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Effect of cube size on moisture loss, weight loss, solid gain and dehydrated yield in osmotically dehydrated pineapple

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Abstract
A study was conducted to investigate the effect of cube size (2, 3, 4 cm^3) and sugar concentration (40, 50, 60ºBrix) on osmotic dehydration of pineapple. Moisture loss, weight loss, solid gain and dehydrated yield during osmotic dehydration of pineapple were studied with respect to cube size and sugar concentration with sample to solution ratio 1:4 with soaking duration of osmotic solution 18 hours. It was observed that Higher moisture loss (27.10), weight loss (12.00), solid gain (15.09) and dehydrated yield (21.06) was observed in 2 cm^3 cubes steeped in 60ºBrix sugar syrup for 18 hours and lower moisture loss, weight loss, solid gain and dehydrated yield was observed in 4 cm^3 cubes steeped in 40ºBrix sugar syrup for 18 hours. It was also observed that decrease in cube size and increase in sugar concentration significantly increases moisture loss, weight loss, solid gain and dehydrated yield.

Keywords: Osmotic dehydration, pineapple, moisture loss, weight loss, solid gain, dehydrated yield

Introduction
Pineapple (*Ananas Comosus* L.) belongs to the family Bromeliaceae and according to Baker and Collins (1939), it probably originated in central and southern Brazil, northern Argentina and paruguay. It is a non-climactric fruit in nature and has characteristic pleasant flavor, distinct aroma, exquisite taste and absence of seeds qualifies it as one of the choicest fruit throughout the world. Pineapple is a good source of vitamin A and C and is fairly rich in vitamin B and B_2 (Lal and Pruthi, 1955) [9]. It also contains phosphorous and minerals like calcium, magnesium, potassium and iron (Lodh, *et al.*, 1972) [12]. Furthermore it contains a proteolytic enzyme called Bromelin, which aids in reducing inflammations and also contributes to good digestion (Lodh, *et al.*, 1973 and Silva, *et al.*, 2014) [11, 7]. India is the fifth largest producer of pineapple. In India, its cultivation is mostly confined to southern part of India (Karnataka, Tamil Nadu, Andhra Pradesh and Kerala). In year 2014-2015 the total area of pineapple under cultivation in India was about 113.0 thousand ha with a production of 1892.0 thousand MT. In Andhra Pradesh, the area under pineapple was 2.79 thousand ha with production of 86 thousand MT (Anonymous, 2015) [3].
The process of osmosis can be used to remove water from dilute solution contained with a semi permeable membrane by surrounding the membrane with a more concentrated solution. Osmotic dehydration can remove 50% of the water from fresh ripe fruits. Osmotic dehydration is considered as a pre- treatment for pineapple with a final aim of obtaining high quality dried fruit products. Osmotic dehydration is widely used to remove part of water content of fruit to obtain a product of intermediate moisture or as a pre treatment before further processing (Lenart, 1996 and Torreggiani, 2004) [10, 15].

Material and Methods
Fully matured fresh fruits with uniform size and shape, free from transportation injuries, bruises, insect damages and diseases were procured from the Bramhanandam Reddy fruit market, Tadepalligudem, West Godavari District, Andhra Pradesh, India. The selected fruits were washed under running tap water, peeled using stainless steel knife and cut in to cubes of different sizes viz., 2 cm^3, 3 cm^3, 4 cm^3 and cube size was measured with the help of normal scale. Three different concentrations of sugar syrup *i.e* 40, 50, 60°Brix were prepared. During heating of the sugar solution, 0.1 per cent citric acid and 0.05 per cent potassium metabisulphite (KMS) was added as preservative by dissolving in little drinking water after the syrup was cooled.

Fruit syrup were put in a ratio of 1:4 (slice to sugar syrup) and left for 18 hours for osmosis. osmosed pineapple cubes were drained and loaded uniformly over stainless steel trays and was kept in tray drier for dehydration. Fruit slices were dried at 60°C temperature to get desired moisture content and product quality.

The following characters of osmo-dehydrated pineapple cubes were recorded during experimentation.

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

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

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

$$\text{Dehydrated yield (\%)} = \frac{\text{Weight of dehydrated segments}}{\text{Weight of fresh segments}} \times 100$$

Results and Discussion

Moisture loss (%)

Generally the decrease in cube size and increase in sugar concentration increases the amount of moisture loss. Among the treatments moisture loss (27.10 %) was significantly high in steeping of 2 cm^3cubes in 60ºBrix sugar syrup for 18 hours, while the lowest moisture loss (11.21 %) was recorded in steeping the cubes of 4 cm^3 in 40ºBrix syrup for 18 hours.

The results indicated that the increase in the concentration of sugar and decrease in thickness of slice increased the moisture loss.

This might be due to the increased diffusional changes and osmotic pressure exerted on the fruit cell structure which consequently resulted in greater moisture reduction in higher concentration solutions. Similar observations recorded by Khanom *et al*. (2014) [8] in pineapple.

It was also observed that the size of fruit samples had a negative effect on water loss and solute gain. This was because of the distance travelled by water to reach the fruit surface was smaller causing higher water loss in thinner slices.

Similar results were observed by Fito *et al*. (2001) [6] and Agnelli *et al*. (2005) [2] in apple cubes and Jalali *et al*. (2008) [7] in banana and Devinder *et al*. (2013) [5] in pineapple.

Weight loss (%)

With decrease in cube size and increase in sugar concentration there was a corresponding increase in the weight loss.

Among the treatments, maximum weight loss (12.00 %) was observed in pineapple cubes of 2 cm steeped in 60^{O}Brix sugar syrup for 18 hours, whereas the lowest (5.33 %) was recorded in 4 cm^3 treated with 40^{O}Brix sugar syrup for 18 hours.

Decrease in the cube size of osmosis from 2 cm^3 to 4 cm^3 resulted in an increase in weight loss from 10.72 % to 5.33 % in pineapple cubes. Variation in weight loss among different sizes of cubes and concentration of sugars was attributed to osmosis.

Increase in weight loss (%) with increase in sugar syrup concentration and decrease in cube size might be due to lowered viscosity of hypertonic solution. Similar results were observed by Khanom *et al*. (2014) [8] and Chaudhari *et al*. (2015) [4] in pineapple.

Solid gain (%)

Among the treatments, steeping of 2 cm^3 pineapple cubes in 60^{O}Brix sugar syrup for 18 hours recorded significantly superior solid gain (15.09 %) over the other treatments and the lowest (5.75 %) was observed in the treatment 4 cm^3 in 40 °Brix for 18 hours.

An increase in sugar syrup concentration of osmosis or decrease in cube size resulted in an increase in solid gain. By increasing the sugar syrup concentrations from 40^{O}Brix to 60^{O}Brix and cube size from 2 cm^3 to 4 cm^3 and steeping for 18 hour resulted in an increase in solid gain from 5.75 % to 15.09 %.

Osmotic treatment promotes higher water loss than sugar gain since water removal and solid gain takes place due to diffusion mechanisms. Solid gain is largely a diffusional process while water removal is due to osmotic mechanism resulting from differences in water chemical potential between the cells and osmotic solutions (Fito *et al.*, 2001) [6]. The results are in harmony with the results of Khanom *et al*. (2014) [8] and Chaudhari *et al*. (2015) [4] in pineapple.

Treatments	Moisture loss (%)	Weight loss (%)	Solid gain (%)	Dehydrated yield (%)
T1: Steeping of 2 cm^3cubes in 40ºBrix sugar syrup	14.97	6.51	8.46	17.94
T_2: Steeping of 2 cm^3cubes in 50ºBrix sugar syrup	22.41	11.03	11.37	20.47
T_3: Steeping of 2 cm^3cubes in 60ºBrix sugar syrup	27.10	12.00	15.09	21.06
T_4: Steeping of 3 cm^3cubes in 40ºBrix sugar syrup	13.12	5.20	7.92	14.31
T_5: Steeping of 3 cm^3cubes in 50ºBrix sugar syrup	20.07	9.49	10.58	20.06
T_6: Steeping of 3 cm^3cubes in 60ºBrix sugar syrup	24.76	10.72	14.04	20.40
T_7: Steeping of 4 cm^3cubes in 40ºBrix sugar syrup	11.21	5.33	5.75	12.61
T_8: Steeping of 4 cm^3cubes in 50ºBrix sugar syrup	18.50	9.11	9.38	17.83
T_9: Steeping of 4 cm^3cubes in 60ºBrix sugar syrup	23.24	9.70	13.53	20.28
CD at (0.05)	0.42	0.42	0.67	0.93
S.Em±	0.14	0.14	0.22	0.31

Dehydrated yield (%)

Various osmotic concentrations and cube sizes significantly affected the yield of osmotically dehydrated pineapple.

Significantly the highest dehydrated yield (21.07 %) was observed in 2 cm^3 pineapple cubes treated with 60^{O}Brix sugar syrup concentration for 18 hours period, while the lowest yield (12.61 %) was observed in steeping of 4 cm^3 in 40 °Brix sugar syrup for 18 hours.

The increase in recovery of dehydrated yield may be attributed to the transfer of sugars from syrup to fruit slices through osmosis during period of osmodehydration. Similar results were obtained by Adambounov and Costaigue (1983) [1] in banana and Nanjundaswamy *et al*. (1978) [13] in indigenous fruits.

Conclusion

It was concluded that decrease in cube size and increase in sugar concentration increased moisture loss, weight loss, solid gain and dehydrated yield of pineapple slices. The moisture loss (27.10), weight loss (12.00), solid gain (15.09) and dehydrated yield (21.06)) was observed in 8 mm slices steeped in 60^{O} Brix syrup concentration for 18 hours.

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