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Effect of different sugar syrup concentrations on osmotic dehydration of pineapple fruits during storage

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Abstract
The present investigation was carried out in Department of Horticulture and Postharvest Technology, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal during 2017-18. Pineapple cv. Kew cut into 0.5 mm slices and were subjected to osmotic dehydration with different sugar concentration (35°B, 40°B, 45°B, 50°B, 55°B, 60°B) during the experiment. Various chemical qualities of the osmotic dehydrated fruit products were analyzed at Initial, 2, 4, 6 and 8 months during the cold storage. The results revealed that highest TSS at Initial (22.48ºB), 2 (21.74ºB), 4 (16.81ºB), 6 (17.76ºB) and 8 (19.84ºB) months were observed in 60ºB, 60ºB, 50ºB, 60ºB and 40ºB sugar syrup respectively. Highest Titratable acidity at Initial (2.3%), 2 (2.33%), 4 (2.31%), and 6 (1.91%) months was observed in T_4 (40°B) sugar solution, whereas highest acidity at 8 (1.83) month was observed in T_5 (55°B) sugar solution. Whereas highest reducing sugar found at initial (18.48), 2 (18.90), 4 (17.22), 6 (17.94) and 8 (18.27) months were observed at T_4 (50°B). Total sugars at Initial (27.29), 2 (27.57) months were found highest at T_3 (45°B) and in 4 (23.49), 6 (21.42), 8 (19.65) months were maximum at T_4 (50°B). Thus it can be concluded that treating the pineapple slices with sugar syrup having concentration at (50^0B) T_4 is ideal for osmotic dehydration of pineapple.

Keywords: sugar concentrations, osmotic dehydration, storage, chemical properties

Introduction

Pineapple (*Ananas comosus* L. Merr.) is one of the commercial fruit crops of tropical world belonging to the family Bromeliaceae, comprising chromosome number (2n=50). It has about 50 genera and 2000 species mostly epiphytic (Bartholomew and Maleieux, 1994) [3]. It has originated from American continent, Brazil and Paraguay (NHB, 2014). It is introduced to India in 1548. It is an important economic fruit of tropical areas with the top world producers being Costa Rica, Brazil, Philippines, Thailand, Indonesia, India, Nigeria, China, Mexico, and Colombia. In India pineapple is commercially grown in the states of Assam, Meghalaya, Tripura, Manipur, West Bengal, Kerala, Karnataka, Goa, Gujarat, and Maharashtra. In year 2014-2015 the total area of pineapple under cultivation in India was about 116.0 thousand ha with a production of 1984.0 thousand MT. Area and production in West Bengal (2016-2017) is 11.20 thousand ha and 336.11 thousand MT (Anonymous. 2017).

Pineapple is a good source of beneficial nutrients as 100 gram of fresh edible pineapple contains 81-91g of moisture, 0.3-0.6 g of crude fibre, 37 mg calcium, 11.9 mg phosphorus, Iron 1.05 mg, carotene 0.003-0.055 mg and finally ascorbic acid of 27-162 mg. Pineapple fruits are characteristics of pleasant flavour, distinct aroma, exquisite taste and absence of seeds and it contains water, carbohydrates, sugar, vitamin A and β-carotene. It contains low amount of protein, fat, ash, fiber and anti-oxidants namely flavonoids in addition to citric acid and malic acid and moderate amount of ascorbic acid (Hebbar *et al*., 2008) [8]. Pineapple helps several enzymes present in the body to produce energy as it contains magnesium and vitamin B, which are essential for the normal functioning of some enzymes (Samson, 1986). Over 70% of the annual production is consumed in the fresh form. Pineapple fruits are an excellent source of bromelein, an enzyme used as meat tenderizing agent and as a neutraceutical (Lotz-Winter, 1990).

Pineapple plant grows within tropical and sub-tropical climate. The optimal climatic conditions for growing pineapple are an average temperature of between 21 – 27°C and relative humidity of 70-80%. Injury occurs from transpiration and respiration at temperatures above 27°C. The crop is grown with annual rainfall of 1200-1500 mm. The soil pH is 5-6.5.

With regard to soil texture, pineapple does best in light, friable, well-aerated free-draining clayey-sandy soils. Although pineapple is one of the most important commercial fruits, due to its very pleasant aroma and flavour (Rattanathanalerk *et al*., 2005), the storage life of fresh pineapples is limited to 1–2 weeks at ambient temperature. Seventy percent of the pineapple produced in the world is consumed as fresh fruit (Loeillet, 1997) [9].

However, in many developing countries, only a limited quantity of pineapple products (canned fruit, canned juice or frozen juice concentrate) is produced. The postharvest loss of pineapple is reported to be about 15-20% of the total production. During the peak production period there is always glut in the market, which leads to distress sale among the growers. To increase the storage period of pineapple fruits dehydration method is an important operation for preserving pineapple. Osmotic treatment is one of the popular method of pre-treatment for producing the fresh products from the fruits which has short harvest season and poor storability (Torreggiani and Bertolo, 2001; Escriche *et al*., 2000a; Suutarinen *et al*., 2000) [20]. Osmotic dehydration is considered as a pre-treatment for pineapple with the final aim of obtaining high quality dried fruit products. This method has been successfully used in conjunction with air drying, freezing, freeze drying, vacuum drying, fluidized bed drying and microwave drying in the laboratory, pilot and commercial scales (Zhao and Xie, 2004) [21].

Osmotic dehydration is a promising and advanced method for the preservation and value addition for pineapple. It is a useful technique for the production of safe, stable, nutritious, tasty, economical and concentrated food obtained by placing the solid food, whole or in pieces in sugar or salt solution of high osmotic pressure (Rashmi *et al*., 2005) [15]. With this view, the present investigation was taken up to study osmotic dehydration of pineapple fruits with the following objective:

1. Quality analysis of osmotic dehydrated pineapple fruits with different sugar concentrations during storage.

Material and Methods

The present research study entitled “Quality analysis of osmotic dehydrated pineapple fruits with different sugar concentrations during storage” were conducted in the laboratory, Department of Horticulture and Post-Harvest technology, Bolpur, Palli Siksha Bhavana (Institute Of Agriculture),Visva-Bharati, Sriniketan, Birbhum (District), West Bengal during the year, 2017-18. The present experiment was laid out in completely randomized design with six treatments (35°B, 40°B, 45°B, 50°B, 55°B, 60°B) and control (no sugar).Pineapple (*Ananas comosus* L.) fruits were obtained from the fruit market, with fully matured fresh fruits with uniform size and shape, free from diseases and insect damages, transportation injuries and bruises, were selected for making the nutritious osmotically dehydrated slices.

Fruit slice preparation

The selected Pineapple fruits of uniform size and colour were weighed by using electronic digital balance, washed thoroughly with running tap water. The washed fruits were peeled by removing the upper skin with stainless steel knife. Edible portion of the whole fruit was cut in to uniform slices having 0.5 mm thickness. Prepared slices were weighed to record the yield recovery of fresh slices for osmotic dehydration.

Preparation of sugar syrup

Sugar syrup of six different concentrations *viz*., 35°,40°, 45°, 50°, 55°, and 60°Brix was prepared. For 35°Brix 350grams of sugar in 650 ml of water for 40°Brix 400grams of sugar in 600 ml of water for 45°Brix 450gram of sugar in 550 ml of water, 50°Brix 500 gram of sugar in 500 ml of water, for 55°Brix 550 gram of sugar in 450 ml of water, 60°Brix 600 gram of sugar in 400 ml of water all the treatments were made up to one litre volume.

Treatments

Slice thickness: 0.5 mm
Sugar °Brix
T_1: 35°B, Steeping of 0.5 mm slices in 35^0B sugar syrup
T_2: 40°B, Steeping of 0.5 mm slices in 40^0B sugar syrup
T_3: 45°B, Steeping of 0.5 mm slices in 45^0B sugar syrup
T_4: 50°B, Steeping of 0.5 mm slices in 50^0B sugar syrup
T_5: 55°B, Steeping of 0.5 mm slices in 55^0B sugar syrup
T_6: 60°B, Steeping of 0.5 mm slices in 60^0B sugar syrup
T_7: Control.

The fruits were washed, peeled and cut into slices followed by steeping the slices for 24 hours in the above mentioned solution, later tray dried at (55-60^0C).

Immersion of slices in sugar syrup (osmosis)

Prepared pineapple slices of 0.5mm thickness were dipped in 35°, 40°, 45°, 50°, 55° and 60°Brix sugar syrup solution and this setup was left undisturbed for 24 hours at room temperature (25^0C). The process of osmosis takes place and water moves out of the fruit pieces to the syrup and fraction of solute moves into the fruit slices. At the end of the osmosis, the fruit slices were taken out of the osmotic solution and were drained in order to remove the sugar coating adhering to the surface of the fruit pieces.

Dehydration

After taking samples for analysis, the osmosed slices of pineapple were spread thinly on aluminium trays which were kept in a tray drier for dehydration. Pineapple slices were thoroughly dried at 55-60°C temperature till the fruits reached the desired moisture content and product quality.

Total soluble solids (TSS)

The total soluble solids (TSS) level of the fruits was determined using a digital refractometer (AR-2008, Kruss, Germany) according to the method of Daramola and Asunni, (2007). Total soluble solids (TSS) content of the fruits was estimated with the help of a digital refractrometer (0 to 32ºBrix) and the values were corrected at 20ºC. The refractometer was adjusted at 0% level with the help of distilled water. It was cleaned by absorbent cotton and dried. One drop of fruit juice was placed on the glass disc of the refracto meter and the percentage of TSS was observed and noted for different treatments. The glass disc was thoroughly cleaned after each operation and the TSS was expressed as ºBrix of juice. The reading shown was the reading of the total soluble solids for the juice. Sugar’s content was determined according to AOAC (2000).

Titratable acidity of fruit (%)

The acidity of the fruit slices was determined by diluting a known volume of the fruit slice with distilled water and titrating the same against standard N/10 NaOH solution, using phenolphthalein as an indicator. The appearance of light pink colour was taken as the end point. The results were expressed in terms of per cent acidity of the fruit pulp. Titratable acidity was determined from juices extract and expressed as lactic acid (%) according to the standard methods in AOAC (2000).

$$\text{Acidity (\%)} = \frac{\text{Titre x Normality of alkali x milli eq. weight of acid}}{\text{Weight volume of the sample X 100}}$$

Total sugars (%)

Total sugars were determined following the method described by Lane and Eynon, AOAC (1965). A quantity of 50 ml lead free filtrate was taken in a 100 ml volumetric flask to which 5 ml of concentrated HCL was added, mixed well and then kept for 24 hours at room temperature. Acid was then neutralized with NaOH using a drop of phenolphthalein as an indicator till the pink colour persisted for at least few seconds. Then volume was made up to 100 ml. Total sugars were then estimated by taking this solution in a burette and titrating it against standard Fehling's solution mixture of A and B (1:1) using methylene blue indicator, taking brick red colour as the end point.

$$\text{Total sugar \%} = \frac{\text{Factor x volume made up}}{\text{Titre value x weight of sample}} \text{X 100}$$

Reducing Sugars (%)

Reducing sugars (%) Reducing sugars were determined by following method described by Lane and Eynon, 1965. Twenty five ml of fruit juice was taken in a 250 ml volumetric flask. Two ml of lead acetate solution (45%) was added to flask for precipitation of colloidal matter and 2 ml Potassium oxalate (22%) was added to this solution to precipitate the excess lead and the volume made up to 250 ml using distilled water. The contents were then filtered through Whatman No. 1 filter paper after testing a little of filtrate for its freedom from lead by adding a drop of potassium oxalate. Reducing sugars in the lead free solution was taken in burette and titrated against 10 ml of standard Fehling's solution mixture of A and B (1:1) using methylene blue as an indicator till the end point was indicated by the formation of brick red precipitate. The titration was carried out by keeping the Fehling's solution boiling on the heating mantle.

$$\text{Reducing sugar (\%)} = \frac{\text{Factor x volume made up}}{\text{Titre value x weight of sample}} \text{ X 100}$$

Statistical analysis

The experiment was laid out in Complete Randomized Design. Data obtained on various characters were analyzed statistically according to the analysis of variance techniques for CRD (Fisher 1950) [7]. The critical difference (CD) was calculated to access the significance or non-significance of difference between treatment means. Wherever, it was found significant through 'F' test at 1 or 5 per cent level of significance, marked as star in ANOVA Tables.

Result and Discussion

TSS

Data pertained in Table. 1 and Fig.1 at initial stage of storage highest TSS (22.48°B) was recorded in treatment T_6 (60^0B) next to that (19.23°B) in T_4 (50°B) and it was minimum (8.11°B) in control. TSS of osmotically dehydrated pineapple slices are decreasing during 2nd and 4th months of storage. As the storage period increased there is a continuous significant decline in TSS from the initial up to 4 months of storage irrespective of treatments. The similar results observed from findings of (Tejib Tripura 2017) [18]. This may be due to metabolic changes especially utilization of oxidative metabolism with prolonged storage period, the pore space in the product decreases or increases due to fluctuations in moisture level and imbibes water due to decrease in total sugar%. The trend of TSS goes on increasing during 6th and 8th months of storage of osmotic dehydrated pineapple slices this may be due to decrease in moisture. The moisture loss could be due to evaporation during storage. The results are in agreement with the findings of (Chavan *et al.*, 2010) [5] that the TSS content increases in all the osmotically dehydrated banana slices during storage.

Table 1: Effect of sugar concentrations on sequential changes on TSS of osmotically dehydrated pineapple slices under storage

Treatments	Initial	2 months	4 months	6 months	8 months
T1 35°B Sugar syrup	18.70	18.50	15.08	17.53	18.56
T2 40°B Sugar syrup	18.01	17.73	15.52	16.81	19.84
T3 45°B Sugar syrup	18.30	17.70	16.35	17.72	18.91
T4 50°B Sugar syrup	19.23	19.15	16.81	17.14	19.42
T5 55°B Sugar syrup	18.52	17.76	16.19	16.84	18.27
T6 60°B Sugar syrup	22.48	21.74	16.48	17.76	19.12
T7 CONTROL	8.11	9.92	8.82	9.93	9.35
C.D (5%)	0.29	0.42	0.41	0.33	0.40
S.E.(m) ±	0.10	0.14	0.12	0.10	0.12

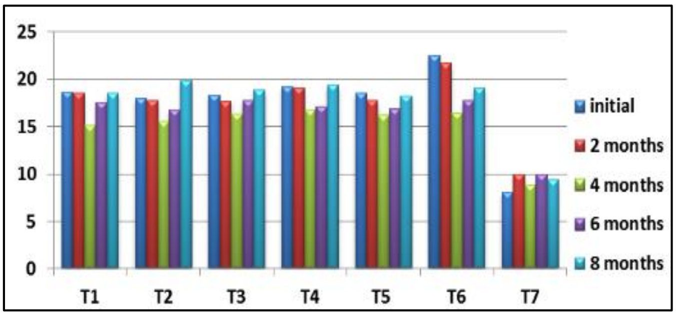

Fig 1: Effect of sugar concentration on total soluble solids (°B) of osmotically dehydrated pineapple slices

Titratable acidity

Initial stage of dried product values recorded in Table. 2 and Fig.2 different treatments significantly affected the Titratable acidity in osmotically dehydrated pineapple Among the different treatments highest Titratable acidity (2.39%) was recorded in treatment T_2 (40^0B) after that (2.22%) in (T_4 50°B) and it was minimum (1.22%) in control. Titratable acidity of osmotically dehydrated pineapple slices are decreasing during 2, 4, 6 and 8 months of storage. As the storage period increased there was a continuous significant decline in Titratable acidity from the initial to 8 months of storage irrespective of treatments. This may be due to the leaching of acids from fruits to hypertonic solution through a semi-permeable membrane (Sharma and kaushal 1999) [14]. The results obtained with the findings of Moy *et al.,* (1978) in tropical fruits. Titratable acidity decreased significantly during storage period of 90th day as reported by (Rani and Bhatia 1985) [14] in pear candy. (Priya and Khatkar 2013) [13] in aonla preserves, (Suneetha *et al*., 2011) [17] and Mehta and Tamar (1980a and b) in dehydrated guava pieces and papaya slices.

Table 2: Effect of sugar concentrations on sequential changes of Titratable acidity (%) of osmotically dehydrated pineapple slices under storage

Treatments	initial	2 months	4 months	6 months	8 months
T1 35°B Sugar syrup	2.05	2.01	1.98	1.82	1.74
T2 40°B Sugar syrup	2.39	2.33	2.31	1.91	1.82
T3 45°B Sugar syrup	2.10	2.02	1.85	1.76	1.70
T4 50°B Sugar syrup	2.22	2.11	2.03	1.80	1.71
T5 55°B Sugar syrup	2.12	2.10	2.10	1.87	1.83
T6 60°B Sugar syrup	1.45	1.37	1.40	1.33	1.24
T7 CONTROL	1.22	1.17	1.15	1.02	1.00
C.D (5%)	0.04	0.03	0.03	0.03	0.04
S.E.(m) ±	0.01	0.01	0.01	0.01	0.11

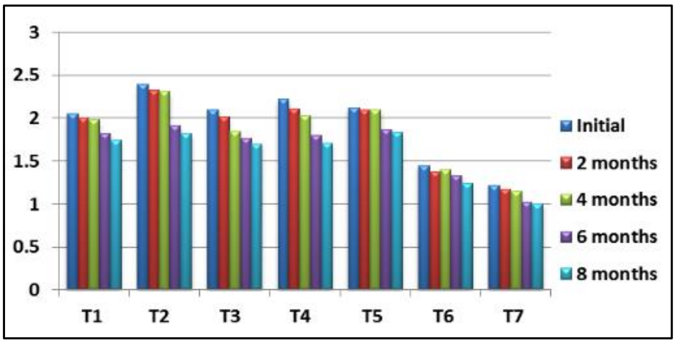

Fig 2: Effect of sugar concentrations on sequential changes of Titratable acidity (%) of osmotically dehydrated pineapple slices under storage

Effect of sugar concentrations on sequential changes of reducing sugars (%) of osmotically dehydrated pineapple slices under storage

Data showed in Table. 3 and Fig. 3 at initial stage after drying, different treatments significantly affected the reducing sugars in osmotically dehydrated pineapple. There was a significant difference between the sugar syrup concentrations. Among the different treatments highest reducing sugars (18.48%) was recorded in treatment T_4 (50^0B) and it was minimum (3.40%) in control. Reducing sugar of osmotically dehydrated pineapple slices during 2 and 4 months of storage. As the storage period increased there was a continuous significant decline in reducing sugar from the initial up to 4 months of storage to irrespective of treatments. On all the days of storage, reducing sugars was initially minimum during 2 and 4 months and it is gradually increased in the storage period of 6 and 8 months in all the treatments except T_1 (35%) and T_7 (control). This may be due to hydrolysis of total sugar into reducing sugar.

These results were in similar trend with (Chavan *et al.*, 2010) [5]. (Damame *et al.*, 2002) [6], (Anitha and Tiwari 2007) [2] in guava.

Table 3: Effect of sugar concentrations on sequential changes of reducing sugar (%) of osmotically dehydrated pineapple slices under storage

Treatmeninitial	2 months	4 months	6 months	8 months
T_1 35°B Sugar syrup 12.72	12.53	11.03	12.81	12.36
T_2 40°B Sugar syrup 11.35	11.11	10.52	13.25	13.49
T_3 45°B Sugar syrup 17.63	17.22	16.07	16.39	16.86
T_4 50°B Sugar syrup 18.48	18.90	17.22	17.94	18.27
T_5 55°B Sugar syrup 17.30	16.89	14.28	14.83	15.38
T_6 60°B Sugar syrup 15.59	15.17	12.50	13.36	14.20
T_7 CONTROL 3.40	3.06	4.01	5.66	4.19
C.D (5%) 0.81	1.04	0.72	0.66	0.92
S.E.(m) ± 0.25	0.31	0.23	0.21	0.29

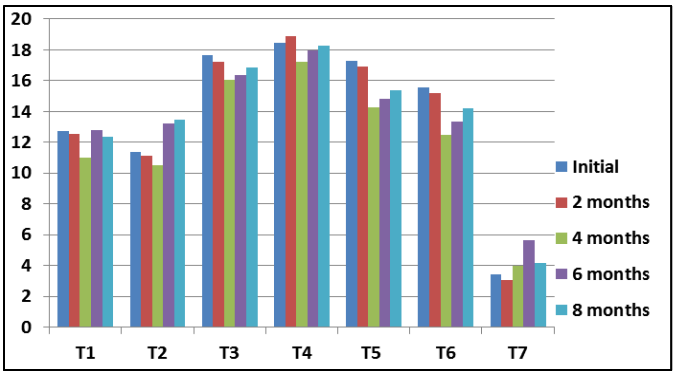

Fig 3: Effect of sugar concentrations on sequential changes of reducing sugars (%) of osmotically dehydrated pineapple slices under storage

Effect of sugar concentrations on sequential changes of total sugars of osmotically dehydrated pineapple slices under storage

Results depicted from the Table. 4 and Fig. 4 at initial stage of storage, different treatments significantly affected the total sugar in osmotically dehydrated pineapple. There was a significant difference between the sugar syrup concentrations. Among the different treatments highest total sugar (27.29%) was recorded in treatment T_3 (45^0B) and it was minimum (7.56%) in control. From the results it is depicted that total sugars (%) decreases in initial to 8 months of storage in all the treatments. 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 content of total sugar was decreased in dehydrated pineapple cubes during storage intervals. Paul *et al.*, (2014) [11].

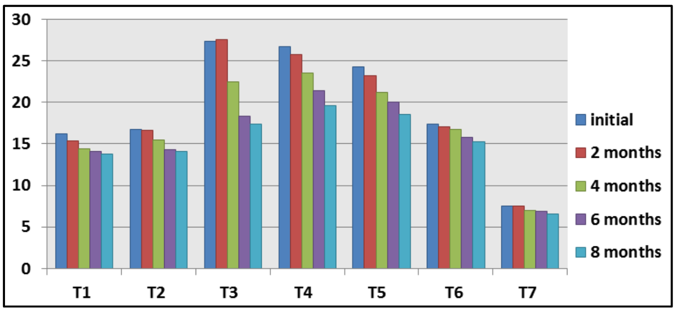

Fig 4: Effect of sugar concentrations on sequential changes of total sugars (%) of osmotically dehydrated pineapple slices under storage

Table 4: Effect of sugar concentrations on sequential changes of total sugars (%) of osmotically dehydrated pineapple slices under storage

Treatments	Initial	2 months	4 months	6 months	8 months
T1 35°B Sugar syrup	16.20%	15.38	14.37	14.08	13.80
T2 40°B Sugar syrup	16.78	16.66	15.43	14.29	14.07
T3 45°B Sugar syrup	27.29	27.57	22.51	18.36	17.42
T4 50°B Sugar syrup	26.70	25.80	23.49	21.42	19.65
T5 55°B Sugar syrup	24.31	23.25	21.20	20.01	18.52
T6 60°B Sugar syrup	17.35	17.01	16.74	15.78	15.24
T7 CONTROL	7.56	7.50	6.95	6.84	6.52
C.D (5%)	1.03	1.39	1.02	1.13	0.72
S.E.(m) ±	0.38	0.43	0.31	0.40	0.22

Conclusion: From the findings of the present experiment, it is clear that for osmotically dehydrated pineapple prepared from different sugar syrup concentrations both the physical and chemical quality has been improved with the treatments. From the initial to 8th month of storage highest TSS was obtained in T_2 (40°B) followed by T_4 (50°B). Though minimum acidity was estimated under T_7 (control) moderate acidity was recorded in T4 (50°B). Maximum reducing sugar and total sugar was found in T_4 (50°B) at initial stage as well as other stages of storage. Thus it can be concluded that treating the pineapple slices with sugar syrup having concentration at (50°B) T_4 is ideal for osmotic dehydration of pineapple.

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