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Research Article

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Modeling and Optimization of the Osmotic Dehydration of Cantaloupe

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Abstract

In current research, the optimization of osmotic dehydration of cantaloupe pieces aimed to maximize water loss (WL) and minimize moisture reabsorption using artificial neural network (ANN). The effects of three parameters were studied: osmotic solution temperature (40 - 60 °C), immersion time (40 - 240 min), and solution concentration (40 - 60 °Brix), employing central composite design (CCD). Various parameters including WL, solid gain (SG), reduction in WL to SG ratio, and reduction in sample weight were analyzed. The results indicated that the optimal conditions for osmotic dehydration were achieved with a solution temperature of 60 °C, immersion time of 85.71 min, and solution concentration of 40% sucrose (sugar). Under these conditions, the following parameters were observed: WL of 3.79%, SG of 43.74%, WL to SG ratio of 14.48, and sample weight reduction of 47.71%. Furthermore, results from the ANN revealed that a network structure with one hidden layer comprising 5 nodes (3-5-4 network with 3 inputs, 5 nodes in the hidden layer, and 4 outputs) provided the most accurate predictions. This network achieved correlation coefficients (R2) of 0.999 and root mean squared error (RMSE) of 0.000039, demonstrating high reliability and precision in predicting the selected responses.

Keywords

Osmotic dehydration, Response surface methodology, Artificial neural network, Cantaloupe

Introduction

The dehydration process of food materials, particularly fruits and vegetables, has been utilized since ancient times to enhance the shelf life of food products. Nowadays, dehydration is widely recognized as one of the most frequently used processes in the food industry. Maintaining the nutritional value of food materials and enhancing the water reabsorption rate of dehydrated foods are two critical parameters considered as quality indices in food production. Achieving these goals is an essential objective of the food industry to minimize undesirable alterations while preserving the nutritional and organoleptic properties of food products.

Osmotic dehydration, due to its ability to maintain stability, improve quality and applicability of food properties, and reduce energy consumption, has garnered

significant interest among researchers [1-3]. Cantaloupe (*Cucumis melon* L), known for its economic importance, has been cultivated since ancient times. Iran is recognized for its extensive preservation of various varieties of this plant, ranking second globally [4].

In Iran's agricultural industries, cantaloupe faces challenges as nearly 30% of the harvested produce decomposes during transportation to customers, limiting its application. Cantaloupe varieties are typically enjoyed and sold fresh due to their perishable nature. Despite this, cantaloupe holds significant nutritional value, being rich in vitamins K and C, folic acid, potassium, and various micronutrients like zinc, copper, and iron, alongside antioxidants. However, due to its seasonal availability and underutilization in agricultural industries, its shelf life is reduced, contributing to increased waste [5]. Some researchers have approached drying cantaloupe in various ways. For example, studies by Zadhossein et al. [6] investigated drying cantaloupe using hot air, while Chang et al. [7] utilized infrared waves.

Osmotic dehydration involves removing moisture from plant or animal tissues through direct contact with an osmotic solution, typically concentrated solutions of sugar, salt, or a combination of both [8]. This process serves as an intermediate or preprocessing technology that significantly impacts fruit storage processes by reducing energy consumption, enhancing fruit quality, and improving the dehydration rate of various food materials in the food industry [9].

In this process, various pieces of food materials, such as fruits and vegetables, are immersed in an osmotic solution where the natural cell membranes act as semi-permeable barriers. A concentration gradient between the osmotic solution and the internal cell fluids creates the driving force necessary for extracting moisture from the cells [8, 10].

ANNs are currently influential in predicting diverse processes. While numerous studies have focused on predicting different parameters, the authors of this research found no studies specifically modeling the osmotic dehydration of Iranian cantaloupe.

A group of researchers has investigated the modeling of mass transfer during the osmotic dehydration of African lemon peel using ANNs. The results showed that increasing the osmotic solution concentration and processing temperature led to decreased moisture content and increased SG.

The study utilized a multi-layer feedforward neural network with three inputs: solution temperature, immersion time in the osmotic solution, and solution concentration. This configuration yielded the most reliable results, achieving a low RMSE of 0.0066 and a high R^2 of 0.9725 between experimental and predicted values. The network architecture included a hidden layer with 5 nodes, and the Ljungberg-Marguerite algorithm was identified as the optimized learning pattern [11].

Another group of researchers demonstrated that modeling synthetic osmotic dehydration using an ANN with a hidden layer of 4 nodes showed high efficiency in predicting the WL parameter [12].

Numerous studies have explored the application of osmotic pretreatment in food product dehydration. For instance, researchers studied the effects of ultrasound pretreatment on mass transfer and microstructural characteristics of orange fruit peel during hot air dehydration. Their findings highlighted significant kinetics in the dehydration process of orange fruit peel, with increased mass transfer coefficients and effective moisture diffusion [13].

In another study, the effect of osmotic dehydration conditions on the qualitative properties of dehydrated apple pieces using subsequent hot air dehydration was investigated. Two different osmotic solutions, prepared with glucose and sucrose at varying concentrations, were used as osmotic agents. It was observed that samples treated with glucose solution initially lost more water compared to those treated with sucrose solution. Furthermore, hardening of the external surface was noted during dehydration with glucose solution [14]. Some researchers have used ANN for the classification of cantaloupe, stating that this method is highly effective for categorizing this fruit. Additionally, other researchers have applied this method to predict the properties of cantaloupe [15, 16].

Given the abundant production of cantaloupe in Iran and the significant waste of this product from production to consumption, the main objective of this study is to reduce the waste of this product and to produce a byproduct that will be available to consumers during other seasons as well.

The current study aims to determine optimized conditions for cantaloupe fruit dehydration using osmotic solutions. Maximizing WL while minimizing SG and optimizing the WL to SG ratio are primary considerations. Osmotic dehydration, known for its rapid processing rate, quality improvement, and cost-effectiveness, may be extensively employed in conjunction with other methods such as vacuum dehydration and cabinet drying as a novel dehydration approach. The study employs an ANN to predict parameters including reductions in WL, sample weight after dehydration, and the WL to SG ratio during the dehydration process.

Materials and Method

Sample preparation

Cantaloupe samples were sourced from a local market in Gonbad Kavoos, Golestan Province, Iran, and stored at 4 °C in a refrigerator. The initial moisture content of the samples was determined to be 85% based on their wet weight. Moisture content measurements were conducted by placing the samples in an oven maintained at 102 ± 0.5 °C until a constant weight was reached [17].

Osmotic dehydration process

For this study, cantaloupe samples were sliced to a width of 12 ± 0.1 mm using a sharp cutter, and the slice width was verified and recorded with a caliper. Slices with firm and tough textures were selected for the experiments. Osmotic dehydration conditions were determined through preliminary tests and set as follows: temperatures of 4, 50, and 60 °C; immersion times of 60, 150, and 240 min in osmotic solutions, and

sucrose solution concentrations ranging from 40 to 60 °Brix.

The prepared slices were weighed immediately before placement in special containers. After the specified immersion times, the slices were removed from the osmotic solution, rinsed with distilled water to remove surface residues, and then placed on filter paper to drain surface water. Their weights were recorded to assess WL.

To determine moisture content and dry matter, sample pieces were placed in an oven set at 102 ± 0.5 °C until a constant weight was achieved.

Solution preparation and experiments

Various solutions of sucrose (98.5% purity) were prepared at concentrations of 40%, 50%, and 60% (w/w). In the experiments, a sample weight to solution weight ratio of 1:10 was selected, and all experiments were conducted under identical conditions.

SG, WL, and weight loss rate of the slices at different stages (before osmotic dehydration, after osmotic dehydration, and after hot air drying) were determined using Equations 1, 2, and 3 respectively [14].

$$SG = \frac{W_t S_t - W_0 S_0}{W_0} \times 100 \quad (1)$$

$$WL = \frac{W_0 X_0 - W_t X_t}{W_0} \times 100 \quad (2)$$

$$WR = \frac{W_0 - W_t}{W_0} \quad (3)$$

Where: S_0 denotes the solid material content of the initial sample (g), S_t indicates the solid material content after osmotic dehydration (g), W_0 is the initial weight of the sample (g), WL denotes WL (%), W_t represents the weight of the sample after dehydration (g), X_0 denotes the moisture content of the initial sample (%), X_t indicates the moisture content of the dehydrated sample (%), and WR is the amount of weight loss of the samples after completion of the dehydration process [14].

Experimental design and statistical analysis

In the present study, the ranges of different selected independent variables were chosen based on optimized conditions aimed at maximizing WL and the WL to SG ratio, while minimizing SG. The experiment included three levels for the temperature of the osmotic solution (40, 50, and 60 °C), three levels for immersion time of the sample in the osmotic solution (60, 150, and 240 min), and three levels for sucrose concentration (40, 50, and 60 °Brix).

The experimental design was conducted using design of experiment software version 6.02 with the CCD method. To evaluate the response surface behavior, a second-degree polynomial equation was fitted for each independent variable (Equation 4).

$$Y = \beta_0 + \sum_{i=1}^{3} \beta_i X_i + \sum_{i=1}^{3} \beta_{ii} X_{ii}^2 + \sum_{i=1}^{2} \sum_{j=i+1}^{3} \beta_{ij} X_i X_j \quad (4)$$

Where: Y is the estimated response (for SG, WR, and WL), β_0, β_i, β_{ii}, and β_{ij} are the constant coefficients, and X_i and X_j represent the coded independent variables. The quality and accuracy of the regression model, as well as the appropriateness of the fitting, are determined by the parameters of model analysis, lack of fit, and the coefficient of determination.

The details of the experimental design are clearly presented in table 1.

ANN

An ANN consists of interconnected neurons that process input data and information through layers. The initial layer, which receives input data, is called the input layer. Subsequent layers are referred to as hidden layers, while the final layer that produces predicted output is known as the output layer. A commonly used type of ANN, included in this study, is the multilayer perceptron, which adjusts its connections based on training data to minimize errors.

In the current network, the number of nodes or neurons in the input layer corresponds to the selected inputs or independent variables. Determining the optimal number of nodes in the hidden layer and the number of hidden layers typically requires preliminary testing and experimentation. The number of nodes in the hidden layers depends on the complexity of the inputs and is determined empirically. Each neuron in a layer is connected to neurons in the subsequent layer, but not within the same layer. The output of each neuron is described by equation 4:

$$\alpha = f\left(\sum_{i=1}^{n} p_i W_{j,i} + b_j\right) \quad (4)$$

Where: $W_{j,i}$ represents the weight of the connection between node j in a layer and node i from the previous layer, indicating the significance of the relationship between two consecutive nodes. b_j denotes the bias weight of neuron, pi represents the number of neurons in the previous layer.

Various functions can be employed to transmit data from one layer to the next. For example, functions such as hyperbolic sigmoid, gaussian, hyperbolic tangent, linear, and hyperbolic secant are commonly used in modeling processes in life sciences. However, in engineering applications, functions like hyperbolic tangent and hyperbolic sigmoid, as described in equation 5, are frequently utilized:

$$f(z) = \frac{1}{1 + \exp(-z)} \quad (5)$$

The concentration of the osmotic solution (C), its temperature (T), and immersion time (t) are considered as the inputs or independent variables, while SG, WL, the ratio of WL to SG, and weight loss are treated as outputs or responses in the current study. Therefore, an ANN with three inputs and four outputs was designed and implemented.

To determine the optimal design, two factors were utilized: maximizing the R2R^2R2 and minimizing the RMSE. These parameters can be calculated using equations 6 and 7, respectively:

Table 1: Independent and dependent variables in the process of osmotic dehydration.

S. No.	Variables			Answers			
	Conc (X_1) (%)	Temperature (°C) (X_2)	Time (min) (X_3)	WL (%)	SG (%)	WL/SG	WR
1	60 (1)	60 (1)	240 (1)	68.41	5.07	13.49	54.89
2	40 (-1)	40 (-1)	240 (1)	56.159	7.16	7.84	52.33
3	40 (-1)	60 (1)	60 (-1)	27.84	2.8	9.94	28.65
4	60 (1)	40 (-1)	240 (1)	57.57	7.69	7.48	48.65
5	50 (0)	50 (0)	150 (0)	55.7	6.81	8.17	56.5
6	50 (0)	50 (0)	150 (0)	55.76	7.09	7.86	54.76
7	50 (0)	40 (-1)	150 (0)	50.31	7.49	6.71	49.67
8	50 (0)	50 (0)	60 (-1)	37.66	6.44	5.84	39.75
9	40 (-1)	60 (1)	240 (1)	46.48	5.81	8	45.26
10	60 (1)	40 (-1)	60 (-1)	30.56	6.57	4.66	32.22
11	60 (1)	50 (0)	150 (0)	61.3	6.04	10.15	58.5
12	50 (0)	50 (0)	150 (0)	55.74	7.09	7.86	56.02
13	50 (0)	50 (0)	150 (0)	55.73	7.15	7.8	56.34
14	40 (-1)	40 (-1)	60 (-1)	21.98	1.02	21.54	19.06
15	50 (0)	50 (0)	240 (1)	60.48	8.51	7.1	57.56
16	50 (0)	50 (0)	150 (0)	55.35	7.11	7.78	56
17	50 (0)	60 (1)	150 (0)	58.67	8.57	6.85	57.58
18	50 (0)	50 (0)	150 (0)	54.77	7.12	7.69	56.39
19	60 (1)	60 (1)	60 (-1)	56.93	9.39	6.06	55.1
20	40 (-1)	50 (0)	150 (0)	46.05	2.49	18.49	47.11

$$R^2 = 1 - \left[\frac{\sum_{i=1}^{N} (P_{ANN,i} - P_{\exp,i})^2}{\sum_{i=1}^{N} (\overline{P}_{ANN,i} - MR_{ANN,i})^2} \right] \quad (6)$$

$$MRE = \left(\frac{1}{N} \sum_{i=1}^{N} \frac{\left| (P_{ANN,i} - P_{\exp,i}) \right|}{P_{\exp,i}} \right) \times 100 \quad (7)$$

Where: P_{ANN} expresses the predicted value of the responses, P_{exp} is the experimental values achieved in the present study and N presents the number of experiments [18].

Results and Discussion

The regression analysis of osmotic dehydration of Iranian cantaloupe fruit revealed significant linear, quadratic, and interactive effects of the independent variables on WL, as shown in table 2. Increasing the immersion time and osmotic solution temperature enhanced WL (Figure 1). Longer immersion times allow osmotic agents to penetrate more efficiently into the cantaloupe fruit texture, thereby increasing WL until a balance is achieved between product dehydration and osmotic agent penetration.

Similarly, the effects of osmotic solution temperature and concentration on WL rate showed an upward trend, as illustrated in figure 1. These findings are consistent with previous studies [8]. The increase in osmotic solution concentration intensifies osmotic pressure, leading to greater WL as a significant volume of water is required to maintain equilibrium once the sample is immersed in the solution [19, 20].

The equation depicting the relationship between immersion time, concentration, and temperature of the osmotic solution with WL is as follows:

$$WL = +55.58 + 7.63X_1 + 4.18X_2 + 11.41X_3 - 2.01X_1^2 - 1.19X_2^2 - 6.61X_3^2 + 5.13X_1X_2 - 1.79X_1X_3 - 3.88X_2X_3$$

The effects of the independent variables on SG value

The correlation analysis between experimental and predicted values of osmotic dehydration of cantaloupe fruit indicated significant linear and quadratic effects of the selected parameters on SG ($p < 0.05$). Figure 2 illustrates that increasing immersion time with temperature of the solution resulted in a higher percentage of SG in the initial product. This phenomenon can be attributed to temperature-dependent diffusion, characterized by Arrhenius kinetics, where higher temperatures accelerate water diffusion in food products. Additionally, reduced viscosity of the osmotic solution at higher temperatures enhances mass transfer efficiency [8].

Table 2: Analysis of variance for determined parameters.

Source	DF	WR		SG		WL/SG		WL	
		Sum of square	Pb > F	Sum of square	Pb > F	Sum of square	Pb > F	Sum of square	Pb > F
Model	9	2811.73	< 0.001	82.38	< 0.001	313.59	< 0.0001	2307.93	< 0.001
X_1	1	581.57	< 0.001	23.96	< 0.001	57.46	< 0.0001	324.33	< 0.001
X_2	1	174.31	< 0.001	0.29	0.017	1.51	< 0.0001	156.42	< 0.001
X_3	1	1302.54	< 0.001	6.43	< 0.001	1.71	0.3686	704.09	< 0.001
X_1^2	1	11.56	< 0.001	21.29	< 0.001	90.52	< 0.0001	35.25	< 0.001
X_2^2	1	4.2	< 0.001	2.65	0.0013	8.94	0.056	20.96	< 0.001
X_3^2	-	121.81	< 0.001	0.5	0.001	12.27	0.0301	164.34	< 0.001
X_1X_2	1	210.42	< 0.001	0.0066	0.829	44.42	0.0007	88.45	< 0.001
X_1X_3	1	25.67	< 0.001	19.07	< 0.0001	83.79	< 0.0001	141.62	< 0.001
X_2X_3	1	120.66	< 0.001	9.18	< 0.0001	33.5	0.0019	138.61	< 0.001
Residual	10	0.13	-	1.36	-	19.24	-	3.19	-
Lack of fit	5	0.011	0.991	1.27	0.47	19.13	0.1	1.17	0.718
Pure error	5	0.12	-	0.083	-	0.11	-	2.02	-
Cor total	19	2811.87	-	83.73	-	332.83	-	2311.12	-

Similarly, the relationship between osmotic solution concentration and immersion time demonstrated similar trends in SG percentage (Figure 3). Both temperature and osmotic solution concentration showed an ascending effect on SG, as observed in previous studies [8, 20, 21].

The equation describing the effects of immersion time, osmotic solution temperature, and concentration on SG is as follows:

$$SG = +7.06 + 1.55X_1 + 0.17X_2 + 0.80X_3 - 2.78X_1^2 + 0.98X_2^2 + 0.43X_3^2 - 0.029X_1X_2 - 1.59X_1X_3 - 1.07X_2X_3$$

The effects of the selected variables on the ratio of WL to SG

Regarding the analysis of the obtained results, it has been detected that the interactive effects between immersion time with osmotic solution concentration has the most significant effect on the WL to SG proportion followed by interactive effect between immersion time with osmotic solution concentration on the same response. The correlation between osmotic solution concentrations with solution temperature demonstrated that the ratio of WL to SG decreased at the beginning of dehydration process then increased after a while. Furthermore, the obtained results revealed that enhancements in temperature and concentration of osmotic solution showed significant effect on the ratio of WL to SG. The equation demonstrating the effects of immersion time, temperature and osmotic solution concentration on WL to SG proportion as a response has been shown at the following:

$$WL/SG = +8.15 - 2.40X_1 - 0.39X_2 - 0.41X_3 - 5.74X_1^2 - 1.80X_2^2 - 2.11X_3^2 + 2.36X_1X_2 + 3.24X_1X_3 + 2.05X_2X_3$$

The effects of different variables on weight loss of sample after dehydration process

The regression analysis of osmotic dehydration of cantaloupe fruit revealed significant linear and quadratic effects of the selected independent variables on weight loss of the samples ($p < 0.05$). Figure 4 illustrating the impact of osmotic solution temperature and immersion time on WL of the samples indicate that higher temperatures and longer immersion times result in increased weight loss compared to the initial product. This phenomenon can be attributed to the reduced viscosity of the osmotic solution at higher temperatures, which enhances mass transfer processes [8].

Similarly, alterations in osmotic solution concentration showed comparable effects to those observed with immersion time. Both temperature and concentration of the osmotic solution demonstrated an increasing effect on weight loss of the samples, as depicted in figure 4. These findings are consistent with previous studies [8].

The equation describing the effects of immersion time, solution temperature, and concentration on weight loss of the samples is as follows:

$$WR = 56.16 + 5.69X_1 + 3.96X_2 + 8.39X_3 - 3.58X_1^2 - 2.76X_2^2 - 7.73X_3^2 + 3.33X_1X_2 + 4.21X_1X_3 - 4.16X_2X_3$$

The optimization of osmotic dehydration of cantaloupe fruit

The goal of this study was to minimize SG and moisture content while maximizing WL percentage and the ratio of WL to SG. The optimized conditions determined were an immersion time of 60 min, osmotic solution temperature of 40 °C, and osmotic solution concentration of 54.49 °Brix.

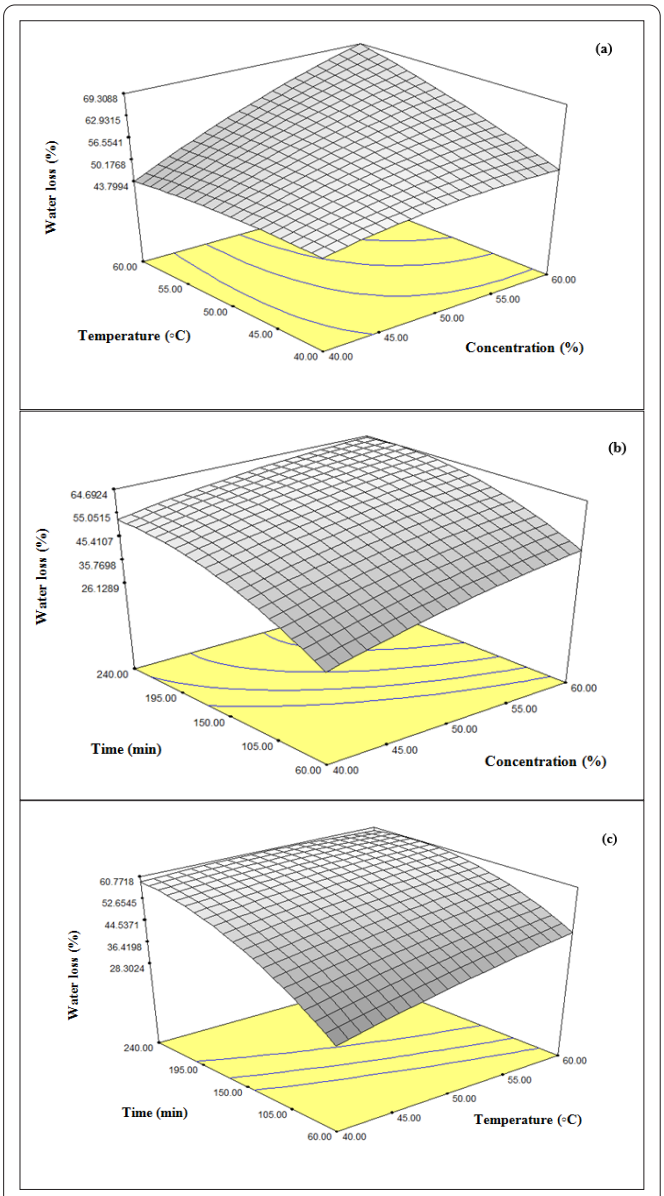

Figure 1: Three-dimensional charts: the impact of **(a)** concentration and temperature, **(b)** the concentration and time, and **(c)** reducing the water temperature and time on the percentage of cantaloupe.

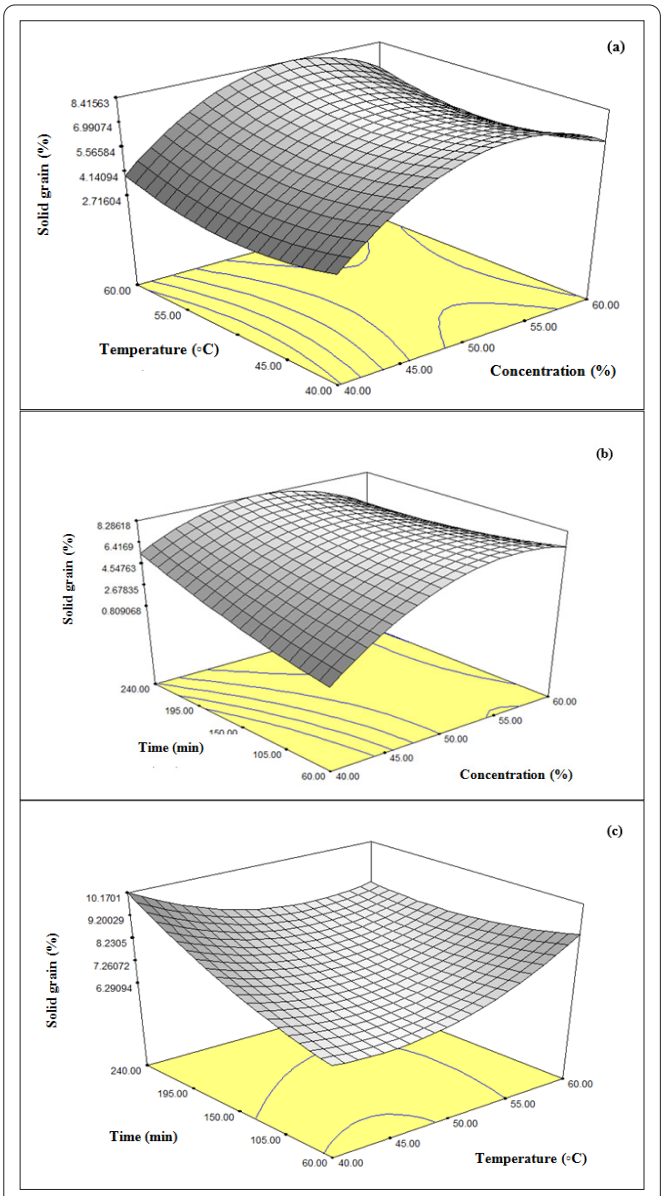

Figure 2: Three-dimensional charts: the impact of **(a)** concentration and temperature, **(b)** the concentration and time, and **(c)** the time and temperature on the percentage of SG of cantaloupe.

The optimized responses obtained in the study were as follows: SG of 7.26%, WL of 29.82%, ratio of WL to SG of 4.66, and weight loss of 31.38%. The achieved desirability for the studied independent variables and responses was 0.729 (Figure 5).

Modelling by ANN

In this study, alongside optimizing the influential parameters in osmotic dehydration using response surface methodology, ANN was employed to predict responses such as SG, WL, the ratio of WL to SG, and weight loss of the sample. The ANN architecture was composed of multiple layers and neurons, designed as a perceptron neural network.

Various configurations of neural networks were tested, including architectures with one and two hidden layers and 2 - 10 nodes per layer, chosen randomly to assess the model's reliability and accuracy in predicting the osmotic dehydration process of Iranian cantaloupe. For the feedforward propagation neural network, activation functions such as hyperbolic tangent and sigmoid were deemed suitable for connections from the input layer to the first hidden layer, and from the first hidden layer to the second.

A linear activation function was found appropriate for the output layer. Additionally, the Lambert-Marquardt learning algorithm, with a learning cycle of 1000 iterations, was utilized. Evaluation metrics including R2 and MSE were employed to gauge the accuracy of the selected networks.

The dataset was split into 60% for training, 15% for validation, and the remaining 25% for testing the chosen ANN models. The results obtained from the neural network showed that a configuration with a hidden layer comprising 5 nodes (structured as 3-5-4) provided the most reliable predictions for the responses (Table 3). This particular network achieved a

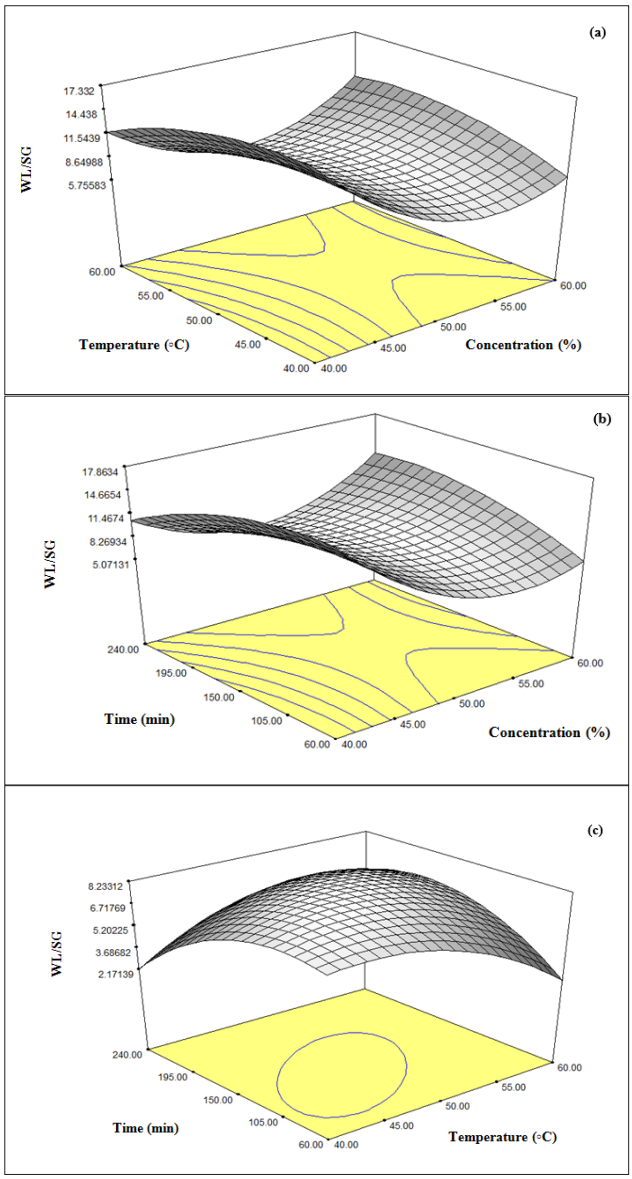

Figure 3: Three-dimensional graphs of the effect **(a)** concentration and temperature, **(b)** concentration and process time, and **(c)** temperature and process time on the WL/SG.

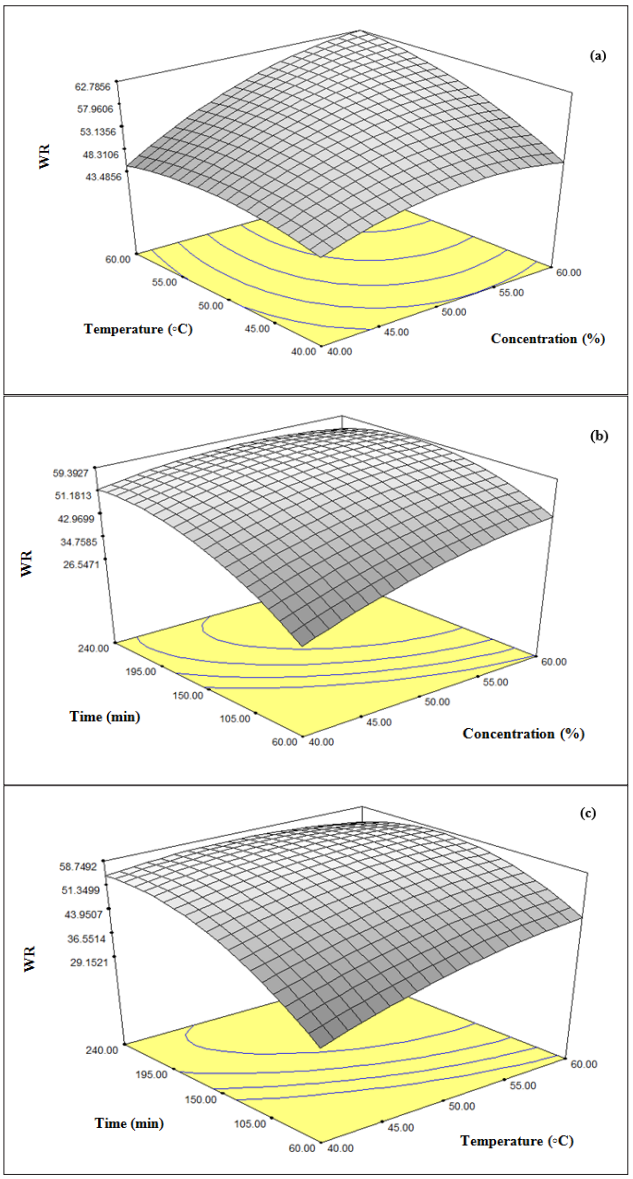

Figure 4: Three-dimensional graphs of the effect **(a)** concentration and temperature, **(b)** concentration and process time, and **(c)** temperature and process time on the WR.

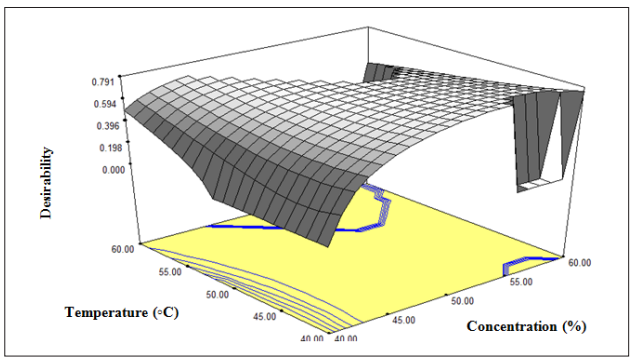

Figure 5: The optimum conditions for variables and answers during the process of osmotic dehydration cantaloupe.

high R2 of 0.999 and a low MSE of 0.000039, indicating its superior performance compared to other configurations tested.

Conclusion

The independent variables selected for the dehydration process-immersion time, osmotic solution temperature, and solution concentration-were optimized. The results demonstrated that the optimal conditions were achieved with an immersion time of 85.71 minutes, solution concentration of 40 °Brix, and solution temperature of 60 °C. Under these optimized conditions, the following responses were obtained: 3.79% for SG, 43.74% for WL, 14.48 for the ratio of WL to SG, and 47.71% for sample weight loss. The achieved desirability value for the optimized independent variables and responses was reported as 0.729.

Additionally, the results from the ANN indicated that a network with a hidden layer containing 5 nodes (structured as 3-5-4) provided the most reliable predictions for the studied responses.

Table 3: The results of comparison of suggested ANN in prediction of osmosis characteristics of cantaloupe.

The number of neurons in hidden layers		R^2	MSE
First	Second		
2	-	0.95391	0.00063
3	-	0.94833	0.00017
4	-	0.99891	0.00079
5	-	0.99983	0.000039
6	-	0.99933	0.00052
7	-	0.99933	0.00083
8	-	0.99578	0.00086
9	-	0.99949	0.00052
10	-	0.99378	0.00087
2	2	0.99408	0.00085
3	3	0.9951	0.0004
4	4	0.9934	0.001
5	5	0.9942	0.00038
6	6	0.99186	0.001
7	7	0.99349	0.00011
8	8	0.9944	0.00087
9	9	0.9652	0.0417
10	10	0.99406	0.000712

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Conflict of Interest

None.

References

1. Kar A, Gupta DK. 2001. Osmotic dehydration characteristics of button mushrooms. *J Food Sci Technol* 38(4): 352-357.
2. Seiiedlou S, Ghasemzadeh HR, Hamdami N, Talati F, Moghaddam M. 2010. Convective drying of apple: mathematical modeling and determination of some quality parameters. *Int J Food Sci Technol* 12(2): 171-178.
3. Jabrayili S, Farzaneh V, Zare Z, Bakhshabadi H, Babazadeh Z, et al. 2016. Modelling of mass transfer kinetics in osmotic dehydration of kiwifruit. *Int Agrophys* 30(2): 185-191. https://doi.org/10.1515/intag-2015-0091
4. Boualem A, Troadec C, Kovalski I, Sari MA, Perl-Treves R, et al. 2009. A conserved ethylene biosynthesis enzyme leads to andromonoecy in two *Cucumis* species. *PLoS One* 4(7): e6144. https://doi.org/10.1371/journal.pone.0006144
5. Park OH. 2004. Quality and customer acceptability of frozen cantaloupe. Texas Tech University.
6. Zadhossein S, Abbaspour-Gilandeh Y, Kaveh M, Nadimi M, Paliwal J. 2023. Comparison of the energy and exergy parameters in cantaloupe (*Cucurbita maxima*) drying using hot air. *Smart Agric Technol* 4: 100198. https://doi.org/10.1016/j.atech.2023.100198
7. Chang A, Zheng X, Xiao H, Yao X, Liu D, et al. 2022. Short- and medium-wave infrared drying of cantaloupe (*Cucumis melon* L.) slices: drying kinetics and process parameter optimization. *Processes* 10(1): 114. https://doi.org/10.3390/pr10010114
8. Lazarides HN, Mavroudis N. 1996. Kinetics of osmotic dehydration of a highly shrinking vegetable tissue in a salt-free medium. *J Food Eng* 30(1-2): 61-74. https://doi.org/10.1016/S0260-8774(96)00042-8
9. Eroglu E, Yildiz HJ. 2010. Recent developments in osmotic dehydration. *Akademik Gıda* 8(6): 24-28.
10. Jayaraman KS, Gupta DKD, Rao BN. 1990. Effect of pretreatment with salt and sucrose on the quality and stability of dehydrated cauliflower. *J Food Sci Technol* 25(1): 47-60. https://doi.org/10.1111/J.1365-2621.1990.TB01058.X
11. Lertworasirikul S, Saetan S. 2010. Artificial neural network modeling of mass transfer during osmotic dehydration of kaffir lime peel. *J Food Eng* 98(2): 214-223. https://doi.org/10.1016/j.jfoodeng.2009.12.030
12. Ochoa-Martínez C, Ayala-Aponte A. 2007. Prediction of mass transfer kinetics during osmotic dehydration of apples using neural networks. *Lebensm Wiss Technol* 40(4): 638-645. https://doi.org/10.1016/j.lwt.2006.03.013
13. Ortuño C, Pérez-Munuera I, Puig A, Riera E, Garcia-Perez JV. 2010. Influence of power ultrasound application on mass transport and microstructure of orange peel during hot air drying. *Physics Procedia* 3(1): 153-159. https://doi.org/10.1016/j.phpro.2010.01.022
14. Mandala I, Anagnostaras E, Oikonomou C. 2005. Influence of osmotic dehydration conditions on apple air-drying kinetics and their quality characteristics. *J Food Eng* 69(3): 307-316. https://doi.org/10.1016/j.jfoodeng.2004.08.021
15. El-Habil B, Abu-Naser SS. 2021. Cantaloupe classifications using deep learning. *Int J Acad Eng Res* 5(12): 7-17.
16. Ghasemi-Varnamkhasti M, Ghanbarian D, Shojaei Z, Yadollahi A, Razdari AM, et al. 2017. Application of artificial neural network for estimating the qualitative characteristics of cantaloupe melon and comparison with the regression model. *Res J Food Sci Nutr* 2(1): 1-8. https://doi.org/10.31248/RJFSN2017.023
17. Association of Official Analytical Chemists. 1990. Official Method of Analysis. Arlington, Inc.
18. Poonnoy P, Tansakul A, Chinnan M. 2007. Artificial neural network modeling for temperature and moisture content prediction in tomato slices undergoing microwave-vacuum drying. *J Food Sci* 72(1): E042-E047. https://doi.org/10.1111/j.1750-3841.2006.00220.x
19. Islam M, Flink JM. 1982. Dehydration of potato: II. Osmotic concentration and its effect on air drying behaviour. *Int J Food Sci Technol* 17(3): 387-403.
20. Chenlo F, Moreira R, Fernández-Herrero C, Vázquez G. 2006. Experimental results and modeling of the osmotic dehydration kinetics of chestnut with glucose solutions. *J Food Process Eng* 74(3): 324-334. https://doi.org/10.1016/j.jfoodeng.2005.03.002
21. Torreggiani D, Forni E, Maestrelli A, Quadri F. 1999. Influence of osmotic dehydration on texture and pectic composition of kiwifruit slices. *J Sci Food Agric* 17(7-8): 1387-1397. https://doi.org/10.1080/07373939908917622