J Krishi Vigyan 2023, 11 (2) : 259-264 DOI : 10.5958/2349-4433.2023.00049.1

Optimization of Process Parameters for Osmotic Dehydration as a Pretreatment for Making Papaya Candy

Gurpreet Kaur Dhillon and Rajni Goel[1]

Punjab Agricultural University, Regional Research Station, Bathinda, Punjab

ABSTRACT

Papaya slices were osmosed using jaggery instead of sucrose to lessen the deteriorating health effect of refined sugar. The Box-Behnken design was used to optimize time (1-4 hr), temperature (35-45ºC) and jaggery concentration (45 to 55ºBrix) to achieve maximum water loss (WL) and optimum solute gain (SG) in papaya slices. The optimized conditions for osmotic dehydration of papaya slices were immersion time (4.0 hr), temperature (44ºC) and jaggery concentration (55ºBrix) for a water loss of 34.35 (g/100g) and solute gain of 9.61 (g/100g). Further, the sample prepared using optimized conditions was dried by convective drying for making papaya candy. Proximate and mineral analysis of the samples suggested an improvement in the nutritional quality of jaggery-based papaya candy by significantly increasing the ash and mineral content of jaggery-based candy compared to sucrose-based candy. In addition, sensory attributes suggested higher acceptability of jaggery-based papaya candy, which was comparable with the control.

Key Words: Fruit candy, Jaggery, Mineral, Osmotic dehydration, Papaya, Profile.

INTRODUCTION

Papaya (*Carica papaya* L.) is an important fruit of tropical and subtropical region (Salinas *et al*, 2019). It is a highly perishable fruit, and various techniques can preserve it. In recent years, fruit candies are gaining popularity among consumers, especially children. Osmotic dehydration is widely used as a pretreatment for making fruit candies owing to its non-thermal process, as it reduces the moisture content without altering fruits and vegetables' nutritional and physical properties (Rastogi *et al*, 2014). However, the most commonly used osmotic agent for fruits is refined sugar or sucrose. Refined sugar is composed of 99.9% sucrose, which has very little nutritious value and is high in empty calories. In addition to these negative consequences of refined sugar, its use has also been linked to an increased risk of dental disorders (Seguí *et al*, 2015). As refined has become synonymous with harmful in the food world, it must be replaced with a better option. Jaggery is one of the healthy alternatives to refined sugar, and people are returning to their roots and preferring jaggery over refined sugar. Moreover, jaggery is better than sugar as it is rich in minerals and vitamins and is considered the world's healthiest sugar (Kumar and Singh, 2020).

To the best of our knowledge, jaggery has not been explored as an efficient osmotic agent for papaya candy. Hence, the present investigation aims to use jaggery as an osmotic agent for the osmotic dehydration of papaya slices. Optimization of time, temperature and osmotic concentration are important to obtain maximum water loss and optimum solute gain in osmo-dried fruit. Therefore, objectives of this study were to optimize processing parameters for osmotic dehydration of papaya slices using jaggery using Response Surface Methodology (RSM) and also to characterize and compare the jaggery-based papaya candy with sucrose-based papaya candy.

---

*Corresponding Author's Email: rajnigoel-ptl@pau.edu

[1] Krishi Vigyan Kendra, Patiala, Punjab

MATERIALS AND METHODS

Papaya (under-ripe) fruits of the variety Red Lady were collected from the papaya growers (02) of the Bathinda district. The initial moisture content of papaya was 88.21±2.15%; no blanching was done before osmosis. The fruits were washed and sliced (4-5cm long and 0.5cm thick). The cumulative effect of immersion time (hour), temperature (ºC) and jaggery concentration (ºBrix) was studied using Box-Behnken design (BBD) using response surface methodology using Design Expert software version 13.0 (Stat-Ease Inc., Minneapolis, USA). The levels of processing parameters chosen as independent variables were 1) immersion time (1-4 hr), 2) temperature (35-45ºC) and jaggery concentration (45-55ºBrix); initial trials finalized jaggery concentration. Each independent variable was tested at three coded levels, low, medium and high, as -1, 1 and +1. The software generated 17 experimental runs, of which five were at the central values (Table 1). The statistical significance was calculated by analysis of variance (ANOVA), coefficient of determinations and lack of fit tests. Significant parameters were obtained from $p<0.05$. Water loss and solute gain were predicted to generate a second-order polynomial mode.

$$Y= \beta_o+\beta_1 {}_2+\beta_3x_3+\beta_{12}x_1x_2+\beta_{13}x_1x_3+\beta_{23}x_2x_3+ \beta_{11}x_{12}+ \beta_{22}x_2+\beta_{33}x_3{}^2 \quad \textbf{(1)}$$

Y is the predicted response, A, B, and C are the coded levels of independent parameters (x1-time (A), x2 temperature (B) and x3-jaggery concentration(C), β_0 (constant term), β_1, β_2 and β^3; β_{11}, β_{22} and β_{33}; β_{12}, β_{13} and β_{23} are offset term, linear effects; squared effects and interaction effects, respectively. The quality of the model was estimated by R^2 (Predicted R^2) and R^2 (coefficient of determination). For osmotic dehydration, Jaggery syrup was made at 40, 45 and 55°Brix and 50g of papaya slices fruit was immersed in different osmotic solutions for each trial at a particular time and temperature as per the designed experiment (Table 2). The fruit to osmotic solution ratio (1:4) was kept at a constant level. All the experiments were run in triplicates for accurate results. Solute gain (SG) and water loss (WL) were calculated by using the procedures of Chauhan *et al* (2011).

Weight reduction (WR)= W_0-W_t

After osmotic dehydration, solute gain at tome (t), SG= (St-S_0)

WL= Weight reduction + Solute gain

$$\text{SG (g/100g of fruit)} = \frac{(S_t-S_0)\ X100}{W_0}$$

$$\text{WL (g/100g of fruit)} = \frac{(W_0-W_t)+ (S_t-S_0)\ X100}{W_0}$$

Where W_0, W_t, S_0, and S_t are the initial weight (g) of papaya slices, weight (g) of the osmotically dehydrated papaya after time t (h), the initial weight of solids content in papaya slices (g) and weight of solids of the osmotically dehydrated papaya slices after time t (h), respectively. Proximate composition (crude protein, ash and moisture) were determined by (AOAC, 1991). For mineral analysis, one gram of sample was taken and digested using HNO_3 and $HClO^4$ in (a 3:1) ratio. After digestion, samples were diluted with 50mL deionized water; dilution was followed by filtration. The minerals were measured by coupled plasma-mass spectrometry (ICP-MS) (X-Series2; ThermoFisher Scientific). Mineral content was expressed in mg/100g (Kaur *et al,* 2018). Jaggery osmosed papaya slices under optimized conditions were conventionally dried in a cabinet drier at 50-55ºC for 4 hr. For the control sample, papaya slices were osmosed in 60ºBrix sucrose solution for 3.5 hours at 45ºC. The conditions were finalized by conducting initial trials. The sensory evaluation of jaggery-based candy was conducted and compared with the control (sugar-based papaya candy). For sensory evaluation, untrained panelists (50) were selected randomly; each panelist received two samples and assigned scores through a hedonic scale of nine points from 1 (disliked extremely) to 9 (liked very much) for the attributes: colour, flavour, texture, taste; the overall acceptability was calculated by the given scores for sensory attributes.

Table 1. Experimental design of independent variables and responses for osmotic dehydration of Papaya slices.

Time (hr)	Temperature (°C)	Jaggery concentration (°Brix)	Water Loss (g/100g of fresh weight)	Solute Gain (g/100g of fresh weight)
1.00	35.00	50.00	15.89	4.23
4.00	35.00	50.00	18.39	7.67
1.00	45.00	50.00	19.25	5.34
4.00	45.00	50.00	32.34	8.67
1.00	40.00	45.00	18.45	4.67
4.00	40.00	45.00	22.34	8.12
1.00	40.00	55.00	20.67	7.56
4.00	40.00	55.00	34.24	10.56
2.50	35.00	45.00	15.34	4.32
2.50	45.00	45.00	30.09	9.59
2.50	35.00	55.00	22.78	9.68
2.50	45.00	55.00	32.12	9.56
2.50	40.00	50.00	26.89	8.53
2.50	40.00	50.00	27.45	8.98
2.50	40.00	50.00	25.45	9.32
2.50	40.00	50.00	26.45	8.21
2.50	40.00	50.00	25.89	8.12

Statistically, the data was analyzed using ANOVA at $p \leq 0.05$ significance level using SPSS 19.0 statistical software. The results were expressed as the mean ± S.D. of three replications.

RESULTS AND DISCUSSION

The independent variables (immersion time, temperature and jaggery concentration) and responses of dependent variables, water loss (WL) and solute gain (SG) are given in Table 1. The analysis of variance (ANOVA) for all the studied responses is shown in Table 2. F-values of 36.65 and 21.57 for WL and SG, respectively and a non-significant lack of fit suggested the significance of the models ($p<0.05$). The predicted $R^2$and the actual R^2 (the coefficient of determination) values are 0.97 and 0.95 for water loss and 0.96 and 0.92 for solute gain, respectively; depicted the adequacy the models for predicting the studied responses.

The regression coefficients developed a relationship between the independent and dependent variables. The time of osmotic dehydration had the most significant ($p \leq 0.01$) and positive role in WL, followed by temperature and jaggery concentration (equation 2). Immersion time was found to be the most significant factor in WL during osmotic dehydration of Chinese ginger (An *et al,* 2013). During osmotic dehydration of peach, immersion time was observed to be the most significant factor, followed by temperature (Dhillon *et al,* 2022). In SG, immersion time was found to be the most significant factor, followed by jaggery concentration (equation 3). A review conducted by Yadav and Singh (2014) reported that solute concentration plays an essential role in solute gain during osmotic drying of fruits. Further, the quadratic effect of jaggery concentration resulted in a solute gain in the papaya slices. In the

Table 2 Analysis of Variance for second order polynomial model for the responses

Source	Df	Water Loss		Solute gain	
		SS	p-value	SS	p-value
Model	9	536.78	$< 0.0001^a$	61.37	0.0003^a
Residual	7	11.39		2.21	
Lack of Fit	3	8.89	0.0837^b	1.17	0.3450^b
Pure Error	4	2.50		1.05	
Cor Total	16	548.17		63.58	

a: Significant b: Non-significant

form of coded independent process variables, the developed models are formulated in equations 2 and 3.

$$WL = 26.45+4.13A+5.17B+2.95C+2.65AB+2.42AC-1.35BC-3.05A^2-1.90B^2+0.56C^2 \quad (2)$$

$$SG = 8.63+1.65A+0.90B+1.33C-0.02AB-.11AC-1.35BC-1.36A^2-0.79B^2+0.45C^2 \quad (3)$$

Where, WL= water loss (g/100g of fresh weight), SG= solid gain (g/100g of fresh weight),

A= Immersion time (h), B= temperature (°C), C= jaggery concentration (°Brix)

The main criteria for constraint optimization were maximum water loss with optimum solute gain. The optimized conditions for osmotic dehydration of papaya slices were immersion time (4.0 h), temperature (44ºC) and jaggery concentration (55ºBrix) for a water loss of 34.35 (g/100 g) and solute gain of 9.61 (g/100 g). Osmosed papaya slices were further dried in a convective air drier for further reduction in the moisture content required to make papaya fruit candy. For control samples, papaya slices were osmo-dried using sucrose and then subjected to convective air drier for final moisture reduction.

Proximate and mineral analysis of jaggery osmosed and sucrose osmosed papaya slices are given in Table 3. A significant difference was observed in ash content; ash content is an indicator of the mineral profile of the product (Sezer *et al,* 2017). Further, mineral analysis of candies indicated a significant difference; jaggery-based papaya candy had a 40.03%, 31.69 and 25.80% higher calcium, phosphorus and potassium, respectively, than sucrose-based candy. This was mainly due to higher mineral content in jaggery than in refined sugar (Kumar and Singh, 2020; Singh, 2013). Hence the utilization of jaggery in the osmotic drying of fruits is beneficial from a nutritional point of view.

Papaya candies prepared using sucrose and jaggery were analyzed colour, flavour, taste, texture, and overall acceptability using 9 point hedonic scale. Results suggested acceptability of jaggery based candy was comparable with the control. Some of panelist preferred the flavor and taste of jaggery based candies over sucrose candies. Jaggery based candy had a dark colour compared to sucrose based candy (Figure 1); however, the difference was non-significant and both the candies were liked by the panelist.

Figure 1. A: Sucrose-based papaya candy, B: Jaggery-based papaya candy

Table 3. Characterization of jaggery and sucrose based papaya candies.

Parameter	**Properties**	**Jaggery based candies**	**Sucrose based candies**
Proximate composition (g/100g of dry weight)	Moisture content	17.49±2.12^a	18.14±1.89^a
	Protein	0.89±0.11^a	0.85±0.14^a
	Ash	5.89±0.36^a	3.48±0.24^b
Mineral (mg/100g)	Calcium	12.24±2.34^a	7.34±1.46^b
	Phosphorus	21.36±2.18^a	14.59±1.37^b
	Iron	1.58±0.21^a	0.47±0.17^b
	Magnesium	31.23±2.89^a	23.17±1.79^b
	Potassium	46.67±4.39^a	29±2.34^b
Sensory attributes (9 point hedonic scale)	Colour	8.02±0.56^a	8.48±0.89^a
	Flavor	8.61±0.39^a	8.21±0.77^a
	Taste	8.27±0.78^a	8.15±0.58^a
	Texture	8.29±1.21^a	8.45±0.73^a
	Overall acceptability	8.28±0.89^a	8.31±0.79^a

CONCLUSION

Response surface methodology effectively optimized the conditions for the osmotic dehydration of papaya slices. Optimized conditions were time (4.0 hr), temperature (44ºC) and jaggery concentration (55º Brix) for a water loss of 34.35 (g/ 100 g) and solute gain of 9.61 (g/100 g). Results suggested that immersion time and jaggery concentration were the significant factors for water loss and solute gain. Further, osmosed papaya slices were dried in a conventional air drier to make papaya candy. From a sensory point of view, jaggery-based candies are highly acceptable and comparable to the control (sucrose-based candy). A Comparison between the jaggery and sucrose-based candies suggested the potential of jaggery as an osmotic agent as it enhanced the ash and mineral profile of jaggery candies compared to sucrose candies.

REFERENCES

An K, Ding S, Hongyan T, Zhao D, Wang X, Wang Z and Hu X (2013). Response surface optimisation of osmotic dehydration of Chinese ginger (*Zingiber officinale Roscoe*) slices. *Int J Food Sci Technol,* **48**(1): 28–34.

AOAC (1991). Official Methods of Analysis. The Association of Official Analytical Chemists. *Analytica Chimica Acta* (15th ed., Vol. 242). Washington, DC.: Washington, DC.

Chauhan O P, Singh A, Singh A, Raju P S and Bawa A S (2011). Effects of Osmotic Agents on Colour, Textural, Structural, Thermal, and Sensory Properties of Apple Slices. *Int J Food Prop* **14**(5): 1037–48.

Kaur B, Singh B, Kaur N and Singh D (2018). Phytoremediation of cadmium-contaminated soil through multipurpose tree species. *Agroforestry Sys* **92**(2): 473–83.

Dhillon G K, Kour A and Gupta N (2022). Optimization of Low-cost Drying Technology for Preservation of Peach (Prunus Persica) Using RSM. *Int J Fruit Sci* **22**(1): 525–38.

Kumar A and Singh S (2020). The benefit of Indian jaggery over sugar on human health. In Preuss H G and & D. B. T.-D. S. Bagchi D B (Eds) *Dietary Sugar, Salt and Fat in Human Health* (pp. 347–59). Academic Press.

Rastogi N K, Raghavarao K S M S and Niranjan K (2014). Recent Developments in Osmotic Dehydration. In Sun D W (Ed.) *Emerging Technologies for Food Processing* (pp. 181–212). Academic Press.

Salinas I, Hueso J J and Cuevas J (2019). Fruit growth model, thermal requirements and fruit size determinants in papaya cultivars grown under subtropical conditions. *Sci Hort* **246**: 1022–27.

Seguí L, Calabuig-Jiménez L, Betoret N and Fito P (2015). Physicochemical and antioxidant properties of non-refined sugarcane alternatives to white sugar. *Int J Food Sci Technol* **50** (12): 2579–88.

Sezer B, Bilge G, Sanal, T, Koksel H and Boyaci I H (2017). A novel method for ash analysis in wheat milling fractions by using laser-induced breakdown spectroscopy. *J Cereal Sci* **78**: 33–38.

Singh J (2013). Manufacturing Jaggery, a Product of Sugarcane, As Health Food. *Agrotech.,* **01**: 1-3

Yadav A K and Singh S V (2014). Osmotic dehydration of fruits and vegetables: a review. *J Food Sci Technol* **51**(9): 1654–1673.

Received on 16/12/2022 *Accepted on 5/4/2023*