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Effect of osmotic dehydration on mass transfer kinetics in pineapple slices

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Abstract
Application of osmotic dehydration for different fruits has been increased significantly in recent years. Among different fruits, pineapples have characteristic pleasant flavour, distinct aroma and exquisite taste and are one of the most suitable fruit used for osmotic dehydration. Many studies have suggested that increasing consumption of plant foods like pineapples decreases the risk of obesity, overall mortality, diabetes, and heart disease. The effect of osmotic dehydration on mass fluxes (water loss, solids gain and weight reduction) was investigated. The rate of mass transfer in the fruit varied with osmotic solution concentration and the best treatment for production of osmotically dehydrated pineapple was using 60 per cent sucrose solution which gave high solid gain and weight loss (16.39 and 25.22 respectively) and highest scores for sensory attributes like colour, texture, flavour and overall acceptability (26.88, 26.75, 36.50 and 93.31 respectively).

Keywords: Osmotic dehydration, mass transfer kinetics, pineapple slices

Introduction

Pineapple (*Ananas comosus*) is a tropical plant originated from tropical America with anedible fruitand the mosteconomically significant plant in the family Bromeliaceae. It is a rich source of Vit-C, carotenoids, calcium and magnesium. It deals with age related muscular degeneration, asthma, blood pressure, diabetes, cancer and other health related issues. In India it covers an area of about 89000 hectares with an annual production of 1.9 M tonnes (FAOSTAT). It is available from July to October in Karnataka and round the year in Kerala and Tamil Nadu. Pineapples may be cultivated from the offset produced at the top of the fruit, possibly flowering in five to ten months and fruiting in the following six months. 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 don't 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].
Application of osmotic dehydration process could result in production of safe, stable, nutritious, tasty and economical product. The recent increased interest in osmotic treatments aroused primarily from the need for quality improvement and from economic factors. This process involves placing solid food, whole or in pieces in sugar or salt aqueous solution of high osmotic pressure which removes 30-50 per cent of the water from fresh ripe fruits (Lewickiand Lenart 1995). The driving force for the diffusion of water from the tissue into the solution is provided by the higher osmotic pressure of the hyper tonic solution. Aspects of pineapple mass transfer kinetics during osmotic dehydration have been studied by Beristain *et al*. 1990 [9]; Jena and Das 2005 [11]; Ramallo, *et al.* (2004); Rastogi and Raghavarao (2004) [20]. The diffusion of water is accompanied by the simultaneous counter diffusion of solutes from the osmotic solution into the fruit tissue (Dixon and Jen, 1977; Giangiacomo *et al*. 1987; Lerici *et al*. 1985) [6, 9, 12]. In this regard, the present study is aimed at investigating the effect of osmotic dehydration on the different parameters of mass transfer kinetics in 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 T_1, T_2 and T_3

respectively. Sucrose of 60° Brix concentration was used instead of fructose in T_4 and T_5 was control without any pretreatment. Slices were drained and rinsed with water to remove adhering syrup.

T1-Fructose 40o Brix.+ 18 hrs of immersion
T2-Fructose 50o Brix.+ 18 hrs of immersion
T3-Fructose 60o Brix.+ 18 hrs of immersion
T4-Sucrose 60o 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.

Analysis of mass transfer kinetics

The dried samples were analyzed for different attributes. Moisture content was determined by drying the samples to a constant weight in a hot air oven at 70±1 °C and using the following formula. The total solids were calculated by subtracting the moisture content from 100. Also the moisture loss, weight loss, weight loss and solid gain were calculated using the following formulae.

$$\text{Moisture content} = \frac{\text{Initial weight} - \text{Dried weight}}{\text{Dried weight}} \times 100$$

Total solids = 100 – Moisture content (%)

$$\text{Moisture loss (\%)} = \frac{\text{Initial moisture} - \text{moisture at time}}{\text{Initial moisture}} \times 100$$

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{weight at time}}{\text{Initial weight}} \times 100$$

Solid gain (%) = Moisture loss (%) – weight loss (%)

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

The Table 1 depicts the data pertaining to effect of osmotic treatment on mass transfer kinetics in pineapple slices over three experimental years. According to the pooled result, maximum weight loss due to osmosis (27.12 %) and solid gain (18.53 %) was found in T_4 (Sucrose 60 ° Brix) which was followed by T_3 (Fructose 60 °Brix) and minimum moisture loss was observed in T_1 (Fructose 40 °Brix). This difference clearly indicated the influence of the syrup concentration on the slices (Heng *et al*., 1990; Park *et al*., 2002; Fernandes *et al*., 2006) [10, 16, 8]. The effect of solution concentration on mass transfer rates (Moisture loss, solids gain and weight loss) during OD, using sucrose as dehydrating agent, has been studied for a numbers of fruits such as pear (Park *et al*., 2002) [16], carrot (Rastogi *et al*., 2002) [19, 21], pineapple (Rastogi and Raghavarao, 2002) [19, 21] and melon (Lima *et al*., 2006) [14] and it has been found that the sucrose treatment gives higher solid gain and weight loss due to its potential to create higher osmotic pressure than fructose.

Table 1: Effect of Osmotic Treatment on mass transfer Kinetics-1

	2014-15			2015-16			2016-17			Pooled		
Treatments	**WL (%)**	**SG (%)**	**ML (%)**	**WL (%)**	**SG (%)**	**ML (%)**	**WL (%)**	**SG (%)**	**ML (%)**	**WL (%)**	**SG (%)**	**ML (%)**
T1-Fructose 40 °Brix	21.79	11.43	10.36	22.11	11.59	10.52	22.08	11.59	10.49	21.99	11.54	10.46
T2-Fructose 50 °Brix	22.64	13.38	9.26	22.91	13.36	9.56	22.94	13.46	9.49	22.83	13.40	9.43
T3-Fructose 60 °Brix	25.19	16.11	9.08	25.50	16.71	8.79	24.96	16.36	8.60	25.22	16.39	8.82
T4-Sucrose 60 ° Brix	26.83	18.43	8.40	27.24	18.48	8.76	27.28	18.67	8.61	27.12	18.53	8.59
T5-Control without osmosis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

C D @ 1%	1.15	1.11	1.38	1.12	1.34	1.16	1.24	1.38	1.12	1.08	1.15	1.08
S Em±	0.32	0.32	0.42	0.29	0.41	0.31	0.32	0.42	0.28	0.25	0.31	0.26

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

The data pertaining to effect of osmotic treatment on mass transfer kinetics in pineapple slices over three experimental years presented in Table 2. The pooled data reveals minimum moisture content (56.82 %) and maximum total solids (43.19 %) was recorded in T4 (T4-Sucrose 60 ºBrix). This data was reciprocated by T5 (control) with maximum moisture content (86.56%) and minimum total solids (13.44%). Osmosis decreased moisture content of fruit slices and also facilitated the absorption of sugar by the slices which ultimately increased the total solids content of osmosed fruit slices. These findings are in conformity with the result obtained in osmotic dehydration of pineapple slices by Rashmi *et al.* (2005) [18] and pineapple by Dionello *et al*. (2009) [5].

Table 2: Effect of Osmotic Treatment on mass transfer Kinetics-2

	2014-15		**2015-16**		**2016-17**		**Pooled**	
Treatments	**MC (%)**	**TS (%)**	**MC (%)**	**TS (%)**	**MC (%)**	**TS (%)**	**MC (%)**	**TS (%)**
T1-Fructose 40 ºBrix	62.01	37.99	61.69	38.31	62.04	37.96	61.91	38.09
T2-Fructose 50 ºBrix	61.16	38.84	60.89	39.11	60.18	39.82	60.74	39.26
T3-Fructose 60 ºBrix	58.61	41.39	58.30	41.70	58.30	41.70	58.41	41.60
T4-Sucrose 60 º Brix	56.98	43.03	56.56	43.44	56.91	43.09	56.82	43.19
T5-Control without osmosis	86.33	13.68	86.33	13.68	87.02	12.98	86.56	13.44
C D @ 1%	1.48	1.48	1.46	1.46	1.76	1.76	1.41	1.41
S Em±	0.42	0.42	0.39	0.39	0.48	0.48	0.31	0.31

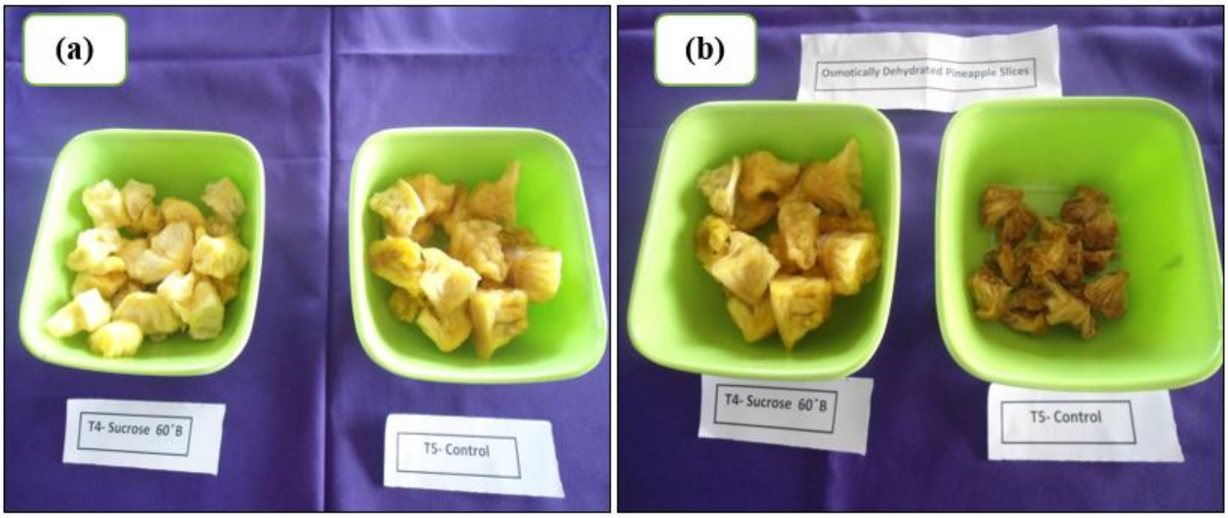

Fig 4: Comparison of T4 and control [(a) initial stage and (b) after 2 month of storage]

The data pertaining to sensory properties of different treatments is presented in Table 3. 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) [23] 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 (Falade and Oyedele 2010) [7].

Table 3: Effect of Osmotic dehydration on sensory properties

	2014-15				**2015-16**				**2016-17**				**Pooled**			
Treatments	**C (30)**	**T (30)**	**F (40)**	**OA (100)**	**C (30)**	**T (30)**	**F (40)**	**OA (100)**	**C (30)**	**T (30)**	**F (40)**	**OA (100)**	**C (30)**	**T (30)**	**F (40)**	**OA (100)**
T1-Fructose 40 ºBrix	23.25	21.25	31.75	76.25	22.50	22.75	33.75	79.00	22.38	22.13	33.13	77.63	22.88	22.00	32.75	77.63
T2-Fructose 50 ºBrix	26.50	24.75	36.00	87.25	26.50	25.75	36.75	89.00	26.88	25.75	36.38	89.00	26.50	25.25	36.38	83.33
T3-Fructose 60 ºBrix	27.50	26.75	36.00	90.25	26.25	26.75	37.00	90.00	26.75	27.00	36.63	90.38	26.88	26.75	36.50	93.31

T4-Sucrose 60 ° Brix	25.00	24.25	34.25	83.50	25.50	28.00	35.75	89.25	25.75	26.25	35.75	87.75	25.25	26.13	35.00	88.06
T5-Control without osmosis	8.75	10.38	6.25	25.38	8.75	9.50	6.50	24.75	10.00	10.69	10.75	31.44	8.75	9.94	6.38	25.06
C D @ 1%	3.63	2.62	2.86	4.95	4.71	2.91	2.91	7.18	3.80	2.81	4.75	7.43	3.52	2.25	2.53	5.32
S Em±	1.19	0.86	0.90	1.56	1.51	0.93	0.91	2.15	1.24	0.89	1.59	2.23	1.15	0.71	0.82	1.53

Texture of osmotically dehydrated samples was seen to improve which might be due to positive role of sugars available in the fruit slices. Influence of osmotic agents on product quality have been reported by earlier workers in fruits such as papaya (Ahemed and Choudhary 1995) [1], mango (Sagar and Khurdiya 1999; Varany-Anond *et al*. 2000 and Madamba and Lopez 2002) [22, 25, 15]. Improvement in taste of osmotically treated slices fromthe above treatments was mainly due to better sugar acid ratio.Variables affecting osmotic dehydrationkinetics, as well as final ratio of water loss and sugar gainhas great influence on product characteristics and improved product from fruits can be obtainedthrough osmotic dehydration (Torreggiani 1993; Raoult-Wack 1994; Bongirwar 1997) [23, 3].

Conclusion

With regard to the results obtained for the mass transfer kinetics, it was concluded that the treatments T2, T3 and T4 performed well. However the sensory scores revealed that T3 (Fructose 60 °Brix) had better acceptability. There was added advantage about this treatment as it replaced sucrose with fructose, hence making this product recommendable for diabetic patients as well.

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