

RESEARCH PAPER

# Effect of Packaging Materials and Storage duration on Osmo-convective Hot Air and Osmo-microwave Vacuum Dried Pineapple (*Ananas comosus*) Cubes

Yogesh Vasantrao Patil<sup>1</sup> and Shrikant Baslingappa Swami<sup>2\*</sup>

<sup>1</sup>Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist Ratnagiri, Maharashtra State, India

<sup>2</sup>Department of Post-Harvest Engineering, Post-Graduate Institute of Post-Harvest Technology and 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.: 327

Received: 18-09-2025

Revised: 12-11-2025

Accepted: 27-11-2025

## ABSTRACT

Pineapple has been identified as a valuable source of nutrients and antioxidants, which are beneficial for human health. To preserve the nutritional properties after drying, appropriate storage specifications should be considered. This study aimed to investigate the quality and stability of osmo-convective and osmo-microwave vacuum dried pineapple cubes in terms of quality characteristics during storage for up to 2 months in two packaging materials: aluminum and polypropylene. Packaging in aluminium pouches under ambient conditions was found to better preserve quality characteristics of dried pineapple cubes. The packaging and storage study of osmo-convective dried pineapple cubes indicated that the pineapple cubes can be stored in good condition in aluminium pouch packaging material up to 60 days; The sensory scores were in the range of colour 6.8, texture 8.2, taste 8.2, flavour 6.5 and overall acceptability 8.2. The nutritional retention of osmo-convective dried pineapple cubes stored up to 60 days was TSS 31.85%, pH 4.02, acidity 0.579%, reducing sugar 18.82%, non reducing sugar 42.86% and total sugar 61.67%. The packaging and storage study of Osmo-microwave vacuum dried pineapple cubes stored up to 60 days indicated that the pineapple cubes can be stored in good condition in aluminium pouch packaging material up to 60 days; The sensory scores were for osmo-microwave vacuum dried pineapple cubes stored up to 60 days range of colour 7.5, texture 7.0, taste 8.2, flavour 7.5 and overall acceptability 8.0. The nutritional retention was TSS 32.22%, pH 3.97, acidity 0.503%, reducing sugar 25.83%, non reducing sugar 46.40% and total sugar 72.23%.

**Keywords:** Pineapple, Packaging and storage, osmo-convective dried, osmo-microwave vacuum dried, nutritional analysis, sensory analysis

Food security is a critical issue in many countries around the world, while globalization has placed a strain on leading agricultural countries to provide the world's food supply. Thus, innovative solutions that are economically and socio-culturally appropriate must be devised and implemented to ensure food security, not only with respect to food quantity, but also increased attention must be given to food quality

attributes, particularly nutritional content and safety. Post-harvest losses not only include physical losses in quantity, but also highly significant degradation

**How to cite this article:** Patil, Y.V. and Swami, S.B. (2025). Effect of Packaging Materials and Storage duration on Osmo-convective Hot Air and Osmo-microwave Vacuum Dried Pineapple (*Ananas comosus*) Cubes. *Int. J. Food Ferment. Technol.*, 15(02): 303-319.

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



of essential bio-active compounds and overall quality attributes.

Pineapple are highly perishable. The technology for the storage of the pineapple to ensure availability during the off-season is not available. Pineapple is an important fruit crop, which serves as a good source of vitamins A and C as well as calcium, potassium and magnesium (Hossain *et al.* 2015). Considerable post-harvest losses occur in fresh pineapple due to its rapid senescence, which causes high perishability. Consequently, postharvest processing is required to extend shelf life and preserve quality.

Osmo-convective and osmo-microwave vacuum drying of pineapple cubes are the most common preservation method of fruits that allows for greater flexibility in the availability and marketability of products, regardless of high production volume. By convention, dried pineapple cubes can be consumed directly or used as an ingredient in snacks, chocolates, breakfast cereals and other foodstuffs. Now a days, there is even an increasing demand for natural products, including high quality dried fruits in which nutritional properties have minimal alteration.

In food industries, packaging materials and storage conditions are considered as the last step in product development to extend the conservation of dried fruits. 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). During storage and distribution, dried fruits can experience a wide range of environmental conditions, such as high temperature and humidity as well as exposure to light and oxygen, which can trigger various physicochemical changes. However, improper film selection and packaging technique can lead to loss of quality in a very short period. Selection of an appropriate packaging film, package fill weight and temperature are the important conditions to increase the shelf-life of fresh produce. These factors have

been reported to facilitate reducing TSS, acidity, pH, reducing sugar and total sugar. A process has been developed to prepare shelf stable ready-to-eat (RTE) osmo-convective and osmo-microwave vacuum dried pineapple cubes. As reported in literature the shelf life of the intermediate moisture pineapple slices was found to be 40 days at ambient temperature (26°C) (Saxena *et al.* 2009). The RTE intermediate moisture pineapple slices were found to have good texture, colour and sensory acceptability during this 40 days storage (Saxena *et al.* 2009).

Osmotic dehydration reduce water activity ( $a_w$ ), which prevented microbial growth. Silveira *et al.* 1996 investigated osmotic dehydration kinetics and resulting product quality and found that osmotically pre-treated, air-dried pineapple was organoleptically acceptable after at least 3 months storage at 25°C. Review Although the quality of stored samples decreased, osmotically dehydrated pineapple was still acceptable since it scored above 6.5 on a hedonic scale of 1 to 9. Thus, osmo-air dried pineapple product can be stored in a polypropylene and aluminium foil pouches at ambient conditions for at least 2 months (Expedito *et al.* 1996). Additionally, chemical reactions can degrade antioxidants such as polyphenols, carotenoids and vitamin C, which is a particular concern for consumers as it decreases the nutritional value (Hymavathi and Khader, 2005). Lavelli and Vantaggi (2009) found that dried apples were relatively stable during storage and had optimal conservation of antioxidants as long as the proper packaging materials were used. Pua *et al.* (2008) suggested that aluminum laminated polyethylene (ALP) pouches with storage conditions of 28°C and relative humidity less than 75% were better suited for preserving qualities of jackfruit powder. Also, Dak *et al.* 2014 agreed that ALP is more effective to retain anthocyanins and phenolic compounds in dried pomegranate arils than packaging without aluminum coating. Overall, it should be noted that properties of the packaging materials play an important role for shelf life stability of dried fruits. Ultimately, the challenge in modern food sciences is not only to minimize the chemical degradation

reactions, but also to maximize the conservation of beneficial nutrients during storage.

To store dried pineapple cubes for maximum period, it requires good packaging material to extend the shelf life of the dried pineapple cubes by better protection from hazards during storage. The objective of this study was to evaluate the effects of two packaging materials, namely aluminum and polypropylene on quality characteristics TSS, pH, acidity, reducing sugar, non-reducing sugar, total sugar of dried pineapple cubes samples during long-term storage.

## MATERIALS AND METHODS

### Packaging and storage study of pineapple cubes

The pineapple cubes of size 10 mm × 10 mm × 10 mm were dried by Osmo-convective and microwave-vacuum dried pineapple cubes was used for the packaging and storage study. For osmo-convective dried pineapple cubes the cubes were deeped in sugar concentration 60°Brix, and exposed to soaking temperature 60°C and dried at temperature 60°C by convective hot air dryer up to 360 min. Similarly for microwave-vacuum dried pineapple cubes, the

cubes were deeped in sugar concentration 60°Brix, and exposed to soaking temperature 60°C and dried by microwave vacuum drying system at magnetron ON/OFF time 20s/30s in sec dried up to were taken for storage study.

50 g dried pineapple cubes so prepared as discussed above was taken in two different packaging materials i.e. polypropylene and aluminium laminated pouches Table 1 shows the specification of the packaging material. Fig. 1 shows (a) Aluminium foil pouch (b) Polypropylene pouch packaging material. Storage of osmo-convective dried and osmo-microwave vacuum dried pineapple cubes were observed up to for 2 months duration.

50 g of osmo-convective and microwave-vacuum dried pineapple cubes sample was filled separately in polypropylene and aluminium laminated pouches and sealed properly. Fig. 1 shows the (a) aluminium foil and (b) polypropylene pouch packaging material. These packets were kept at ambient temperature up to 2 months. The stored samples were analyzed at every 15 days interval up to 2 months. The observations for the nutritional properties of stored sample were taken during 5 duration ( 0, 15, 30, 45 and 60 days)

**Table 1:** Specifications of packaging material for storage of dried pineapple cubes

Sl. No.	Packaging material	Size	Gauge	Capacity
1	Polypropylene pouches	20 cm × 9 cm	393	50 g
2	Aluminium laminated pouches	20 cm × 9 cm	157	50 g



(a)



(b)

**Fig. 1:** Packaging materials used for storage of dried pineapple cubes; (a) Aluminium foil pouch (b) Polypropylene pouch

i.e. total no. of samples for all the trials were, 5 duration  $\times$  2 packaging material  $\times$  3 replication = 30 samples of Osmo-Convective dried pineapple cubes and 30 samples of Osmo-microwave vacuum dried pineapple cubes were kept for storage study. The nutritional properties (i. e. TSS, pH, acidity, reducing sugar, non-reducing sugar, total sugar) for the stored samples were determined for each storage duration i.e. 0, 15, 30, 45 and 60 days.

#### **Sensory Evaluation of Osmo-convective and osmo-microwave vacuum dried pineapple cubes stored at 0 days to 60 days stored in polypropylene and aluminium packaging material**

The sensory evaluation was carried out using trained taste panel consisting of students and staff from the College of Agricultural Engg. and Tech., Dapoli. The number of panelists who evaluated Osmo-Convective and osmo-microwave vacuum dried products was 20 (12 female and 8 male). Samples were coded using random code A to D (4 samples). Panelists were served with salted potato chips, water to break the monotony in taste of the dried pineapple cubes.

Mean sensory scores for quality attributes (colour, taste, texture, flavour) and overall acceptability were recorded in individual sheet and average scores are reported. The sensory method employed a nine-point hedonic scale used to assess colour, flavour, taste and texture: 9 (like extremely), 8 (like very much), 7 (like moderately), 6 (like slightly), 5 (neither like nor dislike), 4 (dislike slightly), 3 (dislike moderately), 2 (dislike very much), 1 (dislike extremely). These samples for each treatment were placed in the paper dish. These samples were organoleptically tested for different quality attributes like colour, texture, taste, flavour and overall acceptability.

#### **Statistical analysis of sensory evaluation of stored product**

ANOVA with replicated factor for sensory analysis was done. The significant and non-significant treatment was judged with the help of F (variance ratio) table and t-test. The significant difference between the means was tested against the critical difference at  $p \leq 0.05$ .

#### **Quality characteristics analysis of stored dried pineapple cubes**

TSS, pH, acidity, reducing sugar, non-reducing sugar, total sugar of osmo-convective and osmo-microwave vacuum dried pineapple cubes packed in polypropylene and aluminium laminated pouches was determined for each storage period 0, 15, 30, 45 and 60 days as per the procedure described in section.

#### **Optimization of best packaging material**

Stored Osmo-Convective and osmo-microwave-vacuum dried pineapple cubes in polypropylene and aluminum laminated pouches were evaluated for better retention of quality characteristics (i.e. TSS, pH, acidity, reducing sugar, non-reducing sugar, total sugar) up to 2 months (0, 15, 30, 45, 60 days) storage duration. Considering the better retention of quality characteristics and sensory properties the best packaging material was decided for Osmo-convective and Osmo-microwave-vacuum dried pineapple cubes.

## **RESULTS AND DISCUSSION**

### **(I) Packaging and storage study of Osmo-convective hot air dried pineapple cubes**

#### **1. Quality Characteristics of stored sample**

The quality characteristics of stored sample include the TSS,  $p^H$ , acidity, reducing sugar, non-reducing sugar, total sugar.

#### **1. TSS**

Table 2 shows effect of packaging material and storage duration on TSS content of osmo-convective dried pineapple cubes. The TSS decreased from 33.27 to 31.85 % and 33.27 to 31.37 %, in aluminium foil and Polypropylene pouch respectively. Table 5.28 shows the ANOVA for change in TSS content in 60 days storage duration for osmo-convective dried pineapple cubes.

Decrease in TSS content with increase in storage period from 0-60 days is higher in polypropylene

**Table 2:** Effect of packaging material and storage duration on TSS of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	33.27±0.46 <sup>a</sup>	32.29±0.18 <sup>b</sup>	32.21±0.09 <sup>b</sup>	31.96±0.10 <sup>cb</sup>	31.85±0.08 <sup>cb</sup>			
Polypropylene	33.27±0.46 <sup>a</sup>	32.37±0.33 <sup>b</sup>	32.11±0.15 <sup>b</sup>	31.91±0.08 <sup>cb</sup>	31.37±0.13 <sup>c</sup>			
<b>ANOVA</b>								
SE <sub>Material</sub>	0.06775	SV	DF	SS	MSS	F <sub>cal</sub>	F <sub>tab</sub> 1%	Result
CD <sub>Material</sub>	0.27581	Duration	4	9.417	2.354	34.19	<.0001	Sig at 0.05%
SE <sub>Duration</sub>	0.10712	Material	1	0.089	0.089	1.30	0.2688	Sig at 0.05%
CD <sub>Duration</sub>	0.43609	Interaction	4	0.280	0.070	1.02	0.4237	
SE <sub>Interaction (M×D)</sub>	0.08298	Replication	2	0.046	0.023	0.33	0.7202	
CD <sub>Interaction (M×D)</sub>	0.33779	Error	18	1.239	0.068			
		Total	29	11.073				

Same letter are not significantly different ( $p \leq 0.05$ ).

**Table 3:** Effect of packaging material and storage duration on pH of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	4.33±0.10 <sup>a</sup>	4.25±0.04 <sup>ba</sup>	4.14±0.03 <sup>bac</sup>	4.09±0.09 <sup>bc</sup>	4.01±0.09 <sup>c</sup>			
Polypropylene	4.33±0.10 <sup>a</sup>	4.30±0.03 <sup>a</sup>	4.15±0.08 <sup>bac</sup>	4.17±0.05 <sup>bac</sup>	3.98±0.15 <sup>c</sup>			
<b>ANOVA</b>								
SE <sub>Material</sub>	0.021578	SV	DF	SS	MSS	F <sub>cal</sub>	F <sub>tab</sub> 1%	Result
CD <sub>Material</sub>	0.0878	Duration	4	0.410	0.102	14.70	<.0001	Sig at 0.05%
SE <sub>Duration</sub>	0.034117	Material	1	0.003	0.003	0.46	0.5069	Sig at 0.05%
CD <sub>Duration</sub>	0.1389	Interaction	4	0.010	0.002	0.37	0.8258	
SE <sub>Interaction (M×D)</sub>	0.026427	Replication	2	0.021	0.010	1.51	0.2477	
CD <sub>Interaction (M×D)</sub>	0.107578	Error	18	0.125	0.006			
		Total	29	0.571				

Same letter are not significantly different ( $p \leq 0.05$ ).

pouch than aluminium foil pouch for dried pineapple cubes. This decrease in TSS content with increase in storage duration was significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum TSS is recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the TSS of the dried pineapple cubes was significant effect at  $p \leq 0.05$ . As the difference between the means of TSS contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has significant effect at  $p \leq 0.05$  from each other.

A decrease in TSS content was also observed in all the packaging material with the increase in storage period from 0-60 days with significant effect at  $p \leq 0.05$ . Similar results have been observed for osmo-convective hot air dried pineapple slices up to 2 months duration stored in polypropylene pouch (Expedito *et al.* 1996).

## 2. pH

Table 3 shows effect of packaging material and storage duration on pH content of dried pineapple cubes. The pH content decreased from to 4.33 to 4.01 and 4.33 % to 3.98 % in aluminium foil and Polypropylene pouch respectively. Table 5 shows

the effect of packaging material and storage duration on pH of osmo-convective dried pineapple cubes. Table 5 shows the ANOVA for change in pH in 60 days storage duration for osmo-convective dried pineapple cubes.

Decrease in pH content with increase in storage period from 0-60 days is higher in polypropylene pouch than aluminium foil pouch for dried pineapple cubes. This decrease in pH content with increase in storage duration was significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum pH is recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the pH of the dried pineapple cubes was significant effect at  $p \leq 0.05$ . As the difference between the means of pH contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has significant effect at  $p \leq 0.05$  from each other.

A decrease in pH was also observed in all the packaging materials with the increase in storage period from 0-60 days with significant effect at  $p \leq 0.05$ . Similar results have been observed for osmo-convective hot air dried pineapple slices up to 2 months duration pH decreases from 3.52 to 3.48 stored in polypropylene pouch (Expedito *et al.* 1996).

### 3. Acidity

Table 4 shows effect of packaging material and storage duration on acidity of osmo-convective hot air dried pineapple cubes. The acidity decreased from 0.657 to 0.578 %, and 0.657 to 0.576 % in aluminium foil and Polypropylene pouch respectively. Table 5 shows the ANOVA for change in acidity content in 60 days storage duration for Osmo-convective dried pineapple cubes.

Decrease in acidity content with increase in storage period from 0-60 days is higher in polypropylene pouch than aluminium foil pouch for dried pineapple cubes. This decrease in acidity with increase in storage duration was significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum acidity is recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the acidity of the dried pineapple cubes was significant at  $p \leq 0.05$ . As the difference between the means of acidity contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has significant effect at  $p \leq 0.05$  from each other.

A decrease in acidity content was also observed in both packaging materials with the increase in storage period from 0-60 days with significant effect

**Table 4:** Effect of packaging material and storage duration on acidity of osmo-convective dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	0.657±0.05 <sup>a</sup>	0.633±0.02 <sup>ba</sup>	0.596±0.01 <sup>b</sup>	0.593±0.01 <sup>b</sup>	0.578±0.00 <sup>b</sup>			
Polypropylene	0.657±0.05 <sup>a</sup>	0.615±0.05 <sup>ba</sup>	0.607±0.02 <sup>ba</sup>	0.599±0.00 <sup>b</sup>	0.576±0.01 <sup>b</sup>			
ANOVA								
		SV	DF	SS	MSS	F <sub>cal</sub>	F <sub>tab</sub> 1%	Result
SE <sub>Material</sub>	0.006303	Duration	4	0.022	0.00561	9.41	0.0003	Sig at 0.05%
CD <sub>Material</sub>	0.0257	Material	1	0.0000048	0.00000	0.01	0.9295	Sig at 0.05%
SE <sub>Duration</sub>	0.009967	Interaction	4	0.00071	0.00017	0.30	0.8739	
CD <sub>Duration</sub>	0.0406	Replication	2	0.00373	0.00186	3.14	0.0679	
SE <sub>Interaction (M×D)</sub>	0.00772	Error	18	0.0107	0.00059			
CD <sub>Interaction (M×D)</sub>	0.031426	Total	29	0.0376				

Same letter are not significantly different ( $p \leq 0.05$ ).

at  $p \leq 0.05$ . Similar results have been observed for osmo-convective hot air dried pineapple slices up to 2 months duration acidity decreases from 0.490 to 0.410% stored in polypropylene pouch (Expedito *et al.* 1996).

#### 4. Reducing sugar

Table 5 shows effect of packaging material and storage duration on reducing sugar content of osmo-convective dried pineapple cubes. The reducing sugar content decreased from 20.49 to 18.81 % and 20.49 to 18.68 % in aluminium foil and Polypropylene pouch respectively. Table 5 shows the ANOVA for change in reducing sugar content up to 60 days storage duration for osmo-convective dried pineapple cubes.

Decrease in reducing sugar content with increase in storage period from 0-60 days is higher in polypropylene pouch than aluminium foil pouch for dried pineapple cubes. This decrease in reducing sugar content with increase in storage duration had significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum reducing sugar was recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for stored dried pineapple cubes. The effect of packaging materials and storage durations on the reducing sugar content of the dried pineapple cubes was significant

effect at  $p \leq 0.05$ . As the difference between the means of reducing sugar contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has significant effect at  $p \leq 0.05$  from each other.

A decrease in reducing sugar content was also observed in all the packaging material with the increase in storage period from 0-60 days with significant effect at  $p \leq 0.05$ . Similar results have been observed for osmo-convective hot air dried pineapple slices up to 2 months duration reducing sugar decreases from 35.48 to 35.45% stored in polypropylene pouch (Expedito *et al.* 1996).

#### 5. Non-Reducing sugar

Table 6 shows effect of packaging material and storage duration on Non-Reducing sugar content of dried pineapple cubes up to 60 days. The non-reducing sugar content decreased from 43.21 to 42.85 % and 43.21 to 42.86 %, in aluminium foil and Polypropylene pouch respectively. Table 5 shows the ANOVA for change in non-reducing sugar content in 60 days storage duration for Osmo-convective dried pineapple cubes.

Decrease in non-reducing sugar content with increase in storage period from 0-60 days was higher in polypropylene pouch than aluminium foil pouch for

**Table 5:** Effect of packaging material and storage duration on reducing sugar of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	20.49±0.31 <sup>a</sup>	19.86±0.12 <sup>b</sup>	19.37±0.07 <sup>cbd</sup>	19.07±0.16 <sup>fed</sup>	18.81±0.14 <sup>fe</sup>			
Polypropylene	20.49±0.31 <sup>a</sup>	19.72±0.31 <sup>cb</sup>	19.45±0.08 <sup>cbd</sup>	19.26±0.05 <sup>ced</sup>	18.68±0.25 <sup>f</sup>			
ANOVA								
SE <sub>Material</sub>	0.05415	SV	DF	SS	MSS	F <sub>cal</sub>	F <sub>tab</sub> 1%	Result
CD <sub>Material</sub>	0.2204	Duration	4	10.44518	2.611295	59.37	<.0001	Sig at 0.05%
SE <sub>Duration</sub>	0.0541	Material	1	0.000003	0.000003	0.00	0.9932	Sig at 0.05%
CD <sub>Duration</sub>	0.3485	Interaction	4	0.116046	0.029011	0.66	0.6280	
SE <sub>Interaction (M×D)</sub>	0.0663	Replication	2	0.120660	0.060330	1.37	0.2790	
CD <sub>Interaction (M×D)</sub>	0.26997	Error	18	0.791740	0.043985			
		Total	29	11.47363				

Same letter are not significantly different ( $p \leq 0.05$ ).

**Table 6:** Effect of packaging material and storage duration on non-reducing sugar of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	43.41±0.30 <sup>a</sup>	43.23±0.60 <sup>a</sup>	42.92±0.05 <sup>a</sup>	42.81±0.16 <sup>a</sup>	42.85±0.19 <sup>a</sup>			
Polypropylene	43.41±0.30 <sup>a</sup>	43.28±0.66 <sup>a</sup>	43.00±0.16 <sup>a</sup>	42.94±0.04 <sup>a</sup>	42.86±0.38 <sup>a</sup>			
<b>ANOVA</b>								
SE <sub>Material</sub>	0.093199	<b>SV</b>	<b>DF</b>	<b>SS</b>	<b>MSS</b>	<b>F<sub>cal</sub></b>	<b>F<sub>tab</sub> 1%</b>	<b>Result</b>
CD <sub>Material</sub>	0.3794	Duration	4	1.47864	0.369661	2.84	0.0550	Sig at 0.05%
SE <sub>Duration</sub>	0.093199	Material	1	0.02028	0.020280	0.16	0.6978	Sig at 0.05%
CD <sub>Duration</sub>	0.5999	Interaction	4	0.01628	0.004071	0.03	0.9979	
SE <sub>Interaction (M×D)</sub>	0.114145	Replication	2	0.13528	0.067643	0.52	0.6037	
CD <sub>Interaction (M×D)</sub>	0.464654	Error	18	2.34524	0.130291			
		Total	29	3.99574				

Same letter are not significantly different ( $p \leq 0.05$ ).

**Table 7:** Effect of packaging material and storage duration on total sugar of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	63.90±0.58 <sup>a</sup>	63.76±0.14 <sup>a</sup>	62.25±0.07 <sup>cd</sup>	61.89±0.09 <sup>cde</sup>	61.67±0.09 <sup>de</sup>			
Polypropylene	63.91±0.58 <sup>a</sup>	63.00±0.32 <sup>b</sup>	62.46±0.09 <sup>cde</sup>	62.20±0.06 <sup>cde</sup>	61.55±0.13 <sup>e</sup>			
<b>ANOVA</b>								
SE <sub>Material</sub>	0.07276	<b>SV</b>	<b>DF</b>	<b>SS</b>	<b>MSS</b>	<b>F<sub>cal</sub></b>	<b>F<sub>tab</sub> 1%</b>	<b>Result</b>
CD <sub>Material</sub>	0.2962	Duration	4	21.850	5.462633	68.79	<.0001	Sig at 0.05%
SE <sub>Duration</sub>	0.07276	Material	1	0.0388	0.038880	0.49	0.4931	Sig at 0.05%
CD <sub>Duration</sub>	0.4683	Interaction	4	1.0530	0.263263	3.32	0.0335	
SE <sub>Interaction (M×D)</sub>	0.08911	Replication	2	0.2450	0.122530	1.54	0.2407	
CD <sub>Interaction (M×D)</sub>	0.36276	Error	18	1.4294	0.079415			
		Total	29	24.6170				

Same letter are not significantly different ( $p \leq 0.05$ ).

dried pineapple cubes. This decrease in non-reducing sugar content with increase in storage duration was non significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum non-reducing sugar was recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the non-reducing sugar content of the dried pineapple cubes was non significant effect at  $p \leq 0.05$ . As the difference between the means of non-reducing sugar contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has non significant effect at  $p \leq 0.05$  from each other.

A decrease in non-reducing sugar content was also observed in all the packaging materials with the increase in storage period from 0-60 days with non significant effect at  $p \leq 0.05$ . Similar results have been observed for osmo-convective hot air dried pineapple slices up to 2 months duration non-reducing sugar decreases stored in polypropylene pouch (Expedito *et al.* 1996).

## 6. Total sugar

Table 7 shows effect of packaging material and storage duration on total sugar content of dried pineapple cubes. The total sugar content decreased from, 63.90 to 61.67 % and 63.90 to 61.55 % in aluminium foil and Polypropylene pouch respectively. Table 5.33 shows

the ANOVA for change in total sugar content in 60 days storage duration for Osmo-convective dried pineapple cubes.

Decrease in total sugar content with increase in storage period from 0-60 days is higher in polypropylene pouch than aluminium foil pouch for dried pineapple cubes. This decrease in total sugar content with increase in storage duration was significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum total sugar was recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the total sugar content of the dried pineapple cubes was significant effect at  $p \leq 0.05$ . As the difference between the means of total sugar contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has significant effect at  $p \leq 0.05$  from each other.

A decrease in total sugar content was also observed in all the packaging materials with the increase in storage period from 0-60 days with significant effect

at  $p \leq 0.05$ . Similar results have been observed for osmo-convective hot air dried pineapple slices up to 2 months duration total sugar decreases from 51.84 to 50.95% stored in polypropylene pouch (Expedito *et al.* 1996).

#### Sensory evaluation of osmo-convective hot air dried pineapple cubes stored up to 60 days

This osmo-convective hot air dried pineapple cubes stored in two different packaging material aluminium and polypropylene for 60 days. Sensory evaluation of the Osmo-convective dried pineapple cubes stored in aluminium and polypropylene pouch shown in Table 8. Overall score of sensory characteristics ranged from 6.5 to 8.2. Increase in sugar concentration increased the sensory score. Maximum acceptability was observed either at the maximum level of sugar concentration and vice versa.

The sensory analysis of osmo-convective dried pineapple cubes indicated that the overall acceptability of the dried pineapple cubes were highest at (sample code 'B') aluminium pouch at which the colour, texture, taste, flavour and overall

**Table 8:** Sensory Evaluation of Osmo-convective dried pineapple cubes stored at 0 days to 60 days stored in polypropylene and aluminium packaging material

Polypropylene (A)					
Duration	Sensory parameters score (out of 9)				
	Colour (9)	Texture (9)	Taste (9)	Flavour (9)	Overall Acceptability (9)
0 days	6.2	6.1	6.3	6.4	6.2
15 days	6.3	6.1	6.5	6.1	6.4
30 days	6.3	6.3	6.4	6.9	7.0
45 days	6.3	6.2	6.5	6.2	6.4
60 days	7.3	7.5	7.5	6.2	7.2
Aluminium foil (B)					
Duration	Sensory parameters score (out of 9)				
	Colour (9)	Texture (9)	Taste (9)	Flavour (9)	Overall Acceptability (9)
0 days	7.1	6.9	7.3	7.35	7.4
15 days	7.2	7.1	7.5	7.35	7.3
30 days	7.1	7.2	7.1	7.1	7.3
45 days	7.4	7.3	7.3	7.2	7.7
60 days	6.8	8.2	8.2	6.5	8.2

**Table 9:** ANOVA for Sensory Evaluation of Osmo-convective dried pineapple cubes stored at 0 days to 60 days stored in polypropylene and aluminium packaging material

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	10.1622	9	1.1291	3.675697	0.002403	2.152607
Columns	2.6692	4	0.6673	2.172279	0.091835	2.633532
Error	11.0588	36	0.30718			
Total	23.8902	49				

acceptability was 6.8, 8.2, 8.2, 6.5 and 8.2 respectively. Table 5 shows the ANOVA for the sensory analysis of the scores obtained for osmo-convective dried pineapple cubes at each treatment combinations. All the sensory scores was significantly different at  $p \leq 0.05$ .

Although the quality of stored samples decreased, osmotically dehydrated pineapple slices by air dried was still acceptable since it scored above 6 on a hedonic scale of 1 to 9. Thus, osmo-air dried pineapple product can be stored in a polypropylene pouches at ambient conditions for at least 2 months (Expedito *et al.* 1996).

#### Nutritional quality and optimization of best packaging material

The Packaging and storage study of Osmo-convective dried pineapple cubes indicated that the pineapple cubes can be stored in good condition in aluminium pouch packaging material up to 60 days; The sensory scores were colour 6.8, texture 8.2, taste 8.2, flavor 6.5 and overall acceptability 8.2; The nutritional retention was TSS 31.85%, pH 4.02, acidity 0.579%, reducing sugar 18.82%, non reducing sugar 42.86% and total sugar 61.67%.

#### (II) Packaging and storage study of osmo-microwave vacuum dried pineapple cubes

##### Quality Characteristics of stored sample

The quality characteristics of stored sample include the TSS, pH, acidity, reducing sugar, non-reducing sugar, total sugar.

#### 1. TSS

Table 10 shows effect of packaging material and storage duration on TSS content of dried pineapple cubes. The TSS content decreased from 34.67 to 32.22 % and 34.67 to 32.09 % in aluminium foil and polypropylene pouch respectively. Table 10 shows the ANOVA for change in TSS content in 60 days storage duration for Osmo- microwave vacuum dried pineapple cubes.

Decrease in TSS content with increase in storage period from 0-60 days is higher in polypropylene pouch than aluminium foil pouch for dried pineapple cubes. This decrease in TSS content with increase in storage duration was significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum TSS is recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the TSS content of the dried pineapple cubes was significant effect at  $p \leq 0.05$ . As the difference between the means of TSS contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has significant effect at  $p \leq 0.05$  from each other.

Although the quality of stored samples decreased, osmotically dehydrated pineapple was still acceptable since it scored above 6.5 on a hedonic scale of 1 to 9. Thus, osmo- microwave vacuum dried pineapple product can be stored in a polypropylene and aluminium foil pouches at ambient conditions for at least 2 months.

A decrease in TSS content was also observed in all the packaging material with the increase in storage

period from 0-60 days with significant effect at  $p \leq 0.05$ . Similar results have been observed for osmo-vacuum dried pineapple slices up to 2 months duration TSS decreased stored in polypropylene pouch (Expedito *et al.* 1996).

## 2. pH

Table 11 shows effect of packaging material and storage duration on pH of osmo-microwave vacuum dried pineapple cubes. The pH content decreased from to 4.63 to 3.97 % and 4.63 to 3.99 % in aluminium

foil and polypropylene pouch respectively. Table 11 shows the ANOVA for change in pH content in 60 days storage duration for Osmo- microwave vacuum dried pineapple cubes.

Decrease in pH with increase in storage period from 0-60 days is higher in polypropylene pouch than aluminium foil pouch for dried pineapple cubes. This decrease in pH content with increase in storage duration was significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum pH was recorded at 0 days which was significantly higher than other

**Table 10:** Effect of packaging material and storage duration on TSS of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	34.67±0.46 <sup>a</sup>	33.32±0.18 <sup>b</sup>	32.80±0.09 <sup>cb</sup>	32.45±0.10 <sup>cd</sup>	32.22±0.08 <sup>d</sup>			
Polypropylene	34.67±0.46 <sup>a</sup>	33.32±0.33 <sup>b</sup>	33.20±0.15 <sup>b</sup>	33.14±0.08 <sup>d</sup>	32.09±0.13 <sup>d</sup>			
<b>ANOVA</b>								
SE <sub>Material</sub>	0.058522	<b>SV</b>	<b>DF</b>	<b>SS</b>	<b>MSS</b>	<b>F<sub>cal</sub></b>	<b>F<sub>tab</sub> 1%</b>	<b>Result</b>
CD <sub>Material</sub>	0.238219	Duration	4	20.87034	5.21758	101.57	<.0001	Sig at 0.05%
SE <sub>Duration</sub>	0.092528	Material	1	0.280333	0.28033	5.46	0.0313	Sig at 0.05%
CD <sub>Duration</sub>	0.376658	Interaction	4	0.712933	0.17823	3.47	0.0287	
SE <sub>Interaction (M×D)</sub>	0.071672	Replication	2	0.357020	0.17851	3.48	0.0529	
CD <sub>Interaction (M×D)</sub>	0.291758	Error	18	0.924646	0.05136			
		Total	29	23.14528				

Same letter are not significantly different ( $p \leq 0.05$ ).

**Table 11:** Effect of packaging material and storage duration on pH of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	4.63±0.10 <sup>a</sup>	4.39±0.04 <sup>b</sup>	4.15±0.03 <sup>ced</sup>	4.06±0.09 <sup>ed</sup>	3.97±0.09 <sup>e</sup>			
Polypropylene	4.63±0.10 <sup>a</sup>	4.32±0.03 <sup>b</sup>	4.21±0.08 <sup>cbd</sup>	4.18±0.05 <sup>ced</sup>	3.99±0.15 <sup>e</sup>			
<b>ANOVA</b>								
SE <sub>Material</sub>	0.022975	<b>SV</b>	<b>DF</b>	<b>SS</b>	<b>MSS</b>	<b>F<sub>cal</sub></b>	<b>F<sub>tab</sub> 1%</b>	<b>Result</b>
CD <sub>Material</sub>	0.093526	Duration	4	1.51724667	0.37931167	47.90	<.0001	Sig at 0.05%
SE <sub>Duration</sub>	0.036327	Material	1	0.00481333	0.00481333	0.61	0.4457	Sig at 0.05%
CD <sub>Duration</sub>	0.147878	Interaction	4	0.02895333	0.00723833	0.91	0.4770	
SE <sub>Interaction (M×D)</sub>	0.028139	Replication	2	0.01580667	0.00790333	1.00	0.3881	
CD <sub>Interaction (M×D)</sub>	0.114546	Error	18	0.14252667	0.00791815			
		Total	29	1.70934667				

Same letter are not significantly different ( $p \leq 0.05$ ).

**Table 12:** Effect of packaging material and storage duration on acidity of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	0.581±0.05 <sup>a</sup>	0.541±0.02 <sup>b</sup>	0.536±0.01 <sup>cb</sup>	0.518±0.01 <sup>ced</sup>	0.503±0.14 <sup>e</sup>			
Polypropylene	0.581±0.05 <sup>a</sup>	0.535±0.03 <sup>cbd</sup>	0.513±0.02 <sup>ed</sup>	0.513±0.05 <sup>ed</sup>	0.501±0.01 <sup>e</sup>			
<b>ANOVA</b>								
SE <sub>Material</sub>	0.00249	<b>SV</b>	<b>DF</b>	<b>SS</b>	<b>MSS</b>	<b>F<sub>cal</sub></b>	<b>F<sub>tab</sub> 1%</b>	<b>Result</b>
CD <sub>Material</sub>	0.010136	Duration	4	0.02177433	0.00544358	58.54	<.0001	Sig at 0.05%
SE <sub>Duration</sub>	0.003937	Material	1	0.00039603	0.00039603	4.26	0.0538	Sig at 0.05%
CD <sub>Duration</sub>	0.016026	Interaction	4	0.00050580	0.00012645	1.36	0.2869	
SE <sub>Interaction (M×D)</sub>	0.00305	Replication	2	0.00082140	0.00041070	4.42	0.0275	
CD <sub>Interaction (M×D)</sub>	0.012414	Error	18	0.00167393	0.00009300			
		Total	29	0.02517150				

Same letter are not significantly different ( $p \leq 0.05$ ).

days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the pH of the dried pineapple cubes was significant effect at  $p \leq 0.05$ . As the difference between the means of pH contents of dried pineapple cubes at all the intervals for polypropylene pouch, and aluminium foil pouch was higher than CD and has significant effect at  $p \leq 0.05$  from each other.

A decrease in pH was also observed in all the packaging material with the increase in storage period from 0-60 days with significant effect at  $p \leq 0.05$ . Similar results have been observed for osmo-vacuum dried pineapple slices up to 2 months duration pH decreased from 3.40 to 3.39 stored in polypropylene pouch (Expedito *et al.* 1996).

### 3. Acidity

Table 12 shows effect of packaging material and storage duration on acidity of osmo-microwave vacuum dried pineapple cubes. The acidity decreased from 0.581 to 0.503 % and 0.581 to 0.501 % in aluminium foil and polypropylene pouch respectively. Table 12 shows the ANOVA for change in acidity content in 60 days storage duration for Osmo- microwave vacuum dried pineapple cubes.

Decrease in acidity content with increase in storage

period from 0-60 days is higher in polypropylene pouch than aluminium foil pouch for dried pineapple cubes. This decrease in acidity content with increase in storage duration was significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum acidity is recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the acidity content of the dried pineapple cubes was significant effect at  $p \leq 0.05$ . As the difference between the means of acidity contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has significant effect at  $p \leq 0.05$  from each other.

A decrease in acidity content was also observed in all the packaging material with the increase in storage period from 0-60 days with significant effect at  $p \leq 0.05$ . Similar results have been observed for osmo-vacuum dried pineapple slices up to 2 months duration acidity decreased from 0.300 to 0.290% stored in polypropylene pouch (Expedito *et al.* 1996).

### 4. Reducing sugar

Table 13 shows effect of packaging material and storage duration on reducing sugar content of osmo-microwave vacuum dried pineapple cubes.

The reducing sugar content decreased from 27.48 to 25.83 % and 27.48 to 25.53 % in aluminium foil and Polypropylene pouch respectively. Table 13 shows the ANOVA for change in A reducing sugar content in 60 days storage duration for Osmo- microwave vacuum dried pineapple cubes.

Decrease in reducing sugar content with increase in storage period from 0-60 days is higher in polypropylene pouch than aluminium foil pouch for dried pineapple cubes. This decrease in reducing sugar content with increase in storage duration was significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum reducing sugar is recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the reducing sugar content of the dried pineapple cubes was significant effect at  $p \leq 0.05$ . As the difference between the means of reducing sugar contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has significant effect at  $p \leq 0.05$  from each other.

A decrease in reducing sugar content was also observed in all the packaging material with the increase in storage period from 0-60 days with significant effect at  $p \leq 0.05$ . Similar results have been

observed for osmo-vacuum dried pineapple slices up to 2 months duration reducing sugar decreased from 31.98 to 31.46% stored in polypropylene pouch (Expedito *et al.* 1996).

### 5. Non-Reducing sugar

Table 14 shows effect of packaging material and storage duration on non-reducing sugar content of osmo-microwave vacuum dried pineapple cubes. The non-reducing sugar content decreased from 48.04 to 46.40 % and 48.04 to 46.15 % in aluminium foil and polypropylene pouch respectively. Table 14 shows the ANOVA for change in non-reducing sugar content in 60 days storage duration for Osmo-microwave vacuum dried pineapple cubes.

Decrease in non-reducing sugar content with increase in storage period from 0-60 days is higher in polypropylene pouch than aluminium foil pouch for dried pineapple cubes. This decrease in non-reducing sugar content with increase in storage duration was non significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum non-reducing sugar is recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the non-reducing sugar content of the dried pineapple cubes was non

**Table 13:** Effect of packaging material and storage duration on reducing sugar of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	27.48±0.31 <sup>a</sup>	26.54±0.12 <sup>b</sup>	26.14±0.07 <sup>c</sup>	26.14±0.16 <sup>c</sup>	25.83±0.14 <sup>dc</sup>			
Polypropylene	27.48±0.31 <sup>a</sup>	26.12±0.36 <sup>c</sup>	25.98±0.08 <sup>c</sup>	25.83±0.05 <sup>dc</sup>	25.53±0.25 <sup>d</sup>			
<b>ANOVA</b>								
SE <sub>Material</sub>	0.038048	<b>SV</b>	<b>DF</b>	<b>SS</b>	<b>MSS</b>	<b>F<sub>cal</sub></b>	<b>F<sub>tab</sub> 1%</b>	<b>Result</b>
CD <sub>Material</sub>	0.154884	Duration	4	11.637253	2.9093	133.98	<.0001	Sig at 0.05%
SE <sub>Duration</sub>	0.06016	Material	1	0.427213	0.427213	19.67	0.0003	Sig at 0.05%
CD <sub>Duration</sub>	0.244893	Interaction	4	0.160320	0.040080	1.85	0.1641	
SE <sub>Interaction (M×D)</sub>	0.046599	Replication	2	0.441526	0.220763	10.17	0.0011	
CD <sub>Interaction (M×D)</sub>	0.189693	Error	18	0.390873	0.021715			
		Total	29	13.057186				

Same letter are not significantly different ( $p \leq 0.05$ ).

**Table 14:** Effect of packaging material and storage duration on non-reducing sugar of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	48.04±0.30 <sup>a</sup>	47.38±0.60 <sup>bc</sup>	47.02±0.05 <sup>dc</sup>	46.67±0.25 <sup>de</sup>	46.40±0.19 <sup>def</sup>			
Polypropylene	48.04±0.30 <sup>a</sup>	47.86±0.66 <sup>ba</sup>	46.98±0.16 <sup>dc</sup>	46.02±0.04 <sup>f</sup>	46.15±0.38 <sup>ef</sup>			
<b>ANOVA</b>								
SE <sub>Material</sub>	0.069503	<b>SV</b>	<b>DF</b>	<b>SS</b>	<b>MSS</b>	<b>F<sub>cal</sub></b>	<b>F<sub>tab</sub> 1%</b>	<b>Result</b>
CD <sub>Material</sub>	0.282926	Duration	4	14.419253	3.604813	49.75	<.0001	Sig at 0.05%
SE <sub>Duration</sub>	0.109893	Material	1	0.0616533	0.061653	0.85	0.3685	Sig at 0.05%
CD <sub>Duration</sub>	0.447345	Interaction	4	1.0048800	0.251220	3.47	0.0288	
SE <sub>Interaction (M×D)</sub>	0.085123	Replication	2	0.5411466	0.270573	3.73	0.0440	
CD <sub>Interaction (M×D)</sub>	0.346512	Error	18	1.3042533	0.072458			
		Total	29	17.331186				

Same letter are not significantly different ( $p \leq 0.05$ ).

significant effect at  $p \leq 0.05$ . As the difference between the means of non-reducing sugar contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has non significant effect at  $p \leq 0.05$  from each other.

A decrease in non-reducing sugar content was also observed in all the packaging material with the increase in storage period from 0-60 days with non significant effect at  $p \leq 0.05$ . Similar results have been observed for osmo-vacuum dried pineapple slices up to 2 months duration non-reducing sugar decreased stored in polypropylene pouch (Expedito *et al.* 1996).

## 6. Total sugar

Table 15 shows effect of packaging material and storage duration on total sugar content of osmo-microwave vacuum dried pineapple cubes. The total sugar content decreased from 75.53 to 72.23 % and 75.53 to 71.68 %, in aluminium foil and polypropylene pouch respectively. Table 15 shows the ANOVA for change in total sugar content in 60 days storage duration for osmo-microwave vacuum dried pineapple cubes.

Decrease in total sugar content with increase in storage period from 0-60 days is higher in

polypropylene pouch than aluminium foil pouch for dried pineapple cubes. This decrease in total sugar content with increase in storage duration was significant effect at  $p \leq 0.05$  for dried pineapple cubes. Maximum total sugar was recorded at 0 days which was significantly higher than other days; all the day intervals are significantly different for dried pineapple cubes. The effect of packaging materials and storage durations on the total sugar content of the dried pineapple cubes was significant effect at  $p \leq 0.05$ . As the difference between the means of total sugar contents of dried pineapple cubes at all the interval for polypropylene pouch, and aluminium foil pouch was higher than CD and has significant effect at  $p \leq 0.05$  from each other.

A decrease in total sugar content was also observed in all the packaging material with the increase in storage period from 0-60 days with significant effect at  $p \leq 0.05$ . Similar results have been observed for osmo-vacuum dried pineapple slices up to 2 months duration total sugar decreased from 49.43 to 48.89 stored in polypropylene pouch (Expedito *et al.* 1996).

## Sensory evaluation of osmo-microwave vacuum dried pineapple cubes stored in packaging material.

This osmo-microwave vacuum dried pineapple cubes stored in two different packaging material aluminium

**Table 15:** Effect of packaging material and storage duration on total sugar of dried pineapple cubes

Packaging material	Storage Duration (Days)							
	0	15	30	45	60			
Aluminium	75.53±0.58 <sup>a</sup>	73.92±0.14 <sup>b</sup>	73.16±0.07 <sup>c</sup>	72.81±0.09 <sup>c</sup>	72.23±0.09 <sup>d</sup>			
Polypropylene	75.53±0.58 <sup>a</sup>	73.98±0.32 <sup>b</sup>	72.96±0.09 <sup>c</sup>	71.86±0.06 <sup>cd</sup>	71.68±0.13 <sup>c</sup>			
<b>ANOVA</b>								
SE <sub>Material</sub>	0.059196	<b>SV</b>	<b>DF</b>	<b>SS</b>	<b>MSS</b>	<b>F<sub>cal</sub></b>	<b>F<sub>tab</sub> 1%</b>	<b>Result</b>
CD <sub>Material</sub>	0.24097	Duration	4	48.934746	12.233686	232.75	<.0001	Sig at 0.05%
SE <sub>Duration</sub>	0.093597	Material	1	0.8134533	0.8134533	15.48	0.0010	Sig at 0.05%
CD <sub>Duration</sub>	0.381007	Interaction	4	1.0623466	0.2655866	5.05	0.0066	
SE <sub>Interaction (M×D)</sub>	0.0725	Replication	2	0.0050866	0.0025433	0.05	0.9529	
CD <sub>Interaction (M×D)</sub>	0.295126	Error	18	0.9461133	0.0525618			
		Total	29	51.761746				

Same letter are not significantly different ( $p \leq 0.05$ ).

and polypropylene for 60 days. Sensory evaluation of the osmo-microwave vacuum dried pineapple cubes stored in aluminium and polypropylene pouch shown in Table 16. Overall score of sensory characteristics ranged from 7.0 to 8.2. Increase in sugar concentration increased the sensory score. Maximum acceptability was observed either at the maximum level of sugar concentration and vice versa. The sensory analysis of Osmo-microwave vacuum dried pineapple cubes indicated that the overall acceptability of the dried pineapple cubes were highest at (sample code 'D') aluminium pouch at which the colour, texture, taste, flavour and overall acceptability was 7.5, 7.0, 8.2, 7.5 and 8.0 respectively. Table 17 shows the ANOVA for the sensory analysis of the scores obtained for osmo-microwave vacuum dried pineapple cubes at each treatment combinations. All the sensory scores was significantly different at  $p \leq 0.05$ .

Although the quality of stored samples decreased, osmotically dehydrated pineapple slices by osmo-vacuum dried was still acceptable since it scored above 6 on a hedonic scale of 1 to 9. Thus, osmo-vacuum dried pineapple product can be stored in a polypropylene pouches at ambient conditions for at least 2 months (Expedito *et al.* 1996).

#### Nutritional quality and optimization of best packaging material

The Packaging and storage study of osmo-microwave vacuum dried pineapple cubes indicated that the pineapple cubes can be stored in good condition in aluminium pouch packaging material up to 60 days; The sensory scores were colour 7.5, texture 7.0, taste 8.2, flavour 7.5 and overall acceptability 8.0; The nutritional retention was TSS 32.22%, pH 3.97, acidity 0.503%, reducing sugar 25.83%, non reducing sugar 46.40% and total sugar 72.23%.

#### CONCLUSION

The Packaging and storage study of Osmo-convective dried pineapple cubes indicated that the pineapple cubes can be stored in good condition in aluminium pouch packaging material up to 60 days; The sensory scores were colour 6.8, texture 8.2, taste 8.2, flavor 6.5 and overall acceptability 8.2; The nutritional retention was TSS 31.85%, pH 4.02, acidity 0.579%, reducing sugar 18.82%, non reducing sugar 42.86% and total sugar 61.67%.

The Packaging and storage study of osmo-microwave vacuum dried pineapple cubes indicated that the pineapple cubes can be stored in good condition

**Table 16:** Sensory Evaluation of osmo-microwave vacuum dried pineapple cubes stored at 0 days to 60 days stored in polypropylene and aluminium packaging material

Polypropylene (C)					
Duration	Sensory parameters score (out of 9)				
	Colour (9)	Texture (9)	Taste (9)	Flavour (9)	Overall Acceptability (9)
0 days	6.6	6.7	6.3	6.3	6.6
15 days	6.6	6.2	6.3	6.8	6.8
30 days	6.9	6.9	6.7	7.2	7.1
45 days	6.3	6.1	6.0	5.9	6.4
60 days	7.0	6.5	7.8	6.8	8.5
Aluminium foil (D)					
Duration	Sensory parameters score (out of 9)				
	Colour (9)	Texture (9)	Taste (9)	Flavour (9)	Overall Acceptability (9)
0 days	8.3	8.1	8.0	8.1	8.3
15 days	8.5	8.2	8.1	8.3	8.5
30 days	8.2	8.4	8.3	8.3	8.3
45 days	7.9	8.0	7.9	7.9	8.2
60 days	7.5	7.0	8.2	7.5	8.0

**Table 17:** ANOVA for Sensory Evaluation of Osmo-microwave vacuum dried pineapple cubes stored at 0 days to 60 days stored in polypropylene and aluminium packaging material

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	30.2432	9	3.360356	17.37915	1.28E-10	2.152607
Columns	0.4432	4	0.1108	0.573038	0.683919	2.633532
Error	6.9608	36	0.193356			
Total	37.6472	49				

in aluminium pouch packaging material up to 60 days; The sensory scores were colour 7.5, texture 7.0, taste 8.2, flavour 7.5 and overall acceptability 8.0; The nutritional retention was TSS 32.22%, pH 3.97, acidity 0.503%, reducing sugar 25.83%, non reducing sugar 46.40% and total sugar 72.23%.

#### References

- Basantia, N.C., Arora, S., Seth, R. and Singh, A. 2000. Milk proteins in the preparation of edible coatings. *Indian Food Industry*, **19**: 36–47.
- Bautisa-Baños, S., Sivakumar, D., Bello-Pérez, A., Villanueva-Arce, R. and Hernández-López, M. 2013. A review of the management alternatives for controlling fungi on papaya fruit during the postharvest supply chain. *Crop Protection*, **49**: 8–20.
- Bignardi, B., Lupi, D., Scalzo,, Mastrelli, A., Torreggiani, D. 2000. Partial removal of water before freezing to obtain quality frozen cantaloupe melon balls. u: Congress Osmotic treatment in food processing EU-FAIR concerted action CT) &-1118 Improvement of overall food quality by application of osmotic treatments in conventional and new process, 23-24 June.
- Dak, M., Sagar, V.R. and Jha, S.K. 2014. Shelf-life and kinetics of quality change of dried pomegranate arils in flexible packaging. *Food Packaging and Shelf Life*, **2**: 1–6.
- Daramola O.A., Idowu M.A., Atanda O.O. and C.R.B. Oguntona. 2010. Effects of packaging material on the quality of pupuru flour during storage. *African Journal of Food Science*, **4**(5): 258-263.
- Drouzas, A.E., Tsami, E. and Saravacos, G.D. 1999. Microwave/ vacuum drying of model fruit gels. *Journal of Food Engineering*, **39**: 117-122.

- Expedito, T.F. Silveira, M. Shafiur Rahman and Ken A. Buckle, 1996. Osmotic dehydration of pineapple: kinetics and product quality, *Food Research International*, **29**(34): 2272-233.
- Hossain Md. Farid, Shaheen Akhtar and Mustafa Anwar. 2015. Nutritional Value and Medicinal Benefits of Pineapple *International Journal of Nutrition and Food Sciences*, **4**(1): 84-88
- Hymavathi, T.V. and Khader, V. 2005. Carotene, ascorbic acid and sugar content of vacuum dehydrated ripe mango powders stored in flexible packaging material. *Journal of Food Composition and Analysis*, **18**: 181-192.
- Jay, J.M. 1991. Intrinsic and extrinsic parameters of foods that affect microbial growth. In *Modern food microbiology* (pp. 45). New York: Chapman & Hall.
- Kumar, A.J., Singh, R.R.B., Patil, G.R. and Patel, A.A. 2008. Effect of temperature on moisture desorption isotherms of kheer. *Food Science and Technology*, **38**(3): 303-310.
- Lavelli, V. and Vantaggi, C. 2009. Rate of antioxidant degradation and color variations in dehydrated apples as related to water activity. *Journal of Agriculture and Food Chemistry*, **57**: 4733-4738.
- Ledward, D.A. 1981. Intermediate moisture meats. In R. A. Lawrie (Ed.), *Developments in meat science*, Vol. 2 (pp. 159-194). England: *Applied Sciences Publisher Ltd*.
- Mishra A., Bapat, M.M., Tilak, J.C. and Devasagayam, P.A. 2000. Antioxidant activity of *Garcinia Indica* (Kokum) and its syrup. *Current Science*, **91**(1).
- Nsonzi, 2001. Influence of osmotic concentration, continuous high frequency ultrasound and dehydration on antioxidants, colour and chemical properties of rabbiteye blueberries. *Food Chemistry*, **101**: 898-906.
- Otegbayo, B.O., Samuel, F.O. and Alalade, T. 2013. Functional properties of soy-enriched tapioca. *African Journal of Biotechnology*, **12**(22): 3583- 3589.
- Pua, C.K., Hamid, N.S. Abd., Tan, C.P., Mirhosseini, H., Rahman, R. Abd. and Rusul, G. 2008. Storage stability of jackfruit (*Artocarpus heterophyllus*) powder packaged in aluminium laminated polyethylene and metallized co-extruded biaxially oriented polypropylene during storage. *Journal of Food Engineering*, **89**: 419-428.
- Rahman, M.S. and Perera, C.O. 1999. Drying and food preservation. In: M. S. Rahman (Ed.), *Handbook of food preservation* (pp. 173- 216). New York: Marcel Dekker.
- Raoult-Wack, A.L. 1994. Advances in osmotic dehydration. *Trends in Food Science and Technology*, **5**: 255-260.
- Rashmi, H.B., Doreyappa Gowda, I.N. and Mukanda, G.K. 2005. Studies on osmo-air dehydration of pineapple fruits. *Journal Food Science Technology*, **42**: 64-67.
- Sagar, K. and Khudria. 1998. Osmotic dehydration of mango, *Journal of food science Engineering*, pp. 527-529.
- Silveira, E.T.F., Rahman, M.S. and Buckle, K. 1996. Osmotic dehydration of pineapple: kinetics and product quality. *Food Research International*, **29**(3-4): 227-233.
- Silveria, T.F., Shafiru Rahman, M. and Ken A. Buckle. 1987. Osmotic dehydration of pineapple; Kinetics and product quality. *Food Research International*, **29**: 227-233.
- Thakur, B.R. and Singh, R.K. 1995. Combination processes in food irradiation. *Trends in Food Science & Technology*, **6**: 7-11.
- Torreggiani, D. 1993. Osmotic dehydration in fruit and vegetable processing. *Food Research International*, **26**: 59-68.

