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Effect of Storage Period with Different Packaging Materials on Physico Chemical Parameters and Shelf Life of Osmotically Dehydrated Pineapple Cubes (*Ananas comosus. var. Queen*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present study was carried out to determine the suitable packaging material for osmo dehydrated pineapple product and also to assess quality of the product during storage. Pineapple slices were steam blanched for 2 min, followed by immersion in osmotic solution containing sucrose syrup of three concentrations *i.e* of 50°Brix, 60ºBrix and 70°Brix in combination with 0.1% KMS + 0.3% citric acid + 0.1 % sodium benzoate followed by drying in two methods i.e. cabinet tray drying and hot air oven drying at 60ºC until the moisture content of the product attained equilibrium. The physico-chemical properties and evaluated for the four months of storage period. During storage period, moisture%, reducing sugars and pH showed an increasing trend while other parameters like TSS ºBrix, non-reducing sugars %, total sugars%, acidity%, ascorbic acid%, organoleptic properties showed a decreasing trend. Among the packaging materials, osmo-dehydrated pineapple cubes packed in Aluminum laminated polyethylene of 200 gauge stored at ambient temperature were found to be the best followed by high density polyethylene packaging of 200 gauge in retaining various attributes like minimal moisture gain, better retention of TSS ºBrix, acidity%, ascorbic acid% and organoleptic properties when compared to the other packaging material during the four months storage period.

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1. INTRODUCTION

Fruits and vegetables play an significant role in human nutrition as they are supplying complex carbohydrates and proteins, essential minerals, vitamins and dietary fiber [1]. Pineapple (*Ananas comosus* (L.) *Merr*.) is one of the commercially important temperate fruit crops of tropical world with edible multiple fruit consisting of coalesced berries, and the most economically significant plant in the *Bromeliaceae* family. Pineapples may be cultivated from a crown cutting of the fruit, possibly flowering in 20–24 months and fruiting in the following six months. The main producer countries reported are Brazil, Philippines, Costa Rica, Thailand and China. Pineapple fruit accepted by majority of consumers around the world, mainly due to its sensory characteristics, pleasant flavour, distinct aroma, taste and absence of seeds. Furthermore, this fruit contains a proteolytic enzyme called bromelin, which aids in reducing inflammations and also contributes to good digestion. The major pineapple producing states in India are West Bengal, Assam, Karnataka, Tripura, Bihar, Manipur, Meghalaya, Nagaland, Kerala, Arunachal Pradesh, Goa, Jharkhand, Madhya Pradesh, Odisha, Sikkim, Tamil Nadu and Uttarakhand. The aim of this study is to enhance the shelf life of the Pineapple by processing it into a value added dry fruit chunks by using Osmo solar dehydration technology which can be rehydrated and used in fruit salads, laddus, bakery and confectionary items. Though pineapple is having a better post-harvest life, but during the glut season the growers are forced to sell the produce at meager price since the small farmers cannot afford to produce processed forms either canned slices or juice due to higher in processing cost. Value addition has become the watchword as it involves processing and preservation of the commodities which otherwise get disposed at cheaper price or lost without intellectual and technical inputs. In order to prevent losses, avoid gluts in the season and to ensure optimum utilization, it is required to subject these perishables for processing into more stable value-added products. Osmotic dehydration is a simpler preservation technique that does not require any sophisticated equipment. It is a process that entails the partial removal of water from fruits which is based on a tendency to reach equilibrium between osmotic pressure inside the biological cells (fruit) and the surrounding osmotic solution, which has an increased osmotic pressure caused by high concentration of soluble osmotic agent. Unlike conventional drying processes, osmotic dehydration does not produce a stable product and as such further steps like drying, freezing, pasteurization, canning and frying, or the addition of preservatives are needed [2]. Therefore, storage stability of osmotically pre-treated products needs to be evaluated critically in order to ensure microbial safety of such products. Therefore, the present work was carried out to evaluate the stability of osmotically pre-treated and subsequently vacuum dried pineapple cubes using three different types of packaging materials on storage.

2. MATERIALS AND METHODS

The present study was conducted at Post harvest Laboratory, department of Fruit science at college of Horticulture, Rajendranagar, Hyderabad, SKLTSHU during the year 2017-2018. Pineapple (*Ananas comosus* L.) cv. queen fruits of commercial maturity were collected from gudimalkapoor market, Hyderabad. The fruits, after receiving in the laboratory, were crowned and washed thoroughly in running tap water and air-dried to remove the surface moisture. They were then manually peeled and cored. The prepared fruits were then cut in to cubes measuring 10 ± 0.5 mm^3 using a sharp knife from the central portion of fruit. The cut surfaces of the cubes were blotted gently with a tissue paper to remove the surface moisture before the osmotic treatment. Three different concentrations of sugar syrup i.e. 50, 60 and 70°Brix were prepared. One kg of sucrose and one kg of water were used to prepare 50°Brix sucrose syrup concentration, 1.2 kg of sucrose and 0.8 kg of water were mixed to prepare 60°Brix sucrose syrup concentration and also 1.4 kg of sucrose and 0.6 kg of water were used to prepare 70°Brix sucrose syrup concentration as fruit pieces to sucrose syrup ratio was 1:2 [3] (Noroes et al. 2010). During heating of the sucrose syrup solution, 0.3% per cent of citric acid was added. After adjusting the concentration of sucrose syrup, 0.1% of potassium metabisulphite (KMS) and 0.1% Sodium benzoate was added as preservative in sucrose syrup in dissolved form when the syrup got cooled [4]. The prepared fruit pieces were put in sucrose syrup solution and left for 24 h for osmosis. After 24h, the fruit pieces were drained out of the osmotic solution. Osmosed pineapple cubes were drained and loaded uniformly over stainless steel trays .Before loading, the cubes are shade dried to avoid browning. Inner and bottom of the tray was wiped with glycerin to avoid metal contact. Loaded stainless steel trays were kept in a cabinet tray drier (Ultra Fabtech) and hot air oven (Vista Biocell) for dehydration with intermittent turning of cubes for quick drying. Fruit pieces were dried at 60°C temperature until constant weight is obtained. Dried cubes under each treatment were inspected and the small bits and inferior cubes were discarded before packaging. The dehydrated pineapple cubes were packed in Aluminium laminated polyethylene of 200 gauge & High density polyethylene packaging of 200 gauge and were sealed. The packages were stored under ambient temperature respectively for 4 months. Three treatments i.e. Sucrose concentration 60ºBrix. + cabinet tray drying, Sucrose concentration 60ºBrix. + hot air oven drying and Sucrose concentration 70ºBrix. + cabinet tray drying were choosen for experiment for storage in different packaging material. These treatments were packed in two different packaging materials (High density polyethylene packaging of 200 gauge and Aluminum laminated polyethylene packaging of 200 gauge) storage at ambient temperature. This experiment was carried out in complete randomized design withfour replication. The data was recorded on TSS (°brix), Reducing sugars (%), Non reducing sugars (%), Total sugars (%), Acidity (%), pH, Ascorbic acid (mg /100g-¹) and Moisture (%).

2.1 Treatment Combinations

T_1C_1- Sucrose concentration 60ºBrix. + Cabinet tray drying + Aluminum laminated polyethylene of 200 gauge.

T_1C_2- Sucrose concentration 60ºBrix. + Cabinet tray drying + High density polyethylene packaging of 200 gauge.

T_2C_1- Sucrose concentration 60ºBrix. + Hot air oven drying + Aluminum laminated polyethylene of 200 gauge.

T_2C_2- Sucrose concentration 60ºBrix. + Hot air oven drying + High density polyethylene packaging of 200 gauge.

T_3C_1- Sucrose concentration 70ºBrix. + Cabinet tray drying + Aluminum laminated polyethylene of 200 gauge.

T_3C_2- Sucrose concentration 70ºBrix. + Cabinet tray drying + High density polyethylene packaging of 200 gauge.

3. RESULTS AND DISCUSSION

3.1 TSS (^{0}Brix)

Among the treatments, the highest mean TSS (74.49^{0}Brix) was observed in T_3C_1- osmodehydrated cubes packed in aluminum laminated polyethylene of 200 gauge covers stored at ambient temperature (25°C±2°C) followed by T_3C_2- osmodehydrated cubes packed in High density polyethylene packaging of 200 gauge(73.24^{0}Brix). Whereas, the lowest mean TSS was observed in T_1C_2 (67.44^{0}Brix) As the storage period increased there was a continuous significant decline in mean TSS (^{0}Brix) from the initial to fourth month storage irrespective of the treatments. There were significant differences among treatments with respect to the TSS (^{0}Brix) and the duration of storage. With any given treatment, the TSS (^{0}Brix) decreased significantly till fourth month (Table 1). The results of the present investigation reveals that osmo-dehydrated pineapple cubes packed in aluminum laminated polyethylene of 200 gauge have retained maximum TSS (^{0}Brix) during storage as compared to osmodehydrated cubes packed in high density polyethylene packaging of 200 gauge bags. The TSS (^{0}Brix) content of dehydrated pineapple cubes decreased during the storage. As a result of increase in moisture content the TSS decreased during storage which might be due to the hygroscopic nature of dried product and permeability characteristics of the packaging materials. The similar findings was reported by Patel et al. [5] in Aonla.

3.2 Reducing Sugars (%)

On first and second month of storage, the highest reducing sugar was observed in treatment T_1C_1 (35.48%, 36.82%) followed by T_1C_2 (34.83%, 36.09%). On the third month of storage the highest reducing sugars was also observed in treatment T_1C_1 (37.46%) followed by T_1C_2 (37.05%) and T_2C_1 (36.85%) over the other treatments. On the fourth month of storage the highest reducing sugars was observed in treatment T_3C_1 (39.79%) followed by T_1C_1 (39.75%). While on first and second month of storage the lowest mean reducing sugars was observed in T_3C_2 (32.61%, 34.63%) followed by T_3C_1 (33.35 %and 35.25%) respectively. In third and fourth month of storage the lowest mean reducing sugars was observed in T_3C_1 (34.16%) and T_2C_2 (38.17%) respectively (Table 2). The results of the present investigation reveals that osmo-dehydrated pineapple cubes packed in aluminum laminated polyethylene of 200 gauge have retained maximum reducing sugars during storage as compared to High density polyethylene packaging of 200 gauge bags. The reducing sugar content of dehydrated pineapple cubes increased during the storage. These results was similar to the findings of Patel et al. [5] in Aonla.

3.3 Non Reducing Sugars (%)

On first and second month of storage, the highest non-reducing sugar (%) was observed in treatment T_3C_1 (39.82%, 36.52%) followed by T_3C_2 (39.40%, 36.32%). On the third month of storage the highest non-reducingsugars (%) was observed in treatment T_3C_1 (36.32%) followed by T_3C_2 (34.99) over the other treatments (Table 3). On the fourth month of storage the highest non-reducingsugars (%) was observed in treatment T_3C_1 (29.62%) which was on par with T_3C_2 (28.82%). While on first, secondmonth of storage the lowest mean non-reducing sugars (%)was observed in T_2C_1 (30.97%, 28.96%) respectively followed by T_2C_2 (31.06%, 28.99%) while in third and fourth month of storage the lowest mean non- reducing sugars (%). The results of the present investigation reveals that osmo-dehydrated pineapple cubes packed in aluminium laminated polyethylene of 200 gauge have retained maximum non reducing sugars during storage as compared to High density polyethylene packaging of 200 gauge bags. These results was in conformity with the findings of Patel et al. [5] in Aonla.

3.4 Total Sugars

On first, second, third and fourth month of storage, the highest total sugars (%) was observed in treatment T_3C_1 (72.75, 71.58, 70.81 and 68.62 %) followed by T_3C_2 (72.44, 71.16, 70.32, 68.15%). While on first, second, third and fourth month of storage the lowest mean total sugars (%) was observed in T_2C_2 (65.19, 64.24, 63.29 and 62.16%) followed by T_2C_1 (65.74, 64.80, 63.84 and 62.46%) respectively (Table 4). With increase in the storage period, there was a significant decrease in the total sugars in all the treatments. The results in the present investigation reveals that osmo-dehydrated pineapple cubes packed in aluminium laminated polyethylene of 200 gauge have retained maximum total sugars (%) during storage as compared to high density polyethylene packaging 200 of gauge bags upto four months of storage. This was supported by the findings Giraldo et al. [6] in mango, and Paul et al. [7] in pineapple.

3.5 Acidity (%)

On all the days of storage T_1C_1 recorded the highest acidity (%) (1.61, 1.50, 1.49 and 1.44%) followed by T_2C_1 recorded the (1.56, 1.47, 1.44 and 1.41 %). Lowest values for acidity (%) was recorded in T_1C_2 (1.32%) during first month, T_2C_2 (1.31%) during second month, T_3C_2 (1.29%) during third month and T_2C_2 (1.25) during fourth month respectively (Table 5). The results of the present investigation reveals that osmo-dehydrated pineapple cubes packed in aluminium laminated polyethylene of 200 gauge have retained maximum acidity (%) during storage as compared to high density polyethylene packaging of 200 gauge bags upto four months of storage. There is a decline in acidity during storage this might be due to leaching of acid from fruits The similar results was also recorded by Patel et al. [5] in aonla.

3.6 P^H

On the first month of storage T_3C_1recorded the highest P^H (3.67) followed by T_3C_2 (3.60), while T_1C_2recorded the lowest P^H (3.23). On the second month of storage T_3C_1recorded the highest P^H (3.73) which was followed byT_1C_1 (3.71), T_2C_1 (3.68) and T_3C_2 (3.64), T_1C_2 (3.55) while T_2C_2 recorded the lowest P^H (3.38). On the third month of storage T_3C_1recorded the highest P^H (3.858) which was followed by T_1C_1 (3.770), T_2C_1 (3.76), andT_1C_2 (3.75) while T_2C_2recorded the lowest P^H (3.50). On the fourth month of storage T_3C_1 recorded the highest P^H (3.89) followed byT_1C_1 (3.84), T_2C_1 (3.81) and T_3C_2 (3.74), while T_2C_2 recorded the lowest P^H (3.60) (Table 6). The results in the present investigation reveals that osmo-dehydrated pineapple cubes packed in aluminium laminated polyethylene of 200 gauges have retained better pH during storage as compared to high density polyethylene packaging of 200 gauge bags upto four months of storage. This may be due to decrease in acidity and also increase in moisture level during the storage. Similar type of observations was recorded by Kumar [8] in osmo-dehydrated carrot slices and Patel et al. [5] in aonla.

Table 1. Effect of packaging materials on total soluble solids (TSS °Brix) of osmo - dehydrated pineapple cubes during storage

Treatments	Storage period (months)			
	1	2	3	4
$T_1 C_1$	69.030	68.798	67.833	65.780
$T_1 C_2$	67.443	66.733	66.070	65.240
$T_2 C_1$	68.493	68.138	66.728	65.020
$T_2 C_2$	67.508	66.480	65.985	65.000
$T_3 C_1$	74.490	74.433	73.895	72.798
$T_3 C_2$	73.235	72.520	73.253	72.443
C.D. at 5 %	2.461	3.756	3.962	3.558
S.Em. ±	0.822	1.256	1.323	1.188
CV%	2.347	3.609	3.838	3.510

Table 2. Effect of packaging materials on reducing sugars of osmo - dehydrated pineapple cubes during storage

Treatments	Storage period (months)			
	1	2	3	4
$T_1 C_1$	35.488	36.823	37.468	39.755
$T_1 C_2$	34.828	36.095	37.048	39.305
$T_2 C_1$	34.683	35.818	36.845	38.775
$T_2 C_2$	34.223	35.270	36.128	38.178
$T_3 C_1$	33.350	35.253	34.160	39.790
$T_3 C_2$	32.613	34.633	35.330	38.528
C.D. at 5 %	1.182	1.198	2.070	1.188
S.Em. ±	0.395	0.650	0.691	0.680
CV%	2.308	3.649	3.824	3.481

Table 3. Effect of packaging materials on non-reducing sugars of osmo - dehydrated pineapple cubes during storage

Treatments	Storage period (months)			
	1	2	3	4
$T_1 C_1$	32.425	30.60	28.078	24.850
$T_1 C_2$	32.133	30.00	28.143	24.900
$T_2 C_1$	30.970	28.96	27.165	23.985
$T_2 C_2$	31.065	28.99	26.995	23.685
$T_3 C_1$	39.828	36.65	36.32	29.620
$T_3 C_2$	39.400	36.52	34.993	28.825
C.D. at 5 %	1.229	1.714	1.767	1.375
S.Em. ±	0.410	0.572	0.590	0.459
CV%	2.393	3.582	3.897	3.532

Table 4. Effect of packaging materials on total sugars of osmo - dehydrated pineapple cubes during storage

Treatments	Storage period (months)			
	1	2	3	4
$T_1 C_1$	67.620	66.822	65.608	64.660
$T_1 C_2$	67.253	66.698	65.115	64.155
$T_2 C_1$	65.748	64.808	63.840	62.460
$T_2 C_2$	65.193	64.238	63.293	62.163
$T_3 C_1$	72.750	71.580	70.810	68.615
$T_3 C_2$	72.440	71.158	70.322	68.148
C.D. at 5 %	2.408	3.651	3.328	3.408
S.Em. ±	0.804	1.219	1.278	1.138
CV%	2.348	3.610	3.845	3.501

Table 5. Effect of packaging materials on acidity of osmo - dehydrated pineapple cubes during storage

Treatments	Storage period (months)			
	1	2	3	4
$T_1 C_1$	1.613	1.500	1.495	1.440
$T_1 C_2$	1.320	1.353	1.315	1.253
$T_2 C_1$	1.558	1.475	1.440	1.413
$T_2 C_2$	1.450	1.310	1.298	1.245
$T_3 C_1$	1.443	1.398	1.320	1.248
$T_3 C_2$	1.390	1.323	1.288	1.250
C.D. at 5 %	0.051	0.075	0.075	0.066
S.Em. ±	0.017	0.025	0.025	0.022
CV%	2.308	3.610	3.685	3.353

Table 6. Effect of packaging materials on P^H of osmo - dehydrated pineapple cubes during storage

Treatments	Storage period (months)			
	1	2	3	4
$T_1 C_1$	3.560	3.718	3.723	3.783
$T_1 C_2$	3.323	3.555	3.608	3.635
$T_2 C_1$	3.598	3.683	3.513	3.775
$T_2 C_2$	3.518	3.383	3.663	3.555
$T_3 C_1$	3.668	3.735	3.788	3.768
$T_3 C_2$	3.598	3.653	3.783	3.633
C.D. at 5 %	0.125	0.115	0.109	0.119
S.Em. ±	0.042	0.065	0.070	0.064
CV%	2.363	3.606	3.812	3.441

Table 7. Effect of packaging materials on ascorbic acid of osmo - dehydrated pineapple cubes during storage

Treatments	Storage period (months)			
	1	2	3	4
$T_1 C_1$	29.338	27.350	25.605	22.838
$T_1 C_2$	29.223	27.073	25.170	22.113
$T_2 C_1$	28.800	25.665	24.565	21.188
$T_2 C_2$	28.468	25.550	24.205	20.515
$T_3 C_1$	26.043	23.363	21.633	18.343
$T_3 C_2$	24.148	21.753	19.645	17.440
C.D. at 5 %	0.951	1.386	1.328	1.049
S.Em. ±	0.318	0.463	0.444	0.350
CV%	2.297	3.684	3.780	3.433

Table 8. Effect of packaging materials on moisture of osmo - dehydrated pineapple cubes during storage

Treatments	Storage period (months)			
	1	2	3	4
$T_1 C_1$	12.428	12.750	12.165	13.108
$T_1 C_2$	12.548	12.838	12.755	13.713
$T_2 C_1$	12.633	12.713	12.968	13.565
$T_2 C_2$	12.728	12.900	13.415	13.853
$T_3 C_1$	12.405	13.175	13.215	13.895
$T_3 C_2$	12.638	13.920	13.565	14.230
C.D. at 5 %	0.653	0.713	0.753	0.703
S.Em. ±	0.146	0.238	0.251	0.242
CV%	2.329	3.652	3.862	3.524

3.7 Ascorbic Acid (%)

On the first month of storage T_1C_1 recorded the highest ascorbic acid (%) (29.33%) followed by T_1C_2 (29.22%), while T_3C_2 recorded the lowest ascorbic acid (%) (24.14%). On the second month of storage T_1C_1 recorded the highest ascorbic acid (%) (27.35%) followed byT_1C_2 (27.07), T_2C_1 (25.66%) and T_2C_2 (25.55%), while T_3C_2 recorded the lowest ascorbic acid(%) (21.75%). On the third month of storage T_1C_1 recorded the highest ascorbic acid (%) (25.06%) followed by T_1C_2 (25.17%), T_2C_1 (24.56%) and T_2C_2 (24.20), while T_3C_2 recorded the lowest ascorbic acid (%) (19.64%). On the fourth month of storage T_1C_1 recorded the highest ascorbic acid (%) (22.83%) which followed by T_1C_2 (22.11), T_2C_1 (21.18%) and T_2C_2 (20.51%), while T_3C_2 recorded the lowest ascorbic acid (%) (17.44%) (Table 7). The results in the present investigation reveals that osmo-dehydrated pineapple cubes packed in aluminium laminated polyethylene of 200 gauges have retained maximum ascorbic acid (%) during storage as compared to High density polyethylene packaging of 200 gauge bags upto four months of storage this may be due to leaching of ascorbic acid in hypertonic solution also plays a little role in loss of ascorbic acid. A similar finding was recorded by Rashmi et al. [3] and Surabhi et al. [9] in osmo-dehydrated pineapple slices.

3.8 Moisture Content

On the first month of storage T_2C_2recorded the highest moisture content (12.72%) followed by T_3C_2 (12.63%), while T_1C_1recorded the lowest moisture content (12.42%). On the second month of storage T_3C_2recorded the highest moisture content (13.92%) followed by T_3C_1 (13.17%), T_2C_2 (12.90%) and T_1C_2 (12.83%), while T_2C_1recorded the lowest moisture content (12.71%). On the third month of storage T_3C_2recorded the highest moisture content (13.56%) followed by T_2C_2 (13.41%), T_3C_1 (13.21%) and T_2C_1 (12.96%), while T_1C_1 recorded the lowest moisture content (12.16%). On the fourth month of storage T_3C_2recorded the highest moisture content (14.23%) followed by T_3C_1 (13.89%), T_2C_2 (13.85%) and T_2C_1 (13.56%), while T_1C_1 recorded the lowest moisture content (13.10%) (Table 8). The results of the present investigation reveals that osmo-dehydrated pineapple cubes packed in aluminum laminated polyethylene of 200 gauges have retained less moisture content (%) during storage as compared to High density polyethylene packaging of 200 gauge bags up to four months of storage. Moisture content exhibited an increasing trend with increase in storage period. The changes in moisture content may be due to differences in water vapour permeability of the packaging film and aluminum foil having very low water vapour transmission rate. The increase moisture content might be due to the higher relative humidity that was absorbed by the fruit slices during storage period. Similar findings was reported in dehydrated apple rings by Ahsan et al. [10] and Saji et al. [11].

4. CONCLUSION

Among the packaging materials, osmo-dehydrated pineapple cubes packed in aluminum laminated polyethylene packaging of 200 gauge were found to be the best in retaining various attributes like minimal moisture gain, better retention of TSS ºBrix, acidity %, ascorbic acid %, and organoleptic properties. Thus it can be concluded that Osmo dehydrated pineapple packed in aluminium pouch is best in shelf stability for a period of 6 months.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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