0.30
	45th	-	6.5±1.00	6.1±0.29	6.5±0.00	6.8±2.47	6.3±1.44	6.3±1.44	6.6±0.47	6.8±0.29	6.2±0.88	6.5±1.00	6.2±1.07	6.5±0.58
	50th	-	**6.3±0.00**	**5.6±0.58**	**6.2±0.88**	**5.9±0.50**	**5.2±0.58**	**5.4±.50**	**6.4±0.88**	**6.2±0.30**	**5.4±0.77**	**6.5±1.44**	**5.8±0.10**	**6.0±0.50**
Taste	0th	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69
	15th	6.2±2.75	7.2±0.00	6.9±0.30	7.1±0.29	7.3±0.07	6.6±0.79	6.8±2.08	7.0±0.50	6.9±0.68	6.7±1.57	8.3±0.58	7.2±0.00	6.9±0.68
	30th	5.3±0.50	6.9±0.30	6.5±0.58	6.8±2.08	6.6±0.79	6.5±0.29	6.3±1.75	6.8±0.29	6.7±1.39	6.4±0.29	7.3±1.40	6.9±0.30	6.7±1.39
	45th	-	6.2±0.53	6.0±0.50	6.3±1.75	6.5±0.29	6.1±0.29	6.2±1.07	6.2±0.30	6.1±0.29	6.2±1.07	6.8±0.77	6.2±0.53	6.1±0.29
	50th	-	**6.8±0.64**	**5.6±0.50**	**5.2±1.07**	**6.5±0.29**	**5.5±0.58**	**5.5±0.53**	**6.5±0.53**	**5.6±0.58**	**5.8±0.76**	**6.5±0.58**	**5.7±0.64**	**5.6±0.58**
After Taste	0th	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58
	15th	6.5±0.50	7.0±0.50	6.6±0.79	6.8±2.08	7.8±2.08	6.4±0.12	7.1±0.29	7.1±0.29	6.8±0.00	7.1±0.29	7.8±0.76	6.9±0.58	7.2±0.00
	30th	5.2±1.00	6.8±0.29	6.5±0.29	6.7±1.39	7.4±1.39	6.1±0.58	6.7±1.57	6.7±1.57	6.5±0.50	6.7±1.57	7.1±0.00	6.4±0.50	6.9±0.30
	45th	-	6.2±0.30	6.1±0.29	6.1±0.29	6.8±0.29	5.5±0.07	6.4±0.29	6.4±0.29	6.0±0.61	6.4±0.29	6.5±1.00	5.9±0.50	6.2±0.53
	50th	-	**6.5±0.58**	**5.5±0.58**	**5.6±0.58**	**6.5±0.58**	**5.0±0.00**	**6.3±1.44**	**6.4±0.00**	**5.5±0.29**	**6.1±0.00**	**6.3±1.44**	**5.7±1.05**	**5.8±0.64**
Overall acceptability	0th	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58
	15th	6.9±0.00	7.3±0.07	6.5±0.58	7.2±0.00	7.2±0.00	6.9±0.30	6.4±0.12	7.0±0.50	6.8±0.58	6.7±1.39	7.5±0.87	7.0±0.39	6.6±0.50
	30th	5.8±0.29	6.6±0.79	6.0±0.50	6.9±0.30	6.9±0.30	6.2±0.53	6.1±0.58	6.8±0.29	6.5±0.50	6.1±0.29	7.0±0.39	6.6±0.50	6.1±0.53
	45th	-	6.5±0.29	5.8±0.50	6.2±0.53	6.2±0.53	5.7±0.64	5.5±0.07	6.2±0.30	6.2±0.50	5.6±0.58	6.7±0.50	6.1±0.53	5.9±2.30
	50th	-	**6.1±0.29**	**5.5±1.05**	**5.7±0.64**	**6.1±0.64**	**5.4±0.39**	**5.0±0.00**	**6.0±0.50**	**5.5±1.05**	**5.1±0.76**	**6.5±0.58**	**5.9±2.30**	**5.4±0.89**

Table 2b: Sensory evaluation of coated fruits and vegetables packed in HDPE and LDPE bags at ambient temperature (31±2°C).

Quality Attributes	Storage Time (Days)	Treatments							
		CH-HEC		AL-HEC		CS-HEC		BW-HEC	
		T_4	T_5	T_9	T_{10}	T_{14}	T_{15}	T_{19}	T_{20}
Appearance/Color	0th	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00
	15th	7.3±0.29	8.1±0.58	7.2±0.00	6.9±0.30	8.3±0.58	7.2±0.00	8.3±0.07	8.6±0.79
	30th	5.8±0.50	7.5±0.50	6.9±0.30	6.2±0.53	7.3±1.40	6.9±0.30	7.6±0.79	7.5±0.29
	45th	-	6.2±0.50	6.2±0.53	5.7±0.64	6.8±0.77	6.2±0.53	6.5±0.29	6.7±0.29
	50th	-	**5.5±1.05**	**5.7±0.64**	**5.4±0.39**	**6.5±0.58**	**5.7±0.64**	**6.2±0.29**	**6.3±0.58**
Texture	0th	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29
	15th	6.6±0.79	6.6±0.79	7.2±0.00	6.9±0.30	7.3±0.07	6.5±0.58	8.3±0.58	8.2±0.29
	30th	5.9±0.29	6.5±0.29	6.9±0.30	6.2±0.53	6.6±0.79	6.0±0.50	7.3±1.40	7.6±0.15
	45th	-	6.1±0.29	6.2±0.53	5.7±0.64	6.5±0.29	5.8±0.50	6.8±0.77	7.0±2.75
	50th	-	**5.5±0.58**	**5.7±0.64**	**5.4±0.39**	**6.1±0.29**	**5.5±1.05**	**6.5±0.58**	**6.4±0.29**
Taste	0th	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69
	15th	7.3±1.40	7.2±0.00	7.8±1.04	7.7±1.57	7.8±1.04	6.7±1.57	7.2±0.00	6.9±0.30
	30th	5.5±0.58	6.9±0.30	7.1±0.00	6.4±0.29	7.1±0.00	6.4±0.29	6.9±0.30	6.2±0.53
	45th	-	6.2±0.53	6.5±1.00	6.2±1.07	6.5±1.00	6.2±1.07	6.2±0.53	5.7±0.64
	50th	-	**5.7±0.64**	**6.3±1.44**	**5.8±0.10**	**6.3±1.44**	**5.8±0.10**	**5.7±0.64**	**6.4±0.39**
After Taste	0th	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58
	15th	6.5±0.58	7.4±0.58	7.3±0.07	6.6±0.79	7.2±0.00	6.9±0.30	7.3±0.07	6.5±0.58
	30th	5.4±2.22	6.8±0.29	6.6±0.79	6.5±0.29	6.9±0.30	6.2±0.53	6.6±0.79	6.0±0.50
	45th	-	6.2±0.30	6.5±0.29	6.1±0.29	6.2±0.53	5.7±0.64	6.5±0.29	5.8±0.50
	50th	-	**5.9±1.05**	**5.9±0.29**	**5.5±0.58**	**5.7±0.64**	**5.4±0.39**	**6.1±0.29**	**5.5±1.05**
Overall acceptability	0th	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58
	15th	6.9±0.30	6.9±0.30	7.0±0.50	6.9±0.68	7.1±0.00	7.4±0.58	7.8±1.04	6.7±1.57
	30th	5.7±0.64	6.2±0.53	6.8±0.29	6.7±1.39	6.5±0.58	6.8±0.29	7.1±0.00	6.4±0.29
	45th	-	5.7±0.64	6.2±0.30	6.1±0.29	6.0±0.50	6.2±0.30	6.5±1.00	6.2±1.07
	50th	-	**5.4±0.39**	**6.0±0.53**	**5.6±0.58**	**5.4±2.22**	**5.9±1.05**	**6.3±1.44**	**5.8±0.10**

Table 3: Sensory evaluation of coated fruits and vegetables packed in HDPE and LDPE bags at low temperature (4°C).

Quality Attributes	Storage Time (Days)	Uncoated (TC_2)	Treatments							
			CH-HEC		AL-HEC		CS-HEC		BW-HEC	
			T_{21}	T_{22}	T_{23}	T_{24}	T_{25}	T_{26}	T_{27}	T_{28}
Appearance/ Color	0th	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00	9.0±0.00
	15th	7.5±0.87	8.7±0.29	8.4±0.29	8.4±0.47	8.2±0.58	8.3±0.29	8.2±0.29	8.6±0.29	8.2±0.58
	30th	6.4±0.29	7.3±0.58	8.0±0.50	7.4±0.41	7.3±1.04	7.4±0.29	7.5±0.50	8.1±0.41	7.8±1.04
	45th	5.0±0.29	6.9±0.50	7.4±1.04	6.7±0.29	6.6±1.00	6.5±0.50	6.8±1.04	7.2±0.29	7.0±1.00
	60th	-	6.3±0.29	6.5±0.87	6.2±0.29	5.7±2.75	6.0±1.00	6.5±0.87	6.8±0.29	6.5±2.75
	75th	-	**5.6±3.04**	**5.8±2.00**	**5.5±1.04**	**5.3±1.00**	**5.6±0.68**	**5.8±2.00**	**6.5±1.04**	**5.7±1.00**
Texture	0th	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29	8.8±0.29
	15th	7.0±0.39	8.8±0.29	8.4±0.29	8.4±0.29	8.3±0.50	7.8±0.29	8.0±1.00	8.4±0.41	8.2±0.77
	30th	6.6±0.50	7.5±1.57	7.3±0.29	7.2±0.77	7.8±0.58	7.1±0.76	7.8±0.76	8.2±1.00	7.2±0.72
	45th	5.4±0.89	7.0±1.00	6.9±1.00	6.8±2.59	7.1±0.29	6.7±0.50	6.8±2.47	7.2±1.00	6.7±0.42
	60th	-	6.4±0.87	6.3±0.29	6.1±1.57	6.8±0.77	6.2±1.76	6.2±1.55	6.7±0.29	6.4±0.35
	75th	-	**5.8±1.57**	**5.4±0.77**	**5.5±1.32**	**5.6±0.72**	**5.7±0.29**	**5.3±0.30**	**6.1±0.77**	**5.7±0.29**
Taste	0th	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69	8.8±0.69
	15th	7.8±0.29	7.8±0.29	8.0±1.00	8.4±0.41	7.7±0.77	8.5±0.87	7.5±1.50	8.7±0.29	7.8±0.29
	30th	6.4±0.29	7.0±0.76	7.8±0.76	8.2±1.00	7.1±0.72	7.8±1.04	7.1±0.25	7.6±0.29	7.4±0.77
	45th	5.2±0.50	6.5±0.50	6.8±2.47	7.2±1.00	6.2±0.42	7.2±1.04	6.8±0.25	7.0±0.29	6.7±0.72
	60th	-	6.2±1.76	5.8±1.55	6.8±0.29	5.8±0.35	6.7±2.17	6.4±1.87	6.7±0.29	6.4±1.40
	75th	-	**5.8±0.29**	**5.2±0.30**	**5.7±0.77**	**5.1±0.29**	**5.6±0.29**	**5.9±0.58**	**6.1±0.12**	**5.9±1.75**
After Taste	0th	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58	8.7±0.58
	15th	7.0±1.00	8.2±1.00	7.6±0.42	7.8±1.04	7.3±0.25	7.8±0.29	7.0±2.59	7.8±0.29	7.5±0.50
	30th	6.5±3.04	7.8±0.29	7.2±0.35	6.5±2.17	7.2±1.87	6.7±0.29	6.7±1.57	7.7±0.77	7.2±1.76
	45th	5.2±0.53	7.0±0.77	6.8±0.29	6.4±0.29	6.3±0.58	6.4±0.12	6.5±1.32	7.1±0.72	6.8±0.29
	60th	-	6.7±0.72	6.4±0.58	6.2±1.07	6.0±0.61	6.1±0.58	6.2±0.53	6.4±1.40	6.4±0.30
	75th	-	**6.2±1.40**	**5.1±0.76**	**6.0±0.76**	**5.9±2.30**	**6.3±1.44**	**5.7±0.64**	**6.3±1.75**	**6.0±0.58**
Overall acceptability	0th	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58	8.6±0.58
	15th	7.5±0.29	8.2±0.58	7.8±0.29	8.2±0.76	7.8±0.53	7.7±0.77	8.7±0.58	8.0±1.25	8.0±0.50
	30th	6.5±1.50	7.3±1.40	7.3±1.04	7.2±1.89	7.0±3.04	7.2±0.29	8.0±0.00	7.8±0.76	7.8±0.58
	45th	5.8±1.04	6.8±2.47	7.0±0.29	7.0±1.25	6.7±0.29	6.5±0.00	7.5±0.50	7.5±0.26	7.7±1.04
	60th	-	6.0±1.25	6.8±0.00	6.5±0.29	6.5±0.87	6.3±0.29	7.0±0.29	6.8±0.58	7.8±1.25
	75th	-	**5.5±1.00**	**6.0±0.53**	**5.6±0.77**	**5.8±0.29**	**5.5±0.00**	**6.2±0.50**	**6.0±0.00**	**7.3±1.15**