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Fruit of Mandacaru: Kinetics of Drying and Physical-Chemical Characterization

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Abstract

The drying of the mandacaru fruit consists in an alternative way to reduce loss during its harvest and therefore minimizes its waste. The objective of this study was to physicochemically characterize the mandacaru fruit both fresh and dehydrated in an air circulation oven using three drying temperatures (40, 50 and 60 ºC), related to the water content, water activity, pH, acidity and phenolic compounds. Three empirical mathematical models were used to describe the drying (Henderson and Pabis, Midilli and Page). The Midilli's model had the best statistical indicators, fitting better to the experimental data. The fresh fruit showed water content of 82.75%, water activity of 0.986, titratable acidity of 0.18%, pH of 4.35 and phenolic compounds of 28.35 mg.100^{-1}g. The parameters luminosity (L), intensity of red (+a), yellow intensity (+b), hue angle (hº) and chromaticity (C*) were respectively equal to 59.84±0.08; 5.72±0.06; 89.25±0.08; 5.72±0.06. The physicochemical compounds of the fruit were influenced by the drying, in which water content was 10.83, 8.31 and 7.56%, and the water activity was 3.99. 3.24 and 2.40 for the temperatures of 40, 50 and 60 ºC, respectively. The highest temperature caused a greater removal of water in the product along the drying. The dried mandacaru pulp showed titratable acidity of 0.41, 4.86 and 4.98%, pH of 4.76, 4.86 and 4.98 and phenolic compounds of 252.26, 156.53 and 196.10 mg.100^{-1}g, and the parameters L (19.72, 23.41 and 26.15), a* (3.13, 1.31 and 1.30), b* (7.31, 6.53 and 9.14), H* (66.79, 78.69 and 81.92) and C* (7.95, 6.95 and 9.23) at the temperatures of 40, 50 and 60 ºC, respectively. The results of the characterization suggest the technological exploitation of the dried mandacaru fruit to add nutritional value to other foods or in the development of new products.

Keywords: cactaceae, *Cereus jamacaru*, mathematical models

1. Introduction

The mandacaru (*Cereus jamacaru* P.) is a native species of the Caatinga vegetation (dry shrubland from Brazil) which belongs to the Cactaceae family. Its growth is in stony soils and along with another cactus species it molds the typical landscape from the semi-arid region in the Northeast (Silva & Alves, 2009). Mandacaru can reach up to 10 meters in height and has a woody trunk that can reach 60 cm in diameter, with many upright stems, forming a compact top. In the dry season, the stem is cut and the spines burned to be used as feed for cattle due to the capacity to store large amounts of water (Zara et al., 2012).

According to Almeida et al. (2011), the mandacaru fruit is an oval berry, approximately 12 cm long, red, fleshy and its pulp is white with numerous tiny black seeds. The size of the mandacaru fruit varies from 10-13 × 5-9 cm, being oval, juicy, with smooth pinkish to red epicarps. It has funicular pulp, both mucilaginous and white, with black seeds ranging from 1.5 to 2.5 mm in length.

Mandacaru is an exotic fruit and, unlike cactus pear, is not commercially exploited, so there are large losses of these fruits. Thus, it is necessary to look for alternatives and use technology in order to minimize these losses and generate profits (Almeida et al., 2011). Because it is a perishable fruit with a short shelf life, it is recommended that the fruit be subjected to processing to increase its shelf life and thus reach further consumer markets. One of the possible alternatives to the exploitation of the fruits is drying or dehydration (Melo et al., 2013).

The drying process is one of the most widely used methods by the agroindustry to extend the shelf life of organic products and to ensure their quality. The convective drying is still the most popular method applied to remove water from fruits and vegetables. However, many of the properties of agricultural products are affected by the drying conditions. Therefore, modeling studies of product drying are necessary, not only including aspects of heat and mass transfer, but also aiming to minimalize possible quality losses (Dehghannya et al., 2016).

The purpose of this study was to physicochemically characterize the mandacaru fruit both fresh and dehydrated in the drying oven with rotating air at three different drying temperatures.

2. Materials and Methods

2.1 Acquisition and Selection of the Fruits

The mandacaru fruits were acquired on the premises of the Universidade Federal de Campina Grande, at the Campina Grande Campus, state of Paraíba, Brazil. The fruits were harvested when they were ripe and firm. After the acquisition, the fruits were taken to the lab—Laboratório de Armazenamento e Processamento de Produtos Agrícolas (LAPPA)—which belongs to the Universidade Federal de Campina Grande (UFCG-PB).

In the laboratory, the fruits were selected according to the uniformity of their size, color and absence of defects, while discarding unripe, stained, cracked or diseased ones. Afterwards, the selected fruits were washed with a 1% (v/v) solution of neutral detergent, then after rinsing the fruits were sanitized with a 100 ppm sodium hypochlorite solution for fifteen minutes. After drying in the open air, the fruits were individually weighed and then cut with the help of stainless steel knives and the pulp with seeds was extracted with a spoon (Figure 1). The pulp was submitted to physical and chemical analyses, and drying was carried out in a drying oven with forced air circulation. The dry samples were characterized with regard to the physical and chemical parameters.

Figure 1. Mandacaru fruits by the time of their harvest and pulp with seeds

2.2 Physical Characterization of the Fruit

Ten fruits were randomly sorted based on the absence of defects and submitted to determination of fruit weight, peel weight, pulp with seeds weight and pulp/peel ratio. The weighing process was performed on a digital analytical balance and the results were expressed in grams. The percentage of pulp with seed and peel was determined, and the results were expressed as percentage.

2.3 Physical and Chemical Characterization of the Dehydrated and Fresh Pulp

The water content (%) was determined by oven drying at 105 °C until constant weight according to the method of IAL (2008).

The water activity (A_w) was determined using the Decagon® Aqualab CX-2T device at 25 °C, according to the methodology described by Santos et al. (2018).

The titratable acidity (AT-% in citric acid) was determined by the titration method using a 1.0-g aliquot of the sample, which was mixed with 49.0 mL of distilled water and 3 drops of 1% alcoholic phenolphthalein, using 0.1 N sodium hydroxide solution (NaOH), standardized with potassium biphthalate, as titrant (IAL, 2008).

The pH was determined using a Tecnopon® pH meter (Model mPA-210P/Version 7.1), with direct insertion of the electrode, according to IAL (2008).

The phenolic compounds were determined by the Folin-Ciocalteu method described by Waterhouse (2006), using gallic acid as standard. The extract was prepared from the dilution of 1 g of sample in 50 ml of distilled water and left to rest for 1h. An aliquot of 250 µL of the extract was transferred to a test tube, in which 1875 µL of water and 125 µL of Folin Ciocalteau reagent were added. The mixture was left to rest for 5 minutes and shortly after 250 µl of 20% sodium carbonate was added, followed by vortexing and standing in a water bath at 40 °C for 30 min. In the calculations made to determine the phenolic compounds, a standard curve with gallic acid (GAE) was used, and the readings were taken in a spectrophotometer at 765 nm. The analysis was performed in triplicate and the results expressed in mg of gallic acid (GAE).100^{-1}g of sample.

The color was determined by direct reading using the MiniScan HunterLab XE Plus spectrophotometer, model 4500 L, with Cielab color system. The instrument, equipped with D65/10° illuminant, was calibrated with black plate and standard white plate (x = 80.5, y = 85.3, z = 90.0), according to the manufacturer's instructions. The determined parameters were: L* which represents the luminosity, transition from white (0) to black (100); a* which represents the transition from green (-a*) to the red color (+a*); and b* the transition from blue (-b*) to the yellow color (+b*).

The data of the physical and chemical characteristics of the fresh mandacaru pulp were evaluated by descriptive statistics using a measure of central tendency (mean) and data variability (standard deviation).

The data of the physicochemical characteristics of the dehydrated mandacaru were submitted to analysis of variance (ANOVA), and means were compared by Tukey's test at 0.05 probability level.

2.4 Drying Kinetics

The pulp of the fruit was dehydrated in a drying oven with forced air circulation adjusted to operate at temperatures of 40, 50 and 60 ºC. Drying temperatures were chosen based on the ranges usually used for agricultural products. The drying procedures were performed in triplicate, the water content was determined by the gravimetric method, and the weighings of the pulp were carried out on an analytical scale, until reaching the equilibrium water content.

The readings of sample weight loss were performed at regular intervals, starting every 5 minutes, followed up to constant weight. The experimental data were expressed in the form of moisture ratio (X*).

The drying curves were obtained after the conversion of the original data of moisture content on dry basis *X(t)* to the corresponding parameter in the dimensionless form (moisture ratio), X*(t), according to Equation (1):

$$X^* = \frac{X_{db} - X_e}{X_{db\ initial} - X_e} \quad (1)$$

where,

X^* = water content ratio (dimensionless); X_e = equilibrium water content on a dry basis; X_{db} = water content on dry basis; $X_{db\ initial}$ = initial water content on dry basis.

The observed values for each drying air temperature were simulated by three empirical models frequently used to describe the non-linear regression of drying phenomena described in Table 1.

Table 1. Empirical models used to predict the mandacaru drying phenomenon

Models	Equations
Henderson and Pabis	$\chi^* = a \cdot \exp(-k \cdot t)$
Midilli	$\chi^* = a \cdot \exp(-k \cdot t^n) + (b \cdot t)$
Page	$\chi^* = \exp(-k \cdot t^n)$

Note. *t: drying time (min); k: drying constants; a, n: coefficient of the models.

The criteria used to determine the best fit of the models to the experimental data were the coefficient of determination (R^2) and the chi-square (χ^2), calculated by the equation:

$$\chi^2 = \sqrt{\sum (X^*_{\exp} - X^*_{pre})^2} \quad (2)$$

where,

χ^2 = chi-square; X^*_{pre} = moisture ratio predicted by the model; $X^*_{\exp}$ = experimental moisture ratio.

The drying curves obtained experimentally were fitted in the computer program Statistica version 5.0 using the non-linear regression analysis by the Quasi-Newton method.

3. Results and Discussion

3.1 Physical Characterization of the Fruits

The mean values and standard deviations of the physical characterization of the fresh mandacaru fruit are described in Table 2.

Table 2. Mean values and standard deviation of the physical characteristics of the fresh mandacaru fruit

Analyzed characteristics	**Mean and standard deviation**
Weight of the fruit (g)	162.86±4.88
Weight of the pulp and seed (g)	64.21±6.49
Weight of the peel (g)	98.37±0.83
% of pulp and seed	29.52±1.84
% of peel	60.47±2.20

The mean values obtained in this work regarding the fruit weight (162.86 g) were lower than those found by Almeida et al. (2009) of 241.16 g in fruits from the city of Queimadas-PB. However, it is observed that the mean value found is within the range of the fruit weights mentioned by the authors (164.50 g) in fruits from the city of Lagoa Seca, in Paraíba.

Chitarra and Chitarra (2005) assert that the size and shape are important parameters when they vary among the same products and will affect the consumer's choice, the handling practices, the storage potential, the market selection and the final destination, concerning fresh consumption or industrialization.

For the fresh fruit market the average weight of the fruits is an important feature, since larger fruits become more attractive to consumers. Nonetheless, for fruits destined to the elaboration of products such as juices, sweets, jams and ice creams, the physicochemical parameters related to the soluble solids content and the titratable total acidity are more relevant.

Weight of the pulp and seed (g) was 64.21 g and the weight of the peel was 98.37 g. Almeida et al. (2009) reported higher values for pulp and seed (76.79 g) and lower values for peel weight (87.34 g) in fruits from the city of Lagoa Seca-PB.

The percentages of pulp and peel are equal to 29.52% and 60.47%, respectively. Different results were reported by Almeida et al. (2009), who found higher percentages of pulp and seed (43.51 and 46.00%) and consequently lower percentages of peel (56.44 and 53.76%) in fruits from the cities of Queimadas and Lagoa Seca, respectively.

3.2 Physicochemical Characterization of the Fresh Pulp

The mean values and standard deviations of the analyzed parameters in the physicochemical determination of the fresh mandacaru fruit are described in Table 3.

Table 3. Mean values and standard deviation of the physicochemical characteristics of the fresh mandacaru fruit

Analyzed characteristics	Mean and standard deviation
Water content (%)	82.75± 0.58
Water activity (Aw)	0.986±0.002
Titratable acidity (% in citric acid)	0.18±0.01
pH	4.35±0.01
Phenolic compounds (mg GAE 100^{-1} g)	28.35±0.89
L	59.84±0.05
a*	0.08±0.01
b*	5.72±0.06
H*	89.25±0.08
C*	5.72±0.06

Note. GAE = Gallic acid equivalent, L = luminosity, a* = red intensity, +b* = yellow intensity, H* = hue angle (hº) and C* = Chromaticity.

It is observed that the water content of the mandacaru pulp was 82.75%, and this result was lower than those reported by Almeida et al. (2009), who found 90.58 and 90.24% in mandacaru fruits from the cities of Queimadas and Lagoa Seca, respectively, and similar to the one found by Pereira et al. (2013), for the fruit of mandacaru-de-três-quinas (*Cereus hildmannianus* K. Schum.), which was 83.72%. Jerônimo et al. (2015) reported water content of 86.03% for red pitaya pulp. The high water content found in the fruit can cause its quick deterioration, because water favors the proliferation of microorganisms, compromising fruit quality.

The value found for water activity (0.986) characterizes the fruit as a high water content food. Galdino et al. (2016a) found water activity equal to 0.976 for the cactus pear pulp. Moreira et al. (2018) reported Aw for the kiwi pulp equal to 0.980. According to Fellows (2006), water activity is an important factor for controlling the rate of deterioration of the product and generally foods with water activity superior to 0.95 are classified as fresh, highly perishable foods. The high water content justifies the water activity above 0.90, which requires the use of efficient conservation methods with the purpose of reducing microbial growth and the enzymatic reactions.

The percentage of titratable acidity found in this study was 0.18% of citric acid. Souza et al. (2012) found acidity between 0.08 and 1.95% for fruits of the Brazilian Cerrado. According to these authors this level of acidity in food products results in a mild taste, which increases the acceptance of the fresh fruit. Galdino et al. (2016a) also reported a low acid content for the cactus pear pulp (0.07% citric acid). However, it is observed that the citric acid value found indicates low acidity in the fruit, and can be classified as a moderate taste and well accepted for consumption as fresh fruit.

The average value of pH found was of 4.35. Similar values were reported by Almeida et al. (2009) in their study on the characterization of the mandacaru fruit, in which these authors observed pH values of 4.38 to 4.50 in pulp of fruits from the municipalities of Queimadas and Lagoa Seca, PB, respectively. In view of the result, the mandacaru fruit can be classified as sour food (pH between 3.7 and 4.5). Higher values were reported by Galdino et al. (2016a) in cactus pear pulp (5.59).

The fresh mandacaru pulp has a phenolic compound content equal to 28.35 mg GAE 100^{-1} g. Yahia and Mondragon-Jacobo (2011) studied 10 different fruit cultivars of *Opuntia ficus-indica* and observed a high variability of results ranging from 10 to 130 mg GAE 100^{-1} g. The differences found between the samples of the same species may be related to the edaphoclimatic factors of each region.

It is observed that the mean value of luminosity (L*) was equal to 59.84. Nunes et al. (2013) while studying the chemical and colorimetric characterization of the mandacaru pulp, found lower values of luminosity (24.07 for the whole pulp).

It can be seen that the positive values of +a* (0.08) indicate low-intensity red color components. The value found for the parameter a* was lower than that determined by Nunes et al. (2013) for the mandacaru whole pulp, 0.78.

The intensity of +b* (5.72) indicates the presence of yellow components in the mandacaru pulp. Nunes et al. (2013) when studying the mandacaru whole pulp determined a value equal to 4.21 for the parameter b*, which is close to the one found in this work.

By evaluating the values of the Hue Angle (H*), it is observed that the mandacaru pulp has a value equal to 89.25, parameter which indicates the tone of the sample. According to Table 3, it was observed that the chromaticity value (C*) was equal to 5.72, and this parameter represents the color saturation in relation to white.

3.3 Drying Kinetics

Table 4 presents the parameters obtained from the fits of the models of Henderson and Pabis, Midilli and Page to the experimental data of the drying kinetics of the mandacaru pulp with seeds. This table also shows the coefficient of determination (R^2) and the chi-square (χ^2), obtained for drying at the temperatures of 40, 50 and 60 ºC.

Table 4. Fitting parameters, coefficient of determination (R^2) and chi-square (χ^2) of the models of Henderson and Pabis, Midilli and Page in the drying process of the mandacaru fruit at the temperatures of 40, 50 and 60 °C

Models	**T (ºC)**	**Parameters**				**R^2**	**χ^2**
		a	k	n	b		
Henderson and Pabis	40	549.2810	2.3724	-	-	0.9828	135.8172
	50	1.08921	0.0155	-	-	0.9890	0.2405
	60	1.1033	0.0232	-	-	0.9849	0.2796
Midilli	40	0.9772	0.0002	1.4791	-0.00014	0.9990	0.0034
	50	0.9845	0.0020	1.4456	-0.000092	0.9993	0.0124
	60	0.9721	0.0019	1.6029	-0.000072	0.9988	0.0133
Page	40	-	0.0025	1.0790	-	0.9848	0.0678
	50	-	0.0022	1.4330	-	0.9988	0.1287
	60	-	0.0025	1.5474	-	0.9982	0.1348

It is observed that the models of Midilli and Page showed satisfactory statistical indicators for the description of the drying of the mandacaru fruit, with R^2 higher than 0.9848 and χ^2 lower than 0.1348. Although the model of Henderson and Pabis has high R^2, high values of χ^2 are observed, indicating a large difference between the values predicted by the model and those observed experimentally.

Table 4 shows that the models of Midilli and Page can be used to represent the drying process of the mandacaru pulp with high coefficients of determination (R^2), higher than 0.9848, which increases the confidence level of the fits, and low chi-square (χ^2).

Among the models used, the Midilli model fitted best to the experimental data, showing the best coefficients of determination (R^2), from 0.9988 to 0.9993, and the lowest chi-squares (χ^2) (Figure 2). Considering this same criterion, the Page model had good representation of fit to the experimental points. Among the applied models, the model of Henderson and Pabis showed unsatisfactory fitting parameters.

The fit of the Midilli model to the data was similar to those reported by Galdino et al. (2016b) in the drying kinetics of atemoya pulp at the temperatures of 60 to 80 °C. Maciel et al. (2017), studying the kinetics of guava pulp drying, reported that among the applied models the Midilli's fitted best to the experimental data.

Figure 2 shows the drying curves of the mandacaru pulp at temperatures of 40, 50 and 60 °C, represented by the moisture ratio (X^*) as a function of the dehydration time. It is observed that the period of constant rate of water removal is emphasized by a longer time under the temperature of 40 °C. Because the mandacaru pulp has a high content of free water on the surface, this water is quickly withdrawn under the highest temperatures (50 and 60 °C), which lead to faster reduction in the beginning of the rate of decline. Sousa et al. (2011) report that the rise of the temperatures causes higher rate of water removal from the product due to the greater transfer of energy in the form of heat.

The drying periods were 630, 240 and 180 min at the temperatures of 40, 50 and 60 °C, respectively.

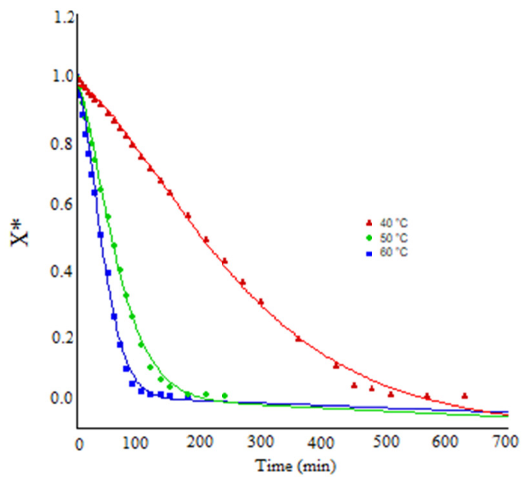

Figure 2. Values observed and estimated by the Midilli's equations fitted to the experimental data of mandacaru pulp drying at temperatures of 40, 50 and 60 °C

3.4 Physicochemical Characterization of the Dehydrated Mandacaru

Table 5 shows the results obtained for water content (WC), water activity (Aw), titratable acidity (TA), pH and phenolic compounds (PC), of the dehydrated mandacaru pulp at the temperatures of 40, 50 and 60 °C.

Table 5. Physicochemical characteristics of the mandacaru fruit dehydrated at different temperatures

T (ºC)	**Evaluated characteristics**				
	WC (%)	Aw	TA (%)	pH	PC (mg 100^{-1} g)
40	10.83 a	0.399 a	0.41 c	4.76	252.26 a
50	8.31 b	0.324 b	0.75 a	4.86	196.10 b
60	7.56 c	0.240 c	0.64 b	4.98	156.53 c
Mean	8.90	0.32	0.60	4.87	201.63
CV(%)	2.97	0.66	4.72	1.39	1.23

Note. *Means followed by the same letter in the column do not differ by Tukey's test at the 5% probability level.

According to Table 5 it can be seen that the final water content of the dehydrated mandacaru pulp was influenced by the drying temperature. The highest temperature caused a greater removal of water from the product during drying, diverging from the other temperatures used. According to Reis (2002) the drying is greater when the food is submitted to high temperatures, because the heated air promotes a heating of the product increasing the vapor pressure and thus allowing water exit.

It was found that the water activity (A_w) differed among the temperatures used, and the temperature of 60 °C led to a lower value of A_w when compared to the other temperatures (40 and 50 °C). This fact can be explained by the lower moisture content found in the mandacaru pulp dehydrated at 60 °C. Thus, it was found that the fruits dehydrated at 40 °C had a higher moisture content and consequently a higher value of A_w (Table 5).

According to Guimarães and Silva (2008), the water activity values for dry fruits can vary between 0.510 and 0.890. In this study the samples showed water activity between 0.240 and 0.399%, lower than the values reported by these authors. However, the values obtained for the dehydrated pulp are within the established range for dry and stable foods from a microbiological point of view, as they exhibit A_w inferior to 0.6 and water content lower than 25%, a range considered minimum for the development of microorganisms (Gava et al., 2007).

Table 5 shows a significant difference in the titratable acidity content between the drying temperatures used. It was observed that, after drying the mandacaru pulp, there was an increase in titratable acidity, from 0.41% to 0.75% of citric acid. This increase can be attributed to the concentration of acids present in the product due to the removal of water. After drying, the mandacaru pulp had pH varying from 4.76 to 4.98, indicating a slightly acid fruit (pH above 4.5).

It was found that the content of phenolic compounds was significantly ($p < 0.01$) affected by the drying temperature compared to the drying time (Table 5). For example, the drying temperature of 40 °C, despite having the longest drying time, provided the highest retention of phenolic compounds, which was 252.26 mg/100 g. On the other hand, the temperature of 60 °C, despite having the shortest drying time, kept the lowest amount of phenolic compounds, which was 156.53 mg/100 g.

In Table 6 are the mean values obtained in the colorimetric analysis: Luminosity (L*), intensity of red (+a*), intensity of yellow (+b*), chromaticity (C*) and hue angle (Hº) in the mandacaru pulp dehydrated at temperatures of 40, 50 and 60 °C.

Table 6. Color determination in the mandacaru fruit dehydrated at different temperatures

T (ºC)	**Color parameters**				
	L*	a*	b*	H*	C*
40	19.72 c	3.13 a	7.31 b	66.79 c	7.95 b
50	23.41 b	1.31 b	6.53 c	78.69 b	6.95 c
60	26.15 a	1.30 b	9.14 a	81.92 a	9.23 a
Mean	23.09	1.91	7.66	75.80	7.95
CV(%)	0.50	2.18	2.25	0.57	2.09

Note. L = luminosity, a* = red intensity, +b* = yellow intensity, H* = hue angle (hº) and C* = Chromaticity.

*Means followed by the same letter in the column do not differ by Tukey's test at 0.05 probability level.

It can be seen in Table 6 that the color parameters were affected by the drying process. It is observed that the higher the drying temperature, the greater the luminosity (L *). This fact may have occurred because the higher drying temperature (60 °C) provides the shortest exposure time to the product (binomial time x temperature). In physical terms, a bleaching occurred in the samples with the use of the drying temperature, where the sample at 40 °C led to darker shade than the samples at 50 and 60 °C.

Regarding the parameter +a*, which indicates components with red color of low intensity, it is observed that the drying temperature had a significant effect on the product color, since fruits dehydrated at 40 ºC differed statistically from those dried at the temperatures of 50 and 60 °C.

The intensity of +b* indicates the presence of yellow components in the dehydrated mandacaru pulp. The temperature of 60 °C differed statistically from the other temperatures, causing a higher value.

The parameter H* (Hue angle) indicates the hue of the sample. According to Table 5, it is verified that there was an increase in the hue of the dehydrated pulp with the increase in the temperature. The temperature of 60 °C led to higher value when compared to the other temperatures, and the lowest value was found in samples dehydrated at 40 °C.

The color saturation is represented by the parameter C*, which indicates the purity or intensity of the color in relation to white, determined by the coordinates a* and b*. It was found that the temperature of 60 °C led to higher value of the parameter C* when compared to the other temperatures, and the lowest value was found in samples dehydrated at 50 °C, the same fact was observed for parameter b*.

4. Conclusions

Mandacaru fruit has physical and physico-chemical characteristics that are important for fresh consumption and technological use, mainly for industry, and can be used to elaborate new products. The mathematical model that fitted best to the data of mandacaru pulp drying kinetics was the Midilli equation, with determination coefficients higher than 0.9988 and chi-square lower than 0.0133. According to the results obtained, the drying temperature influenced the loss of water. The higher the temperature, the shorter the drying time. Drying of the mandacaru pulp had an important influence on the final color of the dehydrated product and on other physical and chemical properties.

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