

Effect of temperature and sample thickness on the hot-air drying kinetics of cupuassu pulp

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Tarciana Castro Alves

ORCID: <https://orcid.org/0009-0001-3575-7922>

Universidade Federal do Sul e Sudeste do Pará, Brazil

E-mail: tarciana.castro@unifesspa.edu.br

Suélen Maria de Amorim

ORCID: <https://orcid.org/0000-0003-4519-5641>

Universidade Federal do Sul e Sudeste do Pará, Brazil

E-mail: suelen.amorim@unifesspa.edu.br

Mariane Wolf

ORCID: <https://orcid.org/0000-0002-6061-7681>

Universidade Federal de Santa Catarina, Brazil

E-mail: marianewolf4@gmail.com

Jhony Tiago Teleken

ORCID: <https://orcid.org/0000-0003-3642-8124>

Universidade Federal do Sul e Sudeste do Pará, Brazil

E-mail: jhony.teleken@unifesspa.edu.br

Abstract

Cupuassu (*Theobroma grandiflorum*) is one of the main non-timber forest products of the Amazon biome. The pulp of the fruit is widely used in beverages, ice creams, and desserts. However, its high moisture content makes the pulp highly susceptible to spoilage. This study aimed to examine the impact of temperature (50, 60, and 70 °C) and sample thickness (1.5, 3.0, and 4.5 mm) on the hot-air drying of cupuassu pulp to obtain a more stable product. In general, drying time can be reduced by 15% to 30% for every 10 °C increase in air temperature at the three thickness. Additionally, when the sample thickness is reduced from 4.5 mm to 1.5 mm, drying time can be decreased by approximately 60% at the three temperature conditions. The modified Page model close agreement with experimental data ($R^2 > 0.99$), showing that the drying curves exhibited an initial increasing dry rate period followed by a falling dry rate period. Furthermore, the moisture effective diffusion coefficient in the cupuassu pulp was estimated to range between 2.65×10^{-10} - $1.56 \times 10^{-9} \text{ m}^2 \text{ s}^{-1}$ under the studied conditions. This research contributes to advancing knowledge about food processing, particularly those of regional interest such as cupuassu.

Keywords: Amazonian fruit. Mathematical Modeling. Mass transfer.

1. Introduction

Cupuassu (*Theobroma grandiflorum*) is a native fruit of the Amazon biome that holds great economic importance, especially for the northern region of Brazil (Rosa, Oliveira Moreira, Carvalho, & Freitas-Silva, 2024). The main form of processing this raw material is the production of frozen fruit pulp, which has a light-yellow color, fibrous composition, acidic flavor, and an intense aroma, making it an excellent ingredient for producing foods such as beverages, ice cream, and sweets (Pombo, de Medeiros, & Pena, 2020; Rosa *et al.*, 2024). Additionally, the cupuassu pulp is a rich source of bioactive compounds, such as ascorbic acid and phenolic compounds, which have antioxidant properties (Pugliese, Tomas-Barberan, Truchado, & Genovese, 2013).

Drying is an attractive option for processing cupuassu pulp as it results in a product with greater chemical and microbiological stability, as well as lower mass and volume, which reduces transportation and storage costs (Barbosa-Carvalho, da Silva Pena, & Chisté, 2024; Giraldo-Zuniga *et al.*, 2010; Pombo *et al.*, 2020). Hot-air drying or convective drying is the most commonly used method in the food industry for dehydrating fruits and vegetables (Karam, Petit, Zimmer, Baudelaire Djantou, & Scher, 2016). During this process, hot and dry air (low relative humidity) comes into contact with the moist surface of the food. Thermal energy is transferred from the air to the product, heating it, while water is transferred from the product to the air, reducing its moisture content (Chen & Mujumdar, 2008). Despite being a well-established process, the literature still lacks information about the convective drying applied to cupuassu pulp. A recent work by Barbosa-Carvalho *et al.* (2024) evaluate the effect of different air temperatures (40, 55, and 70 °C) on the drying of cupuassu pulp. However, there are no studies about the effect of the other process conditions on the kinetic drying of this fruit.

Several factors, such as temperature, relative humidity, air velocity, and the characteristics of the food, influence the convective drying process. These factors impact the drying rate and drying time, affecting the nutritional and sensory quality of the dried product (Barbosa-Carvalho *et al.*, 2024; Demiray *et al.*, 2023; Lemus-Mondaca, Betoret, Vega-Galvéz, & Lara-Aravena, 2009; Velić, Planinić, Tomas, & Bilić, 2004). Understanding how these variables affect the kinetic drying is crucial for controlling, optimizing, or designing the operation, and mathematical modeling is a helpful tool in this regard (Buzrul, 2022; Teleken *et al.*, 2025). Mathematical models aid in characterizing the behavior of the drying curve, providing quantitative information about the process. Additionally, they can be used to estimate the food's intrinsic parameters, such as the effective moisture diffusion coefficient (Onwude, Hashim, Janius, Nawi, & Abdan, 2016).

In this scenario, the objective of this study was to assess the impact of different process conditions on the hot-air drying kinetics of cupuassu pulp. To achieve this, drying was carried out using different pulp thicknesses (1.5, 3.0, and 4.5 mm) and varying air temperatures (50, 60, and 70 °C). The modified Page model was employed to characterize the kinetic drying curve, and Fick's second law was utilized to determine the effective moisture diffusion coefficient in the food.

2. Material and Methods

2.1 Cupuassu pulp

Pasteurized cupuassu pulp produced by the Cooperativa Agrícola Mista de Tomé-Açu (CAMTA) was used in this study. The frozen pulp was acquired from a local market in Marabá-PA and stored in a freezer at -18 °C until use. The moisture content of the sample was determined by the gravimetric method in an oven at 105 °C for 24 hours (AOAC, 1998). The pH was obtained using a digital pH meter previously calibrated with standard solutions of pH 4.0 and 7.0, and the soluble solids content was obtained using an optical refractometer with a scale range from 0 to 32 °Brix and precision of ± 0.2 °Brix. All analyses were replicated five times.

2.2 Drying procedure

The cupuassu pulp was thawed at room temperature (26-28 °C) and spread on an aluminum plate covered with Teflon® film and adjustable edge height, specifically designed for drying experiments (Figure 1a). A Teflon® film, due to its hydrophobicity and low surface energy, facilitates the removal of the dried material (Frabetti, de Moraes, Jury, Boillereaux, & Laurindo, 2021). The pulp was spread on the plate at thicknesses of 1.5, 3.0, and 4.5 mm and then dried at temperatures of 50, 60, and 70 °C in a forced convection oven (SolidSteel, SSDcr-85L, Brazil), resulting in a total of nine experimental conditions.

The experimental drying kinetics, i.e., moisture content (X_{db} , [g g⁻¹] in dry basis) vs. time (t , [min]), of the cupuassu pulp was determined by taking samples from pulp spread in on the aluminum plate using a metal spatula at predetermined time intervals and measuring its moisture content (Parisotto, Teleken, Laurindo, & Carciofi, 2020). This procedure was performed in triplicate for

each experimental condition. Figure 1b illustrates a pulp sample taken from the cupuassu film with thicknesses of 1.5 mm during the drying process.

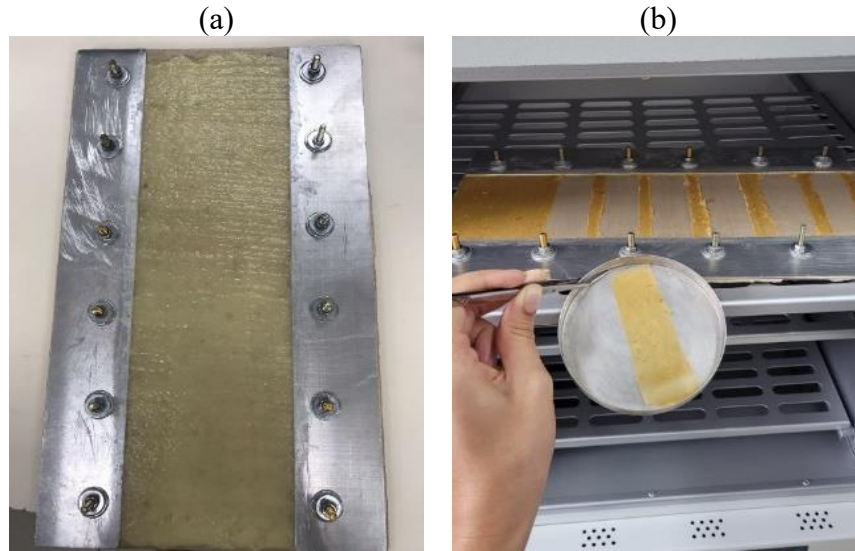


Figure 1 – Imagens of the (a) cupuassu pulp spread on an aluminum plate (before drying) and (a) a sample taken from the pulp during drying.

2.3 Mathematical modeling of the drying kinetics

For the mathematical modeling, the experimental drying kinetics were represented by the moisture ratio (X^* , [-]) as defined in Equation 1 (Onwude *et al.*, 2016).

$$X^*(t) = \frac{X_{db}(t) - X_{db,e}}{X_{db,0} - X_{db,e}} \quad (1)$$

where $X_{db}(t)$ is the moisture content of the pulp [g g^{-1} in dry basis] at time t [min]; $X_{db,0}$ is the initial moisture content [g g^{-1} in dry basis], and $X_{db,e}$ is the equilibrium moisture content [g g^{-1} in dry basis]. The value of $X_{db,e}$ is relatively small compared to $X_{db}(t)$ and $X_{db,0}$, then in this study the moisture ratio (Equation 1) was simplified to (Khaled *et al.*, 2020; Velić *et al.*, 2004):

$$X^*(t) = \frac{X_{db}(t)}{X_{db,0}} \quad (2)$$

The experimental drying kinetics of the cupuassu pulp ($X^*(t)$ vs. t) were described using the modified Page model (Equation 3). This two-parameter model (k and n) is commonly employed to analyze the drying process of fruits and vegetables (Erbay & Icier, 2010; Onwude *et al.*, 2016).

$$X^*(t) = \exp[-(kt)^n] \quad (3)$$

Figure 2 shows the effect of k [min^{-1}] and n [-] on the drying kinetic. The parameter k is related to the drying rate; higher values, result in the faster drying (Figure 2a). On the other hand, the parameter n is related to the shape of the curve. For $n \leq 1$, the curve shows a monotonous decreasing behavior, while for $n > 1$ the curve exhibits a sigmoid behavior (Figure 2b). When the parameter n is equal to 1, Equation 3 is known as the Lewis model or Newton model (Erbay & Icier, 2010).

The drying rate curve ($dX^*(t)/dt$, [min^{-1}]) was determined by calculating the time derivative of the Equation 3 to obtain Equation 4.

$$\frac{dX^*(t)}{dt} = -nk(kt)^{n-1}X^*(t) \quad (4)$$

When $n \leq 1$, the drying kinetics exhibits only a falling rate period. Conversely, when $n > 1$, there is a period of increasing rate followed by a falling rate period, and the maximum drying rate (dX^*/dt_{max}) is reached at the inflection point (t_i, X_i^*) of the sigmoid drying curve as illustrated in Figure 2c.

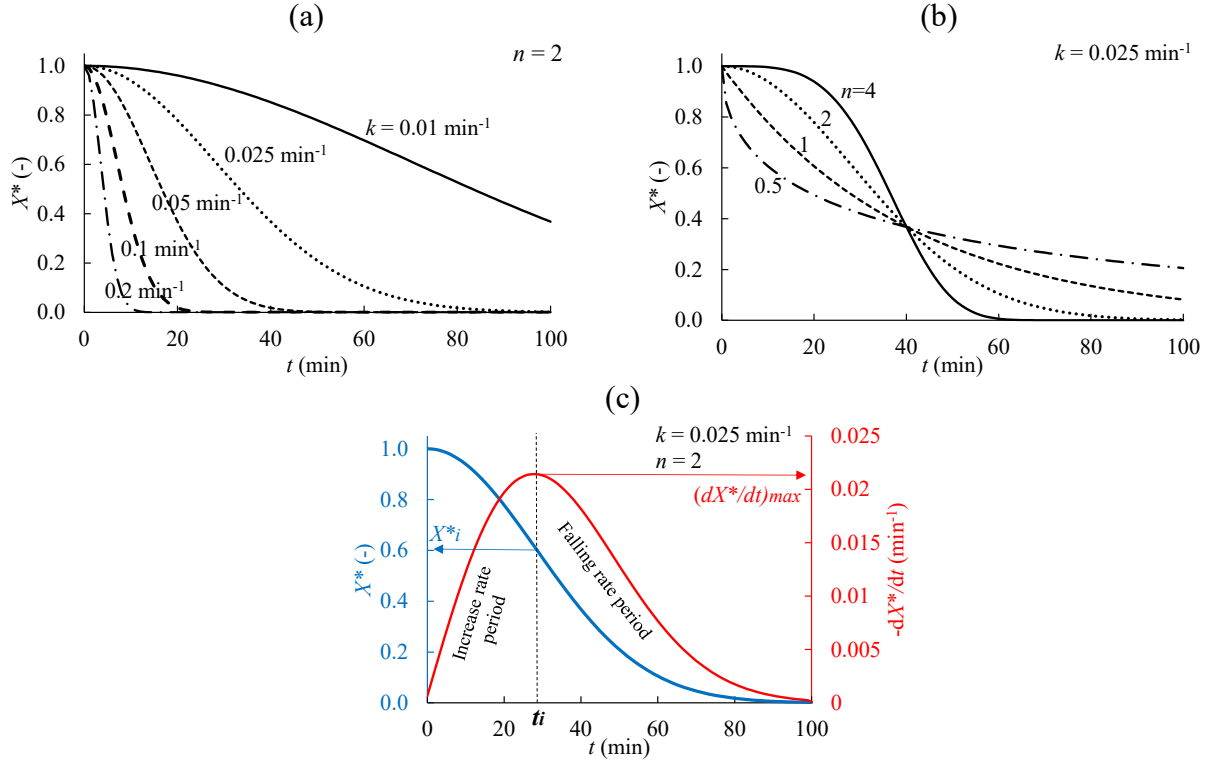


Figure 2 – Drying kinetics predicted by the modified Page model. (a) Curves obtained with $n = 2$ and $k = 0.01, 0.025, 0.05, 0.10$ and 0.20 min^{-1} . (b) Curves obtained for $k = 0.025 \text{ min}^{-1}$ and $n = 4, 2, 1$ and 0.5 . (c) The drying kinetics and drying rate curve showed the inflection point (t_i, X_i^*) and the maximum drying rate (dX^*/dt_{max}) .

2.4 Moisture diffusion coefficient

The method based on the solution of Fick's second law fitted to drying experimental data was used to determine the effective diffusion coefficient (D , [m^2s^{-1}]) (Pinheiro & Castro, 2023; Velić *et al.*, 2004). The analytical solution of Fick's second law for a flat plate with assumptions of moisture migrating only by diffusion, negligible shrinking, isothermal process and constant diffusion coefficient, is given by Equation 5 (Crank, 1975).

$$\frac{X_{bs}(t \geq t_i) - X_{bs,e}}{X_{bs,c} - X_{bs,e}} = \frac{X^*(t \geq t_i)}{X_i^*} = \frac{8}{\pi^2} \sum_{n=1}^{\infty} \frac{1}{(2n+1)^2} \exp \left[-(2n+1)^2 \frac{\pi^2}{4L^2} D(t - t_i) \right] \quad (5)$$

where L represents the thickness of the cupuassu pulp [m]; $X_{bs,c}$ is the critical moisture content [g g^{-1} in dry basis] which correspond to the beginning of the falling drying rate period, i.e., the drying phase governed by moisture diffusion within the pulp; X_i^* is the critical moisture ratio ($X_i^* = \frac{X_{bs,c} - X_{bs,e}}{X_{bs,0} - X_{bs,e}} \cong \frac{X_{bs,c}}{X_{bs,0}}$) and t_i is the drying time to reach X_i^* (Figure 2c). The falling rate period was defined as that comprised in $t > t_i$ following the proposal of Velić *et al.* (2004).

2.5 Numerical methods and statistical analysis

The numerical procedures were conducted using Scilab® software (<https://www.scilab.org/>). The modified Page model (Equation 3) and the analytical solution of Fick's second law (Equation 5) were fitted to the experimental data using the *leastsq* function, which is designed to solve non-linear least squares problems. To fit Equation 5, it was considered 5 terms of the series, which is a reasonable approximation as the infinite series converges rapidly to the first terms of the sum for long process times (Crank, 1975). The performance of the models was evaluated using the coefficient of determination, R^2 (Equation 6).

$$R^2 = 1 - \frac{\sum_{i=1}^I (X_{exp}^* - X_{cal}^*)^2}{\sum_{i=1}^I \left(X_{exp}^* - \frac{1}{I} \sum_{i=1}^I X_{exp}^* \right)^2} \quad (6)$$

Where, X_{exp}^* stands the experimental values of the moisture ratio, X_{cal}^* stands the result calculated by the models and I represents the total number of experimental points.

3. Results and Discussions

The cupuassu pulp used in this study has a moisture content of $88.03 \pm 0.3\%$, soluble solids content of 14.0 ± 0.2 °Brix, and a pH of 3.61 ± 0.02 . These values are in agreement with literature results as reported by Nazareno *et al.* (2019), that found soluble solids content of 13.24 ± 0.74 °Brix and pH of 3.02 ± 0.02 , and by Silva-Júnior *et al.* (2019), that found moisture content of $86.73 \pm 0.4\%$, soluble solids content of 11.67 ± 1.9 °Brix, and pH of 3.34 ± 0.7 . Both studies utilized pasteurized and frozen cupuassu pulp, similarly which was used in this work.

Figure 3a shows the drying kinetics obtained experimentally and calculated by the mathematical model for different air temperatures and pulp thicknesses. It is observed that with the increase of the temperature and reduction of thickness, the time required to achieve certain moisture content decreased. Using the pulp thickness of 1.5 mm and the temperature of 70 °C, the drying time was approximately 76 minutes, whereas, under condition of 4.5 mm thickness and 50 °C, the drying process exceeded 370 minutes. Jiang *et al.* (2023) also studied the effect of air temperature (60, 70, 80, and 90 °C) and thickness (3 and 5 mm) on the drying kinetics of apple slices. They observed that for the thickest slices and the lowest temperature, it took 260 minutes to reach the equilibrium moisture content, while for the highest temperature and thinnest slices, the time required was 100 minutes.

To illustrate the effect of process parameters on cupuassu pulp drying, Figure 4 presents the drying time required to reduce the moisture content of the sample to 5% of its initial value under different thicknesses (Figure 4a) and air temperatures (Figure 4b). As shown in Figure 4a, at the temperature of 50 °C, the drying time for samples with thicknesses of 3.0 mm and 1.5 mm is reduced by 46.3% and 61.5%, respectively, compared to the 4.5 mm samples. Similarly, at 60 °C, the drying times decrease by 34.4% and 61.8%, respectively, and at 70 °C, the reductions are 35.6% and 64.8%. Overall, drying time can be reduced by approximately 60% when the sample thickness is decreased from 4.5 mm to 1.5 mm across all temperature conditions. Figure 4b illustrates that for a sample thickness of 4.5 mm, increasing the air temperature from 50 °C to 60 °C and then to 70 °C results in a decrease in drying time of 28.3% and 42.2%, respectively. This trend is also observed for samples with thicknesses of 3 mm and 1.5 mm. Barbosa-Carvalho *et al.* (2024) reported drying times for cupuassu pulp with a thickness of 4.0 mm at temperatures of 40, 55, and 70 °C as approximately 580 minutes, 460 minutes, and 340 minutes, respectively. This indicates that increasing the temperature above 40 °C reduces drying time by 22% at 55 °C and by 42% at 70 °C. In the present study, it was found that drying time can be reduced by 15% to 30% for every 10 °C increase in air temperature across all three thickness values. Similar results were observed by Liu *et al.* (2023) during the drying of sludge at thicknesses of 2 mm and 6 mm, exposed to air temperatures of 40, 50, and 60 °C.

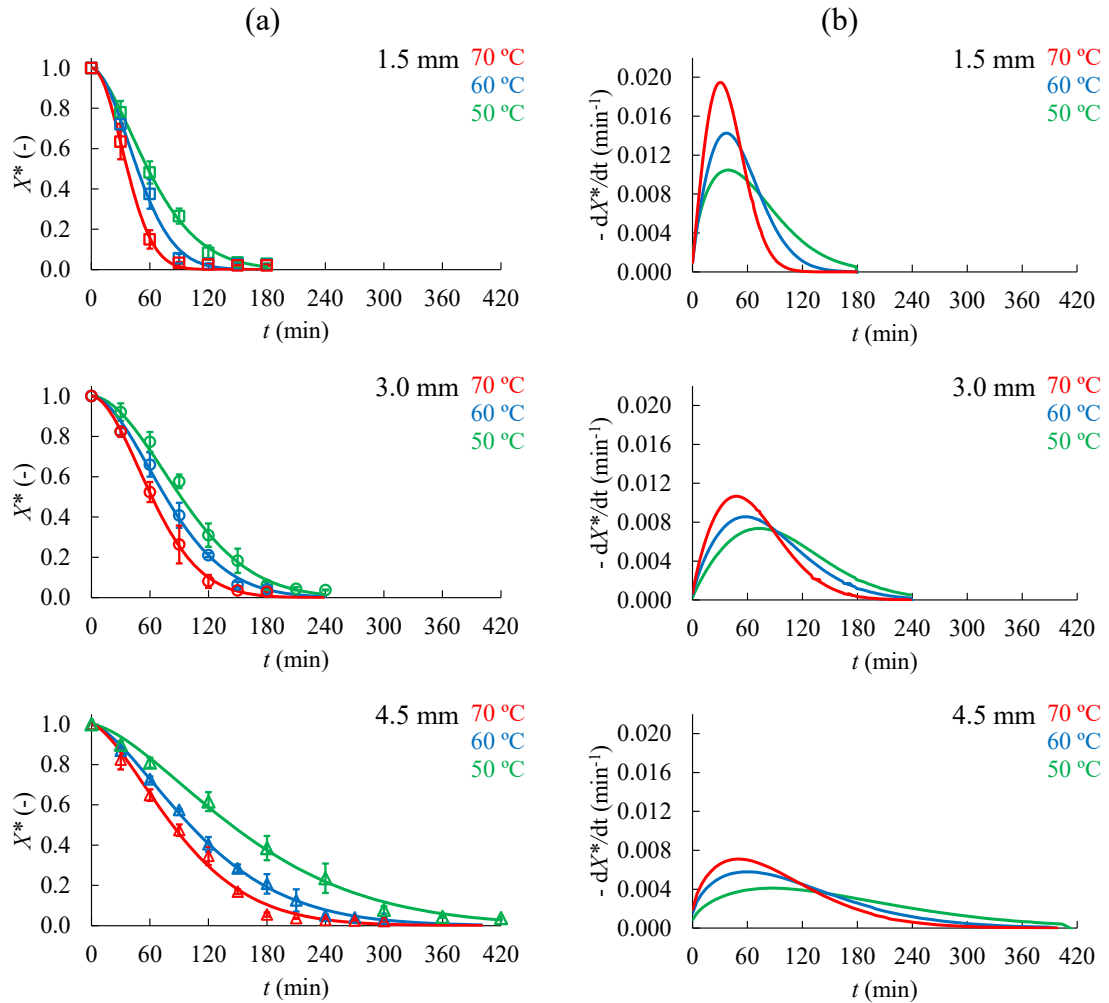


Figure 3 – (a) Drying kinetics (X^* vs. t) at different temperatures (50, 60 and 70 °C) and pulp thicknesses (1.5, 3.0, and 4.5 mm). The dots represent average experimental data with the standard deviations (bars) and the solid lines represent the values calculated by Equation 3. (b) Drying rates ($-dX^*(t)/dt$ vs. t) calculated by Equation 4 at different temperatures (50, 60 and 70 °C) and pulp thicknesses (1.5, 3.0, and 4.5 mm).

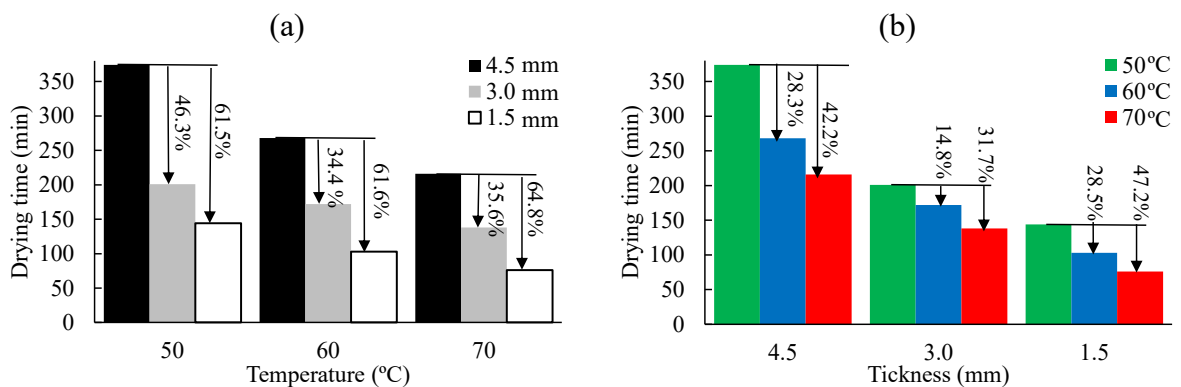


Figure 4 - (a) Comparison of the drying time for different sample thickness at the temperatures of 50, 60 and 70 °C; (b) Comparison of the drying time for different temperatures at the sample thickness of 4.5, 3.0 and 1.5 mm.

The modified Page model (Equation 3) effectively described the experimental data (Figure 3a), with R^2 values exceeding 0.99 in all conditions. The model revealed that the drying kinetics exhibit a sigmoidal behavior, with parameter values of $n > 1$. Barbosa-Carvalho *et al.* (2024) modeling the drying kinetics of cupuassu pulp with 4 mm of thickness in an oven at 40, 55, and 70 °C using the Page model, also found R^2 values of 0.99 and n parameter higher than 1. When the $n > 1$ means that the drying rates rise until reaching a maximum value and then decrease as illustrated in Figure 3b. Similar behavior of the drying rate curves ($-dX^*(t)/dt$ vs. t) was also observed by (Velić *et al.*, 2004) in the convective drying of apple slices at 60 °C at different air velocities. Initially, the drying rate increases quickly because the cupuassu pulp contains a high moisture content, and the water removed during this stage is primarily surface free water. Although not observed, it is possible that there was a brief period of constant drying rate. Following this, the resistance to internal mass transfer becomes the main factor, leading to a decrease in the drying rate. In general, hygroscopic materials such as food tend to exhibit a very short constant-rate period during drying (Hosseinpour, Rafiee, & Mohtasebi, 2011; Liu *et al.*, 2023; Velić *et al.*, 2004).

Additionally, it is observed that the maximum drying rate (dX^*/dt_{max}) increased with temperature. This occurs due to an increase in the driving force of moisture transfer between the cupuassu pulp and the air. Increasing the process temperature increases the equilibrium vapor pressure in the food and the air's capacity to retain moisture. On the other hand, the increase in thickness causes a reduction in the drying rate because there is an increase in the resistance to mass transfer (R_m) within the pulp. The R_m in a flat plate is directly proportional to its characteristic dimension ($R_m \sim L/D$, where L is the thickness of the flat plate and D is the moisture effective diffusion coefficient) (Chen & Mujumdar, 2008).

The values of parameters k and n of the Page model are shown in Figure 5. It is observed that the parameter n did not display any correlation with temperature and pulp thickness, ranging from 1.50 to 2.01, with an average of 1.72 (Figure 5a). Similarly, Vega-Castro *et al.* (2023) also noted no correlation of the parameter n with air temperature and material thickness during the convective drying. They used the modified Page model to analyze the drying kinetics of passion fruit peel at 50, 55, and 60 °C and obtained values of 1.13, 1.02, and 1.02, respectively. For drying coffee grounds with thicknesses of 1 cm and 2 cm, they found values of 1.23 and 1.20, respectively. On the other hand, the relationship of parameter k with air temperature (T) and thickness (L) (Figure 5b) was described by Equation 7 ($R^2=0.99$). The parameter k is associated with the process velocity, and its value increased with air temperature and decreased with pulp thickness, a trend similar to that observed by Demiray *et al.* (2023) in the convective drying of apple slices at different air temperatures (55-65 °C) and slice thicknesses (3 and 5 mm).

$$k(T, L) = -0.003396 - 0.003298L + 0.000531T + 0.000795L^2 - 8.19 \times 10^{-5}LT \quad (7)$$

In which k it is represented in [min^{-1}], L in [mm] and T in [°C].

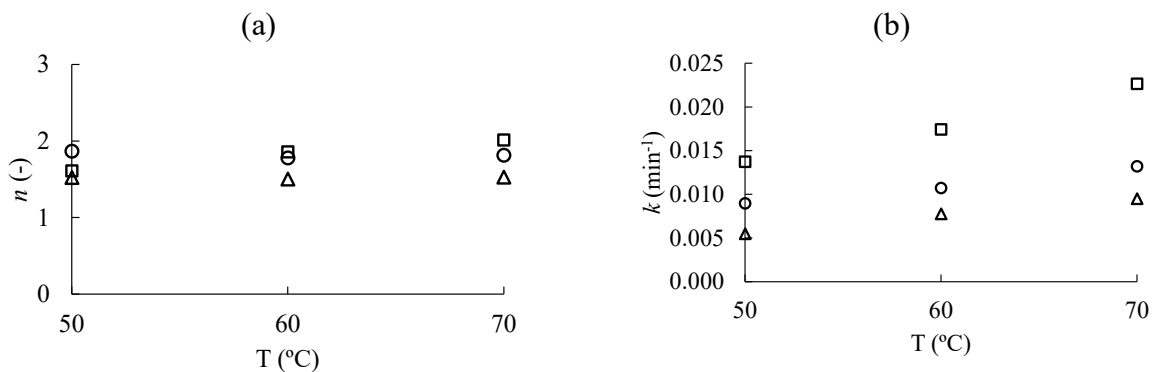


Figure 5 - Effect of temperature and pulp thickness in sections (a) n and (b) k of the modified Page model. The symbols represent the different thicknesses of the cupuassu pulp: $\square$ = 1.5 mm, $\circ$ = 3.0 mm and Δ = 4.5 mm.

Table 1 shows the values of time and moisture ratio at the inflection point of the drying curves (t_i , X_i^*) and maximum drying rate (dX^*/dt_{max}). The t_i values decreased with temperature, while the dX^*/dt_{max} values increased. In terms of thickness, there was an inverse relationship, with an increase in t_i and a decrease in dX^*/dt_{max} . These effects can be explained by the increase in the driving force for mass transfer with temperature and the increase in internal resistance to mass transfer with thickness. Velić *et al.* (2004) showed that when decreased the external resistance to mass transfer (increasing the relative importance of internal resistance) by increasing the drying air speed over apple slices, there was an increase in the dX^*/dt_{max} values of apples and a reduction in the value of t_i . Demiray *et al.* (2023) studied the effect of different thicknesses (1.5 and 5 mm) and air temperatures (45, 55, and 65 °C) on the drying rate of the apple slices, and they observed that the drying rate increased with increasing drying temperature and decreasing slice thickness. The values of dX^*/dt_{max} for cupuassu pulp (ranging from 0.0041 - 0.0195 min⁻¹) were close to those found by Velić *et al.* (2004) of 0.0070 - 0.0145 min⁻¹ for 5 mm apple slices dehydrated at 60 °C with air velocities of 0.64 and 2.75 m s⁻¹, respectively. When examining the maximum drying rates of cupuassu pulp based on thickness, it was found that the drying rates for a thickness of 1.5 mm are approximately 1.4 to 1.8 times higher than those for a thickness of 3.0 mm, and 2.4 to 2.7 times higher than those for a thickness of 4.5 mm. On the other hand, when we examine the maximum drying rates of cupuassu pulp based on temperature, it was found that rates of 70 °C are approximately 1.2 to 1.4 times higher than those for 60 °C, and 1.5 to 1.9 times higher than those for 50 °C. The values of X_i^* varied between 0.60 and 0.71 and did not depend on the process variables studied.

Table 1 - Maximum drying rate (dX^*/dt_{max} , [min⁻¹], time (t_i , [min]) and moisture ratio (X_i^* , [-]) at the inflection point of drying kinetics.

$T(^{\circ}\text{C})$	1.5 mm			3.0 mm			4.5 mm		
	t_i	X_i^*	dX^*/dt_{max}	t_i	X_i^*	dX^*/dt_{max}	t_i	X_i^*	dX^*/dt_{max}
50	39.8	0.69	0.0105	73.4	0.63	0.0073	90.6	0.71	0.0041
60	37.9	0.63	0.0142	58.8	0.64	0.0086	62.2	0.71	0.0058
70	31.4	0.60	0.0195	48.8	0.64	0.0107	52.6	0.71	0.0071

Figure 6 shows the fitting of Fick's second law (Equation 5) to the experimental drying data during the falling drying rate period for different process conditions. Additionally, Table 2 summarizes the values obtained for the effective moisture diffusion coefficient for cupuassu pulp, which varied from 2.65×10^{-10} to 1.56×10^{-9} m²s⁻¹. Such values are comparable to moisture diffusion coefficient values of cupuassu pulp 1.51×10^{-10} - 1.30×10^{-9} m²s⁻¹ (Barbosa-Carvalho *et al.*, 2024) and other fruits, such as pineapple 7.30×10^{-10} - 2.69×10^{-9} m²s⁻¹ (Chokngamvong & Suvaranjumrat, 2023), apple 1.70×10^{-9} - 4.40×10^{-9} m²s⁻¹ (Velić *et al.*, 2004), banana 1.3×10^{-10} - 7.8×10^{-10} m²s⁻¹ (Nguyen & Price, 2007), mango 1.74×10^{-10} - 3.28×10^{-10} m²s⁻¹ (Corzo, Bracho, & Alvarez, 2008) and papaya 6.25×10^{-10} - 2.43×10^{-9} m²s⁻¹ (Lemus-Mondaca *et al.*, 2009).

Furthermore, it is also possible to observe that the estimated values for D increased with temperature and pulp thickness, similar to the behavior found by Demiray *et al.* (2023), Royen *et al.* (2020) and Dissa *et al.* (2008) in convective drying of apple and mango. The effective moisture diffusion coefficient in the food increases with temperature because the vibration levels of water molecules rise, leading to faster moisture transport (Chen & Mujumdar, 2008). On the other hand, the diffusion coefficient is an intrinsic property of a material and is not expected to change with its thickness. However, the estimated D value can be influenced by the characteristic dimensions of the sample, which may vary drastically during the drying process (Royen *et al.*, 2020).

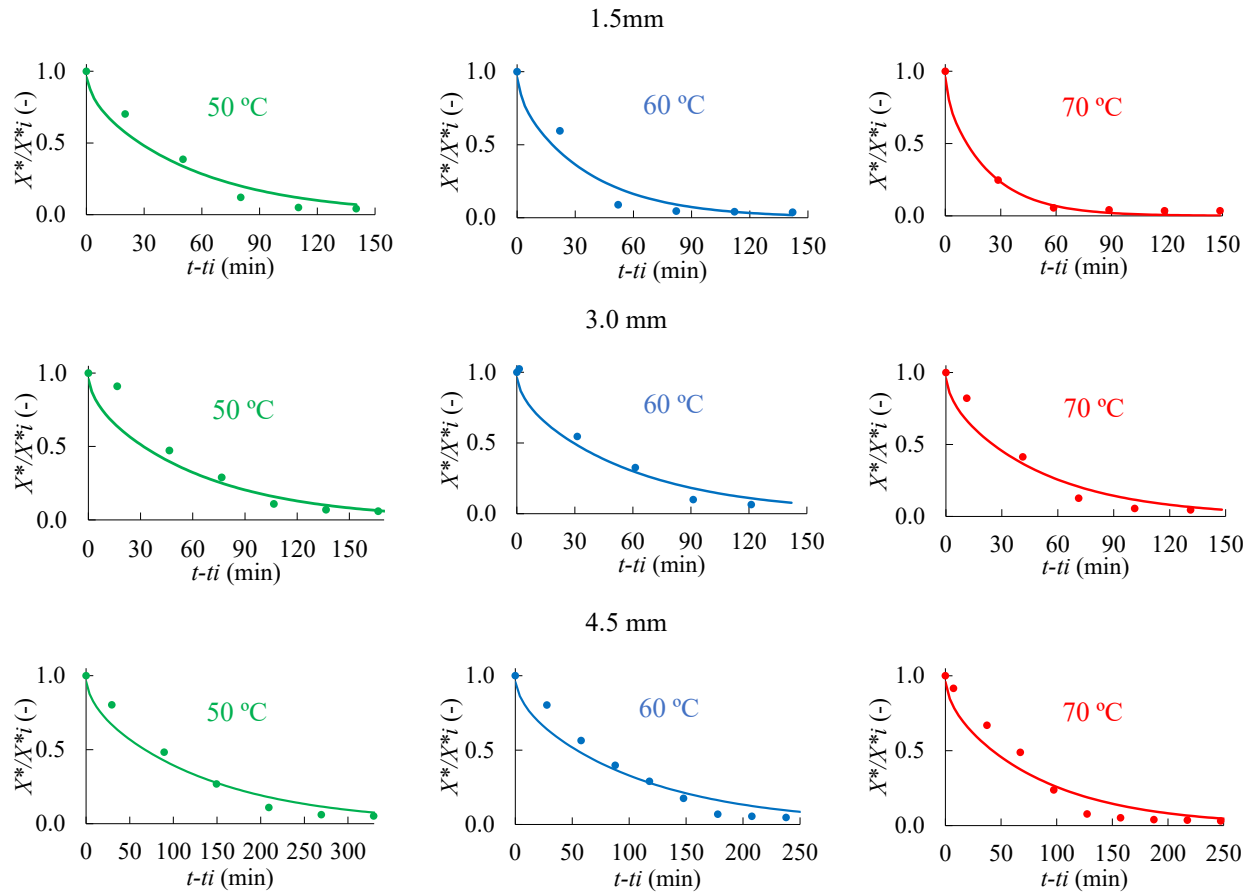


Figure 5 - Falling drying rate period (X^*/X_i^* vs. $t - t_i$) at different process temperatures (50, 60, and 70 °C) and pulp thickness (1.5, 3.0, and 4.5 mm). The points represent the experimental data and the solid lines the values calculated by Equation 5.

Table 2. Effective moisture diffusion coefficient (D , [$\text{m}^2 \text{s}^{-1}$]) and determination coefficient (R^2) obtained by fitting Equation 5 to the experimental data.

T (°C)	1.5mm		3.0 mm		4.5 mm	
	D [$\text{m}^2 \text{s}^{-1}$]	R^2	D [$\text{m}^2 \text{s}^{-1}$]	R^2	D [$\text{m}^2 \text{s}^{-1}$]	R^2
50	2.65×10^{-10}	0.958	9.32×10^{-10}	0.944	9.85×10^{-10}	0.964
60	4.06×10^{-10}	0.954	10.05×10^{-10}	0.966	12.33×10^{-10}	0.945
70	6.30×10^{-10}	0.994	11.70×10^{-10}	0.955	15.62×10^{-10}	0.945

4. Conclusions

This study evaluated the effects of air temperature and sample thickness on the drying kinetics of cupuassu pulp in an oven with forced air circulation. It was found that drying time can be reduced by 15%–30% for every 10 °C increase in air temperature independently of sample thickness. In addition, the drying time can be reduced about 60% at the temperatures of 50, 60 and 70 °C when sample thickness is reduced from 4.5 mm to 1.5 mm. The drying curves exhibited a sigmoidal shape, indicating that the drying process has a phase with an increasing drying rate followed by a phase with a falling drying rate. The modified Page model provided a good fit for the experimental data and allowed the calculation of important process parameters, such as the maximum drying rate and the time at which the falling drying rate period begins. The maximum drying rate for the sample thickness of 1.5 mm are approximately 2.4 - 2.7 times higher than those for a thickness of 4.5 mm from all temperature conditions, while the increase in the temperature from 50 to 70 °C cause an increasement of 1.5 - 1.9 times. Additionally, the effective moisture diffusion coefficient for the

cupuassu pulp was estimated to range from 2.65×10^{-10} to $1.56 \times 10^{-9} \text{ m}^2 \text{ s}^{-1}$ under the studied conditions.

The selection of appropriate temperature, sample thickness, and drying time for each food product can lead to more efficient processes in terms of energy consumption and result in dried products with higher nutritional and sensory quality. This study expands the understanding of the cupuassu pulp drying process, contributing to the technical and scientific development of processing fruits from the Amazon region.

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