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Quality changes in osmotically dehydrated pineapple as influenced by fructose syrup

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Abstract
The main cause of perishability of fruits and vegetables are their high water content. Osmotic dehydration is one of the best and suitable method to increase the shelf life of fruits and vegetables. This process is preferred over others due to their vitamin and minerals, color, flavor and taste retention property. In the present study, influence of osmotic dehydration on the physic-chemical and sensory attributes of pineapple has been investigated. The results revealed that osmotically dehydrated pineapple slices using sucrose (60 °Brix) showed the highest amount of reducing sugars (41.48%) and total sugars (68.49%). Even after two months of storage, it maintained higher values for reducing sugars (42.70%) and total sugars (67.01%). However the treatment T3 (Fructose 60 °Brix) obtained the higher sensory scores for colour (26.88), texture (26.75), flavour (36.50) and overall acceptability (93.31) after two months of storage hence making it the most desirable treatment for osmotic dehydration of pineapple.

Keywords: Osmotically dehydrated pineapple, influenced, fructose syrup

Introduction
Pineapple (*Ananas comosus*) is an important fruit crop originated from tropical America and belongs to family Bromeliaceae. Many studies have suggested that increasing consumption of plant foods like pineapples decreases the risk of obesity, overall mortality, diabetes, and heart disease. It also promotes a healthy complexion and hair, increased energy, and an overall lower weight. It is a rich source of Vit-C, carotenoids, calcium and magnesium. In Central and South America, pineapple is not only valued for its sweet taste, it has been used for centuries to treat digestion problems and inflammation. According to FAOSTAT, pineapple covers an area of about 89000 hectares with an annual production of 1.9 M tonnes in India. In appearance, the plant has a short, stocky stem with tough, waxy leaves. When creating its fruit, it usually produces up to 200 flowers. Once it flowers, the individual fruits of the flowers join together to create a multiple fruit. Pineapples do not ripen significantly after harvest. The pineapple carries out CAM photosynthesis, fixing carbon dioxide at night and storing it as the acid malate, then releasing it during the day aiding photosynthesis (Coppens and Leal, 2003) [4].

Osmotic dehydration 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 (Nazaneen *et al.*, 2017) [15]. This process involves placing solid food, whole or in pieces in sugar or salt aqueous solution of high osmotic pressure which removes 30–50% of the water from fresh ripe fruits such as mango, pineapple, sapota, papaya, guava and jackfruit (Lewicki and Lenart 1995) [13]. Its main advantages are: inhibition of ezymatic browning; retention of natural colour without addition of sulphites; higher retention of volatile compounds during further dehydration; and no phase change involved and therefore, less energy consumed. The process has been studied in apples (Farkas & Lazar, 1969; Karel, 1976; Dixon *et al.*, 1976; Hawkes & Flink, 1978; Conway *et al.*, 1983; Magee *et al.*, 1983; Bolin *et al.*, 1985) [8, 11, 6, 10, 3, 14, 2] on peaches and apricots (Bolin *et al.*, 1985) [2], cherries, grapes and plums (Raev *et al.*, 1984) [8]. Osmotic dehydration also helps to retain the physico-chemical properties and the organoleptic properties of pineapple. Hence, the present study aims to throw light on the effects of osmotic dehydration on the physic-chemical and sensory qualities of the pineapple slices.

Materials and methods
The experiment was conducted in College of Horticulture, Bidar (2014-17). The fruits of variety Kew were purchased from the market. They were peeled, cored and sliced to standard size for subjecting to the osmotic pretreatments.

Treatment

The fruits were dipped in 40, 50 and 60° Brix fructose syrup in 1:2 fruit to syrup ratio and allowed to undergo osmosis for 18 hours at room temperature (25–35 °C) for T1, T2 and T3 respectively. Sucrose of 60° Brix concentration was used instead of fructose in T4 and T5 was control without any pretreatment. Slices were drained and rinsed with water to remove adhering syrup.

T1-Fructose 40 O Brix.+ 18 hrs of immersion
T2-Fructose 50 O Brix.+ 18 hrs of immersion
T3-Fructose 60 O Brix.+ 18 hrs of immersion
T4-Sucrose 60 O Brix.+ 18 hrs of immersion
T5-Control without osmosis

Fig 1: Pineapple slices subjected to Osmosis

Dehydration

Osmosed slices from different treatments were spread on stainless steel trays and were dehydrated in a cabinet drier at 60 °C on to a constant moisture level. The dried samples were packed in polythene covers.

Physic-chemical analysis

Total acids

The dried samples were analyzed for different attributes. Titratable acidity was analyzed by titrating a known aliquot of sample against standard 0.1N NaOH using phenolpthalein as indicator and was expressed as per cent citric acid.

$$\text{Total acid (\%)} = \frac{\text{Titre value X N of alkali X Vol. made up X Eq. wt. of acid x 100}}{\text{Vol. of sample taken for estimation X Wt. or vol. of sample taken x 1000}}$$

Sugars

Reducing sugars

Reducing sugars in the fresh and osmotically dehydrated pineapple samples were estimated using Lane and Eynon (1923) method with modifications as suggested by Ranganna (1991) [20].

$$\text{\% reducing sugars} = \frac{\text{Factor x Volume made up x Dilution x 100}}{\text{Titre value x Weight of the sample}}$$

Total sugars

For the estimation of total sugars, the lead acetate free filtrate was taken by the method given for reducing sugars by Ranganna (1991) [20]

$$\text{\% Total sugars} = \frac{\text{Factor x Volume made up x Dilution x 1000}}{\text{Titre x weight of sample taken}}$$

Non-reducing sugars

Non-reducing sugar was estimated using the formula.
% Non-reducing sugars =%Total sugars – %Reducing sugars.

Sensory evaluation

Osmotically dehydrated pineapple slices were evaluated by a panel of judges using hedonic scale having score for colour (30), texture (30) and flavour (40). Total sensory range was very good (80–100), good (60–79), average (30–59) and poor (0–29).

Statistical analysis

The experiment was carried out by using a Completely Randomized Design (CRD) with 5 treatments and 3 replications. The data for variations in different physico-chemical attributes were analyzed by using Analysis of variance (ANOVA) technique.

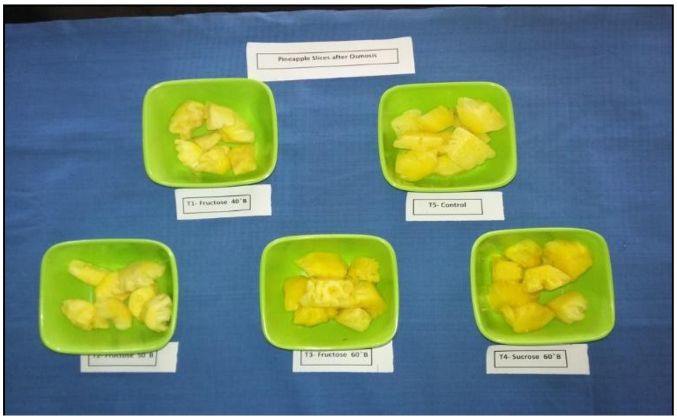

Fig 2: Osmotically treated pineapple slices (Initial stage)

Results and discussion

At initial stage

The data pertaining to the effect of osmotic dehydration on physic-chemical properties of pineapple at initial is presented in Table 1. According to the pooled data the maximum amount of titrable acidity (1.60%) was observed in the treatment T1 (Fructose 40 °Brix) which was followed by T2 (Fructose 50 °Brix) whereas the minimum (1.04%) was observed in T5 (Control). Varying degree of concentration or drying ratio resulted in more acidity in dehydrated slices. The variation in acidity of osmotically dehydrated samples was attributed to differential level of solid uptake by the slices. These results are in conformity with the findings of Sharma *et al*. (2004) [24], Suneetha *et al*. (2011) and Priya and Khatkar (2013) [17].

Table 1: Effect of Osmotic dehydration on Physico-chemical character at initial stage

Treatments	2014-15				2015-16				2016-17				Pooled			
	TA (%)	RS (%)	NRS (%)	TS (%)	TA (%)	RS (%)	NRS (%)	TS (%)	TA (%)	RS (%)	NRS (%)	TS (%)	TA (%)	RS (%)	NRS (%)	TS (%)
T1-Fructose 40 °Brix	1.55	37.40	25.42	62.82	1.61	37.24	25.86	63.09	1.63	37.19	25.58	62.77	1.60	37.28	25.62	62.89
T2-Fructose 50 °Brix	1.49	37.97	25.41	63.38	1.53	37.68	24.48	62.15	1.54	38.08	24.87	62.94	1.52	37.91	24.92	62.82
T3-Fructose 60 °Brix	1.42	41.28	27.05	68.34	1.44	41.21	26.85	68.06	1.46	41.20	27.23	68.43	1.44	41.23	27.05	68.28
T4-Sucrose 60 ° Brix	1.41	42.25	26.74	69.00	1.44	41.96	26.28	68.25	1.42	41.32	26.91	68.23	1.42	41.84	26.65	68.49
T5-Control without osmosis	1.03	29.67	15.36	45.03	1.04	29.82	15.51	45.32	1.06	28.99	15.23	44.22	1.04	29.49	15.37	44.86
C D @ 1%	0.08	2.39	2.81	3.74	0.06	2.60	3.16	3.76	0.09	1.60	2.83	3.29	0.06	1.87	2.63	3.09
S Em±	0.03	0.78	0.91	1.15	0.02	0.81	1.01	1.15	0.03	0.51	0.91	1.03	0.02	0.61	0.81	1.01

TA: Titrable acidity, RS: Reducing sugars, NRS: Non-reducing sugars, TS: Total sugars

The amount of reducing sugars was more (41.84%) in T4 (Sucrose 60 ° Brix) which was on par with T3 (Fructose 60 ° Brix) with 41.23 per cent reducing sugars. The treatment T3 (Fructose 60 ° Brix) recorded the highest amount of non-reducing sugars (27.05%) which was on par with T4 (Sucrose 60 ° Brix) with 26.65 per cent non-reducing sugars. The total sugars quantity was highest (68.49%) in T4 (Sucrose 60 ° Brix) which was on par with T3 (Fructose 60 °Brix) having 68.28 per cent total sugars. The lowest amount of reducing sugars (29.49%), non-reducing sugars (15.37%) and total sugars (44.86%) was recorded in T5 (control). These results indicate that syrup concentration has significant effect on the composition of osmotically dehydrated slices. This characteristics phenomenon of uptake of solutes and a resultant increase in sugar content in fruit slices during osmotic dehydration process has been reported (Torreggiani 1993; Raoult-Wack *et al*. 1991 and Sankat *et al*. 1996; Damame *et al.*, 2002; Priya and Khatkar, 2013; Paul *et al*., 2014; Kaur and Sogi, 2016; Uppuluti *et al.*, 2017) [25, 21, 23, 5, 17, 16, 12, 27]. Giraldo *et al*. (2003) [9] stated that variables affecting osmotic dehydration kinetics also affect sugar content in the final products. The results of present study are in conformity with the observations made by several earlier workers (Ahemedand Choudhary 1995; Sagar and Khurdiya 1999 and Sharma *et al.* 2004) [1, 24].

Fig. 3: Osmotically treated pineapple slices (after 2 month of storage)

After storage for 2 months

The Table 2 depicts the effect of osmotic dehydration on pineapple slices after 2 months of storage. The results obtained were as initial stage. The pooled data revealed that highest titrable acidity (1.57%) was recorded in T1 (Fructose 40 °Brix) which was followed by T2 (Fructose 50 °Brix) with 1.50 per cen ttitrable acidity. Lowest amount of titrable acidity (1.01%) was recorded in control.

The concentration of reducing sugars was highest in T4 (Sucrose 60 ° Brix) which was on par with T3 (Fructose 60 °Brix) having reducing sugar of 41.80 per cent. The maximum amount of non-reducing sugars (24.99%) was observed in T3 (Fructose 60 °Brix) which was on par with T4 (Sucrose 60 ° Brix) having 24.31 per cent non-reducing sugars. Also the total sugar content was maximum (67.01%) in T4 (Sucrose 60 ° Brix) which was on par with T3 (Fructose 60 °Brix) having 66.80 per cent total sugars.

Table 2: Effect of Osmotic dehydration on Physico-chemical character at 2 months after storage

Treatments	2014-15				2015-16				2016-17				Pooled			
	TA (%)	RS (%)	NRS (%)	TS (%)	TA (%)	RS (%)	NRS (%)	TS (%)	TA (%)	RS (%)	NRS (%)	TS (%)	TA (%)	RS (%)	NRS (%)	TS (%)
T1-Fructose 40 °Brix	1.52	39.74	21.67	61.41	1.61	37.24	22.91	60.15	1.58	37.21	25.08	62.28	1.57	38.06	23.22	61.28
T2-Fructose 50 °Brix	1.46	40.01	21.00	61.00	1.53	37.68	21.70	59.37	1.52	38.29	24.87	63.16	1.50	38.66	22.52	61.18
T3-Fructose 60 °Brix	1.38	42.63	23.94	66.58	1.44	41.21	23.99	65.20	1.43	41.56	27.05	68.61	1.41	41.80	24.99	66.80

T4-Sucrose 60 º Brix	1.35	43.79	23.30	67.09	1.44	41.96	23.65	65.61	1.40	42.34	25.99	68.33	1.40	42.70	24.31	67.01
T5-Control without osmosis	0.98	30.27	12.00	42.26	1.04	29.82	11.76	41.58	1.01	30.37	14.66	45.03	1.01	30.15	12.81	42.96
C D @ 1%	0.06	1.76	2.18	2.74	0.06	2.60	3.24	3.81	0.04	1.64	3.06	3.77	0.05	1.75	2.18	2.86
S Em±	0.02	0.51	0.65	0.89	0.02	0.81	0.99	1.25	0.01	0.45	1.01	1.20	0.01	0.61	0.71	0.92

TA: Titrable acidity, RS: Reducing sugars, NRS: Non-reducing sugars, TS: Total sugars

The control had shown lowest quantity of reducing sugars (30.15%), non-reducing sugars (12.81%) and total sugars (42.96%). The results of present study are in conformity withthe observations made by several earlier workers (Ahemedand Choudhary 1995; Sagar and Khurdiya 1999 and Sharma *et al.* 2004) [1, 22, 24]. The amount of total sugars had decreased and amount of reducing sugars had increased after two months of storage as compared to initial stage. This might be because of the hydrolysis of total sugars into reducing sugars during storage (Rahim *et al*, 2018) [19].

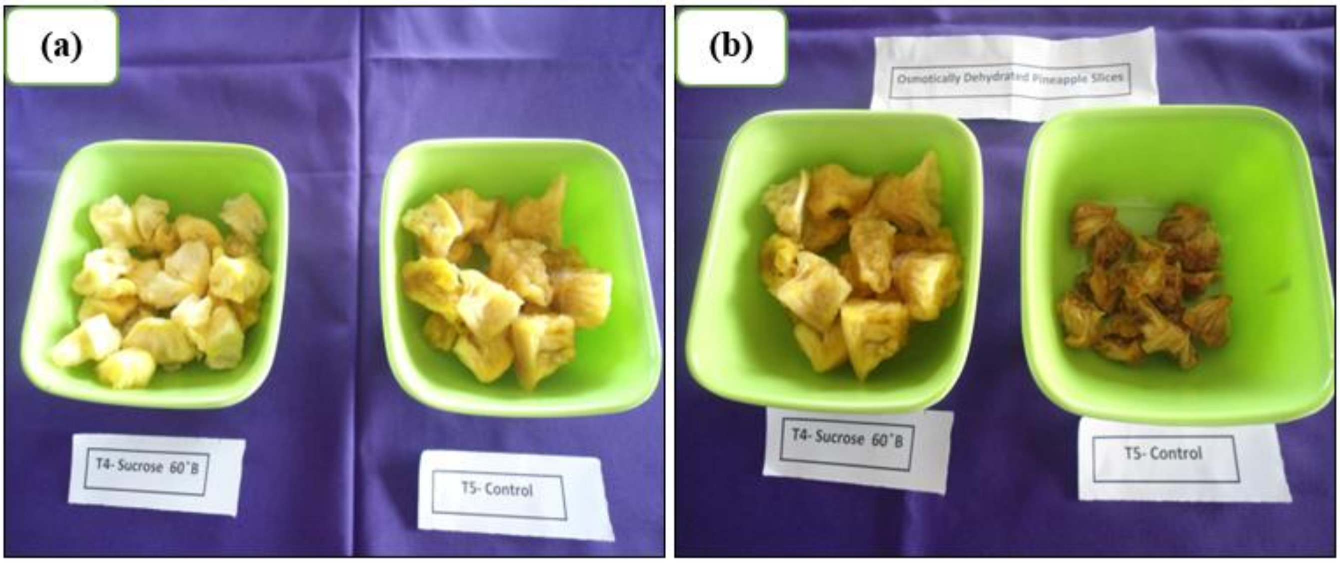

Fig 4: Comparison of T4 and control [(a) initial stage and (b) after 2 month of storage]

Sensory properties

At initial stage

The data pertaining to sensory properties of different treatments at initial stage is presented in Figure 5. It is clear from the pooled data that the maximum scores for all the attributes like colour (26.88), texture (26.75), flavour (36.50) and overall acceptability was obtained by T3 (Fructose 60 °Brix) and they were closely followed by T4 (Sucrose 60 º Brix) and T2 (Fructose 50 ºBrix). The lowest scores for all the parameters were obtained by T5 (control) which indicates the desirability of osmotic dehydration in obtaining quality product. Torreggiani (1993) [25] reported that sugar uptake owing to the protective action of the sugars in syrup helps in the stability of product color during osmotic process and subsequent storage. Osmotic pretreatment and drying temperature had significant effect on chroma and hue angle values of dried peppers (Damame *et al.*, 2002; Falade and Oyedele 2010; Priya and Khatkar, 2013; Uppuluti *et al.*, 2017) [5, 7, 17, 27].

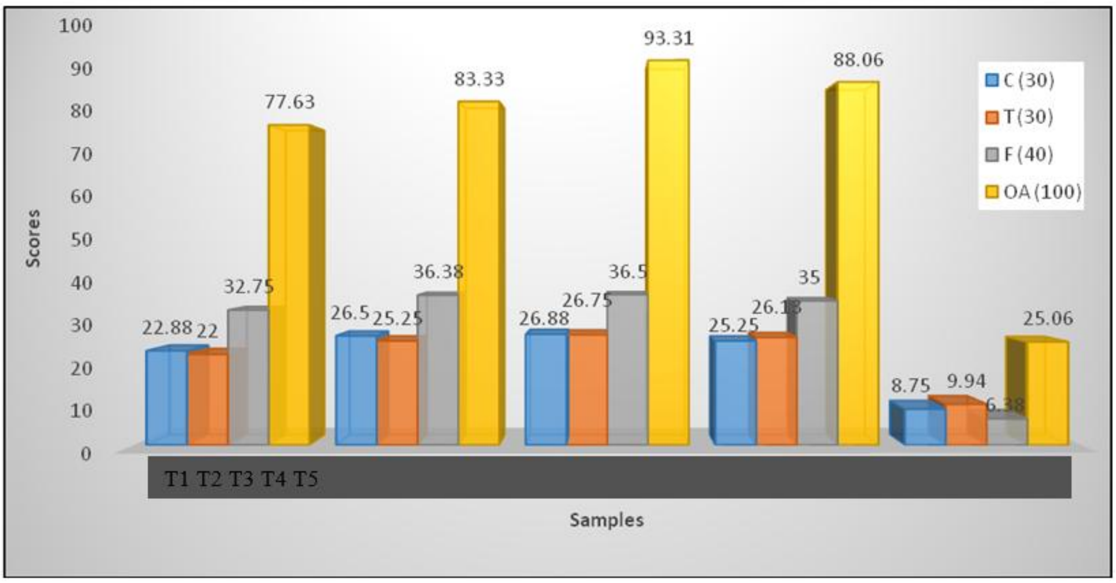

Fig 5: Effect of osmotic dehydration on sensory properties (initial stage) C-colour: T-texture: F-flavour: OA-overall acceptability

After storage for 2 months

The data pertaining to sensory properties of different treatments at initial stage is presented in Figure 6. Similar trend of results was obtained for the sensory properties after 2 months of storage. The treatment T3 (Fructose 60 °Brix) obtained maximum scores for colour (26.88), texture (26.75), flavour (36.50) and overall acceptability (93.31). This treatment was found to be on par with T4 (Sucrose 60 º Brix) and T2 (Fructose 50 ºBrix). This may be attributed due to converting of complex sugar into simpler form and degradation of large molecular sugar during the course of storage. The same results are in support to our findings who reported that the sensory scores decreased in dehydrated pineapple cubes during storage intervals (Priya and Khatkar, 2013; Paul *et al*., 2014; Uppuluti*et al.*, 2017) [17, 16, 27].

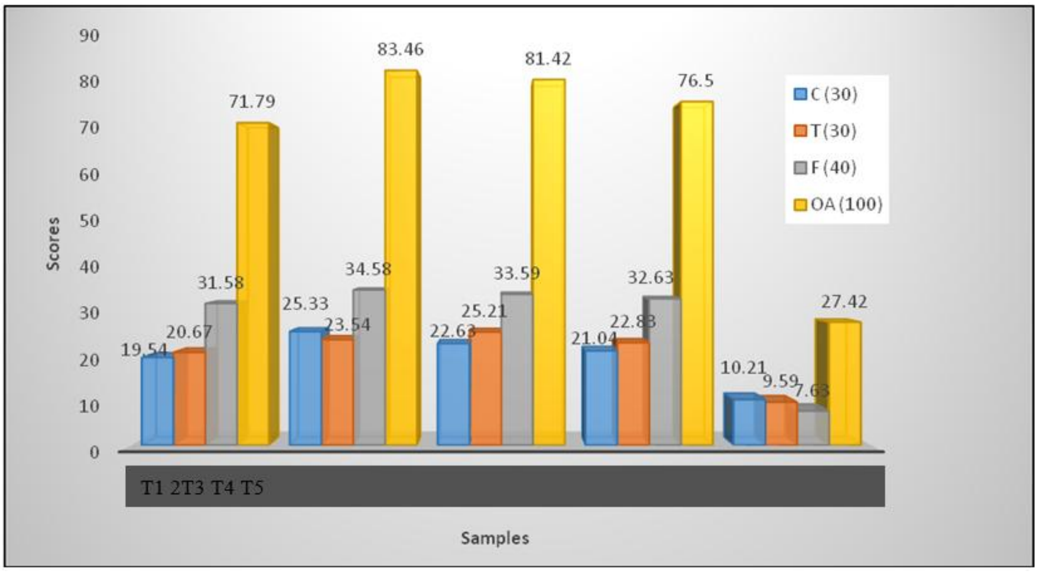

Fig 6: Effect of osmotic dehydration on sensory properties (initial stage) C-colour: T-texture: F-flavour: OA-overall acceptability

Conclusion

After analyzing the different physic-chemical and sensory parameters, it was concluded that osmotic dehydration of pineapple slices could be done using fructose syrup (60 ºBrix) which can result in and excellent product with high organoleptic scores and consumer acceptability. Since the use of sucrose is replaced by fructose, this product may be recommendable to the diabetic patients.

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