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Plinia peruviana "Yvapurũ" Fruits and Marmalade from Paraguay: Autochthon Products with Antioxidant Potential †

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† Presented at the 2nd International Conference of Ia ValSe-Food Network, Lisbon, Portugal, 21–22 October 2019.

Published: 6 August 2020

Abstract: In this study, we aimed to describe the antioxidant content and physicochemical characteristics of the marmalade and fruits of *Plinia peruviana* "Yvapurũ", harvested in Paraguay. The morphological characteristics, moisture, pH, vitamin C, total phenols, and anthocyanins were analyzed in mature wild and cultivated fruit samples. The values of anthocyanins (282–288 mg of cyanidin 3-O-glucoside/100 g) and total phenols in fruits and marmalades (214–224 and 719–817 mg GAE/100 g, respectively) make this fruit and its marmalade byproduct potential sources of phenolic compounds of interest to the dye, flavoring, and antioxidant industries.

Keywords: *Plinia peruviana;* antioxidants; total phenols; marmalade; anthocyanins; Yvapurũ

1. Introduction

The systematic investigation of native fruits and their derived products promotes their re-evaluation and contributes to a better exploration of the national species, which motivates new economic activities [1]. The biodiversity of fruits in Paraguay is considerable; however, the limited information on their composition results in a lack of use on the agronomic, industrial, and medicinal levels. *Plinia peruviana* (Poir.) Govaerts "Yvapurũ" is a perennial tree of the Myrtaceae family that is distributed in the Southern Cone of America in the regions of Central Department, Cordillera, Ñeembucu, and Paraguarí in Paraguay. This species is currently accepted as *Eugenia guapurium* DC., *Guapurium peruvianum* Poir., *Myrciaria guapurium* (DC.) O. Berg, *Myrciaria cauliflora* auct. non (DC.) O. Berg, *Eugenia cauliflora* Miq., hom. illeg., *Plinia trunciflora* (O. Berg) Kausel, *Myrciaria trunciflora* O. Berg and *Myrciaria peruviana* (Poir.) Mattos var. trunciflora synonyms [2]. In the region, the chemical composition and biological activities of these fruits have been characterized and studied, highlighting a high total phenol content in the fruit with antioxidant activity. The content of phenols varies with the environment, plant growth, genetic variety, and the stage of maturation of the fruit factors, among others [2–4]. One of the most traditional products that uses all the parts of the fruit is marmalade. We aimed to describe the antioxidant content and physicochemical characteristics of *Plinia peruviana* "Yvapurũ" fruits harvested in Paraguay, as well as determine the physicochemical characteristics and content of total phenols in marmalade (Figures 1 and 2).

Figure 1. Fruit of *Plinea peruviana.*

Figure 2. Batches of Yvapurũ marmalade.

2. Materials and Methods

2.1. Sampling

Samples of wild and cultivated fruits were collected in the ripe state from Emboscada, Cordillera, Paraguay (Cabaña ITAPÉ) (Sample 1) and Caacupé, Coordillera, Paraguay (Sample 2) from the Paraguayan Institute of Agrarian Technology (IPTA), respectively. The handmade whole-fruit marmalades were elaborated from the Sample 1 collection by traditional washing, slicing, cooking, and sieving without additives in three different batches.

2.2. Processing of Samples

For the determination of the morphological and physicochemical characteristics and vitamin C content in the fruit, whole fruits were used. To analyze total anthocyanins and total phenols, the peel and seeds of the pulp were separated. All determinations were made in triplicate; the data obtained are expressed as the mean ± standard deviation.

2.3. Analytical Methods

For the morphological studies, 30 fruits were taken for each sample, their weight was measured in analytical balance (AYD, model HR 120, Bradford, England), longitudinal and transversal diameter (measured in cm), and pH was measured with a potentiometer (Accurate pH 900, Horiba, Kyoto, Japan) at 25 °C. For humidity and vitamin C analysis, official A.O.A.C. techniques were used [5]. All reagents used were analytical grade. All determinations were made in triplicate. The determination of total anthocyanins by the differential pH method [1] was based on monomeric anthocyanin color loss at pH 4.5 and the presence of color at pH 1. The absorbance was measured at 510 and 700 nm.

Total phenols were determined using the Folin–Ciocalteau method with some modifications based on a colorimetric oxide reduction reaction. The extraction was carried out as described by Rufino et al. [6].

2.4. Statistical Analysis

The data were recorded and processed in a form of the GraphPad Prism 5.0 program (GraphPad Software Inc., San Diego, CA, USA). To determine significant differences, $p \leq 0.05$ was considered.

3. Results and Discussion

3.1. Yvapurũ Fruit Characteristics

No significant differences were observed in the morphological characteristics of weight and longitudinal and transversal diameter (Table 1) between the fruit samples. This result showed that the analyzed fruits harvested in Paraguay are smaller than those of synonymous species fruits in the state of Paraná, Brazil. These fruits weigh between 6.4 and 11.4 g and their diameter is near to 2.65 cm [7,8].

Table 1. Physicochemical characteristics of *Plinia peruviana* "Yvapurũ" fruits.

Physical Characteristics	Sample 1	Sample 2
Longitudinal diameter (cm)	1.98 ± 0.19 [a]	2.07 ± 0.18 [a]
Transversal diameter (cm)	2.01 ± 0.18 [a]	2.12 ± 0.19 [a]
Weight (g)	5.5 ± 1.3 [a]	5.6 ± 1.4 [a]
pH	3.17 ± 0.04 [a]	3.13 ± 0.01 [a]
Moisture (g/100 g)	79.7 ± 0.5 [a]	78.8 ± 0.1 [b]
Vitamin C (mg/100 g fw)	9.87 ± 0.30 [a]	7.03 ± 0.02 [b]

Results are expressed as mean ± SD of three independent assays. Values in the same row with the same superscript letter are not significantly different ($p > 0.05$) as measured by Student's *t*-test.

The pH values in the fruits are acidic and differ from the results reported by other authors (pH = 3.6–4.3) for the synonymous species of *Plinia peruviana* harvested in Brazil [7] *P. cauliflora* and *P. trunciflora*. These characteristics are explained by soil type and different environmental conditions, as well as genetic variations in the varieties distributed at different latitudes [9]. Thus, this indicated that the characteristics and composition of native fruits vary with soil type, genetics, and environmental conditions during the development of the species [7].

The moisture values in whole fruits were lower than 80%, with a significant difference between the average and the lower percentage observed by other authors (85.9%) in Brazil [6]. These values, however, are similar to the values observed by Seraglio et al. [10] for whole fruits of "Jaboticaba" (79.63%). Significant differences were observed in the vitamin C content between the fruits (Table 1). The values were lower than those reported for whole fruit in Brazil for *Myrciaria cauliflora* (238 mg/100 g) by Rufino et al. [6].

3.2. Anthocyanins and Total Phenol Content in Fruits

Significant differences in anthocyanins and total phenol content in different parts of the fruit were observed. Total phenols were highest in the peel (Table 2). Anthocyanins in the Sample 1 collection peel were smaller than in the Sample 2 collection. It was reported that this fruit has up to 58.1 mg/100 g of anthocyanins in fresh whole fruit [6] and 298.8–426.3 mg/100 g in peel, which agrees with the values observed in the present work. In the pulp, they reported lower values, 0.071–2.024 mg/100 g [8], than what was observed in pulps and seeds, which are used for the preparation of handmade marmalade in Paraguay. The values obtained in the pulp and seed were higher than those reported by other authors for *Plinia cauliflora* pulp in Brazil (32.4 mg GAE/100 g), and lower than the values reported in fruit peel harvested in Minas Gerais, Brazil [8].

Table 2. Anthocyanins and total phenols in fruits of *Plinia peruviana* "Yvapurũ".

Parameter	Sample 1		Sample 2	
	Peel	Pulp + Seeds	Peel	Pulp + Seeds
Monomeric anthocyanins (mg/100 g of cyanide nidin 3-glucoside)	282 ± 3 [a]	18.6 ±1.1 [b]	288 ± 2 [c]	10.0± 0.8 [d]
Total phenols (mg GAE/100 g FW)	811 ± 21 [a]	719 ± 15 [b]	817 ± 31 [a]	749 ± 22 [b]

Results are expressed as mean ± SD of three independent assays. Values in the same row with the same superscript letter are not significantly different ($p > 0.05$) as measured by Student's *t*-test.

3.3. Yvapurũ Plinia peruviana *Marmalade Results*

Significant differences in the titratable acidity were observed between batches 2 and 3 (ANOVA and Tukey's post-hoc test, $p \leq 0.05$) as shown in Table 3.

Table 3. Characteristics of the fruit marmalade of *Plinia peruviana* "Yvapurũ".

Parameter	Batch 1	Batch 2	Batch 3
Soluble solids (°Brix)	68.7 [a]	68.9 [a]	66.2 [b]
pH	2.80 ± 0.06 [a]	2.82 ± 0.01 [a]	2.82 ± 0.06 [a]
Total solids (g/100 g)	3.21 ±0,30 [a]	3.02 ± 0.28 [a]	3.63 ± 0.88 [a]
Titratable acidity (g citric acid/100 g)	0.88 ± 0.02 [a,b]	0.82 ± 0.02 [a]	0.97 ± 0.06 [b]
Total phenols (mg GAE/100 g FW)	224 ± 11 [a]	223 ± 7 [a]	214 ± 10 [a]

Results are expressed as mean ± SD of three independent assays. Values in the same row with the same superscript letter are not significantly different ($p > 0.05$) as measured by ANOVA and Tukey's post-hoc test, $p \leq 0.05$.

The total phenol content did not show statistically significant differences (ANOVA and Tukey's post-hoc test, $p \leq 0.05$). The results showed that the "Yvapurũ" marmalade, with its acidic pH, its organic acid content (titratable acidity 0.828–0.937 g citric acid/100 g fw), and sugar content (66.2–68.9° Brix), allows for the natural conservation of the product without the addition of artificial additives.

The marmalade has about 27–30% fewer total phenols than the pulp + seed and peel fruits, and provides about 22 mg of the total phenols per 10 g serving (one tablespoon of marmalade). Major polyphenols described for these species are quercetin, gallic acid, cyanidin-3-O-glucoside, isoquercetin, 3,4-dihydroxybenzoic acid, and kaempferol. These polyphenols give the product its antioxidant potential and other bioactive properties, such as anti-inflammatory, antibacterial, antifungal, antiproliferative, antimutagenic, hypoglycemic, and hypolipidemic activities [9,10]. The pomace, obtained as a byproduct (skin and seeds), can be of use in the food industry.

4. Conclusions

The fruits of *Plinea peruviana* "Yvapurũ" are important sources of vitamin C, anthocyanins, and phenolic compounds. Anthocyanins are found mainly in the peel; however, phenols are distributed in the peel, pulp, and seeds. Phenolic compounds may be of interest to the food industry, as colorants, antioxidants, and flavorings. The marmalade provides polyphenols that give it added value. Studies on native fruits and their elaborated products should be furthered to characterize their unique chemical properties, with a possible denomination of their origin.

Acknowledgments: This work was supported by a grant from the Ia ValSe-Food CYTED Project (119RT0567). The authors are especially grateful to Cabaña Itapé and IPTA for the provision of the samples and the Facultad de Ciencias Químicas of the Universidad Nacional de Asunción for providing their facilities.

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