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Effect of Packaging Material on Shelf Life and Quality Attributes of Grapes (*Vitis Vinifera* L.)

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ABSTRACT
The effect of packaging material on shelf life and quality of grapes (Vitis Vinifera L.) i.e. Thomson seedless was taken for the study purpose packed with three different packaging materials viz., Low Density Poly Ethylene (LDPE) of 100 gauges, Polypropylene (PP) of 90 gauges and laminated Aluminum Foil (LAF). The samples were stored at 5˚C and 90-95 % RH in the Walk-in-cold chamber. Control group of grapes samples were stored at room temperature without packaging. The parameters like Viscoelastic Behavior, Physiological Loss in Weight (PLW), Moisture Content, Colour, Total Soluble Solid (TSS), Ascorbic acid content and Titrable acidity were measured at the regular interval of 5 days during the course of investigation. The quality parameters like Ascorbic acid content, Titrable acidity was least affected with the LAF packaging than other. The decrease in titrable acidity (%) and ascorbic acid content with LAF was found 2.80mg/ 100g and 0.03% whereas LDPE packaging content 1.54mg/ 100g and 0.03% respectively. The PP was the most effective packaging material for maintaining TSS values up to 14.92°B and in case of LDPE was found 14.33°B of fresh grapes. The hardness and thickness of loading for packaging containers of grapes with LDPE packaging material found with the minimum reduction up to 22.00N and 44.84 cm thickness reduction. The physical properties like PLW (0.55%), moisture content (% db) (513.07 %), change in L, a, b colour values (-2.53) was observed minimum with LDPE as compared with LAF and PP, so that the grapes stored in LDPE Packaging at refrigerated conditions at 5°C was found the effective quality attributes and optimum shelf life of 4 weeks (up to 25-28 days) as compared to control samples with 7 days.
Key words: *Grapes, Packaging, Shelf life, Quality, Storage, Colour, Titrable acidity.*

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INTRODUCTION

India is one of the largest producers of fruits and vegetables in the world. However, 30 to 50 % of the produce lost in transit due to poor post harvest facilities. There is an urgent need to stop these losses by improving the post harvest management. Among all the fruit crops grown in India, it being perishable and high moisture fruit, start decaying after about four days of storage. Considering perishability of grapes, the storage of surplus produce seems to be inevitable. This not only regulates the market but also provides supply in the off-season with increased financial gains to farmers [6]. The fresh grapes have good demand in domestic and international markets. If they are packed with suitable packaging material, not only provides good market value but also ensures quality for consumer's requirements. Grapes (*Vitis sp.*) belonging to Family *Vitaceae* is a commercially important fruit crop of India. It occupies fifth position amongst fruit crops in India in terms production about 1.08

MT (around 2% of world's production of 57.40 million tons) from an area of 0.04 million ha [1]. The combination of crunchy texture and dry, sweet flavor has made grapes an ever popular between meal snack as well as a refreshing addition to both fruit and vegetable salads. Grapes are excellent sources of minerals like manganese, potassium, calcium, iron, phosphorus, magnesium and selenium. They are also rich sources of Vitamin B_6, Vitamin B_1, Vitamin A and Vitamin C [3]. Table grapes show characters of both viscous as well as elastic food so it falls under viscoelastic materials. Knowledge of viscoelastic properties of foods and agricultural materials required for making the mathematical models, which describe and predict internal stress and cracking during different handling and processing procedures [9]. Besides other important functions of marketing like handling, storage, efficient transportation, grading and retailing, packaging of fruits is a key component of distributional system of fruits which protects them from deterioration during their handling and marketing by reducing mechanical damage, fruit wastage wastage

a loss of product or productivity; in terms of animal production includes losses due to deaths of animals, lowered production from survivors, including reproduction, and lost opportunity incom

wastage Fetal wastage, see there and losses [7]. Packaging also ensures that product arrives at the point of distribution in its optimum conditions. It increases their potential shelf life and makes product more attractive to buyers [6]. The effectiveness of different packaging materials will not be the same. Each material will show various impacts on the quality and shelf life. So the changes in grapes with the use of different available packaging materials should be studied. The present study has been taken with the objectives to study the viscoelastic properties of grapes for determining the hardness, loading thickness of packaging and to study the effect of packaging material on physical properties, quality attributes and shelf life storage of grapes.

MATERIALS AND METHODS

Materials: Grapes of common variety Thomson seedless were procured from local market. It was washed, sorted and then packaged with three different packaging materials *viz.,* Low Density Polyethylene (LDPE) of 100 gauges, Polypropylene (PP) of 90 gauges and Laminated Aluminum Foil (LAF). A grape bunches of 200 g each was packed with leaving 15 mm length on the top of package for sealing and having an effective area about 0.024 m^2.

Storage: The wrapped grapes fruits with packaging and without packaging (as a control) were stored in plastic crates with single layer pattern inside the Walk-in-cold chamber at 5˚C and 90 to 95% RH and ambient condition respectively for the comparative analysis of effect of different packaging materials on the grapes in accordance with its storage life.. Physical and chemical parameters of the stored grapes fruit were determined at the regular interval of 5 days.

Determination of Hardness: The grape berries were selected at randomly to calculate the hardness by compression test with the help of texture analyzer (TA-XT plus) [8]. Before performing the test, the machine was calibrated with Probe: 75 mm dia. Flat plate, Test Speed: 1.00 mm/sec, Strain: 15 %, Time: 5 sec. for the accuracy in observation to determined the idea about stress relaxation and creep behavior.

Loading thickness for grapes: In order to maintain the grapes in their natural safe state during storage and transportation, the grapes at the bottom should not be compressed with overloaded containers. Therefore, maximum bearable force load by the grapes is needed to be calculated. The maximum thickness of loading for packaging containers of grapes was calculated as:

$$\text{Thickness of loading} = \frac{\text{hardness force} \times \text{thickness of single layer of pocket}}{\text{weight force of single layer}}$$

Physical properties of grapes: In order to study the change in physical properties of grapes packaged with different materials and with advancement in storage time, Physiological loss in weight (PLW), Moisture content and Colour development of skin was studied.

Physiological loss in weight (PLW): The weighing was done with the digital balance having least count of 0.5 g. The readings were taken at an interval of 5 days. The PLW at each interval was calculated as:

$$\text{Physiological loss in weight (PLW)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Moisture content: The standard hot air oven method of moisture content determination was used for determination of the moisture content of the grapes [2].

$$\text{Moisture content (\% db)} = \frac{\text{Initial wet material weight} - \text{Final bonedry material weight}}{\text{Final bonedry material weight}} \times 100$$

Colour development of skin: The colour of grapes was measured by using Miniscan XE plus Hunter Lab Colorimeter. The colour was described by a tristimulas value of 'L', 'a' and 'b' where L indicates intensity of colour i.e. lightness which varies from L=100 for perfect white to L=0 for black. The value of 'a' measured redness when positive, grey when zero and greenness when negative and the value of 'b' measured yellowness when positive, grey when zero and blueness when negative.

Chemical properties: The effect of different packaging material on nutritional value of grapes, the chemical properties of grapes including TSS, ascorbic acid content and titrable acidity were found.

Total soluble solids: To measure the TSS value of the fresh and packaged grapes an Erma hand Refractometer covering a range of 0˚ Brix to 32˚ Brix was used.

Ascorbic acid: The ascorbic acid content present in the sample was calculated by comparing the sample reading and standard vitamin C reading.

$$Ascorbic\ acid\ content\ \left(\frac{mg}{100g}\right) = \frac{Volume\ of\ dye\ solution\ needed\ for\ grapes\ sample\ \times Vit.C\ in\ the\ std.solution}{Volume\ of\ dye\ needed\ for\ std.solution}$$

Titrable acidity (%):Titrable acidity (%) present in the sample was was calculated by:

$$\text{TA as tartaric acid (\%)} = \frac{V \times N \times 75 \times 100}{1000 \times v}$$

Where,

V = Difference (ml) of sodium hydroxide solution for titration of sample and blank,
N = Normality of sodium hydroxide solution,
v = Sample volume (ml).

Statistical analysis: The data were statistically analyzed by employing factorial experiment in Completely Randomized Design (CRD**)** using CPCS1 computer programme package [4]. Means were computed and tested at 5 percent level of significance of critical difference to arrive at the best results of the treatments.

RESULTS AND DISCUSSION

Effect of hardness and Thickness of loading for packaging containers of grapes: Hardness of the fresh grapes and grapes packaging with different materials stored at low temperature with storage time is given in Table 1. The hardness values were decreased from 26.96 to 22 N with LDPE, from 26.74 to 11.05 N with PP and from 26.78 to13.34 N with LAF at the end of 25th day of cold storage. The data for change in hardness of grapes during storage with different packaging materials was statistically analyzed. The storage period mean in all the cases showed that the hardness (N) decreased with the increase in storage period in all the treatments. The maximum treatment mean was observed with LDPE which was followed by mean of LAF and PP respectively. The CD at 5% level of significance was 0.130435 for treatments, 0.184462 for storage duration and 0.319498 for their interaction. The minimum reduction was found in samples packed with LDPE which were 26.16, 25.05, 23.81, 23.31 and 22.00 N on 5th, 10th, 15th, 20th, and 25th day of storage respectively. The thickness of loading for packaging containers of the grapes is given in the table 1. There was declining trend with all the three packaging materials with the advancement of storage period. The initial loading thickness of 54.54 cm was observed reduced to 44.84 cm after 25 days of cold storage with LDPE. In all the cases showed that the loading thickness decreased with the advancement in storage period in all the treatments. The maximum treatment mean was observed with LDPE which is followed by mean of LAF and then PP respectively. The CD at 5% level of significance was 0.272812 for treatments, 0.385814 for storage duration and 0.668250 for their interaction. The loading thickness decreased with the duration of storage irrespective of treatments and the decrease being maximum in the control unit. The minimum reduction was found in samples packed in LDPE which were

53.33, 51.07, 48.53, 47.52 and 44.84 cm on 5th, 10th, 15th, 20th, and 25th day of storage respectively. The hardness and loading thickness in LDPE stored samples was significantly more than in the other two treatments which proved it best in terms of textural properties. The hardness value and loading thickness of control fruits decreased very rapidly on the 5th, 10th and 15th day of storage and were reported to 22.96, 18.96 and 15.56 N and 46.82, 38.65 and 31.72 cm respectively as the sample kept at ambient conditions was observed damaged only after 15 days. The decrease in hardness and loading thickness was most pronounced in control fruits. Therefore, LDPE was the best packaging material in terms of maintaining desirable hardness of fruits among all the three materials used for experiment.

Table 1: Effect of Hardness (N) and loading thickness during storage period.

	Treatment	Days (Storage period)						Treatment mean
		0	5	10	15	20	25	
Hardness (N)	**T1**	26.96	26.16	25.05	23.81	23.31	22.00	24.55
	T2	26.74	24.40	21.12	18.20	14.83	11.05	19.39
	T3	26.78	24.03	21.20	18.15	16.32	13.34	19.97
	Duration mean	26.83	24.87	22.46	20.05	18.15	15.46	
	Control mean	26.83	22.96	18.96	15.56			21.08
	CD at 5% level: Treatment (A)=0 .130435; Duration (B) = 0.184462; Interaction (AB) = 0.319498							
Thickness of loading	**T1**	54.54	53.33	51.07	48.53	47.52	44.84	49.97
	T2	54.50	49.75	43.05	37.11	30.23	22.53	39.53
	T3	55.31	48.99	43.21	36.99	33.27	27.20	40.83
	Duration mean	54.78	50.69	45.78	40.87	37.00	31.53	
	Control mean	54.50	46.82	38.65	31.72			42.96
	CD at 5% level: Treatment (A) = 0.272812; Duration (B) = 0 .385814; Interaction (AB) = 0 .668250							

Physical Properties:

Physiological loss in weight (PLW): The values of PLW (%) in grapes packaged with different materials are shown in Table 2.The trends of PLW during storage period of 25 days showed that the minimum PLW occurred in the fruits packed in the LDPE from 0.15 to 0.55 followed by LAF and then with PP. In all the cases showed that the physiological loss in weight (%) increases with the advancement in storage duration in all the treatments. The maximum treatment mean was observed with PP which was followed by mean of LAF and LDPE respectively. The CD at 5% level of significance was 0.0217283 for treatments, 0.0280511 for storage duration and 0.0485859 for their interaction. It is clear that the PLW (%) increased with the duration of storage irrespective of treatments. The increase was observed maximum in the control fruits. The minimum increase was found in samples packed in LDPE which were 0.15, 0.25, 0.35 ,0.45 , and 0.55 % on 5th, 10th, 15th, 20th, and 25th day of storage respectively. The PLW (%) of control fruits increased very rapidly on the 5th, 10th and 15th day of storage and were reported 1.06 , 1.73 and 8.6674 % respectively, as the sample kept at ambient conditions was observed to be damaged only after 15 days.

Table 2: Physiological losses in weight (%), of packaging materials during storage

	Treatment	Days						Treatment mean
		0	5	10	15	20	25	
Physiological losses in weight (%)	**T1**	-	0.15	0.25	0.35	0.45	0.55	0.35
	T2	-	0.21	0.36	0.52	0.66	0.74	0.50
	T3	-	0.22	0.35	0.47	0.59	0.72	0.47
	Duration mean	-	0.19	0.32	0.45	0.57	0.67	

	Control mean	-	1.06	1.73	8.667			3.83
CD at 5% level: Treatment (A) = 0 .0217268; Duration (B) = 0 .0280511; Interaction (AB) = 0 .0485859								

Variation in moisture content: The moisture content values on dry basis (%) of grapes during storage of 25 days packaged with different materials are shown in Table 3. It was conclude that moisture variation was minimum with LDPE film as compared to PP and LAF. The data for change in moisture content (db%) of grapes during storage packaged with different packaging materials was statistically analyzed. The moisture content (db %) decline with the advancement in storage duration in all the treatments. The maximum treatment mean was observed with LDPE which is followed by mean of LAF and PP respectively. The CD at5% level of significance was 2.05937 for treatments, 2.91239 for storage duration and 5.04441for their interaction. The moisture content (db %) decreased with the duration of storage irrespective of treatments. The decrease was maximum in the control fruits and minimum decrease was found in samples packed with LDPE which were 638.28, 589.56, 579.13, 556.39, 537.21 and 513.07 % on 5th, 10th, 15th, 20th, and 25th day of storage respectively. This was followed by LAF and then PP. The moisture content (db%) of control fruits decreased very rapidly on the 5th, 10th and 15th day of storage and were reported to be 589.56,579.12 and 556.39 % respectively, as the sample kept at ambient conditions was observed to be damaged only after 15 days. The variation in moisture content (db%) with LDPE stored samples was significantly less than in the other two treatments.

Table 3: Moisture content (%db) with different packaging materials during storage

Moisture content (db %)	Treatment	Days						Treatment mean
		0	5	10	15	20	25	
	T1	638.28	589.56	579.13	556.39	537.21	513.07	568.94
	T2	638.20	531.60	511.46	489.68	476.39	461.52	518.14
	T3	638.83	562.28	549.04	527.82	510.19	481.84	544.99
	Duration mean	638.44	561.15	546.54	524.63	507.93	485.47	
	Control mean		589.56	579.12	556.39			590.84
CD at 5% level: Treatment (A) = 2.05937; Duration (B) = 2.91239; Interaction (AB) = 5.04441								

Colour: The trends of colour change in the 'L', 'a' and 'b' values of grapes packaged with different materials and in control samples. The colour of the fruits showed changes with the advancement in the storage period. This was measured considering the change in its 'a' values as shown in Fig 1. The change in 'a' value was from -1.86 to -2.53 which showed that greenness in fruits was going on increasing with storage time up to 25th days of storage period. The colour change was very rapid for control fruits and the least change was in samples packed with LDPE followed by PP and LAF respectively. 'L' indicates lightness, the decrease in 'L' value showed that lightness decreased. This was evident from the appearance of yellow colour. The samples packed in LDPE, the value of 'L' changed from 34.84 to 23.82 till 25th day of storage and 'b' varied from 13.26 to 13.36 which indicated that yellowness in fruits increased during storage period of 25 days. For PP packed samples, the value of 'a' changed from -1.88 to -2.44 and the value of b varied from 13.26 to 13.33 and for control samples a and b values changed from -1.87 and 13.26 to 1.84 and 9.14 respectively at the end of 25 days of storage period. The data regarding the colour change in terms of a-value during the storage period under different treatments were statistically analyzed showed that minimum value was in samples packed in LDPE (-2.53) followed by PP (-2.44) and LAF (-2.28), which indicates that maximum greenness appeared in the samples stored in LDPE. CD at 5% level of significance was 0.0168605 for treatments, 0.0238444 for storage duration and 0.0412997 for their interaction. The change in a value was maximum with LDPE but with the negative sign which signify appropriate selection of LDPE in terms of colour change was concerned.

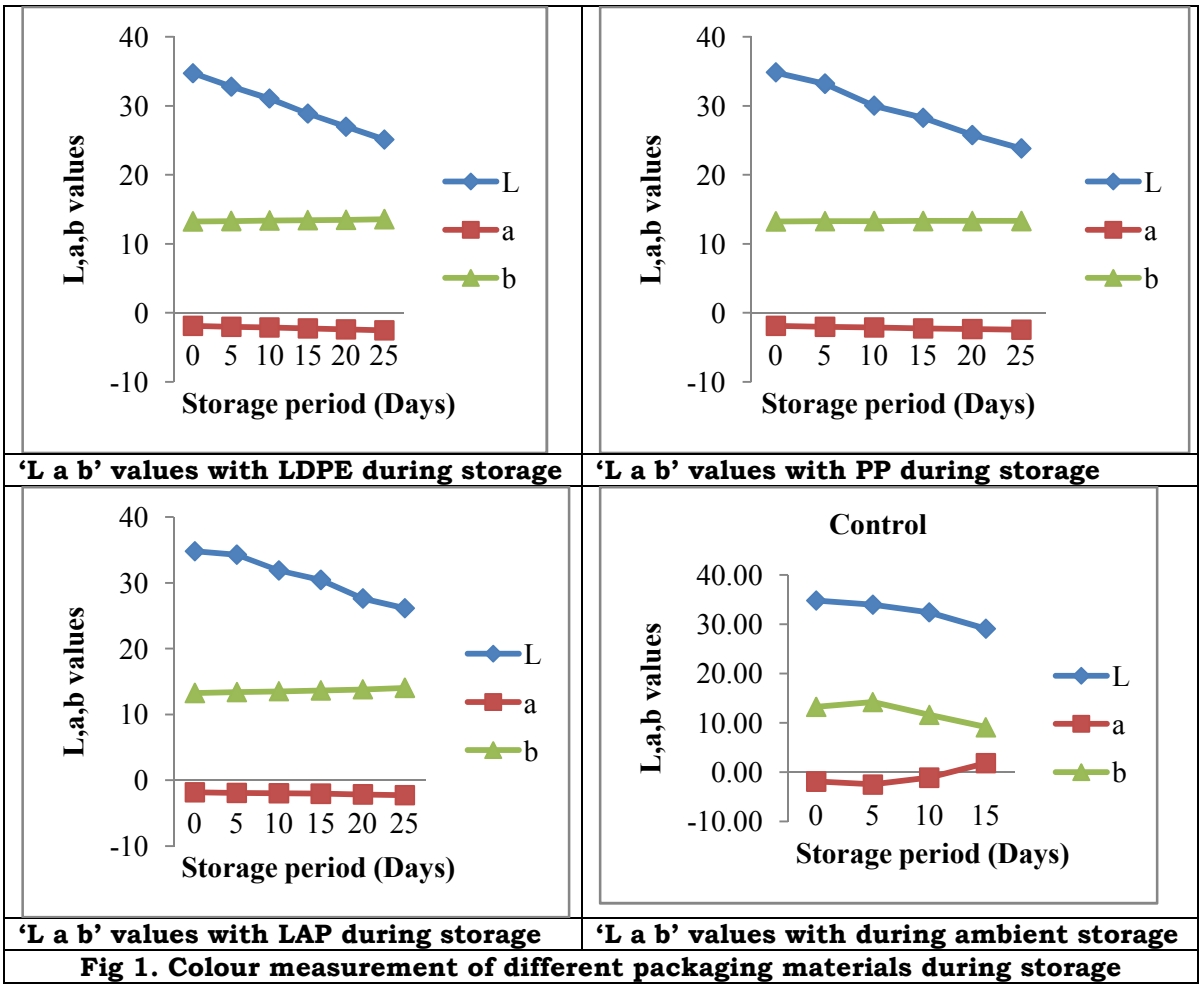

Fig 1. Colour measurement of different packaging materials during storage

Chemical properties:

Total soluble solids: Table 4 shows the average values of the TSS (˚Brix) at five days interval for grapes packaged in different materials. Significantly, the data for change in TSS (˚B) resulted that, the PP was shows the better retention in TSS values as compared to the LDPE and LAF. It was observed that duration mean was increased from 16.97 to 17.47 in between the storage period of 15-20 days. The mean value obtained at the end of 20th day was again observed to be reduced to15.08 at the end of 25th day of walk in cold chamber. The maximum treatment mean was observed with PP which was followed by mean of LAF and LDPE respectively. The CD at 5% level of significance was 0.775794 for treatments, 1.09714 for storage duration and NS for their interaction. Total Soluble Solids (˚B) alternately increasing and decreasing with duration of storage irrespective of treatments. The change in fresh fruit Total Soluble Solids (˚B) value was maximum in the control fruits. The minimum decrease was found in samples packed with PP which were 18.23, 17.47, 17.50, 17.17 and 16.00 on 5th, 10th, 15th, 20th, and 25th day of storage respectively. Total Soluble Solids (˚B) of control fruits changes was decreased from 18 to 16.92. The variation in Total Soluble Solids (˚B) with PP stored samples was significantly less than in the other two treatments.

Ascorbic acid: The minimum change in the ascorbic acid content of the fresh fruit was observed with the LAF. From table 4, The LDPE showed the largest change in the fresh grapes readings. The Ascorbic acid content of 6.68 mg/100g for fresh grapes was decreased to 1.54 mg/100g for grapes packaged with LDPE at the end of 25th day of cold storage. The Ascorbic acid content of 6.74 and 6.71 were reduced to 1.88 and 2.80 for PP and LAF after 25 days respectively. The data for Ascorbic acid content (mg/100g) of grapes with storage with different packaging materials was statistically analyzed. The maximum treatment mean was observed with LAF which was followed by mean of PP and LDPE respectively. The CD at 5% level of significance was 0.217342 for treatments,

0.307368 for storage duration and. 0.532377 for their interaction. The Ascorbic acid content (mg/100g) decreased with the duration of storage irrespective of treatments.

Titrable acidity: The changes in the titrable acidity of fresh grapes with storage period and different packaging materials have been displayed in table 4. For every packaging material the titrable acidity values showed a diminishing pattern with advancement in storage period. The minimum decrease was found in samples packed with LAF which was followed by PP and then LDPE. The data for change in titrable acidity (%) of grapes with storage under different packaging materials was statistically analyzed. The duration means were observed decreased with the advancement in storage period for all three treatments. The maximum treatment mean was observed with PP which was followed by mean of LAF and LDPE respectively. The CD at 5% level of significance was 0.0633782 for treatments, NS for storage duration and NS for their interaction. The decrease in titrable acidity (%) was observed maximum in the control fruits. The minimum decrease was found in samples packed with LAF which were and 0.14, 0.11, 0.09, 0.04 and 0.03 % on 5th, 10th, 15th, 20th, and 25th day of storage respectively. This was followed by LDPE and then PP. The titrable acidity (%) of control fruits decreased very rapidly on the 5th, 10th and 15th day of storage and were reported to be 0.105, 0.09 and 0.0125 % respectively, as the sample kept at ambient conditions was observed damaged only after 15 days. The decrease in the titrable acidity (%) was the most pronounced in control fruits.

Table 3: Total soluble solids, Ascorbic acid content (mg/100g) and Titrable acidity of grapes with different packaging materials during storage

	Treatment	Days						Treatment mean
		0	5	10	15	20	25	
Total soluble solids	**T1**	18.00	16.52	18.10	16.42	17.50	14.33	16.81
	T2	17.67	18.23	17.47	17.50	17.17	16.00	17.34
	T3	18.00	18.83	17.17	17.00	17.75	14.92	17.28
	Duration mean	17.89	17.86	17.58	16.97	17.47	15.08	
	Control mean	17.57						
	CD at 5% level: Treatment (A)= 0 .775794; Duration (B) =1.09714; Interaction (AB) = NS							
Ascorbic acid content (mg/100g)	**T1**	6.68	4.49	4.08	2.94	2.56	1.54	3.72
	T2	6.74	5.78	4.49	3.75	2.47	1.88	4.18
	T3	6.70	5.77	5.49	4.55	3.73	2.80	4.84
	Duration mean	6.71	5.35	4.68	3.75	2.92	2.07	
	Control mean	4.29						
	CD at 5% level: Treatment (A)= 0 .21734; Duration (B) = 0.307368; Interaction (AB) = 0 .532377							
Titrable acidity	**T1**	0.15	0.09	0.07	0.04	0.04	0.03	0.07
	T2	0.15	0.13	0.09	0.06	0.04	0.03	0.08
	T3	0.14	0.11	0.09	0.04	0.04	0.03	0.08
	Duration mean	0.15	0.11	0.08	0.05	0.04	0.03	
	Control mean	0.09						
	CD at 5% level: Treatment (A) = 0.0633782; Duration (B) =NS; Interaction (AB) = NS							

CONCLUSION

Keeping in view all the studied parameters under low temperature storage LDPE film was the most suitable for the less PLW, moisture variation, colour change. LDPE film was also best suited for maintaining the hardness of fruit. The LAF was proved best for maintaining the ascorbic acid content and titrable acidity of fresh fruit. It can be concluded that the LDPE film was the most appropriate for maintaining the physical appearance including the

colour, weight, moisture and hardness of grapes. LAF was the best suited for maintaining the quality parameters like ascorbic acid content and titrable acidity. The PP film was the best effective packaging material among all three packaging materials for TSS values. In the end it can be inferred that LDPE was proved the best packaging material for the storage of grapes.

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