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Influence of Drying Temperature of Jambu Leaves (*Acmella Oleracea*) in a Spray Dryer

Nathan Mickael de Bessa Cunha[1], Gicelly da Silva Maia[1] & Ivano Alessandro Devilla[1]

[1] Institute of Agricultural Science, State University of Goiás, Anápolis-GO, Brazil

Correspondence: Nathan Mickael de Bessa Cunha, Institute of Agricultural Science, State University of Goiás, Anápolis-GO, BR 153, Campus Henrique Santillo, Brazil. E-mail: nathan.cunha@aluno.ueg.br

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Abstract

Jambu (*Acmella oleracea*), also known as Pará cress, is a plant widely used in cuisine and traditional medicine, standing out for causing a tingling sensation in the mouth due to the presence of the compound spilanthol. This research aimed to analyze the effects of inlet temperature on the drying process of Jambu leaf extract using a spray dryer. The experiment was conducted at temperatures of 110°C and 140°C, respectively. The results indicated that the higher temperature (140°C) provided a greater powder yield (40.10%) compared to 110°C (30.94%). Water activity remained below 0.3 in both conditions, indicating microbiological stability. The color of the powder showed no significant variations, maintaining favorable visual characteristics. The bulk density was lower at 140°C (0.22 g.cm^{-3}) compared to 110°C (0.39 g.cm^{-3}). Morphological analysis revealed that higher temperature resulted in more spherical and regular particles.

Keywords: medicinal plants, extract, atomization, powder

1. Introduction

1.1 Introduce the Problem

The Jambu (*Acmella oleracea*), also known as agrião-do-Pará, is a small-sized plant with creeping and branched stems, belonging to the Asteraceae family. Jambu offers several health benefits and is appreciated in different regions, especially in gastronomy, in dishes such as tacacá, pato no tucupi, and fresh salads. Additionally, it is used in traditional medicine to treat stomatitis, colds, and as an analgesic (MOREIRA et al., 2023; NASCIMENTO et al., 2013).

As indicated by Lorenzi and Matos (2002), consuming Jambu causes a mild tingling and numbing sensation in the mouth, distinctive characteristics of this herbaceous plant, attributed to the presence of spilanthol. This compound has attracted interest due to its various biological and pharmacological activities, making it a subject of study for researchers and industry (LIMA, 2021).

The increasing demand for this plant and its benefits has led researchers and industries to invest in techniques and methods to maintain the quality, efficacy, and safety of these food products. Hertwig (1986) highlights that the drying of medicinal and aromatic plants aims to remove free water from cells and tissues, preventing enzymatic degradation and preserving chemical quality for a longer period.

Various drying methods can be applied to fruit, vegetable, and medicinal herb extracts, such as freeze-drying, oven drying, and the atomization process known as spray drying. This equipment is frequently used due to its ability to convert aqueous solutions into powder, thanks to high temperatures and the short exposure time of the product in the drying chamber. These conditions result in a rapid evaporation rate, producing high-quality products (CAMPOS et al., 2022; OLIVEIRA, 2021).

The use of a spray dryer for drying products of interest results in high-value-added products, requiring prior precautions. The operational conditions applied in drying and processing can significantly influence the properties and costs of the product, leading to different levels of loss.

Given the above, this study aimed to analyze the impacts of drying temperatures on the physical properties of Jambu leaf powder obtained through the atomization process.

2. Materials and Methods

2.1 Obtaining the Raw Material

Jambu leaves (*Acmella oleracea*) were purchased from the local market in the city of Belém-PA. After acquisition, the leaves were transported to the Laboratory of Drying and Storage of Plant Products, part of the State University of Goiás, in Anápolis-GO, in October 2023, when the experiment began.

In the laboratory, the leaves were manually selected and visually inspected to ensure uniformity in appearance, size, and preservation. Then, they were washed under running potable water to remove surface impurities and subsequently subjected to thermal treatment.

2.2 Blanching

The samples underwent thermal blanching by immersion in hot water at 90°C ± 2°C, using a digital water bath NT267, for 30 seconds. After this period, they were removed with the aid of a spatula and immediately immersed in cold water at 10°C ± 2°C, where they remained for approximately 60 seconds until completely cooled. The samples were then packed in transparent polyethylene bags, each containing approximately 200 g, and stored in a horizontal freezer (H500) at -10°C.

2.3 Extract Preparation

Before the spray drying process in experiments involving blanching, the frozen Jambu leaf samples were processed in a Multiprocessor PMP1600. During this process, water was added in a 1:2 ratio (one part of leaves to two parts of water by mass) to obtain an extract, as illustrated in Figure 1. The extract was sieved through a 1.00 mm mesh to remove larger particles, which were discarded. This procedure was adopted to prevent the risk of clogging the atomizer nozzle during spray drying.

An amount equivalent to 30% of maltodextrin, relative to the solid content, was added to the extract. The determination of solid content was carried out by drying in a forced-air circulation oven at 40°C, with the process maintained until a constant mass was reached, indicating the complete removal of moisture.

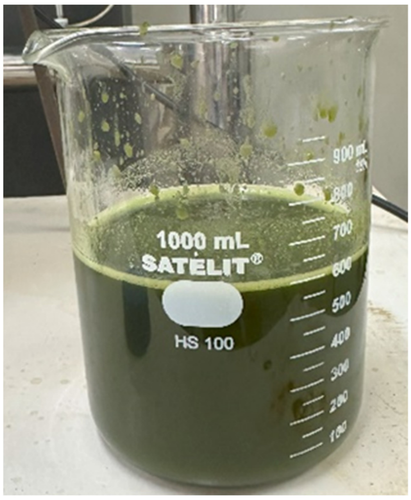


Figure 1. Jambu leaf extract

2.4 Spray Dryer Drying

The spray drying process was performed using a spray dryer (LM MSD 1.0, LabMaq, Brazil) with a nominal capacity of 1 $L \cdot h^{-1}$. The model used for drying is shown in Figure 2. The equipment consists of an atomizing nozzle, air inlet (valve), solution inlet, cyclone, drying chamber, and exhaust system. The experiments employed an atomizing nozzle with a 1.2 mm diameter and an atomization flow rate of 0.26 $L \cdot h^{-1}$.

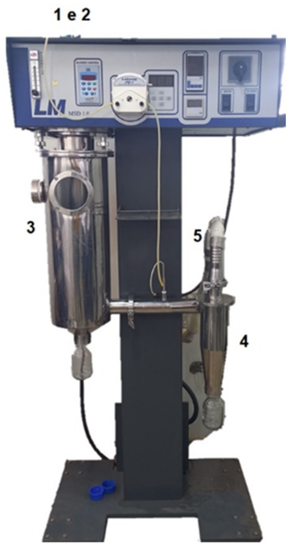


Figure 2. Spray dryer used for drying the Jambu extract, where: (1 and 2) indicate the position of the atomizing nozzle and the air and solution inlets; (3) denotes the drying chamber location; (4) refers to the cyclone; (5) represents the air and fine particle exhaust (non-collected)

The experiment involved drying the leaves at two different temperatures: 110°C and 140°C. The following variables were considered for evaluation: powder yield, water activity, color, and bulk density. Each of these variables provided essential data for understanding the behavior of the material during the drying process.

2.5 Physical Characterization of the Powdered Product

2.5.1 Yield

The drying yield for each test in the study was estimated as the ratio between the mass of solids in the collected powder product and the mass of solids in the Jambu extract fed into the spray dryer, as shown in Equation 1:

$$RS = \frac{mass\ \ of\ \ solid\ \ powder}{mass\ \ of\ \ solid\ \ extract} \text{ x } 100 \quad (1)$$

Where RS is the drying yield (%).

2.5.2 Water Activity

Water activity (A_w) was determined in triplicate using an Aqualab Series 4 TEV, previously calibrated with a LiCl solution (A_w = 0.500) until stabilization at room temperature (25ºC), as recommended by the equipment manual. The A_w reading was then taken from the sample. This indicator is associated with the moisture content in the powder and is crucial for identifying the amount of available water, which can influence microbial growth as well as the chemical and enzymatic reactivity of the material.

2.5.3 Color

The analyzed parameters included luminosity (L*), referring to the visual aspect of the powder in terms of brightness (100 = bright, 0 = dark), hue angle (°Hue), and color saturation (Chroma). A Konica Minolta CR-400 colorimeter (Figure 3) was used to obtain, via reflectance, information on luminosity and coordinates:

a*: indicating green intensity (-a) to red intensity (+a).

b*: indicating blue intensity (-b) to yellow intensity (+b).

For each sample, the hue angle (°Hue) and Chroma were determined using Equations 2 and 3, respectively.

$$\text{Hue} = arctang\left(\frac{a^*}{b^*}\right) \quad (2)$$

$$\text{Chroma} = \sqrt{a^{*2} + \ \ b^{*2}} \quad (3)$$

Figure 3. Konica Minolta CR-400 colorimeter

2.5.4 Bulk Density

Bulk density was determined by individually weighing 1 g of each sample and transferring it into 10 mL graduated cylinders. This procedure was repeated three times for each sample. Bulk density was then estimated as the ratio between the volume (mL) occupied by the powdered material and the total weighed mass (g).

2.5.5 Scanning Electron Microscopy (SEM)

In addition to these analyses, a detailed morphological characterization of the powder was conducted using a Scanning Electron Microscope (SEM). This procedure allowed for a more in-depth observation of the structure and physical characteristics of the material obtained after drying.

2.5.6 Data Processing and Analysis

After all laboratory analyses, the data were tabulated and the mean values obtained in each evaluation were estimated. This approach provided a consolidated and comparative view of the characteristics of the Jambu powder produced at both tested temperatures, ensuring consistency and appropriate interpretation of the results.

3. Results and Discussion

The average powder yield was 30.94% at 110°C and 40.10% at 140°C. According to Kiritsakis (2018), when evaluating the spray drying of Olive leaf extract, the product yield increased proportionally with the increase in the drying air temperature, reaching significant values around 150°C. The study by Santhalakshmy et al. (2015) while evaluating the effect of inlet temperature on the physicochemical properties of spray dried jamun fruit juice powder also indicated an increase in yield when evaluating the powder obtained at temperatures between 140°C and 160°C, with the maximum yield recorded at 150°C.

As highlighted by Goula and Adamopoulos (2005), wall deposits decrease as drying temperature increases. This occurs because higher temperatures result in drier droplets upon reaching the chamber walls, reducing deposits caused by improper particle drying. However, when the inlet air temperature exceeds 150°C, higher outlet temperatures lead to greater residue accumulation. In this study, the cyclone walls did not reach sufficiently low temperatures to promote cooling and solidification of thermoplastic particle surfaces upon contact. As a result, the droplets remained in a plastic state due to the high ambient temperature.

It is worth noting that the dryer design does not allow direct adjustment of the outlet air temperature via a controller, unlike the inlet temperature. Instead, the outlet temperature is determined by the interaction of inlet temperature, vacuum settings, pump flow, and feed concentration.

Water activity (A_w) refers to the amount of free water available in a food system, playing a critical role in biochemical and microbiological reactions. Higher A_w levels indicate greater water availability, which reduces the shelf life of the product (Quek et al., 2007).

All analyzed powder samples exhibited A_w values below 0.3, which is favorable for powder stability. The average A_w values were 0.21 (110°C) and 0.14 (140°C), indicating significant biochemical and microbiological stability. Similar results were reported by Gomes et al. (2021) in their study on *Lippia alba* extract powder, which showed

A_w values of 0.2 and 0.49 for drying temperatures of 70°C and 50°C, respectively.

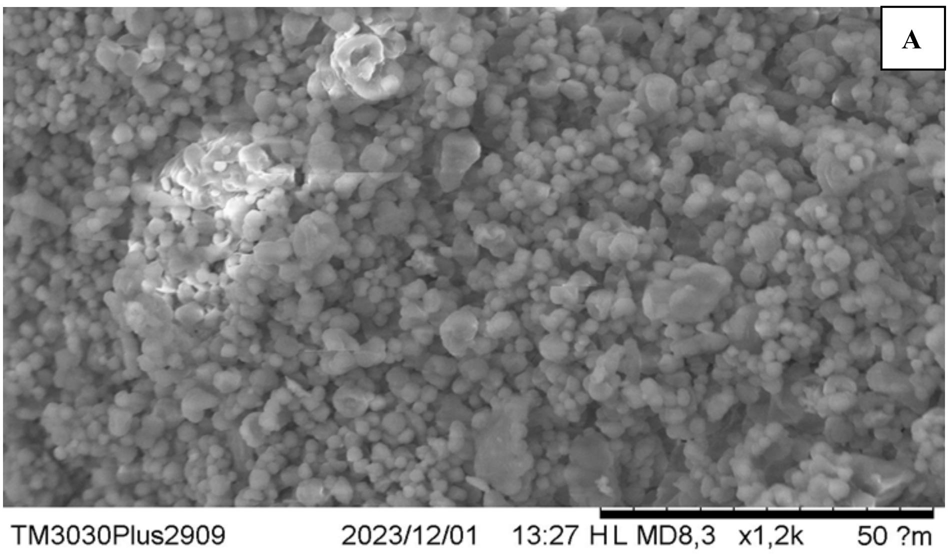
Conversely, Battiston et al. (2016) found higher A_w values for mate extract powder, registering 0.58. The use of higher temperatures resulted in lower A_w values, meaning that microbial development was practically nonexistent. Thus, the product can be considered a powder with favorable storage and production characteristics.

Color is crucial in food quality, particularly in dehydrated products, as it directly affects visual appeal. The L*, a*, and b* parameters were assessed in Jambu powder. The average luminosity (L*) values were 33.52 and 33.00 for 110°C and 140°C, respectively, indicating no abrupt color variations.

The b* parameter is essential for evaluating the product's color, as it can indicate the degree of yellowing in the samples. It is important to analyze this parameter alongside the a* parameter, which, the more negative it is, the closer it indicates to the green color. The hue angle (°Hue) had an average of 105° for both temperatures, while the average Chroma values were 27.20 and 26.73, respectively, indicating that both temperatures maintained the color variation in the powders.

The results for the bulk density of the powder were 0.39 g cm^{-3} and 0.22 g cm^{-3} for the drying temperatures of 110°C and 140°C, respectively. Bulk density is a key property included in the final product specifications, playing a crucial role in guiding industrial practices related to storage, processing, packaging, and distribution (Erbay, 2015). According to Walton (2000), apparent density decreases as drying temperature increases, due to high evaporation rates, resulting in the formation of products with a more porous structure.

The morphological characteristics of the Jambu extract powder, obtained by spray drying at different inlet temperatures, are illustrated in Figure 4. The powder produced at a higher temperature (140°C; Fig. 4B) exhibited spherical particles with some degree of shrinkage, in contrast to the powder produced at lower temperature (110°C; Fig. 4A), which displayed smooth surfaces. The presence of larger particles was observed at lower inlet temperature, while higher inlet temperature resulted in more uniform and spherical particles. Similar behaviors have been observed for forage cactus (Gandia-Herrero et al., 2010) and açaí (Tonon et al., 2008).



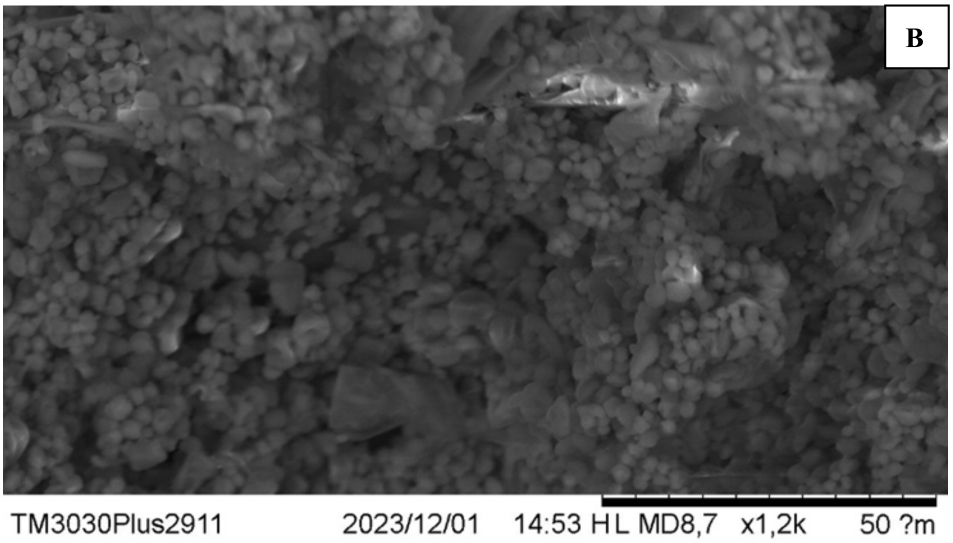


Figure 4. Micrographs of spray-dried Jambu extract powder produced at different inlet temperatures (A) 110°C and (B) 140°C

4. Conclusions

This study reveals that an inlet temperature of 140°C resulted in a higher powder yield compared to 110°C. The inlet temperatures directly influenced the physical properties of the powder. The use of higher temperature during atomization led to powders with lower water activity and bulk density values. The powder color remained stable, without significant variations, maintaining favorable characteristics.

Regarding morphology, lower inlet temperature generated particles with smooth surfaces, while higher temperature produced spherical particles with some degree of shrinkage. The results suggest the need for further studies to assess the feasibility of incorporating this dried product into seasonings and herbal formulations.

References

Battiston, C. S. Z., Dalla Rosa, C., Barro, N. P. R., & Mignoni, M. L. (2016). Caracterização físico-química e atividade antioxidante de chocolate branco com extrato de erva-mate. *Revista Virtual de Química*, 8(6), 1878-1888. https://doi.org/10.21577/1984-6835.20160128

Campos, P. S., Oliveira, M. É., Oliveira, L. F., & Dias, T. P. V. B. (2022). Avaliação da influência da temperatura e concentração de adjuvante na secagem por atomização da folha de maracujá doce (passiflora alata) / Evaluation of the influence of temperature and adjuvant concentration in the spray drying of sweet passion fruit (passiflora alata) leaves. *Brazilian Journal of Development*, 8(4), 30400-30416. https://doi.org/10.34117/bjdv8n4-495

Erbay, Z., Koca, N., Kaymak-Ertekin, F., & Ucuncu, M. (2015). Optimization of spray drying process in cheese powder production. *Food and Bioproducts Processing*, 93, 156-165. https://doi.org/10.1016/j.fbp.2013.12.008

Gandia-Herrero, F., Jimenez-Atienzar, J., Cabanes, J., Garcia-Carmona, F., & Escribano, J. (2010). Stabilization of the bioactive pigment of Opuntia fruits through maltodextrin encapsulation. *Journal of Agricultural and Food Chemistry*, 58, 10646-10652. https://doi.org/10.1021/jf101695f

Gomes, M. E. De M., Rodrigues, T. J. A., Albuquerque, A. P., Wanderley, A. M. A., Rocha, A. P. T., & Silva, O. S. Da. (2021). Obtenção do extrato seco de Lippia alba em pó por secagem em Spray Drying. *Revista Principia-Divulgação Científica e Tecnológica do IFPB*, (54), 180-192. https://doi.org/10.18265/1517-0306a2021v1n54p180-192

Hertwig, I. F. V. (1986). *Plantas aromáticas e medicinais*. São Paulo: Ícone.

Kiritsakis, K., Goula, A. M., Adamopoulos, K. G., & Gerasopoulos, D. (2018). Valorization of olive leaves: Spray drying of olive leaf extract. *Waste and Biomass Valorization*, 9, 619-633. https://doi.org/10.1007/s12649-017-0023-x

Lima, T. M. de F. G. (2021). Caracterização de extrato de Jambu (Acmella ciliata) e análise do potencial de aplicação como ingrediente funcional (Master's thesis). Universidade Federal do Ceará, Fortaleza.

Lorenzi, H., & Matos, F. J. A. (2002). *Plantas medicinais do Brasil: nativas e exóticas cultivadas*. Nova Odessa, São Paulo: Instituto Plantarum.

Moreira, P. A., Barroso, E. M., & Jeremias, F. (2023). Aplicabilidade do jambu (acmella oleracea) na área da saúde: uma revisão narrativa. *Plantas medicinais e suas potencialidades*, 1(1), 12-27. https://dx.doi.org/10.37885/221211417

Nascimento, A. M., Souza, L. M. de, Baggio, C.H., Werner, M. F. de P., Maria-Ferreira, D., Silva, L.M. da, Sassaki, G.L., Gorin, P.A.J., Iacomini, M., & Cipriani, T.R. (2013). Gastroprotective effect and structure of a rhamnogalacturonan from Acmella oleracea. *Phytochemistry*, 85, 137-142. https://doi.org/10.1016/j.phytochem.2012.08.024

Oliveira, P. P. de. (2021). Obtenção e caracterização de hortelã em pó em spray dryer (Master's thesis). Universidade Federal de Uberlândia, Patos de Minas.

Quek, S. Y., Chok, N. K., & Swedlund, P. (2007). The physicochemical properties of spray-dried watermelon powders. *Chemical Engineering and Processing*, 46, 386-392. https://doi.org/10.1016/j.cep.2006.06.020

Sanathalakshmy, S., Don Bosco, S. J., Francis, S., & Sabeena, M. (2015). Effect of inlet temperature on physicochemical properties of spray-dried jamun fruit juice powder. *Powder Technology*, 274, 37-43. https://doi.org/10.1016/j.powtec.2015.01.016

Tonon, R. V., Brabet, C., & Hubinger, M. D. (2008). Influence of process conditions on the physicochemical properties of acai (Euterpe oleraceae Mart.) powder produced by spray drying. *Journal of Food Engineering*, 88, 411-418. https://doi.org/10.1016/j.jfoodeng.2008.02.029

Walton, De. (2000). A morfologia das partículas secas por pulverização - uma visão qualitativa. *Seco. Tecnologia*, 18(9), 1943–1986.

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Authors contributions

NMBC, GSM and Prof. Dr. IAD were responsible for study design and revising. NMBC and GSM was responsible for data collection. NMBC and GSM drafted the manuscript and Prof. Dr. IAD revised it. All authors read and approved the final manuscript. Authors contributed equally to the study.

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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