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"Packaging materials effect on quality of raisins to enhance the shelf life of stored raisins"

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KEYWORDS
Raisins, Packaging, Shelf life, Vacuum Packaging, Storage, PP, LAF, LDPE

ABSTRACT
The packaging materials effect on quality of raisins to enhance the shelf life of stored raisins for Thompson seedless. Raisins samples are packed with four different packaging materials *viz.*, polypropylene (PP) (100 gauge), Low density polyethylene (LDPE 1) (200 gauge), laminated aluminum foil (LAF) (300 gauge), and low-density polyethylene (LDPE 2) (400 gauge) for to check the quality of raisin. The samples were stored at 10±2ºC at 85 – 90% RH in refrigerator and ambient condition (room temperature). The parameters like Color Intensity, Reducing Sugars and Microbial Analysis were done at the 30 days of regular interval. The reducing sugar value was highest recorded 66.85% to 68.21% and total plate count was found of 9.8×10^3 cfu/gm in non-vacuum packed PP packaging material at room temperature and lowest recorded was 66.85% to 67.72% and total plate count was not recorded any colonies 180 days after storage in vacuum packed LAF packaging material stored at cold temperature (10±2ºC). The results were obtained from study shows that the samples stored at cold temperature in LAF packaging material with vacuum packaging shows better results compared to other three. Polypropylene cost 189.86 and Low-Density Polyethylene (400 gauge) 191.55. Thus, polypropylene (100 gauge) is the cheapest packaging material for raisins. The mean score for color/appearance, texture, taste, flavor and overall acceptability of samples packed in different types of packaging materials and stored at different conditions ranged from 6.6 to 6.9 and 6.9 to 7.1 respectively.

INTRODUCTION

Grapes come from the family Vitaceae. Grapes are called Vitis by scientists. Grapes are round, juicy, and sweet fruits that are in high demand in India during the summer when it is hot and humid. People claim that not only do these fruits taste wonderful, but they are also one of the highest yielding harvests that can be grown. As a result, India's grape output has increased significantly, and the country has routinely ranked among the top 10 grape-producing countries in the globe. Not all grape varieties, meanwhile, were developed with human consumption in mind. More than 80% of the grapes harvested worldwide are used to make wine. Viticulture is the harvesting of grapes. It is thought that viticulture began in Armenia, a region of Russia closes to the Caspian Sea, before spreading east to Iran and Afghanistan then west to Europe. In 1300 A.D., grapes were introduced to India by Iranian and Afghan foreigners (Angamuthu *et al.*, 2021).

Indian grape output is expected to go up by 26% to 2.9 million MT, which is about the same as before the pandemic. Maharashtra, Karnataka, Tamil Nadu, and Mizoram are major grape-producing states. In 2020-21, Maharashtra will be the most productive state in the nation, with over 71% of the nation's total output. With a share of 24%, Karnataka will be the second biggest producer of grapes in 2020-21. People think that the best places in India to grow grapes are the states of Maharashtra, Karnataka, Tamil Nadu, and Mizoram.

In 2020-21, grapes will cover 155,300 hectares, or 2.24 % of the total land region. This makes them one of the most important foods. The nation is also one of the world's most significant producers of raw grapes. In the years 2021–2022, the nation exported 263, 075, 67 MT of grapes for a total cost of 305.66 million dollars or Rs. 2, 302, 16 crores (Golicic, S. L. 2022).

The production of raisins usually takes place over the course of three stages: pretreatment stage, drying stage, and post-drying stage. According to Sério *et al.* (2014), Methods of drying raisins have a substantial impact on the total time raisins are dried, the quantity of sugar that remains in raisins, and the enzyme activity that remains in raisins. According to Franco *et al.*, (2004), raisins and other dried grape products have much more antioxidant activity than their fresh counterparts. In every nutrient area, including the amount of fiber, total carbohydrates, minerals, vitamins, fruity volatile compounds, and antioxidant activity, dried grapes surpass fresh grapes. According to the USDA, Grapes may be dried with both conventional and cutting-edge techniques, including microwave, hot air, sun, and vacuum drying. Traditional techniques include sun and shade-based drying. Traditional techniques for drying consist of hanging one's clothing to dry in the sun and hanging one's clothing to dry in the shade. Typically, grapes are sun-dried on stands or baskets placed on the ground. This permits the raisins to be put through to the outside a two- to three-week period (EL-Mesery *et al.*, 2022). Because of this, the grapes can be allowed to be dried in the sun. Accordance with Panagopoulou *et al.*, 2019a,

Ninety percent of the raisins produced worldwide come from the Thompson Seedless variety. The Thompson Seedless grape, which has a white skin and is rather thin, is famous for producing raisins of the greatest possible value. These raisins are currently on the market. The fruits of this plant have a form that is in between round and oval. It is completely devoid of any seeds yet has an exceptionally high concentration of sugar. Other grape varieties with white and colorful seeds are also used in the manufacturing of raisins,

It is essential to choose packaging and storage methods that are adequate in order to avoid unfavorable physiochemical processes that are detrimental to the quality of the objects. These processes can be prevented, however, by choosing the right procedures. The fundamental purpose of the materials used in the packaging as well as the internal atmosphere is to maintain the integrity of the food in its unaltered form until it is consumed.

Various fruits are used to preserve, store, and package processed goods to increase their lifespans. (Conte, 2013, Miranda, Ranđelović, 2014). When it comes to the storage of beyond-of-season fruits, it is essential to take consideration of the effect of the various packaging materials, in addition to the amount of time and temperature spent in preservation (Mgaya Kilima *et al.*, 2015).For the packing of dried fruits and vegetables to be appropriate, the material must demonstrate its efficacy as a barrier against water vapor, O_2, SO_2, and other volatiles, depending on the product. The headspace contained within the packaging and the material's permeability to oxygen and other gases determine the amount of oxygen that is permitted to circulate into the package during storage (Van Bree *et al.*, 2010).

Polyethylene and polypropylene effectively combine a number of characteristics, including among other things, Stability, stiffness, stiffness, strength, lightness, and impermeability. An efficient barrier is plastic is used to package food, preserving the natural flavor of the food, and preventing contamination. According to Bhunia *et al.* (2013), Recent advancements in bioplastics and the ambition to make glass lighter and smaller as well as metal containers contribute to the rapid growth of flexible and rigid polymeric wrapping. Innovative packaging methods, such as modified active packaging, active and intelligent packaging, and the use of antimicrobials, can significantly increase the shelf life of food. The most efficient active packaging systems include antimicrobial active packaging systems in addition to oxygen absorbers, humidity and ethylene absorbers, ethanol and carbon dioxide emitters, and ethylene and ethylene oxide absorbers. The sensors utilized in Biosensors and time-temperature sensors are included in intelligent packaging devices, O_2 and CO_2 sensors, microbial growth indicators, among many more (Nayik *et al.*, 2014).

MATERIAL AND METHODS

1. Preparation of sample

1.1 Sample selection

Location- MIT College of Food Technology and ICAR- National Research Centre for Grapes, Loni Kalbhor, Pune.

Variety: Fresh Thompson Seedless grapes will be used due to its good variety.

Moisture content: The moisture content of Thompson seedless grapes is between 75 to 85%.

Availability: February to May

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1.2 Flow sheet of raisins making process

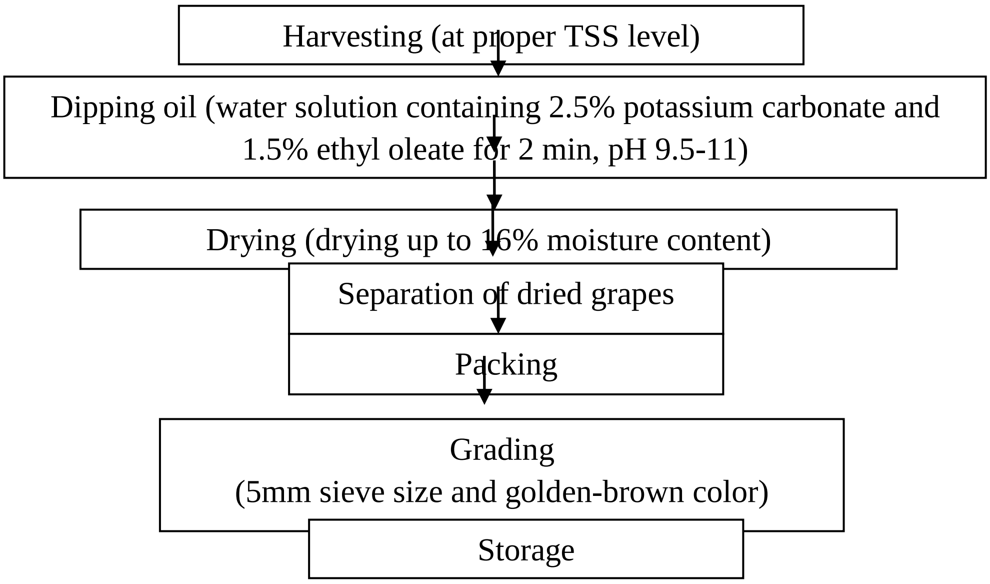

Fig 1.1 Flow chart of raisins preparation

1.3 Packaging material for Raisins:

Polypr
opylene (100 gauge)

Low Density Polyethylene (200 gauge)

Laminated Aluminum Foil (300 gauge)

Low Density Polyethylene (400 gauge)

Plate 1: Different Types of Storage Packaging Materials

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The various forms of storage media are depicted in Plate 1. along with their effects on raisin quality. The four different categories of material are as: polypropylene (PP) (100 gauge), Low density polyethylene (LDPE 1) (200 gauge), laminated aluminum foil (LAF) (300 gauge), and low-density polyethylene (LDPE 2) (400 gauge) for to check the quality of raisin up to 180 days.

2. Evaluation of Raisins

2.1. *Extraction method*

Using a pestle and mortar and 10 ml of 80% methanol at room temperature (25°C), 0.5 g of raisins representing four kinds from two species was extracted. The sample is removed from the orbital shaker the next day. Once the supernatant has been separated from the sediment by centrifuging at 10 °C for 10 minutes at 2000 rpm, the sediment is extracted once more with 10 ml of 80% methanol. By using this technique, all chemicals will be removed. There were three extractions altogether. Until more biological analysis can be done, these extracted materials are kept in liquid nitrogen.

2.2 *Color intensity*

Spectrophotometric color analysis:

The absorbance of raisin extract samples was measured by a (LABINDIA ®, UV 3000 +) spectrophotometer at 420, 520 and 620 nm. We were able to determine the following important metrics as a result: The relationship between color intensity and 420 nm absorbance is known as the extent of yellow tone (% Ye), whereas the relationship between color intensity and 520 nm absorbance is known as the extent of red tone (% Rd), and the relationship among color intensity and 620 nm absorbance is known as the extent of blue tone (% Bl) (Glories, 1984).

2.3 *Reducing sugars.*

The DNSA method was used to determine the reduced sugar content (S. Sadashivam, 1996). After adding distilled water to get the total volume to 3 ml, 0.5-3 ml of raisin extract was pipetted into test tubes. After adding 3 ml of DNS reagent, the mixture needs to be cooked in a water bath for 5 minutes. A 40% Rochelle salt solution, or 1 ml, should be added to the liquid while it is still boiling. Once it has cooled, the dark red color at 510 nm can be measured using a spectrophotometer. The amount of decreasing sugar in the samples can be calculated using the standard glucose solution's graph.

2.4 Microbial Analysis

In the samples of berries and raisins, the total number of yeast and mold plates was counted. We looked at each one after sterilizing the needed petri dishes, plastic ware, and glasses and making the right specialized medium (potato dextrose agar, nutritional agar). Each experiment's bespoke material was created in a germ-free setting. The samples were serially diluted (from 10-2 to 10-6) and laminar flow was distributed across the media using the saline-filled test tubes.

By submerging the sample and repeatedly washing it in salt water, the microbial population on the surface of the grapes and raisins (1 g) was washed off into the ocean. Following that, the modest quantity was transferred to medium-sized, numbered Petri plates. Following the addition of sample saline and medium aliquots, each plate's number of colonies was counted after the incubation period. The serial dilution test and the growth of particular bacteria, yeast, and mold on specified media were used to assess the presence or absence of specific bacteria, yeast, and mold on the surface of the grapes and raisins. The number of CFUs per unit of volume or mass is determined by the microbiological parameter.

2.5 Sensory evaluation

The sensory evaluation of different organoleptic properties namely colour, taste, texture and overall acceptability were carried out by panel members. The 9 point hedonic scale was used for sensory evaluation of dried grapes (raisins).

2.6 Techno-economic Feasibility for Different Packaging Techniques

The technological and financial feasibility of various packaging material was assessed. The price of the various packaging materials was calculated using the local market's current pricing for those components. The final product's price per kilogram has been calculated.

2.7 Statistical Analysis

The sensory evaluation results obtained were statistically analyzed by Completely Randomized Design (CRD) for different treatments as per the method given by Panse and Sukhatme (1987). The analysis of variance revealed at significance of $P<0.05$ level, S.E. and C.D at 5% is mentioned whenever required.

RESULTS AND DISCUSSION

The results of the present study entitled “Packaging Materials Effect on Quality of Raisins to Enhance the Shelf Life of Stored Raisins” are presented and discussed.

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Table No. 1: Color Intensity of Raisins (Thompson Seedless) in Non-Vacuum and Vacuum Packaging at Ambient Conditions

Storage Condition	Color Intensity (%) Day After Storage (DAS)							ANOVA
	0	**30**	**60**	**90**	**120**	**150**	**180**	
NV T PP	0.758	0.789	0.808	0.833	0.854	0.877	0.936	**0.0034**
NV T LDPE 1	0.758	0.781	0.802	0.823	0.844	0.865	0.911	**0.0028**
NV T LDPE 2	0.758	0.778	0.798	0.818	0.838	0.859	0.907	**0.0025**
NV T LAF	0.758	0.777	0.796	0.815	0.834	0.853	0.900	**0.0022**
ANOVA	**0.00***	**0.003***	**0.003***	**0.006***	**0.01***	**0.01***	**0.02***	
V T PP	0.758	0.782	0.805	0.829	0.852	0.875	0.920	**0.0032**
V T LDPE 1	0.758	0.790	0.800	0.821	0.842	0.863	0.908	**0.0029**
V T LDPE 2	0.758	0.775	0.796	0.817	0.837	0.858	0.901	**0.0027**
V T LAF	0.758	0.772	0.792	0.812	0.832	0.852	0.892	**0.0025**
ANOVA	**0.00***	**0.01***	**0.00***	**0.01***	**0.01***	**0.01***	**0.01***	

***Each value represents the average of three determinations**

NVT stands for Non-Vacuum Thompson Seedless, VT stands for Vacuum Thompson Seedless,

When raisins (Thompson Seedless) are packaged in both vacuum and non-vacuum containers, and stored at room temperature, Table 1 displays the color intensity of each packaging material with different storage days from 0 to 180 days. The vacuum laminated aluminum foil was suitable for packaging the raisin supported by earlier similar review base results. The present results are in close agreement with results reported by earlier scientists Bai J W, *et al.*, (2013) and Bingol G *et al.*, (2012).

Table No. 2: Color Intensity of Raisins (Thompson Seedless) in Non-Vacuum and Vacuum Packaging at 10±2˚C.

Storage Condition	Color Intensity (%) Day After Storage (DAS)							ANOVA
	0	**30**	**60**	**90**	**120**	**150**	**180**	
NV T PP	0.758	0.780	0.802	0.824	0.846	0.868	0.918	**0.0029**
NV T LDPE 1	0.758	0.779	0.800	0.821	0.842	0.863	0.905	**0.0025**
NV T LDPE 2	0.758	0.778	0.798	0.818	0.838	0.858	0.900	**0.0023**
NV T LAF	0.758	0.776	0.795	0.815	0.833	0.852	0.893	**0.0021**
ANOVA	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.01%**	
V T PP	0.758	0.777	0.798	0.819	0.840	0.861	0.911	**0.0027**
V T LDPE 1	0.758	0.780	0.799	0.820	0.840	0.860	0.899	**0.0023**
V T LDPE 2	0.758	0.775	0.794	0.813	0.832	0.851	0.891	**0.0021**
V T LAF	0.758	0.774	0.792	0.809	0.826	0.843	0.883	**0.0018**
ANOVA	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.01%**	**0.01%**	

***Each value represents the average of three determinations**

Table 2 displays the color intensity of raisins (Thompson Seedless), packed either in non-vacuum or vacuum containers, and stored at 10±2°C. When comparing findings at different temperatures, variations can be detected across all storage situations supported by earlier similar review base results by Bai J W, *et al.*, (2013) and Bingol G *et al.*, (2012).

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Table No. 3: Reducing Sugar of Raisins (Thompson Seedless) in Non-Vacuum and Vacuum Packaging at Ambient Conditions

Storage Condition	Reducing Sugar (%) after Day of Storage (DAS)							ANOVA
	0	**30**	**60**	**90**	**120**	**150**	**180**	
NV T PP	66.85	67.07	67.33	67.55	67.73	67.97	68.21	**0.0235**
NV T LDPE 1	66.85	67.06	67.31	67.50	67.70	67.94	68.15	**0.0218**
NV T LDPE 2	66.85	67.06	67.28	67.48	67.69	67.90	68.12	**0.0207**
NV T LAF	66.85	67.05	67.25	67.45	67.64	67.86	68.05	**0.0187**
ANOVA	**0.00%**	**0.01%**	**0.01%**	**0.01%**	**0.01%**	**0.02%**	**0.02%**	
V T PP	66.85	67.03	67.21	67.4	67.58	67.75	67.98	**0.0161**
V T LDPE 1	66.85	67.01	67.19	67.36	67.53	67.70	67.87	**0.0136**
V T LDPE 2	66.85	67.02	67.17	67.36	67.54	67.69	67.82	**0.0127**
V T LAF	66.85	67.01	67.17	67.34	67.51	67.67	67.73	**0.0111**
ANOVA	**0.00%**	**0.00%**	**0.01%**	**0.01%**	**0.02%**	**0.02%**	**0.03%**	

***Each value represents the average of three determinations**

Table 3 findings suggest that raisins (Thompson Seedless) packaged in vacuum or non-vacuum containers and stored at room temperature may require less sugar to be added. Depending on the temperature and storage circumstances, raisins may be able to lower different amounts of sugar. The present results are in close agreement with results reported by earlier scientists Bai J W, *et al.*, (2013).

Table No. 4: Reducing Sugar of Raisins (Thompson Seedless) in Non-Vacuum and Vacuum Packaging at (10±2°C).

Storage Condition	Reducing Sugar (%) after Day of Storage (DAS)							ANOVA
	0	**30**	**60**	**90**	**120**	**150**	**180**	
NV T PP	66.85	67.05	67.26	67.43	67.63	67.84	68.03	**0.0133**
NV T LDPE 1	66.85	67.06	67.24	67.42	67.59	67.77	67.94	**0.0108**
NV T LDPE 2	66.85	67.03	67.22	67.40	67.55	67.75	67.91	**0.0107**
NV T LAF	66.85	67.04	67.20	67.38	67.57	67.73	67.89	**0.0103**
ANOVA	**0.00%**	**0.02%**	**0.04%**	**0.04%**	**0.04%**	**0.04%**	**0.06%**	
V T PP	66.85	67.04	67.22	67.39	67.56	67.77	67.91	**0.0108**
V T LDPE 1	66.85	67.03	67.19	67.37	67.55	67.7	67.82	**0.0919**
V T LDPE 2	66.85	67.03	67.18	67.35	67.53	67.69	67.80	**0.0886**
V T LAF	66.85	67.00	67.14	67.28	67.43	67.57	67.72	**0.0725**
ANOVA	**0.00%**	**0.03%**	**0.07%**	**0.02%**	**0.04%**	**0.05%**	**0.02%**	

***Each value represents the average of three determinations**

This shows that how raisins stored for 180 days lose sugar. Thompson Seedless raisins were vacuum- and non-vacuum-packed. Polypropylene (PP), low-density polyethylene 1 (LDPE 1), LDPE 2, and laminated aluminum foil (LAF) packaging were used. Days 0, 30, 60, 90, 120, 150, and 180 measured lowering sugar.

The raisins' decreasing sugar content increased with storage time, although the rate varied by type and

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packing manner. Vacuum packaging had the lowest decreasing sugar level, while LDPE 2 performed best. NV PP-packaged Manik Chaman raisins had the most lowering sugar. ANOVA indicated that storage conditions and time significantly reduced sugar content.

Table No. 4: Microbial Analysis of Raisins (Thompson Seedless) in Non-Vacuum and Vacuum Packaging at Ambient Conditions.

Storage Condition	Microbial Analysis (cfu/gm) Day After Storage (DAS)													
	0		30		60		90		120		150		180	
	TPC	Yeasts & Molds	TPC	Yeasts & Molds	TPC	Yeasts & Molds	TPC	Yeasts & Molds	TPC	Yeasts & Molds	TPC	Yeasts & Molds	TPC	Yeasts & Molds
NV T PP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.8×10^3 cfu/gm	ND
NV T LDPE 1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.1×10^3 cfu/gm	ND
NV T LDPE 2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.8×10^3 cfu/gm	ND
NV T LAF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0×10^3 cfu/gm	ND
V T PP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.7×10^3 cfu/gm	ND
V T LDPE 1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2×10^3 cfu/gm	ND
V T LDPE 2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.2×10^3 cfu/gm	ND
V T LAF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
***Each value represents the average of three determinations**														

This shows that the microbiological examination of Thompson Seedless (T) raisins packed in non-vacuum (NV) and vacuum (V) polypropylene (PP), low-density polyethylene (LDPE) 1, LDPE 2, and laminated aluminium foil (LAF) packaging. Microbial analysis was performed on raisins stored at ambient temperatures from 0 to 180 days after storage (DAS). TPC and cfu/gm yeast and mold counts were part of the

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microbiological analysis. The initial storage time (0 DAS) showed no microbial development. All samples except V T LAF showed microbial growth during storage. On 180 DAS, NV T samples showed TPC counts of 9.8×10^3, On the last day of storage, V T LDPE 2 samples had TPC counts of 1.2×10^3, the lowest microbial growth. LDPE 2 vacuum packaging prevents microbial growth in raisins.

Table No. 6: Microbial Analysis of Thompson Seedless Raisins in Non-Vacuum and Vacuum Packaging at (10±2 °C).

Storage Condition	Microbial Analysis (cfu/gm) Day After Storage (DAS)													
	0		30		60		90		120		150		180	
	TPC	Yeasts & Molds	TPC	Yeasts & Molds	TPC	Yeasts & Molds	TPC	Yeasts & Molds	TPC	Yeasts & Molds	TPC	Yeasts & Molds	TPC	Yeasts & Molds
NV T PP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.2×10^3 cfu/gm	ND
NV T LDPE 1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NV T LDPE 2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NV T LAF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
V T PP	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
V T LDPE 1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
V T LDPE 2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
V T LAF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
***Each value represents the average of three determinations**														

Table illustrates the microbiological examination of raisins held under non-vacuum (NV) and vacuum (V) packaging conditions in polypropylene (PP), low-density polyethylene 1 (LDPE 1), LDPE 2, and laminated aluminum foil (LAF). Microbial studies were done at 0, 30, 60, 90, 120, 150, and 180 DAS on raisins stored at 10 ± 2°C for 180 days.

The total plate count (TPC) and yeasts and molds were not detected (ND) in all samples at the start of storage and stayed below detectable levels until the end. Other samples showed no significant microbial growth during storage.

Table No. 7: Sensory Examination of Raisins (Thompson Seedless) Stored in Non-Vacuum and Vacuum Packing after 180 days in Ambient Conditions.

Sample	Color and Appearance	Texture	Taste	Flavor	Overall Acceptability
Control (T)	8.6	7.8	8.0	8.4	8.4
T1 PT_1	6.6	6.6	6.7	6.5	6.6
T1 P T_2	6.7	6.7	6.8	6.7	6.7
T1 PT_3	6.8	6.7	6.9	6.8	6.8
T1 P T_4	**6.9**	**6.9**	**7.0**	**6.9**	**6.9**
T2 PT_1	6.9	6.9	7.0	6.9	6.9

T2 PT_2	6.9	7.0	7.1	7.0	7.0
T2 P T_3	6.9	7.1	7.0	7.0	7.0
T2 P T_4	**7.0**	**7.0**	**7.1**	**7.1**	**7.1**
SE	**0.17**	**0.15**	**0.14**	**0.18**	**0.13**
CD @5%	**0.06**	**0.04**	**0.09**	**0.02**	**0.05**
***Each value represents the average of ten determinations**					

T1 = ambient condition and non-vacuum packing, T2 = ambient condition and vacuum packaging, (PT_1 to PT_4 = packaging material for Thompson Seedless).

Table 7 presents the findings of the sensory assessment of Thompson Seedless Raisins. These raisins were either vacuum or non-vacuum packaged and kept at room temperature for 180 days. T1 shows the ambient condition as well as the non-vacuum packaging, while T2 shows the ambient condition in addition to the vacuum packaging. For each of the variable parameters, this table displays the degree of coefficient as well as the standard error. The S.E. (0.15) and CD (0.04) ratings for texture are the lowest. The overall acceptability of vacuum packing is higher than non-vacuum packaging.

Table No. 8: Sensory Study of Raisins (Thompson Seedless) Packed in Non-Vacuum and Vacuum Packing after 180 days at 10±2 °C

Sample	**Color and Appearance**	**Texture**	**Taste**	**Flavor**	**Overall Acceptability**
Control (T)	8.6	7.8	8.0	8.4	8.4
T3 PT_1	6.6	6.6	6.7	6.5	6.6
T3 P T_2	6.7	6.7	6.8	6.7	6.7
T3 P T_3	6.8	6.7	6.9	6.8	6.8
T3 PT_4	**6.9**	**6.9**	**7.0**	**6.9**	**6.9**
T4 PT_1	6.9	6.9	7.0	6.9	6.9
T4 P T_2	6.9	7.0	7.1	7.0	7.0
T4 PT_3	6.9	7.1	7.0	7.0	7.0
T4 PT_4	**7.0**	**7.0**	**7.1**	**7.1**	**7.1**
SE	**0.17**	**0.15**	**0.14**	**0.18**	**0.14**
CD @5%	**0.06**	**0.04**	**0.01**	**0.04**	**0.07**
***Each value represents the average of ten determinations**					

T3 is cold condition with non-vacuum packaging, T4 is cold condition and vacuum packing, while PT_1 through PT_4 are the packaging materials for Thompson Seedless.

Table 8 displays the findings of the sensory assessment of Thompson Seedless Raisins. The raisins were either vacuum-sealed or non-vacuum-sealed, and they were stored at 10±2°C for 180 days. The degree of coefficient (0.01) and standard error (0.14) are both lowest for the taste parameter. The overall acceptability of vacuum packing is higher than non-vacuum packaging.

Table No. 9: Techno-economic viability of various raisins-packaging materials

Sr. No.	**Particular**	**Packaging Materials**			
		Polypropylene (100 gauge)	Low Density Polyethylene (200 gauge)	Laminated Aluminum Foil (300 gauge)	Low Density Polyethylene (400 gauge)
1	Cost of Packaging Material per Kg (Rs.)	365	680	640	850
2	Number of packets per kg	650	500	450	350
3	Cost of Raisins per Kg (Rs.)	180	180	180	180
4	Cost of per packet (Rs.)	0.56	1.36	1.42	2.43
5	Cost of Raisins and packet	180.56	181.36	181.42	182.43

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	material. (Rs.)				
6	Miscellaneous Cost 5% (Rs.)	9.03	9.07	9.07	9.12
7	Total Cost (Rs.)	189.86	190.43	190.49	191.55

Table 9 presents the techno-economics of raisin packing. Comparative packaging materials are shown in the table for polypropylene (100 gauge), low-density polyethylene (200 gauge), laminated aluminium foil (300 gauge), and polypropylene (400 gauge). Packaging material cost Rs. 365 per kg for Polypropylene and Rs. 850 for Low-Density Polyethylene (400 gauge). Polypropylene had 650 packets per kg and Low-Density Polyethylene (400 gauge) 350. All packaging cost Rs. 180 per kg of raisins. Polypropylene had the lowest packet cost (Rs. 0.56) and Low-Density Polyethylene (400 gauge) the highest (Rs. 2.43). Raisins and packaging material cost 180.56 for Polypropylene and 182.43 for Low-Density Polyethylene (400 gauge). 5% of all packaging material costs were miscellaneous. Polypropylene cost 189.86 and Low-Density Polyethylene (400 gauge) 191.55. Thus, polypropylene (100 gauge) is the cheapest packaging material for raisins.

CONCLUSIONS

Grape is one of the most important fruit crop in the world due to its nutritional and therapeutic value. It is a good source of dietary sugars, organic acids, excellent source of dietary fibres, some amount of minerals and vitamins.

Compare the color intensity of raisins (Thompson Seedless) packaged in non-vacuum and vacuum packaging at room temperature and 10±2°C, respectively. During storage, the color intensity is measured at various intervals, for instance, the percentages of color intensity for various storage conditions (NV T PP, NV T LDPE 1, NV T LDPE 2, NV T LAF, V T PP, V T LDPE 1, V T LDPE 2, V T LAF) at various time points (0 DAS, 30 DAS, 60 DAS, etc.). Raisins are best preserved under storage conditions where their color intensity increase the least. Laminated aluminum foil (LAF) with vacuum packaging at 10±2°C was the best material for the packaging.

Thompson Seedless raisin, the reducing sugar value was highest recorded 66.85% to 68.21% in non-vacuum packed PP packaging material at room temperature and lowest recorded was 66.85% to 67.72% in vacuum packed LAF packaging material stored at cold temperature (10±2ºC) after 180 days of storage.

The microbial analysis was done for Thompson Seedless raisins samples in every 30 days of interval. The highest total plate count was found of 9.8×10^3 cfu/gm non-vacuum packed in PP material and stored at room temperature after 180 days of storage. The Thompson Seedless raisin samples non-vacuum and vacuum packed in LAF packaging material at room temperature 4.2×10^3 cfu/gm and cold temperature (10±2ºC) was not recorded any colonies 180 days after storage.

From the sensory evaluation, the mean score for color/appearance, texture, taste, flavor and overall acceptability of samples packed in different types of packaging materials and stored at different conditions ranged from 6.6 to 6.9 and 6.9 to 7.1 respectively.

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