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# Production and characterization of powdered acerola juice obtained by atomization

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**ABSTRACT.** Acerola is considered a superfruit due to its high vitamin C content, but it is highly perishable. Dehydrating acerola juice using a spray dryer is a significant alternative to reduce seasonality and extend the product's shelf life. Moreover, the demand for more natural and convenient products is on the rise. In this context, this study aims to examine the impact of different temperatures (150, 170, and 190°C) on the spray drying process of 'Junko' acerola juice, supplemented with 15% w/w maltodextrin. The dehydrated juice was evaluated for pH parameters, Titratable acidity (g of malic acid 100 $g^{-1}$), Soluble solids, (°Brix), Water content (%), Total solids (%), Vitamin C (mg 100 $g^{-1}$), and was reconstituted in water to evaluate color (L*, a*, b*). The resulting powdered acerola juice exhibited average vitamin C levels ranging from 11,541.22 to 11,371.35 mg $100^{-1}$. There was an increase in organic acid content and a reduction in water content to values between 5.56 and 4.81%. The average soluble solids content in the rehydrated juice was 9.6 °Brix. Concerning the red intensity (a*) of the rehydrated juice, the temperature of 170°C yielded a greater value. As for yellow intensity, there was a notable increase with the increase of drying temperature. These results highlight the importance of considering not only the addition of encapsulating agents, such as maltodextrin, but also the temperature during the spray dryer atomization process.

**Keywords:** *Malpighia emarginata*; spray-dryer; quality; vitamin C.

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## Introduction

Brazil is the third-largest fruit producer in the world, surpassed only by China and India, accounting for approximately 5% of world production (Kist, Carvalho, & Beling 2021). Simultaneously, it is the world's largest producer of acerolas, with cultivation primarily concentrated in the Northeast, notably in the states of Pernambuco, Paraíba, Bahia, and Ceará (Prakash & Baskaran, 2018).

Acerola (*Malpighia emarginata*) is a fruit of high economic value due to its elevated content of ascorbic acid (vitamin C), becoming a superfruit. It also contains significant amounts of anthocyanins, carotenoids, calcium, phosphorus, iron, and vitamins A, B1, B2, B3, providing an acidic flavor and distinctive texture for consumers (Prakash & Baskaran, 2018).

As the fruit is highly perishable, post-harvest losses remain high due to its fragile structure, susceptibility to deterioration, and improper handling, making transportation and commercialization in its fresh form challenging over long distances (Ferreira et al., 2019). To mitigate these losses, various preservation techniques are employed, including dehydration (Silva, Santos, Abud, & Junior, 2019).

Dehydration of food produces stable products by reducing water content and limiting microbial and biochemical activity (Tapia, Alzamora, & Chirife, 2020). It also reduces volume, facilitating transport and storage without the need for refrigeration, and concentrates the nutritional value of the product (Ramya & Jain, 2017). Moreover, under suitable conditions, dehydrated products can be stored throughout the year, preserving their nutritional value and reducing the seasonality of the product (Zhang, Zhang, Chen, & Quek, 2020).

Juice consumption has significantly increased due to a growing concern for healthier foods. The demand for instant beverages obtained through the dehydration process and rapid preparation emerges as a promising alternative to replace artificial drinks in the market (Sousa, Figueirêdo, Queiroz, & Fernandes, 2015).

Among the drying or dehydration methods, spray drying is widely used in the food industry for processing juices and pulps into powder. Under ideal conditions, it has proven effective in obtaining various products (Zhang et al., 2020; Tontul & Topuz, 2017). In this continuous process, liquid is sprayed using a high-pressure system, and the droplets come into contact with a flow of hot air, leading to quick evaporation (Szczap & Jacobs, 2023). This process helps maintain a low temperature in the final product, preserving heat-sensitive compounds such as phenolic compounds, antioxidants, and especially vitamin C (Rezaul et al., 2017).

Due to the presence of low molecular weight sugars and acids with a low glass transition temperature, dehydrated fruit juices and pulps may exhibit undesirable attributes like hygroscopicity and adherence to dryer walls, making handling and storage challenging (Szczap & Jacobs, 2023; Tontul & Topuz, 2017; Rezaul et al., 2017). Therefore, it is crucial to employ suitable temperatures in the drying process and use carrier agents with high molecular weight before drying to facilitate and increase process yield (Tontul & Topuz, 2017; Rezaul et al., 2017).

According to Adetoro. Opara, and Fawole (2020), in spray drying, maltodextrin is a commonly used carrier agent because it prevents particle binding, possesses antioxidant properties, and retains volatile substances at a high rate (65 to 80%). Additionally, maltodextrin has well-defined physical properties, is water-soluble, and is cost-effective, making it a commonly used additive in the food industry (Ribeiro, Costa, & Afonso, 2019).

Therefore, this study aims to investigate the influence of different temperatures on the spray drying of acerola juice 'Junko' with the addition of maltodextrin.

## Material and methods

"The experiment was conducted at the Experimental Food Laboratory of the Food Technology course at the Federal Institute of Education, Science and Technology of the Sertão Pernambucano Petrolina campus.

'Junko' acerola fruits in the mature ripening stage were sourced from small producers in the Irrigated Perimeter Senador Nilo Coelho in Petrolina, Pernambuco, and maltodextrin was obtained from the local market.

### Juice extraction

The fruits were washed in running water, sanitized with 50 ppm chlorinated water, and rinsed to remove excess chlorine. Subsequently, the juice was extracted by macerating the fruits in plastic bags, followed by filtration using rapid paper filtration. After extraction, 1000 g of the whole juice was weighed for each test, and 15% (w/w) maltodextrin was added.

### Drying

The acerola juice, combined with 15% maltodextrin, underwent dehydration at temperatures of 150, 170, and 190°C. The process utilized the Spray-dryer Model MSD 1.0 by Labmaq do Brasil, equipped with a spray nozzle with a 1.2 mm diameter opening, a feed speed of 0.30 $L.h^{-1}$, a drying flow of 3.5 $m^3$. $min^{-1}$, and a compressed air flow of 30 L $min^{-1}$.

### Quality assessment of powdered juice

Following the drying process, the samples (fresh juice, additive, and powder) underwent analysis for parameters such as pH, soluble solids, titratable acidity, ascorbic acid (vitamin C), moisture content, total solids, and color (L*, a*, and b*). To assess pH, soluble solids content, and the color of the powdered juice, 2 g of the atomized sample (powder) were dissolved in 20 mL of water with agitation until complete homogenization, following the methodology of Freitas, Lima Lopes, Freitas Alves, and de Campos (2019).

The pH was determined by potentiometry, using a digital pH meter calibrated with buffer solutions of pH 4.0 and 7.0. Soluble solids (°Brix) were determined with an Abbe-type bench refractometer with corrected data at 20°C. Moisture content (%) and total solids (%) were determined by direct drying in an oven at 105 ± 1°C until reaching a constant weight. Titratable acidity, expressed as malic acid, was determined by acid-base volumetry using a 0.1 mol $L^{-1}$ alkaline NaOH solution as the titrating agent and 1% phenolphthalein alcoholic solution as an indicator. These analyses followed the methodologies described by the Instituto Adolfo Lutz

(IAL, 2008). Ascorbic acid content was determined by oxide-reduction volumetry, using a 0.015 mol $L^{-1}$ iodine solution as the titrating agent and a 1% starch solution as an indicator, according to the method described by Andrade and Baccan (2001). Color was measured using a Minolta brand digital colorimeter, model CR 10, employing the CIELab system, with results expressed in L* (brightness), a* (intensity of red [+] and green [-]), and b* (intensity of blue [-] and yellow [+]).

### Statistical analysis

The experimental data for quality assessment parameters underwent Analysis of Variance (ANOVA) in a completely randomized design (DIC). Averages were compared using the Tukey test at a 5% probability level, utilizing the Sisvar 5.3 *software* (Ferreira, 2014)."

## Results and discussion

Table 1 presents the average values and standard deviations of the physical-chemical characteristics and color of both fresh acerola juice and the formulated juice. Comparing the characterization parameters of the two samples, it is observed that all values, except L* (Brightness), differ statistically from each other, according to the Tukey test at a 5% probability.

For pH values (Table 1), both fresh acerola juice and the formulated juice exhibited values less than 3.0. Both can be classified as highly acidic or very acidic foods since they have pH values <4.0. Maciel, Mélo, Lima, Souza, and Silva (2010), in a study with acerola genotypes, reported values ranging from 2.9 to 3.5. This pH range aligns with the quality standard requirements for fruit pulp set by the Ministry of Agriculture, Livestock, and Supply, which mandates a minimum pH of 2.8 (Brasil, 2018).

The titratable acidity of fresh acerola juice was higher than the value found for the formulation (Table 1). According to Sousa et al. (2015), this difference is expected, as the incorporation of maltodextrin typically reduces acidity and increases pH.

The total soluble solids (°Brix) of the fresh acerola juice were 152.94% lower compared to the value of the formulation. Sousa et al. (2015) also reported higher values after adding maltodextrin to atemoya pulp. The obtained values exceed the minimum value (5.5°Brix) recommended by the Ministry of Agriculture, Livestock, and Supply, as per the Identity and Quality Standards of Juice and Fruit Pulp (Brasil, 2018).

The water content in the juice formulation was lower (Table 1). This is attributed to maltodextrin's role as a carrier agent, which increases solids content, reduces water content, and facilitates the spray drying process. Given that most fruit pulps have high sugar content, these conditions are conducive to caramelization, making the spray drying process impractical (Ribeiro et al., 2019).

Due to the higher water content, total solids were lower in fresh acerola juice (Table 1). Sousa et al. (2015), in a study involving the addition of atemoya pulp with distilled water and maltodextrin, also reported an increase in total solids content.

**Table 1**. Chemical composition of lychee peel flour.

| Parameter | Fresh juice | Formulation | CV (%) |
|---|---|---|---|
| pH | 2.95 ± 0.01 b | 2.98 ± 0.01 a | 0.19 |
| Titratable acidity (g of malic acid $100g^{-1}$) | 1.77 ± 0.01 a | 1.58 ± 0.01 b | 0.39 |
| Soluble solids (°Brix) | 7.63 ± 0.05 b | 19.30 ± 0.01 a | 0.61 |
| Water content (%) | 94.11 ± 0.04 a | 82.26 ± 0.27 b | 0.22 |
| Total solids (%) | 5.89 ± 0.04 b | 17.74 ± 0.27 a | 1.64 |
| Vitamin C (mg $100g^{-1}$) | 2541.9 ± 63.4 a | 2163.1 ± 41.7 b | 2.28 |
| L* | 16.9 ± 1.1 a | 16.4 ± 0.3 a | 4.71 |
| a* | 5.84 ± 1.25 a | 3.62 ± 0.31 b | 19.3 |
| b* | 4.93 ± 0.50 a | 3.77 ± 0.09 b | 9.71 |

*Data are presented as mean ± standard deviation. Averages followed by the same letter do not differ statistically from each other by Tukey's test at 5% probability.

With the preparation of the formulation, it was observed that the ascorbic acid content for the formulation decreased by 14.90% compared to the content found in fresh juice. This reduction was less than that reported by Sousa et al. (2015), which was 40.4% when comparing atemoya pulp with a formulation prepared with distilled water + pulp + maltodextrin.

Regarding luminosity (L*) of both fresh juice and the formulation, no significant difference was observed. Analyzing color parameters, specifically red intensity (a*) and yellow intensity (+b*), a 38.01% reduction in red intensity (+a*) and a 23.53% reduction in yellow intensity (+b*) were noted. In a study by Jaeschke, Marczak, and Mercali (2016), different values were found for acerola pulp, with L* of 39.91, a* of 20.68, and b* of 25.06.

Food color is an important visual characteristic that affects sensory quality and the consumer. Acceptability (Oliveira, Brandao, & Silva, 2016). It was noticed that, the increase in air temperature in the drying chamber influenced the visual appearance of the juice powder (Figures 1A, 1B and 1C). According to Oliveira et al. (2016), these results show that the use of heat, through drying, can lead to loss of pigments and darkening.


**Figure 1.** Color of powdered acerola juice obtained by spray drying in a spray dryer at temperatures of 150°C (A), 170°C (B), and 190°C (C).

Table 2 presents the mean values and standard deviations of the chemical, physical, and physicochemical characterization of acerola powder juice samples obtained by spray dryer drying at temperatures of 150, 170, and 190°C.

It is noteworthy that the pH of the powder samples differed statistically from each other (Table 2), and the values were lower than 4.0, characterizing them as very acidic foods. This pH range can inhibit the proliferation and development of microorganisms. Dos Santos, Florêncio, Rocha, and da Costa (2014) and Rocha et al. (2014) reported higher pH values of 3.88 ± 0.05 for guava and cashew powder obtained by atomization.

The titratable acidity expressed in malic acid did not differ statistically between treatments (Table 2). De Oliveira, Borges, Faria, Endo, and Gregório (2007), studying pitanga powder samples, also found no statistical difference in total titratable acidity.

Regarding the soluble solids content of rehydrated powder juice, no significant difference was observed between treatments (Table 2). Freitas et al. (2019), in a study on the influence of different concentrations of maltodextrin (5, 10, 15, and 20%) and temperatures (100 and 120°C) on the drying of 'Pérola' pineapple juice, also found no significant difference in the soluble solids content of rehydrated juice.

**Table 2.** Physicochemical characterization and color of acerola powder juice samples produced with 15% maltodextrin, under different drying temperatures.

| Parameter | Drying temperature | | | CV (%) |
|---|---|---|---|---|
| | 150°C | 170°C | 190°C | |
| pH | 3.05 ± 0.01 c | 3.07 ± 0.01 b | 3.09 ± 0.01 a | 0.19 |
| Titratable acidity (g malic acid $100g^{-1}$) | 8.32 ± 0.06 a | 8.33 ± 0.05 a | 8.28 ± 0.01 a | 0.53 |
| Soluble solids (°Brix) | 9.63 ± 0.06 a | 9.63 ± 0.15 a | 9.63 ± 0.1 a | 1.15 |
| Water content (%) | 5.56 ± 2.37 a | 5.31 ± 0.59 a | 4.81 ± 1.55 a | 20.68 |
| Total solids (%) | 94.44 ± 2.37 a | 94.7 ± 0.6 a | 95.19 ± 1.55 a | 1.14 |
| Vitamin C (g $100g^{-1}$) | 11541.2 ± 96.3 a | 11560.4 ± 46.3 a | 11371.3 ± 43.2 a | 0.58 |
| L* | 14.84 ± 0.30 b | 14.8 ± 0.1 b | 15.03 ± 0.30 a | 0.18 |
| a* | 1.35 ± 0.09 b | 1.68 ± 0.16 a | 1.30 ± 0.07 b | 7.99 |
| b* | 3.21 ± 0.03 c | 3.40 ± 0.07 b | 3.65 ± 0.05 a | 1,65 |

*Data are presented as mean ± standard deviation. Averages followed by the same letter do not differ statistically from each other by Tukey's test at 5% probability.

Powder samples, with water content ranging between 4.81 and 5.56%, fall within a safe range for storage. This range limits the development of deteriorating and pathogenic microorganisms while also inhibiting chemical and enzymatic reactions (Preetha & Narayanan, 2020). These values align with legislation for dehydrated products, recommending a maximum humidity of 25.00% for dried or dehydrated fruit products (Brazil, 2005). Consequently, the reduction in water content leads to an increase in total solids content (Table 2).

The water content values found in this study are comparable to those reported by Dos Santos et al. (2014), which were 5.69% for whole guava pulp with 10% maltodextrin and 50% distilled water, atomized at an input temperature of 120ºC.

Regarding the content of vitamin C (ascorbic acid), it was observed that there was no significant difference between the treatments (Table 2), showing an average increase of 22.18% compared to fresh juice. Rocha et al. (2014) found an adverse effect on the atomization process of cashew juice, resulting in 82.25% reduction in vitamin C content.

In a study by Garcia, Borges, Vanin, and Carvalho (2020), concentrations of vitamin C in acerola powder (Table 2) using 5% maltodextrin under an inlet temperature of 120°C showed a reduction in vitamin C concentration of approximately 22.8% for acerola powder only. According to Wang, Yuan, and Yue (2015), this difference, compared to the results of this study, may be attributed to the low concentration of maltodextrin, which possesses oxidation protection properties, offering higher encapsulation efficiency with lower oxygen permeability content.

According to the results, the increase in air temperature in the drying chamber influenced the visual appearance of powdered juice rehydrated in water (Figures 2A, 2B and 2C), when compared to fresh juice. According to Oliveira et al. (2016), these results show that the use of heat, through drying, can lead to the loss of pigments, specifically anthocyanins, which lead to loss of color.

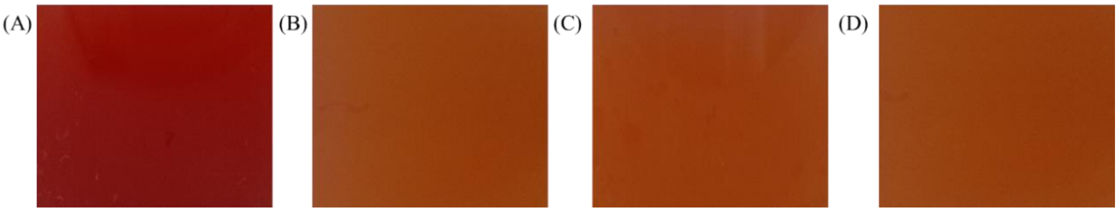


**Figure 2.** Color of fresh acerola juice (A), and powder obtained by atomization in a spray dryer at temperatures of 150ºC (B), 170ºC (C) and 190ºC (D), rehydrated in water.

Analyzing the results obtained for the L* parameter (luminosity), it was found that the temperature of 190ºC impacted the luminosity. Rocha et al. (2014) suggested that this difference in luminosity could be related to the processing used, as higher temperatures during the drying process may favor darkening due to the high sugar content present in acerola powder juice.

Concerning the red intensity (+a*), the juice dehydrated by atomization at a temperature of 170°C, after rehydration, presented a higher value compared to the other temperatures, indicating a tendency towards a more intense red. The intensity of yellow (+b*) underwent statistically significant and progressive reductions with the increase in temperature, indicating the effect of heating on the pigments present in the samples.

Maltodextrin has a white coloration, and when added to the juice, it can dilute the pigments present in the fruit, resulting in a lighter coloration. In a study by Garcia et al. (2020), when evaluating the color of acerola powder pulp obtained by atomization, both observed coordinated values a* and b* in the first quadrant, indicating a tendency of the powder to a reddish color, corroborating the values found in this study.

## Conclusion

The addition of maltodextrin to acerola juice at a proportion of 15% (w/w) resulted in several changes in quality parameters. There was a significant reduction in pH, malic acid content, water content, vitamin C, red intensity, and yellow intensity. However, a notable increase in soluble solids and total solids content was observed.

Regarding the quality of the resulting powdered juice, it was found that the addition of maltodextrin had no significant impact on titratable acidity, soluble solids content, water content, total solids content, and vitamin C, even with the increase in temperature during the drying process.

There was a further reduction in pH, while luminosity increased, and the yellow color intensified, resulting in a whitish appearance. Notably, the juice powder obtained at 170°C exhibited a higher red intensity.

These results highlight the importance of considering not only the addition of encapsulating agents, such as maltodextrin, but also the temperature during the spray dryer atomization process. These variables directly influence the physical-chemical and sensory characteristics of the final product, impacting its acceptance and applicability in the market.

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