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EFFECTS OF DIFFERENT PACKAGING MATERIALS ON PHYSIOLOGICAL AND BIOCHEMICAL PROPERTIES OF GRAPES (*VITIS VINIFERA* L.) DURING STORAGE

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ABSTRACT

Grapes (*Vitis vinifera* L.), integral to human culture and agriculture are celebrated for their versatility and health benefits. This study was conducted in 2023-24 at ITM University, Gwalior. The experiment involved nine treatments with three replications using fully matured, disease-free grapes. Packaging materials tested included cotton bags, HDPE, polyethylene bags, brown paper, transparent boxes, food wrapping paper, CFB boxes, tissue paper and a control. Physiological parameters measured were fruit volume and spoilage percentage, while biochemical parameters included fruit pH, total soluble solids (TSS), titratable acidity, and ascorbic acid content. Results indicated significant differences among treatments. HDPE packaging excelled in minimizing weight loss and spoilage, and in maintaining quality attributes such as pH, TSS, titratable acidity, and ascorbic acid content. Transparent boxes initially preserved fruit volume best, but HDPE out performed in later stages. Control treatments consistently showed the poorest results. The study highlights the importance of specialized packaging in extending grape shelf life by reducing metabolic activity and maintaining an optimal environment. These findings provide valuable insights for optimizing storage conditions to preserve grape quality and suggest future research directions to further improve postharvest preservation techniques.

Key words : Grapes, Packaging materials, Shelf life, Quality, Storage.

Introduction

Grapes (*Vitis vinifera* L.), originating from West Asia and Europe, have been integral to human culture and agriculture for millennia. Celebrated for their versatility, grapes are enjoyed as a fruit, in winemaking, culinary arts, and traditional medicine. With cultivation spanning diverse global regions, grapes exhibit vast genetic diversity, resulting in varied flavours, colours and textures. They are rich in antioxidants, vitamins and minerals, offering numerous health benefits. Economically, the global grape industry thrives on fresh fruit markets, wine production and value-added products, highlighting their significance. Long-term storage of grapes ensures availability beyond harvest, maintaining market supply through refrigeration and controlled atmospheres. This preserves quality, facilitates distribution to distant markets and allows year-round consumption, enhancing dietary diversity. In India, grapes are grown on 1.2% of fruit crop areas, contributing 2.8% to the national fruit output. Maharashtra leads with 440 thousand metric tonnes, followed by Karnataka, Tamil Nadu, and Andhra Pradesh. Grape farming is crucial to India's agricultural economy, supporting numerous farmers. Understanding the viscoelastic properties of grapes is vital for optimizing handling, processing and storage, ensuring quality preservation from vineyard to consumer.

Materials and Methods

The experiment was carried out during 2023-24 at Department of Horticulture, ITM University, Gwalior. The Fully matured and disease & pest free high quality graded grapes were collected and different types of packaging materials were used for treatments. This investigation comprised of 09 different treatments with 03 replications.

The experiment were conducted with different treatments with cotton bag, HDPE, polyethylene bag, brown paper, transparent box, food wrapping paper, CFB box, tissue paper along with one control. During the experiment different physiological and biochemical parameters were observed.

Physiological parameters

Vernier calliper is used to measure the diameter of grape fruits, which is expressed in centimetres. Decay or Spoilage %; Decay or spoilage of grape fruits was recorded at 0, 4, 8 and 12 days of experiment. The data on fruit decline or spoilage were also collected from the three replications. After that, it was statistically averaged and examined. The decay or spoilage was calculated as per the formula which was used by Srivastava and Tandon (1968).

Biochemical parameters

Fruit pH

The pH of the fruit juice was measured using a pH meter. The electrode was inserted into the grape juice, ensuring it was fully submerged. After waiting for the reading to stabilize, the pH value displayed on the meter was recorded.

TSS

TSS was determined using a refractometer and expressed in degrees Brix (^{0}Brix).

Titratable acidity (%)

Acidity was determined by titration method. 10 gram of fruit pulp was macerated with distilled water, filtered through muslin cloth and volume was made up to 100 ml with distilled water. A known volume was titrated against standard 0.1N NaOH using phenolphthalein as an indicator. The appearance of light pink colour was marked as the end point. The value was expressed in terms of citric acid as percent titratable acidity of fruit pulp (Anonymous, 1984).

Ascorbic acid (mg/100g)

A ten-gram sample of homogenized pulp was transferred to a 100-milliliter volumetric flask. A 4 percent oxalic acid solution was used to make up the difference in volume. The suspension was filtered via Whatman No. 1 filter paper after 30 minutes. The dye factor was calculated after the 2, 6-Dichlorophenol indophenol (Dye solution) was normalized by titrating against a standard ascorbic acid solution. Five milli liter of the filtrate were collected and titrated against a standardized dye solution using a burette. The titration was kept going until the light pink colour lasted 15 seconds. The ascorbic acid content was determined using the formula below.

$$\text{Ascorbic acid} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Aliquot of extract taken} \times \text{Volume of juice taken}} \times 100$$

Statistical analysis

Following the guidance of Panse and Sukhatme (1985), the statistical method of "Analysis of Variance" was employed to analyse the data collected from the set of observations for each character. The ANOVA design was structured in accordance with their recommendations.

Results and Discussion

Physiological observations

On the 0th day of observation, equal and uniform weights of grapes were allocated to different treatments, with subsequent observations made on the 4th, 8th and 12th days after storage, revealing significant differences among the treatments. The highest fruit volume was recorded in the transparent box treatment (T_5) on the 0th (33.04 ml) and 4th (26.6 ml) days of observation, but on the 8th (21.207 ml) and 12th (17.597 ml) days, the HDPE treatment (T_2) showed the best results, while the control treatment (T_0) consistently showed the lowest results throughout the observation period. Initially, the transparent box treatment (T_5) showed the highest fruit volume, likely due to its ability to provide a stable environment with minimal physical compression on the grapes. However, the HDPE treatment (T_2) exhibited better performance in later observations, which may be explained by the HDPE's superior capacity to maintain a low-oxygen, high-carbon dioxide environment that slows down respiration

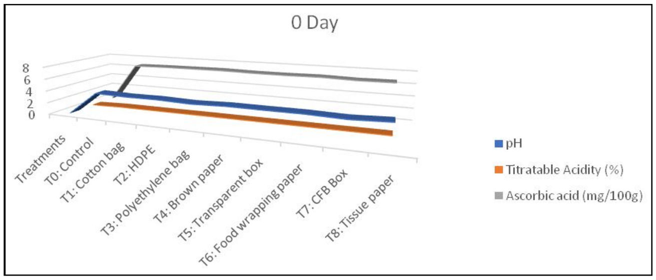

Fig. 1 : Effect of packing materials on pH, Titratable acidity and Ascorbic acid content at 0th day observation.

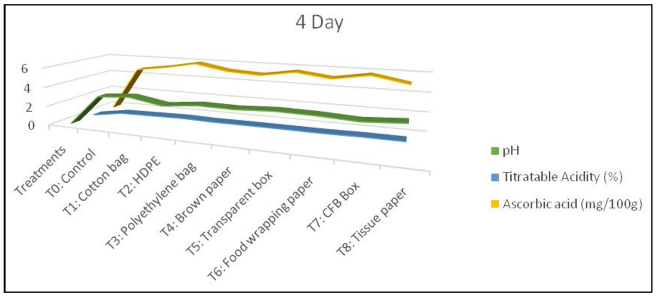

Fig. 2 : Effect of packing materials on pH, Titratable acidity and Ascorbic acid content at 4th day observation.

Table 1 : Effect of different packing material on physical attributes of grapes.

Treatments	Fruit volume 0th day	Specific gravity 0th day	Fruit volume 4th day	Specific gravity 4th day	Decay % 4th day	Specific gravity 4th day	Fruit volume 8th day	Specific gravity 8th day	Decay % 8th day	Fruit volume 12th day	Specific gravity 12th day	Decay % 12th day
T_0: Control	29.38	1.057	25.56	1.063	10.443	1.063	20.18	0.944	14.7	15.74	0.88	19.3
T_1: Cotton bag	29.213	1.093	25.607	1.084	6.77	1.084	20.197	0.878	10.147	16.677	0.737	14.147
T_2: HDPE	29.423	1.07	22.707	1.074	6.567	1.074	21.207	0.898	9.937	17.597	0.793	12.767
T_3: Polyethylene bag	28.517	1.105	24.373	1.074	7.397	1.074	19.263	0.988	11.563	14.443	0.957	15.557
T_4: Brown paper	28.833	1.079	25.077	1.091	8.2	1.091	19.333	1.017	11.6	14.857	0.947	14.633
T_5: Transparent box	33.04	1.099	26.6	1.081	8.667	1.081	20.107	1.0	11.067	16.293	0.913	14.767
T_6: Food wrapping paper	29.267	1.109	25.077	1.08	8.767	1.08	19.663	0.99	11.867	15.887	0.907	15.133
T_7: CFB Box	29.663	1.117	24.757	1.075	9.3	1.075	20.29	0.988	11.833	16.89	0.907	13.7
T_8: Tissue paper	29.953	1.137	23.69	1.057	10.567	1.057	18.613	0.976	12.533	14.33	0.89	13.867
CD	0.3	N/A	N/A	0.11	0.736	0.11	0.452	0.01	1.287	0.529	0.082	2.038
S.Em.	0.1	0.035	1.146	0.021	0.246	0.021	0.151	0.064	0.43	0.177	0.027	0.67

and subsequent volume loss in the grapes. The consistent poor performance of the control treatment (T_0) suggests that ambient storage conditions fail to prevent volume loss, highlighting the importance of using specialized packaging materials. On the 4th day of observation, the minimum spoilage percentage was observed in the HDPE treatment (T_2) at 6.567%, a trend that continued on the 8th day with a spoilage percentage of 9.937% and on the 12th day with 12.767%, while the control treatment (T_0) consistently showed the highest spoilage percentages throughout the observation period. The lowest spoilage percentage observed in the HDPE treatment (T_2) indicates its effectiveness in delaying microbial growth and decay, likely due to the hermetic properties of HDPE creating an environment less conducive to microbial activity. Conversely, the high spoilage rates in the control treatment (T_0) underscore the need for protective packaging to enhance grape shelf life. On the 0th day of observation, no significant differences were noted, as bunches had uniform weight and size. By the 4th day of observation, the fruit kept in brown paper (T_4) exhibited the highest specific gravity value of 1.091, maintaining this trend on the 8th day (1.017) and the 12th day (0.947), while the control treatment (T_0) consistently showed the lowest specific gravity throughout the observation period. The highest specific gravity values observed in grapes stored in brown paper (T_4) suggest that this material provided an optimal balance between breathability and protection, allowing sufficient moisture exchange to prevent excessive water loss while avoiding moisture build up that could lead to decay. The consistently low specific gravity in the control treatment (T_0) indicates greater water loss and potential cellular breakdown, emphasizing the importance of using appropriate packaging to maintain grape quality. These results align with the findings of Martínez Romero *et al*. (2003), Nelson *et al.* (1970), Xu *et al.* (2013), Cejudo-Bastante *et al.* (2021), Secer *et al*. (2020), Li *et al*. (2023).

Biochemical observations

On the 0th day, there was no significant difference observed among the treatments. However, by the 4th day, the fruits under HDPE (T_2) exhibited the lowest pH content at 2.9 and this trend continued on the 8th day (1.867) and the 12th day (1.633). Conversely, the control treatment (T_0) consistently resulted in the highest pH content throughout the observation period. The pH content of grapes is a critical indicator of their acidity and overall quality. The initial absence of significant differences among treatments confirms that initial conditions were consistent. By the 4th day, grapes under HDPE (T_2) exhibited the lowest pH content (2.9), which continued to decrease further on the 8th (1.867) and 12th (1.633) days. This consistent reduction in pH under HDPE

Table 2 : Effect of different packing material on biochemical attributes of grapes.

	pH	Titratable Acidity (%)	Ascorbic acid (mg/100g)	pH	Titratable Acidity (%)	Ascorbic acid (mg/100g)	pH	Titratable Acidity (%)	Ascorbic acid (mg/100g)	pH	Titratable Acidity (%)	Ascorbic acid (mg/100g)
Treatments	**0th day**	**0th day**	**0th day**	**4th day**	**4th day**	**4th day**	**8th day**	**8th day**	**8th day**	**12th day**	**12th day**	**12th day**
T_0: Control	3.9	0.153	6.64	3.2	0.54	4.81	2.93	0.497	4.127	2.867	0.333	**2.867**
T_1: Cotton bag	3.767	0.153	6.737	3.467	0.61	5.267	2.567	0.57	4.61	2.5	0.373	**3.36**
T_2: HDPE	3.8	0.153	6.78	2.9	0.68	5.883	1.867	0.653	5.393	1.633	0.393	**4.517**
T_3: Polyethylene bag	3.633	0.157	6.82	3.247	0.62	5.26	2.597	0.603	4.9	2.3	0.543	**3.8**
T_4: Brown paper	3.8	0.153	6.707	3.2	0.64	5.06	2.593	0.61	4.747	2.4	0.37	**3.33**
T_5: Transparent box	3.767	0.157	6.693	3.377	0.64	5.61	2.55	0.607	4.447	2.2	0.553	**3.707**
T_6: Food wrapping paper	3.767	0.153	6.76	3.32	0.63	5.167	2.833	0.607	4.9	2.6	0.32	**3.933**
T_7: CFB Box	3.6	0.157	6.613	3.143	0.683	5.747	2.12	0.633	4.67	1.833	0.387	**3.823**
T_8: Tissue paper	3.833	0.157	6.66	3.39	0.67	5.087	2.75	0.5	4.923	2.5	0.313	**3.947**
CD	N/A	N/A	N/A	0.267	0.017	0.359	0.524	0.02	0.129	0.537	N/A	**0.25**
S.Em.	0.071	0.003	0.079	0.089	0.006	0.12	0.175	0.007	0.043	0.18	0.063	**0.084**

treatment can be attributed to the modified atmosphere within the HDPE packaging, which likely slowed down the respiration rate and metabolic activities, thus preserving the acidic environment longer. In contrast, the control treatment (T_0) maintained the highest pH levels throughout, indicating lesser retention of acidity due to more rapid respiration and metabolic processes in an unprotected environment. In the context of titratable acidity, no significant differences were observed among the treatments on the 0th day of observation. However, by the 4th day, the fruits stored in CFB Box (T_7) and HDPE (T_2) showed the highest titratable acidity content at 0.68%. On the 8th day, HDPE (T_2) recorded the highest value at 0.653%. By the 12th day, no significant differences were observed among the treatments once again. Titratable acidity is an essential quality attribute, impacting the taste and preservation of grapes. The initial lack of differences among treatments on the 0th day established a uniform starting point. By the 4th day, the highest titratable acidity was found in grapes stored in CFB Box (T_7) and HDPE (T_2) at 0.68%. On the 8th day, HDPE (T_2) continued to show the highest value at 0.653%, indicating that HDPE packaging was effective in retaining acidity. This could be linked to the reduced oxygen permeability of HDPE, which slows down the degradation of organic acids. By the 12th day, the lack of significant differences among treatments suggests a convergence of acidity levels, potentially due to the prolonged storage affecting all treatments similarly. In the context of ascorbic acid content, no significant differences were observed among the treatments on the 0th day of observation. However, by the 4th day, fruits under the HDPE treatment (T_2) exhibited the highest ascorbic acid content at 5.883 mg/100g. This trend continued, with HDPE-treated fruits maintaining the highest ascorbic acid levels on the 8th day (5.393 mg/100g) and the 12th day (4.517 mg/100g) of observation. In contrast, the control treatment (T_0) consistently showed the lowest ascorbic acid content throughout the observation period. Ascorbic acid (vitamin C) is a crucial nutrient and antioxidant in grapes. The absence of significant differences on the 0th day established baseline equality among treatments. By the 4th day, HDPE-treated fruits (T_2) showed the highest ascorbic acid content at 5.883 mg/100g, maintaining this trend on the 8th day (5.393 mg/100g) and 12th day (4.517 mg/100g). The superior preservation of ascorbic acid under HDPE treatment can be attributed to its barrier properties, which protect against oxidation and environmental degradation. Conversely, the control treatment (T_0) consistently showed the lowest ascorbic acid content, indicating more significant nutrient loss due to exposure to air and other environmental factors.

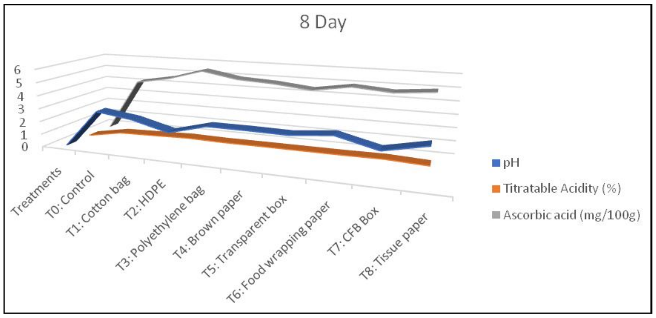

Fig. 3 : Effect of packing materials on pH, Titratable acidity and Ascorbic acid content at 8th day observation.

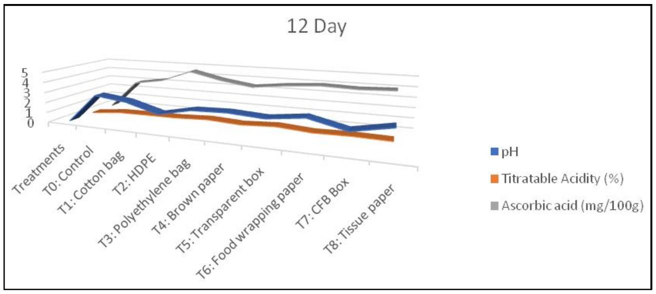

Fig. 4 : Effect of packing materials on pH, Titratable acidity and Ascorbic acid content at 12th day observation.

These results align with the findings of Dewi and *et al.* (2020), Saeed *et al.* (2010), Saito *et al.* (2020), Huwei *et al.* (2021) and Nabiyev *et al.* (2024).

Conclusion

The study demonstrates that HDPE packaging excels in preserving grape quality during storage by minimizing weight loss, spoilage and physiological loss in weight (PLW) and maintaining essential quality attributes such as pH, Total Soluble Solids (TSS), titratable acidity and ascorbic acid content. The controlled atmosphere created by HDPE packaging effectively slows down metabolic activities, reduces respiration rates and maintains an acidic environment, thereby extending the shelf life of grapes. Cotton bags also showed effectiveness, particularly in retaining fruit length due to their breathable nature, which mitigates moisture build up and microbial growth. These findings highlight the critical role of specialized packaging materials over ambient storage conditions in reducing volume loss, water evaporation, and nutrient degradation. Protective packaging is essential for enhancing grape quality and prolonging shelf life. The study offers valuable insights into the impact of different packaging treatments on postharvest grape quality, suggesting potential strategies for optimizing storage conditions and preserving fruit freshness, nutritional value, and sensory attributes. Future research should explore variations in packaging materials and storage parameters to refine preservation techniques and further improve fruit quality.

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