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Effect of pre-treatments and drying methods on the quality attributes of dehydrated pineapple slices

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ABSTRACT

Purpose: Pineapple fruit is a rich source of minerals and vitamins. Its shelf life is very short due to perishability characteristic. **Research Method:** In this research, the effect of pre-treatments on pineapple slices for its preservation and acceptability was studied. The pineapple slices were treated with three different osmotic (table sugar) solution concentrations, temperature, and vacuum pressure levels to find the most suitable treatment in term of quality. Different parameters such as weight reduction, water loss, solid gain, nutritional quality and sensory test (texture, taste, odor, and appearance) were studied. To perform these parameters pineapple slices were immersed in sugar solution on 50, 60 ºB (degree Brix) at 30, 40 and 50 ºC followed by three vacuum pressures including 435 mmHg, 110 mmHg and atmospheric 760 mmHg pressures for up to 180 min. **Findings:** Results showed that water loss in pineapple slices increased with increase in vacuum level in all three sugar concentrations and degrees of temperatures in osmotic solution. Weight reduction, water loss, solid gain, water activity, total color, ascorbic acid content, whereas sugar content was found significantly affecting the process followed by temperature and levels of vacuum. **Research limitations:** There were no limitations to report. **Originality/Value:** It was found that the most affecting treatment was vacuum pressure, whereas the highest changes occurred in appearance followed by the ascorbic acid content of the samples treated with different parameters.

INTRODUCTION

Pineapple [*Ananas comosus* (Linn.) Merrill] in India commercially grown in the states of West Bengal, Assam, Karnataka, Bihar, Tripura, Meghalaya, Manipur, Kerala, Nagaland and Arunachal Pradesh, and spanning an area of 3.13 lakh ha and production of 2.49 million ton (NHB database, 2014). It contains a considerable amount of calcium, potassium, fiber and vitamin C. It is low in fat and cholesterol and also having exceptional juiciness, vibrant tropical flavor, and immense health benefits.

With the potential application of osmotic dehydration and the recent study made by researches, osmotic dehydration technology became bold and gain more attention among other drying and dehydration methods in the food processing industry (Rastogi et al., 2002; Kumar et al., 2008). Quality improvement is related not only to the water removal without thermal stress but also to the impregnated solutes. With the correct choice of process variables, water removal, and impregnation, it is possible to enhance natural flavour and colour retention in fruit products (Marcotte & Le Maguer, 1992). Osmotic dehydration is the useful technique which can be used in the engineering process, industrial research and biological investigation for optimizing the processing system.

MATERIALS AND METHODS

The fresh pineapple (ripen) were procured from Azadpur fruit market, New Delhi, brought and stored at Division of Food Science and Postharvest Technology, IARI, New Delhi at 8 °C temperature for overnight. Next day the fruits were cleaned and about 3 cm bottom portion was removed with the help of a knife. Pineapple corer was used to take out the core and flesh of pineapple fruit was cut into slices (1 cm thickness), the slices were further treated in sugar solution containing 0.5% KMS for osmosis dehydration at the ratio of 1:4 (w/v), 180 min over the samples were drained and osmotic dehydration was done. The osmotically dehydrated pineapple slices were further dried in the tray drying oven model (MAC-MSW-216) at 55 ± 2 °C up to 10 hrs up to 10% moisture level. Response surface methodology (RSM) design was applied to reduce the number of experiments as well as to improve statistical interpretation possibilities. The Box-Behnken Design was applied for RSM study.

Weight reduction (WR), water loss (WL) and solid gain (SG) were estimated using the following equations (1, 2 and 3) (Sridevi & Genitha, 2012):

$$WR = \frac{M^0 - M}{M^0} \qquad (1)$$

Where, M^0 is initial mass of sample in (g); M is mass of the sample after dehydration

$$WL = \frac{\{(W_0 - W_t) + (S_t - S_0)\}}{W_0} X\ 100 \qquad (2)$$

$$SG = \frac{S_t - S_0}{W_0} X\ 100 \qquad (3)$$

Where,
W_0 is initial weight taken for osmosis dehydration in (g)
W_t is the weight of the osmotically dehydrated sample at time t in (g)
S_0 is the initial dry matter in (g)
S_t is the dry matter after osmotic dehydration for a particular time

The colour was determined using Hunter Lab System and the colour value was expressed as *L**, a* and b*. Ascorbic acid determined by the volumetric method by using 2, 6-dicholorophenol-indophenol dye (Ranganna, 1999). Water activity (a_w) was measured using a water activity meter (Hygrolab, Rotronic). The texture of the dehydrated samples was found using Stable Micro System model TA.XT Plus machine, two disc samples were taken and pressed to remove the space between the slices, puncture test compression mode was carried using needle P/2n with speed of 1.5 mm/sec for penetration of (zero mm) in test sample Bourne (1975). The sensory quality evaluation of the product was done by a panel of 5 judges using a 9 point Hedonic scale (Amerine et al., 1965).

RESULTS AND DISCUSSION

The reduction in weight of the samples varied from 7.63% to 13.00%. Same way the estimated regression coefficients show the significant effect of vacuum on WR of slices (p=0.018) (Table 1). Similarly, °Brix and temperature were also found to affect the WR significantly at (p=0.1). This difference in behavior might be due to the difference in size of the contact surface between fruit pieces and the syrup, different structure, compactness of tissues and also other intrinsic properties which could vary in fruit to fruit and variety to variety (Pedapati & Tiwari., 2014). The variables such as pressure and temperature had also been reported significant in weight reduction during osmotic dehydration (Corzo & Gómez, 2005).

Solid gain ranged from 0.98% to 3.37%. Estimated regression coefficients for SG shows significant changes (Table 2) and it °Brix had (p= 0.016) indicates an increase in °Brix has a significant effect on the solid gain of pineapple slices. The increase in solid gain during osmosis process could be due to diffusional differences between water and sugar, related to their different molar masses (Torregiani, 1993). Paes et al. (2008) reported that solid gain was not greatly affected by temperature during the osmotic process. Many other authors have reported that the increase in water loss had been observed with respect to increasing in °Brix of sugar solution and temperature (Islam & Flink, 1982; Hawkes & Flink, 1978; Ponting, 1966).

Table 1. Estimated Regression Coefficients for WR

	Coef	StDev	T	p
Constant	10.283	1.4570	7.058	0.001
Vacuum	-3.105	0.8922	-3.480	0.018
Brix	2.271	0.8922	2.546	0.052
Temp	1.881	0.8922	2.109	0.089
Vacuum×Vacuum	-0.095	1.3133	-0.073	0.945
Brix×Brix	1.982	1.3133	1.509	0.192
Temp×Temp	0.617	1.3133	0.470	0.658
Vacuum×Brix	0.410	1.2618	0.325	0.758
Vacuum×Temp	-0.410	1.2618	-0.325	0.758
Brix×Temp	1.008	1.2618	0.798	0.461

Table 2. Estimated Regression Coefficients for SG

Term	Coef	StDev	T	p
Constant	2.1267	0.2304	9.232	0.000
Vacuum	0.1912	0.1411	1.356	0.233
Brix	0.5000	0.1411	3.544	0.016
Temp	0.0812	0.1411	0.576	0.590
Vacuum×Vacuum	0.0379	0.2076	0.183	0.862
Brix×Brix	0.4904	0.2076	2.362	0.065
Temp×Temp	-0.1871	0.2076	-0.901	0.409
Vacuum×Brix	-0.0700	0.1995	-0.351	0.740
Vacuum×Temp	0.0325	0.1995	0.163	0.877
Brix×Temp	0.4300	0.1995	2.155	0.084

Table 3. Estimated Regression Coefficients for WL

Term	Coef	StDev	T	p
Constant	2.1267	0.2304	9.232	0.000
Vacuum	0.1912	0.1411	1.356	0.233
Brix	0.5000	0.1411	3.544	0.016
Temp	0.0812	0.1411	0.576	0.590
Vacuum×Vacuum	0.0379	0.2076	0.183	0.862
Brix×Brix	0.4904	0.2076	2.362	0.065
Temp×Temp	-0.1871	0.2076	-0.901	0.409
Vacuum×Brix	-0.0700	0.1995	-0.351	0.740
Vacuum×Temp	0.0325	0.1995	0.163	0.877
Brix×Temp	0.4300	0.1995	2.155	0.084

Table 4. Estimated Regression Coefficients for colour

Term	Coef	StDev	T	P
Constant	5.8900	0.6713	8.774	0.000
Vacuum	-0.9588	0.4111	-2.332	0.067
Brix	-0.1663	0.4111	-0.404	0.703
Temp	0.2075	0.4111	0.505	0.635
Vacuum×Vacuum	-0.5713	0.6051	-0.944	0.388
Brix×Brix	0.0138	0.6051	0.023	0.983
Temp×Temp	0.9313	0.6051	1.539	0.184
Vacuum×Brix	-0.1675	0.5813	-0.288	0.785
Vacuum×Temp	-0.2500	0.5813	-0.430	0.685
Brix×Temp	-0.8350	0.5813	-1.436	0.210

Water loss varied from minimum 6.45% to maximum 16.46% in 15 samples. The estimated regression coefficient for WL is presented in (Table 3). It was observed from the table that increase in the level of vacuum had a significant effect on loss of water (p=0.016).

Similarly, °Brix and temperature were found significant on WL at (p=0.1). Increase in water loss could be due to combination level of vacuum, temperature, and concentration of sugar syrup which might have a greater impact on water loss and solid gain of the food under osmotic dehydration. Paes et al. (2008) reported that vacuum and temperature during vacuum osmo-dehydration had a significant increase in water loss rate during osmotic dehydration. Campos et al. (2012) also reported that an increase in solution temperature and concentration during osmotic dehydration influences the solid diffusivity and this causes greater water loss.

The total colour values recorded for all the 15 samples varying from 69.12 to 81.78 presented in clearly shows differences in colour amongst the samples. The study of total colour applying estimated regression coefficients (Table 4) shows that the vacuum had a significant effect on colour (p=0.1). This might be due to the sensitivity of colour pigments with thermal processing that at lower temperatures pigments are not affected by the temperature and had high colour retention (Valencia et al., 2011). Ponting et al. (1966) suggested a maximum solution temperature of 49 °C during osmotic dehydration for a better colour retention.

Table 5. Water activity and Ascorbic acid content of dried pineapple slices

Design	Coded values				
	X1	X2	X3	Aw	Ascorbic Acid (mg 100 g^{-1})
1	-1	0	-1	0.345	49.68
2	-1	0	1	0.387	41.40
3	0	1	-1	0.419	52.44
4	0	-1	1	0.398	41.40
5	0	0	0	0.377	44.16
6	1	0	1	0.423	41.40
7	0	0	0	0.413	41.40
8	-1	1	0	0.378	44.16
9	-1	-1	0	0.388	49.68
10	0	1	1	0.411	47.62
11	1	0	-1	0.365	38.64
12	0	0	0	0.328	44.16
13	0	-1	-1	0.335	52.44
14	1	-1	0	0.422	38.64
15	1	1	0	0.384	49.68

The data recorded for (A_w) of osmotically dried pineapple slices presented in (Table 5) shows that difference in (A_w) of the samples was not significant. Variation between the lowest and highest water activity found (0.095), whereas the lowest (A_w) (0.328) was recorded at 40 °C and 60 °B at 435 mmHg, and the highest (0.423) (A_w) was observed at 50 °C and 60 °B at 110 mmHg. This might be due to the effect of osmotic dehydration in all the treatments which might have reduced the A_w (Valencia et al., 2011). The results of our experiment are in corroborate with the findings of Silva et al. (2014) who reported that overall the osmotic dehydration had significantly decreased water activity of fresh pineapple in all the temperatures and concentrations.

The ascorbic acid content of pineapple slices presented in (Table 5) shows that content ranged among the different pre-treatments between (38.64 mg 100 g^{-1}) to highest (52.44 mg 100 g^{-1}) of the samples. Similarly, ascorbic acid was found to be affected by the parameters while estimated regression coefficients was applied, the all three parameters were found significantly affecting the ascorbic acid value of dehydrated pineapple slices. The reduction in ascorbic acid may be due to the degradation of ascorbic exposing at higher temperature Zanoni et al. (2000). Osmotic treatment lowered the quality changes in green peas as well as had a good retention of ascorbic acid in frozen samples compared to untreated samples (Giannakourou & Taoukis, 2003).

Organoleptic

Texture

The overall acceptability recorded minimum of 5.2 and maximum 7.8, indicates the ranges between the slightly like and very liking of the product. Similarly, the average score 6.1 of texture given by panel shows that they liked the texture of the product (Fig. 1). Application of vacuum affected the texture of dehydrated pineapple as compared to atmospheric pressure this might be due to the opening of pores by both osmotic pressure and vacuum pressure which are acting as an external force to open the pores (Ferrari et al., 2011).

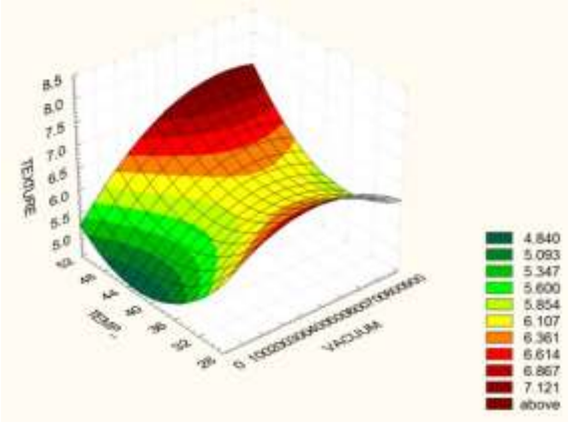

Fig. 1. Effect of vacuum and temperature on of osmotically dehydrated pineapple slices

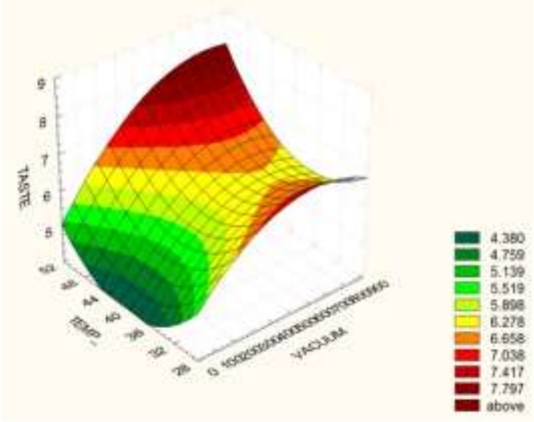

Fig. 2. Effect of vacuum and temperature on the taste of osmotically dehydrated pineapple slices.

Taste

Taste of dehydrated pineapple slices scored (6.4) by the members of the organoleptical evaluation panel (Fig. 2). This due to the concentration of sugar solution and temperature in the taste of dehydrated pineapple slices. Chaudhari et al. (2015) reported that pineapple slices dipped in 50 °B sugar solution had a better acceptability for its taste than the sample dipped in 60 °B.

Odour

Dehydrated pineapple slices scored (7.31) for its odour by the panel members of sensory evaluation (Fig. 3). Silva et al. (2014) who have reported that osmotic dehydration controlled the aroma losses and increased the sensory acceptance.

Appearance

The sensory panel scored (6.38) for the dehydrated pineapple slices for its appearance (Fig. 4). Changrue et al. (2008) reported that osmotic pre-treatment in microwave vacuum drying lead to higher acceptance of dried product with respect to appearance. Similarly, Sridevi and Genitha (2012) reported that appearance and overall acceptability of osmotically dehydrated pineapple were increased with an increase in sugar solution of 40-60 °Brix and temperature of 30-50 °C, respectively.

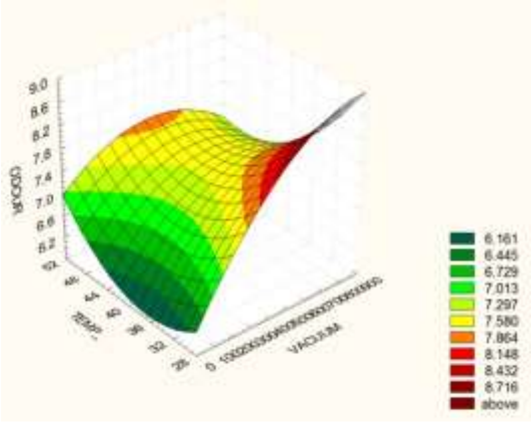

Fig. 3. Effect of vacuum and temperature on the odour of osmotically dehydrated pineapple slices.

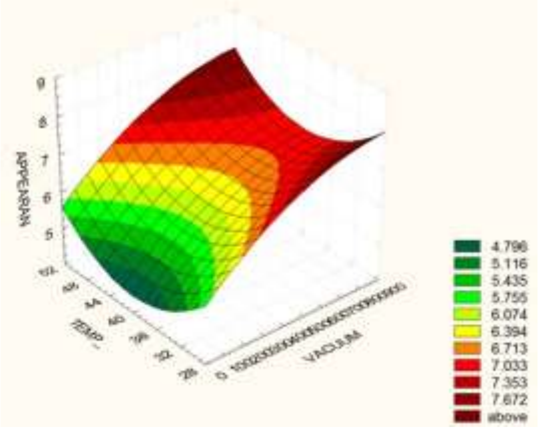

Fig. 4. Effect of vacuum and temperature on the appearance of osmotically dehydrated pineapple slices.

Conflict of Interest

The authors declare that they have no conflict of interest.

CONCLUSIONS

The percentage of water loss in dehydrated pineapple slices varied from minimum 6.45% to maximum 16.46% in 15 samples, increase in the level of vacuum had a significant effect on loss of the total colour values recorded for all the 15 samples varying from 69.12 to 81.78, that shows vacuum has a significant effect. Ascorbic acid was found most affecting from all the parameters while estimated regression coefficients were applied, all three parameters were found significant (highest; 52.44 mg 100 $g^{-1}$and lowest; 38.64 mg 100 g^{-1}). The sensory test had been found significantly affected by most of the treatments applied. The texture of the osmotically dehydrated pineapple was significantly affected by application vacuum. With regard to taste, the osmotically dehydrated pineapple slices were significantly affected by temperature. Dehydrated pineapple slice scored (7.31) for its odour was affected by temperature and vacuum and found statistically significant. Appearance was found to be the most affected parameter by the experimented treatments by vacuum, °Brix, vacuum×vacuum, temperature×temperature and °Brix×temperature.

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