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Chemical characterization and antioxidant activity of fermented beverages from the fruits of *Passiflora nitida* Kunth

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Abstract

Passiflora nitida Kunth is a wild plant species, commonly known as "wild passion fruit" in the northern region of Brazil. The fresh fruit is consumed and sold in Manaus, Amazonas. Due to its nutraceutical potential, this study aimed to produce fermented beverages from the fruit pulp using four types of commercial yeasts and two filtration parameters. Additionally, physicochemical parameters, chemical profile analyses, total phenolic content, and radical scavenging capacity were evaluated. Nuclear magnetic resonance (NMR) analyses allowed for the identification of 16 compounds in total. Among these were citric, malic, and succinic acids, L-alanine, methionine, proline, threonine, tyrosine, vitexin, and choline. Furthermore, the fermented beverages produced by Cuvée and Maestoso yeasts (unfiltered) exhibited greater sweetness, justified by lower acidity and higher soluble solids content. The beverage produced with Cuvée yeast (unfiltered) showed a high radical scavenging capacity for 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt (ABTS●$^+$) (712.0 ± 5.0 µmol TE g^{-1}, $p < .05$) and 2,2-diphenyl-1-picrylhydrazyl (DPPH●) (344.6 ± 16.1 µmol TE g^{-1}) compared to the juice ($p > .05$). Therefore, we suggest that the fermented beverage obtained from Cuvée yeast may provide health benefits and be an alternative for the region's economic development.

Keywords: wild passion fruit; fermentation; phenolic compounds; antioxidant.

Practical Application: *Passiflora nitida* Kunth, known as wild passion fruit, is native to northern Brazil and widely consumed in Manaus. This study produced fermented beverages from its pulp using four commercial yeasts and two filtration methods. Physicochemical parameters, chemical composition, phenolic content, and antioxidant capacity were evaluated. Nuclear magnetic resonance (NMR) identified 16 compounds, including organic acids, amino acids, vitexin, and choline. The unfiltered beverage with Cuvée yeast showed higher sweetness and antioxidant activity, suggesting potential health benefits and value-added applications for regional development.

1 INTRODUCTION

The passion fruit pulp is recognized for its rich chemical composition and the health benefits it offers. It contains compounds such as carotenoids, phenolic acids, flavonoids, and tannins, which have in vitro antioxidant properties and may exert various biological activities. The pulps of *Passiflora* spp. also demonstrate potential to inhibit enzymes involved in carbohydrate digestion, although further studies in living organisms are necessary to validate these effects and better understand how they function. Additionally, there is great potential for the development of functional products, such as juices, fermented foods, and ice creams, particularly in the non-dairy food segment. These products also show the ability to maintain viable probiotic microorganisms under simulated gastrointestinal conditions, enhancing their functional properties (Pereira et al., 2023).

Passiflora nitida Kunth (Passifloraceae), commonly known as "wild passion fruit" or "maracujá-suspiro," is a wild plant species widely distributed across Brazilian territory (Grisi et al., 2019). In the northern region of Brazil, especially in Manaus,

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Amazonas, the fresh fruit is appreciated and sold in open-air markets and local markets (Kinupp & Lorenzi, 2021). The fresh fruits have good acceptability for consumption and are used in the preparation of sweets and juices (Grisi et al., 2019; Lima et al., 2012). In traditional medicine, they are used to treat gastrointestinal disorders (Carvalho et al., 2010). Additionally, they are a source of carbohydrates, fiber, flavonoids, phenolic acids, and inorganic components such as calcium, iron, phosphorus, sodium, copper, and zinc, among others, making it an excellent option for daily consumption (Bendini et al., 2006; Lima et al., 2012; Pereira et al., 2024). Scientific studies indicate that the *P. nitida* species possesses promising pharmacological properties, such as antioxidant, gastroprotective, anticoagulant, hypoglycemic, and antimicrobial activities (Bendini et al., 2006; Carvalho et al., 2010; Lima et al., 2012; Pereira et al., 2024; Wasicky et al., 2015).

Given this, the fruit presents great potential for the production of a bioproduct with nutraceutical properties, potentially adding even more value and becoming an alternative for the region's economic development. An efficient option is the use of alcoholic fermentation, as it increases the shelf life of a food product and reduces the need for refrigeration or other forms of preservation (Boeira et al., 2020). This is especially important in remote areas, where other preservation techniques are not available (Sales et al., 2021). According to Brazilian legislation, fruit fermented beverages are alcoholic drinks with an alcohol content ranging from 4 to 14% by volume (20°C) obtained through alcoholic fermentation. This process is performed from the must of ripe and fresh fruits of a single species, using either the respective whole or concentrated juice, or pulp (Brasil, 2009). Despite the evidence of the nutraceutical potential of *P. nitida*, as far as we know, there are no scientific studies characterizing the juice pulp and fermented beverages from this species. Nuclear magnetic resonance (NMR) technique offers advantages due to the speed and simplicity of sample preparation, the ability to identify multiple metabolites in the same spectrum, high reproducibility, and the non-destructive nature (Dutra et al., 2023; Oliveira et al., 2021).

In this context, this study aimed to produce fermented alcoholic beverages from the pulp of *P. nitida* fruits using four types of commercial yeasts and two filtration parameters. Additionally, physicochemical parameters were determined, chemical profiles were analyzed using NMR, the 2,2-diphenyl-1-picrylhydrazyl (DPPH●) and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt (ABTS●⁺) radical scavenging capacities were evaluated, and the total phenolic content (TPC) was measured.

1.1 Relevance of the work

This study is relevant as it explores the functional potential of *Passiflora nitida* (wild passion fruit), a native Amazonian species, through the production of fermented beverages. Fermentation enhanced sweetness and acidity and led to the formation of new metabolites. The unfiltered beverage fermented with Cuvée yeast showed higher phenolic content and antioxidant activity. The results indicate a promising alternative to provide health benefits and add value to wild passion fruit, promoting the sustainable use of regional biodiversity.

2 EXPERIMENTAL

2.1 Standards, reagents, and solvents

The commercial yeast of Blastosel Grand Cru was purchased from Perdomini IOC (San Martino Buon Albergo, Italy), Arom Cuvée was purchased from Biotecsul (Caxias do Sul, Brazil), and the yeasts Andante and Maestoso were purchased from Renaissance Yeast (Vancouver, Canada). Quercetin, gallic acid, resazurin sodium salt, DPPH·, ABTS·⁺, and 6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid (Trolox) were purchased from Sigma-Aldrich (St. Louis, USA). Water solvent (D_2O) and sodium-3-trimethylsilyl propionate (TMSP-d_4) were purchased from Cambridge Isotope Laboratories Inc. (Andover, USA).

2.2 Alcoholic beverage production process

The fruits of *P. nitida* were purchased at the Adolpho Lisboa Market (Manaus, Amazonas, Brazil). After washing and sanitizing with a peracetic acid solution (0.5 g L^{-1}), the pulp with seeds was processed in a blender to obtain the juice. The must was prepared at a ratio of 1.0:1.0 (fruit, m/v), and the pH was adjusted to between 3.0 and 4.0 using tartaric acid. Subsequently, vacuum filtration with diatomaceous earth filtration was performed. Chaptalization of the acidified and filtered juice was carried out until reaching 21°Brix. The prepared must was divided into four batches, and a different yeast was added to each sample (Andante, Blastosel Grand Cru, Arom Cuvée, and Maestoso). The yeasts were used according to the manufacturer's instructions. Fermentations were conducted at 20°C in 2 L glass bottles equipped with an airlock valve. The evolution of fermentation was monitored by measuring the total soluble solids (TSS) every 24 h, and the end of the process was determined by the stabilization of TSS content (°Brix). After 9 days, racking, vacuum filtration using diatomaceous earth, bottling in glass bottles, and the use of synthetic corks were performed (Boeira et al., 2020). The obtained fermented beverages were evaluated regarding the filtration parameter, filtered (F) and unfiltered (NF), resulting in eight fermented samples: Andante (And-F and And-NF), Blastosel Grand Cru (BCG-F and BCG-NF), Arom Cuvée (Cuv-F and Cuv-NF), and Maestoso (Maest-F and Maest-NF).

2.3 Qualitative NMR acquisition data

One-dimensional (1D) (^{1}H) and two-dimensional (2D) (correlation spectroscopy [COSY], heteronuclear single quantum correlation [HSQC], and heteronuclear multiple bond correlation [HMBC]) NMR analyses were performed on a spectrometer Bruker® Avance III HD (500.13 MHz for ^{1}H and 125.8 MHz for ^{13}C, BBFO Plus SmartProbe™, New York, NY, USA) at 298 K.

An aliquot of juice and fermented samples (550 µL) from *P. nitida* fruits was mixed with 50 µL of D_2O (TMSP-d_4 0.6 mM, ≥ 99.0% purity). After ethanol evaporation, the dry extracts obtained from the fermented samples were solubilized with 600 µL of D_2O (TMSP-d_4 0.6 mM). The prepared samples were placed in a 5-mm NMR tube and subjected to ^{1}H NMR analysis using the ZGPR pulse sequence for water signal suppression. The 2D experiments were performed using the standard pulse sequence of the spectrometer. For all spectra, phase adjustment and baseline correction were performed manually. The TopSpin™ 4.1.3 software was used for NMR spectra processing (see Suppl. Mat.).

2.4 Physicochemical characterization

The fermented beverages from the pulp of *P. nitida* fruits were analyzed for color using the CIELAB method (L, a, and b*) with a portable spectrophotometer Delta Vista 450G (Delta Color, RS, Brazil). The hydrogen potential (pH) was determined by direct reading of the samples using a pH meter AK90 (AKSO, RS, Brazil). Additionally, the TSS content was determined using three drops of each sample with direct readings taken on a digital refractometer model MA871 (Milwaukee, NC, USA), and the results were expressed in °Brix. All analyses were performed in triplicate.

2.5 Quantification of total phenolic content

The TPC was determined according to the method described by Velioglu et al. (1998). An aliquot of 150 µL of Folin–Ciocalteu reagent (1:10) was reacted with 2.0 µL of the sample solution (1,000 µg mL^{-1}) for 5 min. Then, 150 µL of sodium bicarbonate was added (6 g L^{-1}), and the reaction mixture was incubated for 90 min under protection from light. Absorbance measurements at 750 nm were performed on a microplate reader (Epoch 2, BioTek). The standard gallic acid curve ($y = .0043x+.0289$, $R^2 = 0.9996$) was obtained from different concentrations (7.8–500 µg mL^{-1}). The TPC result was expressed as mg of gallic acid equivalent (GAE) per gram of a sample (mg GAEq g^{-1}). This assay was performed in triplicate.

2.6 Antioxidant assays using the DPPH• and ABTS•⁺ free-radical methods

The samples (juice and fermented beverages) were subjected to DPPH• and ABTS•+ radical scavenging capacity assays based on methodologies with slight modifications for microplate reading. For the DPPH• radical assay, 10 µL of the sample was added to 190 µL of DPPH solution (60 µM) and incubated in the dark for 30 min. Subsequently, absorbance readings were taken using a BioTek Epoch 2 microplate reader at 515 nm (Agilent, CA, USA). A linear regression curve for the Trolox standard was obtained at concentrations ranging from 100 to 500 µM ($y = -.0007x+0.5322$, $R^2 = 0.9992$) (Molyneux, 2004). For the ABTS•+ radical assay, the sample was mixed with the ABTS solution at a 1:100 ratio and incubated in the dark for 6 min. Subsequently, absorbance readings were taken on the microplate reader at 734 nm. A linear regression curve for the Trolox standard at concentrations from 62.5 to 500 µM was obtained ($y = -.0002x+0.6374$, $R^2 = 0.9998$). The results of both assays were expressed in micromoles of Trolox equivalents per liter of sample (µM TE) (Re et al., 1999).

2.7 Statistical analysis

The results were expressed as mean ± standard deviation. The assays were analyzed using analysis of variance (ANOVA) (one-way) followed by multiple comparisons using the Tukey test (95% confidence level) with Minitab® 18.1 software. Values of $p < .05$ were considered statistically significant.

3 RESULTS AND DISCUSSION

3.1 Physicochemical parameters

The results of the soluble solids content (TSS), pH, and color analyses of the alcoholic fermented beverages obtained from the pulp of *P. nitida* fruits are presented in Table 1. According to our data, the beverage produced by Andante yeast (And-NF) showed a significant difference in TSS content (7.5 ± 0.25) compared to the beverages produced by Cuvée yeast (8.1 ± 0.23 [Cuv-F] and 8.2 ± .05 [Cuv-NF]) ($p < .05$). On the other hand, the beverages produced by Blastosel Grand Cru (BCG-F/NF) and Maestoso (Maest-F/NF) yeasts did not show significant differences in TSS values compared to the Cuv-F beverage ($p > .05$). Additionally, the pH values of the samples ranged from 3.0 ± .05 to 3.3 ± 0.11, which are in accordance with the pH levels for wines (Boeira et al., 2020). Furthermore, these values are consistent with those of fermented beverages produced from the pulp of *Passiflora cincinnata* (Caatinga passion fruit) (Santos et al., 2021). Thus, these results indicate that the fermented beverages produced from Cuvée (Cuv-F/NF) and Maestoso (Maest-NF) yeasts exhibit greater sweetness, a characteristic justified by lower acidity and higher soluble solids content (Santos et al., 2021).

Table 1. Physicochemical parameters analyzed in the fermented beverages produced with *P. nitida* fruits.

Samples	TSS (°Brix)	pH	Color		
			L*	a*	b*
And-F	7.6 ± 0.2^{b,c}	3.1 ± 0.1^{b,c}	42.0 ± 0.4^{d}	3.5 ± 0.1^{c}	17.5 ± 0.0^{e}
And-NF	7.5 ± 0.2^{c}	3.0 ± 0.1^{b,c}	39.7 ± 0.0^{e}	4.6 ± 0.0^{a}	18.3 ± 0.0^{c}
BCG-F	8.0 ± 0.2^{a,b,c}	3.0 ± 0.0^{c}	46.1 ± 0.0^{a}	2.6 ± 0.0^{f}	16.6 ± 0.0^{f}
BCG-NF	8.1 ± .0^{a,b,c}	3.1 ± .0^{a,b,c}	44.5 ± 0.1^{b}	3.2 ± 0.0^{d}	16.8 ± 0.2^{f}
Cuv-F	8.1 ± 0.2^{a,b}	3.3 ± 0.1^{a}	42.7 ± 0.1^{c,d}	3.0 ± 0.0^{e}	18.0 ± 0.0^{d}
Cuv-NF	8.2 ± 0.0^{a}	3.2 ± 0.1^{a,b,c}	42.0 ± 0.0^{d}	2.8 ± 0.0^{e}	20.2 ± 0.0^{a}
Maest-F	7.7 ± 0.2^{a,b,c}	3.2 ± 0.0^{a,b}	39.7 ± 0.0^{e}	4.6 ± 0.0^{a}	19.0 ± 0.0^{b}
Maest-NF	8.0 ± 0.1^{a,b,c}	3.3 ± 0.0^{a}	43.5 ± 1.0^{b,c}	4.0 ± 0.1^{b}	17.6 ± 0.0^{e}

Results are expressed as mean ± standard deviation ($n = 3$); $^{a-f}$Same letters in the same column are statistically significant ($p < .05$); And: Andante; BCG: Blastosel Grand Cru; Cuv: Cuvée; Maest: Maestoso; F: filtered; NF: unfiltered.

Regarding color parameters, the filtered beverage produced by BCG-F yeast showed the highest brightness ($L = 46.1$). For the a* color value, which indicates red/green intensity, the And-NF and Maest-F beverages had the highest values ($a^* = 4.6$) and differed significantly from the other beverages. As for the b* color value, which indicates yellow/blue intensity, the Cuv-NF beverage had the highest level ($b^* = 20.2$) compared to the other fermented beverages ($p < .05$).

3.2 Qualitative chemical description

The chemical profiles of the constituents of the juice and fermented beverages from *P. nitida* fruit pulp were determined by NMR. All ^{1}H NMR spectra revealed a spectral complexity of signals attributed to aliphatic (δ_H 0.88–3.0), carbinolic (δ_H 3.0–5.40), and aromatic (δ_H 5.58–9.45) regions. The metabolite analysis was conducted by assigning the signals based on the ^{1}H and ^{13}C chemical shifts, coupling constants (J), and spectral data described in the literature (Table 2). Figure 1 shows an amplification of the ^{1}H NMR spectrum of *P. nitida* juice in the 1.4–5.5 ppm region, as well as signals attributed to amino acids (L-Alanine, methionine, and proline), organic acids (citric, malic, and succinic acids), carbohydrates (sucrose, α-Glucose, β-Glucose, and fructose), and choline. The most intense signals are the doublets at δ_H 2.94 and δ_H 2.80 ($J = 15.6$ Hz), corresponding to the hydrogens of citric acid, and the signals at δ_H 5.40 (d, $J = 3.8$ Hz), attributed to sucrose.

In addition, the organic acids (citric, malic, and succinic acids), carbohydrates (sucrose, α-Glucose, β-Glucose, and fructose), and choline were also easily identified in the fermented beverages and are shown in Figure 2. The ^{1}H NMR spectra of the beverages exhibited signals of metabolites generated during the fermentation process. The detected signals are consistent with the amino acid threonine (**12**) and the carbohydrates trehalose (**13**) and maltose (**14**). Compound (**12**) was confirmed by the

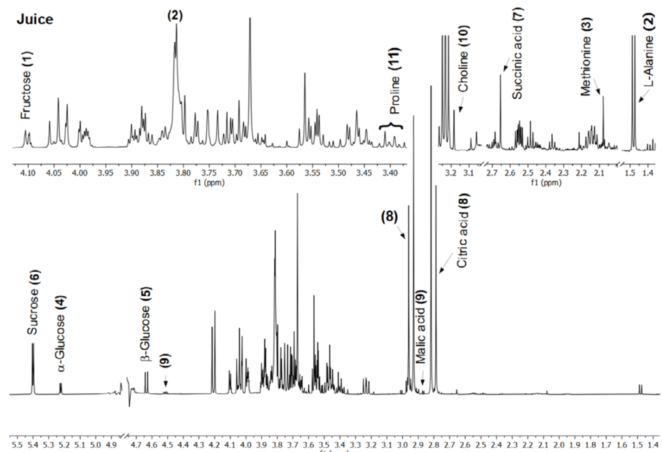

Figure 1. Amplification of the ^{1}H NMR spectra (1.4–5.5 ppm) for the signals of the compounds identified in the *P. nitida* juice (500.13 MHz, H_2O:D_2O).

Table 2. Compounds identified in juice and fermented beverages from the pulp of *P. nitida* fruits by NMR 1D and 2D.

Samples	Compounds	δ ^{1}H in ppm (J, Hz)	δ ^{13}C in ppm	References
Juice	Fructose (**1**)	δ 4.10 (m)	78.0, 77.8, 65.3	Kim et al., 2021)
	L-Alanine (**2**)	δ 1.48 (d; *J* = 7.2 Hz); δ 3.83 (m)	19.1, 53.5, 178.4	(Kim et al., 2021)
	Methionine (**3**)	δ 2.07 (s)		(Nor et al., 2022)
Juice; present in all fermented beverages	α-Glucose (**4**)	δ 5.22 (d; *J* = 3.7 Hz)	95.3, 75.1	Kim et al., 2021)
	β-Glucose (**5**)	δ 4.63 (d; *J* = 7.9 Hz) δ 3.23 (dd; *J* = 9.2; 7.9 Hz)	98.9, 78.8, 77.3	Kim et al., 2021)
	Sucrose (**6**)	δ 5.40 (d; *J* = 3.8 Hz)	95.3, 74.0, 75.8	Kim et al., 2021)
	Succinic acid (**7**)	δ 2.64 (s)	32.2, 180.5	(Sales et al., 2021)
	Citric acid (**8**)	δ 2.80 (d; *J* = 15.6 Hz); δ 2.94 (d; *J* = 15.6 Hz)	46.7, 76.5, 177.4, 181.1	(Sales et al., 2021)
	Malic acid (**9**)	δ 2.85 (d; *J* = 4.5 Hz); δ 2.72 (d; *J* = 7.2 Hz); δ 4.51 (dd; *J* = 7.2; 4.5 Hz)	42.3, 70.6, 178.3, 180.5	(Hu et al., 2020)
	Choline (**10**)	δ 3.18 (s)	56.7, 57.0, 69.0	(Nor et al., 2022)
	Proline (**11**)	1.97–2.03 (m), 1.95 (m), 2.09 (m), 2.34 (m), 3.32 (m), 3.40 (m), 4.13 (m)	26.7, 31.8, 64.2, 49.0, 177.6	(Nor et al., 2022)
	Threonine (**12**)	δ 1.38 (d; *J* = 7.0 Hz); δ 4.29 (d; *J* = 7.0 Hz),	22.5, 7.0, 182.8	(Kim et al., 2021)
	Trehalose (**13**)	δ 5.18 (d; *J* = 3.8 Hz) δ 3.65 (d; *J* = 4.3 Hz)	96.8, 96.2, 75.7, 75.2	(Nor et al., 2022)
Present in all fermented beverages	Maltose (**14**)	δ 5.43 (d; *J* = 3.8 Hz) δ 5.36 (d; *J* = 3.8 Hz) δ 3.55 (d; *J* = 6.6 Hz)	95.2, 95.0, 75.0, 75.2	(Nor et al., 2022)
	Tyrosine (**15**)	δ 6.85 (d; *J* = 8.3 Hz); δ 7.17 (d; *J* = 8.3 Hz);	156.8, 133.2, 118.5	(Nor et al., 2022)
	Vitexin (**16**)	δ 7.85 (d; *J* = 8.0 Hz); δ 6.70 (s, H3)		(Flores et al., 2020)

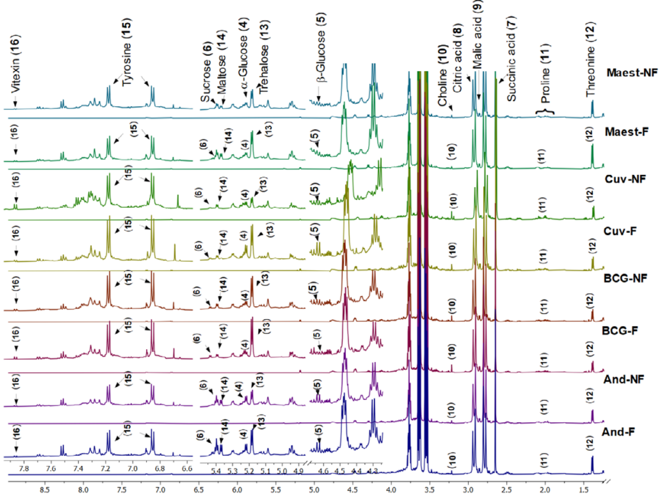

Figure 2. Amplification of the ^{1}H NMR spectra (1.4–8.0 ppm) for the signals of the compounds identified in fermented beverages of *P. nitida fruits* (500.13 MHz, H_2O:D_2O).

doublets at δ_H 1.38 (d; J = 7.0 Hz) and δ_H 4.29 (d; J = 7.0 Hz), which showed long-range correlations with carbon atoms at δ 182.8 ppm. In the carbinolic region, the intense signal at δ_H 5.18 (d; J = 3.8 Hz) and the doublet at δ_H 5.36 (d; J = 3.8 Hz) were attributed to constituents (**13**) and (**14**), respectively. These constituents were previously identified in *Passiflora edulis* species (Nor et al., 2022). Additionally, in the aromatic region, two doublets were observed at δ_H 6.85 (d; J = 8.3 Hz) and δ_H 7.17 (d; J = 8.3 Hz). The ^{1}H–^{13}C HSQC and HMBC correlation maps confirmed the identification of the amino acid tyrosine (**15**) (Table 2). Furthermore, the signals at δ_H 7.85 (d; J = 8.0 Hz) and δ_H 6.70 (s) confirm the presence of the flavone vitexin (**16**). This flavonoid was previously identified in *P. cincinnata* and *Passiflora alata* species (Dutra et al., 2023; Sales et al., 2024).

3.3 Free-radical scavenging activities

The juice and fermented beverages obtained from *P. nitida* fruits were evaluated for TPC using the Folin–Ciocalteu (FC) method and free-radical scavenging activity using the DPPH● and ABTS●⁺ methods. These two methods are widely used to assess the ability of substances to eliminate radicals through electron transfer (Magalhães et al., 2008). The results are presented in Table 3.

The TPC measured in the juice was 297.9 ± 4.8 mg GAE g^{-1}, significantly different from that of the fermented beverages ($p < .05$). Consequently, the juice exhibited a high radical scavenging capacity according to the methods used. These results are consistent with previous findings for teas made from *P. nitida* fruit pulp (Pereira et al., 2024) and the pulp and powder of *P. edulis* fruits (purple passion fruit) (Samyor et al., 2021). The beverage produced by Cuvée yeast using the unfiltered process (Cuv-NF) showed a high capacity to scavenge the ABTS●⁺ radical (712.0 ± 5.0 μmol TE g^{-1}, $p < .05$) and did not show a significant difference in antioxidant capacity in the DPPH● method (344.6 ± 16.1 μmol TE g^{-1}) compared to the juice ($p > .05$). It is important to note that, among the fermented beverages produced and analyzed by ^{1}H NMR, the Cuv-NF beverage exhibited the highest intensity of the electronic signal at μ_H 7.85 (d; J = 8.0 Hz), corresponding to the glycosylated flavone vitexin (**16**). This flavonoid has been reported to possess various pharmacological effects, including antioxidant capacity against reactive oxygen species, lipid peroxidation, and other damage related to oxidative stress (Babaie et al., 2020). Additionally, citric acid (**8**), present in all samples, has demonstrated in vivo, in experimental models, the ability to attenuate lipid peroxidation, brain inflammation, liver damage, and DNA fragmentation (Abdel-Salam et al., 2014). According to the literature, amino acids that primarily contain hydroxyl groups in their side chains (Thr, **12**) and benzene groups (Tyr, **15**) have shown significant DPPH● radical scavenging activity (Guidea et al., 2020). The synergistic effect of these constituents may explain the observed results. Additionally, a positive correlation was found between TPC and antioxidant assays for DPPH● (0.939, $p < .05$) and ABTS●⁺ (0.695, $p < .05$). Therefore, these correlations suggest that the phenolic constituents in the juice and fermented beverages are the primary contributors to the free-radical scavenging capacity.

Table 3. Total phenolic content and free-radical scavenging activities of fermented beverages obtained from *P. nitida* fruits.

Samples	TPC (mg GAEq L^{-1})	DPPH (mmol TEq)	ABTS (mmol TEq)
Juice	297.9 ± 4.8 [a]	334.1 ± 20.6 [a]	1075.3 ± 11.5 [a]
And-F	96.0 ± 3.9 [ef]	252.7 ± 1.4 [b, c]	607.0 ± 45.0 [c]
And-NF	92.4 ± 3.8 [f]	266.2 ± 2.1 [b]	542.0 ± 26.5 [c, d]
BCG-F	109.2 ± 1.1 [d]	269.4 ± 5.0 [b]	507.0 ± 13.2 [d]
BCG-NF	126.9 ± 4.1 [c]	245.1 ± 12.5 [b, c]	587.0 ± 15.0 [c]
Cuv-F	127.5 ± 4.5 [c]	277.5 ± 10.7 [b]	495.3 ± 10.4 [d]
Cuv-NF	139.3 ± 0.7 [b]	344.6 ± 16.1 [a]	712.0 ± 5.0 [b]
Maest-F	97.4 ± 3.3 [ef]	227.7 ± 0.7 [c]	497.0 ± 35.0 [d]
Maest-NF	102.7 ± 2.8 [de]	250.3 ± 20.5 [b, c]	515.3 ± 18.9 [c, d]

Resulted are expressed as means ± standard deviation (n = 3); [a-f]Different letters in same column are significant (p-value < .05); mmol TEq: micromolar of Trolox equivalent, mg GAEq L^{-1}: milligram of Gallic acid equivalent per liter of sample; And: Andante; BCG: Blastosel Grand Cru; Cuv: Cuvée; Maest: Maestoso; F: filtered; NF: unfiltered.

CONCLUSION

The NMR analyses of the juice and fermented beverages from *P. nitida* fruit pulp allowed for the identification of 16 compounds in total, including six carbohydrates, three organic acids, five amino acids, one glycosylated flavonoid, and choline. Among these, the metabolites threonine, trehalose, maltose, tyrosine, and vitexin were identified only in the beverages, demonstrating that fermentation can generate additional metabolites and contribute to the quality of the beverage. Thus, the fermented beverages obtained from Cuvée and Maestoso yeasts (unfiltered) exhibited greater sweetness, a characteristic justified by the increase in pH and soluble solids content. Furthermore, all beverages demonstrated the capacity of sequester free radicals. However, the juice and the unfiltered beverage obtained from Cuvée yeast showed higher TPC, and no significant difference was observed in the radical scavenging capacity for DPPH●

and ABTS●⁺ assays. Considering these results, we suggest that the fermented beverage produced with Cuvée yeast may provide health benefits and be an alternative to add more value to wild passion fruit. Therefore, further studies are needed to analyze other physicochemical parameters established by legislation and to evaluate the sensory acceptability of the product.

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