International Journal of Food and Fermentation Technology
Citation: *Int. J. Food Ferment. Technol.*, **16**(01): 147-163, June 2026
DOI: 10.30954/2277-9396.01.2026.10

ASSOCIATION FOR AGRICULTURE ENVIRONMENT AND BIOTECHNOLOGY

RESEARCH PAPER

Effect of Different Drying Methods and Packaging Materials on Quality Parameters of Stored Beetroot Slices

Santosh Ankush Nale 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

Paper No.: 353 **Received:** 20-03-2026 **Revised:** 30-05-2026 **Accepted:** 07-06-2026

ABSTRACT

In this paper beetroot slices dried by two different methods, i.e. microwave convection drying (60°C) and the convective hot air drying (70°C) was taken after being packed in polythene bags and aluminium laminated bags for storage study up to three months (90 days). The effect of different drying methods on quality parameters i.e. acidity, pH, TSS, reducing sugar, and colour (*L*, *a* and *b*) of the stored product were evaluated. The quality parameters were tested at fifteen days intervals. Among two packaging materials, aluminium coated bags was found best for beetroot slices storage up to three months as compared with polythene bags. Deterioration occurred as changes in acidity, lightness, and redness over the storage period from the 0th to the 3th month. However, the TSS and b value increased as storage duration extended.

Keywords: Beetroot slices, storage, drying methods, packaging materials, quality evaluation

Beetroot (*Beta vulgaris L.*) is botanically classified as an herbaceous biennial from chenopodiaceae family and has several varieties with bulb colours ranging from yellow to red (Singh *et al.* 2014). It is commonly known as '*chukander*', is mainly cultivated in India for its juice and vegetable value. It is ranked among the 10 most powerful vegetable with respect to antioxidant capacity described to total phenolic content of 50-60 µmol/dry weight (Kahkonen *et al.* 1999; Vinson *et al*. 1998). The plant consists of roots and rosette of leaves. The sugar is formed by photosynthesis in the leaves and then stored in the roots. The main source of natural red dye, known as beetroot red (Ninfali and Angelina, 2013).

Beetroot are rich in valuable, active compounds such as carotenoids (Dias *et al.* 2009), betacyanines (Patkai., 1997), folates (Jastrabova *et al*. 2003), betanin, polyphenols and flavonoides (Vali *et al.* 2007). Therefore beetroot ingestion can be considered a factor in cancer prevention (Kapadia *et al*. 1996).

Beetroot is popularly consumed as red food colorants, e.g. to improve colour of tomato paste, sauces , dessert, jam and jellies , ice-cream, sweet and cereals,(Kaur and Singh, 2014). The beetroot being an alkaline food with pH from 7.5 to 8.0 has been acclaimed for its health benefits, in particular for its disease fighting antioxidant potential, significant amount of vitamin C and vitamin B_1, B_2, niacin, B_6, B_{12} (Singh *et al*. 2013). Juice of beetroot is also consumed as a natural remedy for sexual weakness and to expel the kidney and blades stone (Sharma *et al*. 2014). Extract of root posses antihypertensive, hypoglycaemic, antioxidant

How to cite this article: Nale, S.A. and Swami, S.B. (2026). Effect of Different Drying Methods and Packaging Materials on Quality Parameters of Stored Beetroot Slices. *Int. J. Food Ferment. Technol.*, **16**(01): 147-163.

Source of Support: None; **Conflict of Interest:** None

(Ninfali and Angelina, 2013), anti-inflammatory and hepato-proctective activities (Singh *et al*. 2013; Jain *et al*. 2011; Kujala *et al*. 2000). The claimed therapeutic use of beetroot includes its antitumor, carminative, emmenagogue and haemostatic and renal protective properties and is potential herb used in cardiovascular condition (Vali *et al*. 2007). Beetroot is an excellent source of foliate and a good source of manganese (USDA nutritional database, 2014). It is beneficial for digestive problems, such as constipation, for the skeletal system and a good circulation of blood. (Profir *et al*. 2013).

Dried beetroots can be consumed directly in the form of chips as a substitute of traditional snacks that are rich in tran's fatty acid (Aro *et al*. 1998; Krejcova *et al*. 2007) or after easy preparation as a component of instant food. Red beetroot powder as a natural red food colorant offers application in dry mixes (soups, Indian curry mixes), sweets, jam, jellies etc the bright red colour of beetroot is owing to a group of red pigments known as betalains. Betalains are antioxidants and having profound health benefits.

India ranks second in fruits and vegetables production in the world, after China. India produced 81.285 million metric tonnes of fruits and 162.19 million metric tonnes of vegetables in 2012-2013 (APEDA., 2014). As fruits and vegetables contain high moisture in it, they are perishable at atmospheric conditions. Preservation of fruits and vegetables can overcome this problem. Drying is one of the oldest methods of processing and preserving food for later use. It is a complex operation involving heat and mass transfer which may cause change in food quality (Maskan *et al*. 2002). The major objective in drying agricultural product is the reduction of the moisture content to a level, which allows safe storage over an extended period (Ibrahim D. 2004a) and its availability in off season. Packaging provides the correct environmental conditions for food during the length of time it is stored and/or distributed to the consumer. 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 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 200°F (CE plastic., 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 geopardize the flavor and texture of the product. The Low density polyethylene (LDPE) is widely used to package 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.

The present study investigates the effect of different packaging material on quality of beetroot slices. Beetroot slices were stored for three months in two different packaging material viz. Low Density Polythene (LDPE) and Aluminum laminated bags. The present study was undertaken to determine the effect of packaging treatment and storage duration on quality parameter, sensory attributes and microbial count of dried beetroot slices.

MATERIALS AND METHODS

Drying of beetroot slices by convective hot air drying

Tray drying of beetroot slices was performed at Department of Post Harvest Engineering, Post Graduate Institute of Post Harvest Management, Killa-Roha. The drying was carried out in the tray dryer (Make M/s. Aditi Associates, India; Model: ATD-124) having capacity of 5 kW. There were nine numbers of trays inside the trays dryer. The size of the tray was 81cm × 41cm × 3.4 cm. the beetroot slices were dried in thin layer drying. The slices were spread on the tray in single layer. The mesh (square) size of the tray was 1x1 mm. The temperature of the drying was 70°C. The air velocity inside the dryer was 2-3 m/s. The drying was carried out from an initial moisture content 669.89±2.13 to final moisture content 6.94±0.36 (%db) in 7 hours.

Drying of beetroot slices by microwave-convection drying

The drying was carried out in the Microwave convective batch dryer (Make M/s. Twin Engineering, Vadodara, Gujarat; Model: TW/CMDRY/2/17-18) having capacity of 3 kW with maximum output of 625W at 2450MHz and drying chamber having dimensions 900 mm × 900 mm × 600 mm (*L* × *W* × *H*). The dryer had the capability of convective temperature adjustment at fixed power (wattage) adjustment.

The temperature of the microwave convective dryer kept as 60°C temperature and the microwave power was kept constant at 50W. The ON and OFF time of the magnetron was adjusted at 20 sec ON and 40 sec OFF respectively. Drying was carried out from an initial moisture content 669.89±2.13 to final moisture content 6.51±0.01 in 34 minutes.

Packaging and storage study of dried beetroot slices by convective hot air and microwave convection drying method

The best treatment of convective hot air drying and microwave convection drying obtained after drying at 70°C and 60°C was used for the packaging and storage study. 150 g of dried beetroot powder prepared as discussed above was taken in two different packaging material at each dried by tray and microwave-convection drying i.e. polythene and aluminum laminated pouches. The details of the packaging material are given in Table 1. Fig. 1 (a) and 1 (b) shows the packaging material i.e. polythene and aluminum laminated pouches used for packaging and storage of dried beetroot slices for 3 months duration. 150 g of dried beetroot slices sample was filled separately in polythene and aluminum

(a)

(b)

Fig. 1: Packaging material used for packaging of dried beetroot powder **(a)** Aluminium laminated pouch **(b)** Polythene pouch

laminated pouches and sealed properly. These packets were kept at ambient temperature up to 8 weeks. The stored samples were analyzed at every 15 days interval up to 3 months. The observations for the sensory analysis, The observation of acidity, pH, reducing sugar, TSS and total sugar etc 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 beetroot slices were kept for storage study. The sensory analysis i.e. colour, flavor, texture and taste for the stored samples were determined for each storage duration i. e. 0, 15, 30, 45, 60, 75 and 90 days.

Table 1: Specifications of packaging material for storage of beetroot slices

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

Quality analysis of beetroot slices before and after drying

1. Moisture content

The moisture content of dried and stored beetroot slices was determined as per AOAC, 2010. Initial moisture content of beetroot slices was calculated by the hot air oven at 105 °C ±1 °C for 24 hours. The final weight of beetroot slices were recorded after 24 hours. The moisture content of the beetroot slices was determined by following formula (Chakraverty, 1994).

$$\text{Moisture content (db) \%} = \frac{W_1 - W_2}{W_2} \times 100 \qquad \ldots(1)$$

Where,

W_1 = Weight of sample before drying, g

W_2 = Weight of sample after drying, g

2. Total soluble solids

Total soluble solids of dried and stored beetroot slices was determined by using Refractometer (M/s. Atago, Japan) and the values were corrected at 20°C. The equipment was calibrated with distilled water and the TSS of the beetroot juice before drying and slices powder after drying was determined by adding the 5 g sample in to the 20 ml of distilled water and TSS were measured by hand refractometer. The experiments were replicated three times.

3. pH

pH of dried and stored beetroot slices 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. 10 ml of beetroot slice and dried slices powder 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 experiments were replicated three times.

4. Titratable acidity

The titratable acidity of dried and stored beetroot slices was determined as per procedure reported in Ranganna (1997). A known quantity of sample was blended in mortar and pestle with 20-25 ml distilled water. It was then transferred to 100 ml volumetric flask, made up the volume and filtered. A known volume of aliquot (10ml) was titrated against 0.1N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator (Ranganna, 1997). The acidity was calculated as given below and the results were expressed as percent anhydrous citric acid. The three replication were carried out and the average reading was reported.

$$\text{Titratable acidity (\%)} = \frac{N \times T \times E}{W \times V \times 1000} \times 100 \qquad \ldots(2)$$

Where,

N = normality of alkali

T = titrate reading

E = equivalent mass of acid, g

W = weight of the sample, g

V = total volume of the sample, g

5. Reducing sugars

The reducing sugars of dried and stored beetroot slices was estimated by using Lane and Eynon Method with modifications suggested by Ranganna (1997). A known weight of beetroot slices were crushed with distilled water using lead acetate (45%) for precipitation of extraneous material and potassium oxalate (22%) to de-lead the solution. This lead free extract was used to estimate reducing sugars titrating against standard Fehling mixture (Fehling '*A*' and '*B*' in equal proportion) using methylene blue as an indicator to brick red end point. The three replication were carried out and the average reading was reported.

Reducing sugar % =

$$\frac{100}{\text{Burettereading}} \times \frac{\text{Volume prepared}}{\text{Inital volume}} \times GV \text{ of fehling's solution} \quad \ldots(3)$$

Where,

GV = Glucose value

6. Total sugars

Total sugars was of dried and stored beetroot slices estimated was by same procedure of reducing sugar after acid hydrolysis of an aliquot of deleaded sample with 50 percent of hydrochloric acid followed by neutralization with sodium hydroxide (40%) and calculated as below (Eq. 14). The experiment was repeated three times to get the replication.

Total sugar (%) =

$$\frac{\text{Factor} \times \text{Dilution}}{\text{Titre reading} \times \text{Weightn of sample}} \times 100 \quad \ldots(4)$$

7. Colour

The dried grounded Beetroot slices was used to measure the colour value by using colorimeter (Konica minotta, Japan model-Meter CR-400).The equipment was calibrated against standard white tile and black tile. Around 20 g dried beetroot slices powder was taken in the glass cup, the cup was placed on the aperture of the instrument. 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).

Sensory analysis

The sensory attribute of dried dehydrated beetroot slices packed in polythene and aluminium laminated pouches was determined for each storage period 0, 15, 30, 45 and 60 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 dehydrated beetroot slices powder samples were placed into plastic plate. The beetroot slices packed in polythene and aluminium laminated pouches were coded as A and B for evaluation of sensory parameter i.e. colour, flavor, texture and taste attributes. The rating was based on nine- point hedonic scales. 09 scales for colour, 9 scales for flavor 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 average score for total 14 panelists have been reported. The data were analyzed statistically for the significance of each attributes by ANOVA.

Microbial analysis

The microbial analysis of dried beetroot slices packed in polythene and aluminium laminated pouches was determined for storage period of 30, 60 and 90 days i.e. after one month interval as per the procedure of APHA (1992). The beetroot slice 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/gm methods prescribed by Bureau of Indian Standards, (1999).

Formula for calculating CFU/g;

$$CFU = \frac{\text{Average plate count} \times \text{Dilution}}{\text{Weight of sample}} \quad \ldots(5)$$

1. Statistical analysis

Statistical analysis was performed using Factorial completely randomized design (FCRD) for stored sample properties like acidity, pH, reducing sugar, TSS and total sugar etc, sensory attributes i.e. colour, flavor, 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.

Table 2: Treatment combinations of beetroot slices for storage study

Sl. No.	Drying methods	Packaging materials	Combinations
1	Tray Drying	Polythene	T_1P_1
2	Microwave-convection drying	Aluminium Coated Bags	T_2P_1
3	Tray Drying	Aluminium Coated Bags	T_1P_2
4	Microwave drying	Polythene	T_2P_2

RESULTS AND DISCUSSION

Storage study of dried beetroot slices in different packaging materials

1. Acidity

Fig. 2 shows the effect of storage duration and packaging material on acidity of dried beetroot slices by different methods. In all treatments, highest acidity percentage was observed at 0th month. As storage period increased acidity decreased in the dried beetroot slices. Fig. 2 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on acidity of dried beetroot slices by convective drying and microwave convective drying. In all the treatments the acidity decreases as storage duration increases from 0 days to 90 days. The acidity varies in the range of 0.031 to 0.162 %. For T_1P_1 acidity decreases from 0.162 to 0.074 %, for T_1P_2 the acidity decreases from 0.167 to 0.043 %, for T_2P_1 acidity decreases from 0.105 to 0.031 % and for T_2P_2 the acidity decreases from 0.093 to 0.033 %. This decrease in titratable acidity was observed for dried apple powder which was stored for 6 months, dried of banana powder stored for 4 months and dried kokum rind which was stored up to 9 months by the scientist Sharma and Kaushal, 2013; Sahoo *et al*. 2015 and Hande *et al*. 2014 respectively.

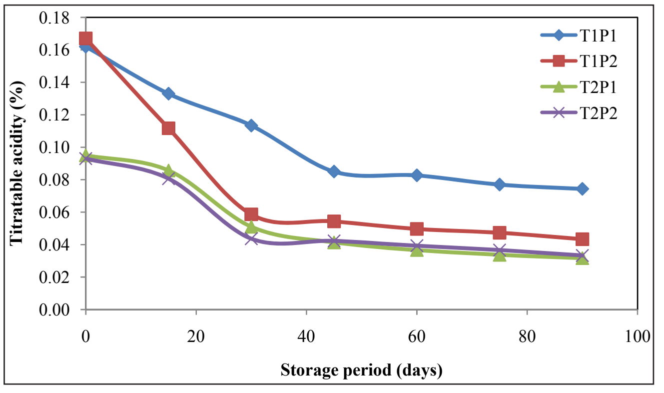

Fig. 2: Effect of storage duration on acidity of beetroot slices packed in different packaging materials

Table 3 shows the retention of acidity during storage of beetroot slices during 0 to 90 days by various packaging material. Effect of packaging material on acidity indicated that better retention of acidity (45.88%) was observed in T_1P_1 polythene material (beetroot slices dried by convective hot air drying) followed by treatment T_2P_2 (35.727 %) aluminium material (beetroot slices dried by microwave convective drying). Table 3 shows the ANOVA of change in acidity w.r.t. packaging material, storage duration and their interaction. From Table

Table 3: f–test for determination of effect of storage life on acidity of dried beetroot slices packed in different packaging

Treatments	Storage duration (days)								Retention
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Average	%
T_1P_1	0.162±0.032	0.133±0.006	0.113±0.014	0.085±0.002	0.082±0.001	0.077±0.001	0.074±0.004	0.103	45.884
T_1P_2	0.167±0	0.111±0.003	0.058±0.001	0.054±0.001	0.049±0.001	0.047±0.001	0.043±0.001	0.076	25.948
T_2P_1	0.095±0.003	0.085±0.003	0.051±0.008	0.041±0	0.036±0.008	0.03±0	0.031±0	0.053	33.193
T_2P_2	0.093±0.002	0.080±0.005	0.043±0.003	0.042±0	0.039±0	0.036±0.001	0.033±0.001	0.052	35.727
Mean	0.129	0.102	0.066	0.055	0.052	0.048	0.045	0.071	
		SE_m			$CD_{at\ 1\%}$				
Treatment (T)		0.0016			0.0061				
Storage (S)		0.0021			0.0080				
Interaction (T×S)		0.0042			0.0159				

3, it indicates that effect of drying 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 drying methods, packaging material and storage duration has significant effect on the acidity at *p*≤0.01.

2. pH

Fig. 3 shows the effect of storage duration and different packaging materials on pH of dried beetroot slices by different drying methods i.e. tray and microwave convection drying. There was not any specific trend observed in the pH value of beetroot slices during storage. The increase in pH was observed in tray and microwave convectively dried beetroot slices packed in both polythene pouches and aluminium pouches respectively. The lowest pH was observed at 0 days storage. Fig. 3 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on pH of dried beetroot slices by convective drying and microwave convective drying. In all the treatments the acidity increases as storage duration increases from 0 days to 90 days. The pH varies in the range of 4.6 to 6.966 For T_1P_1 pH increases from 5.27 to 6.066, for T_1P_2 the pH increases from 5.27 to 6.8, for T_2P_1 acidity pH increases from 5.23 to 6.9 and for T_2P_2 the pH increases from 5.23 to 6.966. Table 4 shows the retention of pH during storage of beetroot slices during 0 to 90 days by various packaging material. Effect of packaging material on pH indicated that better retention of pH (86.81%) was observed in T_1P_1 polythene material (beetroot slices dried by convective hot air drying) followed by treatment T_2P_2 (75.11 %) aluminium material (beetroot slices dried by microwave convective drying). Table 4 shows the ANOVA of change in pH w.r.t packaging material, storage duration and their interaction. From Table 4, it indicates that effect of drying methods and packaging material on pH was significant at *p*≤0.01. Similarly, the effect of storage duration on acidity was significant at *p*≤0.01. The interaction effect of drying methods, packaging material and storage duration has significant effect on the pH at *p*≤0.01. This increase in pH was observed for dried date juice concentrate which was stored for 6 months, dried of banana powder stored for 4 months and dried jackfruit bulb powder which was stored up to 12 months by the scientist; Kulkarni *et* al. 2010; Sahoo *et al*. 2015 and Swami *et al*. 2016 respectively.

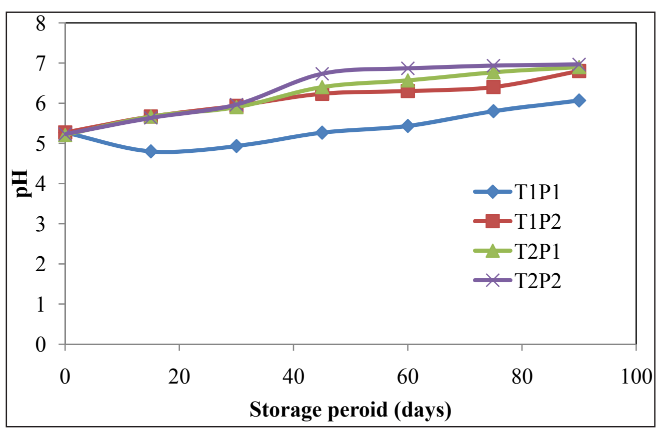

Fig. 3: Effect of storage duration on pH of beetroot slices packed in different packaging materials

Table 4: f – test for determination of effect of storage life on pH of dried beetroot slices packed in different packaging materials

Treatments	Storage duration (days)								Retention %
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Average	
T_1P_1	5.27±0.264	4.80±0.2	4.93±0.057	5.27±0.115	5.43±0.378	5.80±0.1	6.07±0.152	5.37	86.81209
T_1P_2	5.27±0.152	5.67±0.115	5.93±0.577	6.23±0.152	6.30±0.1	6.40±0.1	6.80±0.1	6.09	74.45
T_2P_1	5.21±0.1	5.67±0.057	5.90±0.1	6.40±0.1	6.57±0.057	6.77±0.152	6.90±0.1	6.20	75.50725
T_2P_2	5.23±0.152	5.63±0.057	5.97±0.057	6.73±0.115	6.87±0.057	6.93±0.057	6.97±0.057	6.33	75.11962
Mean	5.24	5.44	5.68	6.16	6.29	6.48	6.68	6.00	
		SE_m			$CD_{at\ 1\%}$				
Treatment (T)		0.0297			0.1137				
Storage (S)		0.03934			0.1504				
Interaction (T×S)		0.07868			0.29670				

3. TSS

Fig. 4 shows the effect of storage duration and packaging material on TSS of beetroot slices dried with tray (at 70°C) and microwave (at 60°C) drying methods. As the storage period increased, TSS also increased in the dried beetroot slices. Fig.4 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on TSS of dried beetroot slices by convective drying and microwave convective drying. In all the treatments the TSS increases as storage duration increases from 0 days to 90 days.

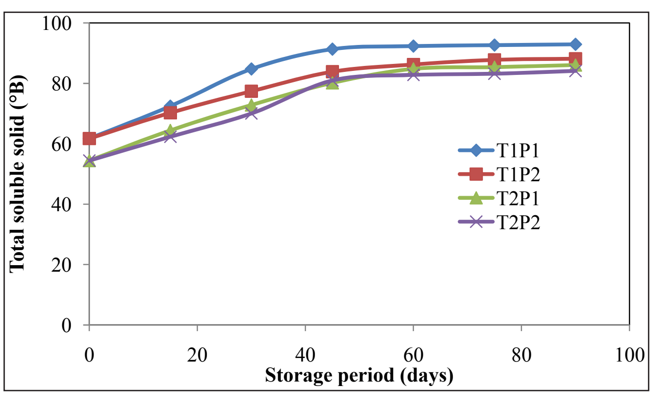

Fig. 4: Effect of storage duration on TSS of beetroot slices packed in different packaging materials

The TSS varies in the range of 54.43 to 92.93 °B For T_1P_1 TSS increases from 61.73 to 92.93 °B, for T_1P_2 the TSS increases from 61.73 to 88.17 °B, for T_2P_1 acidity TSS increases from 54.43 to 86.07 °B and for T_2P_2 the TSS increases from 54.43 to 84.13 °B. Table 4 shows the retention of TSS during storage of beetroot slices during 0 to 90 days by various packaging material. Effect of packaging material on TSS indicated that better retention of TSS (66.42%) was observed in T_1P_1 polythene material (beetroot slices dried by convective hot air drying) followed by treatment T_1P_2 (70.01 %) aluminium material (beetroot slices dried by convective hot air drying). Table 5 shows the ANOVA of change in TSS w.r.t packaging material, storage duration and their interaction. From Table 5, it indicates that effect of drying methods and packaging material on TSS was significant at $p \leq 0.01$. Similarly, the effect of storage duration on TSS was significant at $p \leq 0.01$. The interaction effect of both drying methods, packaging material and storage duration has significant effect on the TSS at $p \leq 0.01$. This increase in total soluble solids was observed for apple ring which was stored for 5 months, dried of banana powder stored for 4 months and dried date juice concentrate which was stored for 6 months by the scientist Rizzalo *et al*. 2011; Sahoo *et al*. 2015 and Kulkarni *et* al. 2010 respectively.

4. Reducing sugar

Fig. 5 shows effect of storage duration and packaging materials on reducing sugar (%) of beetroot slices dried by tray and microwave convection drying. Fig.5 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on reducing sugar of dried beetroot slices by convective drying and microwave convective drying. In all the treatments the reducing sugar decreases as storage duration increases from 0 days to 90 days. The reducing sugar

Table 5: f–test for determination of effect of storage life on TSS of dried beetroot slices packed in different packaging materials

Treatments	Storage duration (days)								Retention %
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Average	
T_1P_1	61.73±1.616	72.47±0.416	84.77±0.802	91.33±0.230	92.33±0.404	92.67±0.611	92.93±0.450	84.03	66.427
T_1P_2	61.73±2.433	70.27±0.832	77.40±0.6	83.87±0.832	86.27±1.006	87.80±0.2	88.17±0.305	79.36	70.018
T_2P_1	54.43±1.222	64.43±0.404	72.83±0.750	80.17±0.208	84.80±0.3	85.37±0.850	86.07±0.378	75.44	63.245
T_2P_2	54.43±0.802	62.33±0.808	70.03±1.429	80.97±1.594	82.80±0.4	83.20±0.4	84.13±0.351	73.99	64.698
Mean	58.08	67.38	76.26	84.08	86.55	87.26	87.83	78.20	

	SE_m	$CD_{\text{at 1\%}}$
Treatment (T)	0.1959	0.7495
Storage (S)	0.2592	0.9915
Interaction (T×S)	0.51850	1.95529

Table 6: f– test for effect of storage life on reducing sugar of dried beetroot slices packed in different packaging materials

Treatment	Storage duration (days)								Retention %
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Average	
T_1P_1	4.60±0.103	3.12±0.070	1.90±0.036	1.59±0.026	1.36±0.022	1.067±0.016	0.961±0.014	2.088	20.868
T_1P_2	4.84±0.037	3.28±0.058	1.99±0.052	1.66±0.047	1.62±0.324	1.222±0.181	1.006±0.032	2.233	20.764
T_2P_1	2.90±0.024	2.23±0.022	1.53±0.018	1.32±0.016	1.16±0.014	0.938±0.012	0.856±0.011	1.563	29.522
T_2P_2	2.95±0.28	2.28±0.016	1.57±0.010	1.36±0.008	1.20±0.010	0.972±0.009	0.888±0.007	1.606	30.118
Mean	3.82	2.72	1.75	1.48	1.33	1.05	0.92	1.87	

	SE_m	$CD_{\text{at 1\%}}$
Treatment (T)	0.017066	0.065273
Storage (S)	0.022576	0.086347
Interaction (T×S)	0.045153	0.170272

varies in the range of 0.88 to 4.84 %. For T_1P_1 reducing sugar decreases from 4.60 to 0.961%, for T_1P_2 the reducing sugar decreases from 4.84 to 1.006 %, for T_2P_1 reducing sugar decreases from 2.90 to 0.856 % and for T_2P_2 the reducing sugar decreases from 2.95 to 0.888 %. Table 6 shows the retention of reducing sugar during storage of beetroot slices during 0 to 90 days by various packaging material. Effect of packaging material on reducing sugar indicated that better retention of reducing sugar (29.522%) was observed in T_2P_1 polythene material (beetroot slices dried by microwave convective drying) followed by treatment T_2P_2 (30.118 %) aluminium material (beetroot slices dried by microwave convective drying). Table 6 shows the ANOVA of change in reducing sugar (%) w.r.t packaging material, storage duration and their interaction.

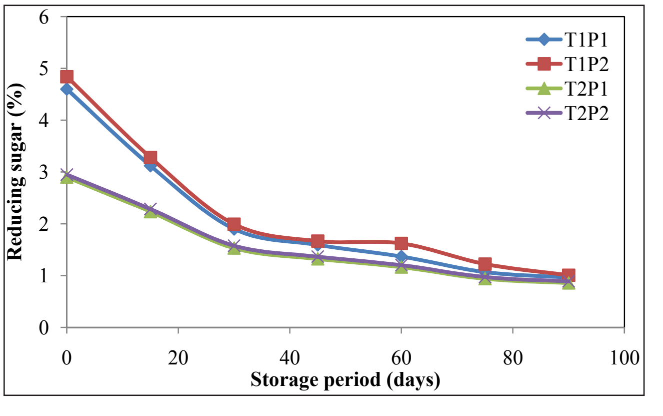

Fig. 5: Effect of storage duration on reducing sugar of beetroot slices packed in different packaging materials

From Table 6, it indicates that effect of drying methods and packaging material on reducing sugar (%) was significant at $p \leq 0.01$. Similarly, the effect of storage duration on reducing sugar (%) was significant at

$p \leq 0.01$. The interaction effect of both drying methods, packaging material and storage duration has significant effect on the reducing sugar (%) at $p \leq 0.01$. This decrease in reducing sugar was observed for dried of banana powder stored for 4 months, dried date juice concentrate which was stored for 6 months, dried jackfruit bulb powder which was stored up to 12 months and dried bael powder which was stored up to 6 months by the scientist Sahoo *et al*. 2015, Kulkarni *et al.* 2010, Swami *et al.* 2016 and Sagar and Kumar, 2015 respectively.

5. Total sugar

Fig. 6 shows effect of storage duration and packaging materials on total sugar (%) of beetroot slices dried by tray drying (at 70°C) and microwave convective drying (at 60°C) method.

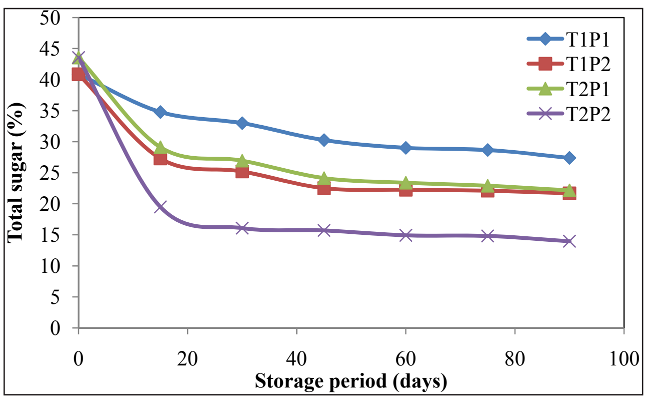

Fig. 6: Effect of storage duration on total sugar of beetroot slices packed in different packaging materials

Fig. 6 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on total sugar of dried beetroot slices by convective drying and microwave convective drying. In all the treatments the total sugar decreases as storage duration increases from 0 days to 90 days. The total sugar varies in the range of 43.55 to 13.96 %. For T_1P_1 total sugar decreases from 40.86 to 27.39%, for T_1P_2 the total sugar decreases from 40.86 to 21.67 %, for T_2P_1 total sugar decreases from 43.55 to 22.14 % and for T_2P_2 the total sugar decreases from 43.55 to 13.96%.

Table 7 shows the retention of total sugar during storage of beetroot slices during 0 to 90 days by various packaging material. Effect of packaging material on total sugar indicated that better retention of total sugar (67.03%) was observed in T_1P_1 polythene material (beetroot slices dried by convective hot air drying) followed by treatment T_1P_2 (53.05 %) aluminium material (beetroot slices dried by convective hot air drying). Table 7 shows the ANOVA of change in total sugar (%) w.r.t packaging material, storage duration and their interaction. From Table 7, it indicates that effect of drying methods and packaging material on total sugar (%) was significant at $p \leq 0.01$. Similarly, the effect of storage duration on total sugar (%) was significant at $p \leq 0.01$. The interaction effect of both drying methods, packaging material and storage duration has significant effect on the total sugar (%) at $p \leq 0.01$. This decrease in total sugar was observed for dried of banana powder stored for 4 months,

Table 7: f– test for effect of storage life on total sugar of dried beetroot slices packed in different packaging materials

Treatment	Storage duration (days)								Retention %
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Average	
T_1P_1	40.86±0.0796	34.78±0.396	32.98±0.383	30.25±0.187	29.00±0.168	28.66±0.135	27.39±0.781	31.990	67.03377
T_1P_2	40.86±0.520	27.28±0.120	25.20±0.529	22.51±0.113	22.25±0.083	22.11±0.051	21.67±0.225	25.984	53.05107
T_2P_1	43.55±0.330	29.10±0.580	26.93±0.859	24.12±0.095	23.37±0.181	22.89±0.360	22.14±0.049	27.447	50.84571
T_2P_2	43.55±0.657	19.48±0.240	16.08±0.087	15.70±0.498	14.91±0.035	14.81±0.106	13.96±0.13	19.786	32.05266
Mean	42.20	27.66	25.29	23.149	22.38	22.11	21.29	26.302	
		SE_m			$CD_{at\ 1\%}$				
Treatment (T)		0.5343			2.0435				
Storage (S)		0.7068			2.7034				
Interaction (T×S)		1.41367			5.33097				

dried date juice concentrate which was stored for 6 months, dried jackfruit bulb powder which was stored up to 12 months and dried bael powder which was stored up to 6 months by the scientist Sahoo *et al.* 2015, Kulkarni *et al.* 2010, Swami *et al.* 2016 and Sagar and Kumar, 2015 respectively.

6. Colour- L

Fig. 7 shows the effect of storage duration and packaging materials on colour-L of dried beetroot slices by tray (at 70°C) and microwave convection (at 60°C) drying methods. In all treatments, highest *L* value was observed at the 0^{th} month. As storage period increased darkness increased in the dried beetroot slices.

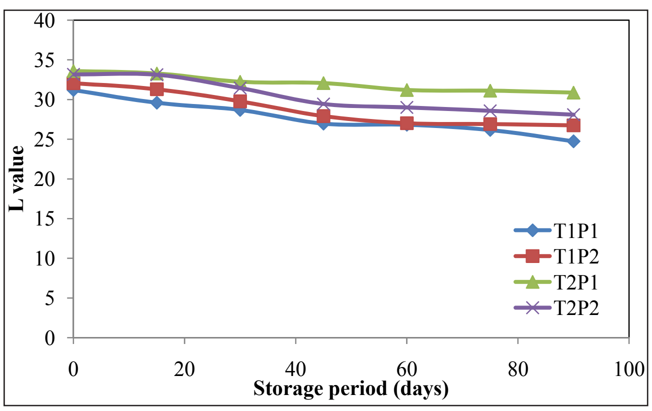

Fig. 7: Effect of storage duration on colour value *L* of beetroot slices

Fig. 7 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on *L* value of dried beetroot slices by convective drying and microwave convective drying. In all the treatments the *L* value decreases as storage duration increases from 0 days to 90 days. The *L* value varies in the range of 33.59 to 24.74. For T_1P_1 *L* value decreases from 31.20 to 24.74, for T_1P_2 the *L* value decreases from 32.06 to 26.74, for T_2P_1 *L* value decreases from 33.59 to 30.87 and for T_2P_2 the *L* value decreases from 33.17 to 28.09. Table 8 shows the retention of *L* value during storage of beetroot slices during 0 to 90 days by various packaging material. Effect of packaging material on *L* value indicated that better retention of *L* value (91.89%) was observed in T_2P_1 polythene material (beetroot slices dried by microwave convective drying) followed by treatment T_2P_2 (84.67 %) aluminium material (beetroot slices dried by microwave convective drying). Table 8 shows the ANOVA of change in *L* value w.r.t packaging material, storage duration and their interaction. From Table 8, it indicates that effect of drying methods and packaging material on *L* value was significant at $p \leq 0.01$. Similarly, the effect of storage duration on *L* value was significant at $p \leq 0.01$. The interaction effect of both drying methods, packaging material and storage duration has significant effect on the *L* value at $p \leq 0.01$. This decrease in colour *L* was observed by (Hande *et al.* 2014) for dried kokum rind which was stored for 9 months.

7. Colour- a

Fig. 8 shows the effect of storage duration and

Table 8: f- test for colour-L value of dried beetroot slices packed in different packaging materials

Treatments	Storage duration (days)								Retention %
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Average	
T_1P_1	31.20±0.533	29.59±0.015	28.69±0	26.96±0.170	26.82±0.32	26.16±0.490	24.74±1.005	27.86	79.277
T_1P_2	32.06±0.619	31.29±0.032	29.77±0.005	27.91±0	27.01±0.025	26.91±0.026	26.74±0.026	28.82	83.406
T_2P_1	33.59±0.140	33.28±0	32.23±0.005	32.07±0.036	31.2±0.04	31.11±0.005	30.87±0.015	32.05	91.894
T_2P_2	33.17±0.068	33.12±0.055	31.45±0.026	29.44±0.011	29.01±0.005	28.58±0.597	28.09±0.060	30.47	84.676
Mean	32.82	31.82	30.53	29.09	28.51	28.19	27.61	32.8283	
		SE_m				$CD_{at\ 1\%}$			
Treatment (T)		0.0631				0.2416			
Storage (S)		0.0835				0.3196			
Interaction (T×S)		0.1671				0.63041			

packaging materials on colour-a of dried beetroot slices by tray (at 70°C) and microwave convection (at 60°C) drying methods. In all treatments, highest redness value was observed at the 0th month. As storage period increased, redness decreased in the dried beetroot slices.

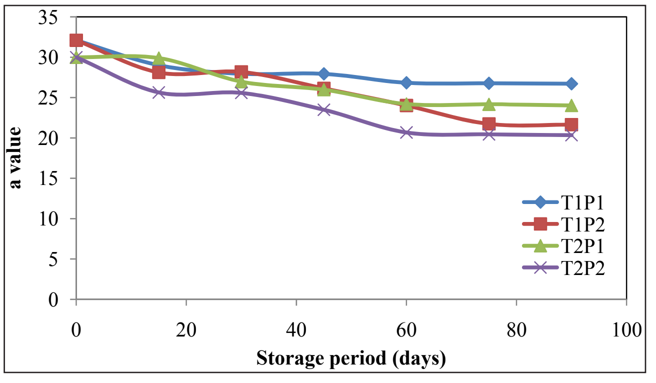

Fig. 8: Effect of storage duration on colour value *a* of beetroot slices

Fig. 8 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on a value of dried beetroot slices by convective drying and microwave convective drying. In all the treatments the *a* value decreases as storage duration increases from 0 days to 90 days. The *a* value varies in the range of 32.1 to 20.35. For T_1P_1 a value decreases from 32.1 to 26.72, for T_1P_2 the *a* value decreases from 32.1 to 21.64, for T_2P_1 *a* value decreases from 29.99 to 24.03 and for T_2P_2 the *a* value decreases from 29.99 to 20.34. Table 9 shows the retention of a value during storage of beetroot slices during 0 to 90 days by various packaging material. Effect of packaging material on a value indicated that better retention of *a* value (83.25%) was observed in T_1P_1 polythene material (beetroot slices dried by convective hot air drying) followed by treatment T_2P_1 (80.12 %) polythene material (beetroot slices dried by microwave convective drying). Table 9 shows the ANOVA of change in a value w.r.t packaging material, storage duration and their interaction. From Table 9, it indicates that effect of drying methods and packaging material on redness value was significant at $p \le 0.01$. Similarly, the effect of storage duration on redness value was significant at $p \le 0.01$. The interaction effect of both drying methods, packaging material and storage duration has significant effect on the redness value at $p \le 0.01$. This decrease in redness value of colour was observed by (Hande *et al*. 2014) for dried kokum rind which was stored for 9 months.

8. Colour- b

Fig. 9 shows the effect of storage duration and packaging materials on yellowness of dried beetroot slices by tray drying (at 70°C) and microwave convective drying (at 60°C) methods. In all treatments, lowest yellowness value was observed at the 0th month. As storage period increased, yellowness increased in the dried beetroot slices.

Table 9: f- test for colour-a value of dried beetroot slices packed in different packaging materials

Treatment	Storage duration (days)								Retention %
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Average	
T_1P_1	32.10±0.02	29.02±0.410	27.95±0.011	27.94±0.107	26.84±0.02	26.78±0.005	26.72±0.015	28.19	83.25026
T_1P_2	32.10±0.025	28.11±0.020	28.19±0.056	26.15±0.025	24.02±0.087	21.74±0.047	21.65±0.060	25.99	67.4351
T_2P_1	29.99±0	29.90±0.020	26.97±0.020	25.98±0.040	24.20±0.056	24.17±0.045	24.03±0.043	26.46	80.12671
T_2P_2	29.99±0.030	25.64±0.015	25.58±0.04	23.49±0.040	20.68±0.034	20.45±0.066	20.35±0.094	23.74	67.84484
Mean	31.05	28.17	27.17	25.89	23.94	23.29	23.19	25.27	
		SE_m			$CD_{at\ 1\%}$				
Treatment (T)		0.0196			0.0753				
Storage (S)		0.026			0.0996				
Interaction (T×S)		0.052118			0.196537				

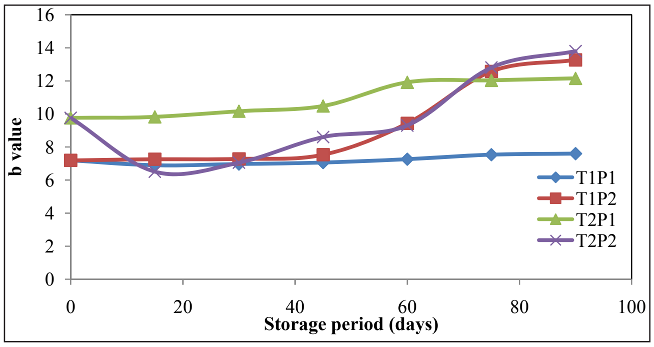

Fig. 9: Effect of storage duration on colour value b of beetroot slices

Fig. 9 shows the effect of storage duration (0, 15, 30, 45, 60, 75 and 90 days) and packaging material on b value of dried beetroot slices by convective drying and microwave convective drying. In all the treatments the b value increases as storage duration increases from 0 days to 90 days. The b value varies in the range of 7.19 to 13.80. For T_1P_1 a value increases from 7.19 to 7.60, for T_1P_2 the a value increases from 7.19 to 13.27, for T_2P_1 a value increases from 9.76 to 12.75 and for T_2P_2 the a value increases from 9.76 to 13.80. Table 10 shows the retention of *b* value during storage of beetroot slices during 0 to 90 days by various packaging material. Effect of packaging material on a value indicated that better retention of b value (94.69%) was observed in T_1P_1 polythene material (beetroot slices dried by convective hot air drying) followed by treatment T_2P_1 (80.30 %) polythene material (beetroot slices dried by microwave convective drying). Table 9 shows the ANOVA of change in a value w.r.t packaging material, storage duration and their interaction. From Table 10, it indicates that effect of drying methods and packaging material on yellowness value was significant at $p \leq 0.01$. Similarly, the effect of storage duration on yellowness value was significant at $p \leq 0.01$. The interaction effect of both drying methods, packaging material and storage duration has significant effect on the yellowness value at $p \leq 0.01$. This increase in colour b was observed by (Hande *et al*. 2014) for dried kokum rind which was stored for 9 months.

Yeast and Mould Count

The effect of packaging treatments (polythene pouches and aluminium pouches) and storage duration on microbial characteristics of dried beetroot slices, 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 of 90 days for both the packaging material i.e. polythene pouches and aluminium pouches. It was seen from Table 11 shows the ANOVA for the effect of packaging treatments and storage duration on yeast and mould count of dried beetroot slices.

No yeast and mould growth was observed during storing of dried of banana powder for 4 months and

Table 10: f- test for colour-b value of dried beetroot slices packed in different packaging materials

Treatment	Storage duration (days)								Retention %
	0 days	15 days	30 days	45 days	60 days	75 days	90 days	Average	
T_1P_1	7.19±0.045	6.89±0.045	6.97±0.076	7.06±0.025	7.26±0.045	7.53±0.128	7.60±0.167	7.21	94.69065
T_1P_2	7.19±0.015	7.26±0.045	7.28±0	7.53±0.128	9.43±0.026	12.57±0.613	13.27±0.045	9.22	54.20749
T_2P_1	9.76±0.062	9.82±0.045	10.16±0.0335	10.48±0.043	11.91±0.011	12.03±0.068	12.15±0.030	10.90	80.30719
T_2P_2	9.76±0.01	6.51±0.025	7.05±0.035	8.60±0.058	9.30±0.196	12.81±0.280	13.80±0.076	9.69	70.74173
Mean	8.48	7.62	7.87	8.42	9.48	11.24	11.70	9.26	
	SE				**CD 1%**				
T	0.0319				0.122				
S	0.0422				0.1614				
T×S	0.084417				0.318337				

dried bael powder which was stored up to 6 months by the scientist Sahoo *et al*. 2015 and Sagar and Kumar., 2015 respectively.

Table 11: Effect of packaging material and storage duration of beetroot slices 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

Sensory analysis

The data obtained for sensory properties viz. colour, flavour, texture, and taste of dried dehydrated beetroot slices stored for 0, 15, 30, 45, 60, 75 and 90 days as per the nine point hedonic scale determined by trained panel for two packaging treatment polythene pouches and aluminum pouches are given in Table 12. Sensory analysis was conducted at 15 days interval.

The average scores for dehydrated beetroot slices stored in polythene pouches and aluminum pouches for 0, 15, 30, 45, 60, 75 and 90 days was obtained as shown in Table 12. The highest average sensory score was obtained for treatment T_2P_2 (dried by microwave convection drying and packed in aluminium pouches). The sensory score for colour was 7.68 point, 7.16 point for the flavour, 7.14 point for the texture and 7.21 point for the taste with average score was 7.39 which was highest than the other. From table 12. It can be seen that the overall acceptability of product was 7.39 for the T_2P_2 (beetroot slices dried by microwave drying and packed in the aluminium coated bags).

Table 12: Sensory score of dried beetroot slices packed in polythene and aluminium pouches

Parameter	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	7.60±0.080	7.50±0.1	7.11±0.045	7.50±0.1	7.17±0.577	7.10±0.1	6.90±0.1	7.268
	T_1P_2	8.21±0.040	7.57±0.107	8.04±0.155	7.16±0.062	7.01±0.045	6.97±0.05	6.53±0.199	7.355
	T_2P_1	7.77±0.763	7.37±0.251	7.08±0.058	7.49±0.032	7.16±0.04	6.77±0.416	6.40±0.3	7.148
	T_2P_2	8.12±0.049	8.02±0.208	7.30±0.151	7.43±0.040	7.75±0.110	7.87±0.115	7.33±0.152	7.688
	Mean	7.925	7.615	7.3825	7.395	7.2725	7.1775	6.79	7.365
		Treatment		Storage			Interaction (T × S)		
	SE	0.197919		0.261822			0.523644		
	CD $_{\text{at 1\%}}$	0.756977		1.001386			1.974671		
Parameter	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	7.37±0.057	7.47±0.057	6.74±0.055	7.12±0.102	6.80±0	7.10±0.2	6.73±0.208	7.047
	T_1P_2	8.03±0.037	7.77±0.030	6.80±0.1	7.13±0.152	7.37±0.251	7.20±0.458	6.80±0.1	7.310
	T_2P_1	7.63±0.125	7.43±0.056	7.03±0.115	7.37±0.251	7.03±0.280	6.80±0.1	6.53±0.112	7.117
	T_2P_2	7.37±0.1	7.47±0.057	6.74±0.264	7.12±0.041	6.80±0.212	7.10±0.07	6.73±0.101	7.047
	Mean	7.7075	7.56	7.0425	7.1975	6.97	6.99	6.705	7.167
		Treatment		Storage			Interaction (T × S)		
	SE	0.035489		0.046947			0.093895		
	CD $_{\text{at 1\%}}$	0.135734		0.179559			0.35408		

Parameter	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	7.45±0.045	6.75±0.050	6.55±0.050	7.12±0.028	7.20±0.050	7.35±0.050	6.93±0.152	7.050
	T_1p_2	7.70±0.050	7.57±0.041	7.45±0.055	7.67±0.030	6.38±0.026	6.24±0.040	6.43±0.052	7.062
	T_2P_1	7.09±0.073	7.03±0.075	7.17±0.041	7.88±0.025	6.88±0.025	6.62±0.051	6.67±0.037	7.048
	T_2p_2	7.55±0.011	7.25±0.051	7.15±0.373	7.79±0.051	7.30±0.030	7.50±0.313	7.43±0.047	7.424
	Mean	7.4475	7.15	7.08	7.615	6.94	6.9275	6.865	7.146
		Treatment		Storage			Interaction (T × S)		
	SE	0.03588		0.047464			0.094929		
	CD $_{\text{at 1\%}}$	0.137229		0.181537			0.357979		
Parameter	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	7.72±0.041	7.36±0.047	7.07±0.055	7.13±0.041	6.94±0.064	7.25±0.045	6.93±0.173	7.200
	T_1p_2	7.79±0.130	7.40±0.073	7.24±0.047	7.17±0.026	6.87±0.030	6.81±0.045	6.59±0.305	7.124
	T_2P_1	7.59±0.126	7.37±0.049	7.15±0.06	7.73±0.058	6.92±0.075	6.49±0.206	6.43±0.105	7.097
	T_2p_2	7.90±0.280	7.58±0.364	7.26±0.225	7.28±0.404	7.17±0.166	7.56±0.191	7.24±0.126	7.427
	Mean	7.75	7.4275	7.18	7.3275	6.975	7.0275	6.7975	7.212
		Treatment		Storage			Interaction (T × S)		
	SE	0.023785		0.031464			0.062928		
	CD $_{\text{at 1\%}}$	0.090968		0.12034			0.237302		
Parameter	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	7.54	7.27	6.87	7.22	7.03	7.20	6.87	7.141
	T_1p_2	7.93	7.58	7.38	7.28	6.91	6.81	6.59	7.210
	T_2P_1	7.52	7.30	7.11	7.62	7.00	6.67	6.51	7.102
	T_2p_2	7.735	7.58	7.112	7.405	7.255	7.5075	7.182	7.396
	Mean	7.680	7.431	7.117	7.380	7.0468	7.0456	6.787	7.212

CONCLUSION

1. During the storage period from the 0^{th} to the 3^{th} month, acidity, lightness (*L*) and redness (*a*) were found to decrease.
2. During the 3-month storage, TSS and b value increased.
3. Packaging and storage period did not affect pH and reducing sugar significantly ($p \leq 0.01$).
4. During the 3-month storage, lightness (L) and redness (a) decreased while yellowness (b) increased in the beetroot slices packed in the aluminium coated bags and polythene bags.
5. Beetroot slices can be dried by tray and microwave convection method while dried beetroot slices 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.

REFERENCES

APEDA. 2014. Fresh fruits and vegetables.. http://www.apeda.gov.in/ apeda website/six_ head product/ FFV.htm. Access on [2017-07-21].

Aro, A., Amaral, E., Kesteloot, H., Rimestad, A., Thamn, M. 1998. Trans fatty acid in French fries, soups and snacks from 14 European countries: The TRANSFAIR study. *Journal of Food Composition and Analysis,* **11**: 170-177.

CE Plastics Inc. Characteristics & Benefits of Polypropylene. 2012. http://www.ceplastics.com/_papers/Polyprop_Rev 2008_ver2.pdf. Access on [2017-06-18].

Daramola, O.A., Idowu, M.A., Atanda, O.O. and Oguntona, C.R.B. 2010. Effrcts of packaging material on the quality of pupuru flour during storage. *African Journal of Food Science,* **4**(5): 258-263.

Ibrahim, D. 2004a. Convective air drying characteristics of thin layer carrots. *Journal of Food Engineering,* **61**: 359–364.

Jain, S., Georgive, V. and Sharma, P.K. 2011. Anti-inflammatory activity of aqueous extract of (*Beeta vulgaris L*), *Journal of Basic and Clinical Pharmacy,* **2**: 83-86.

Jastrebova, J., Witthoft, C., Grahn, A., Svensson, U. and Jagerstad, M. 2003. HPLC determination of folates in raw and processed beetroots, *Food Chemistry,* **80**: 579–588.

Kahkonen, M.P., Hopia, A.I., Vuorela, H.J., Rauha, J.P., Pihlaja, K., Kujala, T.S. and Heinonen, M. 1999. Antioxidant activity of plant extracts containing phenolic compounds. *Journal Agricultural and Food Chemistry,* **47**: 3954–3962.

Kaminski, W., Tomczak, E. and Skorupska, E. 2014. Estimation of the effect of shape and temperature on drying kinetics using M.L.P. *Drying Technology,* **22**(1&2): 191-200.

Kapadia, G.J., Tokuda, H., Konoshima, T. and Nishino, H. 1996. Chemoprevention of lung and skin cancer by (*Beta vulgaris*) beetroot extract, *Cancer Letters,* **100**: 211–214.

Kaur, K. and Singh, A.K. 2014. Drying kinetics and quality characteristics of beetroot slices under hot air followed by microwave finish drying. *Af. J. Agril. Res.*, **9**(12): 1036-1044.

Krejecova, A., Cernohorsky, T. and Meixter, D. 2007. Element analysis of instant souos and seasoning mixture by IPC-OES, *Food Chemistry,* **105**: 242 247.

Kujala, T.S., Loponen, J.M., Klika, K.D. and Pihlaja, K. 2000. Phenolics and betacyanins in red beetroot (*Beta vulgaris*): Distribution and effect of cold storage on the content of total phenolics and three individual compounds. *Journal of Agricultural and Food Chemistry*, **48**(1): 5338-5342.

Kulkarni, S.G, Vijayanand, P. and Shubha, L. 2010. Effect of processing of dates into date juice concentrate and appraisal of its quality characteristics. *J. Food Sci. Technol.*, **47**(2): 157–161.

Kumar, S.P. and Sagar, V.R. 2015. Effect of packaging materials and storage temperature on quality of osmo-vac dehydrated guava slices during storage. *Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci.*

Mahmutoglu, T., Ferhunde, E. and Birol, S.Y. 1996. Sun/solar drying of differently lkeated grapes and storage stability of dried grapes. *Journal of Food Engineering,* **29**: 289–300.

Maskan, A., Kaya, S. and Maskan, M. 2002. Hot air and sun drying of grape leather (pestil). *J. Food Engi.,* **54**: 81–88.

Ninfali, P. and Angelina, D. 2013. Nutritional and Functional Potential of Beetroot (*Beta vulgaris L*) *cida* and *rubra*, fitoterapia, **89**(1): 188-199.

Pareek, S. and Kaushik, R.A. 2012. Effect of drying methods on quality of Indian gooseberry powder during storage. *Journal of Scientific and Industrial Research,* **71**: 727–7.

Patkai, G., Barta, J. and Varsanyi, I. 1997. Decomposition of anticarcinogen factors of the beetroot during juice and nectar production, *Cancer Letters,* **114**: 105–106.

Pavithra, J.P.A. 2008. Study on Packaging and Value Addition in Traditional and Modern Consumer Retail Units: An 126 August, 2014. Int. J. Agric. & Biol. Eng. Open Access at http://www.ijabe.org Vol. 7 No.4 Economic Analysis. MBA Thesis, University of Agricultural Sciences, Dharwad.

Profir, A.G. and Vizireanu, C. 2013. Evolution of antioxidant capacity of blend juice made from beetroot, carrot and celery during refrigerated storage, *AUDJG-Food Technology,* **37**(2): 93-99.

Ranganna, S. 1986. Handbook of Analysis and Quality Control for Fruits and Vegetables products, Tata McGraw-Hill Publishing Company Limited, New Delhi.

Ranganna, S. 1978. Manual of analysis of fruit and vegetable products. Tata McGraw- Hill Publisher, New Delhi.

Rizzolo, A., Vanoli, M., Cortellino, G., Spinelli, L. and Torricelli, A. 2011. Quality characteristics of air-dried apple rings: influence of storage time and fruit maturity measured by time-resolved reflectance spectroscopy. *Procedia Food Science,* **1**: 216–223.

Sagar, V.R. and Kumar, R. 2014. Effect of drying treatments and storage stability on quality characteristics of bael powder. *Journal of Food Science Technol.*, **51**(9): 2162–2168.

Sahoo, A.K., Sonkamble, A.M., Patil, S.R., Bhoyar, R.K. and Papade, J.N. 2015. Effect of drying methods on consumer acceptability of banana powder. *Asian Journal of Dairy and Food Research*, **34**(1): 63-66.

Sharma, K.D., Alkesh and Kaushal, B.L. 2003. Quality of apple powder as affected by packaging material during storage. *Journal of Scientific and Industrial Research,* **62**: 609-615.

Sharma, N., Tanwer, B.S. and Vijayvergia, R. 2011. Study of medicinal plant for Aravali region of Rajasthan for treatment of kidney stone and urinary tract troubles. *International Journal of Pharmacy Technology Research,* **3**(1): 110-113.

Singh, S., Gaikwad, K., Omre, P.K. and Kumbhar, B.K. 2013. Microwave convection drying characteristics of beet root (*Beta vulgaris L.*) using modeling equations for drying. *Journal of Food Process Technology*, **4**: 9.

Swami, S.B., Thakor, N.J., Orpe, S. and Kalse, S.B. 2016. Development of ripe jackfruit bulb powder and its quality evaluation. *J. Food Research and Technol.*, **4**(1): 22-29.

USDA Nutrition facts [Includes USDA commodity foods A099], per 100g, USDA Nutrition Database for Standard (10.12.2014) reference version SR-21.

Vali, L., Tefanovits-Bayani, E and Szentmihalyani, K. 2007. Lives protecting effects of table beet (*Beta vulgaris var. Rubra*) during is chemia-reperfusion, *Nutrition*, **23**(2): 172-178.

Vinson, J.A., Hao, Y., Su, X. and Zubik, L. 1998. Phenol antioxidant quantity and quality in foods and vegetables. *Journal of Agricultural and Food Chemistry*, **46**: 3630-3634.