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RESEARCH PAPER

Effect of Packaging Material and Storage Duration on Quality of Grape Raisins Dried by Open Air Sun Drying

Kunal Umakant Yadav and Shrikant Baslingappa Swami*

Department of Post-Harvest Engineering, Post-Graduate Institute of Post-Harvest Management, Killa-Roha. Dist: Raigad (Maharashtra State) (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli-Campus Roha), India

*Corresponding author: swami_shrikant1975@yahoo.co.in

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ABSTRACT

The quality parameters were tested at fifteen days intervals (0, 15, 30, 45, 60, 75, and 90 days). Among two packaging materials, aluminium bags was found best for grape raisins storage up to three months as compared with polythene bags. Deterioration occurred as changes moisture content decreases from 14.84 to 13.96 % (db), acidity decreases from 2.41 to 2.32 %, colour (yellowness index) decreases from 72.23 to 69.07, pH value decreases from 4.84 to 4.75, ascorbic acid decreases from 20.17 to 18.83 for the treatment T_1P_2; during the 3-month storage, total soluble solid increases from 73.23 to 74.04°B reducing sugar increases from 60.73 to 63.49%, total sugar increases from 63.02 to 65.91 % for the treatment T_1P_2. Grape raisins can be pre-treated with treatment 1 and dried by open air sun drying method can be store for 3 months in the aluminium bags packaging material in good condition.

Keywords: Packaging, polythene, aluminium, grape raisins

Traditionally raisins are obtained by sun drying of the fruit for eight to ten days, which substantially reduces water content. India is an important raisins producer in the world. India produced 20 per cent of world raisin production. In India, raisins are mostly produced in Sangli, Solapur and Nasik districts of Maharashtra, (Adsule *et al.* 2012; Gade & Gaikwad, 2014). However, major produce is derived from the state of Maharashtra and

Raisins are hygroscopic, contact to moisture results in mould, rot and fermentation. During storage at ambient temperatures where RH is above 20%, raisins deteriorate in terms of colour, mouth feel, aroma etc., turns sticky and hard due to exudates syrup and moisture loss, and also get infested with mites turns sticky and hard due to exudates syrup and moisture loss, and also get infested with mites. At temperatures < 10°C, mite growth is usually inhibited. At temperatures > 25°C and on exposure to mechanical pressure, there is a risk of candying, agglomeration, syrup formation and fermentation. Heat generally causes the risk of discoloration and hardening and the product should thus be stored away from heat sources.

Good package must keep the product clean and provide a barrier against dirt and other contaminants. The packaging must be of good quality, strong enough to withstand the shocks and loadings encountered during transport or mechanical handling. Packaging must be properly constructed and closed so as to prevent any loss of contents that might be caused

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under normal conditions of transport, by vibration, or by changes in temperature, humidity or pressure (Pavithra, 2008). Polypropylene is resistant to a wide variety of acids, alkalis and solvent solutions with a temperature range up to 93^{o}C (Anon, 2012).

Packaging is a means of providing the correct environmental conditions for food during storage and the choice of materials for packaging depends on the nature of the product, storage duration and handling conditions (temperature, humidity, risk of physical deterioration) and other environmental factors (Daramola *et al.* 2010). However, these methods could not improve the shelf-life and fully also led to jeopardize the flavour and texture of the product. The Low Density Polyethylene (LDPE) is widely used to package in small scale industries. Packaging requirements and storage characteristics of dehydrated foods are determined by Equilibrium Relative Humidity (ERH) of the product (Rai *et al.* 2009). Storage conditions can have a strong effect on the microbiology, nutrition, and taste of the product (Simal *et al*. 1996). Fruit quality is related to food safety, flavour, texture, colour, healthfulness, and shelf life, and is affected by processing methods, packaging, storage condition, and length of storage (Perera, 2005). Dried fruit are primarily judged by their colour, and the colour of raisins can be altered by browning reactions (Simal *et al*. 1996). Traditional packaging materials such as cans and glass containers are absolute barriers to gases and water. The use of plastic packaging materials is desirable because they are cheaper and easier to handle than cans and glass containers; however, their oxygen and water permeability properties often result in reduced product shelf life (Fernandes and McLellan, 1992). The Low density polyethylene (LDPE) is widely used to package food materials in small scale industries. The polythene pouches and aluminum coated pouches are the popularly used packaging material for storage of processed food products. It is easily available and low cost packaging material which can store the food material for 2-4 months.

In the present paper effect of different packaging material LDPE, Aluminium Laminated bag on quality of dried grapes (raisin) was studied. The grapes (raisins) was prepared by two pre-treatments i.e. Treatment T_1 = 2.5% NaOH for 3 sec followed by 2% KMS for 2 minutes and Treatment T_2 = 2.5% potassium carbonate + 2% ethyl oleate solution for 5 minutes and dried by open air sun drying and sulphitation by 2% sulphur dioxide SO_2 and stored for 0, 15, 30, 45, 60, 75, 90 days upto three months in two different packaging material viz. Low Density Polythene (LDPE) and Aluminium laminated bags. The effect of packaging materials and storage duration on quality parameter, sensory attributes and microbial count of dried grape (raisins) was studied.

MATERIALS AND METHODS

The Grapes treated with Treatment T_1 = 2.5% NaOH for 3 sec followed by 2% KMS for 2 minutes and Treatment T_2= 2.5% potassium carbonate + 2% ethyl oleate solution for 5 minutes and dried by open air sun drying for 106 hrs for Treatment T_1 and 78.5 hrs for Treatment T_2. The grape raisins was exposed to sulphitation treatment for 2 hrs and then used for the packaging and storage study. 150 g of dried grapes (raisins) prepared by this methods as discussed above was taken in two different packaging materials i.e. P_1= polythene pouches and P_2= aluminium laminated pouches. The details of the packaging material are given in Table 1. The of polythene pouches were 15×9 cm and capacity 150 g similarly size of aluminium laminated pouches were 13×9 cm having capacity 150g. Fig. 1 shows the Grape (raisins) prepared by the Treatment T_1 and Treatment T_2 and dried by open air sun drying and sulphitation by 2% sulphur dioxide SO_2. Fig. 2 shows the packaging material i.e., polythene and aluminium laminated pouches used for packaging and storage of dried grapes (raisins) for 0, 15, 30, 45, 60, 75, 90 days interval for 3 months duration.

150 g of dried grape (raisins) sample was filled separately in polythene and aluminium laminated pouches and sealed properly. These packets were kept at ambient temperature up to 12 weeks. The stored samples were analysed at every 15 days

interval up to 3 months. The observations for the sensory analysis.

T_1 T_2

Fig. 1: Grape (raisins) dried by treated with Treatment T_1 and Treatment T_2 and dried by open air sun drying

Table 1: Specifications of packaging material for storage of grape raisins

Sl. No.	Packaging material	Size	Gauge	Capacity
1	Polythene pouches	15 cm × 9 cm	393	150 g
2	Aluminium laminated pouches	13 cm × 9 cm	157	150 g

The observation of acidity, TSS, pH, reducing sugar, Total sugar, Non-reducing sugar, Ascorbic acid, Hardness and Colour (yellowness) of the stored product were determined as per procedure explained at after 0, 15, 30, 45, 60, 75 and 90 days of storage. i.e., total no. of samples for all the trials were, 7 duration × 2 packaging material × 3 replication = 42 samples of dried grapes (raisins) were kept for storage study. The sensory analysis i.e. colour, flavour, texture and taste for the stored samples were determined for each storage duration i.e. 0, 15, 30, 45, 60, 75 and 90 days.

Evaluation of Quality parameters for the grape raisins

1. Total soluble solids

The TSS for store grape raisins for treatment combination T_1P_1, T_1P_2, T_2P_1 and T_2P_2 was determined by using hand refractometer (M/s. Atago, Japan) and the values were corrected at 20^o C with the help of temperature correction table (Mazumdar and Majumder, 2003). 5 g of raisins sample was crushed and mixed with 15 ml of distilled water (A.O.A.C, 1990).Then the prepared juice was used for the TSS determination. The juice was placed on prism plate to record the visible value on scale. The reading of juice

(a) (b)

Fig. 2: Packaging material used for packaging of dried grape (raisins) **(a)** Aluminium laminated pouch **(b)** Polythene pouch

Table 2: Treatment combinations of dried grape (raisins) for storage study

Sl. No.	Pre-treatment methods	Packaging materials	Combinations
1	Treatment T_1 = 2.5% NaOH for 3 sec followed by 2% KMS for 2 minutes	P_1= Polythene Bags	T_1P_1
2	Treatment T_1 = 2.5% NaOH for 3 sec followed by 2% KMS for 2 minutes	P_2= Aluminium Coated Bags	T_1P_2
3	Treatment T_2 = 2.5% potassium carbonate + 2% ethyl oleate solution for 5 minutes	P_1= Polythene Bags	T_2P_1
4	Treatment T_2 = 2.5% potassium carbonate + 2% ethyl oleate solution for 5 minutes	P_2= Aluminium Coated Bags	T_2P_2

sample as ^{0}Brix was obtained and digital reading of the Total soluble solids expressed accordingly. Three observations were taken for replication. The average reading was reported. The similar observations were made at 0, 15, 30, 45, 60, 75, 90 days storage duration of raisins.

2. Titratable acidity

Acidity of raisins were estimated adopting the procedure given by Ranganna (1978). And Titrable acidity of raisins for treatment combination T_1P_1, T_1P_2, T_2P_1 and T_2P_2 was determined for 0, 15, 30, 45, 60, 75 and 90 days as per procedure (A.O.A.C 1975). The raisins was crushed and juice was extracted. 10 ml of juice was extracted and diluted to the volume of 100 ml with distilled water. Using phenolphthalein indicator, 10 ml of filtrate juice was titrated against 0.1 N NaOH till it changed juice to pink colour of end point. The titrated acidity was expressed in percentage. Three observations were taken for replication. The average reading was reported. The similar observations were made at 0, 15, 30, 45, 60, 75, 90 days storage duration of raisins.

$$\frac{N \times T \times E}{W \times V \times 1000} \times 100 \qquad \ldots(1)$$

Where,

N = Normality of alkali

T = Titrate reading, ml

$\underline{E}$ = Equivalent mass of acid, g

W = Weight of the sample, g

V = Total volume of the sample, g

3. pH

pH of dried grapes (raisins) for Treatment combination T_1P_1, T_1P_2, T_2P_1 and T_2P_2 for 0, 15, 30, 45, 60, 75 and 90 days storage duration was measured using digital pH meter. The digital pH meter is firstly calibrated by using 4 pH and 7 pH buffer solution. The electrode was washed with distilled water and blot led with tissue paper. Grape raisins were dissolved in distilled water 1:2.5 (sample:water) and kept for 4 hours (Babaji, 2009). There after the solution was stirred well and 10 ml of sample was taken in beaker, then the tip of electrode and temperature probe was then submerge in to the sample. The pH reading display on the primary LCD and temperature on secondary one. The pH of grape raisins juice was determined by three replication. The average reading was reported. The similar observations were made at 0, 15, 30, 45, 60, 75, 90 days storage duration of raisins.

4. Reducing sugars

The reducing sugars of dried grapes (raisins) for Treatment combination T_1P_1, T_1P_2, T_2P_1 and T_2P_2 for 0, 15, 30, 45, 60, 75 and 90 days storage duration was determined as per procedure of Ranganna (1978). 10 g of sample was grounded well into juice with 20 ml of water then the sample juice volume was made up to 100 ml with distilled water using volumetric flask. This solution was neutralized with 20 % NaOH using few drops of phenolphthalein indicator until the solution turned pink and acidified with 1 N HCl until it caused pink colour disappeared. To this 2 ml of 45 % lead acetate was added, shaken well and kept to settle for 10 minutes. Then 2 ml of 22 % potassium oxalate was added to remove excess lead and the volume was made up to 250 ml with distilled water. The content was filtered using filter paper. Reducing sugars in the lead free extract was then estimated by taking the solution into burette and titrated against mixed Fehling's solutions (A and B).

10 ml of mixed Fehling's solution taken into 250 ml conical flask to which 50 ml of water was added and ran the burette into flask to the required volume of sugar solution as was prejudged incrementally to reduce the Fehling's solution which indicated by turning the solution to brick red colour on boiling. Then the boiling was continued for 2 minutes and added methylene blue indicator, titrated with sugar solution on heating until indicator was completely decolorized and formed brick red colour precipitate which was the end point. The titrate value obtained and calculated as below (Eq. 2). The experiment was repeated three times to get the replication. The average reading was reported. The similar observations were made at 0, 15, 30, 45, 60, 75, 90 days storage duration of raisins.

Reducing sugar % =

$$\frac{100}{\text{Burettereading}} \times \frac{\text{Volume prepared}}{\text{Inital volume}} \times GV \text{ of fehling's solution} \quad \ldots(2)$$

Where,

GV = Glucose value

5. Total sugars

Total sugars of dried grapes (raisins) were for Treatment combination T_1P_1, T_1P_2, T_2P_1 and T_2P_2 for 0, 15, 30, 45, 60, 75 and 90 days estimated adopting the Lane and Eynon method (Ranganna, 1978). Exactly 50 ml of lead free filtrate was taken to 100 ml volumetric flask. To it 10 ml of HCl (5 ml Conc HCl + 5 ml water) was added and allowed remain stand for 24 hours at ambient temperature in dark room. The invert solution was neutralized and the volume was made up to 100 ml with distilled water. This solution was taken in to burette and titrated against mixed Fehling's solutions as was done for reducing sugars. The aliquot was determined as invert sugars and the total sugars content was calculated below (Eq. 3). The experiment was repeated three times to get the replication. The average reading was reported. The similar observations were made at 0, 15, 30, 45, 60, 75, 90 days storage duration of raisins.

Total sugar (%) =

$$\frac{\text{Factor} \times \text{Dilution}}{\text{Titre reading} \times \text{Weightn of sample}} \times 100 \quad \ldots(3)$$

6. Ascorbic acid (Vit. C)

The ascorbic acid (vit. C) was determined for dried grapes (raisins) were for Treatment combination T_1P_1, T_1P_2, T_2P_1 and T_2P_2 for 0, 15, 30, 45, 60, 75 and 90 days storage duration. Determination of ascorbic acid was done by 2, 6-dichlorophenol indophenol dye method of Johnson (1948) as described by Ranganna (1986). 3% metaphosporic acid (HPO_3) is prepared by dissolving sticks of HPO_3 in distilled water, Dye solution was made up by adding 2, 6-dichlorophenol indophenol and standardise with standard ascorbic acid. 10 g raisins were taken from each replication was grounded well using small amount of 3% meta-phosphoric acid (HPO_3) and the volume was made up to 100 ml with 3% meta-phosphoric acid using volumetric flask. The extract was filtered by using filter paper. 10ml aliquot was taken by using pipette into the conical flask and titrated against standard dye solution at room temperature .End point of the titration was pink colour. The ascorbic acid content of the dried grapes (raisins) was calculated taking into consideration the dye factor as given below. The average reading was reported. The similar observations were made at 0, 15, 30, 45, 60, 75, 90 days storage duration of raisins.

Ascorbic acid (%) =

$$\frac{\text{Titre value} \times \text{Dye Factor} \times \text{Volume made up}}{\text{Aliquate of extract taken for estimation} \times \text{Weightn of sample}} \times 100 \quad \ldots(4)$$

7. Colour

The dried grapes (raisins) were for Treatment combination T_1P_1, T_1P_2, T_2P_1 and T_2P_2 for 0, 15, 30, 45, 60, 75 and 90 days duration was used to measure the colour value (*L*, *a* and *b*) by using colorimeter (Konica Minotta, Japan model-Meter CR-400). The equipment was calibrated against standard white tile and black tile. Around 20 g of dried grapes (grape raisins) was taken in the glass petri dish, the equipment was placed on the sample petri dish. The colour was recorded in terms of *L*= lightness (100) to darkness (0); *a* = Redness (+60) to Greenness (-60); *b* = yellowness (+60) to blueness (-60). The Yellowness Index of the grapes raisins was determined from *L*, *a*, and *b* values as per equation (5) reported by (Rhim *et al.* 1999). The average reading was reported. The similar observations were made at 0, 15, 30, 45, 60, 75, 90 days storage duration of raisins.

$$YI = \frac{142.86b}{L} \qquad \ldots(5)$$

Where,

L = Lightness to darkness

B = Yellowness to blueness

8. Sensory analysis

The sensory attribute of dried grapes (raisins) were for Treatment combination T_1P_1, T_1P_2, T_2P_1 and T_2P_2 for 0, 15, 30, 45, 60, 75 and 90 days storage duration packed in polythene and aluminium laminated pouches was determined for each storage period 0, 15, 30, 45, 60, 75 and 90 days with trained panelists as per nine point hedonic scale. The Panelists were trained for the product testing and were familiar with product sensory evaluation. The grape raisins samples were placed into dish. The grape raisins packed in polythene and aluminium laminated pouches were coded as A, B,C and D for Treatment combination T_1P_1, T_1P_2, T_2P_1 and T_2P_2 evaluation of sensory parameter i.e. colour, flavour, texture and taste attributes. Sample code E was market sample which was used for comparison. The rating was based on nine- point hedonic scales. 09 scales for colour, 9 scales for flavour attribute, 09 scales for texture attribute and 09 scales for taste. The attribute were summed up for total score 36 for each panelist for each treatment. The 14 panel members divided into three groups as five, five and four members .The average score of each group was taken as 3 replications for statistical analysis. The data were analysed statistically for the significance of each attributes by ANOVA.

9. Microbial analysis

The microbial analysis of grape raisins packed in polythene and aluminium laminated pouches for Treatment combination T_1P_1, T_1P_2, T_2P_1 and T_2P_2 was performed for storage period of 30, 60 and 90 days i.e. after one month interval as per the procedure of APHA (1992). The grape raisin samples were analyzed for standard plate counts (SPC) and yeast and mould counts (YMC) using nutrient agar medium and potato dextrose agar medium (Himedia Laboratories Pvt. Ltd. Bombay).

The sample was crushed finely in mortar and pestle. 1g of sample was mixed thoroughly in 10 ml autoclaved distilled water and mixed thoroughly by Vortexing. Serial dilutions from the above suspension were prepared up to 10^{-6}. 1 ml serially diluted sample was plated by pour plate technique on nutrient agar (for total viable count), Potato Dextrose Agar (for yeast and mold count). All plates were incubated at 37°C for 24-48 hrs. After 24-48 hours of incubation the plates were observed for typical colonies of each microorganism and colonies were counted with the help of colony counter. The results were recorded as CFU/g methods prescribed by Bureau of Indian Standards, (1999).

Formula for calculating CFU/g

$$CFU = \frac{\text{Average plate count} \times \text{Dilution}}{\text{Weight of sample}} \qquad \ldots(6)$$

10. Statistical analysis

Statistical analysis was performed using Factorial completely randomized design (FCRD) for stored sample properties like moisture, TSS, acidity, pH, reducing sugar, total sugar, ascorbic acid, colour

(Yellowness Index) and hardness etc. sensory attributes i.e. colour, flavour, texture and taste and microbial analysis packed in polythene and aluminium laminated pouches for 0, 15, 30, 45, 60, 75 and 90 days was carried out by Microsoft Excel 2007.

RESULTS AND DISCUSSION

Packaging and storage study of grape raisins, This section discusses, effect of packaging material and storage duration on quality properties (moisture content, TSS, pH, acidity, reducing sugar, total sugar, ascorbic acid and Colour (yellowness index)), sensory properties (colour, flavour, texture and taste) and microbial analysis of grape raisins pre-treated with Treatment 1 and Treatment 2 and dried by open air sun drying during analysis.

Moisture content

Fig. 3 shows the effect of packaging material and storage duration (0, 15, 30, 45, 60, 75 and 90 days) on moisture content of grape raisins pre-treated with Treatment 1 and Treatment 2 i.e. T_1P_1, T_1P_2, T_2P_1 and T_2P_2. In all the treatments the moisture content decreases as storage duration increases from 0 days to 90 days. The moisture content varies in the range of 13.56 to 14.84 % (db). For T_1P_1 moisture content decreases from 14.84 to 13.77 % (db), for T_1P_2 the moisture content decreases from 14.84 to 13.96 % (db), for T_2P_1 moisture content decreases from 14.57 to 13.56 % (db) and for T_2P_2 the moisture content decreases from 14.57 to 13.75 % (db). Table 3 shows the retention of moisture content during storage of grape raisins during 0 to 90 days by various packaging material. Effect of packaging material on moisture content indicated that better retention of moisture content (93.36%) was observed in T_1P_2 aluminium material (grape raisins treated with treatment 1) followed by treatment T_1P_1 (92.53 %) polythene material (grape raisins treated with treatment 1).

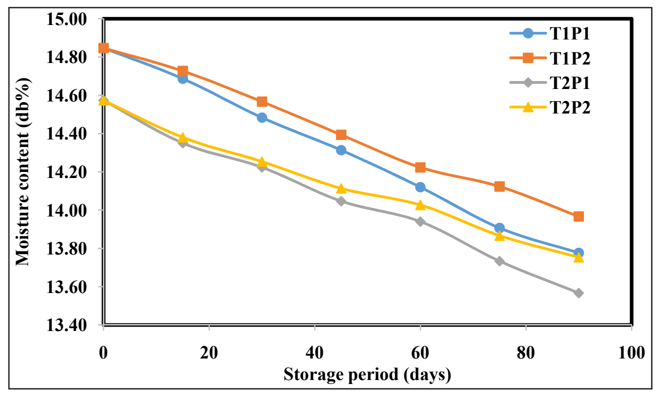


Fig. 3: Effect of storage duration on moisture content of grape raisins packed in different packaging materials

Table 3 also shows the f-test of change in moisture content w.r.t packaging material, storage duration and their interaction. From Table 3, it indicates that effect of pre-treatment methods and packaging material on moisture content was significant at $p \leq 0.01$. Similarly, the effect of storage duration on moisture

Table 3: f–test for determination of effect of storage life on moisture content of grape raisins packed in different packaging

Treatments	Storage duration (days)								% retention
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Avg.	
T_1P_1	14.84±0.045	14.68±0.164	14.48±0.246	14.31±0.167	14.12±0.098	13.90±0.051	13.77±0.066	14.30	92.53
T_1P_2	14.84±0.045	14.72±0.092	14.56±0.115	14.39±0.100	14.22±0.075	14.12±0.064	13.96±0.076	14.41	93.36
T_2p_1	14.57±0.025	14.35±0.030	14.22±0.025	14.04±0.035	13.94±0.036	13.73±0.104	13.56±0.125	14.06	89.14
T_2p_2	14.57±0.025	14.38±0.052	14.25±0.115	14.11±0.072	14.02±0.050	13.86±0.104	13.75±0.123	14.14	91.47
Mean	14.71	14.54	14.38	14.22	14.08	13.91	13.77		
		SEm(±)			$CD_{at\ 1\%}$				
Treatment(T)		0.021			0.060				
Storage (S)		0.028			0.080				
Interaction (T×S)		0.056			0.159				

content was significant at $p \leq 0.01$. The interaction effect of both pre-treatment methods, packaging material and storage duration has non-significant effect on the moisture content at $p \leq 0.01$.

The decrease in moisture content during storage was reported for grape raisins by Venkatram *et al*. 2017: Mahmutoglu *et al*. 1996; Vishala, S. 2010 and Jadhav *et al*. 2010.

TSS

Fig. 4 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on TSS of grape raisins pre-treated with Treatment 1 and Treatment 2 i.e. T_1P_1, T_1P_2, T_2P_1 and T_2P_2. In all the treatments the TSS increases as storage duration in-creases from 0 days to 90 days. The TSS varies in the range of 72.23 to 74.50 °B. For T_1P_1 TSS increases from 72.23 to 74.50 °B, for T_1P_2 the TSS increases from 72.23 to 74.04 °B, for T_2P_1 TSS increases from 73.67 to 74.07 °B and for T_2P_2 the TSS increases from 73.67 to 73.97 °B.

Table 4 shows the % increase of TSS during storage of grape raisins during 0 to 90 days by various packaging material indicated that effect of packaging material on TSS indicated that better (%) increase of TSS (101.47% increase) was observed in T_2P_2 aluminium material (grape raisins treated with treatment 2) followed by treatment T_2P_1 (102.14 % increase) polythene material (grape raisins treated with treatment 2). Table 4 also shows the f-test of change in TSS w.r.t packaging material, storage duration and their interaction. From Table 4, it indicates that effect of pre-treatment methods and packaging material on TSS was significant at $p \leq 0.01$. Similarly, the effect of storage duration on TSS was significant at $p \leq 0.01$.

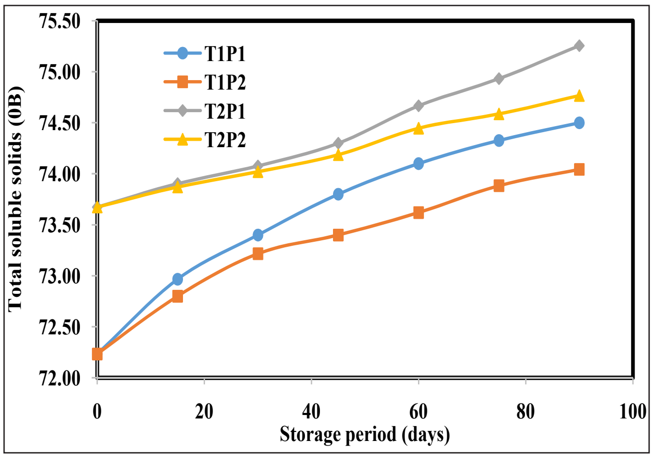


Fig. 4: Effect of storage duration on TSS of grape raisins packed in different packaging materials

The interaction effect of both pre-treatments method, packaging material and storage duration has significant effect on the TSS at $p \leq 0.01$. The increase in TSS during the storage is due to decrease in moisture content of raisins. The increase in TSS was reported for grape raisins by Venkatram *et al*. 2017: Mahmutoglu *et al*. 1996; Vishala, S. 2010; Mukarjee and Dutta, 1967 and Jadhav *et al*. 2010.

Table 4: f–test for determination of effect of storage life on TSS of grape raisins packed in different packaging materials

Treatments	Storage duration (days)								% increase
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Avg	
T_1P_1	72.23±0.251	72.96±0.665	73.40±0.700	73.80±0.608	74.10±0.529	74.32±0.376	74.50±0.300	73.62	103.14
T_1P_2	72.23±0.251	72.80±0.655	73.21±0.812	73.40±0.818	73.62±0.818	73.88±0.728	74.04±0.660	73.31	102.50
T_2P_1	73.67±0.025	73.80±0.098	73.84±0.092	73.88±0.087	73.95±0.045	74.00±0.051	74.07±0.064	73.89	102.14
T_2P_2	73.67±0.0250	73.73±0.065	73.79±0.083	73.84±0.083	73.90±0.055	73.94±0.040	73.97±0.049	73.84	101.47
Mean	72.95	73.33	73.57	73.73	73.89	74.04	74.15		
		SEm(±)			CD $_{at\ 5\%}$				
Treatment(T)		0.095			0.273				
Storage (S)		0.126			0.362				
Interaction (T×S)		0.253			0.718				

3. pH

Fig. 5 shows the effect of packaging material and storage duration (0, 15, 30, 45, 60, 75 and 90 days) on pH of grape raisins pre-treated with Treatment 1 and Treatment 2 i.e. T_1P_1, T_1P_2, T_2P_1 and T_2P_2. In all the treatments the pH decreases as storage duration increases from 0 days to 90 days. The pH varies in the range of 4.50 to 4.84. For T_1P_1 pH decreases from 4.84 to 4.71, for T_1P_2 the pH decreases from 4.84 to 4.75, for T_2P_1 pH decreases from 4.63 to 4.50 and for T_2P_2 the pH decreases from 4.64 to 4.52.

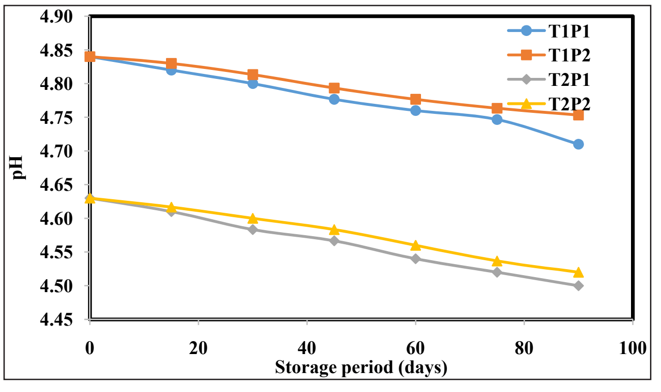


Fig. 5: Effect of storage duration on pH of grape raisins packed in different packaging materials

Table 5 shows the % decreases of pH during storage of grape raisins during 0 to 90 days by various packaging material. Effect of packaging material on pH indicated that better (%) retention of pH (98.14% decrease) was observed in T_1P_2 aluminium material (grape raisins treated with treatment 1) followed by Grape followed by treatment T_2P_2 (raisins treated with treatment 2) (97.41 % decrease). Table 5 also shows the f-test of change in pH w.r.t packaging material, storage duration and their interaction. From Table 5, it indicates that effect of pre-treatment methods and packaging material on pH was significant at $p \leq 0.01$. Similarly, the effect of storage duration on pH was significant at $p \leq 0.01$. The interaction effect of pre-treatment methods, packaging material and storage duration has significant effect on the pH at $p \leq 0.01$.

The decrease in pH during storage was reported for grape raisins by Seylam and Saklar, 2003; Babaji, 2009 and Gulec *et al*. 2009.

4. Acidity

Fig. 6 shows the effect of packaging materials and storage duration (0, 15, 30, 45, 60, 75 and 90 days) on acidity of grape raisins pre-treated with Treatment 1 and Treatment 2 i.e. T_1P_1, T_1P_2, T_2P_1 and T_2P_2. In all the treatments the acidity decreases as storage duration increases from 0 days to 90 days. The acidity varies in the range of 2.52 to 2.28 %. For T_1P_1 acidity decreases from 2.41 to 2.28 %, for T_1P_2 the acidity decreases from 2.41 to 2.32 %, for T_2P_1 acidity decreases from 2.52 to 2.39 % and for T_2P_2 the acidity decreases from 2.52 to 2.42 %. Table 6 shows the retention of acidity during storage of grape raisins during 0 to 90 days by various packaging material.

Table 5: f – test for determination of effect of storage life on pH of grape raisins packed in different packaging materials

Treatments	Storage duration (days)								% retention
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Avg	
T_1P_1	4.84±0.036	4.82±0.034	4.80±0.036	4.77±0.049	4.76±0.051	4.74±0.049	4.71±0.060	4.78	97.31
T_1P_2	4.84±0.036	4.83±0.036	4.81±0.037	4.79±0.047	4.77±0.049	4.76±0.047	4.75±0.047	4.80	98.14
T_2P_1	4.63±0.020	4.61±0.020	4.58±0.015	4.56±0.020	4.54±0.020	4.52±0.020	4.50±0.020	4.56	97.19
T_2P_2	4.64±0.020	4.61±0.020	4.60±0.020	4.58±0.015	4.56±0.017	4.53±0.020	4.52±0.017	4.58	97.41
Mean	4.74	4.72	4.70	4.68	4.66	4.64	4.62		
		SEm(±)			$CD_{at\ 5\%}$				
Treatment(T)		0.007			0.021				
Storage (S)		0.009			0.028				
Interaction (T×S)		0.019			0.056				

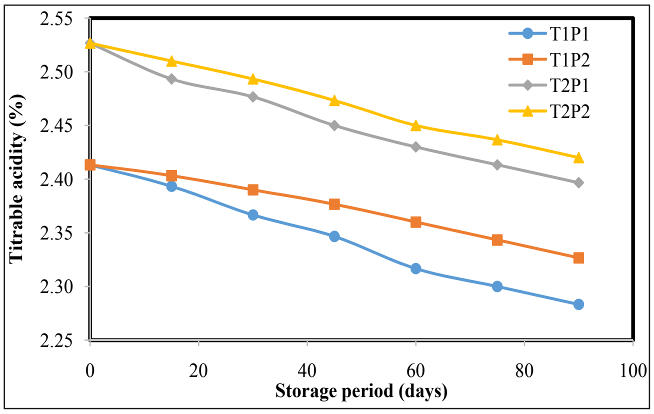


Fig. 6: Effect of storage duration on acidity of grape raisins packed in different packaging materials

Table 6 shows the effect of packaging material on acidity indicated that better retention of acidity (93.36%) was observed in T_1P_2 aluminium material grape raisins treated with treatment 1) followed by treatment T_1P_1 (92.53%) polythene material (grape raisins treated with treatment 1). Table 6 also shows the f-test of change in acidity w.r.t packaging material, storage duration and their interaction. From Table 6, it indicates that effect of pre-treatment methods and packaging material on acidity was significant at p≤0.01. Similarly, the effect of storage duration on acidity was significant at *p*≤0.01. The interaction effect of both pre-treatment methods, packaging material and storage duration has significant effect on the acidity at p≤0.01. The decrease in acidity during storage was reported for grape raisins by Venkatram *et al*. 2017: Pool *et al*. 1972 and Jadhav *et al*. 2010 and Gulec *et al*. 2009.

5. Reducing sugar

Fig. 7 shows the effect of packaging material and storage duration (0, 15, 30, 45, 60, 75 and 90 days) on reducing sugar of grape raisins pre-treated with Treatment 1 and Treatment 2 i.e. T_1P_1, T_1P_2, T_2P_1 and T_2P_2. In all the treatments the reducing sugar increases as storage duration increases from 0 days to 90 days. The reducing sugar varies in the range of 60.73 to 68.22 %. For T_1P_1 reducing sugar increases from 60.73 to 64.05%, for T_1P_2 the reducing sugar increases from 60.73 to 63.49 %, for T_2P_1 reducing sugar increases from 63.44 to 68.22 % and for T_2P_2 the reducing sugar increases from 63.44 to 67.60 %. Table 7 shows the increases of reducing sugar during storage of grape raisins during 0 to 90 days by various packaging material. Effect of packaging material on reducing sugar indicated that better increase of reducing sugar (104.54%) was observed in T_1P_2 aluminium material (grape raisins treated with treatment 1) followed by treatment T_1P_1 (105.46 %) polythene material (grape raisins treated with treatment 1). Table 7 also shows the f-test of change in reducing sugar (%) w.r.t packaging material, storage duration and their interaction.

From Table 7, it indicates that effect of pre-treatment methods and packaging material on reducing sugar (%) was significant at p≤0.01. Similarly, the effect

Table 6: f–test for determination of effect of storage life on acidity of grape raisins packed in different packaging

Treatments	Storage duration (days)								% retention
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Avg	
T_1P_1	2..41±0.015	2.39±0.015	2.36±0.020	2.34±0.025	2.31±0.025	2.30±0.026	2.28±0.028	2.35	92.53
T_1P_2	2.41±0.015	2.40±0.020	2.39±0.026	2.37±0.023	2.36±0.026	2.34±0.030	2.32±0.032	2.37	93.36
T_2P_1	2.52±0.047	2.49±0.049	2.47±0.055	2.45±0.060	2.43±0.069	2.41±0.075	2.39±0.072	2.46	89.14
T_2P_2	2.52±0.047	2.51±0.052	2.49±0.058	2.47±0.058	2.45±0.060	2.43±0.072	2.42±0.069	2.47	91.47
Mean	2.47	2.45	2.43	2.41	2.39	2.37	2.36		
		SEm(±)			$CD_{at\ 5\%}$				
Treatment(T)		0.010			0.029				
Storage (S)		0.013			0.038				
Interaction (T×S)		0.026			0.076				

of storage duration on reducing sugar (%) was significant at $p \leq 0.01$. The interaction effect of both pre-treatment methods, packaging material and storage duration has non-significant effect on the reducing sugar (%) at $p \leq 0.01$. The increase in reducing sugar may be due to hydrolysis of polysaccharides and cell wall materials such as pectin and hemicellulose gets converted into sugars during storage. The increase in reducing sugar during storage was reported for grape raisins by Venkatram *et al*. 2017; Singh *et al*.1974; Vishala, S. 2010 and Jadhav *et al*. 2010.

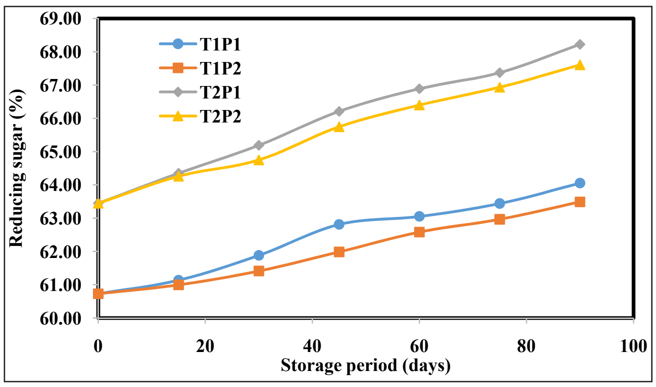


Fig. 7: Effect of storage duration on reducing sugar of grape raisins packed in different packaging materials

6. Total sugar

Fig. 8 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on total sugar of grape raisins pre-treated with Treatment 1 and Treatment 2 i.e. T_1P_1, T_1P_2,T_2P_1 and T_2P_2. In all the treatments the total sugar increases as storage duration increases from 0 days to 90 days. The total sugar varies in the range of 63.02 to 67.64 %. For T_1P_1 total sugar increases from 63.02 to 66.52%, for T_1P_2 the total sugar increases from 63.02 to 65.91 %, for T_2P_1 total sugar increases from 64.99 to 70.08 % and for T_2P_2 the total sugar increases from 64.99 to 69.26 %.

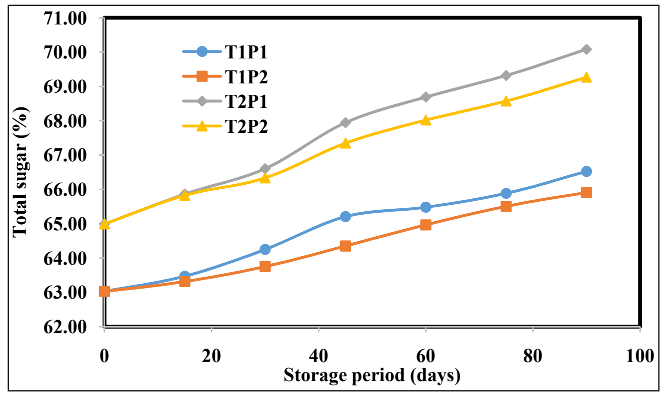


Fig. 8: Effect of storage duration on total sugar of grape raisins packed in different packaging materials

Table 8 also shows the retention of total sugar during storage of grape raisins during 0 to 90 days by various packaging material. Effect of packaging material on total sugar indicated that better retention of total sugar (104.58%) was observed in T_1P_2 aluminium material (grape raisins treated with treatment 1) followed by treatment T_1P_1 (105.55 %)polythene material (grape raisins treated with treatment 2).

Table 7: f– test for effect of storage life on reducing sugar of grape raisins packed in different packaging materials

Treatments	Storage duration (days)								% increase
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Avg	
T_1P_1	60.73±0.020	61.13±0.015	61.88±0.011	62.81±0.100	63.05±0.058	63.44±0.065	64.05±0.134	62.44	105.46
T_1P_2	60.73±0.020	60.99±0.172	61.41±0.300	61.98±0.115	62.58±0.246	62.96±0.230	63.49±0.365	62.02	104.54
T_2P_1	63.44±0.398	64.35±0.433	65.19±0.230	66.21±0.183	66.89±0.212	67.37±0.456	68.22±0.258	65.95	107.53
T_2P_2	63.44±0.398	64.26±0.608	64.75±0.576	65.74±0.435	66.4±0.435	66.93±0.230	67.60±0.368	65.59	106.55
Mean	62.09	62.69	63.31	64.19	64.73	65.18	65.84		
		SEm(±)			$CD_{at\ 5\%}$				
Treatment(T)		0.066			0.190				
Storage (S)		0.088			0.251				
Interaction (T×S)		0.176			0.498				

Table 8: f– test for effect of storage life on total sugar of grape raisins packed in different packaging materials

Treatments	Storage duration (days)								% retention
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Avg	
T1P1	63.02±0.005	63.47±0.010	64.25±0.026	65.20±0.120	65.48±0.079	65.88±0.081	66.52±0.153	64.83	105.55
T1P2	63.02±0.005	63.31±0.170	63.75±0.300	64.35±0.121	64.96±0.243	65.50±0.400	65.91±0.360	64.40	104.58
T2P1	64.99±0.408	65.86±0.512	66.60±0.773	67.94±0.167	68.69±0.156	69.31±0.456	70.08±0.233	67.64	107.83
T2P2	64.99±0.408	65.82±0.621	66.33±0.590	67.34±0.447	68.02±0.453	68.57±0.256	69.26±0.382	67.19	106.57
Mean	64.01	64.62	65.23	66.21	66.79	67.32	67.95		
		SEm(±)			$CD_{\text{at 5\%}}$				
Treatment(T)		0.076			0.217				
Storage (S)		0.100			0.287				
Interaction (T×S)		0.201			0.569				

Table 8 also shows the f-test of change in total sugar (%) w.r.t packaging material, storage duration and their interaction. From Table 8, it indicates that effect of pre-treatment methods and packaging material on total sugar (%) was significant at *p*≤0.01.

Similarly, the effect of storage duration on total sugar (%) was significant at p≤0.01. The interaction effect of both pre-treatment methods, packaging material and storage duration has non-significant effect on the total sugar (%) at *p*≤0.01. The increase in total sugar may be due to hydrolysis of polysaccharides and cell wall materials such as pectin and hemicellulose gets converted into sugars during storage. The increase in reducing sugar during storage was reported for grape raisins by the Venkatram *et al*. 2017; Vishala, S. 2010 and Jadhav *et al*. 2010.

7. Ascorbic acid

Fig. 9 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on ascorbic acid of grape raisins pre-treated with Treatment 1 and Treatment 2 i.e. T_1P_1, T_1P_2, T_2P_1 and T_2P_2. In all the treatments the ascorbic acid decreases as storage duration increases from 0 days to 90 days. The ascorbic acid varies in the range of 18.54 to 20.91 %. For T_1P_1 ascorbic acid decreases from 20.17 to 18.54 mg, for T_1P_2 the ascorbic acid decreases from 20.17 to 18.83 mg, for T_2P_1 ascorbic acid decreases from 20.91 to 19.24 % and for T_2P_2 the ascorbic acid decreases from 20.91 to 29.62 mg. Table 9 also shows the retention of ascorbic acid during storage of grape raisins during 0 to 90 days by various packaging material. Effect of packaging material on ascorbic acid indicated that better retention of ascorbic acid (93.83%) was observed in T_2P_2 aluminium material (grape raisins treated with treatment 2) followed by treatment T_1P_2 (93.35 %) aluminium material (grape raisins treated with treatment 1). Table 9 also shows the f-test of change in ascorbic acid (mg) w.r.t packaging material, storage duration and their interaction. From Table 9, it indicates that effect of pre-treatment methods and packaging material on ascorbic acid (mg) was significant at p≤0.01. Similarly, the effect of storage duration on ascorbic acid (mg) was significant at p≤0.01. The interaction effect of both pre-treatment methods, packaging material and storage duration has significant effect on the ascorbic acid (mg) at *p*≤0.01.

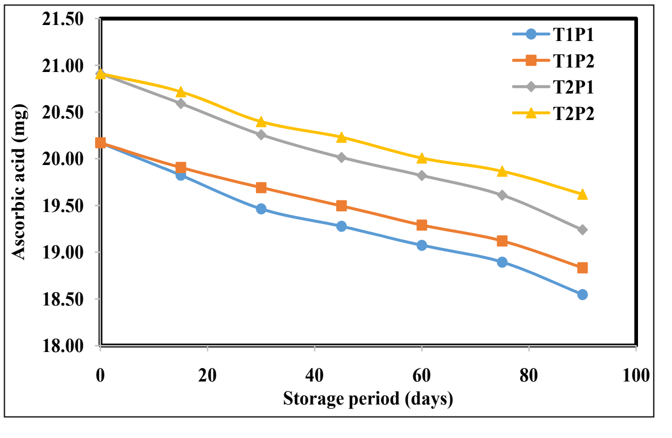


Fig. 9: Effect of storage duration on ascorbic acid of grape raisins packed in different packaging materials

Table 9: f–test for determination of effect of storage life on ascorbic acid of grape raisins packed in different packaging

Treatments	Storage duration (days)								% retention
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Avg	
T_1P_1	20.17±0.020	19.82±0.025	19.46±0.040	19.27±0.149	19.07±0.155	18.89±0.132	18.54±0.306	19.32	91.91
T_1P_2	20.17±0.020	19.90±0.051	19.69±0.036	19.49±0.089	19.29±0.155	19.12±0.175	18.83±0.321	19.50	93.35
T_2P_1	20.91±0.096	20.59±0.208	20.25±0.218	20.01±0.275	19.82±0.320	19.61±0.343	19.24±0.144	20.06	92.01
T_2P_2	20.91±0.096	20.71±0.236	20.39±0.256	20.23±0.289	20.00±0.287	19.86±0.332	19.62±0.355	20.25	93.83
Mean	20.54	20.26	19.95	19.75	19.55	19.37	19.06		
		SEm(±)			$CD_{\text{at 1\%}}$				
Treatment(T)		0.046			0.133				
Storage (S)		0.061			0.176				
Interaction (T×S)		0.123			0.350				

The decrease in ascorbic acid content of raisins may be due to higher rate of oxidation during storage of raisins. The decrease in ascorbic acid during storage was reported for grape raisins by Mapson, 1970 and Simal *et al*. 1996.

8. Colour (Yellowness Index)

Fig. 10 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on colour (Yellowness Index) of grape raisins pre-treated with Treatment 1 and Treatment 2 i.e. T_1P_1, T_1P_2,T_2P_1 and T_2P_2. In all the treatments the colour (Yellowness Index) decreases as storage duration increases from 0 days to 90 days. The colour (Yellowness Index) varies in the range of 63.69 to 72.23. For T_1P_1 colour (Yellowness Index) decreases from 71.72 to 65.57, for T_1P_2 the colour (Yellowness Index) decreases from 72.23 to 69.07, for T_2P_1 ascorbic acid decreases from 68.07 to 63.69 and for T_2P_2 the colour (Yellowness Index) decreases from 68.07 to 65.36. Table 10 also shows the retention of colour (Yellowness Index) during storage of grape raisins during 0 to 90 days by various packaging material. Effect of packaging material on colour (Yellowness Index) indicated that better retention of colour (Yellowness Index) 96.01 % was observed in T_2P_2 aluminium material (grape raisins treated with Treatment T_2) followed by treatment T_1P_2 (95.62%) aluminium material (grape raisins treated with Treatment T_1). Table 10 also shows the f-test of change in colour (Yellowness Index) w.r.t packaging material, storage duration and their interaction. From Table 10, it indicates that effect of pre-treatment methods and packaging material on colour (yellowness index) was significant at *p*≤0.01. Similarly, the effect of storage duration on colour (yellowness index) was significant at p≤0.01. The interaction effect of both pre-treatment methods, packaging material and storage duration has significant effect on the colour (yellowness index) at *p*≤0.01.

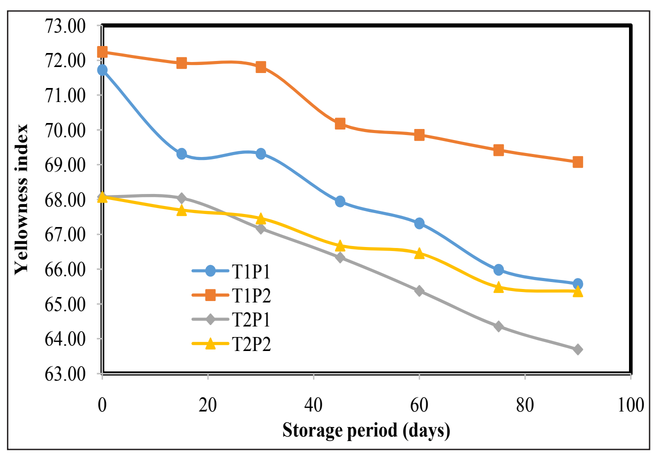


Fig. 10: Effect of storage duration on colour (yellowness index) of grape raisins packed in different packaging material

The changes in colour during storage was reported for grape raisins by Tarr and Clingeleffer, 2005 and Adsule *et al*. 2008.

Table 10: f–test for determination of effect of storage life on colour (yellowness index) of grape raisins packed in different packaging

Treatments	Storage duration (days)								% retentione
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Avg	
T_1P_1	71.72±3.843	69.31±0.385	69.31±0.385	67.94±0.420	67.31±0.505	65.98±0.147	65.57±0.469	68.17	91.42
T_1P_2	72.23±3.422	71.92±1.242	71.80±1.183	70.17±1.198	69.85±0.864	69.41±0.514	69.07±0.355	70.64	95.62
T_2P_1	68.07±0.368	68.03±1.606	67.16±1.209	66.33±1.020	65.37±1.230	64.35±1.080	63.69±1.094	66.15	93.56
T_2P_2	68.07±0.368	67.69±0.359	67.45±0.531	66.67±0.630	66.45±0.680	65.48±0.663	65.36±0.638	66.74	96.01
Mean	70.03	69.24	68.93	67.78	67.25	66.31	65.93	67.92	
		SEm(±)			CD $_{\text{at 1\%}}$				
Treatment(T)		0.274561			1.050109				
Storage (S)		0.36321			1.389164				
Interaction (T×S)		0.726421			2.739345				

9. Sensory analysis

Table 11 (a) shows the sensory colour of grape raisins stored during 0, 15, 30, 45, 60, 75 and 90 days, duration in polythene and aluminium coated bags; the grape raisins was pre-treated with Treatment 1 and Treatment 2 and dried by open air sun drying. The colour score of T_1P_1 decreases from 7.79 to 6.66; for T_1P_2 colour score decreases from 7.44 to 6.42, for T_2P_1 colour score decreases from 7.77 to 7.14 and for T_2P_2 colour score decreases from 7.56 to 6.93 as the storage duration increases from 0 to 90 days respectively. The highest colour score was observed at T_2P_1 at 90 days storage period. Effect of pre-treatment methods and packaging material had significant effect on the colour of the grape raisins at $p \leq 0.01$. The effect of storage duration also had significant effect on the colour of grape raisins at $p \leq 0.01$. The interaction of packaging material and storage duration had also a significant effect and the colour of grape raisins at $p \leq 0.01$.

Table 11 (b) shows the sensory flavour of grape raisins stored during 0, 15, 30, 45, 60, 75 and 90 days, duration in polythene and aluminium coated bags; the grape raisins was pre-treated with Treatment 1 and Treatment 2 and dried by open air sun drying. The flavour score of T_1P_1 decreases from 7.94 to 7.32; for T_1P_2 flavour score decreases from 7.37 to 6.98, for T_2P_1 flavour score decreases from 7.97 to 7.21 and for T_2P_2 flavour score decreases from 7.89 to 7.22 as the storage duration increases from 0 to 90 days respectively. The highest flavour score was observed at T_2P_1 at 90 days storage period. Effect of pre-treatment methods and packaging material had significant effect on the flavour of the grape raisins at $p \leq 0.01$. The effect of storage duration also had significant effect on the flavour of grape raisins at $p \leq 0.01$. The interaction of packaging material and storage duration had also a significant effect and the flavour of grape raisins at $p \leq 0.01$.

Table 11 (c) shows the sensory texture of grape raisins stored during 0, 15, 30, 45, 60, 75 and 90 days, duration in polythene and aluminium coated bags; the grape raisins was pre-treated with Treatment 1 and Treatment 2 and dried by open air sun drying. The texture score of T_1P_1 decreases from 7.73 to 5.36; for T_1P_2 texture score decreases from 7.48 to 6.73, for T_2P_1 texture score decreases from 7.96 to 7.35 and for T_2P_2 texture score decreases from 7.99 to 7.26 as the storage duration increases from 0 to 90 days respectively. The highest texture score was observed at T_2P_1 at 90 days storage period. Effect of pre-treatment methods and packaging material had significant effect on the texture of the grape raisins at $p \leq 0.01$. The effect of storage duration also had significant effect on the texture of grape raisins at $p \leq 0.01$. The interaction of packaging material and

Table 11: Sensory score of dried grape raisins packed in polythene and aluminium pouches

Source of Variance	Storage duration (days)							
	0 days	**15 days**	**30 days**	**45 days**	**60 days**	**75 days**	**90 days**	**Mean**
(a) Colour								
T_1P_1	6.66±0.971	6.78±0.220	7.38±0.653	7.79±0.090	7.22±0.190	7.43±0.381	7.63±0.346	7.27
T_1P_2	7.14±0.776	7.12±0.270	7.08±1.032	7.44±0.259	6.42±0.461	6.95±0.506	7.37±0.156	7.08
T_2P_1	7.14±0.706	7.34±0.336	7.38±0.587	7.69±0.321	7.68±0.169	7.77±0.156	7.65±0.399	7.53
T_2P_2	7.56±0.657	7.24±0.466	7.42±0.811	7.16±0.297	6.93±0.378	7.14±0.474	7.52±0.131	7.28
Mean	7.13	7.12	7.32	7.52	7.07	7.33	7.55	7.29
	Treatment and packaging material		**Storage**			**Interaction (T × S)**		
SEm(±)	0.109		0.145			0.290		
$CD_{\text{at 1\%}}$	0.420		0.555			1.095		
Source of Variance	**Storage duration (days)**							
	0 days	**15 days**	**30 days**	**45 days**	**60 days**	**75 days**	**90 days**	**Mean**
(b) Flavour								
T_1P_1	7.41±0.750	7.48±0.801	7.32±0.737	7.94±0.150	7.55±0.508	7.78±0.465	7.62±0.370	7.59
T_1P_2	7.19±0.901	7.21±0.776	6.98±0.878	7.37±0.237	7.06±0.561	7.34±0.598	7.37±0.380	7.22
T_2P_1	7.76±0.208	7.55±0.422	7.35±0.586	7.68±0.310	7.21±0.191	7.97±0.355	7.58±0.388	7.59
T_2P_2	7.45±0.831	7.22±0.800	7.37±0.809	7.48±0.250	7.65±0.068	7.89±0.263	7.62±0.215	7.53
Mean	7.46	7.37	7.26	7.62	7.37	7.75	7.55	7.48
	Treatment and packaging material		**Storage**			**Interaction (T × S)**		
SEm(±)	0.120		0.159			0.319		
$CD_{\text{at 1\%}}$	0.462		0.611			1.206		
Source of Variance	**Storage duration (days)**							
	0 days	**15 days**	**30 days**	**45 days**	**60 days**	**75 days**	**90 days**	**Mean**
(c) Texture								
T_1P_1	7.63±0.470	7.57±0.535	7.65±0.737	7.73±0.330	7.06±0.709	5.36±3.962	7.66±0.217	7.24
T_1P_2	7.45±0.300	7.17±0.309	6.73±0.696	7.41±0.540	6.96±0.692	7.48±0.404	7.07±0.417	7.18
T_2P_1	7.35±0.598	7.42±0.404	7.57±0.631	7.75±0.174	7.80±0.174	7.96±0.492	7.97±0.399	7.69
T_2P_2	7.26±0.661	7.41±0.353	7.63±0.586	7.57±0.201	7.99±0.288	7.69±0.321	7.64±0.300	7.60
Mean	7.42	7.40	7.40	7.62	7.46	7.13	7.59	7.43
	Treatment and packaging material		**Storage**			**Interaction (T × S)**		
SEm(±)	0.260		0.345			0.690		
$CD_{\text{at 1\%}}$	0.998		1.320			2.603		
Source of Variance	**Storage duration (days)**							
	0 days	**15 days**	**30 days**	**45 days**	**60 days**	**75 days**	**90 days**	**Mean**
(d) Taste								
T_1P_1	7.48±0.835	7.82±0.455	7.55±0.276	7.63±0.586	7.52±0.329	7.86±0.135	7.81±0.125	7.67
T_1P_2	7.76±0.375	7.41±0.554	6.68±0.965	7.47±0.487	7.18±0.921	7.43±0.472	7.54±0.441	7.36
T_2P_1	7.24±0.455	7.17±0.023	7.46±0.515	7.84±0.131	7.66±0.438	7.63±0.200	7.68±0.196	7.53
T_2P_2	7.52±0.595	7.17±0.751	7.29±0.935	7.25±0.185	7.98±0.102	7.76±0.680	7.56±0.298	7.51

Mean	7.50	7.40	7.25	7.55	7.59	7.67	7.65	7.51
	Treatment and packaging material		**Storage**			**Interaction (T × S)**		
SEm(±)	0.113		0.149			0.298		
CD $_{\text{at 1\%}}$	0.432		0.571			1.127		
Source of Variance	**Storage duration (days)**							
	0 days	**15 days**	**30 days**	**45 days**	**60 days**	**75 days**	**90 days**	**Mean**
(e) Average Score								
T_1P_1	7.26	7.75	7.45	7.82	7.50	7.97	7.79	7.65
T_1P_2	7.88	7.48	6.74	7.05	6.95	7.44	6.98	7.22
T_2P_1	7.53	7.44	7.52	7.43	7.21	7.55	7.73	7.49
T_2P_2	7.51	7.46	7.19	7.42	7.04	7.67	7.40	7.39
Mean	7.55	7.54	7.23	7.43	7.18	7.66	7.48	7.44

storage duration had also a significant effect and the texture of grape raisins at $p \leq 0.01$.

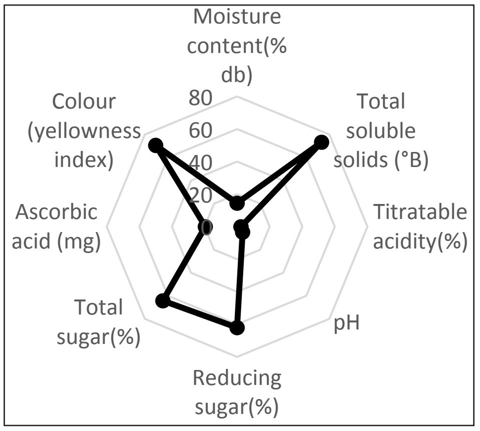
Table 11 (d) shows the sensory taste of grape raisins stored during 0, 15, 30, 45, 60, 75 and 90 days, duration in polythene and aluminium coated bags; the grape raisins was pre-treated with Treatment 1 and Treatment 2 and dried by open air sun drying. The taste score of T_1P_1 decreases from 7.82 to 7.48; for T_1P_2 taste score decreases from 7.76 to 6.68, for T_2P_1 taste score decreases from 7.84 to 7.17 and for T_2P_2 taste score decreases from 7.98 to 7.17 as the storage duration increases from 0 to 90 days respectively. The highest taste score was observed at T_2P_2 at 90 days storage period. Effect of pre-treatment methods and packaging material had significant effect on the taste of the grape raisins at $p \leq 0.01$. The effect of storage duration also had significant effect on the taste of grape raisins at $p \leq 0.01$. The interaction of packaging material and storage duration had also a significant effect and the taste of grape raisins at $p \leq 0.01$.

Table 11 (e) shows the sensory average of grape raisins stored during 0, 15, 30, 45, 60, 75 and 90 days, duration in polythene and aluminium coated bags; the grape raisins was pre-treated with Treatment 1 and Treatment 2 and dried by open air sun drying. The average sensory score of T_1P_1 decreases from 7.97 to 7.26; for T_1P_2 average score decreases from 7.88 to 6.74, for T_2P_1 average score decreases from 7.73 to 7.21 and for T_2P_2 average score decreases from 7.67 to 7.04 as the storage duration increases from 0 to 90 days respectively. The highest average score was observed at T_1P_1 at 90 days storage period. Effect of pre-treatment methods and packaging material had significant effect on the average of the grape raisins at $p \leq 0.01$. The effect of storage duration also had significant effect on the average of grape raisins at $p \leq 0.01$. The interaction of packaging material and storage duration had also a significant effect and the average of grape raisins at $p \leq 0.01$. From all the sensory perception it can be concluded that Treatment T_2P_2 has resulted highest colour, flavour, texture, taste which resulted best sensory treatment upto 90 days storage period.

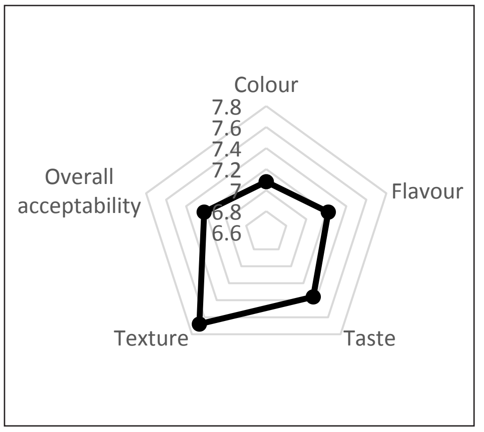
10. Yeast and Mould Count

The effect of packaging treatments (polythene pouches and aluminium pouches) and storage duration on microbial characteristics of dried grapes (raisins), stored at ambient temperature were recorded. Out of total storage duration i.e. 0, 15, 30, 45, 60, 75 and 90 days, the microbial analysis was carried out after 30 days interval. No yeast and mould growth was detected for analysis up to 90 days for both the packaging material i.e. polythene pouches and aluminium pouches. It was seen from Table 12 also shows the ANOVA for the effect of packaging treatments and storage duration on yeast and mould count of grape raisins.

No yeast and mould growth was reported during storing of grape raisins for 4 months reported in the literature Canellas *et al.* (1993).



(a) Quality analysis of T_2P_2



(b) Sensory score of T_2P_2

Fig. 11: (a) and **(b)** Correlation between subjective and objective

11. Correlation between subjective and objective

From the predicted data of quality analysis of stored grape raisins (i.e. acidity, pH, TSS, reducing sugar, total sugar and yellowness index) for treatment T_1P_1, T_1P_2, T_2P_1 and T_2P_2 for the storage duration 0, 15, 30, 45, 60, 75 and 90 days it can be seen that treatment T_1P_2 shows the highest retention of quality parameter as compare to other treatments and from the Table 11 it indicates that the treatment T_1P_2 achieves the maximum sensory score than other treatments.

Table 12: Effect of packaging material and storage duration of grape raisins on yeast and mould count

Treatment and packaging material	Microbial count CFU/g		
	30 Days	**60 Days**	**90 days**
T_1P_1	Not Detected	Not Detected	Not Detected
T_1P_2	Not Detected	Not Detected	Not Detected
T_2P_1	Not Detected	Not Detected	Not Detected
T_2P_2	Not Detected	Not Detected	Not Detected
	$S.E_m(\pm)$	**C.D $_{\text{at 1 \%}}$**	
Treatment (T)	0	0	
Storage (S)	0	0	
Interaction (T×S)	0	0	

CONCLUSION

During the storage period from the 0th to the 3th month moisture content decreases from 14.84 to 13.96% (db), acidity decreases from 2.41 to 2.32 %, colour (yellowness index) decreases from 72.23 to 69.07, pH value decreases from 4.84 to 4.75, ascorbic acid decreases from 20.17 to 18.83 mg for the treatment T_1P_2; during the 3-month storage, total soluble solid increases from 73.23 to 74.04°B reducing sugar increases from 60.73 to 63.49%, total sugar increases from 63.02 to 65.91% for the treatment T_1P_2. Grape raisins can be pre-treated with treatment 1 and dried Open air sun drying can be store for 3 months in the aluminium bags packaging material in good condition.

GENERATIVE AI DECLARATION

The author(s) confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. The authors developed and verified all scientific content, data analysis, interpretation of results, and conclusions. The authors take full responsibility for the accuracy, integrity, and originality of the work presented, and no AI tool was listed as an author.

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