

Original Article

Dehydration of *Byrsonima cydoniifolia* A. Juss. (Canjiqueira): influence of process variables on piceatannol retention

Desidratação da *Byrsonima Cydoniifolia* A. Juss. (Canjiqueira): influência das variáveis de processo na retenção de piceatannol

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Abstract

This study evaluated the retention of piceatannol and the cytotoxicity of *Byrsonima cydoniifolia* A. Juss. pulp, both fresh and dehydrated, under different temperature and storage conditions. Fruits were collected in the Pantanal region (Corumbá, MS, Brazil) and dehydrated using a conventional oven at varying temperatures. Cytotoxicity was assessed using *Artemia salina*, murine fibroblasts, and human umbilical cord cell lines. The fresh extract showed a CL_{50} of 863.23 $mg \cdot L^{-1}$, classified as “low toxicity,” whereas samples dehydrated at 80 °C and 40 °C showed CL_{50} values of 235.28 $mg \cdot L^{-1}$ and 153.31 $mg \cdot L^{-1}$, respectively, classified as “toxic.” Despite dehydration, the fruit retained bioactive compounds, including piceatannol. After storage, the dehydrated sample maintained 71.33% of its antioxidant potential, with piceatannol, tannins, and flavonoids contents of 0.73 mg/g, 36.53 mg/g, and 25.53 mg/g, respectively. The findings support dehydration as an effective preservation method and highlight the potential functional use and valorization of native plant species.

Keywords: food technology, dehydration, sustainability, stilbenes.

Resumo

Este estudo avaliou a retenção de piceatannol e a citotoxicidade da polpa de *Byrsonima cydoniifolia* A. Juss., in natura e desidratada, sob diferentes temperaturas e condições de armazenamento. Os frutos foram coletados no Pantanal (Corumbá, MS) e submetidos à desidratação em estufa convencional. A citotoxicidade foi analisada em *Artemia salina*, fibroblastos murinos e células de cordão umbilical humano. O extrato in natura apresentou CL_{50} de 863,23 $mg \cdot L^{-1}$ (baixa toxicidade), enquanto as amostras desidratadas a 80 °C e 40 °C exibiram CL_{50} de 235,28 $mg \cdot L^{-1}$ e 153,31 $mg \cdot L^{-1}$, respectivamente (tóxicas). Mesmo após a desidratação, os frutos mantiveram compostos bioativos, incluindo piceatannol. Após armazenamento, o potencial antioxidante permaneceu em 71,33%, com teores de piceatannol, taninos e flavonoides de 0,73 mg/g, 36,53 mg/g e 25,53 mg/g, respectivamente. Os resultados indicam a desidratação como método viável de conservação, com potencial para uso funcional e valorização de espécies nativas.

Palavras-chave: tecnologia de alimentos, desidratação, sustentabilidade, estilbenos.

1. Introduction

Byrsonima cydoniifolia A. Juss., popularly known as “canjiqueira”, is a fruit native to the Brazilian Pantanal and Cerrado and grows exclusively in sandy soils. Ripe fruits are yellow, measuring 1.5 to 2 cm. The pulp is fleshy and soft, generally consumed *in natura* or as juices, ice creams, jellies, and liqueurs. Although canjiqueira is a food source for the rural population, this species is among unexploited native fruits in Brazil (Prates et al., 2015).

There are several nutraceutical substances in the fruits of *B. cydoniifolia*, such as ascorbic acid, carotenoids, and important phenolic compounds, such as piceatannol (Marcelino et al., 2019). Piceatannol (3,3',4,5'-*trans*-trihydroxystilbene) is a natural hydroxylated stilbenoid analogue of resveratrol. It is less studied than resveratrol, despite showing a broad spectrum of biological activity (Zomer et al., 2022). In addition to antioxidant effects,

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piceatannol has potential anticancer properties due to its ability to suppress the proliferation of a wide variety of tumor cells, including leukemia, lymphoma, breast, prostate, colon, and melanoma cancers, in addition to showing cardioprotective activity (Yan et al., 2019; Song et al., 2015). Piceatannol is also effective in preventing cardiovascular pathologies (Choi et al., 2010) and anti-inflammatory activity (Wen et al., 2018).

However, the perishability and seasonality of *B. cydoniifolia* fruits *in natura* obtained through extraction are bottlenecks for the pharmaceutical and food industries, which demand raw materials in constancy and in high volumes. In order to increase the supply to the throughout the year, it is thus necessary to explore alternative uses of fruits accessible to native peoples, such as various indigenous ethnicities, riverside dwellers, maroon communities, caipiras, and pantaneiros, who face subsistence difficulties resulting mainly from the lack of food security (Van Noordwijk et al., 2020).

Conventional greenhouse dehydration is an easy-to-apply process that considerably reduces product moisture and consequently water activity, minimizing physical, chemical, biochemical, and microbiological changes during storage, in addition to reducing packaging and transportation costs. As it is a simple technique, conventional dehydration in a greenhouse allows the integration of biodiversity, traditional and scientific-technological knowledge to make the fruits of *B. cydoniifolia* available throughout the year (Sanchez et al., 2020). Given this context, it is necessary to explore efficient drying and storage variables for a greater yield of final product and retention of bioactives, reducing operational costs and maintaining the aroma, flavor, and color of native fruits (Fathi et al., 2022).

Nevertheless, it is important to study how different temperatures and storage conditions may affect the toxicity of canjiqueira pulps to promote the sustainability of its use. They are efficient in predicting cytotoxicity due to biological characteristics and sensitivity to toxic compounds (Bertan et al., 2020).

In addition to invertebrate-based assays such as *Artemia salina*, toxicity evaluations using normal mammalian and human cell lines provide essential insights into potential cytotoxic effects on non-tumorigenic cells (Scapin et al., 2024). The use of NIH/3T3 murine fibroblasts and HUVEC (human umbilical vein endothelial cells) lines, both well-established *in vitro* models, allows for a more

comprehensive understanding of how bioactive compounds from *Byrsonima cydoniifolia* might interact with mammalian cells under physiological conditions (Bertan et al., 2020).

These models are particularly valuable for identifying concentrations that may compromise cell viability without relying on *in vivo* testing, aligning with ethical standards in scientific research (Skehan et al., 1990). Moreover, evaluating cytotoxicity in these cell types supports the safe development of functional foods and phytotherapeutic agents derived from native species, ensuring their application does not pose risks to human health (Khabib et al., 2022). Therefore, the objective of this study is to evaluate the retention of piceatannol and the cytotoxicity of the pulp of *Byrsonima cydoniifolia* A. Juss., both *in natura* and dehydrated, in different temperature and storage conditions.

2. Materials and Methods

2.1. Plant material

The fruits of *B. cydoniifolia* A. Juss. (Canjiqueira) were collected in Passo da Lontra (19°34'13.33" S and 57°01'11.20" W), in the municipality of Corumbá, State of Mato Grosso do Sul, Brazil, in January 2020. Intact fruits (absence of damage caused by injuries or microbial degradation) were weighed to evaluate the percentage of green, "fresh" and ripe fruits aiming to characterize the fruit blend.

For the assays and evaluations, the species counts with authorization from the Biodiversity Authorization and Information System (SISBio)/Ministry of the Environment and authorization for access to genetic heritage for the purpose of scientific research via the National Genetic Heritage and Knowledge Management System Traditional Associate (Sisgen). Figure 1 shows the canjiqueira fruits during ripening in the field and after harvested and selected at the ripening point.

2.2. Dehydration process

Dehydration of whole fruits of *Byrsonima cydoniifolia* A. Juss was conducted artificially in a cabin-type fixed bed dryer (Cienlab, digital) with forced air circulation at 40 °C for 24 hours and at 80 °C for 12 hours. The reduction in water content throughout drying was monitored using gravimetry (the initial water content of the product was known) until reaching the desired water content of 15% moisture (g/100 g).



Figure 1. Canjiqueira fruits (*B. cydoniifolia* A. Juss.) during the ripening process (A), blend of fruits subjected to dehydration (B), and ripe fruits (C). Source: Adapted from Prates et al. (2015).

After drying, the fruits were crushed in a mill. The particle size was standardized using 16-mesh sieves and packaged in rigid, 10- μ m thick high-density polyethylene packaging measuring 120x120 mm. The “40 °C + 30” and “80 °C + 30” samples were stored at room temperature for 30 days. The “40 °C” and “80 °C” samples were stored in a freezer at -12 °C for 30 days.

2.3. Chemical analysis

2.3.1. Sample preparation

The samples from each treatment underwent extraction for 15 min with ethanol:water 7:3 (v/v) at a 4:1 sample/solvent extract ratio using an ultrasonic bath. Then, the extracts were concentrated in a rotary evaporator and freeze-dried for later use as samples in tests for antioxidant potential, phenolic compounds, flavonoids, tannins, and quantification of piceatannol (Santos et al., 2017).

The Strata C18-E cartridge (Phenomenex™, USA) was conditioned with 10 mL of methanol (AP), followed by 10 mL of distilled water. One gram of sample was solubilized in methanol and inserted into the cartridge, which was eluted with 10 mL of methanol (AP) and 5 mL of acetone AP. These eluates were collected in a vial and then evaporated in a fume hood until dry. The extract was resuspended in 1 mL of methanol (AP). The sample was prepared at a concentration of 1000 μ g mL⁻¹ for all analyses.

2.3.2. Antioxidant potential

The antioxidant potential was determined by inhibition of 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical. A 30-min reaction of 100 μ L of sample was conducted in the dark with 2 mL of 0.1 mmol/L DPPH ethanolic solution, reading on a spectrophotometer at a wavelength of 517 nm (Capanoglu et al., 2008). Radical inhibition by samples was calculated using Equation 1, where Q is the inhibition, A₀ is the absorption of the control, and A_c is the absorption of the sample after reaction.

$$\text{Inhibition}_{\text{DPPH}} = \frac{100 \times \left(\frac{\text{Absorbance of control}_{517\text{nm}} - \text{Absorbance of solution}_{517\text{nm}}}{\text{Absorbance of control}_{517\text{nm}}} \right)}{\quad} \quad (1)$$

2.3.3. Content of phenolic compounds

The content of phenolic compounds was determined based on the Folin-Ciocalteu colorimetric method (Djeridane et al., 2006). To this end, 0.5 mL of Folin-Ciocalteu reagent (1:10) and 1 mL of distilled water were added to 0.1 mL of sample. After one minute, 1.5 mL of 20% (w/v) sodium carbonate was added and the solution rested for two hours in a dark place. The spectrophotometer reading was performed at a wavelength of 760 nm. An analytical gallic acid curve was used as standard (10 and 1000 μ g mL⁻¹). The result was expressed in mg of gallic acid equivalent (GAE) per g of sample.

2.3.4. Flavonoid content

The determination of flavonoids followed the methodology of Djeridane et al. (2006). 1 mL of sample

reacted with 1 mL of 2% aluminum chloride (w/v) in methanol, waiting for 15 min to complete the reaction. The reading was performed on a spectrophotometer at a wavelength of 430 nm. A rutin standard curve (10 and 100 μ g mL⁻¹) was used for quantification. The result was expressed as mg of rutin equivalent (RE) per g of sample.

2.3.5. Tannin content

The tannin content was determined by the Folin-Denis spectrophotometric method (Pansera et al., 2003) with adaptations for the volumes of reagents and not changing proportions. 0.5 mL of Folin-Denis reagent was added to 0.5 mL of sample, shaking, and resting three minutes. Then, 0.5 mL of 8% sodium carbonate (w/v) was added, homogenizing and waiting the reaction for 2 h in the dark. Absorbance was read at 725 nm wavelength. To calculate the concentration of tannins, a standard curve was created with tannic acid (0.5 to 150 μ g mL⁻¹). The result was expressed in mg of tannic acid equivalent (TE) per g of lyophilized extract.

2.3.6. Quantification of piceatannol

The analysis of piceatannol in the extract was conducted by High-Performance Liquid Chromatography (HPLC) (Shimadzu, Japan) with a diode array detector (Figure 2). The analytical column consisted of a C18 reversed phase column (Phenomenex, USA) (100 $\times$ 3 mm). The mobile phases were (A) water with 0.1% formic acid and (B) acetonitrile. The flow rate was 0.8 mL/min, and the column temperature was 35 °C. The gradient was as follows: 0-10 min, 0-15% B; 10-20 min, 15% B; 20-25 min, 15-50% B; 25-27 min, 50-100% B; 27-31 min, 0% B. A 20- μ L aliquot of the sample was injected into each analysis. Piceatannol was identified by its retention times and spectral data compared to the standard. Quantification was performed using a five-point calibration curve (0.3-100 μ g/mL) with piceatannol.

2.4. Toxicity in *Artemia salina*

The toxicity test was conducted using neonates of *A. salina* obtained after cysts hatched in synthetic seawater (32 g L⁻¹) with aeration for 48 hours under lighting to heat the incubator. These bioassays were performed in triplicate (ten individuals

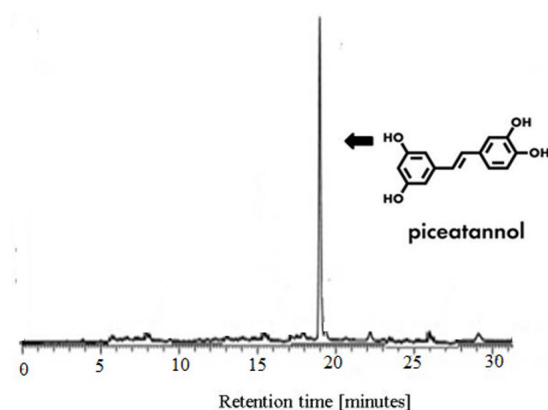


Figure 2. Chromatographic profile of hydroethanol extracts from canjiquiera fruits (*B. cydoniifolia* A. Juss.).

per replicate), kept at $20 \pm 2^\circ\text{C}$, and photoperiod of 16h light/8 h dark, lasting up to 96 hours in a static system in 10 or 15-mL test tubes for each test in alkaline pH (pH 8-9). Furthermore, synthetic sea salt was added to the samples at 32 g L^{-1} aiming to maintain a favorable nutrient environment for the test organism. Another test was the positive with potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) from a solution of 100 mg L^{-1} . The test (100, 50, 25, 12.5, 10, 6.25, and 3.1% v/v) aimed to obtain the value of LC_{50} (El Fels et al., 2016).

2.5. Toxicity in normal murine fibroblast and human umbilical cord cell lines

The samples were tested on the 3T3 cell line (ATCC CRL-1658), murine fibroblasts, adherent, cultured in RPMI medium, available at the Cell Culture Laboratory (FaCFAN-UFMS), and the HUVEC cell line (ATCC CRL-1730), human umbilical cord endothelial cells, adherent, kindly provided by Prof. Dr. Heloísa Sobreiro Selistre de Araújo from the Federal University of São Carlos (UFSCar).

Briefly, 3T3 cells were grown in high-glucose DMEM (Dulbecco's Modified Eagle's Medium), while the other cell lines were cultured in RPMI-1640 (Roswell Park Memorial Institute Medium) (Sigma-Aldrich). Both media were supplemented with 10% fetal bovine serum (Gibco), streptomycin ($100\text{ }\mu\text{g/mL}$), and penicillin (100 U/mL) (Sigma-Aldrich). Cells were then distributed in 96-well plates ($100\text{ }\mu\text{L/well}$) and exposed for 48 hours to increasing concentrations of the test compounds (0.25, 2.5, 25, and $250\text{ }\mu\text{g/mL}$, on a log10 scale), prepared in dimethyl sulfoxide (DMSO) at a final concentration of 0.1%.

Cytotoxicity assays were conducted using the colorimetric method with sulforhodamine B (SRB) (Sigma, USA) as described by Skehan et al. (1990). Treated cells were fixed with trichloroacetic acid (TCA) for 20 minutes and stained with SRB. Absorbance was measured at 540 nm in triplicate. The GI50 value (concentration causing 50% growth inhibition) was determined for each cell line by nonlinear regression analysis (sigmoidal fitting) using Origin 6.0 software (OriginLab Corporation, Northampton, MA, USA). Doxorubicin served as the positive control.

2.6. Organization and statistical analysis

The experimental design was completely randomized. Each analysis/sample was performed in triplicate. Results are expressed on a dry basis with 15% moisture content (g/100 g). Data were subjected to analysis of variance (ANOVA), and means were compared using Tukey's test at a 5% significance level.

For the toxicity assays in normal murine fibroblast and human umbilical cord cell lines, the percentage of cell growth, calculated according to Skehan et al. (1990), was used to generate graphs via nonlinear regression analysis to determine the GI50 value. This analysis was conducted using the Origin 6.0 data analysis software.

3. Results

The canjiqueira fruit *in natura* showed antioxidant potential. The inhibition rate was 79.33% of the

2,2-diphenyl-1-picrylhydrazyl radical, concentration of phenolic compounds was 104.83 mg/g , tannins were 44.23 mg/g , and flavonoids were 31.43 mg/g . These results classify fruits as functional food (Diaz et al., 2020). Furthermore, the observed promising results for antioxidant potential in all dehydrated samples (Figure 3) suggest oven dehydration as a viable conservation strategy. This approach allows the availability of canjiqueira fruits throughout the year, reducing limitations related to perishability and seasonality, which sometimes make large-scale production difficult.

In addition to oven dehydration, other drying methods are recommended to conserve native fruits. Lyophilization has already been used in the dehydration of fruits popularly used in traditional medicine by riverside, Indigenous, and Pantanal populations. The araçá (*Psidium guineense* Swartz), baru (*Dipteryx alata* Vogel), guavira (*Campomanesia pubescens* DC. O. Berg), mangaba (*Hancornia speciosa* Gomez) and marolo (*Annona crassiflora* Mart.) were characterized as for antioxidant activity after dehydration by lyophilization. The researchers found that even after lyophilization, the pulps of fruits showed an antioxidant potential. Probably, these bioactive characteristics of fruits can reduce damage caused by oxidative stress (Araujo et al., 2016).

The dehydration process showed a significant impact on all evaluated chemical parameters in comparison to the fruit *in natura* regardless of drying and storage temperature conditions, as Table 1 shows. However, considering the relevance of dehydration in preserving the shelf life of

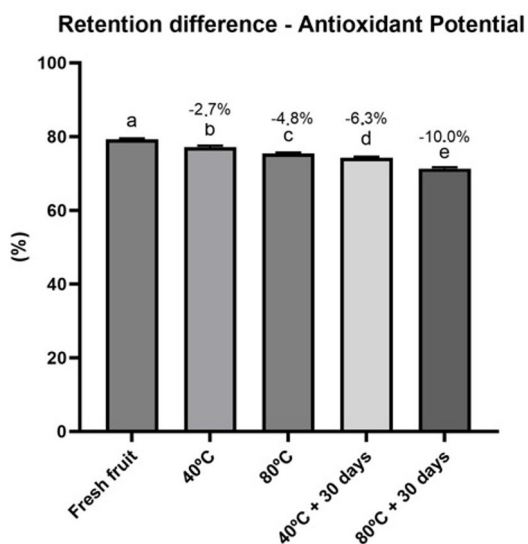


Figure 3. Graph comparing the difference in antioxidant potential in different samples of Canjiqueira (*B. cydoniifolia* A. Juss.). Different letters mean statistical difference. One-way analysis of variance followed by Tukey post-test. (ANOVA) $p < 0.05$. Caption. Fruit: fresh canjiqueira pulp; 80 °C: canjiqueira pulp dehydrated at 80 °C; 80 °C + 30: dehydrated canjiqueira pulp at 80°C and stored at room temperature for 30 days; 40 °C: dehydrated canjiqueira pulp at 40 °C; 40 °C + 30: canjiqueira pulp dehydrated at 40 °C and stored at room temperature for 30 days.

Table 1. Compounds and antioxidant activity in *in natura* and dehydrated canjiqueira fruits (*B. cydoniifolia* A. Juss.).

Sample	Antioxidant potential [%]	Phenolic compounds [mg/g]	Piceatannol [mg/g]	Tannins [mg/g]	Flavonoids [mg/g]
Fruit	79.33 ± 0.07 ^a	104.83 ± 0.7 ^a	1.43 ± 0.07 ^a	44.23 ± 0.17 ^a	31.43 ± 0.07 ^a
40 °C	77.13 ± 0.37 ^b	100.40 ± 0.3 ^b	1.23 ± 0.07 ^b	42.23 ± 0.07 ^b	30.36 ± 0.14 ^b
80 °C	75.50 ± 0.10 ^c	99.63 ± 0.07 ^c	1.06 ± 0.04 ^c	40.60 ± 0.4 ^c	29.06 ± 0.14 ^c
40 °C + 30	74.93 ± 0.97 ^c	97.83 ± 0.07 ^d	0.86 ± 0.04 ^d	39.86 ± 0.04 ^d	27.86 ± 0.04 ^d
80 °C + 30	71.33 ± 0.37 ^d	94.73 ± 0.27 ^e	0.73 ± 0.07 ^d	36.53 ± 0.17 ^e	25.53 ± 0.17 ^e

Fruit: fresh canjiqueira pulp; 80 °C: dehydrated canjiqueira pulp at 80 °C; 80 °C + 30: canjiqueira pulp dehydrated at 80 °C and stored at room temperature for 30 days; 40 °C: dehydrated canjiqueira pulp at 40 °C; 40 °C + 30: dehydrated canjiqueira pulp at 40 °C and stored at room temperature for 30 days. The results are expressed on a dry basis of 15% moisture (g/100 g). Means followed by the same letter in the same column do not differ statistically from each other ($P > 0.05$), SD (standard deviation). The Tukey test was applied at 5% probability.

Source: Prepared by the author (2023).

food, the method is important in retaining the main compounds present in canjiqueira fruits.

4. Discussion

Figure 4 shows the analysis of piceatannol retention of fruits in different drying and storage conditions. When comparing the piceatannol values obtained in *in natura* fruits (1.43 mg/g) with dehydrated fruits, there were significant variations in the retention of the compound after the various stages. In samples dehydrated at 80 °C and stored for 30 days at room temperature, piceatannol retention was 51.1% (0.73 mg/g). This means that half of the original piceatannol was retained after processing and storage. For samples dehydrated at 40 °C and stored for 30 days at room temperature, retention was slightly higher, reaching 60.2% (0.86 mg/g). This suggests that the dehydration process at a lower temperature and the subsequent storage had a slightly positive effect on piceatannol retention.

On the other hand, samples dehydrated at 80 °C and not stored showed an even higher retention, that is, 74.20% (1.06 mg/g). This suggests that dehydration at a higher temperature with no prolonged storage contributed to a more effective retention of piceatannol. Samples dehydrated at 40 °C with no storage showed the highest retention among all conditions analyzed, reaching 86.01% (1.23 mg/g). It is interesting that the concentration of piceatannol obtained in the fruits of canjiqueira *in natura* (1.43 mg/g) is higher than the concentrations of this compound in other species considered as sources of piceatannol, such as grapes and passion fruit (Zomer et al., 2022). Previously, Arakaki et al. (2020) reported a concentration of 1.27 mg/g of piceatannol in canjiqueira seeds. Also, the study of Santos et al. (2017) reported a concentration of 0.16 mg/g when analyzing only the canjiqueira pulp.

Toxicity assays with *Artemia salina* demonstrated that both fresh and dehydrated pulp of *Byrsonima cydoniifolia* (canjiqueira) exhibited acute toxicity after 96 hours of exposure (Table 2). A significant increase in toxicity was observed following the dehydration process, as shown by the LC_{50} values: fresh fruit (863.23 mg·L⁻¹), dehydration

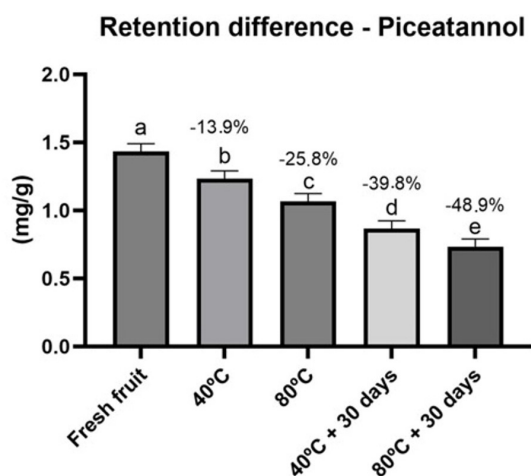


Figure 4. Graph comparing the difference in piceatannol retention in different samples of canjiqueira (*B. cydoniifolia* A. Juss.). Different letters mean statistical difference. One-way analysis of variance followed by Tukey post-test (ANOVA), $p < 0.05$. Caption. Fruit: *in natura* canjiqueira pulp; 80 °C: canjiqueira pulp dehydrated at 80 °C; 80 °C + 30: dehydrated canjiqueira pulp at 80 °C and stored at room temperature for 30 days; 40 °C: dehydrated canjiqueira pulp at 40 °C; 40 °C + 30: canjiqueira pulp dehydrated at 40 °C and stored at room temperature for 30 days.

at 80 °C (256.81 mg·L⁻¹), 80 °C + 30 days (235.28 mg·L⁻¹), 40 °C (153.31 mg·L⁻¹), and 40 °C + 30 days (214.49 mg·L⁻¹). According to the classification proposed by Vergara and Riquelme (2019), plant extracts with LC_{50} values below 500 mg·L⁻¹ are considered toxic, indicating that the dehydrated samples may pose ecological risks, especially to aquatic organisms.

This increase in toxicity may be attributed to physicochemical changes induced by dehydration, such as reduced moisture content and smaller particle size, which may facilitate the release and extraction of bioactive compounds, including phenolics (Sabet et al., 2021). Moreover, post-dehydration storage conditions influenced toxicity levels: samples stored at room temperature showed

Table 2. LC₅₀ values and toxicity classification of canjiqueira samples.

Sample	LC ₅₀ values (mg L ⁻¹) ± SD	Classification of canjiqueira samples	Vergara and Riquelme (2019)
Fruit	863.23±1.00 ^a	Low toxicity	500 < LC ₅₀ ≤ 1000 Low toxicity
80 °C	235.28±0.80 ^c	Toxic	100 < LC ₅₀ ≤ 500 Toxic
80 °C + 30	256.81±0.70 ^b	Toxic	
40 °C	153.31±0.60 ^e	Toxic	
40 °C + 30	214.49±0.90 ^d	Toxic	

Fruit: *in natura* canjiqueira pulp; 80 °C: dehydrated canjiqueira pulp at 80 °C; 80 °C + 30: canjiqueira pulp dehydrated at 80 °C and stored at room temperature for 30 days; 40 °C: dehydrated canjiqueira pulp at 40 °C; 40 °C + 30: canjiqueira pulp dehydrated at 40 °C and stored at room temperature for 30 days; LC50: medium lethal concentration; mg L⁻¹: milligrams per liter. Data are expressed as mean ± standard deviation. Means followed by the same letter in the same column do not differ statistically from each other (P >0.05), SD (standard deviation). The Tukey test was applied at 5% probability.

Source: Prepared by the author (2023).

Table 3. Growth Inhibition Values (GI50)* of Canjiqueira Samples in HUVEC (CRL-1730) and NIH/3T3 (Murine Fibroblast) Cell Lines.

SAMPLES	CELL LINES	
	NIH/3T3 GI ₅₀ (µg/ml)	HUVEC GI ₅₀ (µg/ml)
Fruit	428.3	365.4
80 °C	72.84	68.5
80 °C + 30	70.22	62.3
40 °C	40.55	35.7
40 °C + 30	52.15	48.6
DOXO	2.57	0.023

Fruit: raw canjiqueira pulp; 80 °C: canjiqueira pulp dehydrated at 80 °C; 80 °C + 30: canjiqueira pulp dehydrated at 80 °C and stored at room temperature for 30 days; 40 °C: canjiqueira pulp dehydrated at 40 °C; 40 °C + 30: canjiqueira pulp dehydrated at 40 °C and stored at room temperature for 30 days; CL50: Mean lethal concentration; mg L⁻¹: milligrams per liter. *Concentration that inhibits 50% of cell growth. Determined by nonlinear regression analysis using ORIGIN 6.0 software.

lower toxicity compared to those kept under freezing conditions, suggesting that storage conditions modulate the stability and bioactivity of the compounds.

In vitro cytotoxicity assays using murine fibroblasts (3T3) and human endothelial cells (HUVEC) indicated that the fresh pulp exhibited low cytotoxicity, with cell proliferation maintained at concentrations above 365 µg/mL. This finding suggests that fresh fruit consumption at conventional levels is likely safe. In contrast, dehydrated samples, particularly those processed at 40 °C, exhibited lower GI₅₀ values, indicating a more pronounced cytotoxic effect. These findings imply that low-temperature dehydration may impair cellular integrity and increase toxicity (Table 3).

Conversely, samples processed at 80 °C demonstrated reduced cytotoxicity compared to those treated at 40 °C, possibly due to the thermal degradation of toxic constituents at higher temperatures. These results highlight that processing parameters, especially temperature and storage duration, play a critical role in defining the safety profile of *B. cydoniifolia* pulp.

Given these findings, there is a clear need to standardize dehydration protocols to ensure the safe use of *B. cydoniifolia*

in food and nutraceutical products. Although dehydration can promote the conservation and retention of bioactive compounds, improper processing may increase toxicity and limit its applicability. Future studies should investigate the mechanisms underlying compound degradation or activation during drying, identify the specific constituents responsible for toxicity, assess chronic effects and safe intake thresholds *in vivo* models, and develop formulation strategies that retain the functional benefits of canjiqueira while minimizing its risks. Such investigations are essential for enabling the safe and sustainable use of this native species in food, phytotherapeutic, and biotechnological applications, contributing to biodiversity conservation and public health protection.

5. Conclusion

The results of this study demonstrate the effectiveness of dehydration as a method for preserving bioactive compounds in *Byrsonima cydoniifolia* (canjiqueira). The analysis of chemical parameters, including antioxidants, phenolic compounds, piceatannol, tannins, and flavonoids,

confirms the technique's ability to retain essential constituents even under variations introduced by the drying process. These findings support the classification of canjiqueira as a functional food, highlighting its antioxidant potential and the presence of health-promoting compounds.

Furthermore, this research highlights the importance of conservation methods such as dehydration in the preservation of native South American species. These strategies allow for the production of nutritious and health-promoting foods while also fostering dietary diversity and the sustainable use of natural resources, particularly in the Pantanal biome.

However, the study also revealed the toxicity of canjiqueira samples to *Artemia salina*, indicating the need for careful evaluation of dehydrated products, especially due to the higher concentration of bioactive compounds. The use of *A. salina* as a bioindicator proved to be effective, providing a sustainable and ethical approach for preliminary toxicity screening.

The findings showed that treatment temperature plays a key role in modulating cytotoxic effects, with conditions at 40 °C inducing greater cytotoxicity in the tested cell lines. These results emphasize the importance of *in vivo* studies to confirm the observed effects and to establish safe usage thresholds.

Dehydration at 40 °C for 24 hours proved effective in retaining compounds such as piceatannol, which is particularly relevant for traditional communities with access to solar greenhouses capable of reaching this temperature.

Finally, additional studies are needed to identify the compounds responsible for the observed toxicity and to investigate their implications for human health and the environment. This knowledge is essential for enabling the sustainable use of native species from the Pantanal, such as canjiqueira, and for contributing to the preservation of this vital ecosystem.

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