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Osmotic dehydration kinetics of banana slices with peel

Juliana Gomes Brito[1]*, Josivanda Palmeira Gomes[1],
Wilton Pereira da Silva[1], Cleide Maria Diniz Pereira da Silva e Silva[1],
Kalina Ligia Cavalcante Almeida Farias Aires[2], Juarez Everton Farias Aires[2]

[1]Federal University of Campina Grande, Campina Grande, Brazil
[2]Federal Institute of Paraiba, João Pessoa, Brazil
*Corresponding author, e-mail:juligbrito@hotmail.com

Abstract

The kinetics of dehydration and a process commonly used without processing fruit in concentrated sucrose solutions under different temperatures. The present work aimed to study the osmotic dehydration kinetics of Pacovan banana slices with bark, 5 mm thick, submitted to temperatures of 40 and 70 ° C, with sucrose solution at concentrations of 40, 50 and 60 ° Brix. Accompanied in 4 hours and as equilibrium conditions, the 24 hours of immersion were used. The loss of water and sucrose gas during the osmotic dehydration of the Lewis, Henderson and Pabis, Page, Peleg and Silva *et alii* models, through the LAB Fit program, to describe the process and the best statistical indicators with effects obtained Peleg models and Silva *et alii*, to describe the phenomenon of water transfer, already the Page and Peleg models satisfactorily describe the sucrose gain. A graphical inspection of the water amount (and sucrose) induced by an approximately 80% removal of contained water with no available product up to 800 min. An analysis of the response surfaces obtained in 800 min revealed that treatment at 70 ° C and 60 ° Brix was responsible for increased water loss and sucrose gain.

Keywords: *Musa sapientum* Schum., Mass transfer, mathematical models

Introduction

Banana is a tropical fruit widely consumed around the world and is cultivated by most tropical countries, with Brazil being the fifth largest producer in the world, with a production of 7.3 million tons of fruit, only behind India, China, the Philippines, and Ecuador (FAO, 2017). The Northeast region is responsible for approximately 36% of the annual production, with 2.6 million tons (IBGE, 2016).

It is a fruit of high nutritional value and widely consumed in its fresh form. Its pulp is rich in vitamins A, B1, B2, and C, proteins, niacin, folic acid, starch, and sugars. In addition, it has high levels of potassium, calcium, iron, phosphorus, and sodium. However, it has water contents ranging between 58 and 80%, which can contribute to losses due to deterioration in the various stages of the production chain (Fasolin et al., 2007).

The banana peel represents about 40% of the whole ripe fruit and goes typically in the preparation of new products. Thus, its industrialization, together with the pulp, describes a way to minimize losses and contribute to developing products with longer shelf life and added value (Ribeiro & Finzer, 2010).

The use of osmotic dehydration as a pre-treatment for complementary drying reduces water content and activity in the product and favours the inhibition of enzymatic browning. Additionally, osmotic dehydration further contributes to the maintenance and improvement of sensory properties, low retention of sulphites and energy savings in the complementary drying processes (Silva et al., 2015a).

The preservation of the sensory and nutritional properties of the obtained products is attributed to the moderate treatment temperatures and, in a way, to the solute impregnation that minimizes the activity of the compounds responsible for sensory alterations (Mercali et al., 2011).

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Mathematical modelling is an essential tool in optimizing osmotic dehydration processes. Therefore, it regularly appears in the literature regarding the influence of the various factors involved in these processes, such as the temperature and concentration of the dehydrating solution (Silva et al., 2016).

In this context, the objective of this work was to describe the osmotic dehydration kinetics of circular slices of Pacovan bananas with skin, through empirical models, to study the influence of temperature and concentration of the dehydrating medium on mass transfer processes.

Materials and Methods

Bananas Pacovan (*Musa sapientum Schum*.), from the subgroup Prata, from producer cooperatives in the Vale do Sirigi-PE, were purchased in supermarkets in the city of Campina Grande-PB. During acquisition, the fruits were chosen only those with the same seal of origin, absence of damage to the skins and maturation stage corresponding to the C5 phase – yellow fruits with green ends, according to the Von Loesecke scale (1940). Then, washed in running water and sanitized in a sodium hypochlorite solution at 150 $mg.L^{-1}$ for 15 min and once more washed in running water to eliminate hypochlorite excess.

The osmotic treatment used unpeeled fruits with approximately the same average diameter (about 35 mm). The fruits were cut into circular slices 5 mm thick. Initially, fresh fruit samples' water content and dry matter were determined using the standard method in an oven at 105 °C (Fanem 515) (Mercali et al., 2011).

Sucrose solutions, obtained by diluting crystalline sugar cane sugar in distilled water, are used in osmotic dehydration experiments. A ratio of 1:15 immersion on fruits (fruit:solution), according to the experimental conditions expressed in Table 1. Concentrations of 40, 50, and 60 °Brix measured with the aid of a portable digital sugar refractometer (Instrutemp ITREF 95) and pre-heated in an oven (Fanem 515) to 40 and 70 °C.

Table 1. Concentration (C) and temperature (T) of the solution for osmotic dehydration experiments.

Experiment	C (°BriX)	T (°C)
1	40	40
2	40	70
3	50	40
4	50	70
5	60	40
6	60	70

In the monitoring and evaluation of the osmotic dehydration process, the amount of water and amount of sucrose were determined for 24 hours, using 11 samples of circular slices of banana with skin, in triplicate, individualized and identified in screened baskets, in the following immersion times: t0 = 0, t1 = 10, t2 = 30, t3 = 60, t4 = 90, t5 = 120, t6 = 150, t7 = 180, t8 = 210, t9 = 240 and t10 = 1440 minutes.

The samples collected at each immersion time were identified, respectively, with the following captions: n0, n1, n2, n3, n4, n5, n6, n7, n8, n9 and n10. Initially, sample n0 (corresponding to the initial time) was weighed and then taken to an oven at 105 °C to determine its initial dry mass. At the same time, the other samples weighed on a precision scale (Mars AS5500C) were immersed in the sucrose solution until reaching the stipulated immersion times. After each immersion time, the sample referring to that moment was removed from the solution, washed with distilled water and carefully dried with a paper towel. Then, it was weighed and taken to an oven at 105 °C, according to the methodology described by Mercali et al. (2011).

At the end of the process, only sample n10 remained in the solution. Therefore, the determination of this sample's total mass and dry mass and previous times quantification occurred according to the methodology described by Castro et al., 2014) following equations 1 and 2.

Total mass:

$$m_{10}^{t} = m_{10}^{0} \times \frac{m_{x}^{t}}{m_{x}^{0}} \quad (1)$$

In which:

m_{10}^{t} - mass of sample n10 at time t, in g;

m_{10}^{0} – mass of sample n10 at time 0, in g;

m_{x}^{t} sample mass nx at time t, in g;

m_{x}^{0} – massa de n_x no tempo 0, em g.

Dry mass:

$$ms_{10}^{t} = ms_{x}^{t} \times \frac{m_{10}^{t}}{m_{x}^{t}} \quad (2)$$

In which:

ms_{10}^{t} – dry mass of sample n10 at time t, in g;

ms_{x}^{t} – dry mass of sample nx at time t, in g.

To calculate the water mass of sample n10 at each instant of time, the equation (3):

Where:

$$m_w^t = m_{10}^t - ms_{10}^t \qquad (3)$$

Where:

m_w^t – water mass of sample n10 at time t, in g.

Amount of water (W)(%) present in sample n10 at each time point was calculated by the equation (4):

$$V = \frac{m_w^t}{m_w^0} \times 100 \qquad (4)$$

In which:

m_w^0 – mass of water at instant zero, in g.

The sucrose mass of sample n10 was calculated according to the equation at each instant of time (5):

Where:

$$ms_s^t = ms_{10}^t - m_{10}^0 \qquad (5)$$

Where:

ms_s^t - sucrose mass of sample n10 at time t, in g;

ms_{10}^0 - dry mass of sample n10 at time zero, in g.

The equation calculated the amount of sucrose (S) present in sample n10 at each time point. (6):

$$S = \frac{m_s^t}{ms_{10}^0} \times 10 \qquad (6)$$

For the mathematical modelling of the kinetics of water and sucrose, empirical equations were fitted to the experimental results, according to the models presented in **Tables 2** and **3**.

Table 2. Models for describing the amount of water.

Model	Equation: W=	Reference
Lewis	σe^{-at}	Kaleta and Gornicki (2010)
Henderson and Pabis	ae^{-bt}	Diamante et al. (2010)
Wang and Singh	$\sigma + at + bt^2$	Kaleta and Gornicki (2010)
Peleg	$\sigma - t/(a+bt)$	Mercali et al. (2010)
Page	σe^{-at^b}	Diamante et al. (2010)
Silva et alii	$\sigma e^{-at-b\sqrt{t}}$	Silva et al. (2012)

σ - Initial water amount.

Table 3. Models for describing the amount of sucrose, *S*

Model	Equation: S =	Reference
Lewis	$\sigma(1-e^{-at})$	Kaleta and Gornicki (2010)
Henderson and Pabis	$a(1-e^{-bt})$	Diamante et al. (2010)
Wang and Singh	$\sigma(at+bt^2)$	Kaleta and Gornicki (2010)
Peleg	$t/(a+bt)$	Mercali et al. (2010)
Page	$\sigma(1-e^{-at^b})$	Diamante et al. (2010)

Each model to the experimental data adjustment performed by LAB Fit Curve Fitting Software (Silva et al., 2004). The statistical indicators used to measure the quality of the adjustments were the coefficient of determination (R2) and the chi-square (χ2), calculated by equation (7):

$$\chi^2 = \sqrt[2]{\sum \left(X^*_{exp} - X^*_{pre}\right)^2} \qquad (7)$$

In which:

χ^2 = chi square

X^*_{pre} = amount of water or sucrose found through the model.

X^*_{exp} = experimental value of the amount of water or sucrose.

Results and Discussion

Amount of water

Table 4 presents the three best results obtained from the adjustments of the models shown in Table 2 to the experimental data of the water amount in the circular slices of banana with skin for the experimental conditions of this work. Furthermore, analyzing the statistical indicators corresponding to the mathematical models is verified. In general, the Peleg model obtained the highest coefficients of determination (R2) and the lowest values for the chi-squares (χ2).

The kinetics of the percentage amount of water in the circular slices of unpeeled bananas, obtained using the Peleg model, demonstrated in **Figure 1**.

Atars et al. (2011) also obtained a better coefficient of determination for the Peleg model, in banana slices dehydrated at 30, 40 and 50 °C and concentrations of sucrose solutions with 45, 55 and 65 °Brix. On the other hand, the Figure 1 curves in this study demonstrate that higher temperatures and concentrations had a more significant influence on water loss. Such behaviour can be explained by the osmotic solution viscosity decrease and the increase in the effective mass diffusivity.

Table 4. Coefficients obtained in the adjustment of the models of Peleg, Page and Silva et al. to the experimental data of the amount of water, (W)Peleg

			Parameters			
Exp	C (°Brix)	T(°C)	a	b	R^2	χ^2
1	40	40	$2.49x10^{0}$	$3.04x10^{-2}$	0.9644	32.7111
2	40	70	$8.93x10^{-1}$	$1.30x10^{-2}$	0.9909	46.9280
3	50	40	$1.79x10^{0}$	$1.20x10^{-2}$	0.9665	177.647
4	50	70	$6.08x10^{-1}$	$1.16x10^{-2}$	0.9860	92.7442
5	60	40	$1.63x10^{0}$	$1.22x10^{-2}$	0.9518	236.100
6	60	70	$3.63x10^{-1}$	$1.17x10^{-2}$	0.9826	120.096

Page

			Parameters			
Exp	C (°Brix)	T(°C)	A	b	R^2	χ^2
1	40	40	$4.99x10^{-2}$	$2.92x10^{-1}$	0.8556	133.745
2	40	70	$7.93x10^{-2}$	$4.30x10^{-1}$	0.9426	292.823
3	50	40	$4.15X10^{-2}$	$5.01x10^{-1}$	0.9580	179.647
4	50	70	$7.11x10^{-2}$	$5.19x10^{-1}$	0.9579	300.451
5	60	40	$5.03x10^{-2}$	$4.73x10^{-1}$	0.9739	112.899
6	60	70	$1.35x10^{-1}$	$4.28x10^{-1}$	0.9828	116.623

Silva et alii

			Parameters			
Exp	C (°Brix)	T(°C)	A	b	R^2	χ^2
1	40	40	$-3.84x10^{-4}$	$2.39x10^{-2}$	0.9619	42.7131
2	40	70	$-8.36x10^{-4}$	$6.81x10^{-2}$	0.9752	152.404
3	50	40	$-9.99x10^{-5}$	$4.33x10^{-2}$	0.9608	175.954
4	50	70	$-1.08x10^{-3}$	$9.07x10^{-2}$	0.9705	227.213
5	60	40	$-1.44x10^{-4}$	$4.59x10^{-2}$	0.9743	111.314
6	60	70	$-1.57x10^{-3}$	$1.15x10^{-1}$	0.9940	40.4154

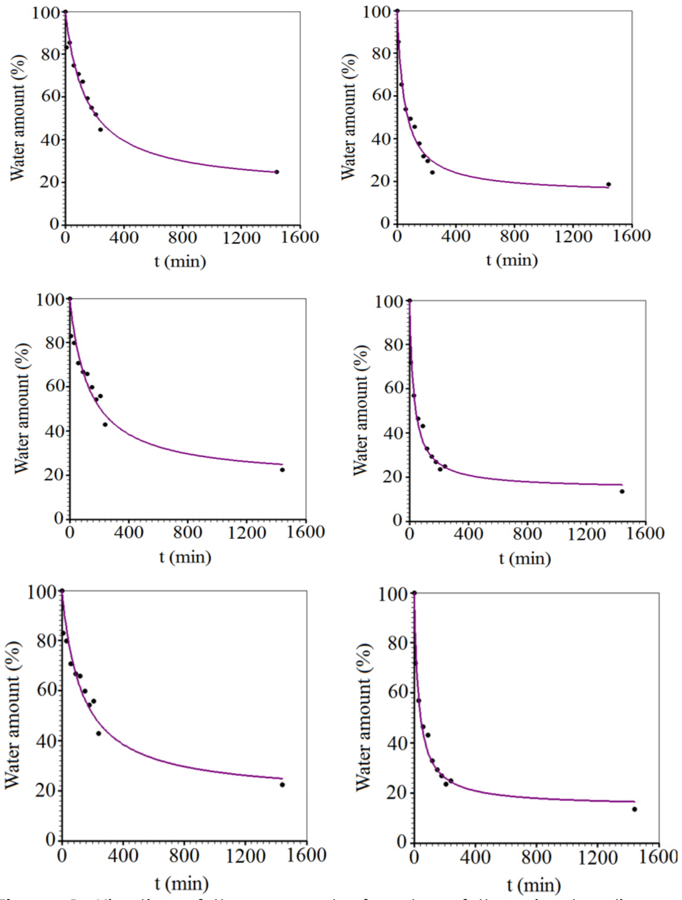

Figure 1. Kinetics of the amount of water of the circular slices of banana with skin described by the Peleg model for (a) 40 °Brix and 40 °C; (b) 40°Brix and 70°C; (c) 50°Brix and 40°C; (d) 50°Brix and 70°C; (e) 60°Brix and 40°C; (f) 60°Brix and 70°C.

Kowalska et al. (2017) also obtained good fits to the Peleg model, of all experimental conditions tested in whole commercial ripening stage strawberries, submitted to the osmotic dehydration process in sucrose solutions with 93% of inulin and using aqueous sucrose solutions at 50 °Brix and a temperature of 50 °C, with or without the addition of chokeberry juice concentrate.

In this work, the temperature and thickness factors significantly influence the samples' water loss processes, whether in osmotic dehydration or during drying. Similar behaviour was observed by Silva-Filho et al. (2016) when studying the conventional drying of Haden mango pulp subjected to drying at different temperatures, noting that the higher temperatures influenced the reduction of drying time.

Although osmotic dehydration is a time-consuming process, according to Figure 1, the most significant water losses occurred in the initial periods in the present work. In the first 240 minutes of osmotic treatments, about 50% of the water loss was achieved during the entire process. In this sense, it appears that a greater driving force, noticeable in the initial moments, was responsible for the significant loss of water in the first hours of the osmotic dehydration process.

The increase in mass transfer at the beginning of the osmotic dehydration process corroborates the results obtained by Jiménez-Hernandéz et al. (2016) when studying the osmotic dehydration process of mango slices immersed in sucrose and inulin solution, in which the mass transfer occurred more intensely at 120 minutes of the process. This effect increases during temperature increase and water loss, which may be due to the turbidity growth of the cells related to the plasticizing effect and the solution temperature rise, contributing to the diffusivity incrementation. The dehydration process also influences the increase in solids gains due to changes in cell membrane permeability.

The increase in temperature during the osmotic dehydration process increases efficiency due to cell membrane enhanced permeability and the reduction in solution viscosity, which cause a decrease in mass transfer resistance, resulting in increased water loss and solids gain, since there is a more significant amount of sugar that flows from the solution to the samples (Prosapio & Norton, 2017).

Notably, with the course of the osmotic dehydration process, the driving force tends to decrease, causing a consequent decrease in the water removal rate for all the experiments described in Figure 1. After an 800 minutes processing time, the percentage amount of water reaches a value close to equilibrium for all experimental conditions.

Since the main objective of osmotic dehydration is removing water, 800 minutes seemed enough time for circular banana slices with a 5 mm thick skin. Thus, using the results in Table 4, it is possible to present an overlap of the water removal kinetics predicted by the Peleg model, through **Figure 2**, facilitating a comparison of the various water quantity kinetics presented individually in Figure 1.

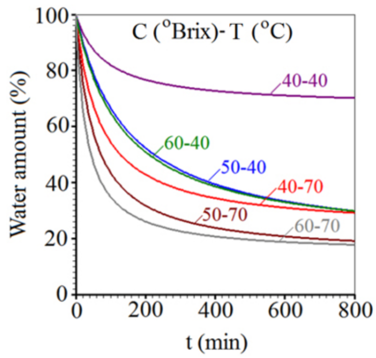

Figure 2. Superposition of the kinetics of the percentage amount of water of the circular slices of banana with peel predicted by the Peleg model up to 800 min.

An inspection of Figure 2 makes it possible to observe that both the process temperatures and the sucrose concentrations of the solution influenced the amount of water at the end of 800 minutes, as warned by Germer et al. (2011). These authors observed that the increase in temperature in the osmotic dehydration process leads to more significant water loss and greater impregnation of soluble solids in the cell membrane of plant tissues. However, this behaviour may be different in different types of plant tissue.

Table 4 also makes it possible to predict, using the Peleg model given in Table 2, the percentage amount of water at 800 minutes of immersion for each experimental condition, which results in **Table 5**.

Table 5. The percentage amount of water in the circular slices of unpeeled banana after 800 min of osmotic treatment.

C (°Brix)	T (°C)	Water amount (%)
40	40	70.2
40	70	29.2
50	40	29.8
50	70	19.1
60	40	29.8
60	70	17.7

The LAB Fit Curve Fitting Software was used to determine a function that describes Table 5. This software has an option called "Finder", which automatically performs non-linear regressions of all the functions in your library to a given set of data. The program ranks the best functions using the smallest reduced chi-square criterion and presents the results obtained to the user. For the data in Table 5, function number 342 in the software library was determined, with only three adjustment parameters. Hence, the amount of water (W) as a function of the concentration (C) and temperature (T) of the solution can be given by the following expression:

$$W = \frac{1}{6.30\times10^{-2} + 6.72\times10^{-4}T - 3.02/C} \qquad (8)$$

with $R^2 = 0.9787$ e $\chi2 = 39.77$.

Through equation (8), it is observed that, after 800 min, for solution C of 40 °Brix concentration, the percentage amount of water W varies from about 70% to 29%, when the temperature T varies from 40 to 70 °C. For 60°Brix, W varies from 25% (40°C) to 17% (70°C). These results are in good agreement with Table 5, as expected.

Figure 3 presents a graphic to visualize the surface representing equation (8) and the data in Table 5.

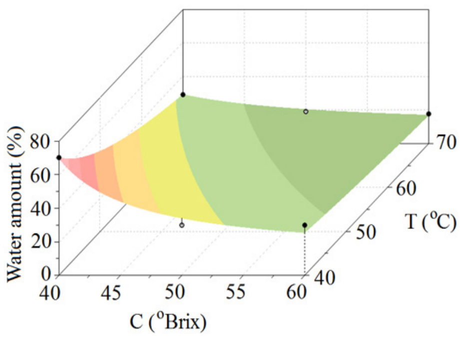

Figure 3. Amount of water in the circular slices of unpeeled banana after 800 min of the process as a function of concentration C and temperature T of osmotic dehydration.

Figure 3 demonstrates that the most significant water loss corresponds to the highest temperature (70 °C) and solution concentration (60 °Brix), as observed in Table 5. Figure 3 table shows that the worst experimental condition, from the point of view of water removal, refers to the temperature of 40 °C and the solution concentration of 40 °Brix. Castro et al. (2017) also evaluated that the most evidenced water losses from guava slices occurred at the highest sucrose concentration (60 °C) and a temperature of 50 °C. However, the increase in temperature is also an essential factor for the increase in water loss. According to Ahmed et al. (2016), the increase in process temperature accelerates water loss while the absorption of solids is lower, with faster water loss occurring with the increase in solution temperature.

Sucrose amount

Table 6 presents the three best results obtained by fitting the models shown in table 3 to the experimental data of the amount of sucrose for the various experimental conditions set out in this work.

The values observed for the coefficient of determination (R2) and the chi-squares (χ2), shown in Table 6, reveal that the three models presented good statistical indicators for representing the kinetics of the amount of sucrose the circular slices of bananas with skin. Furthermore, Tappi et al. (2017) also obtained good results from the Peleg model with the experimental data of the osmotic dehydration kinetics of apples, showing a good fit with the experimental data and high R^2.

Based on results. It was decided to present the results obtained by the Peleg model, already used to represent the kinetics of water. Thus, using the Peleg model, we obtained **Figure 4**.

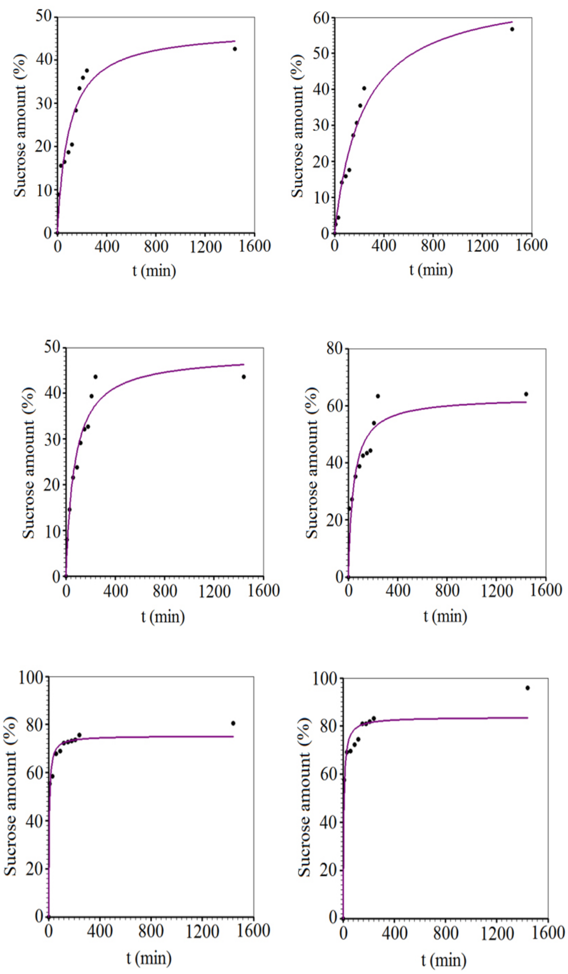

Figure 4. Kinetics of the amount of sucrose in the circular slices of banana with skin described by the Peleg model for (a) 40 °Brix and 40 °C; (b) 40°Brix and 70°C; (c) 50°Brix and 40°C; (d) 50°Brix and 70°C; (e) 60°Brix and 40°C; (f) 60°Brix and 70°C.

Table 6. Coefficients obtained in the adjustments of the models of Peleg, Page and Silva et al. to the experimental data of the amount of sucrose, S.

Peleg

			Parameters			
Exp	C (°Brix)	T (°C)	A	b	R^2	χ^2
1	40	40	$2.01x10^0$	$2.11x10^{-2}$	0.9295	129.453
2	40	70	$3.40x10^0$	$1.47x10^{-2}$	0.9699	99.7926
3	50	40	$1.47x10^0$	$2.06x10^{-2}$	0.9625	77.1562
4	50	70	$6.94x10^{-1}$	$1.58x10^{-2}$	0.9019	362.401
5	60	40	$6.39x10^{-2}$	$1.33x10^{-2}$	0.9792	103.273
6	60	70	$7.03x10^{-2}$	$1.19x10^{-2}$	0.9527	298.840

Page

			Parameters			
Exp	C (°Brix)	T (°C)	A	b	R^2	χ^2
1	40	40	$5.97x10^{-2}$	$3.29x10^{-1}$	0.8726	224.449
2	40	70	$1.97x10^{-2}$	$5.37x10^{-1}$	0.9127	281.124
3	50	40	$7.57x10^{-2}$	$3.10x10^{-1}$	0.8642	280.281
4	50	70	$1.34x10^{-1}$	$3.01x10^{-1}$	0.9215	266.970
5	60	40	$5.63x10^{-1}$	$1.61x10^{-1}$	0.9933	33.3114
6	60	70	$4.88x10^{-1}$	$2.34x10^{-1}$	0.9927	46.2820

Silva et alii

			Parameters			
Exp	C (°Brix)	T(°C)	A	b	R^2	χ^2
1	40	40	$-4.67x10^{-4}$	$3.28x10^{-2}$	0.9295	129.203
2	40	70	$-1.12x10^{-5}$	$2.43x10^{-2}$	0.9163	290.533
3	50	40	$-6.29x10^{-4}$	$3.95x10^{-2}$	0.9591	99.8627
4	50	70	$-9.91x10^{-4}$	$6.49x10^{-2}$	0.9424	198.181
5	60	40	$-3.12x10^{-3}$	$1.58x10^{-1}$	0.9237	505.092
6	60	70	$-3.20x10^{-3}$	$1.86x10^{-1}$	0.9396	463.099

For the two highest concentrations, especially for the highest process temperature, an observation in Figure 4 indicates that the time to reach equilibrium in the amount of sucrose could even be less than 800 minutes. However, as the main objective of this work was the removal of water, **Figure 5** shows the superposition of the kinetics of the amount of sucrose up to 800 min, using the Peleg model.

Notably, Figure 5 facilitates the comparison of the various kinetics of the percentage amount of sucrose presented individually in Figure 4.

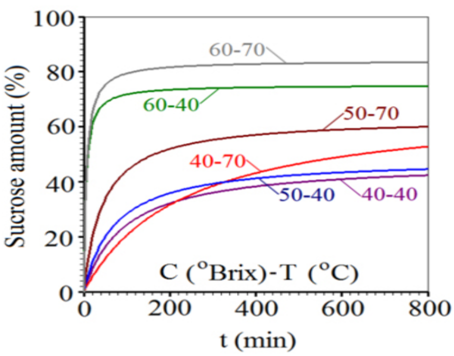

Figure 5. Superposition of the kinetics of the percentage amount of sucrose of the circular slices of banana with skin predicted by the Peleg model up to 800 min

Using the results for the parameters obtained in Table 6 for the Peleg model, given in Table 3, the amounts of sucrose at the end of 800 min were obtained, given in **Table 7**.

Table 7 The percentage amount of sucrose in the circular slices of unpeeled banana after 800 min of osmotic treatment.

C (°Brix)	T (°C)	Sucrose amount (%)
40	40	42.4
40	70	52.8
50	40	44.6
50	70	60.0
60	40	74.7
60	70	83.4

Using the “Finder” function of the LAB Fit again to describe the data in Table 7, we obtained equation (9), which gives the percentage amount of sucrose (S) as a function of concentration (C) and temperature (T) of the solution.

$$S=\frac{113+T}{4.99-7.88\times10^{-4}C^2} \quad (9)$$

with R^2 = 0.9497 e $\chi2$ = 68.67.

The graphical representation of Equation (9) is given in **Figure 6**.

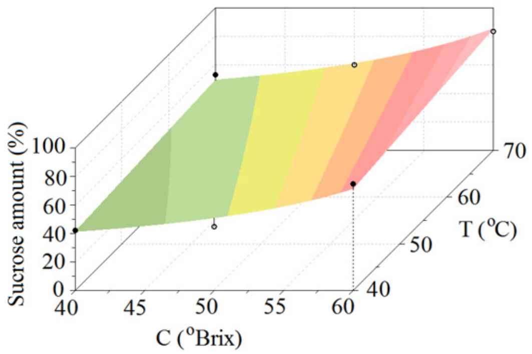

Figure 6. Amount of sucrose in circular slices of unpeeled banana after 800 min of the process as a function of concentration C and temperature T of osmotic dehydration.

Through the observation of Table 7 or Figure 6, it can be seen that the percentage amount of sucrose that penetrates the circular slices of unpeeled banana increases with the increasing concentration and temperature of the desiccant solution.

Similar results were obtained by Souza et al. (2012) when studying the osmotic dehydration of avocado, also corroborated the results achieved in obtaining cagaita raisins, dehydrated in sucrose solutions at 65 and 70 °Brix and temperatures of 50 and 70 °C (Silva et al., 2015b).

Despite slight variations in their values, it is clear that the gain in solids was significant at the end of the process. The solids gain during the osmotic dehydration process is subject to variations in its values over time, which correspond to the mass variations involving the loss of water and the gain of sucrose. This variation can change with each chemical and species involved in possible osmotic dehydration treatments until equilibrium is reached (Germer et al., 2011).

Several scientific works report sucrose as an efficient osmotic agent, confirmed by the results obtained by Barman & Badwaik (2016). When comparing the efficiency of sucrose solutions concerning glucose, fructose and glycerol, all in the concentrations from 50 to 70 °Brix, temperatures from 40 to 60 °C, for 180 min, of slices of carambola cut to 5 mm thick submerged in solutions in a proportion of 1:10.

The sucrose solution can remove up to 84% of the initial water from the fruits, which justifies the results of the present study. However, traditional banana drying processes generally lead to enzymatic browning of the fruit. Based on this, Maeda & Loreto (1998) used the resource of osmotic dehydration in peeled bananas and verified the effect of temperature (60, 65, 70 and 75 °C) and the sucrose solution concentration (60 and 70 °Brix) on the loss of water and sucrose gain in fruits, obtaining results similar to those of the present work.

The conditions of the dehydration process are preponderant factors for obtaining significant values in solids gain. Researches performed with osmotic dehydration of orange and melon, the concentration of the sucrose solution was the factor that most influenced the solids gain and the loss of water due to the increase in the rate caused by the osmotic pressure outside the fruit. However, this factor is closely related to the temperature factor involved in the process (Mendes et al., 2013).

As verified in the present research, one of the advantages of osmotic dehydration is the final appearance presented by bananas. Furthermore, bananas did not undergo enzymatic browning under the conditions studied, even without having been previously subjected to antioxidant treatments.

Conclusion

The results obtained allow us to conclude that the percentage amount of water over time was better described by Peleg and Silva et al. ii, while the models of Page and Peleg adequately described the number of solids. Thus, the Peleg model was chosen as the most adequate in this work, as it satisfactorily describes the two mass transfer processes. In the initial moments of the process, there was a more significant water loss and sucrose gain (first 240 minutes). In general, 800 minutes were enough for the mass transfer processes to practically reach equilibrium values, especially for samples submitted to the highest concentrations and highest temperature of the desiccant solution.

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