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RESEARCH ARTICLE

Effect of different packaging material on storage and quality attributes of kiwi fruits (*Actinidia deliciosa* Planch)

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ABSTRACT

The present study was undertaken at the Dept. of Horticulture, Sikkim University, Gangtok during 2019-2020 to assess the effect of different packaging materials on storage and quality attributes of kiwi fruit (*Actinidia deliciosa* Planch) cv. Monty. After harvesting the fruits, they were packed under different packaging conditions, i.e. six treatments: control (open condition), LDPE, LDPE (perforated), Brown paper, Brown Paper (perforated), and vacuum packaging at room temperature with three replications. The statistical analysis was done using a Completely Randomised Design (CRD). The biochemical parameters, e.g. physiological loss in weight, moisture (%), T.S.S., titratable acidity (%), reducing sugar (%), total sugar (%), were also studied. The sensory evaluation was also done. The lowest PLW (physiological loss in weight) was recorded in T2 (LDPE perforated) and T0 (control), followed by T4 (brown paper perforated) and T5 (vacuum packaging). The maximum average value of TSS (14.510 Bx) was observed on the 25th day. Also, the highest average TSS was observed in T2 (LDPE perforated) (12.350 Bx), followed by T4 (Brown paper perforated) (11.870 Bx). The maximum titratable acidity content was observed in T1 (LDPE) (1.49%) followed by T4 (brown paper perforated) (1.39%). The maximum ascorbic acid content was observed in T2 (LDPE perforated) (80.83 mg/100g) and T4 (brown paper perforated) (79.38%). The maximum reducing sugar content was found in T5 (vacuum packaging) (7.44%), and T4 (brown paper perforated) (7.22%). The highest sugar value was recorded in T3 (brown paper) (9.9%) and T5 (vacuum packaging) (9.42%). The highest percentage of moisture content was recorded in T2 (LDPE perforated) (70.41%) and T3 (Brown paper) (70.38%) respectively. Fruits which were packed in T4 (Brown paper perforated) (7.01) had the highest sensory scoring, followed by T2 (LDPE perforated) (6.86). From the present study, it was revealed that the kiwi fruits kept under different packaging conditions under room temperature can survive up to 30 days after harvesting. Fruits which were kept under brown paper perforated and LDPE perforated extended the shelf life of kiwifruit for the longest duration with the best marketing and edible quality.

Keywords: Kiwifruit, packaging materials, LDPE perforated, brown paper perforated, vacuum packaging.

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INTRODUCTION

The northeastern region of India has tremendous potential for the growth of horticulture, as it offers diverse climatic conditions favorable for growing different types of fruits. Kiwifruit, belonging to the family Actinidiaceae, is also known as

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Chinese Gooseberry or the Wonder of New Zealand. Recently, kiwi has become one of the most popular fruits due to its flavor, aroma, nutritive value, and medicinal purposes. In India, kiwifruit is grown in Arunachal Pradesh, Sikkim, Nagaland, Manipur, and Jammu and Kashmir, as well as in Darjeeling and Kalimpong Hills of West Bengal. The most common cultivars of kiwi fruit are Bruno, Monty, Allison, Hayward, Abbott, and Matua. The fruits are highly nutritious and rich in minerals, sugars, vitamins, and carbohydrates. Seeds contain an average of 62% alpha-linolenic acid, an omega-3 fatty acid. Kiwifruit has a woody, dull greenish-brown skin and bright green flesh with a row of tiny blackedible seeds. Ripe fruit contains a significantly high amount of biologically active compounds with an abundance of chlorophyll, dietary fiber, β-carotene, lutein, phenolics, flavonoids, provitamins A, B1, B2, B3, B6, and vitamin B9, as well as zeaxanthin, which have very high functional properties (Vaidya et al., 2009, Nishiyama 2007, Celik et al., 2007, Hunter et al., 2016). Kiwifruit is a typical climacteric fruit and shows a triple sigmoidal growth curve, which is apparently a unique pattern in fruit development. Kiwi fruit has a high content of vitamin C, which is twice as high as that found in oranges (Strik, 2005), and it contains a powerful enzyme called actinidin for supporting digestion (Chauhan et al., 1997). Regular consumption of kiwifruit reduces the amount of fat in the blood and the formation of blood clots that can lead to heart attacks (Duttaroy and Jorgenson, 2004). The genus Actinidia is widely used in Chinese folk medicine to treat certain diseases, such as hepatitis, edema, gastric and breast cancer, etc. (Shastri et al., 2012). In view of the importance of these fruits, post-harvest management should be followed, including proper care, handling, packaging, transportation, etc. New technology should be adopted for packaging and for extending the shelf life of the fruit, making it available throughout the year. Packaging plays an important role in fruits and vegetables, serving to protect against contamination and damage caused by various pathogens and excessive moisture loss. Fruits and vegetables are highly perishable commodities in post-harvest management, where packaging is a basic tool. It plays a significant role in improving shelf life and storage, providing good market value and consumer satisfaction. Therefore, the storage life of the produce depends on the appropriate selection of packaging film. The use of traditional forms of packaging like bamboo baskets and other packaging types like wooden boxes and gunny bags is still widespread. The recent developments of selective permeable plastic films have opened up the scope of modified atmospheric packaging systems for storage of fruits. Storage of fruits in proper packaging materials is necessary, as it helps in reducing post-harvest losses and at the same time can result in a commodity-generated modified atmosphere that diminishes dehydration and preserves freshness (Ben-Yehoshua et al., 1994). In view of the importance of kiwi fruit, its nutritive value, vitamin and mineral content, essential fatty acid, and the expected success of packaging material on the enhanced shelf life of kiwi fruit, this study was undertaken with the objective to study the effect of different packaging materials on the shelf life and physico-chemical and sensory qualities of kiwi fruit (*Actinidia deliciosa* Planch) cv. Monty.

MATERIALS AND METHODS

The present study was carried out in the Postharvest laboratory, Department of Horticulture, Sikkim University, Gangtok during the year 2019-2020. The freshly harvested Kiwi fruit cv. Monty was obtained from the field of Yuksom village (Geyzing district, Sikkim) for the purpose of studying packaging and shelf life. After harvesting, the fruits were packed in different packaging, i.e., control, LDPE, LDPE (perforated), Brown paper, Brown Paper (perforated), vacuum packaging. All samples were kept under room temperature conditions. The investigation was carried out in CRD with 6 treatments and 3 replications. Five fruits of average weight 200-250g each were taken per replication. Treatment details: T0: Control (unpacked open condition), T1: LDPE, T2: LDPE perforated, T3: Brown paper, T4: Brown paper perforated, T5: Vacuum packaging.

Observations

Observations of various physicochemical changes in kiwi fruits were recorded on the first day of harvesting of fruit and at 5 days, 10 days, 15 days, 20 days, 25 days, 30 days during the storage period at room temperature. The following biochemical parameters were studied:

Physiological loss in weight (PLW) (%): The fruits were weighed on the balance after packaging at each storage interval under study. The loss of weight during storage was expressed as a percentage of the initial weight. The formula used for the calculation of physiological loss in weight was:

$$\% \text{ PLW} = \frac{(\text{Initial weight} - \text{final weight}) \times 100}{\text{Initial weight}}$$

Moisture content (%): The samples of kiwifruit were dried in a hot air oven at 105°C for at least 5 hours and cooled. The loss in weight percentage was calculated as percent moisture on a fresh weight basis (Ranganna, 2009). It should be expressed as:

Moisture content (%) = Weight of fresh sample (g) - Weight of dried sample (g) × 100

Weight of fresh sample (g)

TSS (Total Soluble Solids) : A few drops of juice were placed on the glass surface of the digital refractometer and covered gently. The TSS value was then recorded at respective intervals.

Titratable acidity (%): It was estimated by the method given by Lane and Eynon's volumetric method (Ranganna, 2009). In this method, samples were prepared in a well-blended uniform pulp in a mortar and pestle, and the sample was taken out and blended well so that it becomes uniformly soluble when added to water. It was filtered through a muslin cloth. One to two drops of phenolphthalein indicator were also added to the aliquot. Titration was done against 0.1 N NaOH solution until a light pink color end point was obtained. It can be expressed as a percentage (Ranganna, 2009).

Titratable acidity (%) = Titre × Normality of alkali × Volume made up × Equivalent weight of acid × 100

Wt. × Volume of sample (W) × Vol. of aliquot × 1000

Reducing sugar (%): This method was proposed by Lane and Eynon's volumetric method (Ranganna, 2009). In this method, samples were prepared and the volume was made up to the known volume, followed by titration. Titration was done by adding the Fehling solution A and B, using a drop of methylene blue indicator. The titration was done by continuously heating the flask and pouring the sample from the burette drop by drop until completion of the end point, i.e., brick red color. It is represented as follows:

Reducing sugar (%) = Factor × Dilution × 100

Titre value × Weight of sample taken

Factor = 0.05

It was estimated using Lane and Eynon's volumetric method (Ranganna, 2009). In this method, samples were prepared and the volume was adjusted to a known volume. Then, 1-2 ml of concentrated HCl was added. Additionally, a drop of phenolphthalein was added and the pH was adjusted by adding NaOH solution. Titration was performed by adding Fehling solution A and B, along with half a drop of methylene blue indicator. The titration process involved continuous heating of the flask and adding the sample from the burette drop by drop until the development of a brick red color as the endpoint. The result is represented as a percentage.

Total sugar % = Factor × Dilution × 100

Title value × Weight of sample taken × Aliquot of sample taken for estimation.

This method is followed by AOAC (Ranganna, 2009). In this method, 2,6-Dichlorophenol indophenol dye and 3.0% metaphosphoric acid are added to the sample. Titration is done with the dye solution to obtain a pink light color, which indicates the end point in the titration method.

Reagents:

(i) 3% Metaphosphoric acid (HPO_3) is prepared by dissolving pellets or sticks of (HPO_3) in distilled water.

(ii) Ascorbic acid standard: 100 mg of L-Ascorbic acid is taken and a 100 ml solution is made with 3% HPO_3. Then, 10 ml is diluted with 3% HPO_3 (1ml = 0.1 mg of ascorbic acid).

(iii) Dye solution is prepared by dissolving 50 mg of the sodium salt of 2,6 Dichlorophenol-indophenol in approximately 150 ml of hot distilled water containing 42 mg of sodium bicarbonate. The solution is then cooled and diluted with glass distilled water to 200 ml.

Standardization of dye: A standard ascorbic acid solution (5ml) is taken and 5 ml of HPO3 is added. The solution is filled into a micro burette. Titration is done with the dye solution and the dye factor is calculated using the following formula:

Dye factor = 0.5

titre

Sensory evaluation: The samples were packed in different materials and examined at regular intervals of 5 days for the purpose of sensory evaluation. The sensory evaluation scale for rating the sensory quality of kiwi fruits was based on three main parameters: color, taste, and aroma. These quality characteristics of the samples were examined by using the rating scales as proposed by Wills et al. (1980).

RESULTS AND DISCUSSION

Physiological loss in weight (PLW): The data on the effect of PLW of kiwi fruits, which were kept at room temperature, have been presented in Table 1. The interaction between the storage interval and treatment was found non-significant. The effect of treatment was found statistically significant. During the storage period, the PLW increased by storage interval up to 30 days of storage. The maximum average of PLW was recorded on the 30th day (4.29%), whereas the minimum average value was recorded on the 1st day and 5th day (2.45% and 2.79% respectively). During the investigation, it was found that LDPE perforated (T3) had the lowest average PLW at 3.27%, followed by open condition T0 (control) at 3.7%. So, the highest average PLW in T4 (brown paper perforated) at 3.69%, followed by T5 (vacuum packaging) at 3.56% and T3 (brown paper) at 3.51%, was observed under the storage condition. In this investigation, it was found that in all the treatments, the PLW increased day by day during the storage period. The reason being due to the increase in transpiration and respiration processes, and a high rate of evaporation process should prevail (Wills et al., 1998). Jacobi et al. (2000) reported that the increase in weight loss in fruit is due to increased evaporation or ripening of fruits.

Table 1: Effect of different types of packaging on physiological loss in weight (%) of different treatments

Treatment details	Day1	Day5	Day10	Day15	Day20	Day25	Day30	Mean
T_0 (control)	2.22	2.54	3.32	3.44	3.64	4.05	4.36	3.37
T_1 (LDPE)	2.33	3.22	3.48	3.76	4.04	4.22	4.33	3.63
T_2(LDPE perforated)	2.55	2.68	3.22	3.45	3.62	3.78	3.58	3.27
T_3 (Brown paper)	2.62	2.93	3.34	3.55	3.75	4.04	4.32	3.51
T_4 (Brown paper perforated)	2.52	2.76	3.45	3.77	3.97	4.72	4.61	3.69
T_5 (Vaccum packaging)	2.46	2.65	3.4	3.76	3.9	4.23	4.55	3.56
Mean	2.45	2.79	3.36	3.62	3.82	4.17	4.29	
S.Em	0.0699	0.1387	0.0861	0.0505	0.1291	0.1113	0.1321	
C.D 5%	0.2155	0.4272	0.2652	0.1557	0.3978	0.3430	0.4070	

Total Soluble Solids (TSS): The data on the effect of packaging on TSS of fruits stored at room temperature have been presented in Table 2. The interaction between the storage and treatment was found non-significant. The maximum average TSS (14.510Bx) was recorded on the 25th day, followed by the 30th day (13.690Bx), whereas the minimum average value of TSS was observed on the 1st day (6.850Bx). Table no.2 indicates that the TSS content gradually increased up to a period of 25 days. During the period of storage, the TSS content should be increasing, and after a certain duration of storage, the TSS content declines. It was found that the maximum mean of average TSS was found in T2 (LDPE perforated) i.e., 12.350 Bx, followed by T4 (brown paper perforated) at 11.870Bx, and the lowest average TSS value was recorded in treatment T5 (vacuum packaging) at 10.510Bx. Wills et al. (1980) during the period of investigation found that after a certain period of time and storage of fruits, the TSS content decreases due to the reason that due to respiratory process results in carbohydrate break down into simple sugar and also indicates that the fruits are ready for harvest or not. Sharma and Singh (2010) reported that the perforated LDPE packaging material plays an important role in the extension of storage life and retention of good quality of fruits during storage.

Table 2: Effect of different types of packaging on Total Soluble Solids (0Bx) of different treatments

Treatment details	Day1	Day5	Day10	Day15	Day20	Day25	Day30	Mean
T_0 (control)	6.15	8.05	10.13	12.04	13.08	15.19	14.05	11.24
T_1 (LDPE)	7.04	8.26	10.08	13.25	14.12	14.56	12.1	11.34
T_2(LDPE perforated)	7.28	9.37	11.12	13.6	14.34	15.53	15.22	12.35
T_3 (Brown paper)	7.18	8.1	10.1	12.38	13.19	14.16	13.14	11.18
T_4 (Brown paper perforated)	7.44	9.23	11.52	12.27	13.3	14.26	15.1	11.87
T_5 (Vaccum packaging)	6.02	8.15	9.24	12.33	12.23	13.35	12.25	10.51
Mean	6.85	8.53	10.37	12.65	13.38	14.51	13.64	
S.Em	0.4624	0.6334	0.4764	0.8168	0.6079	0.6196	0.5280	
C.D 5%	1.4000	1.9500	1.4700	2.5168	1.8732	1.9093	1.6268	

Titratable acidity: The data on the effect of packaging on titratable acidity of fruits have been presented in Table no. 3. The table represents that the titratable acidity of kiwi fruit during the storage period gradually declined during 30 days of storage. The maximum average value of titratable acidity was observed on the 1st day (1.82%), and the minimum average value was recorded on the 30th day (0.64%). During the period of storage, T3 (brown paper), T5 (vacuum packaging), and T2 (LDPE perforated) showed minimum titratable acidity i.e., 1.26%, 1.26%, 1.24% respectively. Maximum acidity content was recorded in the treatment T1 LDPE (1.49%), followed by T4 (brown paper perforated) at 1.39% and T0 (control) at 1.36%. The interaction between the treatment and storage interval was found to be significant. In kiwi fruits, over a period of storage, the reduction in citric acid content was observed. The reason behind the reduction of titratable acidity during storage was due to the conversion of organic acid into sugar to cope up with the increasing energy demand during the process of ripening.

Table 3: Effect of different types of packaging on titratable acidity of different treatments

Treatment details	Day1	Day5	Day10	Day15	Day20	Day25	Day30	Mean
T_0 (control)	1.85	1.7	1.55	1.4	1.25	1.1	0.68	1.36
T_1 (LDPE)	1.95	1.8	1.65	1.5	1.35	1.2	1.0	1.49
T_2(LDPE perforated)	1.78	1.63	1.48	1.33	1.18	1.03	0.25	1.24
T_3 (Brown paper)	1.74	1.59	1.44	1.29	1.14	1.08	0.56	1.26
T_4 (Brown paper perforated)	1.88	1.73	1.58	1.43	1.28	1.13	0.72	1.39
T_5 (Vaccum packaging)	1.71	1.57	1.41	1.27	1.12	1.06	0.65	1.26
Mean	1.82	1.67	1.52	1.37	1.22	1.10	0.64	1.33
S.Em	0.0503	0.0493	0.0390	0.0405	0.0298	0.0196	0.0737	
C.D 5%	0.1549	0.1520	0.1203	0.1247	0.0919	0.0603	0.2270	

Ascorbic acid: The data pertaining to the effect of packaging on total ascorbic acid of fruits has been presented in Table 4. The interaction between the treatment and the storage duration was found to be significant. The maximum average value of ascorbic acid was observed on the 1st day, i.e., 91.75 mg/100g, whereas the minimum average value was recorded on the 30th day with 61.58 mg/100g. The treatment T2 (LDPE perforated) had the maximum mean ascorbic acid content (80.83 mg/100g), followed by T4 (Brown paper perforated) (79.38 mg/100g) and T0 (control) (79.31 mg/100g). During the period of investigation, it was observed that the ascorbic acid increased slowly up to 15 days of storage and then slowly declined after 15 days of storage for all the treatments. Piga et al. (2003) and Ishaq et al. (2009) found that when fruits were stored for a certain period of time, the ascorbic acid content in the fruit should decrease due to the respiratory process. In the respiratory process, acids were converted into sugar, so the ascorbic content should decrease during the storage period.

Table 4: Effect of different types of packaging on ascorbic acid (mg/100g) of different treatments

Treatment details	Day1	Day5	Day10	Day15	Day20	Day25	Day30	Mean
T_0 (control)	91.49	90.6	86.3	80.21	76.12	70.28	60.14	79.31
T_1 (LDPE)	92.6	87.56	76.01	74.33	72.23	64.1	60.24	75.30
T_2(LDPE perforated)	94.02	90.01	85.43	81.61	77.56	72.08	65.11	80.83
T_3 (Brown paper)	90.42	86.18	81.26	76.42	69.88	67.17	60.12	75.92
T_4 (Brown paper perforated)	90.66	90.02	85.05	80.13	75.17	70.47	64.14	79.38
T_5 (Vaccum packaging)	91.29	88.12	83.56	78.54	72.21	72.48	59.71	77.99
Mean	91.75	88.75	82.94	78.54	73.86	69.43	61.58	
S.Em	0.5821	1.1021	0.8312	1.4138	1.3041	1.6302	1.8817	
C.D 5%	1.7935	3.396	2.5611	4.3563	4.0183	5.023	5.798	

Reducing sugar: The effects of packaging on reducing sugar content of kiwifruit have been presented in Table 5. In this table, it has been shown that the maximum reducing sugar content was observed and recorded on the 25th day (9.75%), and the minimum reducing sugar content was found on the 1st day (4.18%). The effect of treatment was found to be statistically significant. The interaction between the storage and treatment was non-significant. During the time of investigation, it was found that in the treatment, the highest average reducing sugar content was observed in the treatment T5 (vacuum packaging) (7.44%), followed by T4 (brown paper perforated) (7.22%) and T2 (LDPE perforated) (7.15%). It was noted in the investigation that the reducing sugar increased slowly up to 25 days of storage, and after that period, the reducing sugar content declined in all the treatments.

Total sugar: The influence of total sugar content in kiwi fruits, which were kept at room temperature, has been presented in Table 6. During the 30-day storage period, it was found that the maximum average total sugar was recorded on the 25th day, i.e., 11.26%, and the minimum average value of total sugar was found on the 1st day with 6.72%. Later, based on treatment, it was found that the maximum average total sugar was recorded in treatment T3 (brown paper) (9.99%), followed by T5 (vacuum packaging) (9.42%) and T1 (LDPE) (9.26%) respectively. At a later stage, it was noticed that the total sugar content gradually increased after 25 days of storage and then decreased.

Table 5: Effect of different types of packaging on reducing sugar (%) of various treatments

Treatment details	Day1	Day5	Day10	Day15	Day20	Day25	Day30	Mean
T_0 (control)	4.11	5.1	6.25	6.88	8.05	9.13	8.4	6.85
T_1 (LDPE)	4.26	5.25	6.6	7.24	8.22	9.55	7.58	6.96
T_2(LDPE perforated)	4.06	5.23	6.3	7.63	9.0	9.75	8.09	7.15
T_3 (Brown paper)	4.08	5.28	6.43	7.05	8.46	9.63	8.46	7.06
T_4 (Brown paper perforated)	4.25	5.13	6.31	7.32	9.1	10.06	8.4	7.22
T_5 (Vaccum packaging)	4.31	5.14	6.55	7.22	9.23	10.4	9.22	7.44
Mean	4.18	5.19	6.41	7.22	8.68	9.75	8.36	
S.Em	0.2308	0.0598	0.1149	0.2722	0.2718	0.3351	0.2381	
C.D 5%	0.7113	0.1842	0.3540	0.8389	0.8376	1.0324	0.7336	

Table. 6: Effect of different types of packaging on total sugar (%) of different treatments

Treatment details	Day1	Day5	Day10	Day15	Day20	Day25	Day30	Mean
T_0 (control)	6.7	7.14	7.71	8.57	9.22	10.2	9.83	8.48
T_1 (LDPE)	7.04	8.01	9.21	9.75	10.6	10.78	9.45	9.26
T_2(LDPE perforated)	6.23	7.2	8.2	9.37	10.14	11.26	9.19	8.80
T_3 (Brown paper)	7.1	8.12	9.59	10.12	11.22	12.27	11.53	9.99
T_4 (Brown paper perforated)	6.57	7.76	8.4	9.34	10.02	11.1	10.1	9.04
T_5 (Vaccum packaging)	6.7	7.06	9.23	10.27	11.26	11.95	9.48	9.42
Mean	6.72	7.55	8.72	9.57	10.41	11.26	9.93	
S.Em	0.1308	0.2824	0.1899	0.1563	0.2370	0.4006	0.4517	

Rathore et al. (2009) conducted an experiment and found that during the storage of fruits, the total sugar content gradually increased, reaching its maximum value at the ripening stage and then decreasing gradually. The increase in sugar content during storage was due to the breakdown of starch, complex carbohydrates, and their conversion into sucrose, glucose, and fructose through hydrolysis.

Moisture content: The data presented in Table 7 show that in different packaging and storage periods up to 30 days, a gradual decrease in moisture content was observed over a certain period of time. After that, the moisture content decreased. It was found that the maximum average moisture content was recorded on the 1st day, i.e., 82.25%, and the minimum average value of moisture content was found on the 30th day with 71.40%. The maximum average moisture content was observed in T2 (LDPE perforated) (70.41%), followed by T3 (brown paper) (70.38%). Kader (2000) and Ali et al. (2009) reported that moisture loss indicates deterioration in the quality of the fruit, including texture, color, and nutritional quality. In kiwi fruits, bruising of hair was found on the surface, which was the reason for quick moisture loss.

Table 7: Effect of different types of packaging on moisture content (%) of different treatments

Treatment details	Day1	Day5	Day10	Day15	Day20	Day25	Day30	Mean
T_0 (control)	80.4	79.80	79.18	78.1	77.47	74.36	72.11	70.21
T_1 (LDPE)	83.61	83.01	82.04	80.81	77.07	74.18	72.2	69.64
T_2(LDPE perforated)	81.39	80.89	80.02	78.21	77.24	74.34	72.05	70.41
T_3 (Brown paper)	84.35	83.59	82.18	80.04	78.22	75.16	71.56	70.38
T_4 (Brown paper perforated)	83.5	82.56	81.46	79.11	78.22	73.13	70.25	66.24
T_5 (Vaccum packaging)	80.23	79.85	78.1	77.33	75.45	72.37	70.22	67.86
Mean	82.25	81.68	80.50	78.93	77.28	73.92	71.40	69.12
S.Em	0.5466	0.5320	0.4362	0.5683	0.5576	0.6548	0.6548	0.4549
C.D 5%	1.6843	1.6280	1.3440	1.7521	1.7181	2.0178	2.0178	1.4017

Sensory analysis: The data on the effect of packaging on sensory scores in kiwi fruit kept under room temperature has been presented in Table 8. The interaction between storage and treatment was found to be significant. In this experiment, it was found that during the storage period, the maximum sensory score was recorded on the 1st day (8.03), and the minimum sensory score was observed on the 30th day (3.62). It was found that T4 (brown paper perforated) showed the maximum average score, i.e., 7.01, followed by T2 (LDPE perforated) with 6.86. During the scoring period, it was noted that the scoring decreased with storage period for different packaging types. Ishaq et al. (2009) found that the scoring value increased due to the development of color, aroma, and taste within a certain period of time, but later on, it decreased due to the ripening and senescence, resulting in a decrease in fruit quality. The findings of Abbasi et al. (2016), Panda et al. (2016), Ali et al. (2015), Gill et al. (2015), Hailu et al. (2012), and Alemwati et al. (2010) also support the findings that packaging and storage conditions positively affect the shelf life of fruits and vegetables.

Table 8. Effect of different types of packaging on sensory score of different treatments

Treatment details	Day1	Day5	Day10	Day15	Day20	Day25	Day30	Mean
T_0 (control)	8.05	7.68	7.43	7.22	6.32	5.32	5.0	6.72
T_1 (LDPE)	8.25	7.55	7.21	6.22	5.25	5.05	3.11	6.09
T_2(LDPE perforated)	8.44	7.54	7.42	7.12	6.42	6.04	5.05	6.86
T_3 (Brown paper)	7.73	7.5	7.22	6.22	5.6	5.32	2.32	5.99
T_4 (Brown paper perforated)	8.42	7.66	7.33	7.2	6.82	6.43	5.22	7.01
T_5 (Vaccum packaging)	7.33	7.0	6.0	5.0	4.01	2.08	1.02	4.63
Mean	8.03	7.48	7.1	6.49	5.73	5.04	3.62	
S.Em	0.0821	0.1509	0.088	0.0706	0.1460	0.1459	0.0382	
C.D 5%	0.2529	0.4651	0.3802	0.2176	0.4499	0.4494	0.1179	

CONCLUSION

The packaging of kiwifruits after harvesting can enhance their shelf life up to 30 days. In the present study, LDPE perforated and brown paper perforated treatments extended the shelf life of kiwifruit with the longest duration and good marketable quality. This study is of great relevance to the kiwifruit growing farming community of Sikkim and other states in our country.

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