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Studies on osmotic drying and quality evaluation of selected varieties of mango slices during storage

Dr. AV Ravani, Dr. SV Anadani, Dr. HP Sharma, Dr. BB Patel and Dr. H Pandey

Dr. AV Ravani
Assistant Professor, College of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand, Gujrat, India

Dr. SV Anadani
Senior Research Assistant, College of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand, Gujrat, India

Dr. HP Sharma
Associate Professor, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Lucknow, Uttar Pradesh, India

Dr. BB Patel
Research Associate, College of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand, Gujrat, India

Dr. H Pandey
Associate Professor, College of Food Processing Technology and Bio-Energy, Anand, Agricultural University, Anand, Gujrat, India

Corresponding Author:
Dr. AV Ravani
Assistant Professor, College of Food Processing Technology and Bio-Energy, Anand Agricultural University, Anand, Gujrat, India

Abstract
Mangoes are considered as a king among the tropical fruits and micronutrients namely β-carotene, riboflavin, folic acid and minerals (calcium, iron and phosphorus) are abundant in Mangoes. Value added mango products are well-liked all around the world and are becoming more significant in both domestic and foreign markets. Therefore, the present work was carried out to study osmo-convective drying of selected varieties i.e. *Kesar* and *Rajapuri* of mango fruit slices. For optimization level of pre-treatments a three factor box and behnken design of response surface methodology was adopted with various sugar syrup concentration (50-70 ºB), steeping time (4-8 h) and osmotic solution to fruit ratio (3:1-5:1) for *Kesar* and *Rajapuri* varieties of mango, individually. The optimized parameters were 50 ºBrix osmotic solution concentration, sugar syrup to fruit ratio 3:1; 4 h steeping time for *Kesar* variety and 51.13 ºBrix osmotic sugar syrup concentration, sugar syrup to fruit ratio 3:1; 4 h steeping time for *Rajapuri* variety, for high water loss, retention of ascorbic acid and less solid gain. The pretreated sample dried at 50 °C temperature and 450 mm Hg vacuum using vacuum dryer and packed in HDPE pouches (200 gauge) and stored at ambient temperature (30±2 °C) for 180 days.

Keywords: *Mangifera indica*, sugar syrup concentration, steeping time, sugar syrup to fruit ratio, osmosis

Introduction
India produces 102.48 million tonnes (MT) of fruit annually on an area of 9.6 million hectares, making it the second-largest fruit producer in the world. Mangoes are produced on an average 2.3 million ha in India, where they produce 21.82 MT overall, the biggest percentage of mango output in the world (50%) (Rahman and Lamb, 1991) [11]. Micronutrients namely β-carotene, riboflavin, folic acid and minerals (calcium, iron and phosphorus) are abundant in Mangoes (Sureshkumar *et al.*, 2008) [15]. Mango (*Mangifera indica* L.) is the king of tropical fruits and is worshipped throughout the world for its succulent texture, exotic flavour, and delectable taste.

Mango is used for a variety of preparations after it has ripened in addition to being utilized for table purpose (Attri and Singh, 2010) [2]. The mango fruit is both a perishable and a seasonal crop. About 20% of fruits are transformed into goods like puree, chutney, nectar, pickles, canned slices, and leather because they are only available for a three to four months (April to July) of the year. Mango goods with added value are in high demand globally and are expanding in both domestic and international markets.

With the least amount of energy input, osmotic dehydration enables the development of new products that may be stored without refrigeration. To create new, less perishable food products or ingredients with strong nutritional and sensory qualities, osmotic dehydration could be used prior to drying or freezing (Ciurzynska *et al*., 2016) [5]. Fruit products retain their natural flavour and colour better when water removal and impregnation are done in a controlled, balanced ratio. Mango slices have a longer shelf life due to osmo-convective dehydration, although the quality of dried mangoes is influenced by factors such as sugar syrup concentration, steeping time, and drying conditions. This study shows the impregnation behaviour of osmotically treated fruit slices for a two different mango cultivars.

Osmotic dehydration is a mass transfer technique that partially eliminates water from fruit while also increasing the amount of soluble solids in an osmotic solution (Torreggiani, 1993) [17]. The procedure alters the fruit tissue in a way that can be customised to the sensory, textural, and compositional qualities of dried fruit. Fruit characteristics, including fruit ripeness, variety, physicochemical characteristics, and tissue structure, might affect the osmotic dehydration mass transfer (Sulistyawati *et al.*, 2018) [14].

Osmotic dehydration mass transfer rates are influenced by a number of process variables, including pre-treatments, temperature, the characteristics of the osmotic solution, agitation, fruit to osmotic solution ratio, and additives (Ahmed *et al*., 2016) [1]. In the present study, three different variables of osmotic treatments (sugar syrup concentration, steeping time and sugar syrup to fruit ratio) were studied for two cultivars (*Kesar* and *Rajapuri)* of mangoes.

Materials and Methods

Matured and uniformly ripe Mangoes (var. *Kesar* and *Rajapuri*) were received from Horticulture Farm of Anand Agricultural University, Anand. As shown in Fig. 1, osmotic drying of mango slices was carried out. To eliminate the clinging dirt and dust, fruits of good quality and uniform size were washed in running tap water. Mango fruits were peeled and sliced vertically using a 1.5 cm thick stainless steel knife. Each experiment's osmotic solution was made by combining sugar with potable water to achieve a concentration of syrup from 50–70 °B (Sureshkumar and Sagar, 2009) [16].

The experiment was set up using a box and behnken design with three levels for each variable with code values of -1, 0 and +1. To do the statistical analysis of experimental data, a Design-Expert software (Stat-Ease, Minneapolis, USA; version 7.0.0) statistical package was used. For each mango type, a total of 51 tests were carried out, and their interactions were also investigated in order to standardize the osmotic drying parameters and to optimize the preservation process at a 1% significance level. Table 1 lists the independent variables, their coded levels taken into consideration, and experiment results.

Table 1: Experimental ranges and levels of variables at coded levels for the osmotic drying of mango slices

Independent Variables	Range of Levels (coded)		
	-1	0	1
Sugar syrup concentration (°B)	50	60	70
Steeping time (h)	4	6	8
Sugar syrup to fruit ratio	3:1	4:1	5:1
Dependent variables			
(a) Water loss (%) (b) Solid gain (%) (c) Ascorbic acid (mg/100 g)			

Fruit slices were immersed in sugar syrup at temperatures of 50, 60, and 70°B in a 3:1 to 5:1 syrup-to-slices ratio for 4, 6, and 8 h, respectively, without being stirred. The osmotically prepared mango slice samples from each group were taken out from the solution, drained, and blotted with absorbent paper to eliminate any excess solution. To determine the dependent variables of the experimental planning –Water/ moisture Loss (WL), Solid mass Gain (SG), and ascorbic acid, weight as well as moisture content were each calculated separately. Three repetitions for each experiment were performed.

The terminologies for mass transport figures by osmotic dehydration were first described by Lenart and Flink, (1984) [8].

Water loss: The amount of water lost by food during osmotic digestion is known as water loss. The water loss (WL), which is calculated using the fruit's initial weight as a starting point, is defined as its net weight loss.

$$\text{Water loss in mango slices}\left(\frac{\text{g}}{100\text{g}}\right) = WL = \frac{W_i.X_i - W_t X_t}{W_i}$$

Solid gain: During osmotic dehydration, the solids from the osmotic solution are added to the sample fruit. Osmotic dehydration causes the sample to lose water, which raises the amount of solids in the sample. The fruit's net absorption of solids on an initial weight basis is known as the solid gain. The following equation is used to calculate it.

$$\text{Solid gain in mango slices}\left(\frac{\text{g}}{100\text{g}}\right) = SG = \frac{W_t(1-X_t) - W_i(1-X_i)}{W_i} \times 100$$

W_t	Mass of mango slices after time t, g
W_i	Initial mass of mango slices, g
X_t	Water content as a fraction of mass of mango slices at time t
X_i	Water content as a fraction of initial mass of mango slices

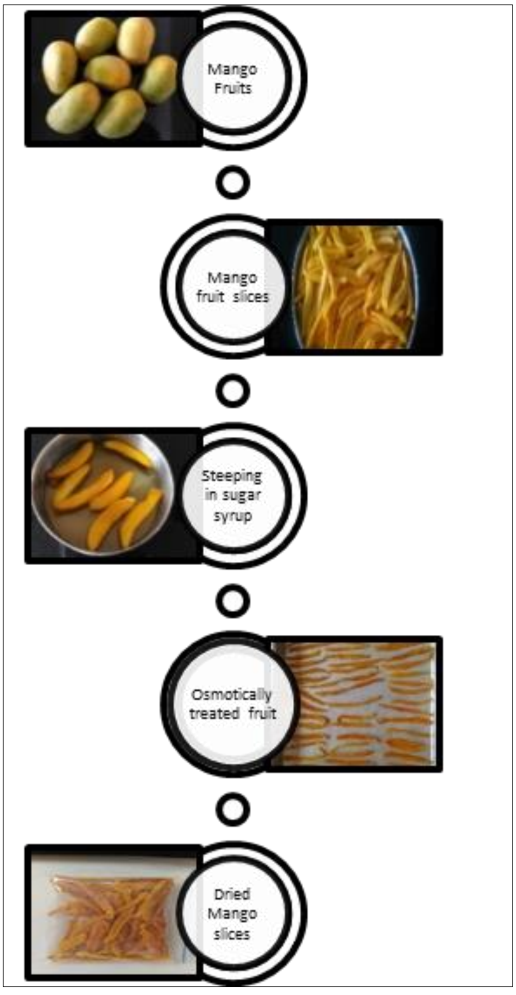


Fig 1: Osmotic drying of Mango slices

By using the dye (2, 6-dichlorophenol-indophenol) visual titration method, the ascorbic acid level of the sample was measured (Ranganna, 2002) [12]. The dye factor was computed using the following equation, and the label values were recorded as mg of ascorbic acid.

$$\text{Dye factor} = \frac{0.5}{\text{titre}} = \frac{0.5}{\text{V}} = \text{mg ascorbic acid per ml dye}$$

Where,
V = Dye solution volume (titre)
Moreover, a 3% HPO3 solution was diluted with 10–20 ml of sample to make up to 100 ml. Two to ten ml of the filtered aqueous extract were collected and titration was done with dye. Ascorbic acid was calculated as:

$$Ascorbic\ acid(mg/100g) = \frac{dye\ factor \times V_2 \times 100 \times 100}{V_1 \times V_3}$$

V_1 = volume of aliquot taken for dye titration, ml
V_2 = volume of the dye required for titration, ml
V_3 = volume of the initial sample taken, ml

The mango slices of *Kesar* and *Rajapuri* variety were treated with optimized conditions of pretreatments. The pretreated mango slices were dried and analyzed for bio-chemical and organoleptic attributes. The standardization of drying parameters for optimized pretreatment of osmosis of Mango was carried out using vacuum dryer at drying temperatures of 50, 60 and 70 ºC and vacuum level of 450, 550 and 650 mm Hg, till the final moisture content of 15-17% (wb) (Gurumeenakshi *et al.*, 2005) [7]. Dried sample was analyzed for overall acceptability, ascorbic acid and non-enzymatic browning. The optimized sample was analyzed for physico-chemical attributes. The samples were stored in 200 gauge HDPE pouch to study shelf life.

Results and Discussion

According to the Response Surface Methodology experimental design, tests were carried out to pre-treat mango slices in osmotic solution. Responses were gathered, and the average of the three replicated data is shown in Tables 2 and 3. For the design analysis, the amount of ascorbic acid, solid gain, and water loss was measured. For each model, three-dimensional graphs were created as a function of two variables, with the third variable's value set as the center, in order to see how two factors affected the responses (Figure 2 & 3). The experimental data were fitted using a linear model, quadratic model, and interaction model, and response of each underwent statistical analysis. The data were further examined with software, and the results of the ANOVA are shown in Table 4.

Table 2: Effect of pre-treatments on physico-chemical attributes of *Kesar* mango slices

Experiment no.	Variables			Responses		
	Sugar syrup concentration (ºBrix)	Steeping time (h)	Syrup to fruit ratio	Water loss (%)	Solid gain (%)	Ascorbic acid (mg/100g)
1	60	6	4	24.57	8.55	33.78
2	60	6	4	24.4	13.61	32.79
3	70	6	3	18.16	11.03	29.64
4	60	8	3	19.94	9.06	30.21
5	60	6	4	35.98	13.55	30.41
6	60	4	5	22.03	7.18	30.56
7	60	6	4	22.45	7.56	31.78
8	50	6	3	29.14	10.64	31.65
9	50	8	4	22.68	9.56	30.56
10	60	4	3	21.45	10.25	31.58
11	60	8	5	21.32	5.64	28.54
12	70	6	5	20.54	8.57	30.57
13	70	4	4	20.34	7.68	30.24
14	50	6	5	30.65	11.56	31.54
15	60	6	4	21.42	7.97	33.21
16	50	4	4	20.33	10.79	28.04
17	70	8	4	23.45	9.07	31.35

Table 3: Effect of pre-treatments on physico-chemical attributes of *Rajapuri* mango slices

Experiment no.	Variables			Responses		
	Sugar syrup concentration (ºBrix)	Steeping time (h)	Syrup to fruit ratio	Water loss (%)	Solid gain (%)	Ascorbic acid (mg/100g)
1	60	6	4	23.74	10.58	31.58
2	60	6	4	21.05	9.54	30.29
3	70	6	3	32.41	13.78	32.53
4	60	8	3	26.98	15.45	31.7
5	60	6	4	24.01	8.54	31.42
6	60	4	5	20.95	6.79	31.54
7	60	6	4	22.56	10.89	31.95
8	50	6	3	24.65	9.04	30.47
9	50	8	4	21.33	11.35	28.42
10	60	4	3	25.64	9.45	32.56
11	60	8	5	19.15	13.06	31.47

12	70	6	5	30.15	10.63	30.65
13	70	4	4	22.17	11.96	33.21
14	50	6	5	21.65	6.65	28.63
15	60	6	4	21.35	8.47	30.69
16	50	4	4	24.56	7.54	29.75
17	70	8	4	36.64	14.25	30.41

Table 4: Regression coefficient and ANOVA of fitted quadratic model for Effect of osmosis on physico-chemical attributes of *Kesar* and *Rajapuri* mango slices

Partial coefficient	*Kesar* variety			*Rajapuri* variety		
	Water loss	**Solid gain**	**Ascorbic acid**	**Water loss**	**Solid gain**	**Ascorbic acid**
Intercept	4.66	3.00	5.55	4.74	3.09	5.58
A-Sugar syrup concentration	0.0038**	0.0064**	0.0138*	0.0027**	0.0022**	0.0032**
B-Steeping Time	0.2148NS	0.0022**	0.0258*	0.1662NS	0.0012**	0.0537 NS
C-Fruit to syrup ratio	0.0831NS	0.1856 NS	0.0050**	0.0199*	0.0167*	0.0564 NS
AB	0.0171*	0.5305 NS	0.9235 NS	0.0057**	0.4423NS	0.3968 NS
AC	0.9733 NS	0.5562 NS	0.0903 NS	0.8051 NS	0.9512NS	0.9889 NS
BC	0.7197 NS	0.2745 NS	0.8343 NS	0.4644 NS	0.6993NS	0.6305 NS
A2	0.0215*	0.3843 NS	0.2533 NS	0.0097**	0.6925NS	0.0311*
B2	0.6511 NS	0.0661 NS	0.6617 NS	0.7828 NS	0.0611 NS	0.5310 NS
C2	0.6502 NS	0.7388 NS	0.2497 NS	0.4348 NS	0.9424 NS	0.3451 NS
Model F Value	4.77	5.18	4.65	6.83	7.31	4.37
R^2	0.86	0.87	0.86	0.89	0.90	0.85
Lack of fit	NS	NS	NS	NS	NS	NS

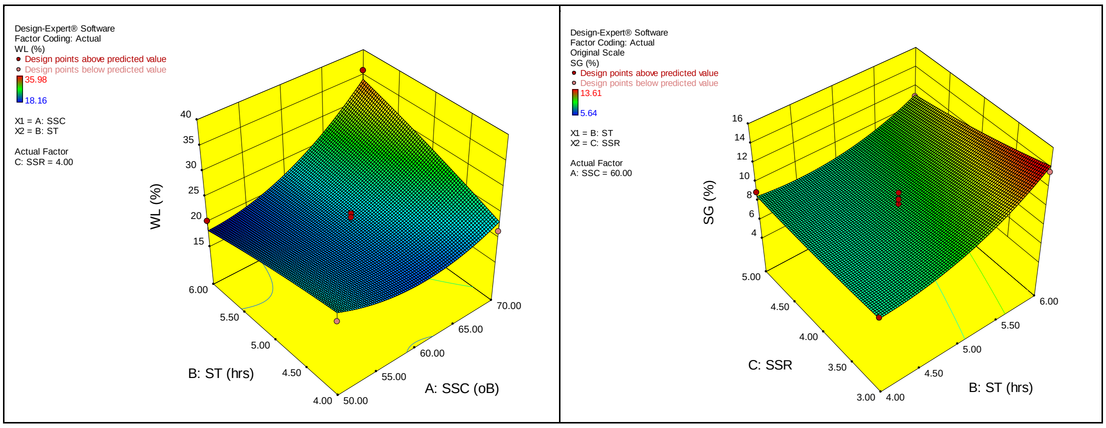
* = Significant at 5%, ** = Significant at 1%, NS = not significant

The above trials yielded an average water loss (%) that ranged from 18.16 to 35.98%. Slices of *Kesar* mango were significantly affected by sugar syrup concentration, its interaction with steeping duration, and its quadratic term (p<0.05) in terms of water loss. The range of the average solid gain (%) from the aforementioned experiments was 5.64 to 13.61%. Both water loss and sugar gain improved as temperature and sugar concentration rose (Rahman and Lamb, 1991) [11].

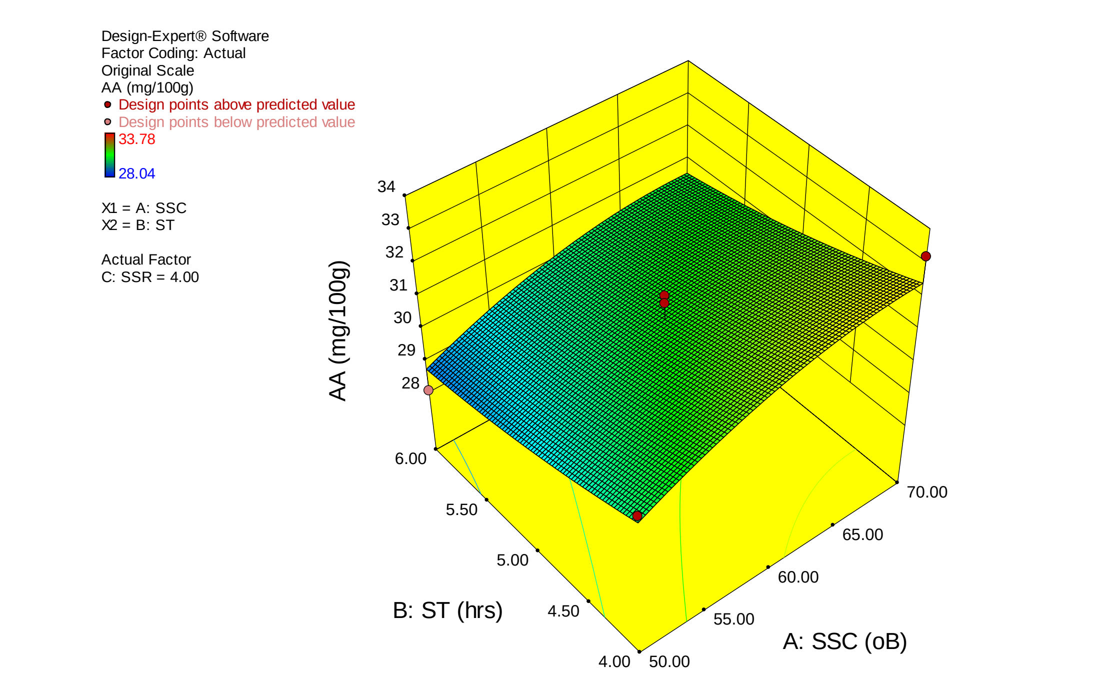
On the solid gain of *Kesar* mango slices, the sugar syrup content, steeping time, and quadratic term of steeping time all had a significant impact (p<0.05). The ascorbic acid concentration (%) obtained on average from the trials above ranged from 28.04 to 33.78 mg/100g. Slices of *Kesar* mango's ascorbic acid were affected significantly (p<0.05) with concentration of osmotic syrup, length of steeping, and the ratio of sugar syrup to fruit time.

The above trials yielded an average water loss (%) that ranged from 19.15 to 36.64%. *Rajapuri* mango slices' water loss was significantly influenced (P<0.05) by osmotic solution concentration, ratio of osmotic solution to fruit, the interaction of steeping duration and sugar syrup concentration, as well as the quadratic term of sugar syrup concentration. The range of the average solid gain (%) from the aforementioned experiments was 6.65 to 15.45%. *Rajapuri* mango slices showed a strong rise when sugar syrup concentration, steeping period, and sugar syrup to fruit ratio were considered (P<0.05).

By utilizing a more concentrated osmotic solution, it was possible to achieve a larger degree of mass transfer in terms of losses in moisture, gain in solids, and reduction in weight during the drying of red pitaya using osmosis. This is explained by the substantial the fruit and the hypertonic medium are driven by the osmotic force in its immediate environment (Azoubel and Murr, 2004; Falade *et al.*, 2007) [3, 6]. Ascorbic acid concentration (%) obtained on average from the trials above ranged from 28.42 to 33.21 mg/100 g. *Rajapuri* mango slices' ascorbic acid was affected by osmotic agent concentration significantly and its quadratic term (P<0.05). Typically, syrups with strengths between 60 and 70 °Brix have been deemed ideal (Chaudhary *et al.*, 1993). The best colour was produced at a temperature of 60°B. This is due to the fact that sugar was used to surround the fruit pieces, preventing enzymatic and oxidative browning and preserving the fruit's bright colour (Sureshkumar and Sagar, 2009) [9].

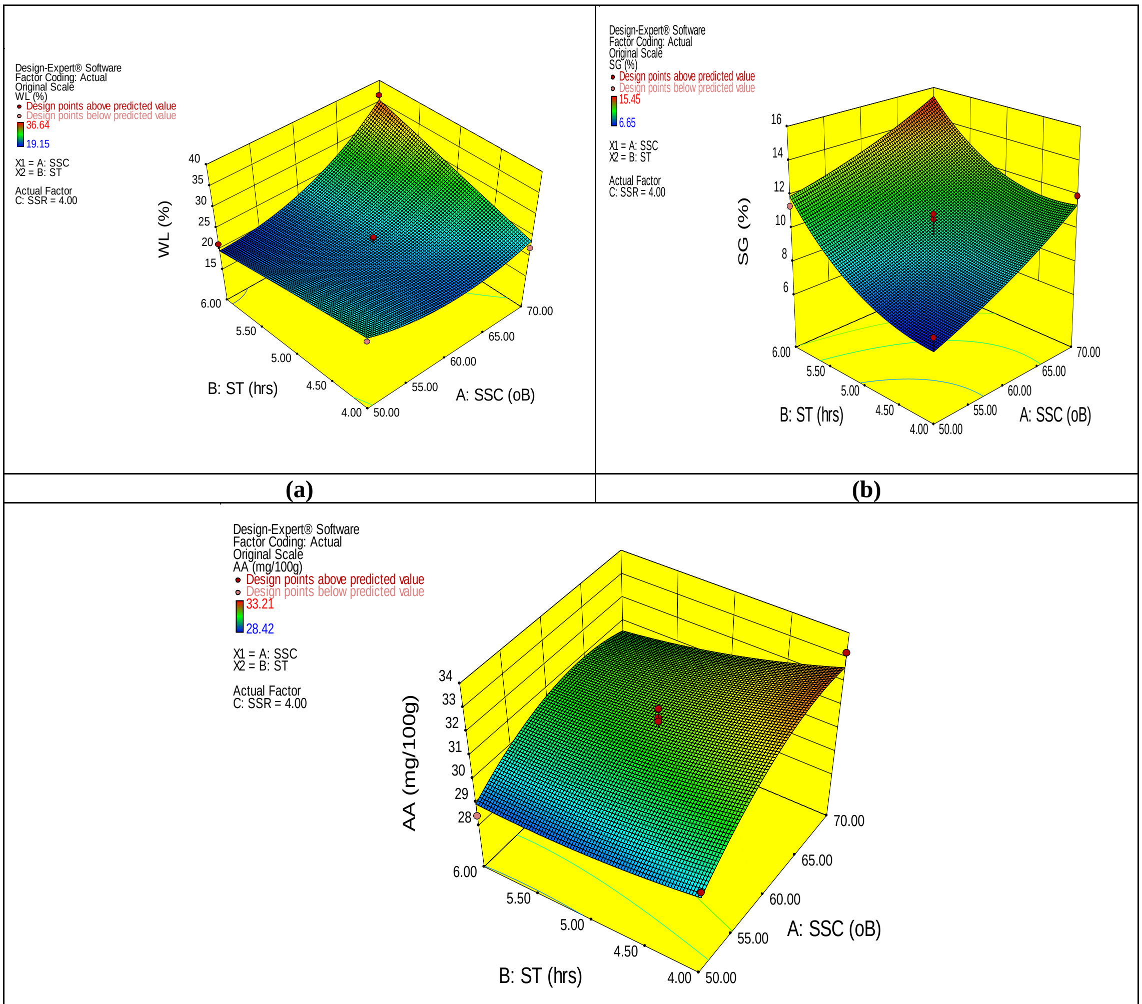


(a)	(b)



(c)

Fig 2: Effect of pre-treatments on water loss (a), solid gain (b) and ascorbic acid (c) of *Kesar* mango



(c)

Fig 3: Effect of pre-treatments on water loss (a), solid gain (b) and ascorbic acid (c) of *Rajapuri* mango

Response surface methodology software used independent variables and anticipated response values to find the best solutions. With a desirability score of 0.660 for the *Kesar* mango, the best solution was discovered. The optimum pre-treatments of *Kesar* mango slices resulted in projected values of water loss of 25.42, solid gain of 7.22, and ascorbic acid of 33.09 mg/100g, which were obtained by sugar syrup concentration of 50°B, steeping time of 4 h, and fruit to sugar syrup ratio of 3:1. The *Rajapuri* mango's attractiveness rating of 0.593 was determined to be the optimum solution. The optimum pre-treatments of *Rajapuri* mango slices resulted in projected water loss of 27.204, solid gain of 8.331 and ascorbic acid of 31.101 mg/100g, which were obtained by sugar syrup concentration of 51.13°B, steeping time of 4 h and fruit to sugar syrup ratio of 3:1.

Validation of the optimized pre-treatment

The experimental observed values and anticipated values (also known as desirable values), which are shown in Table 5, have not been found to significantly differ by the t test. As a result, the model was substantial and exactly matched the data.

Table 5: Validation of the optimized pretreatment of osmotically treated mango slices of *Kesar* and *Rajapuri* variety

Responses	Observed@	Desired*	t-value#
***Kesar* variety**			
Water loss	31.0657NS±5.0381	25.42	1.9145
Solid gain	10.58 NS ±3.98	7.22	2.2282
Ascorbic acid	32.68 NS ±2.1928	33.09	0.4895
***Rajapuri* variety**			
Water loss	32.14NS±4.0384	27.204	1.276
Solid gain	7.35286NS ±1.4052	8.331	1.8419
Ascorbic acid	32.1389 NS ±1.99	31.101	1.3727

A) @ = actual value of optimized product
B) * = Predicted value from design expert software
C) # = Calculated t value (p<0.05), t-critical = 2.447

Standardization of drying conditions for production of osmotically dehydrated mango slices

Pre-treated mango slices were dried in vacuum dryer set to the vacuum level of 450, 550 and 650 mm Hg with a tray load of 0.75 kg / m^2 and operated at different drying temperatures of 50, 60 and 70 °C. Figures 4 and 5 illustrate the variation in the moisture content of the mango slices of *Kesar* and *Rajapuri* variety with respect to the drying time for the range of drying temperatures (50 – 70 °C) and vacuum level (450 – 650 mm Hg). Dried mango slices were analysed for ascorbic acid, non-enzymatic browning and overall acceptability (Table 6 and 7)

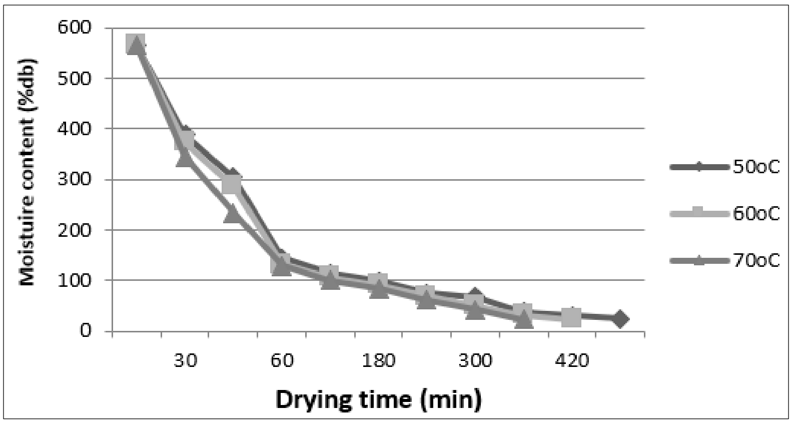


Fig 4: Drying curve for vacuum drying of osmotically treated *Kesar* mango slices at 450 mm Hg

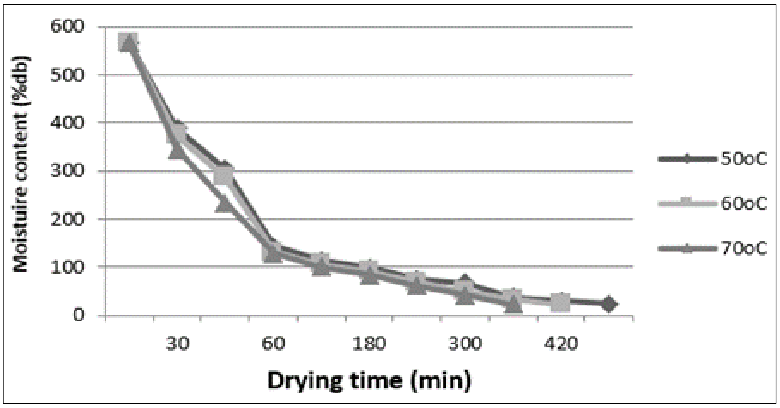


Fig 5: Drying curve for vacuum drying of osmotically treated Rajapuri mango slices at 450 mm Hg

Table 6: Effect of drying temperature on various properties of dried mango slices of *Kesar* variety

Treatments	Temperature	Vacuum level	Ascorbic acid (mg/100 g)	Non enzymatic browning	Overall acceptability
Control	60 ºC	-	28.85	0.12	7.34
T1	50	450	33.27	0.05	8.47
T2	50	550	32.15	0.05	8.15
T3	50	650	32.10	0.07	8.13
T4	60	450	31.28	0.08	8.45
T5	60	550	30.54	0.09	8.10
T6	60	650	30.43	0.08	8.09
T7	70	450	29.63	0.08	7.82
T8	70	550	28.95	0.10	7.42
T9	70	650	28.73	0.10	7.17
SEm			0.045	0.005	0.038
CD (0.05)			0.13	0.01	0.11
CV%			0.26	9.96	0.84

Table 7: Effect of drying temperature on various properties of dried mango slices of *Rajapuri* variety

Treatments	Temperature	Vacuum level	Ascorbic acid	Non enzymatic browning	Overall acceptability
Control	60ºC	-	28.12	0.14	7.19
T1	50	450	32.61	0.04	8.53
T2	50	550	32.22	0.05	8.21
T3	50	650	31.54	0.10	8.15
T4	60	450	31.21	0.08	8.44
T5	60	550	30.20	0.08	8.43
T6	60	650	30.08	0.11	8.16
T7	70	450	29.91	0.07	7.85
T8	70	550	29.65	0.09	7.55
T9	70	650	28.23	0.12	7.23
SEm			0.057	0.005	0.014
CD (0.05)			0.17	0.02	0.04
CV%			0.33	10.04	0.31

During drying, the higher ascorbic acid content (33.27 and 32.6 mg/100g for *Kesar* and *Rajapuri* varieties) was found at 50 °C drying temperature and 450 mm Hg vacuum level as compared to the rest of temperature and vacuum level combinations. Minimum ascorbic acid content was found (28.73 and 28.2 mg/100 g for *Kesar* and *Rajapuri* varieties) when the mangoes were dried at 70 °C temperature at 650 mm Hg vacuum level. The control sample had 28.85 and 28.12 mg/100g ascorbic acid content for *Kesar* and *Rajapuri* varieties. A decreasing trend of ascorbic acid content was found with increase in drying temperature. It might be because of the ascorbic acid gets degraded when it is being exposed to higher temperature.

When the mango slices were dried at different drying combinations, the optical density values as the indicator of non-enzymatic browning of dried mangoes at different drying combinations are shown in observation tables. Increasing trend of non-enzymatic browning was found with increase in temperature and decrease in vacuum level. During drying, the maximum non enzymatic browning (0.10 and 0.12 for *Kesar* and *Rajapuri* variety) was found for sample prepared at 70 °C drying temperature and at 650 mm Hg vacuum level and the minimum non enzymatic browning (0.05 and 0.04 for *Kesar* and *Rajapuri* variety) when it was dried at 50 °C drying temperature and at 450 mm Hg vacuum level. The control sample which was dried using tray drying technique had the highest browning was observed, i.e. 0.12 and 0.14 for *Kesar* and *Rajapuri* variety, respectively. The loss of bright colour with increasing drying temperature was possibly due to the oxidation of carotenoids after long exposure to oxygen and heat. Enzymatic and non-enzymatic reactions are the most important reason of browning development in fruits and vegetables during dehydration. Polyphenoloxidase and peroxidase which is present in low acid fruits involved in enzymatic browning (Moreno-Castillo *et al.*, 2005) [9].

Osmotically dehydrated mango slices were superior in overall acceptability when it was dried at lower range of temperature (50 and 60 ºC) as compared to 70 ºC temperatures. The highest overall acceptability score (8.47 and 8.53 for *Kesar* and *Rajapuri* variety) was observed for mango slices dried at 50 ºC with 450 mm Hg vacuum level, while the lowest highest overall acceptability score (7.17 and 7.23 for *Kesar* and *Rajapuri* variety) was observed for mango slices dried at 70 ºC with 650 mm Hg vacuum level. The control sample had the lowest overall acceptability score i.e. 7.34 and 7.19 for *Kesar* and *Rajapuri* variety.

Overall acceptability of dried mango slices at 50 and 60ºC at vacuum level of 450 mmHg was statistically at par. So, these treatments are suitable for drying of osmotically pre-treated mango slices. If we compare these treatments nutritionally, 50 ºC at vacuum level 450 mmHg is superior as it contains maximum amount of ascorbic acid. So on the basis of maximum overall acceptability and nutritional quality attribute vacuum drying parameters of drying at 50ºC at 450 mmHg vacuum level is suitable for further study. The osmo-dried mango and papaya pieces/slices are to be dried at temperature 60 °C for 6 hours to acquire 16% moisture contented (Guru Meenakshi *et al*., 2005) [7].

Quality characteristics of the osmotically dehydrated mango slices

The final product was prepared using optimized parameters and tested for quality attributes and the results are depicted in Table 8.

Table 8: Quality characteristics of dehydrated Mango slices

Parameters	*Kesar*	*Rajapuri*
Moisture,%	15.62±1.24	15.44±1.64
Acidity,%	1.32±0.24	1.47±0.31
Ascorbic acid, mg/100g	33.27±1.64	32.62±1.94
Reducing sugars,%	28.38±2.64	26.35±2.31
Total sugars,%	62.45±1.44	60.36±2.65
Non enzymatic browning	0.05±0.002	0.04±0.001
Overall Acceptability	8.47±0.54	8.53±0.47
Hardness, N	19.29 ±1.64	21.98±1.32

Storage stability of osmotically dried mango slices

The bulk samples of osmotically dehydrated mango slices were prepared using optimized process parameters for storage study. The sample was packed in HDPE pouch (200gauge) and stored at ambient temperature (30±2 °C). The moisture content was reduced from 13.64 and 13.51% (w.b) to 11.83 and 11.18% (w.b.) after 180 days of storage period for *Kesar* and *Rajapuri* variety mangoes, respectively. The results revealed that storage period had a significant influence (at 5% level of significance) on reduction of moisture content, which decreased at all storage intervals. The decrease in moisture content in the various mango slices with an increase in storage period might be due to the evaporation of moisture from the product.

For storage the lowest (1.32 and 1.34%) mean titratable acidity was found during 180th day storage while the highest (1.45 and 1.49%) mean acidity was found at 0 day storage for *Kesar* and *Rajapuri* variety mangoes, respectively. It is evident from the data that there was declining trend in acidity content of osmotic dehydrated ripe mango slices. The loss of acids might be due to utilization of acids for conversion of non-reducing sugars to reducing sugars and in non-enzymatic browning reaction.

The reducing sugar was increased from 28.38 to 30.54 and 26.35 to 28.31% after 180 days of storage period for *Kesar* and *Rajapuri* variety mangoes, respectively. The results revealed that storage period has a significant influence on reduction of reducing sugar. The increase in reducing sugar with storage might be because of increased degree of inversion of sugars. The lowest (62.48 and 58.74%) total sugar found during 180th day storage, while maximum (64.32 and 60.32%) sugar was found during 0 day of storage for *Kesar* and *Rajapuri* variety mangoes, respectively. A significant decrease in total sugar content of stored osmotic dehydrated ripe mango slices was noticed, slight loss in total sugars may be due to utilization of sugars in the non-enzymatic browning.

Ascorbic acid content during storage at 0 day, highest (33.28 and 32.46 mg / 100g) mean ascorbic acid was recorded. During storage, ascorbic acid content decreased so that the lowest (26.17 and 24.81 mg / 100 g) mean ascorbic acid was found at 180th day storage for *Kesar* and *Rajapuri* variety mangoes, respectively at ambient condition. Ascorbic acid content reduced considerably in osmotic dehydrated ripe mango slices during storage period due to thermal degradation during processing and subsequent oxidation in storage as it is very sensitive to heat, oxidation and light.

The non-enzymatic browning was increased from 0.05 to 0.13 and 0.04 to 0.10 OD after 180 days of storage period for *Kesar* and *Rajapuri* variety mangoes, respectively. The results revealed that storage period has a significant influence on increase of non-enzymatic browning. Progressive increase in browning with the storage period could mainly be due to the non-enzymatic reaction such as organic acid with sugars or oxidation of phenols which leads to the formation of brown pigments. Initial sensory scores for colour and appearance, texture, taste and overall acceptability were higher and at 180 days of storage the scores were reduced considerably. Microbiologically dried mango slices were found to be safe during entire period of storage. The cost of production for osmotically dehydrated mango slices are around 90 and 60 Rs per 100 g of product for *Kesar* and *Rajapuri* variety of mangoes.

Conclusion

For the *Kesar* and *Rajapuri* varieties of mangoes, the method for producing osmotically dehydrated mango slices has been improved. A three factor box and behnken design was used to optimize the degree of pre-treatments for sugar syrup concentration, steeping period, and sugar syrup to fruit ratio. The independent variables were the concentration of sugar syrup (A), steeping duration (B), and the ratio of sugar syrup to fruit (C). The water loss (%), solid gain (%), and ascorbic acid (mg/100g) were all well-fitted by the quadratic model, with coefficient determination (R^2) values for the *Kesar* and *Rajapuri* varieties of 0.89, 0.90, and 0.85, respectively.

According to multiple regression analysis, the ideal pre-treatment parameters for both varieties of mangoes were 50-51°B sugar syrup concentration, 4 h of steeping duration, and a 3:1 sugar syrup to fruit ratio. Mangoes were washed, peeled, and pretreated at 50°B osmotic sugar solution concentration, 3:1 ratio of osmotic agent to fruit, and 4 h steeping duration for *Kesar* variety and 51.13°B sugar syrup concentration, 3:1 sugar syrup to fruit ratio, and 4 h steeping time for *Rajapuri* variety to produce superior quality osmotically dehydrated Mango slices for longer shelf life. The pretreated sample dried at 50 °C temperature and 450 mm Hg vacuum using vacuum dryer and packed in HDPE pouches (200 gauge) and stored at ambient temperature (30±2 °C) for 180 days.

The osmotic drying method is a simple approach that allows us to process a variety of tropical and subtropical produces, including sapota, mango, guava, banana, pineapple, guava, papaya, carrot, and pumpkin, while retentive their basic, primary physiognomies, such as colour, aroma, and nutrition. Osmotic dehydration technology results in wholesomeness and year-round availability while adding healthier and nutritional value.

Authors' contribution

Conceptualization of research (AVR); Designing of the experiments (HPS and HP); Contribution of experimental materials (AVR, SVA, HP); Execution of lab experiments and data collection (AVR and SVA); Analysis of data and interpretation (BBP, AVR); Preparation of the manuscript (AVR and BBP).

Declaration

The authors declare that they have no conflict of interest to this work.

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