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Osmotic dehydration optimization of butternut squash (*Cucurbita moschata* Duch) using response surface methodology

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Abstract

Butternut squash (*Cucurbita moschata* Duch) has a reasonably high carotene content. The flour-making process of it is related to the carotene content and antioxidant activity. It is essential to determine the optimum conditions of osmotic dehydration process by treating the concentration of the salt solution (5-15%), immersion time (60-180 mins), and stirring speed (10-40 rpm) on colour, beta-carotene content, and antioxidant activity using Response Surface Methodology (RSM) with Box-Behnken Design (BBD). All responses had a quadratic model fit ($p<0.05$). The R^2 values are 86.7 for water loss, 84.9 for a solid gain, 96.3 for colour (ΔE), 94.3 for colour (chroma), 65.5 for beta-carotene, and 70 for antioxidant activity, respectively. The decrease in water content was strongly influenced by the salt solution concentration, stirring speed, and soaking time. However, among three factors, the salt solution concentration was the most influential. The stirring speed significantly influences the addition of solids to the material (solid gain) during the osmotic dehydration process. In contrast, ΔE and chroma were influenced by the stirring speed and immersion time for colour changes. Stirring speed influences beta-carotene levels. The amount of antioxidant activity was influenced by the stirring speed and immersion time. The optimization results obtained a salt solution concentration of 15%, a stirring speed of 25 rpm, and an immersion value of 155.8 mins. The magnitude of the three factors above provides a predictive value for water content to decrease to a maximum of 8.57%, solid gain to increase by 8.34%, beta-carotene content to decrease by 11.07% on a wet basis, antioxidant activity to decrease by 2.74, ΔE 20.22, and chroma of 71.07. The composite desirability value was 77.30%. Treating the salt concentration, soaking time, and stirring frequency affect the colour change, water loss, addition of solids, beta-carotene levels and antioxidant activity. The research finds that reducing the water content in the DO process has a significant effect, so the drying process can be carried out more quickly. In addition, the significance of the optimal conditions for the honey gourd DO process can be applied to further processing, for example, for the manufacture of industrial-scale flour.

1. Introduction

Pumpkin is an alternative food that comes from the potential of local food resources (Pendong *et al*., 2017). The shelf life of butternut squash can reach six months or longer, with the most appropriate storage temperature of 10–16°C and 70% humidity (Nopianasanti and Setiadi Daryono, 2018). The bright orange colour of the butternut squash indicates that the pumpkin contains high levels of carotene (Guiné and Barroca, 2012). Butternut squash fibre content is approximately 2.20-2.97%; protein 0.76-1.45%; sugar 2.15-2.90%; fat 0.12-0.17%; carbohydrates 6.47-0.18%; and carotenoids 34.54 - 39.53 mg/g (Armesto *et al*., 2020). Hence, it is suitable as a complementary food for breast milk in babies (MPASI) (Rachmawati *et al*., 2016). Therefore, the butternut squash market has higher economic value.

Pretreatment of butternut squash before drying affects the chemical composition and structure of the material, which can cause changes in the water content of the material (Ciurzyńska *et al*., 2013). Pretreatment of osmotic dehydration in fruits can maintain, and prevent

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colour damage (Rahman *et al*., 2015; Ramya and Jain, 2017), improve the quality of food products (Pisoschi and Pop, 2015; Aras and Salengke, 2019), minimize heat stress, and reduce energy input (Yadav and Singh, 2013; Almena *et al*., 2019). The osmotic dehydration (OD) method involves immersing food in a high-concentration solution to decrease water content (Akbarian *et al*., 2013; Saputra *et al*., 2018).

Several factors influence osmotic dehydration, including osmotic substances, solute concentration, temperature, time, size, shape, compactness of tissue materials, agitation, and solution/sample ratio (Pandharipande *et al*., 2012). Treating osmotic dehydration by increasing the concentration of the osmotic solution increases the water loss and solid gain in the material (Tortoe, 2010; Phisut, 2012). Sugar solutions (sucrose, glucose, and fructose) and salt (NaCl) proved to be the best choices based on effectiveness, convenience, and taste (Tortoe, 2010). Agitation also determines the effectiveness of osmotic dehydration (Mavroudis *et al*., 1998; Moreira *et al*., 2007).

As an indicator of the effectiveness of DO, the magnitude of the decrease in the water content and the amount of solid gain of the material (Mayor *et al*., 2006), while the quality of the dried flour is measured by changes in colour, beta-carotene content, and antioxidant activity (Que *et al*., 2008). The factors studied in this study are drying methods, including freeze-drying and hot air drying. This study showed that freeze-drying significantly reduced the browning and maintained the reddish color of pumpkin flour. Hot air drying method showed stronger antioxidant activity than freeze-dried pumpkin flour. Freeze (low temperature) and hot air drying methods affect the antioxidant activity and colour change (Que *et al*., 2008). Osmoactive substances such as sucrose and sodium chloride used in the osmotic dehydration process can play a role in maintaining and increasing the content of β-carotene (Lee and Lim, 2011). This study aimed to determine the concentration of the salt solution, stirring speed, and optimum soaking time for the osmotic dehydration of butternut squash.

2. Materials and methods

2.1 Materials and tools

Ingredients for butternut squash (*Cucurbita moschata* Duch) from Karanganyar, Central Java, aquades and table salt (NaCl) were purchased from chemical stores (Saba Kimia), methanol (MERCK), DPPH reagent (HIMEDIA), petroleum ether (MERCK), ethanol (Emsure), and $K_2Cr_2O_7$ (MERCK). Sampling ensured that the pumpkins were old or ready to harvest and were selected so that they were not deformed and had average growth. The harvest age was confirmed to be approximately three months, the weight was 1-2 kg, and the skin and flesh of the fruit were orange. A UV-Vis spectrophotometer with a specification of UV min 1240 (Shimadzu Corporation, Japan) was used to analyze β-carotene and antioxidant activity; and a Chromameter Konica Minolta CR- 400/410 was used to measure colour quantitatively (L, a, and b values).

2.2 Research

Selected butternut squash that met the requirements, cleaned, peeled the skin and seeds, was cut into pieces with a size of 1 × 1 × 1 cm, and then subjected to an osmotic dehydration process with a ratio of ingredients and salt solution 1:5% w/v (Manzoor *et al*., 2017) at room temperature (25°C). The pumpkin pieces were then rinsed with clean water to remove excess salt and dried using an absorbent tissue. The result of the analysis performed after the DO process are shown in Table 1. Water content was calculated by gravimetry method (SNI 01-2891-1991), solid gain by gravimetry (Manzoor *et al*., 2017), by L, a, b (Chong *et al*., 2013; Kaemba *et al*., 2017), beta-carotene (Wahyuni and Widjanarko, 2015), and antioxidant activity (Que *et al*., 2008).

2.3 Experimental design

This study used the Response Surface Methodology (RSM) research design, which is a Box-Behnken design with three factors each of which consists of three levels of factors. These factors were the concentration of the salt solution (5–15% w/v), stirring speed (10–40 rpm) and immersion time (60–180 mins). Table 2 shows the values of the factor variables in the coded and uncoded forms for the butternut squash DO optimization process. Table 2 shows the experimental design used to optimize butternut squash DO use Response Surface Methodology with Box-Behnken Design (BBD).

2.4 Water content determination

Determination of the water content of fruits and vegetables using the gravimetric method has shown in Equation 1 (Manzoor *et al*., 2017).

$$MC\,(\%) = \frac{(W + W_1) - W_2}{W} \times 100\% \quad (1)$$

Where MC = water content of the material (%), W = initial sample weight of material (%), W_1 = weight of the cup (g) and W_2 = weight of the cup and weight of the material after drying

The loss of water content and addition of solids (solid gain) was calculated using the equation 2 and 3 as the following below:

$$M_L\,(\%) = \frac{M_o - M_t}{W} \times 100 \quad (2)$$

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Table 1. Experimental design of RSM BBD on DO optimization of butternut squash.

Run	Code			Uncoded			Response
	Salt concentration (X_1)	Stirring speed (X_2)	Soaking time (X_3)	Salt concentration (%)	Stirring speed (rpm)	Soaking time (min)	
1	-1	-1	0	5	10	120	Water loss (Y_1), solid gain (Y_2), ΔE (Y_3), Chroma (Y_4), Decreased levels of β-carotene (Y_5), Decreased antioxidant activity (Y_6),
2	-1	1	0	5	40	120	
3	1	-1	0	15	10	120	
4	1	1	0	15	40	120	
5	-1	0	-1	5	25	60	
6	-1	0	1	5	25	180	
7	1	0	-1	15	25	60	
8	1	0	1	15	25	180	
9	0	-1	-1	10	10	60	
10	0	-1	1	10	10	180	
11	0	1	-1	10	40	60	
12	0	1	1	10	40	180	
13	0	0	0	10	25	120	
14	0	0	0	10	25	120	
15	0	0	0	10	25	120	

Table 2. Coded and uncoded values for research factor level.

Variable	Code		
	-1	0	+1
Salt concentration (%)	5	10	15
Stirring speed (rpm)	10	25	40
Immersion time (min)	60	120	180

$$SG\ (\%) = \frac{S_t - S_o}{W} \times 100 \quad (3)$$

Where M_L = Loss of water content (% b/b db), SG = addition of solids (% b/b) M_o, M_t = Weight of initial sample and current sample t (kg), S_o, S_t = Weight of initial solids and weight of solids at t (kg/kg db).

2.5 Colour (ΔE and chroma)

The colour was measured quantitatively using a chromameter (L, a, and b values). The DE and chroma values were calculated using the following Equation 4 and Equation 5:

$$\Delta E = \sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2} \quad (4)$$

$$Chroma = \sqrt{a^2 + b^2} \quad (5)$$

Where ΔL = difference in L value before and after treatment, Δa = difference in the value of a before and after treatment, and Δb = difference in b value before and after treatment

2.6 Determination of β-carotene

Two grams of a good sample and 2.5 mL of ethanol were added and homogenized with a vortex mixer for 1 min. Another 10 mL of petroleum ether was added and the mixture was homogenized for 10 mins. The solution was pipetted to 2 mL, and 3 ml of petroleum ether was added to dilute the solution. Measurements were carried out on a spectrophotometer at a wavelength of 450 nm using a petroleum ether blank. A standard solution of artificial β-carotene was prepared by dissolving 32.2 mg of potassium dichromate ($K_2Cr_2O_7$) in distilled water to a volume of 50 mL. The wavelength used was 450 nm with an aquatic blank. The absorbance of 20 mg potassium dichromate solution in 100 mL distilled water was equivalent to 5.6 g in 5 mL petroleum ether (Hasbullah *et al.*, 2014). The β-carotene content was calculated using Equation 6 as shown in the following below:

$$\beta - \text{carotene level} = \frac{(\text{Sample absorbance}/\text{Sample absorbance}) \times 5.6\ \text{mL PE}}{\text{sample mass}} \quad (6)$$

2.7 Antioxidant activity

The butternut squash pieces were mashed, weighed (100 mg), and placed in a test tube coated with aluminium foil. The sample was added to 10 mL of methanol and homogenized by vortexing for 5 min. The test tube containing the sample was incubated for 24 h in the dark, and the tubes were closed using aluminium foil.

The control solution was prepared from 1 mL of 0.3 mM DPPH solution dissolved in 5 mL of methanol in a test tube wrapped in aluminium foil. The control solution was vortexed for 1 min and incubated in the dark for 30 min. One millilitre of the sample solution incubated for 24 h was then taken as much as 0.1 mL into another test tube. Then, 4.9 methanol and 1 mL 0.3 mM DPPH solution were added. The sample solution was then homogenized by vortexing for 1 min and incubated in the dark for 30 min. The absorbance of the sample and control solutions was measured at a wavelength of 517 nm using a UV-Vis spectrophotometer (Marinova and Batchvarov, 2011). Antioxidant activity of the sample using the DPPH method was calculated using Equation 7 as shown in the following below:

$$\%\ \text{Antioxidant activity} = \left(1 - \frac{Sample\ absorbance}{Control\ absorbance}\right) \times 100\% \quad (7)$$

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3. Results and discussion

3.1 Model evaluation

Table 3 shows the results of each response of the osmotic dehydration process with the concentration of the salt solution (NaCl), stirring speed, and immersion time. Model selection was carried out based on the simultaneous regression coefficient test, p-value <α (0.05), and the coefficient of determination test (R^2) (Mokhtarian *et al*., 2014; de Andrade Lima *et al*., 2018). The evaluation of the model using ANOVA aims to accurately determine the significance level of each independent variable for the response variable (Umavathi *et al*., 2021). The model analysis data for the honeycomb's response to osmotic dehydration are listed in Table 4.

3.2 Mathematical model for all responses (Y_1 -Y_6)

The mathematical model based on ANOVA analysis was shown below. The quadratic model was chosen because it had a more significant R^2 value and a p-value <0.05. The influential variables are shown in the equation namely, the concentration of the salt solution (X_1), stirring speed (X_2), and immersion time (X_3).

$$Y_1 = 4.9307 - 0.1927 X_1 - 0.0710 X_2 - 0.0694 X_3 + 0.0248 X_1^2 + 0.0004 X_3^2$$
$$Y_2 = 4.7862 - 0.2615 X_1 + 0.0342 X_2 - 0.0638 X_3 + 0.0003 X_3^2$$
$$Y_3 = 15.7476 - 0.2057 X_2 - 0.1185 X_3 - 0.0287 X_1^2 + 0.0038 X_2^2 + 0.007 X_3^2$$
$$Y_4 = 67.1249 + 0.3028 X_1 + 0.0977 X_2 - 0.1761 X_3 + 0.0009 X_3^2 + 0.0037 X_1X_3 - 0.0011 X_2X_3$$
$$Y_5 = -6.6135 + 0.0228 X_2 - 0.1180 X_1^2 + 0.0102 X_2^2 - 0.0040 X_2X_3$$
$$Y_6 = 6.4077 + 0.1299 X_2 - 0.0251 X_3 + 0.0243 X_1^2 - 0.0043 X_2^2 + 0.0002 X_3^2 + 0.0102 X_1X_2$$

3.3 Water loss

The results indicate that solution concentration is the most influential variable in the value of water loss (Lee

Table 3. Factors and optimization responses of butternut squash osmotic dehydration (*Cucurbita moschata* Dusch).

No	Factor			Response					
	X_1	X_2	X_3	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
1	5	10	120	2.14±0.20	2.19±0.13	12.77±0.42	63.46±0.13	7.33±1.02	3.56±0.49
2	15	10	120	3.19±0.36	3.22±0.36	14.21±0.24	64.00±0.31	11.34±0.53	1.19±0.21
3	5	40	120	4.12±0.17	4.18±0.17	11.09±0.14	65.98±0.51	9.13±0.35	1.19±0.08
4	15	40	120	5.92±0.37	5.96±0.38	12.62±0.22	65.97±0.32	14.27±0.82	1.87±0.08
5	5	25	60	0.73±0.08	2.07±0.08	10.08±0.13	62.85±0.33	9.72±0.83	3.05±0.21
6	15	25	60	4.49±0.36	3.84±0.39	17,40±0.29	66.90±0.25	13.00±1.15	3.67±0.72
7	5	25	180	5.51±0.06	5.55±0.07	10.86±0.09	66.38±0.29	6.73±1.53	2.71±0.49
8	15	25	180	9.14±0.13	9.17±0.14	18.59±0.27	74.80±0.42	7.50±1.66	4.58±0.49
9	10	10	60	2.72±0.10	2.75±0.09	12.21±0.17	63.49±0.42	10.07±0.42	1.13±0.55
10	10	40	60	5.81±0.08	5.84±0.09	17.93±0.25	71.53±0.31	18.37±0.57	3.90±0.69
11	10	10	180	3.45±0.21	2.85±0.08	12.80±0.07	67.36±0.20	17.87±1.66	0.68±0.08
12	10	40	180	6.77±0.33	6.54±0.14	20.33±0.17	71.58±0.22	11.61±1.71	1.98±0.55
13	10	25	120	3.86±0.35	3.91±0.49	12.81±0.21	65.17±0.38	13.47±1.54	3.16±0.28
14	10	25	120	2.03±0.10	2.52±0.22	12.33±0.19	65.19±0.26	10.45±0.20	1.81±0.14
15	10	25	120	2.75±0.14	4.58±0.22	12.44±0.67	64.16±0.15	9.61±51	1.98±0.43

Values are presented as mean±SD of triplicates. X_1: Concentration of salt solution, X_2: Stirring speed, X_3: Stirring time, Y_1: Water Loss (%), Y_2: Solid gain (%), Y_3: ΔE, Y_4: Chroma, Y_5: Levels of β-carotene (μg/g), Y_6: Antioxidant activity (%).

Table 4. Results of evaluation of linear and quadratic models on response.

Response	Mathematical Model	p-value	R^2	Adj R^2	Pred R^2
Water loss	Linier	<0.0001	73.57%	71.63%	69.01%
	Quadratic	<0.0001	86.7%	83.29%	77.82%
Solid gain	Linier	<0.0001	74.56%	72.70%	69.80%
	Quadratic	<0.0001	84.94%	81.07%	76.03%
ΔE	Linier	<0.0001	76.19%	74.45%	71.18%
	Quadratic	<0.0001	96.28%	95.32%	93.63%
Chroma	Linier	<0.0001	65.16%	62.61%	57.67%
	Quadratic	<0.0001	94.30%	92.84%	90.15%
Decreased β-carotene	Linier	0.248	9.47%	2.85%	0.0%
	Quadratic	<0.001	65.46%	56.58%	42.91%
Decreased antioxidant activity	Linear	0.002	30.47%	25.38%	15.36%
	Quadratic	<0.001	69.99%	62.28%	52.28%

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and Lim, 2011; Rahman *et al*., 2015). Increasing the concentration of the osmotic solution reduces Aw and increases the derived force, namely the force that encourages the reduction of water content in the material (Mokhtarian *et al*., 2014). A high concentration of the solution causes the osmotic pressure difference outside the material to be greater than the osmotic pressure inside the material. The pressure difference becomes a driving force that causes the water content of the material to enter the solution medium (Aras and Salengke, 2019).

Stirring speed and time also affect the amount of water lost during osmotic dehydration (Pandharipande *et al*., 2012; Yadav and Singh, 2013). The moving process increases the water loss form the material (Akbarian *et al*., 2013; Yadav and Singh, 2013).

3.4 Solid gain response

The results of the study indicated that the concentration of the osmotic solution was an influential variable in the solid gain value (Lee and Lim, 2011; Rahman *et al*., 2015). Dissolved materials such as sugar and salt enter the food network, thereby reducing water permeability particular mechanisms. The more significant difference in the concentration of the osmotic solution with the butternut squash flask, the more two opposing simultaneous flows through the cell wall, namely water moving from the butternut squash flask to the solution and solutes from the solution to the butternut squash flask (Lee and Lim, 2011). This process causes water loss, which is closely related to solid gain during osmotic dehydration.

Mass transfer continued as the osmotic dehydration time increased so the solid gain value increased throughout the osmotic dehydration time (Pandharipande *et al*., 2012). A short stirring period does not affect the solid gain value, whereas for an extended period, the solid gain value of the material decreases drastically with continuous stirring (Akbarian *et al*., 2013; Ramya and Jain, 2017). Using a more significant stirring speed will affect the fluid motion more intensively on the product's surface, making the mass transfer coefficient even more efficacious (Nelwan *et al*., 2015). Figure 1 shows graphs of the effect of salt solution concentration, stirring speed, and stirring time on the response of water loss and solid gain.

3.5 Respond colour response (ΔE) and chroma

The osmotic dehydration process did not significantly affect the colour of butternut squash (Mokhtarian *et al*., 2014). Osmotic dehydration in fruits can change colour, especially a and b values (Dermesonlouoglou *et al*., 2020). The higher the stirring speed used for osmotic dehydration, the darker the colour of fruit (Amami *et al*., 2014). The L* value decreased owing to a change in the colour of the fruit tissue caused by an enzymatic reaction. The agitation speed causes the value of E* to decrease. The immersion time increases the opacity of the material owing to the shrinking tissue structure, and thus the brightness decreases (Anggreini *et al*., 2018). The longer the immersion, the higher the value of E because of the value of L (difference in colour L value before and after osmosis dehydration). Figure 2 shows the graphs of the effect of salt solution concentration, stirring speed, and stirring time on the response of ΔE and chroma**.**

3.6 β-carotene response

Figure 3 shows graph of the effect of salt solution concentration, stirring speed, and stirring time on the response of β-carotene and antioxidant activity. Based on the coefficient value of the β -carotene mathematical model, the influential linear variable was the stirring speed. β-carotene is easily damaged if oxidized at high temperatures, insoluble in water, and soluble in fat. β-carotene is a provitamin A compound that acts as an antioxidant and prevents oxidation (Provesi and Amante, 2015; Kusbandari and Susanti, 2017).

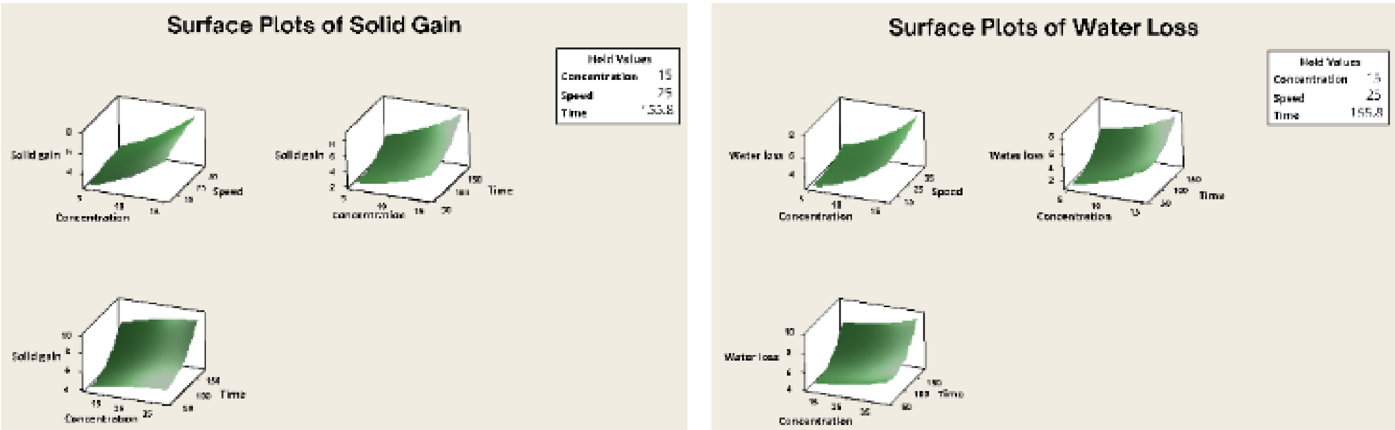

Figure 1. Graph of the effect of salt solution concentration, stirring speed, and stirring time on the response of water loss and solid gain.

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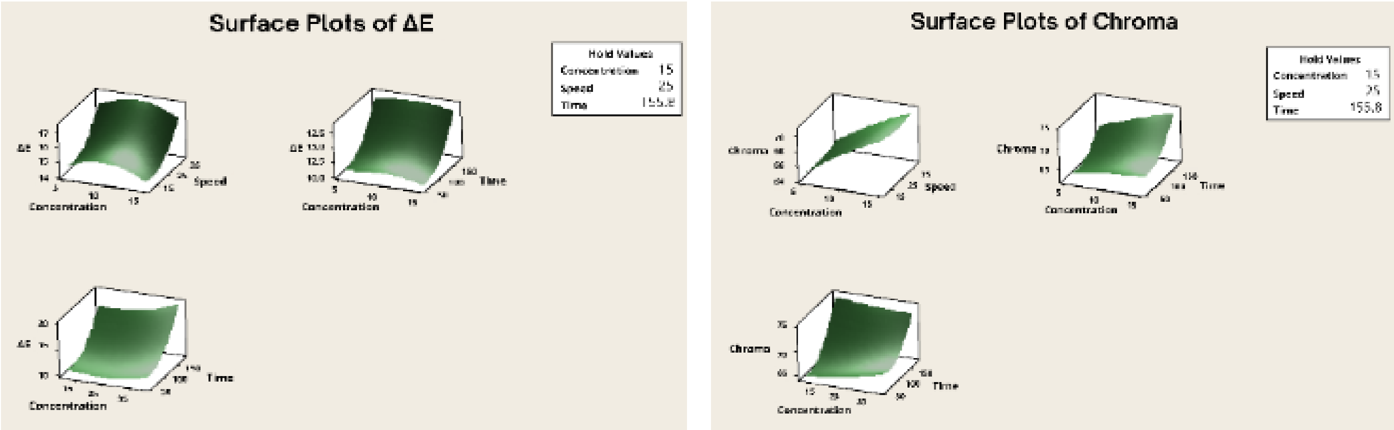

Figure 2. Graph of the effect of salt solution concentration, stirring speed, and stirring time on the response of ΔE and chroma.

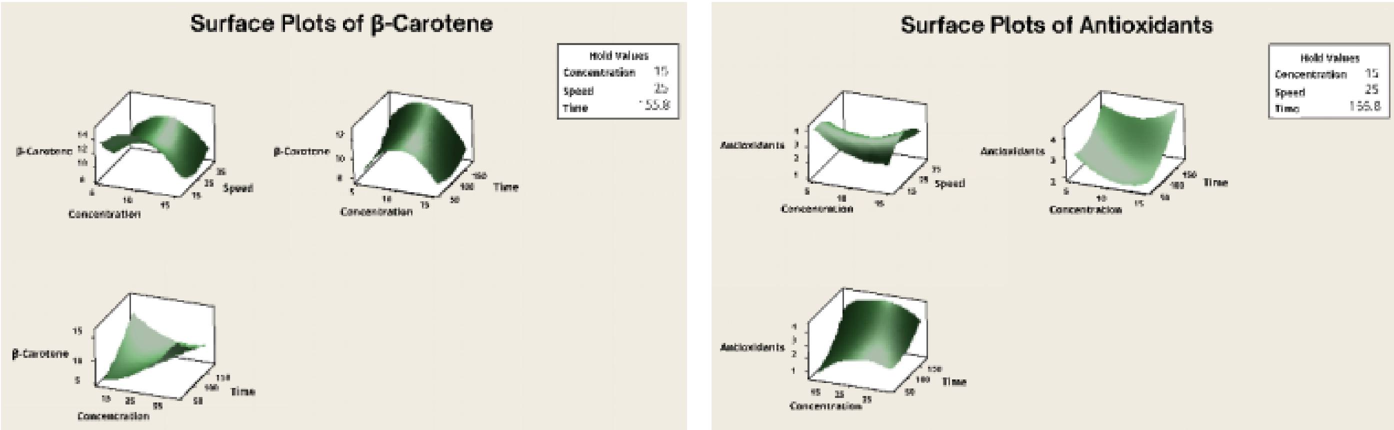

Figure 3. Response graph of the effect of salt solution concentration, stirring speed, and stirring time on the response of β-carotene and antioxidant activity.

3.7 Antioxidant activity response

Stirring speed affects the antioxidant activity of butternut squash. Osmotic dehydration can reduce changes in β-carotene content. β-carotene is the primary antioxidant in the butternut squash gourd, so the decrease in the value of β-carotene also results in changes in antioxidant activity (Lee and Lim, 2011). The duration of the osmotic dehydration stirring process cause the decrease in antioxidant activity (Tortoe, 2010).

3.8 Butternut squash osmosis dehydration optimization

Table 5 shows the criteria for determining the optimum salt solution concentration, stirring speed, and immersion time for the osmotic dehydration process of butternut squash pieces. The stirring speed was set at 25 rpm because, in the field during the research, the use of a moving speed of 40 rpm required large power consumption. The higher the stirring rate, the higher is the power consumption (Nelwan *et al*., 2015). The immersion time was targeted in the range of 60–180 min.

The optimization process using Minitab 16 obtained the following optimization results; the concentration value of the salt solution was 15%, the stirring speed was 25 rpm, and the immersion value was 155.8 min. The three factors above provided a predictive value for maximum water loss of 6.7972%, solid gain increased by 7.3538%, E at least 14.6763, maximum chroma 70.1099, decreased levels of β-carotene at least 8.1983% g/g, and antioxidant activity decreased by at least 3.6616. The desirability value, showing the degree of accuracy of the results according to the optimal, was 61.164%. The closer the desirability value is to 1, the higher the optimization accuracy value (Pereira, Milan, and Tapia-Blácido, 2021).

4. Conclusion

Butternut squash (*Cucurbita moschata* Duch) or

Table 5. Criteria for determining the optimum combination of salt solution concentration, stirring speed, and soaking time in the osmotic dehydration process of butternut squash pieces.

Component	Objective	Lower Limit	Target	Upper Limit	Interest
Water Loss (%)	Maximum	0.615	9.289		++++
Solid Gain (%)	Maximum	1.208	9.334		+++
ΔE	Minimal		9.925	20.534	+++
Chroma	Maximum	62.557	75.344		+++
Decrease in Beta-carotene Levels (µg/g)	Minimal		4.997	20.950	++++
Change in Antioxidant Activity (%)	Minimal		0.452	5.198	+++

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butternut squash has a reasonably high carotene content. The flour-making process of butternut squash has been related to the carotene content and antioxidant activity. It has become essential to focus research on determining the optimum conditions in the osmotic dehydration process by treating the concentration of the salt solution (5-15%), immersion time (60–180 mins), and stirring speed (10-40 rpm) on colour, beta-carotene content, and antioxidant activity using Response Surface Methodology (RSM) with Box-Behnken Design (BBD). All responses have a quadratic model fit ($p<0.005$). The value of R^2 is water loss 86.7, solid gain 84.9, colour (ΔE) 96.3, colour (chroma) 94.3, beta-carotene 65.5, and antioxidant activity 70. The decrease in water content is strongly influenced by the concentration of the salt solution, stirring speed, and soaking time. However, of the three factors, the concentration of the salt solution is the most influential. The stirring speed greatly influences the addition of solids to the material (solid gain) in the osmotic dehydration process. In contrast, ΔE and chroma are influenced by the stirring speed and immersion time for colour changes. The stirring speed influences changes in beta-carotene levels. The amount of antioxidant activity is influenced by the stirring speed and immersion time. The optimization results obtained a salt solution concentration value of 15%, a stirring speed value of 25 rpm, and an immersion value of 155.8 min. The magnitude of the three factors above provides a predictive value for the water content to decrease to a maximum of 8.57%, solid gain to increase by 8.34%, beta-carotene content to decrease by 11.07% on a wet basis, antioxidant activity to decrease by 2.74, ΔE 20.22, and chroma of 71.07. The composite desirability value is 77.30%.

Conflict of interest

The authors declare no conflicts of interest.

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