Effect of drying methods and packaging materials on quality parameters of stored kokum rind

A. R. Hande, Shrikant Baslingappa Swami*, N. J. Thakor

(*Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr.Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli 415 712, India*)

Abstract: In this study kokum rind dried by different methods, i.e. open air sun drying, solar drying and the convective hot air drying (60°C) was taken after being packaged in gunny bags, nylon bags and plastic jars for storage study upto nine months. The effect of different drying methods on quality parameters i.e. acidity, pH, TSS, reducing sugar, non-reducing sugar, colour (L, a and b) and calorific value of the stored product were evaluated. The quality parameters were tested at three-month intervals. Among three packaging materials, plastic jar was found best for kokum rind storage upto nine months as compared with nylon and gunny bags. Deterioration occurred as changes in acidity, non-reducing sugar, lightness, redness and calorific value over the storage period from the 0^{th} to the 9^{th} month. However, the TSS and b value increased as storage duration extended.

Keywords: kokum rind, storage, drying methods, packaging materials, quality evaluation

DOI: 10.3965/j.ijabe.20140704.013

Citation: Hande A R, Swami S B, Thakor N J. Effect of drying methods and packaging materials on quality parameters of stored kokum rind. Int J Agric & Biol Eng, 2014; 7(4): 114－126.

1 Introduction

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[1]. 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[2]. 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[3] 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[4].

Gunny sacks are traditionally used for transporting grains, potatoes, and other agricultural products. They are usually made from jute or other natural fibers, although modern sacks are often made from

Received date: 2014-06-26 **Accepted date:** 2014-08-03

Biographies: A. R. Hande, M.Tech student, research interests: food process engineering. Email: amarja.hande@gmail.com. **N. J. Thakor**, Ph.D, Professor and Head, research interests: food process engineering. Email: nayan07@gmail.com.

∗ **Corresponding author: Shrikant Baslingappa Swami,** PhD, Associate Professor, research interests: food process engineering, drying, storage. Mailing Address: Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr.Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Pin 415 712, Dist Ratnagiri, India. Tel: +91-2358-280414; Fax:+91-2358-282414. Email: swami_shrikant1975@yahoo.co.in.

polypropylene. Because gunny sacks are/were (traditionally) made from natural fibers which considered environment friendly, they are non-carcinogenic and non-toxic. High breathability allows air to pass through them, which helps packaged grains or other agricultural commodities stay fresh. Sacks made from jute, hemp and kenaf fiber have high tensile strength[5]. Polypropylene is resistant to a wide variety of acids, alkalis and solvent solutions with a temperature range upto 200 ℉[6]. PET bottles are convenient for consumers because they are light and very robust. The light weight reduces the energy consumption associated with logistics and transport considerably[7].

Kokum (*Garcinia Indica choisy*) is an important spice tree originated from tropical rain forest of the western ghat of Kerala and Malasia[8]. Kokum has been traditionally used as an acidulant. It is also used to make an alternative red, pleasant flavoured extract for use as a beverage[9]. Kokum rind are commercially used to prepare concentrated syrup which on appropriate dilution can make ready-to-use cool healthy drinks especially during off season[10]. The dried rind of kokum fruit contains three important constituents viz. anthocyanin pigments, hydroxycitric acid and garcinol[9].

Kokum has a long history of use in the Indian traditional system of medicines, the Ayurveda. Being an indigenous tree and localized to selected geographical pockets of India, some of its phytochemicals like cyaniding-3, glucoside, garcinol and hydroxycitric acid have been reported to have been studied in details. It shows antioxidant, antibacterial, antifungal, anti-clastogenic, gastro-protective, cardio-protective, antineoplastic and chemo-preventive effects. It is also responsible for inhibition of lipid peroxidation, control of carbonyl content, neuro-protection, and anti-obesity[10].

Generally, in the Kokan region at the domestic level, kokum fruit rind is dried by sun drying. The dried kokum rind generally is stored in jute bags for use in off season. In the present study, kokum rind was dried by sun, solar and tray methods. The dried rind was stored in jute bags, nylon bags and plastic jars. The quality of the stored product after 0, 3, 6 and 9 months were also evaluated.

2 Materials and methods

2.1 Quality analysis of kokum rind before and after drying

2.1.1 Moisture content

Kokum rind was dried with sun drying, solar drying and tray drying (at 60^0C and 2 m/s) to final moisture content 11% (wb). The various quality parameters i.e. acidity, pH, reducing sugar, non-reducing sugar, protein, carbohydrates, fat, anthocyanin, colour, etc. of kokum rind before drying and after drying (0 months storage) were determined.

Moisture content: Initial moisture content of the kokum rind was calculated by using hot air oven at (105 ± 1) ^{0}C for 24 h. The moisture content of the kokum rind was determined by the following formula[11].

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

where, W_1 = weight of sample before drying, gram; W_2 = weight of bone dried sample, gram

2.1.2 Acidity

Acidity was calculated by using titration method[13]. One gram of ground dried kokum rind was taken. Distilled water 20 mL was added. Pipette out 1 mL of this sample in conical flask and 100 mL distilled water was added. Two or three drops of phenolphthalein indicator was added to the mixture. The solution was titrated with 0.1 N NaOH. End point was when the mixture turned faint pink.

2.1.3 pH value

pH value was recorded by digital pH meter. (Make: Hanna Instruments, Model: pH 211). The equipment was standardized by 4 and 7 pH standard solutions. The pH value of kokum was determined by adding 15 mL of distilled water to 5 g of ground kokum rind.

2.1.4 Reducing sugar

Reducing sugar was estimated by Fehling's method[13]. The process was carried out in three steps. In first part, 5 g dried ground kokum rind was added with 100 mL distilled water. 2-3 drops of phenolphthalein indicator was added to it. This sample solution was titrated with 1 N NaOH. The end point was feint pink colour. It was filtered after addition of lead acetate and potassium oxalate solution. In second part, Fehling solution A, B and distilled water were taken in proportion 1:1:1 in a conical flask. And in the third part, titration of first part solution against second part solutions was carried out by using methylene blue indicator in boiling condition. Titration was continued until the end point of brick red colour appeared.

2.1.5 Non-reducing sugar

Non-reducing sugar was determined as per the procedure[13]. In this method, part one solution of reducing sugar was used. 50 mL of this solution was neutralized with concentrated 20 N NaOH after overnight keeping with 1:1 HCL. By making 100 mL volume with distilled water, this solution was titrated with part two solutions i.e. first part and second part. In the third part same procedure was followed as discussed in reducing sugar. NRS was calculated from the formula,

$$\text{Tital sugar, \%} = \frac{\text{mg of invert sugar} \times \text{Dilution} \times 100}{\text{Titration} \times \text{Wt. or volume of sample} \times 100} \times 100 \quad (2)$$

And non-reducing sugar was calculated by using equation,

$$\text{Non-reducing Sugar, \%} = \text{Total sugar (\%)} \times 0.95 \quad (3)$$

2.1.6 Protein

The protein content of ground dried kokum rind was determined by Lowry's Method[12] using spectrophotometer (Make: Systronics-UV Visible spectrophotometer; Ahmadabad; Model No: 106). In this method, 1 g dried ground Kokum rind was mixed with 5 mL of alkaline solution which was prepared from 50 mL of Part one (2% sodium carbonate in 0.1 N NaOH) solution and 1 mL of part two (0.5% copper sulphate in 1% sodium potassium tartarate) solution. Mixed solution i.e. part one and part two was rapidly diluted with folin-ciocalteu reagent. After 30 min, sample was loaded in the cuvet of spectrophotometer upto >3/4 of its level. The absorbance was read against standard protein solution at 750 nm. Absorbance is recorded as protein content.

2.1.7 Carbohydrate

Carbohydrate from dried kokum rind was estimated by Anthrone Method[13] in which prepared a series of Glucose solution and distilled water in the ratio (0:1; 0.2:0.8; 0.4:0.6; 0.6:0.4; 0.8:0.2; 1:0) by using spectrophotometer. 1 g ground dried kokum rind was mixed with 5 mL of 2.5 N HCL and then heated for 3 h in water bath. The mixture was allowed to cool for 1.3 h and it is added with sodium carbonate till effervescence stops. It is seen by naked eyes. After filtration anthrone reagent (2 g anthrone powder + 100 mL H_2SO_4) was added in filtered solution. The mixture was heated for 8 min and allowed to cool. The solution was taken in the cuvet of spectrophotometer and absorbance was recorded at 630 nm. A graph was plotted i.e. absorbance versus concentration (glucose stock: distilled water) and concentration of unknown sample was measured by using the following formula

$$\text{Concentration (\%)} = \frac{\text{Absorbance of unknown} \times \text{Concentration of standard}}{\text{Absorbance of standard}} \quad (4)$$

2.1.8 Fat

Fat of dried kokum rind was determined using Soxhlet fat extraction system[14] by using Soxhlet apparatus (Make: Elico, Hyderabad). In this method, initialy weight of empty flask was weighed. Dried ground kokum rind 2 g wrapped in filter paper was siphoned for 9-12 times with the petroleum ether in soxhlet apparatus. After removing assembly, evaporation of petroleum ether was allowed by heating. Residue remained at the bottom of the flask and was reweighed with flask. The quantity of residue is determined as fat content of dried Kokum rind powder.

2.1.9 Anthocyanine

Anthocyanin was determined by spectrophotometric method[13]. In this method, Anthocyanine was extracted with ethanolic HCL (85:15). Ground dried kokum rind 1 g mixed with 10 mL of ethanolic HCL and was kept overnight in refrigerator at 4^0C. Mixture was filtered the next day after making volume with ethanolic HCL. Absorbance of this filtered solution was recorded at 535 nm against blank solution. The absorbance was reported as anthocyanin content of dried kokum rind.

2.1.10 Colour

The dried grounded kokum rind was used to measure the colour value by using colour flex meter (Hunter associates Laboratory, USA). The equipment was calibrated against standard white tile and black tile. Around 20 g dried kokum rind powder was taken in the glass cup. The cup was placed on the aperture of the instrument. Colour was recorded in terms of L= lightness (100) to darkness (0); a = redness (+60) to greeness (-60); b= yellowness (+60) to blueness (-60).

2.1.11 Calorific value

The digital bomb calorimeter (Make: Parr Instrument Company, USA; Model: 6110) was used for determination of calorific value. Ground kokum rind 1 g was taken for the measurement of calorific value. The equipment gave the direct digital reading on calorific value (cal/g).

2.2 Packaging and storage study of dried kokum rind

Dried kokum rind by sun drying, solar drying and tray drying was packaged in jute bag (size: 27cm×20 cm), nylon bags (size: 27 cm× 20 cm) and plastic jars (size: 16cm×18cm×0.17cm) of 500 g capacity. Figure 1 shows the different packaging materials used for packaging of dried kokum rind. The bags were sealed and the lid of the plastic jar was closed and kept at ambient condition for its storage. The observation of acidity, pH, reducing sugar, non-reducing sugar, TSS, colour and calorific value of the stored product were determined as per procedure explained in the earlier section after 0, 3, 6, 9 months of storage. Table 1 shows the treatment combinations of drying methods and packaging materials.

a. Jute Bag

b. Nylon Bag

c. Plastic Jar

Figure 1 Different packaging materials used for packaging dried kokum rind

Table 1 Treatment combinations of kokum rind

Sr. No.	Drying methods	Packaging materials	Combinations
1	Sun drying (T_1)	Gunny Bags(P_1)	T_1P_1
2	Solar drying(T_2)	Gunny Bags(P_1)	T_2P_1
3	Tray drying(T_3)	Gunny Bags(P_1))	T_3P_1
4	Sun drying (T_1)	Nylon bags(P_2)	T_1P_2
5	Solar drying(T_2)	Nylon bags(P_2)	T_2P_2
6	Tray drying(T_3)	Nylon bags(P_2)	T_3P_2
7	Sun drying (T_1)	Plastic boxes(P_3)	T_1P_3
8	Solar drying(T_2)	Plastic boxes(P_3)	T_2P_3
9	Tray drying(T_3)	Plastic boxes(P_3)	T_3P_3

2.3 Statistical Analysis

The acidity, pH value, TSS, RS, NRS, protein, carbohydrates, fat, ash, anthocyanin, colour, calorific value were analyzed statistically for 0, 3, 6, 9 months of storage by using SYSTAT 8.0 software.

3 Results and discussion

3.1 Quality evaluation for dried kokum rind

The effect of drying methods on quality parameters including moisture, acidity, pH value, reducing sugar, non-reducing sugar, protein, carbohydrates, fat, ash, anthocyanin, colour, and calorific value of dried kokum rind at the 0^{th} month is given in Table 2. Table 3 shows ANOVA of the quality parameters of kokum rind dried by all drying methods.

3.1.1 Acidity

From Table 2 it can be observed that the acidity of kokum rind increased from 0.85±0.19% to 4.363±0.098%, 4.066±0.40%, and 3.187±0.16% in sun, solar, and tray drying, respectively. Highest acidity was found in sun dried kokum rind followed by solar and tray dried. From the ANOVA Table 3 (a) it can be seen that increase in acidity was significant at $p\leq0.01$. The increase in acidity of kokum rind after drying might be attributed to concentration of constituents such as water solubles, which are present in rind. Similar result has been observed during drying of grapes by [15].

3.1.2 pH value

The pH value of kokum rind was 2.54±0.24 before drying. After drying it was 2.500±0.272, 1.801±0.41, and 2.079±0.21 in sun, solar and tray dried kokum rind. Lowest pH value was observed in solar dried kokum rind and highest was in sun dried kokum rind. Table 3 (b) shows that there is non-significant ($p\leq0.01$) variation in pH value in kokum rind dried by all three methods.

Table 2 Chemical composition of kokum rind before and after drying.

Sr. No.	Chemical Constituents	Fresh kokum rind	After drying		
			Sun drying	Solar drying	Tray drying
1	Moisture, % wb	85.32±0.19	11.49±0.93	11.17±2.06	10.55±0.479
2	Acidity, %	0.85±0.19	4.363±0.098*	4.066±0.40*	3.187±0.16*
3	pH	2.54±0.24	2.500±0.272**	1.801±0.41**	2.079±0.21**
4	Reducing sugar, %	1.32±0.005	3.744±0.602**	3.491±0.48**	5.884±1.22**
5	Non-reducing sugar, %	3.76±0.005	3.596±0.227*	4.819±0.11*	5.687±0.34*
6	Protein, %	1.75±0.005	4.700±0.436*	5.067±0.55*	4.833±0.41*
7	Fat, %	9.53±0.33	9.193±0.161*	9.383±0.35*	9.283±0.09*
8	Carbohydrates, %	3.52±0.07	28.000±1.732*	29.867±1.27*	31.133±0.35*
9	Ash, %	1.25±0.21	4.500*	4.633±0.15*	5.130±0.04*
11	Anthocyanin, %	2.79±0.08	1.261±0.003*	2.5±0.002*	1.321±0.02*
12	Color L	19.17±0.12	20.997±0.77**	19.525±0.57**	17.077±0.20*
	a	4.25±0.12	11.941±2.56*	15.896±0.45*	12.237±0.05*
	b	3.3±0.16	1.544±0.108*	1.131±0.19*	0.781±0.20*
13	Calorific value, cal/g	2626.81±103.57	5115.41±299.42*	4874.08±483.287*	5040.19±430.423*

Note: * = significant at $p\leq0.01$; ** = non-significant at $p\leq0.01$.

Table 3 ANOVA for kokum rind dried by sun, solar and tray drying method.

Sr. No.	Chemical Constituents	Drying Methods	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
(a)	Acidity, %	Sun	18.55042	1	18.55042	790.5007	9.52E-06	21.19769
		Solar	15.52042	1	15.52042	154.0998	0.000242	21.19769
		Tray	8.190017	1	8.190017	249.1891	9.41E-05	21.19769
(b)	pH	Sun	0.0024	1	0.0024	0.036502	0.857788	21.19769
		Solar	0.814017	1	0.814017	6.974297	0.057527	21.19769
		Tray	0.3174	1	0.3174	6.193171	0.067585	21.19769
(c)	Reducing Sugar, %	Sun	0.0006	1	0.0006	0.003328	0.956763	21.19769
		Solar	0.112067	1	0.112067	0.949986	0.384913	21.19769
		Tray	6.7416	1	6.7416	9.039017	0.039687	21.19769
(d)	Non-reducing Sugar, %	Sun	7.548817	1	7.548817	285.0403	7.22E-05	21.19769
		Solar	18.06135	1	18.06135	2944.785	6.9E-07	21.19769
		Tray	28.16667	1	28.16667	491.2791	2.45E-05	21.19769
(e)	Protein, %	Sun	9.126667	1	9.126667	94.41379	0.000628	21.19769
		Solar	12.04167	1	12.04167	136.3208	0.000308	21.19769
		Tray	10.14	1	10.14	66.13043	0.001244	21.19769
(f)	Fat, %	Sun	48.28007	1	48.28007	3111.497	6.18E-07	21.19769
		Solar	51.56802	1	51.56802	798.0606	9.34E-06	21.19769
		Tray	49.82402	1	49.82402	7530.078	1.06E-07	21.19769
(g)	Carbohydrates, %	Sun	1073.344	1	1073.344	704.4094	1.2E-05	21.19769
		Solar	1228.37	1	1228.37	1470.369	2.76E-06	21.19769
		Tray	1339.52	1	1339.52	15682.19	2.44E-08	21.19769
(h)	Ash, %	Sun	15.20042	1	15.20042	912025	7.21E-12	21.19769
		Solar	16.50042	1	16.50042	1412.304	2.99E-06	21.19769
		Tray	21.81227	1	21.81227	20449	1.43E-08	21.19769
(i)	Anthocyanin, %	Sun	3.51135	1	3.51135	924.0395	6.98E-06	21.19769
		Solar	0.12615	1	0.12615	33.19737	0.004502	21.19769
		Tray	3.24135	1	3.24135	820.5949	8.84E-06	21.19769
(j)	Colour - L	Sun	4.992896	1	4.992896	15.99338	0.016141	21.19769
		Solar	0.186091	1	0.186091	1.05769	0.361864	21.19769
		Tray	6.58703	1	6.58703	222.104	0.000118	21.19769
(k)	Colour - a	Sun	88.72979	1	88.72979	26.95732	0.006552	21.19769
		Solar	203.4673	1	203.4673	1862.59	1.72E-06	21.19769
		Tray	95.70689	1	95.70689	9979.093	6.02E-08	21.19769
(l)	Colour - b	Sun	4.622963	1	4.622963	240.0615	0.000101	21.19769
		Solar	7.056119	1	7.056119	213.5222	0.000128	21.19769
		Tray	9.517202	1	9.517202	277.8144	7.59E-05	21.19769
(m)	Calorific value, cal/g	Sun	9289670	1	9289670	185.082	0.000169	21.19769
		Solar	7575289	1	7575289	62.01781	0.001405	21.19769
		Tray	8736605	1	8736605	89.15308	0.000702	21.19769

3.1.3 Reducing sugar

The reducing sugar increased from 1.32±0.005% to 5.884±1.22% in tray dried kokum rind. Highest and lowest reducing sugar was found in tray and solar dried kokum rind with 5.884±1.22 and 3.491±0.48%. From Table 3 (c) it can be seen that the increase in reducing sugar was non-significant at $p\leq0.01$. This increase in reducing sugar might be attributed to concentration of fruit flavors and calories during drying. Similar behavior has been reported by[2] during drying of grape leather (Pestil).

3.1.4 Non-reducing sugar

The non-reducing sugar in sun dried kokum rind was 3.596±0.227% which was lower than in fresh kokum rind with 3.76±0.005%. Highest non-reducing sugar was observed in tray dried kokum rind followed by solar dried i.e. 5.687±0.34 and 4.819±0.11, respectively. This decrease in non-reducing sugar was significant at $p\leq0.01$ as shown in Table 3 (d).

3.1.5 Protein

The protein content of fresh kokum rind had been 1.75±0.005% and it increased up to 5.067±0.55% in solar dried kokum rind which was higher than the sun and tray dried kokum rind. Sun and tray dried kokum rind contains 4.700±0.436 and 4.833±0.41% protein in it. After drying the protein content of kokum rind increased significantly at $p\leq0.01$ which can be seen from Table 3 (e).

3.1.6 Fat

The fat content of fresh kokum rind was 9.53±0.33% and it was observed to be decreased in dried kokum rind. Fat percentage in kokum rind dried by sun, solar and tray drying methods was 9.193±0.161, 9.383±0.35 and 9.283±0.09% respectively. The Table 3 (f) shows that decrease of fat content was significant at $p\leq0.01$.

3.1.7 Carbohydrates

The carbohydrate of fresh kokum rind was 3.52± 0.07% and it increased upto 31.133±0.35% in tray dried kokum rind which was highest. The carbohydrates in sun and solar dried kokum rind was 3.52 ± 0.07 and 28.000±1.732%, respectively. The Table 3 (g) shows that increase in carbohydrate were significant at $p\leq0.01$.

3.1.8 Ash

The ash content of fresh kokum rind was 1.25±0.21%. After drying, highest percentage of ash content was found in tray dried kokum rind with 5.130±0.04% followed by solar and sun dried kokum rind with 4.633±0.15 and 4.500±0.000, respectively. This increase in ash content might be attributed to lost moisture during drying. Table 3 (h) shows that the increase of ash content was significant at $p\leq0.01$.

3.1.9 Anthocyanins

The anthocyanin (%) content of fresh kokum rind was 2.79±0.08%. [13] reported the presence of Anthocyanin B_1 and Anthocyanin B_2 in kokum rind. The Anthocyanin content of dried kokum rind was decreased in dried kokum rind. Lowest anthocyanin was observed in sun dried kokum rind 1.261±0.003% while highest was in solar dried kokum rind with 2.5±0.002%. Tray dried kokum rind contained 1.321±0.02% of anthocyanin in it. This decrease in anthocyanin after drying might be attributed to factors such as heat, light, presence or absence of O_2, and metals and other chemicals that affect the stability of red pigment[16]. Table 3 (i) shows the ANOVA for anthocyanin content of kokum rind dried by sun, solar and tray drying methods. This anthocyanin content shows significant change due to drying at $p\leq0.01$.

3.1.10 L and a value

The L lightness value of kokum rind was 19.17±0.12 before drying. It was observed in increasing order in sun and solar dried kokum rind with 20.997±0.77 and 19.525±0.57 which was non-significant at $p\leq0.01$ respectively. While in tray dried kokum rind it decreased with the value of 17.077±0.20. This variation in lightness was significant at $p\leq0.01$ as shown in Table 3 (j). The redness value before drying for kokum rind was 4.25±0.12 and after drying it increased with 11.941± 02.56, 12.237±0.05 and 15.896±0.45 in sun, tray and solar dried kokum rind respectively. This increase in redness was significant at $p\leq0.01$ (Table 3 (k)). This variation in color is due to pigment degradation because of long drying duration. Similar results were observed by[17] for ciku. Yellowness was also found in decreasing order from 1.544±0.108, 1.131±0.19 and 0.781±0.20 in sun, solar and tray dried kokum rind respectively. The b value of fresh kokum rind was 3.3±0.16. Yellowness of dried kokum rind was significant at $p \leq 0.01$ as shown in Table 3 (l).

3.1.11 Calorific value

Calorific value was recorded as (2626.81±103.57) cal/g in fresh kokum rind. Highest calorific value was found in sun dried kokum rind with (5115.41±299.42) followed by tray and solar dried kokum rind with (5040.19±430.42) and (4874.08±483.287) cal/g, respectively. All calorific values were significantly different at $p \leq 0.01$ as shown in Table 3 (m). This increase in calorific value might be attributed to concentration of fruit flavors and calories during drying. Similar behavior was observed by [2] during drying of grape leather (Pestil).

3.2 Storage study of dried kokum rind in different packaging materials

3.2.1 Acidity

Figure 2 shows the effects of storage duration and packaging material on acidity of dried kokum rind by different methods. In all treatments, the highest acidity percentage was observed at 0^{th} month. As storage period increased acidity decreased in dried kokum rind.

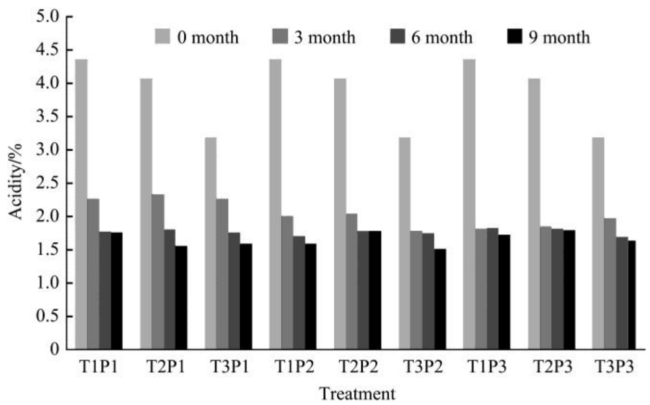

Figure 2 Effects of storage duration on acidity of kokum rind packaged in different packaging materials

In the juke bag-packaged kokum rind, acidity decreased from 4.363-1.764, 4.066-1.557 and 3.187-1.586 in sun, solar and tray dried kokum rind, respectively. In the jute bag-packaged kokum rind, highest retention of acidity was observed in tray dried sample with 49.76% followed by sun and solar drying methods with 40.42% and 38.31%, respectively. This tray dried kokum rind was non-significant at $p \leq 0.01$.

For kokum rind packaged in nylon bag, the acidity was observed to decrease from the 0^{th} to the 9^{th} month with 4.363%-1.593%, 4.066%-1.773% and 3.187%-1.508% in sun, solar and tray dried kokum rind, respectively. The highest retention of acidity in the kokum rind packaged in the nylon bag was observed for tray dried sample with 47.31% followed by solar and sun dried sample with 43.73% and 36.51%, respectively. This acidity decrease was non-significant at $p \leq 0.01$.

Acidity decreased from the 0^{th} to the 9^{th} month in the kokum rind packaged in plastic jar with 4.363%-1.721%, 4.066%-1.792% and 3.187%-1.636% in the sun, solar and tray dried kokum rind, respectively. The highest retention was observed in tray dried kokum rind with plastic packaging material (51.32%) in all treatments. This highest retention of acidity was observed in tray dried kokum rind. The acidity was significant at $p \leq 0.01$ as shown in Table 4.

Table 4 t–test for determination of effect of storage life on acidity of dried kokum rind packaged in different packaging materials

Treatment	Acidity/%				
	0 month	3 month	6 month	9 month	Retention %
T_1P_1	4.363*	2.261	1.771	1.764*	40.42
T_2P_1	4.066*	2.332	1.799	1.557	38.31
T_3P_1	3.187*	2.261	1.764	1.586	49.76
T_1P_2	4.363*	2.005	1.700	1.593	36.51
T_2P_2	4.066*	2.042	1.778	1.778*	43.73
T_3P_2	3.187*	1.785*	1.749	1.508	47.31
T_1P_3	4.363*	1.820	1.828	1.721	39.44
T_2P_3	4.066*	1.849	1.813	1.792*	44.08
T_3P_3	3.187*	1.977	1.692	1.636*	51.32
SE	0.048	0.045	0.080	0.012	
CD at 1%	0.200	0.187	0.331	0.050	

Note: * = significant at $p \leq 0.01$.

3.2.2 pH value

Figure 3 shows the effect of storage duration and different packaging materials on pH of dried kokum rind by different drying methods i.e. sun, solar and tray drying. There was not any specific trend observed in the pH value of kokum rind during storage.

pH value decrease was observed in sun and tray dried kokum rind packaged in gunny bag from the 0^{th} to the 9^{th} month with pH values of 2.500-1.862 and 2.079-1.893, respectively. While in solar drying it increased from

1.801 to 1.896 during 9-month storage. There was no specific trend followed in the pH value of kokum rind.

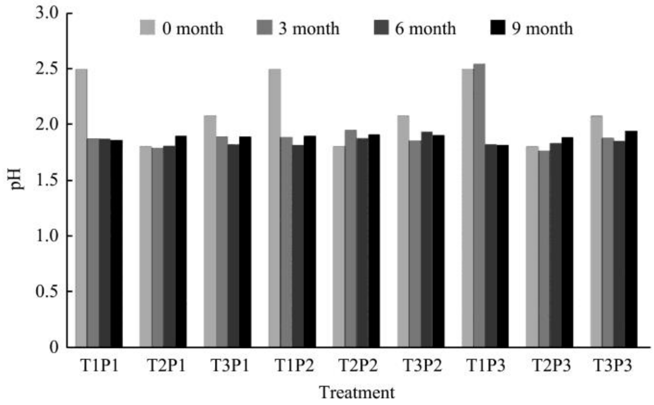

Figure 3 Effects of storage duration on pH value of kokum rind packaged in different packaging materials

The decrease in pH value was observed in kokum rind dried by sun and tray drying method from the 0^{th} to the 9^{th} month with 2.500-1.896 and 2.097-1.904, respectively while in solar dried sample it increased from 1.801% to 1.911% which was non-significant at $p\leq0.01$.

pH value decreased from the 0^{th} to the 9^{th} month in the kokum rind dried by sun and tray method packaged in plastic jar with 2.500%-1.817% and 2.079%-1.942%. In the solar dried kokum rind packaged in the plastic packaging material, pH value increased from 1.801% to 1.888% in the 9-month storage. The pH value of the kokum rind packaged in plastic jar was significant at $p\leq0.01$.

Table 5 t – test for determination of effect of storage life on pH of dried kokum rind packaged in different packaging materials

Treatments	pH value			
	0 month	3 month	6 month	9 month
T_1P_1	2.500*	1.869	1.871*	1.862*
T_2P_1	1.801	1.790	1.810	1.896
T_3P_1	2.079	1.889	1.819	1.893
T_1P_2	2.500*	1.882	1.812*	1.896*
T_2P_2	1.801	1.948	1.877*	1.911
T_3P_2	2.079	1.853	1.934*	1.904
T_1P_3	2.500*	2.540*	1.822	1.817*
T_2P_3	1.801	1.763	1.831	1.888*
T_3P_3	2.079	1.878	1.852*	1.942*
SE	0.099	0.034	0.003	0.003
CD at 1%	0.409	0.139	0.011	0.014

Note: * = significant at $p\leq0.01$.

3.2.3 TSS

Figure 4 shows the effect of storage duration and packaging material on TSS of kokum rind dried with different drying methods. As the storage period increased, TSS also increased in the dried kokum rind. Increase in total soluble solids was also observed by [18] for dried apple ring which was stored for 5 months.

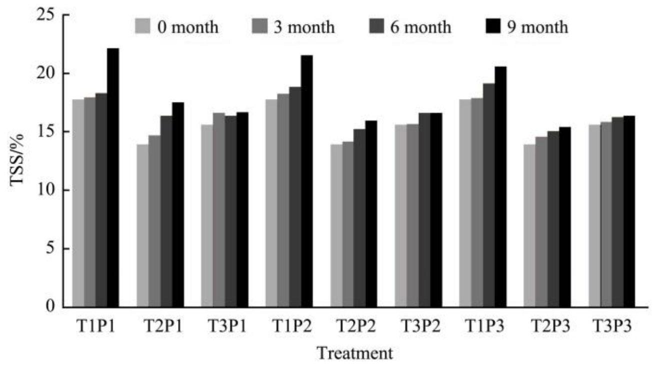

Figure 4 Effect of storage duration on TSS of kokum rind packaged in different packaging materials

In the juke bag-packaged kokum rind, highest retention of TSS was observed in tray dried sample with 93.73% followed by sun and solar drying method with 80.26% and 79.34%, respectively.

Kokum rind packaged in nylon bag was found increase in TSS with the retention of 93.91%, 87.17% and 82.47% in the tray, solar and sun treatments, respectively which was non-significant at $p\leq0.01$ as shown in Table 6.

Highest retention of TSS was observed in Tray dried kokum rind which was packaged in plastic jar with 95.25%. It was observed that the TSS of all samples of tray dried and packaged in plastic jar shows significant differences at $p\leq0.01$. While solar and sun dried kokum rind packaged in plastic jar retained 90.13% and 86.23% TSS in it as shown in Table 6.

Table 6 t–test for determination of effect of storage life on TSS of dried kokum rind packaged in different packaging materials

Treatments	TSS				
	0 month	3 month	6 month	9 month	Retention %
T_1P_1	17.784*	17.977*	18.339*	22.159*	80.26
T_2P_1	13.940*	14.719*	16.391	17.569*	79.34
T_3P_1	15.647*	16.648*	16.392	16.693*	93.73
T_1P_2	17.784*	18.290*	18.841*	21.564*	82.47
T_2P_2	13.940*	14.168*	15.272*	15.992	87.17
T_3P_2	15.647*	15.704*	16.626*	16.662	93.91
T_1P_3	17.784*	17.889*	19.176*	20.623*	86.23
T_2P_3	13.940*	14.622*	15.097*	15.467*	90.13
T_3P_3	15.647*	15.888*	16.268*	16.427*	95.25
SE	0.187	0.229	0.204	0.177	
CD at 1%	0.773	0.947	0.844	0.732	

Note: * = significant at $p\leq0.01$.

3.2.4 Reducing sugar

Figure 5 shows effect of storage duration and packaging materials on reducing sugar (%) of kokum rind dried by sun, solar and tray drying.

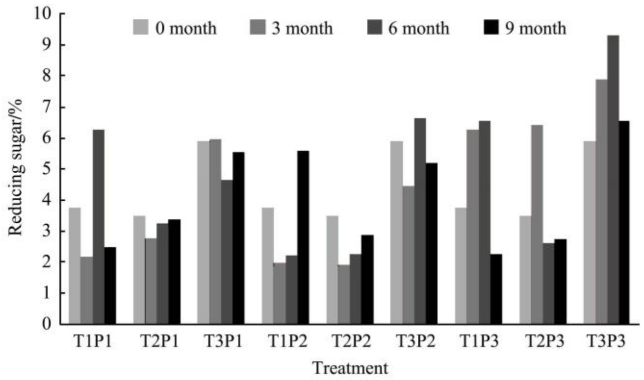

Figure 5 Effect of storage duration on reducing sugar of kokum rind packaged in different packaging materials

The reducing sugar found to be decreased in kokum rind dried by sun and solar drying method and packaged in gunny bag from 3.46 to 2.48 and from 3.53 to 3.37, stored from the 0^{th} to the 9^{th} month, respectively, while in tray dried kokum rind it increased from 5.49% to 5.55%.

The change in the reducing sugar are non-significant at $p\leq0.01$ as shown in Table 7. In nylon packaging material, reducing sugar increased from 0^{th} to 9^{th} month in the sun and tray dried kokum rind, it increased from 3.76% to 5.59% and from 4.81% to 5.19% respectively. In solar dried kokum rind reducing sugar decreased from 3.71% to 2.87%. Reducing sugar was non-significant at $p\leq0.01$ during 9 months of storage.

Table 7 t – test for effect of storage life on reducing sugar of dried kokum rind packaged in different packaging materials

Treatments	Reducing Sugar			
	0 month	3 month	6 month	9 month
T_1P_1	3.744	2.172	6.259*	2.483
T_2P_1	3.491	2.763	3.238*	3.374
T_3P_1	5.884*	5.954	4.641*	5.555
T_1P_2	3.744	1.975	2.220	5.594
T_2P_2	3.491	1.902	2.250	2.874
T_3P_2	5.884*	4.461	6.629*	5.196
T_1P_3	3.744	6.275	6.551*	2.259
T_2P_3	3.491	6.425	2.615*	2.738
T_3P_3	5.884*	7.889	9.315*	6.542
SE	0.219	2.529	0.212	4.053
CD at 1%	0.903	10.447	0.876	16.742

Note: * = significant at $p\leq0.01$.

Reducing sugar in the kokum rind dried by sun and solar method and packaged in plastic jar decrease from 0^{th} to 6^{th} month with 8.09%-2.25% and 3.26%-2.73% while it increase in the tray dried kokum rind. Reducing sugar in the kokum rind was non-significant at $p\leq0.01$ as shown in Table 7.

3.2.5 Non-reducing sugar

Figure 6 shows the effect of storage duration and packaging material of dried kokum rind. As storage duration increased non-reducing sugar (NRS) decreased. Kokum rind packaged in gunny bag reduces NRS in it as storage period increased. Highest retention of NRS was observed in tray dried kokum rind with 89.55% followed by solar and sun drying method i.e. 78.99% and 73.97%, respectively. This decrease in NRS was significantly different at $p\leq0.01$ as shown in Table 8.

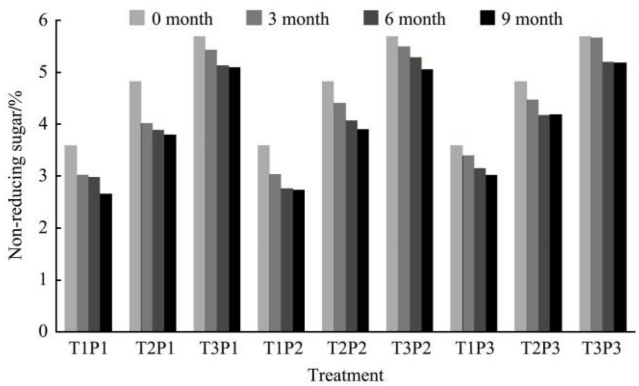

Figure 6 Effect of storage duration on non-reducing sugar of kokum rind packaged in different packaging materials

Table 8 t– test for effect of storage life on non-reducing sugar of dried kokum rind packaged in different packaging materials

Treatments	Non-Reducing Sugar				
	0 month	3 month	6 month	9 month	Retention %
T_1P_1	3.596*	3.020*	2.990*	2.660*	73.97
T_1P_2	4.819*	4.024*	3.899*	3.807*	78.99
T_1P_3	5.687*	5.438*	5.134*	5.092*	89.55
T_2P_1	3.596*	3.041*	2.764*	2.739*	76.17
T_2P_2	4.819*	4.405*	4.073*	3.903*	80.99
T_2P_3	5.687*	5.501*	5.296*	5.064*	89.06
T_3P_1	3.596*	3.403*	3.161*	3.028*	84.21
T_3P_2	4.819*	4.478*	4.175*	4.193*	87
T_3P_3	5.687*	5.667*	5.196*	5.182*	91.13
SE	0.084	0.16	0.1	0.101	
CD at 1%	0.348	0.662	0.414	0.418	

Note: * = significant at $p\leq0.01$.

The highest retention of NRS was observed in the tray dried kokum rind stored in nylon bags with 89.065% followed by solar and sun drying with 80.99% and

76.17%. The effect on non-reducing sugar was significant at $p\leq0.01$.

In the plastic jar highest retention of NRS was observed in tray dried kokum rind stored upto 9 months with plastic jar packaged with 91.13% in all treatments. Solar and sun dried kokum rind with plastic packaging retained 87.00% and 84.21% NRS which was significant at $p\leq0.01$ as shown in Table 8. This decrease in NRS might be attributed to the non-specific hydrolysis of macromolecules, inter-conversion of sugar and aggregation of monomers during storage. Similar results were observed during storage of gooseberry[19].

3.2.6 Colour- L

Figure 7 shows the effect of storage duration and packaging materials on colour-L of dried kokum rind by different methods. In all treatments, highest L value was observed at the 0th month. As storage period increased darkness increased in the dried kokum rind.

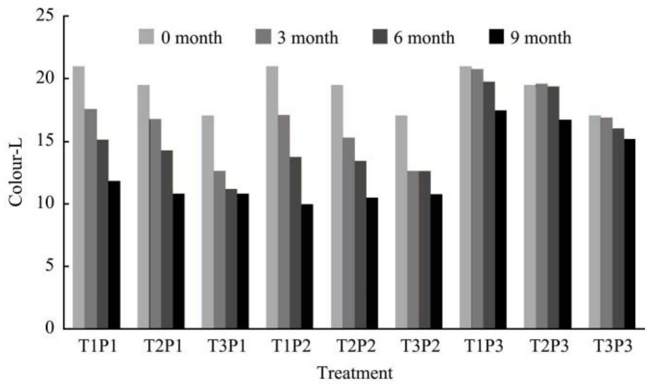

Figure 7 Effect of storage duration on colour value L of kokum rind packaged in different packaging materials

In the gunny packaged kokum rind, lightness decreased from 20.998-11.840, 19.526-10.853 and 17.078-10.824 in sun, solar and tray dried kokum rind stored upto the 9th month, respectively. In the gunny bag-packaged kokum rind, highest retention of L value was observed in tray dried sample with 63.38%, followed by sun and solar drying methods with 56.39% and 55.59%, respectively. The change in the tray dried kokum rind was non-significant at $p\leq0.01$.

Kokum rind packaged in nylon bag, the lightness decrease was observed from 0th to 9th month with 20.998%-9.976%, 19.526%-10.491% and 17.078%-10.776% in sun, solar and tray dried kokum rind, respectively. Highest retention of L value in the kokum rind packaged in nylon bag was observed for tray dried sample with 63.10% followed by solar and sun dried sample with 53.73% and 47.51%, respectively. This lightness decrease was non-significant at $p\leq0.01$.

Lightness decreased from the 0th to the 9th month in the kokum rind packaged in plastic jar with 20.998%-17.484%, 19.526%-16.748% and 17.078%-15.177% in the sun, solar and tray dried kokum rind, respectively. Highest retention was observed in tray dried kokum rind with the plastic packaging material (88.87%) in all treatments. Lightness observed at the 9th month in tray dried kokum rind was non-significant at $p\leq0.01$ for all the treatments as shown in Table 9.

Table 9 t- test for colour-L value of dried kokum rind packaged in different packaging materials

Treatments	Colour-L				
	0 month	3 month	6 month	9 month	Retention %
T_1P_1	20.998*	17.579*	15.147*	11.840*	56.39
T_2P_1	19.526*	16.803*	14.273*	10.853	55.59
T_3P_1	17.078*	12.637*	11.181*	10.824	63.38
T_1P_2	20.998*	17.133*	13.780	9.976*	47.51
T_2P_2	19.526*	15.290*	13.416	11.824	53.73
T_3P_2	17.078*	12.646*	12.644*	12.109	63.10
T_1P_3	20.998*	20.774*	19.751	17.484	83.27
T_2P_3	19.526*	19.614*	19.412	16.748	85.77
T_3P_3	17.078*	16.893*	16.049*	15.177	88.87
SE	0.147	0.182	0.273	1.285	
CD at 1%	0.609	0.754	0.671	5.311	

Note: * = significant at $p\leq0.01$.

3.2.7 Colour-a

Figure 8 shows the effect of storage duration and packaging material on redness of kokum rind dried by different methods. In all treatments, highest redness value was observed at the 0th month. As storage period increased, redness decreased in the dried kokum rind.

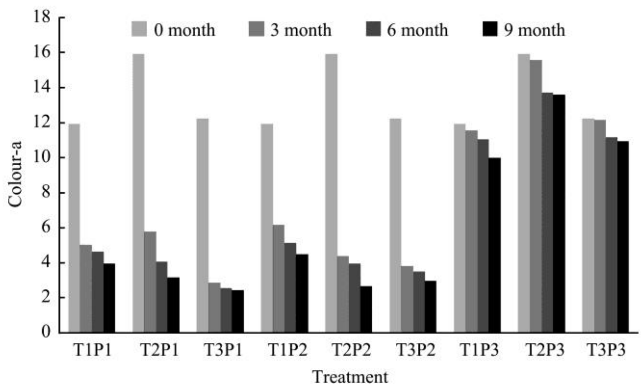

Figure 8 Effect of storage duration on colour value a of kokum rind packaged in different packaging materials

In the gunny packaged kokum rind, redness decreased from 11.941 to 3.952, from 15.897 to 3.158 and from 12.238 to 2.441 in sun, solar and tray dried kokum rind, respectively. In the gunny bag-packaged kokum rind, highest retention of a value was observed in sun dried sample at 33.10%, followed by tray and solar drying methods at 19.95% and 19.86%, respectively. This decrease in the redness in tray dried kokum rind was significant at $p \leq 0.01$

For kokum rind packaged in nylon bag, tredness was observed to decrease from 0^{th} to 9^{th} month with 11.941%-4.480%, 15.897%-2.659% and 12.238%-2.973% in sun, solar and tray dried kokum rind, respectively. Highest retention of a value in the kokum rind packaged in nylon bag was observed for sun dried sample at 37.52%, followed by tray and solar dried samples at 24.30% and 16.73%, respectively. This decrease in the redness was non-significant at $p \leq 0.01$.

Redness decreased from the 0^{th} to the 9^{th} month in the kokum rind packaged in the plastic jar with 11.941%-10.004%, 15.897%-13.614% and 12.238%-10.941% in the sun, solar and tray dried kokum rind, respectively. Highest retention was observed in tray dried kokum rind with the plastic packaging material (89.40%) in all treatments. Redness observed at the 9^{th} month in tray, solar and sun dried kokum rind was significant at $p \leq 0.001$ as shown in Table 10.

Table 10 t- test for colour-a value of dried kokum rind stored in different packaging materials

Treatments	Colour-a				
	0 month	3 month	6 month	9 month	Retention %
T_1P_1	11.941	5.043	4.640	3.952	33.10
T_2P_1	15.897*	5.800	4.083	3.158	19.86
T_3P_1	12.238	2.872*	2.560*	2.441*	19.95
T_1P_2	11.941	6.177*	5.157*	4.480*	37.52
T_2P_2	15.897*	4.371	3.974	2.659	16.73
T_3P_2	12.238	3.797	3.523	2.973	24.30
T_1P_3	11.941	11.551	11.052	10.004*	83.78
T_2P_3	15.897*	15.563*	13.712*	13.614*	85.64
T_3P_3	12.238	12.172	11.169	10.941*	89.40
SE	0.449	0.499	0.320	0.223	
CD at 1%	1.855	2.063	1.325	0.923	

Note: * = significant at $p \leq 0.01$.

3.2.8 Colour-b

Figure 9 shows effect of storage duration and packaging materials on yellowness of dried kokum rind. As storage period increased, yellowness increased.

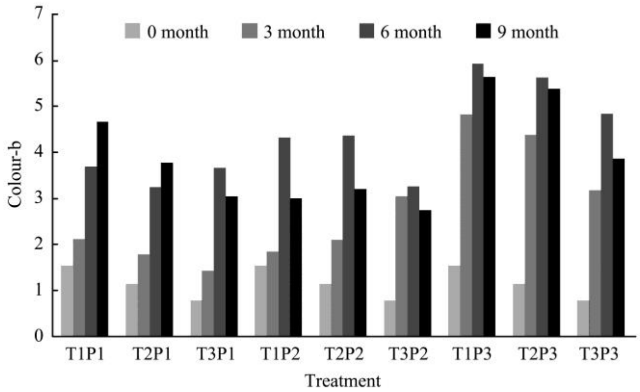

Figure 9 Effect of storage duration on colour value b of kokum rind packaged in different packaging materials

A consistent increase in yellowness was observed in kokum rind dried by sun stored in gunny bag. However, in nylon bag and plastic jar yellowness of kokum rind kept increasing in the first six months and decreased in the last three months. Highest retention of yellowness was observed in sun dried sample at 33.06%, followed by solar and sun drying method at 29.91% and 25.60%, respectively. In tray dried kokum rind, yellowness increased for the first six months and decreased in the last three months. Similar results were observed by [18] for air drying of apple rings. Effect of storage on yellowness of kokum rind packaged in the gunny bag was significant at $p \leq 0.01$ as shown in Table 11.

Table 11 t- test for colour-b value of dried kokum rind packaged in different packaging materials

Treatments	Colour-b				
	0 month	3 month	6 month	9 month	Retention %
T_1P_1	1.544*	2.113*	3.689	4.671*	33.06
T_2P_1	1.131*	1.788	3.243	3.781*	29.91
T_3P_1	0.781*	1.420	3.664	3.051*	25.60
T_1P_2	1.544*	1.843*	4.326	3.008	51.35
T_2P_2	1.131*	2.100*	4.371	3.200	35.35
T_3P_2	0.781*	3.048*	3.260*	2.739	28.52
T_1P_3	1.544*	4.824	5.927	5.638	27.39
T_2P_3	1.131*	4.380	5.623	5.389	20.99
T_3P_3	0.781*	3.171*	4.842*	3.864*	20.21
SE	0.056	0.235	0.231	0.151	
CD at 1%	0.231	0.969	0.956	0.624	

Note: * = significant at $p \leq 0.01$.

Kokum rind dried by sun, solar and tray methods and packaged in the nylon bag was found to increase in yellowness from the 0^{th} to the 6^{th} month (1.544-4.326, 1.131-4.371 and 0.781-3.260) and then to decrease to the end of the test. Increase in yellowness upto the 3rd month and decrease in the following two months was also observed by [18] in the storage of air dried apple ring in a 5-month span. The yellowness in the kokum rind packaged in the nylon bag was non-significant at $p\leq0.01$.

The yellowness of kokum rind packaged in plastic jar and stored from the 0th to the 6th month increased and it decreased in the 9th month, the highest value of yellowness was observed in sun (non-significant at $p\leq0.01$) and tray (significant at $p\leq0.01$) dried kokum rind. Yellowness kept increasing until the 6th month and it decreased in the 9th month. Similar results were obtained by [18].

3.2.9 Calorific value

Figure 10 shows variation in calorific value of kokum rind stored in different packaging materials

Highest calorific value in the kokum rind was observed after drying i.e. the 0th month in all treatments. As storage period increased calorific value decreased as shown in Figure 10.

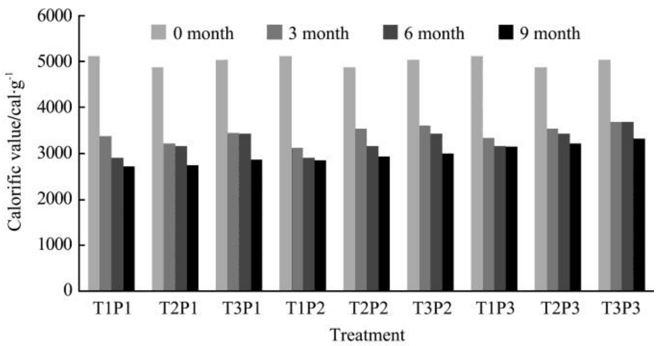

Figure 10 Effect of storage duration on calorific value of kokum rind packaged in different packaging materials

Calorific value in the kokum rind dried by sun, solar and tray drying and packaged in gunny bag was observed to decrease from the 0th to the 9th month. Tray dried kokum rind retained highest calorific value with 56.77% compared to solar and sun dried and gunny bags packaged with 56.37% and 53.05%, which was significantly different at $p\leq0.01$.

In the nylon packaged kokum rind, highest retention (60.30%) of calorific value was observed in solar dried kokum rind while tray and sun dried retains 59.58% and 55.79%, respectively.

Plastic jar: kokum rind packaged in plastic jar and dried by tray drying method retains highest calorific value with 66.13% while tray and sun dried kokum rind retains 66.08% and 61.63%, respectively. Calorific value retained in the kokum rind packaged in plastic jar was significant at $p\leq0.01$ as shown in Table 12.

Table 12 t- test for calorific value of dried kokum rind packaged in different packaging materials

Treatments	Calorific value/cal g^{-1}				
	0 month	3 month	6 month	9 month	Retention %
T_1P_1	5115.41	3382.62*	2902.90*	2713.71	53.05
T_2P_1	4874.08*	3215.13*	3166.80*	2747.73	56.37
T_3P_1	5040.19	3446.25*	3430.70*	2861.11*	56.77
T_1P_2	5115.41	3120.78*	2902.90*	2853.76*	55.79
T_2P_2	4874.08*	3534.79*	3166.80*	2939.22*	60.30
T_3P_2	5040.19	3607.19*	3430.70*	3003.17*	59.58
T_1P_3	5115.41	3335.33*	3166.80*	3152.44*	61.63
T_2P_3	4874.08*	3534.79*	3430.70*	3189.66*	65.44
T_3P_3	5040.19	3695.62*	3694.60*	3330.32*	66.08
SE	61.687	0.004	0.000	20.278	
CD at 1%	254.810	0.015	0.000	83.762	

Note: * = significant at $p\leq0.01$.

4 Conclusions

1) During the storage period from the 0th to the 9th month, acidity, non-reducing sugar, lightness (L), redness (a) and calorific value (cal/g) were found to decrease.

2) During the 9-month storage, TSS and b value increased.

3) Packaging and storage period did not affect pH value and reducing sugar significantly ($p\leq0.01$).

4) During the 9-month storage, lightness (L) and redness (a) decreased while yellowness increased in the kokum rind packaged in the plastic jar.

5) Kokum rind can be dried by solar and tray method while dried kokum rind can be store for 9 months in the plastic packaging material.

[References]

[1] APEDA. Fresh fruits and vegetables. 2014. http://www.apeda.gov.in/apedawebsite/six_head_product/FFV.htm. Access on [2014-07-25].

[2] Maskan A, Kaya S, Maskan M. Hot air and sun drying of grape leather (pestil). Journal of Food Engineering, 2002; 54: 81–88.

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

[4] Pavithra J P A. Study on Packaging and Value Addition In Traditional And Modern Consumer Retail Units: An Economic Analysis. MBA Thesis, University Of Agricultural Sciences, Dharwad, 2008.

[5] Anonymous. Gunny sack. 2013. http://en.wikipedia.org/wiki/Gunny_sack. Accessed on [2014-07-25]

[6] CE Plastics Inc. Characteristics & Benefits of Polypropylene. 2012. http://www.ceplastics.com/_papers/Polyprop_Rev2008_ver2.pdf. Access on [2014-07-25]

[7] Nestal. 2013. http://www.netstal.com/uploads/media/Imagebrochure_PET.pdf. Access on [2014-07-25]

[8] Kureel R S, Kishor R, Pandey A, Dutta. Kokum: Apotential tree borne oilseed. National Oilseeds and Vegetables Oils Development Board, Gurgaon, 2009.

[9] Krishnamurthy N, Lewis Y S, Ravindranath B. Chemical constituents of kokum fruit rind. Journal of Food science and Technology, 1982; 19: 97–100.

[10] Baliga M S, Bhat H P, Pai R J, Boloor R, Palatty P L. The Chemistry and medicinal uses of the underutilized Indian fruit tree garcinia indica choicy(kokum): A review. Food Research International. 2011; 44: 1790–1799.

[11] Chakraverty A. Post Harvest Technology of Cereals, Pulses and Oilseeds. Oxford and IBH Publishing Co., New Delhi, 1994: Third Edition.

[12] Lowry O H, Rosebrough N J, Farr A L, Randall R J. Protein measurement with the Folin Phenol reagent. Journal of Biological Chemistry, 1951; 193: 265–275.

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

[14] A.O.A.C. Official Methods of Analysis. 18th Edition. Association of Official Analytical Chemists. 2010.

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

[16] Clydesdale F M, Main J H, Francis F J, Damon R A. Concord grape pigments as colorants for beverages and gelatin desserts. Journal of Food Science, 1978; 43: 1687–1692.

[17] Chong C H, Law C L, Cloke M, Abdullah, L C, Wan Daud W R. Drying models and quality analysis of sun- dried Ciku. Drying Technology, 2009; 27: 985–992.

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

[19] Pareek S, Kaushik R A. Effect of drying methods on quality of Indian gooseberry powder during storage. Journal of Scientific and Industrial Research, 2012; 71: 727–732.