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Original Article

Influence of drying temperature and cutting thickness on the drying kinetics of banana[1]

Influência da temperatura de secagem e da espessura de corte na cinética de secagem da banana

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HIGHLIGHTS:
Drying temperature and slice thickness significantly affected banana drying time, which ranged from 4 to 66 hours.
The Page model most accurately described the drying kinetics, with $R^2 > 0.99$ under all tested conditions.
Optimal drying conditions were achieved at 55 °C with 10 mm thick slices, ensuring both efficiency and product quality.

ABSTRACT: Banana drying, one of the most cost-effective methods of fruit dehydration, often faces challenges related to drying time and slice thickness. The time required for drying varies depending on temperature, humidity, and slice thickness, making it essential to ensure effective moisture removal without compromising product quality. This study aimed to analyze the influence of drying air temperature and slice thickness on drying time. Bananas were dried at four different temperatures (35, 45, 55, and 70 °C) and with five different slice thicknesses (5, 10, 20 mm, half (14.41 to 16.13 mm) [half the fruit's thickness], and whole (28.82 to 32.26) [entire fruit thickness]). To assess drying time, mathematical models (Lewis, Page, Henderson, and Thompson) were tested. The Page model best fitted the drying curves, with $R^2 = 0.99$ and $p \le 0.01$. According to Tukey's test at $p < 0.05$, both temperature and slice thickness had a significant effect on drying time, which ranged from 4 to 66 hours. A drying temperature of 55 °C and slice thickness of 10 mm resulted in a significantly more efficient drying process.

Key words: *Musa* sp., mathematical modeling, desorption

RESUMO: A secagem da banana, uma das formas mais econômicas de desidratação da fruta, pode apresentar gargalos significativos, especialmente em relação ao tempo de secagem e à espessura das fatias. O tempo necessário para a secagem varia conforme fatores como temperatura, umidade e espessura das fatias, sendo crucial para garantir a remoção adequada da umidade sem comprometer a qualidade do produto. O objetivo deste estudo foi analisar a influência da temperatura do ar de secagem e da espessura de corte no tempo de secagem. As bananas foram desidratadas em diferentes temperaturas de secagem (35, 45, 55 e 70 °C) e nas diferentes espessuras de corte (5, 10, 20 mm, metade (14,41 a 16,13 mm) (metade da espessura do fruto) e inteira (28.82 a 32.26) (espessura total do fruto)). Para avaliação do tempo de secagem foram testados modelos matemáticos (Lewis, Page, Hendersen e Thompson), sendo Page o modelo que melhor se ajustou às curvas de secagem com R^2 de 0,99 e $p \le 0,01$. Verificou-se pelo teste de Tukey at $p \le 0,05$, que a temperatura e a espessura de corte interferem significativamente no tempo de secagem, com períodos que variaram entre 4 e 66 horas. As temperaturas de ar de secagem de 55 °C com fatias cortadas à espessura de 10 mm proporcionaram um processo de secagem significativamente mais eficiente.

Palavras-chave: *Musa* sp., modelagem matemática, dessorção

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Introduction

Bananas are edible fruits from the *Musa* sp. genus, with an annual production of approximately 6.8 million tons and more than 200,000 producing establishments distributed throughout Brazil (IBGE, 2023). Achieving a high-quality product should be the goal of any production system, regardless of scale, as it promotes better market acceptance and increases financial returns for producers. A study on postharvest quality (Al-Dairi et al., 2023) emphasized the need to prioritize banana research focused on reducing postharvest losses in physical, chemical, and nutritional attributes.

The production of dried fruits from tropical species offers a viable alternative to mitigate losses during periods of surplus harvest, while also helping to reduce the volume of imported products. Of the tropical fruits, bananas are especially suitable for drying due to the availability of appropriate cultivars and the widespread nature of their cultivation across Brazil.

Banana raisins are obtained by naturally or artificially drying fully ripened fruits. Due to their nutritional value and desirable characteristics, they are excellent as food supplements in school meals, desserts in institutional food services, energy sources for athletes, and ingredients in the candy and chocolate industries. Most fruit dehydration processes use hot air drying, which is considered the simplest and most economical method. The resulting product typically has a dark color, firm texture, and subtle banana flavor, and can be stored for years without preservatives. However, using optimized drying techniques can yield a product with lighter color, uniform texture, softness, and a more pleasant taste and aroma (Lima et al., 2000).

Several authors have investigated banana raisin production using hot air drying (Khiari et al., 2019; Kumar et al., 2021; Nalbandi et al., 2021; Amer et al., 2023; Kushwah et al., 2023; Candemir et al., 2024). According to literature, the maximum drying air temperature used for banana raisin production is approximately 70 °C, although lower temperatures and ambient air drying have also been explored. Drying method parameters (eg, temperature, relative air humidity, and airflow) significantly influence the drying rate and the final product quality. Structural changes caused by drying may become more evident during storage. In line with Farias et al. (2020), who analyzed processing time, energy savings, and post-drying fruit quality, the authors recommended a drying temperature of 60 °C. Other studies also suggest drying bananas at temperatures between 60 and 70 °C to ensure product quality (Dongbang et al., 2020).

The aim of this study was to evaluate the drying time of bananas (*Musa* sp.) under different air temperatures and slice thicknesses.

Material and Methods

This study was conducted at the Department of Agricultural Engineering, Universidade Federal de Lavras, state of Minas Gerais, Brazil. The raw material used was the 'Nanica' banana (*Musa* sp.), selected at ripening stage 7, characterized by fully yellow peels with brown spots (Chitarra & Chitarra, 2005).

Prior to peeling, bananas were immersed in chlorinated water (300 ppm of active chlorine) for 20 min and then air-dried to reduce microbial load and eliminate potential surface contaminants such as fungi and bacteria. The fruits were then peeled and subjected to sulfitation by immersion in a 0.5% sodium metabisulfite solution for 1 min (Silva, 1995), before being placed on trays for drying. This pretreatment aimed to prevent enzymatic browning.

A completely randomized experimental design was used, with four drying temperatures (40, 50, 60, and 70 °C) and five slice thicknesses: 5, 10, 20 mm, half slices (14.41 to 16.13 mm), and whole slices (28.82 to 32.26 mm), with three replicates. The selected temperatures and thicknesses were based on values reported in literature.

Environmental conditions were controlled using an atmospheric conditioning unit equipped with systems to regulate both air temperature and relative air humidity (average temperature: 21.67 °C; average relative air humidity [RH]: 75.96%). Drying was performed in a convective dryer, model PD-25.

During the desorption process, trays containing the banana slices were periodically weighed to monitor weight loss. Sampling was conducted at one-hour intervals. The drying process was considered complete when the moisture ratio (RX) reached or fell below 0.05.

Mathematical models were fitted to the experimental data to predict hygroscopic equilibrium, which is commonly used to estimate water activity in agricultural products. The best-fitting model was the Modified Halsey model (Eq. 1) (Andrade et al., 2000).

$$U_e = \left[\frac{\exp(-2.7847 - 0.0222T)}{-\ln(a_w)}\right]^{\frac{1}{2.6235}} \tag{1}$$

where:

U_e - equilibrium moisture content (dry basis, d.b.);
T - ambient air temperature (°C); and,
a_w - water activity (decimal).

To fit the mathematical models to the experimental drying curves, nonlinear regression analysis was performed using the Quasi-Newton method in STATISTICA 5.0 software. The model parameters were estimated based on the independent variables: air temperature and equilibrium moisture content of the product.

The experimental drying data of banana samples were fitted to classical drying models (Jayas et al., 1995): Lewis, Page, Henderson, and Thompson, represented by Eq. 2 through 5:

$$RX = \exp\left(-kt^n\right) \tag{2}$$

$$RX = a\exp\left(-kt\right) + c \tag{3}$$

$$RX = a\exp\left(-kt\right) + \left(1-a\right)\exp\left(-kat\right) \tag{4}$$

$$RX = \left\{\left[-a - \left(-a^2 + 4bt\right)^{0.5}\right]\left(2b\right)^{-1}\right\} \tag{5}$$

where:

RX - moisture ratio (dimensionless);

T - drying time (hours); and,

k, a, b, c, n - empirical constants dependent on product characteristics.

Experimental data were compared with the values predicted by each model using the relative mean error (P) and the standard error of estimate (SE), as shown in Eqs. 6 and 7. The model's ability to accurately describe the physical drying process is inversely proportional to the SE value (Draper & Smith, 1981; Chen & Morey, 1989; Chen & Jayas, 1998):

$$P = \frac{100}{n}\sum\left(\frac{\left|Y-\hat{Y}\right|}{Y}\right) \tag{6}$$

$$SE = \left[\frac{\sum\left(Y-\hat{Y}\right)^2}{DF}\right] \tag{7}$$

where:

Y - experimental value;

Y - value predicted by the model; and,

DF - degrees of freedom of the model.

The goodness of fit of the mathematical models to the experimental data was evaluated based on the adjusted coefficient of determination (explained variance) and the magnitudes of the relative mean error and the standard error of estimate.

Drying time was defined using the model that best fit the experimental data. For this analysis, drying was considered complete when the RX reached 0.05.

Data were subjected to ANOVA at a 5% significance level ($p \leq 0.05$) by using a completely randomized design in a 5 × 4 factorial arrangement (cutting thickness × drying temperature). When a significant interaction between factors was observed, a simple effects analysis was performed, with one factor broken down within the levels of the other. The qualitative factor (cutting thickness) was analyzed using Tukey's test for mean comparison, while the quantitative factor (drying temperature) was analyzed using regression. All statistical analyses were conducted using SISVAR software (Ferreira, 2011).

Results and Discussion

Figure 1 shows the drying curves of bananas with different slice thicknesses at various drying air temperatures.

The drying kinetics curves presented in Figure 1 show that increasing the drying air temperature reduces the drying time, while increasing slice thickness prolongs the drying period. For drying air temperatures ranging from 35 to 70 °C and varying slice thicknesses, the drying time ranged from approximately 7 hours to over 100 hours. Nguyen & Price (2007) observed similar behavior when drying banana slices of 1 cm and 2 cm at temperatures of 30, 40, 50, 60, and 70 °C. They reported that drying at 30 °C took nearly ten times longer than at 70 °C.

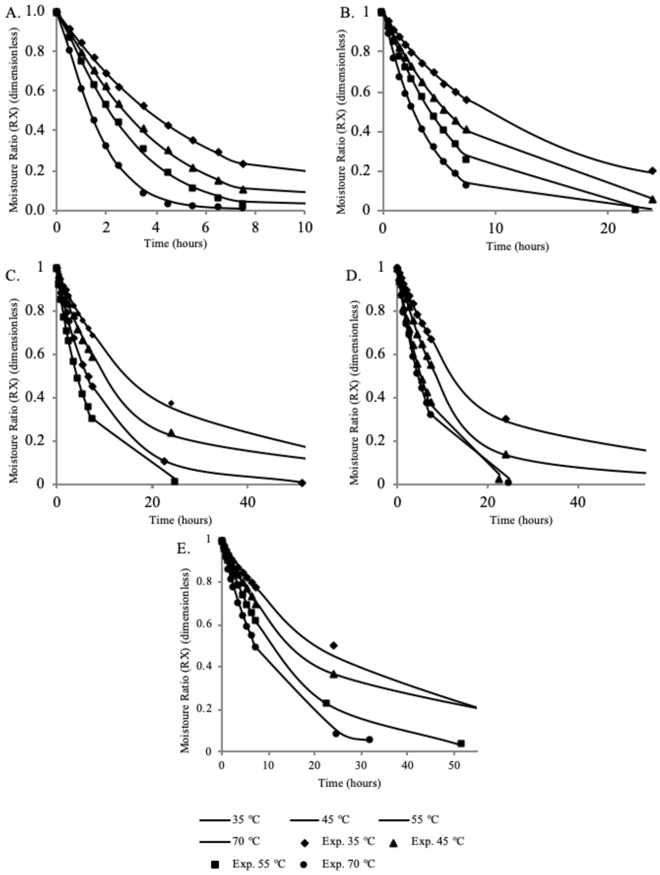


Figure 1. Moisture ratio as a function of drying time for bananas with different slice thicknesses: (A) 5 mm, (B) 10 mm, (C) 20 mm, (D) half, and (E) whole slices, at drying air temperatures of 35, 45, 55, and 70 °C

For the mathematical modeling of drying kinetics, the models described in Eqs. 1 through 4 were applied. For each model, the corresponding parameters, coefficients of determination (R^2), relative mean error (P), and standard error of estimate (SE) were calculated. The modeling results for banana drying kinetics are presented in Table 1.

An analysis of the modeling results presented in Table 1 indicates that the Page model best described the drying behavior of banana slices under most conditions. This model consistently showed the highest R^2 and P below 10%, indicating a good fit (Rios et al., 2020). According to Simha et al. (2016), a model's ability to accurately represent a physical process is inversely proportional to its SE. Therefore, the assessment of model performance considers the magnitude of R^2, P, and SE values.

In addition, the drying constant k, derived from the mathematical models for each temperature and slice thickness, was found to increase with rising drying air temperature (Figure 2) (Oliveira et al., 2020). According to Madamba et al. (1996) and Babalis & Belessiotis (2004), k serves as a useful parameter to characterize the influence of temperature. It is associated with the effective moisture diffusivity during the falling rate period of drying, governed by liquid diffusion mechanisms.

Figure 3 presents the drying times of banana slices with varying thicknesses subjected to different drying air temperatures. A significant difference ($p \leq 0.05$) was observed between the drying temperatures and slice thicknesses. As expected, thicker slices required longer drying times at a given temperature. Drying kinetics for various agricultural products have also been reported in the literature. Ananda, Kumar & Kumar (2024) investigated drying times for raisin grapes at temperatures ranging from 45 to 65 °C, reporting durations between 33.3 and 95.3 hours. Joarder & Karim (2022) evaluated the drying behavior of 10 mm thick apple slices under different drying methods — intermittent

Table 1. Estimated parameters of the models fitted to the drying data of bananas with different slice thicknesses (5, 10, 20 mm, half, and whole) at drying air temperatures of 35, 45, 55, and 70 °C

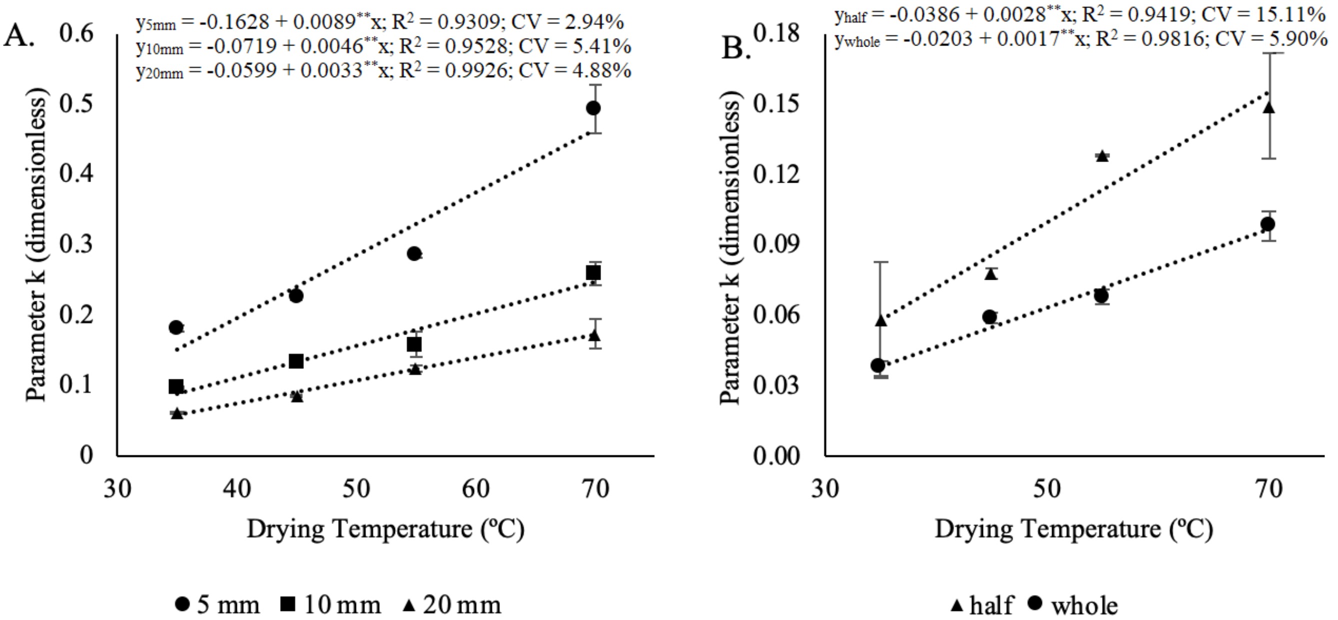
			k	n	c	a	b	R^2	P	SE
35 °C	5 mm	Lewis	0.190					99.928	4.310	0.008
		Page	0.180	1.040				99.971	0.801	0.005
		Hendersen	0.191		1.015	-0.006		99.956	6.419	0.007
		Thompson				0.125	2.068	86.893	772.426	0.401
	10 mm	Lewis	0.080					99.313	3.090	0.018
		Page	0.097	0.893				99.953	0.639	0.005
		Hendersen	0.077	0.030	0.015			99.953	0.639	0.005
		Thompson				0.344	0.674	85.700	33.510	0.268
	20 mm	Lewis	0.048					99.420	5.033	0.020
		Page	0.060	0.906				99.791	11.537	0.013
		Hendersen	0.044		0.985	-0.007		99.651	3.449	0.003
		Thompson				0.290	0.646	85.904	39.280	0.288
	Half	Lewis	0.053					99.915	22.384	0.008
		Page	0.060	0.977				99.933	27.910	0.007
		Hendersen	0.051		1.009	-0.014		99.935	7.590	0.002
		Thompson				0.238	0.767	84.642	144.248	0.199
	Whole	Lewis	0.033					99.659	9.608	0.020
		Page	0.037	0.964				99.691	14.855	0.020
		Hendersen	0.029		1.011	-0.034		99.838	2.547	0.007
		Thompson				0.285	0.640	86.920	32.553	0.296
45 °C	5 mm	Lewis	0.267					99.447	11.018	0.027
		Page	0.224	1.141				99.920	10.166	0.011
		Hendersen	0.262		1.050	-0.027		99.658	5.536	0.008
		Thompson				0.428	1.062	83.960	508.175	0.138
	10 mm	Lewis	0.126					99.934	1.978	0.025
		Page	0.132	0.969				99.965	3.001	0.010
		Hendersen	0.122		0.998	-0.008		99.967	1.045	0.021
		Thompson				0.449	0.706	85.230	39.990	0.148
	20 mm	Lewis	0.071					99.739	9.044	0.007
		Page	0.083	0.919				99.929	5.566	0.005
		Hendersen	0.072		0.969	0.022		99.837	10.692	0.005
		Thompson				0.248	0.824	89.638	63.177	0.266
	Half	Lewis	0.082					99.945	1.365	0.015
		Page	0.077	1.031				99.983	0.527	0.008
		Hendersen	0.078		1.036	-0.035		99.990	0.226	0.004
		Thompson				0.354	0.667	80.799	32.169	0.152
	Whole	Lewis	0.047					99.633	5.243	0.006
		Page	0.058	0.899				99.965	3.786	0.003
		Hendersen	0.044		0.969	0.010		99.888	1.598	0.003
		Thompson				0.284	0.639	87.783	35.408	0.286
55 °C	5 mm	Lewis	0.352					99.026	40.412	0.017
		Page	0.285	1.202				99.860	14.517	0.005
		Hendersen	0.334		1.076	-0.046		99.514	12.448	0.001
		Thompson				0.345	1.418	81.416	343.114	0.288
	10 mm	Lewis	0.170					99.757	2.002	0.026
		Page	0.159	1.049				99.847	1.771	0.007
		Hendersen	0.135		1.159	-0.163		99.918	1.355	0.008
		Thompson				0.475	0.761	81.696	28.809	0.172
	20 mm	Lewis	0.111					99.522	3.125	0.036
		Page	0.123	0.936				99.687	4.857	0.014
		Hendersen	0.104		0.996	-0.014		99.640	2.729	0.024
		Thompson				0.544	0.580	83.855	54.063	0.301
	Half	Lewis	0.134					99.838	19.929	0.012
		Page	0.128	1.032				99.867	16.378	0.010
		Hendersen	0.124		1.046	-0.048		99.970	0.686	0.008
		Thompson				0.474	0.704	83.224	65.295	0.225
	Whole	Lewis	0.067					99.975	1.656	0.018
		Page	0.067	0.999				99.975	1.742	0.016
		Hendersen	0.066		1.005	-0.007		99.978	0.087	0.018
		Thompson				0.235	0.856	84.184	53.935	0.399

Continued on next page

Continuation of Table 1

			k	n	c	a	b	R^2	P	SE
70 °C	5 mm	Lewis	0.586					98.832	106.214	0.011
		Page	0.495	1.278				99.922	24.619	0.011
		Hendersen	0.547		1.080	-0.048		99.467	13.770	0.000
		Thompson				0.475	1.382	81.208	1041.446	0.273
	10 mm	Lewis	0.267					99.900	2.690	0.005
		Page	0.260	1.021				99.916	2.549	0.005
		Hendersen	0.251		1.033	-0.033		99.936	0.029	0.001
		Thompson				0.253	1.514	85.514	98.369	0.148
	20 mm	Lewis	0.166					99.908	0.690	0.048
		Page	0.174	0.966				99.959	0.543	0.024
		Hendersen	0.182		0.941	0.059		99.956	0.013	0.020
		Thompson				0.521	0.702	83.686	34.481	0.304
	Half	Lewis	0.154					99.956	0.431	0.042
		Page	0.150	1.014				99.964	0.512	0.012
		Hendersen	0.151		1.020	-0.017		99.966	0.026	0.030
		Thompson				0.545	0.652	81.594	40.955	0.309
	Whole	Lewis	0.098					99.918	1.997	0.008
		Page	0.097	1.003				99.918	2.282	0.008
		Hendersen	0.097		1.007	-0.007		99.922	0.159	0.000
		Thompson				0.579	0.545	82.989	49.048	0.299

k, a, b, c, n - Constants of equations; P - Relative mean error (%); SE - Standard error of estimate; R^2- Coefficient of determination (%)



** - Significant at p ≤ 0.01 by the F-test. Vertical bars represent the standard deviation of the mean

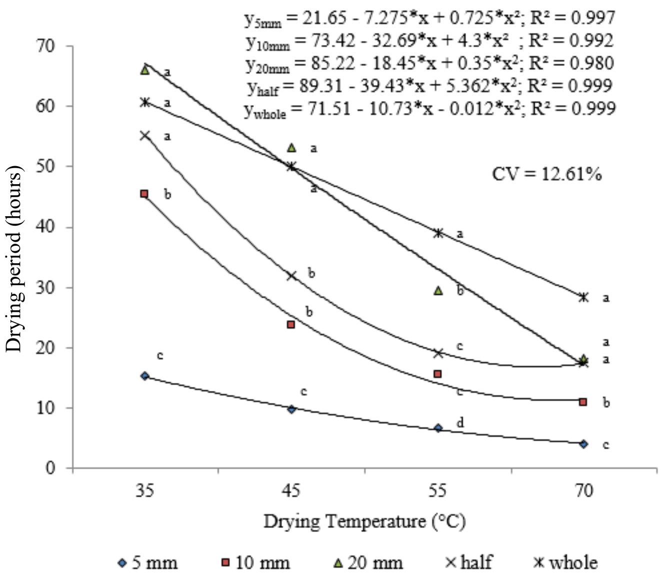
Figure 2. Parameter k of the Page model as a function of drying air temperature and slice thickness: (A) 5, 10, and 20 mm; (B) half and whole slices

microwave-convective, continuous microwave-convective, and conventional convective drying — and observed drying times ranging from 15 to 200 hours. Among the tested methods, convection drying resulted in the longest drying duration.

As shown in Figure 3, the drying period decreased significantly with thinner banana slice cuts, ranging from 4.05 to 65.95 hours. This variation can negatively affect productivity when scaling up to industrial levels. According to El-Mesery & El-Khawaga (2022), higher drying temperatures reduce the energy consumption of the dryer. However, elevated temperatures may also alter the sensory qualities of the fruit, including color, aroma, and texture. Food color changes are associated with surface alterations, pigment degradation, and chemical reactions during drying (Tully et al., 2023).

The reduction in drying time with increasing temperature and decreasing slice thickness is a key factor in enhancing the efficiency of the dehydration process (Tunçkal & Doymaz, 2020). Thinner slices dry faster due to the shorter moisture diffusion path and greater exposed surface area, which improve both heat and mass transfer. Understanding these factors is crucial for optimizing process parameters to reduce energy consumption while improving the final product's quality.

An alternative strategy to shorten drying time without exceeding the maximum temperatures tolerable for maintaining banana quality is to increase the drying air velocity, as reported by Alves et al. (2020). Similarly, Amer et al. (2023) found that high temperatures (up to 70 °C), combined with a moderate air velocity (0.75 m s^{-1}) and thin slices (2 mm), represent optimal conditions for commercial-scale banana drying. These parameters produced shorter drying times and satisfactory final quality in terms of color, firmness, water activity, total soluble solids (TSS), and titratable acidity (TA). In line with



* - Significant at p ≤ 0.05, by the F-test. The means followed by the same letter do not differ according to the Tukey test at p ≤ 0.05

Figure 3. Drying time of banana slices with different thicknesses at various drying air temperatures

these findings, Taskin et al. (2021) demonstrated that proper implementation of convective drying in industrial settings can improve product quality while reducing energy demands.

Conclusions

1. The results of this study provide valuable guidance for fruit dehydration industries in selecting appropriate temperatures for convective drying, a widely used technique in commercial operations.

2. The most efficient drying conditions were achieved at 55 °C with slice thicknesses up to 5 mm, and at 70 °C with slice thicknesses up to 10 mm. These combinations yielded significantly shorter drying times and are recommended as optimal parameters for banana dehydration.

Contribution of authors: Andrade, E. T.: formal analysis, methodology, literature review, investigation, data collection, data curation and supervision of the work. Silva, J. G.; Pereira, R. G.; and Teixeira, L. P.: writing – original draft preparation, methodology, literature review, investigation, data collection. Oliveira, F. S.: writing – review and editing the manuscript, literature review, investigation, data curation. Palacios, S. S. M.; Padilla, J. R. R.; and Sarmento, C. S. A. G.: writing – review and editing the manuscript.

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Literature Cited

Alves, G. E.; Borém, F. M.; Andrade, E. T.; Isquierdo, E. P.; Siqueira, V. C.; Dias, C. A. Influence of different temperatures and airflows on drying of natural and pulped coffee. Engenharia Agrícola, v.40, p.192-200, 2020. https://doi.org/10.1590/1809-4430-eng.agric.v40n2p192-200/2020

Al-Dairi, M.; Pathare, P. B.; Al-Yahyai, R.; Jayasuriya, H.; Al-Attabi, Z. Postharvestquality, technologies, andstrategiestoreducelossesalongthesupplychainof banana: A review.Trends in Food Science & Technology, v.134, p.177-191, 2023. https://doi.org/10.1016/j.tifs.2023.03.003

Amer, B. M.; Azam, M. M.; Saad, A. Monitoring temperature profile and drying kinetics of thin-layer banana slices under controlled forced convection conditions. Processes, v.11, e1771, 2023. https://doi.org/10.3390/pr11061771

Ananda, P. D.; Kumar, G. S.; Kumar, S. A. Drying kinetics and mathematical modelling of raisin production by abrasive and chemical pre-treatment of grapes: drying kinetics of grape with abrasive process. Journal of Scientific & Industrial Research, v.83, p.350-361, 2024. https://doi.org/10.56042/jsir.v83i4.5882

Babalis, S. J.; Belessiotis, V. G. Influence of the drying conditions on the drying constants and moisture diffusivity during the thin-layer drying of figs. Journal of Food Engineering, v.65, p.449-458, 2004. https://doi.org/10.1016/j.jfoodeng.2004.02.005

Candemir, A.; Koç, G. Ç.; Dirim, N.; Pandiselvam, R. Effect of ultrasound pretreatment and drying air temperature on the drying characteristics, physicochemical properties, and rehydration capacity of raisins. Biomass Conversion and Biorefinery, v.14, p.19623-19635, 2024. https://doi.org/10.1007/s13399-023-04269-8

Chen, C.; Jayas, D. S. Evaluation of the GAB equation for the isotherms of agricultural products. Transactions of ASAE, v.41, p.1755-1760, 1998. https://doi.org/10.13031/2013.17319

Chen, C.; Morey, V. Equilibrium relativity humidity (ERH) relationships for yellow-dente corn. Transactions of ASAE, v.32, p.999-1006, 1989. https://doi.org/10.13031/2013.31105

Chitarra, M. I. F.; Chitarra, A. B. Pós-colheita de frutos e hortaliças: fisiologia e manuseio. 2.ed. Lavras: Editora UFLA, 2005. 783p.

Dongbang, W.; Nuantong, W. Investigation of mathematical modeling for banana slices drying using hot air technique. Naresuan University Journal: Science and Technology, v.28, p.79-87, 2020. https://doi.org/10.14456/nujst.2020.28

Draper, N. R.; Smith, H. Applied regression analysis. New York: John Wiley & Sons, 1981. 709p.

El-Mesery, H. S.; El-Khawaga, S. E. Drying process on biomass: Evaluation of the drying performance and energy analysis of different dryers. Case Studies in Thermal Engineering, v.33, e101953, 2022. https://doi.org/10.1016/j.csite.2022.101953

Farias, R. P.; Gomez, R. S.; Silva, W. P.; Silva, L. P.; Oliveira Neto, G. L.; Santos, I. B.; Lima, A. G. Heat and mass transfer, and volume variations in banana slices during convective hot air drying: An experimental analysis.Agriculture, v.10, e423, 2020. https://doi.org/10.3390/agriculture10100423

Ferreira, D. F. Sisvar: um sistema computacional de análise estatística. Ciência e Agrotecnologia, v.35, p.1039-1042, 2011. https://doi.org/10.1590/S1413-70542011000600001

IBGE – Instituto Brasileiro de Geografia e Estatística. PAM: Produção agrícola municipal. Available at: https://www.ibge.gov.br/estatisticas/economicas/agricultura-e-pecuaria/9117-producao-agricola-municipal-culturas-temporarias-e-permanentes.html. Accessed on: dec. 2024.

Jayas, D. S.; White, N. D. G.; Muir, W. E. Stored-Grain ecosystems. New York: Marcel Dekker, 1995. 757p.

Joardder, M. U.; Karim, M. A. Drying kinetics and properties evolution of apple slices under convective and intermittent-MW drying. Thermal Science and Engineering Progress, v.30, e101279, 2022. https://doi.org/10.1016/j.tsep.2022.101279

Khiari, R.; Zemni, H.; Mihoubi, D. Raisin processing: Physicochemical, nutritional and microbiological quality characteristics as affected by drying process. Food Reviews International, v.35, p.246-298, 2019. https://doi.org/10.1080/87559129.2018.1517264

Kumar, R.; Pandey, O. P.; Dhiman, S. K.; Kumar, P. Influence of blanching and drying air temperature on drying kinetics of banana slices. Journal of Biosystems Engineering, v.46, p.375-385, 2021. https://doi.org/10.1007/s42853-021-00114-w

Kushwah, A.; Kumar, A.; Gaur, M. K.; Pal, A. Heat and mass transfer, quality, performance analysis, and modeling of thin layer drying kinetics of banana slices. Journal of Solar Energy Engineering, v.145, e051010, 2023. https://doi.org/10.1115/1.4062447

Lima, A.G.B.; Nebra, S. A.; Queiroz, M. R. Aspectos científico e tecnológico da banana. Revista Brasileira de Produtos Agroindustriais, v.2, p.87-101, 2000.

Madamba, P. S.; Driscoll, R. H.; Buckle, K. A. The thin layer drying characteristics of garlic slices. Journal of Food Engineering, v.29, p.75-97, 1996. https://doi.org/10.1016/0260-8774(95)00062-3

Nalbandi, H.; Seiiedlou, H.; Syied, S.; Gheshlagh, P. Determination of optimum performance characteristics of combined infrared-convectional dryer in drying of banana slices. Agricultural Mechanization, v.6, p.11-21, 2021. https://doi.org/10.22034/jam.2021.13112

Oliveira, F. S.; Andrade, E. T.; Rios, P. A.; Moreira, K. S.; Salvio, L. G. A. Modelagem matemática da cinética de secagem e equilíbrio higroscópico de folhas de *Cymbopogon flexuosus*. Research, Society and Development, v.9, e10973594, 2020. https://doi.org/10.33448/rsd-v9i7.3594

Rios, P. A.; Andrade, E. T.; Moreira, K. S.; Oliveira, F. S.; Araújo, B. L. O. Drying kinetics of chinese garlic (*Allium tuberosum*) and its effect on color. Revista Ciência e Natura, v.42, e3424, 2020. https://doi.org/10.5902/2179460X43424

Silva, C. A. B. Produção de banana-passa. Brasília. Ministério da Agricultura, do Abastecimento e da Reforma Agrária, Secretaria do Desenvolvimento Rural, 1995, 32p. (Série perfis agroindustriais, 5).

Tuly, S. S.; Mahiuddin, M.; Karim, A. Mathematical modeling of nutritional, color, texture, and microbial activity changes in fruit and vegetables during drying: A critical review. Critical Reviews in Food Science and Nutrition, v.63, p.1877-1900, 2023. https://doi.org/10.1080/10408398.2021.1969533

Tunca, C.; Doymaz, İ. Performance analysis and mathematical modelling of banana slices in a heat pump drying system. Renewable Energy, v.150, p.918-923, 2020. https://doi.org/10.1016/j.renene.2020.01.040