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OPTIMIZATION OF PROCESS VARIABLES IN COMBINED EFFECT OF AQUEOUS MIXED SUGAR AND SALT SOLUTION OF OSMOTIC DEHYDRATION OF COCONUT SLICES BY USING RSM

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ABSTRACT

The present work aimed to study the osmotic dehydration of coconut slices by aqueous mixed sugar and salt solution concentration. Response surface methodology with central composite design was used to investigate the influence of three variables, namely aqueous mixed sugar and salt solution concentration (46.59/1.59 to 63.40/18.40% w/w), temperature (26.59 to 43.41°C) and processing time (1.65 to 3.34 hours). The quadratic regression equation describing the effects of these factors on WR, SG and WL were developed. Analysis of the regression coefficients showed that aqueous mixed sugar and salt solution concentration with temperature and temperature with processing time for WR ($p > 0.05$), the aqueous mixed sugar and salt solution concentration with processing time for SG ($p > 0.05$) and aqueous mixed sugar and salt solution concentration with temperature and temperature with processing time for WL ($p > 0.05$) were the most important factor that affects the osmotic dehydration of coconut slices. Optimum conditions for maximum percentage of weight reduction (25.82%), minimum percentage of solid gain (2.76%) and maximum percentage of water loss (28.58%) was predicted as immersion using 55.59/10.59 (% w/w) aqueous mixed sugar and salt solution concentration at 34.74°C for 2.54 hrs.

Key words: Aqueous mixed sugar and salt solution, Osmotic dehydration, Coconut slices.

INTRODUCTION

Coconut (*Coco nucifera L*) is one of the important crops in the tropical and sub-tropical regions. The coconut palm is cultivated in more than 90 tropical countries and it represents an important income source. Indonesia, Philippines and India are the major producers and account for about 75% of world production. India holds third rank in the production of coconut with total production of coconut of 10, 824, 100 tones[1]. Drying is one

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of the most common traditional methods of food preservation for a long time. The existing methods of drying were also constantly changing due to innovation of novel technologies and developments[2]. Low cost technologies should be developed for producing locally and globally consumable commodities need to be developed to encourage fruit and vegetable processing at home scale, cottage and small scale levels. Among drying and dehydration, osmotic dehydration gained attention recently due to its potential application in the food processing industry[3]. In recent years, considerable amount of attention has been paid to osmotic dehydration technique for preservation of fruits and vegetables due to its potential to keep sensorial and nutritional properties similar to the fresh fruits[4]. Osmotic dehydration (OD) is a technique that involves product immersion in a hypertonic aqueous solution leading to loss of water through the cell membranes of the product and subsequent flow along the inter-cellular space before diffusing into the solution[5]. Osmotic dehydration is widely used for the partial removal of water from plant tissues by immersion in a hypertonic solution.

The diffusion of water is accompanied by the simultaneous counter diffusion of solutes from the osmotic solution into the tissue. Since the membrane responsible for osmotic transport is not preferably selective, other solutes present in the cells can also be leached into the osmotic solution[6-8]. The two types of solute most commonly used in food osmotic treatments are sugars (especially for fruits) and salts (for vegetables, fish, meat and cheese), in particular sucrose and sodium chloride. Mixtures of solutes have also been used, the advantages of which have been described by many authors[9-10]. Complex mass transfer mechanisms are involved in OD in ternary solutions. Salt and sucrose concentrations show a synergetic effect on food osmotic treatments, which has led researches to investigate optimum process conditions[11,12]. The rate and dewatering degree of the material and changes in its chemical composition depend on the sort of the osmotic solution used, the kind and the size of raw material, as well as the ratio of material to osmotic solution, temperature, dehydration time, and type of apparatus. Rate of osmotic dehydration is the highest at the beginning of the process. It results from the largest difference of osmotic pressure between the osmotic solution and the cell sap of the material and small mass transfer resistance at this stage of the process[13]. There are several work has been carried out on optimization of fruits and vegetables by RSM method[14-16]. However, no information is available on the statistical modeling of coconut slices drying by osmotic dehydration in aqueous mixed sugar and salt solution concentration through RSM. The aim of this research was to study the influence of aqueous mixed sugar and salt solution concentration on osmotic dehydration of coconut slices by quantifying weight reduction (WR), solid gain (SG) and water loss (WL) and to investigate the optimum for process parameters such as aqueous mixed sugar and salt solution concentration (wt/wt), temperature and processing time to yield maximum weight reduction (WR) and water loss (WL) and minimum solid gain (SG). The process parameters was optimized through RSM.

EXPERIMENTAL

Materials and methods

In this studies, the osmotic dehydration of coconut slices were conducted in aqueous mixed sugar and salt solution. The commercially available sugar and salt was used to prepare osmotic solution by mixing sugar and salt with required amount of distilled water. The concentration of mixed aqueous sugar and salt solution was measured by using refractometer. Coconut of 10 month after flowering was used and kernel portion was taken for the experimental studies. The average moisture content of coconut was found to be 55.02 ± 2.12% on wet basis. The kernel portion of the coconut were sliced to 5 mm thickness and 20 mm length and washed with water to remove debris and other particles.

Experimental design and statistical analysis

In RSM a central composite design was applied for the experimental design consisting of three factors. A second degree polynomial equation was fitted to the data to obtain regression equation.

$$\text{Response} = \alpha_0 + \beta_1 A + \beta_2 B + \beta_3 C + \beta_{12} AB + \beta_{13} AC + \beta_{23} BC + \beta_{11} A^2 + \beta_{22} B^2 + \beta_{33} C^2 \quad \ldots(1)$$

Where the responses are WR, SG and WL, the α_0, β_i are adjustable constants and A, B, C are aqueous mixed sugar and salt solution concentration, temperature and processing time, respectively. The statistical significance of the terms in the regression equation was examined by analysis of variance (ANOVA). Twenty experiments were carried out according to response surface methodology and analysis of variance (ANOVA) for response surface quadratic model for the osmotic dehydration of coconut slices was obtained by using Design Expert 8.0.7.1. The independent variables were aqueous mixed sugar and salt solution concentration (46.59/1.59 to 63.40/18.40% w/w), temperature (26.59 to 43.41°C) and processing time (1.65 to 3.34 hrs).the ranges of selected parameters were determined based on the literature review.

Experimental procedure

The osmotic dehydration process were carried out over a range of aqueous mixed sugar and salt solution concentration (46.59/1.59 to 63.40/18.40% w/w), of the osmotic solution. Initially the coconut slices (100 g) was blanched at 90^{o}C for 2 min. the coconut slices are then submerged in 2% citric acid for 2 mins the initial pre treatment of coconut slices prior to osmotic dehydration was carried out to enhance the shelf life of the coconut slices. The osmotic dehydration process was conducted in a 500 mL Erlenmeyer flask, which was kept in a thermostatically controlled water bath shaker. The samples were weighed and placed into the flask containing osmotic solution. A constant solution to sample ratio of 5:1 (w/w) was used. The flask was placed in the water bath at a constant temperature. After every run, the coconut slices were taken out and then gently blotted with adsorbent paper and weighed. The average moisture and dry matter content of the samples were determined by drying in hot air oven at 105^{o}C for 24 hrs. In each of the experiments fresh osmotic solution was used. All the experiments were done in triplicate and the average value was taken for calculations. For each experiment the agitation speed of 200 rpm was used and maintained constant. Weight reduction (WR), solid gain (SG) and water loss (WL) data were obtained, according to the expressions

$$WR = ((M_i - M)/M_i) \quad \ldots(2)$$

$$SG = ((m_t - m_i)/ M_i) \quad \ldots(3)$$

$$WL = WR + SG \quad \ldots(4)$$

where M_i -initial mass of sample (g), M_t -mass of sample after dehydration (g), m_i-initial mass of the solids in sample (g), m_t-mass of the solids in sample after dehydration (g).

RESULTS AND DISCUSSION

The optimum condition of parameters for the osmotic dehydration of coconut slices by using mixed sugar and salt solution was evaluated according to the CCD experimental design in RSM. In this study, the model F value of 71.36, 48.77 and 51.05 for WR, SG and WL were shown in ANNOVA Tables 3, 4 and 5. It implies that the model is significant. The lack of fit F value for WR, SG & WL were 3.70, 3.25 & 2.96 implies that the model is significant. Non significant lack of fit is good. There is only a 0.01% chance that a model F value and lack of fit F value this could occur due to noise. The statistical analysis shows that the proposed model was adequate, possessing no significant lack of fit and with very satisfactory values of the R^2 for all the responses. The R^2 values for percentage of weight reduction, solid gain and water loss were 0.9847, 0.9777 and 0.9787, respectively. The closer the value of R^2 to the unity, the better the empirical model fits the actual data. The smaller the value of R^2 the less relevant the dependent variables in the model have to explain the behaviour variation. The probability (p) values of all regression models were less than 0.050 depicted highly significant. The range and levels of independent variables was presented in Table 1 with the runs of the experiment in a random form and the values of the response variables obtained in each run.

Table 1: Range of independent variables used for the osmotic dehydration of coconut slices in combined effect of aqueous mixed sugar and salt solution

Factors	Variable	Unit	Range and levels				
			-1.68179	**-1**	**0**	**1**	**+1.68179**
A	Mixed sugar : Salt concentration	% (w/w)	46.59 : 1.59	50:5	55:10	60:15	63.40:18.40
B	Temperature	(^{o}C)	26.59	30	35	40	43.41
C	Processing time	(hrs)	1.65	2	2.5	3	3.34

The experimental values and predicted values for weight reduction (WR), solid gain (SG) and water loss (WL) under different treatment conditions were presented in Table 2. The regression coefficients for the second order polynomial equations and results for the linear, quadratic and interaction terms were presented in Table 3, 4 & 5.

Effects of aqueous mixed sugar and salt solution concentration, temperature and processing time on weight reduction

The linear effects of all independent variables in Table 3 indicates the positive contribution of aqueous mixed sugar and salt solution concentration, temperature and processing time on the weight reduction during osmotic dehydration. It implies that the weight reduction was increased with increase in aqueous mixed sugar and salt solution concentration, temperature and processing time. The quadratic terms of independent variables shows negative contribution of mixed sugar and salt solution concentration, temperature and processing time on the weight reduction during osmotic dehydration. It implies that weight reduction was decreased with increase in aqueous mixed sugar and salt solution concentration, temperature and processing time from above this condition of 55.59/10.59% w/w, 34.74^{o}C and 2.54 hrs of osmotic solution. The effect of independent variable such aqueous mixed sugar and salt solution concentration, temperature and processing time on percentage of weight reduction were reported in Fig. 1, 2 and 3.

Table 2: Experimental conditions and observed response values of CCD

Run order	Sugar: Salt con % (w/w)	Temp. (°C)	Processing time (hrs)	WR (%) Experimental values	SG (%) Experimental values	WL (%) Experimental values	WR (%) Predicted values	SG (%) Predicted values	WL (%) Predicted values
1	0	0	0	25.886	2.759	28.645	25.704	2.685	28.389
2	1.68179	0	0	23.388	3.653	27.041	23.811	3.804	27.616
3	-1	-1	-1	20.158	2.428	22.586	20.239	2.377	22.617
4	0	0	0	25.854	2.728	28.582	25.704	2.685	28.389
5	0	-1.68179	0	23.352	2.548	25.900	23.494	2.638	26.133
6	0	1.68179	0	24.184	3.289	27.473	24.427	3.302	27.730
7	0	0	0	25.546	2.629	28.175	25.704	2.685	28.389
8	-1	1	1	23.389	3.108	26.497	23.363	3.181	26.545
9	0	0	0	25.899	2.791	28.690	25.704	2.685	28.389
10	1	1	-1	23.812	3.436	27.248	23.657	2.334	26.992
11	0	0	-1.68179	21.804	2.508	24.312	21.920	2.668	24.589
12	0	0	0	25.598	2.619	28.217	25.704	2.685	28.389
13	0	0	0	25.507	2.602	28.109	25.704	2.685	28.389
14	1	-1	-1	23.177	2.899	26.076	22.929	2.751	25.680
15	1	-1	1	25.098	3.896	28.994	24.921	3.853	28.774
16	-1	-1	1	23.102	2.948	26.050	22.983	2.975	25.958
17	-1.68179	0	0	21.163	2.551	23.714	21.125	2.503	23.629
18	-1	1	-1	22.498	2.696	25.194	22.401	2.664	25.066
19	0	0	1.68179	24.135	4.086	28.221	24.404	4.029	28.434
20	1	1	1	24.223	4.379	28.602	23.868	4.355	28.223

Table 3: ANOVA for the osmotic dehydration of coconut slices by combined effect of aqueous mixed sugar and salt solution - weight reduction

Source	Coefficient Estimate	Sum of squares	df	Mean square	F value	p-value prob > F
Model		50.66	9	5.63	71.36	< 0.0001 Significant
Intercept	25.70					
A-sugar : Salt concentration (w/w)	0.80	8.71	1	8.71	110.39	< 0.0001
B-temperature (^{o}C)	0.28	1.05	1	1.05	13.31	0.0045
C-time (hrs)	0.74	7.45	1	7.45	94.46	< 0.0001
AB	-0.36	1.03	1	1.03	13.03	0.0048
AC	-0.19	0.28	1	0.28	3.58	0.0878
BC	-0.45	1.59	1	1.59	20.12	0.0007
A^2	-1.14	18.85	1	18.85	239.03	< 0.0001
B^2	-0.62	5.47	1	5.47	69.36	< 0.0001
C^2	-0.90	11.63	1	11.63	147.48	< 0.0001
Residual		0.79	10	0.079		
Lack of fit		0.62	5	0.12	3.70	0.0888 Not significant
Pure error		0.17	5	0.034		
Cor total		51.45	19			

Table 4: ANOVA for the osmotic dehydration of coconut slices by combined effect of aqueous mixed sugar and salt solution-solid gain

Source	Coefficient estimate	Sum of squares	df	Mean square	F value	p-value prob > F
Model		6.14	9	0.68	48.77	< 0.0001 Significant
Intercept	2.69					
A-sugar concentration (w/w)	0.39	2.04	1	2.04	146.18	< 0.0001
B-temperature (^{o}C)	0.20	0.53	1	0.53	38.01	0.0001
C-time (hrs)	0.40	2.24	1	2.24	159.91	< 0.0001

Cont…

Source	Coefficient estimate	Sum of squares	df	Mean square	F value	p-value prob > F
AB	0.074	0.044	1	0.044	3.13	0.1071
AC	0.13	0.13	1	0.13	9.08	0.0130
BC	-0.020	3.280E-003	1	3.280E-003	0.23	0.6386
A^2	0.17	0.40	1	0.40	28.37	0.0003
B^2	0.10	0.15	1	0.15	10.52	0.0088
C^2	0.23	0.79	1	0.79	56.85	< 0.0001
Residual		0.14	10	0.014		
Lack of fit		0.11	5	0.021	3.25	0.1108 Not significant
Pure error		0.033	5	6.578E-003		
Cor total		6.28	19			

Table 5: ANOVA for the osmotic dehydration of coconut slices by combined effect of aqueous mixed sugar and salt solution-water loss

Source	Coefficient estimate	Sum of squares	df	Mean square	F value	p-Value prob > F
Model		62.95	9	6.99	51.05	< 0.0001 significant
Intercept	28.39					
A-sugar concentration (w/w)	1.19	19.19	1	19.19	140.06	< 0.0001
B-temperature (°C)	0.47	3.08	1	3.08	22.44	0.0008
C-time (hrs)	1.14	17.85	1	17.85	130.28	< 0.0001
AB	-0.28	0.65	1	0.65	4.72	0.0549
AC	-0.062	0.031	1	0.031	0.22	0.6465
BC	-0.47	1.73	1	1.73	12.66	0.0052
A^2	-0.98	13.78	1	13.78	100.59	< 0.0001
B^2	-0.52	3.82	1	3.82	27.91	0.0004
C^2	-0.66	6.35	1	6.35	46.32	< 0.0001
Residual		1.37	10	0.14		

Cont…

Source	Coefficient estimate	Sum of squares	df	Mean square	F value	p-Value prob > F
Lack of Fit		1.02	5	0.20	2.96	0.1294 Not significant
Pure error		0.35	5	0.069		
Cor total		64.32	19			

The ANNOVA Table 3 shows A, B, C, AB, BC, A^2, B^2 and C^2 are significant model terms for percentage of weight reduction. The predicted R-Squared of 0.9029 is in reasonable agreement with the Adjusted R-Squared of 0.9709. Interaction effects of aqueous mixed sugar and salt solution concentration with temperature ($p < 0.050$) and temperature with processing time on percentage of weight reduction were highly significant ($p < 0.050$). Initially the percentage of weight reduction increases with increase in aqueous mixed sugar and salt solution concentration with temperature and temperature with processing time due to increase in osmotic pressure gradient between osmotic solution and cellular solution in the coconut slices. It is well recognised that diffusion is a temperature dependent phenomenon. At higher process temperature that seems to promote faster water loss and better water transfer characteristics on the surface due to lower viscosity of the osmotic sugar solution. Above this condition 55.59/10.59% w/w aqueous mixed sugar and salt solution concentration, 34.74°C, temperature and 2.54 hrs processing time, the percentage of weight reduction slightly decreases with concentration of sugar solution with temperature and temperature with processing time due to higher uptake of solute, which forms a dense solute barrier layer at the surface of the coconut slices.

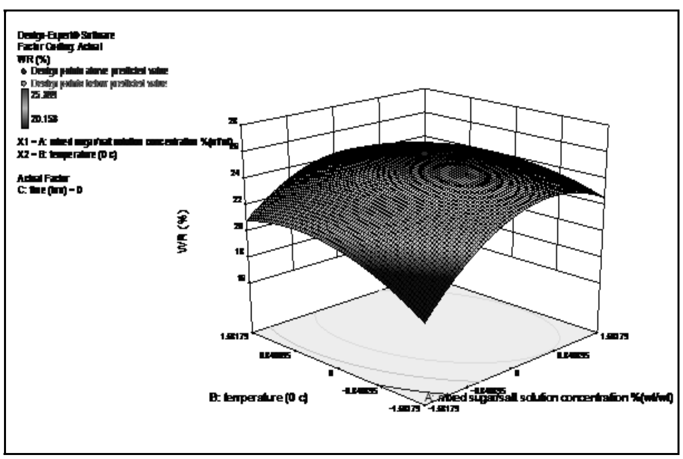

Fig. 1: 3D plot of the combined effect of aqueous mixed sugar and salt solution concentration and temperature on weight reduction

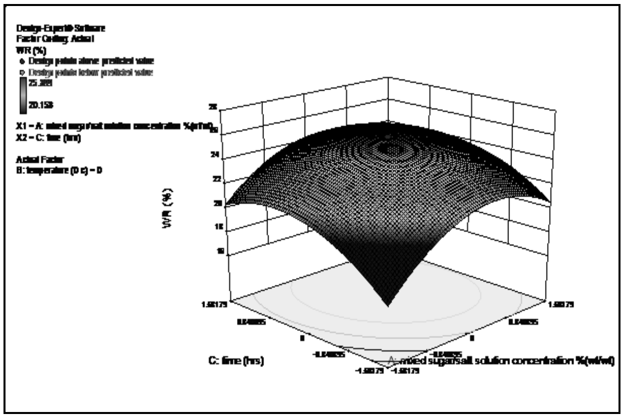

Fig. 2: 3D plot of the combined effect of aqueous mixed sugar and salt solution concentration and time on weight reduction

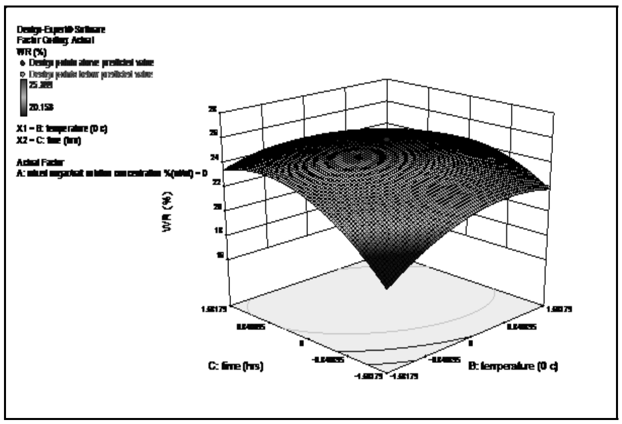

Fig. 3: 3D plot of the combined effect of the temperature and processing time on weight reduction

At higher process temperature and concentration of sugar solution, the swelling and plasticising of cell membranes will occur and favour the cell membrane permeability to sugar molecules[17]. The maximum percentage of weight reduction of 25.82% was attained at aqueous mixed sugar and salt solution concentration (55.59/10.59% w/w), temperature (34.74°C) and processing time (2.54 hrs).

Effects of aqueous mixed sugar and salt solution concentration, temperature and processing time on solid gain

In ANNOVA Table 4, it was clearly depicted that A, B, C, AC, A^2, B^2, C^2 are significant model terms for the percentage of solid gain. The predicted R-Squared of 0.8632 is in reasonable agreement with the Adjusted R-Squared of 0.9577. The percentage of solid gain was positively related to the linear and quadratic effect of aqueous mixed sugar and salt solution concentration ($p < 0.0001$), temperature ($p < 0.050$) and processing time ($p < 0.0001$) of p value less than 0.050. In the Fig. 5, it was clearly shows that, the percentage of solid gain was increased with increase in aqueous mixed sugar and salt solution concentration, temperature and processing time from above this condition 55.59/10.59% w/w aqueous mixed sugar and salt solution concentration, 34.74^{o}C temperature and 2.54 hours processing time of osmotic solution.

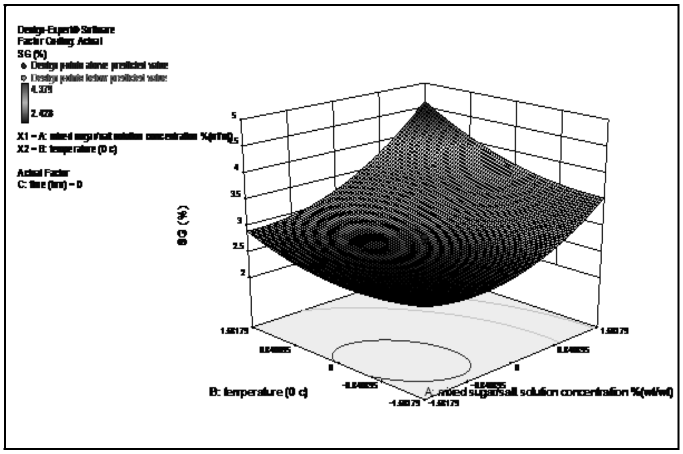

Fig. 4: 3D plot of the combined effect of aqueous mixed sugar and salt solution concentration and temperature on solid gain

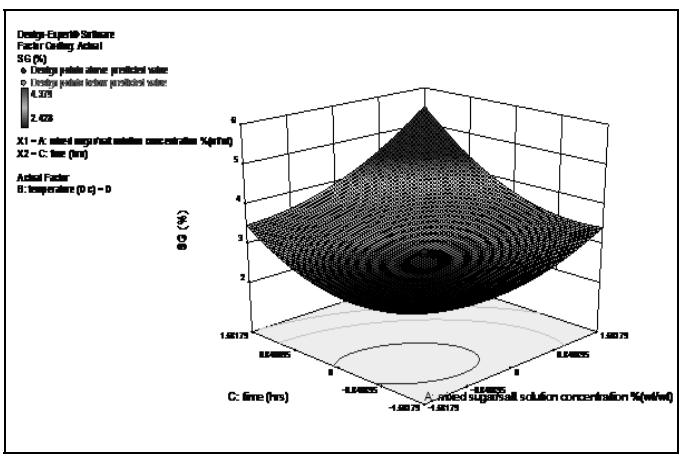

Fig. 5: 3D plot of the combined effect of aqueous mixed sugar and salt solution concentration and time on solid gain

Interaction effects of aqueous mixed sugar and salt solution concentration with processing time on percentage of solid gain were highly significant ($p < 0.050$). In the Fig. 5, it was clearly shows that, the percentage of solid gain was increased with increase in aqueous mixed sugar and salt solution concentration with processing time. It implies that concentration of aqueous mixed sugar and salt solution concentration was increased; it also increased the rate of diffusion of solute into the coconut slices. This may be due to the highly different in concentration between the coconut slices and osmotic solution which increased the rate of diffusion of solute into the coconut slices with processing time. The solute uptake blocks the surface layers of the product, posing an additional resistance to mass transfer and lowering the rates of complementary dehydration[18].

In recent years, the minimizing the solid gain and maximizing the water loss and to maintain the quality characteristics of the final product has attracted extensive research interest. The minimum percentage of solid gain of 2.76% was attained at aqueous mixed sugar and salt solution concentration (55.59/10.59% w/w), temperature (34.74°C) and processing time (2.54 hrs). Whereas this effect was did not appear above this conditions. Due to the highly difference in concentration between coconut slices and osmotic solution which increases the diffusion of solute into the coconut slices with processing time[19].

Effects of aqueous mixed sugar and salt solution concentration, temperature and processing time on water loss

According to Table 5, water loss was significantly affected by aqueous mixed sugar and salt solution concentration with temperature and the temperature with processing time of p value ($p > 0.05$). The Figs. 7, 8 & 9 show the effects of independent variables on percentage water loss. In this case A, B, C, AB, BC, A^2, B^2, C^2 are significant model terms. The predicted R-Squared of 0.8707 is in reasonable agreement with the adjusted R-Squared of 0.9595. the linear effect of aqueous mixed sugar and salt solution concentration ($p < 0.0001$), temperature ($p < 0.050$) and processing time ($p < 0.0001$) shows positive indication and the quadratic terms shows negative indications on aqueous mixed sugar and salt solution concentration ($p < 0.0001$), temperature ($p < 0.050$) and processing time ($p < 0.0001$) for water loss during osmotic dehydration of coconut slices in the Fig. 7, 8 & 9. It was clearly depicted that the water loss was increased with increase in aqueous mixed sugar and salt solution concentration, temperature and processing time up to 55.59/10.59% w/w aqueous mixed sugar and salt solution concentration, 34.74°C, temperature and 2.54 hrs processing time. Above these conditions, the water loss was decreased with increase in aqueous mixed sugar and salt solution concentration, temperature and processing time.

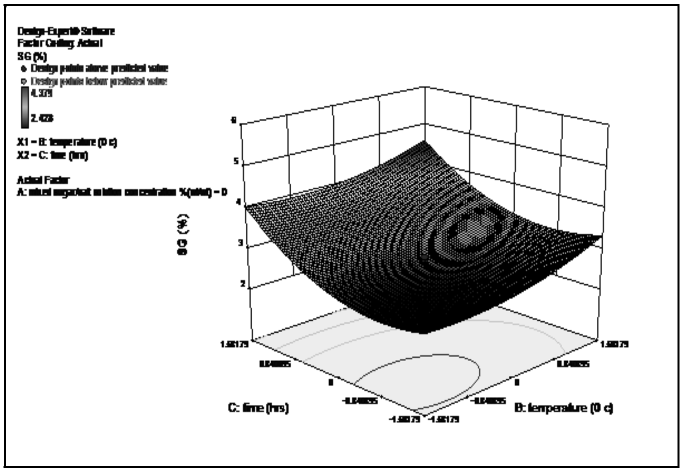

Fig. 6: 3D plot of the combined effect of the temperature and processing time on solid gain

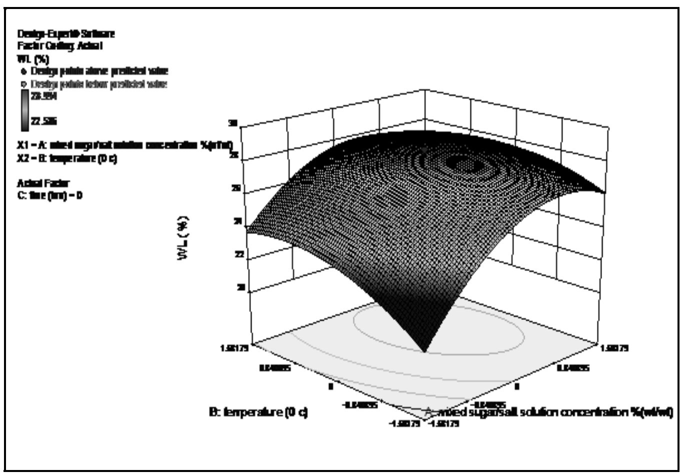

Fig. 7: 3D plot of the combined effect of aqueous mixed sugar and salt solution concentration and temperature on water loss

The interaction effect between aqueous mixed sugar and salt solution concentration with temperature ($p < 0.050$) and Temperature with processing time ($p < 0.050$) towards the percentage of water loss were highly significant. In the Fig. 7 & 9, it was clearly shown that, the percentage of water loss was increased with increase in concentration of sugar solution with temperature and temperature and processing time up to 55.59/10.59% w/w aqueous mixed sugar and salt solution concentration, 34.74^{o}C, temperature and 2.54 hrs processing time. Above these conditions, the water loss was decreased this may be due to uptake of solute at the surface layer of the coconut slices and posing an additional resistance to mass transfer and lowering the rates of complementary dehydration of coconut slices. A case hardening effect could be responsible for the percentage of water loss decreased above these conditions[20]. The maximum percentage of water loss of 28.58% was obtained at concentration of sugar solution (55.59/10.59% w/w), temperature (34.74°C) and processing time (2.54 hrs).

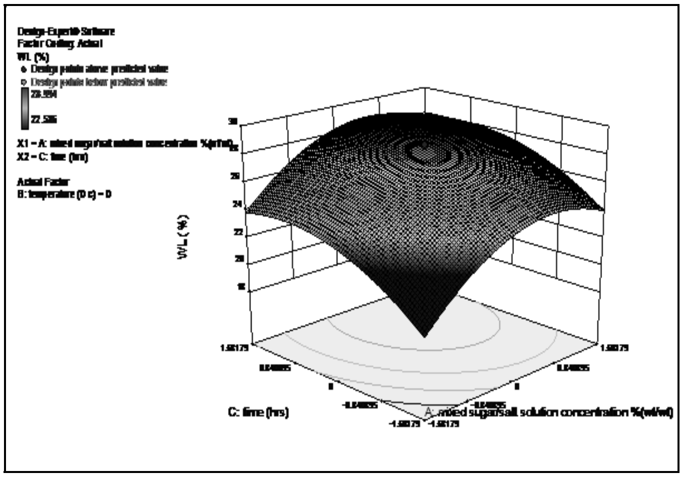

Fig. 8: 3D plot of the combined effect of aqueous mixed sugar and salt solution concentration and time on water loss

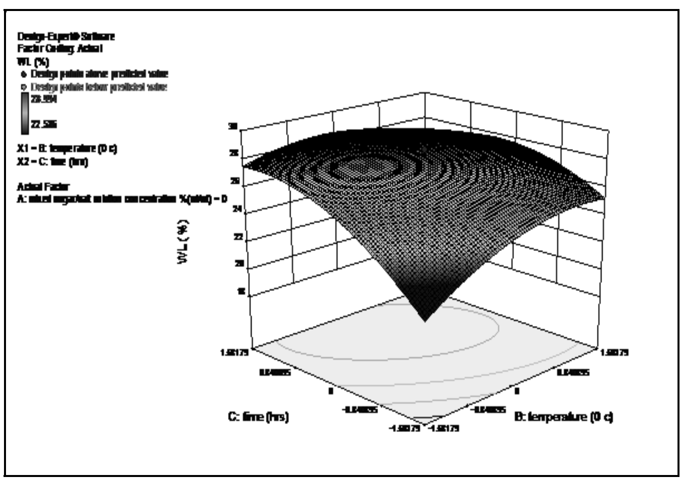

Fig. 9: 3D plot of the combined effect of the temperature and processing time on percentage of water loss

The experimental results were analysed statistically by RSM to obtain an empirical model for the best response. Mathematical expressions to the response with independent variables are shown below.

Weight reduction = 25.70395 + 0.79850* Concentration of sugar solution + 0.27724* Temperature + 0.73862* Process time – 0.35837* Concentration of sugar solution* Temperature – 0.18787* Concentration of sugar solution* Process time + 0.44537* Temperature* Process time – 1.14383* Concentration of sugar solution^2 – 0.61615* Temperature^2 – 0.89846* Process time^2 …(5)

Solid gain = 2.68501 + 0.38686* Concentration of sugar solution + 0.19728* Temperature + 0.40462* Process time + 0.074000* Concentration of sugar solution* Temperature + 0.12600* Concentration of sugar solution* Process time – 0.020250* Temperature* Process time + 0.16591* Concentration of sugar solution^2 + 0.10103* Temperature^2 + 0.23485* Process time^2 …(6)

Water loss = 28.38896 + 1.18536* Concentration of sugar solution + 0.47452* Temperature + 1.14324* Process time – 0.28437* Concentration of sugar solution *Temperature – 0.061875* Concentration of sugar solution *Process time – 0.46562* Temperature* Process time – 0.97792* Concentration of sugar solution^2 –0.51512* Temperature^2 – 0.66362* Process time^2 …(7)

Optimization

The second-degree polynomial regression equation (5), (6) & (7) obtained in this study were utilized for each response in order to found the specified optimum conditions for osmotic dehydration of coconut slices in aqueous mixed sugar and salt solution concentration. The sequential quadratic programming in MAT LAB 7 is used to solve the second-degree polynomial regression equation. Optimization was done with the criteria such as to maximizes percentage of weight reduction, water loss and to minimize percentage of solid gain for osmotic dehydration of coconut slices. The optimum value obtained by substituting coded values of variables are aqueous mixed sugar and salt solution concentration 60.849% w/w, temperature 34.745°C and processing time 3.051 hrs. Optimum conditions for maximum percentage of weight reduction, water loss and minimum percentage of solid gain was found at 60.849% w/w concentration of sugar solution, temperature 34.745°C and processing time 3.051 hrs. At these conditions percentage of weight reduction (WR), solid gain (SG) and water loss (WL) were 20.886, 2.228 and 23.115 %, respectively.

CONCLUSION

In this work, the optimum operating conditions for osmotic dehydration of coconut slices in aqueous mixed sugar and salt solution concentration was determined by using RSM on criteria such as to maximizes percentage of weight reduction, water loss and to minimize percentage of solid gain. The second-degree polynomial regression equation (5), (6) & (7) obtained in this study by RSM for each response was utilized to find the maximum percentage of weight reduction, water loss and minimum percentage of solid gain in osmotic dehydration of coconut slices at optimized independent variables. Analysis of variance has shown that the effects of all the process variables including concentration of sugar solution, temperature and processing time were statistically significant. Optimum conditions for maximum percentage of weight reduction, water loss and minimum percentage of solid gain was found at 60.849 % w/w concentration of sugar solution, temperature 34.745°C and processing time3.051 hrs. At these conditions percentage of weight reduction (WR), solid gain (SG) and water loss (WL) were 20.886, 2.228 and 23.115, respectively.

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