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Composição nutricional de espécies nativas brasileiras de *Campomanesia* spp.

Nutritional composition of Brazilian native species of *Campomanesia* spp.

Composición nutricional de especies nativas brasileñas de *Campomanesia* spp.

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Resumo

Campomanesia eugenioides, Campomanesia xanthocarpa (Berg) e *Campomanesia xanthocarpa var. littoralis* são frutas nativas distribuídas no Brasil, popularmente reconhecidas por seus valores nutricionais, econômicos e culturais. Dada a escassez de estudos científicos controlados comparando variedades nativas de *Campomanesia*, o objetivo deste estudo foi caracterizar os frutos de *Campomanesia eugenioides, Campomanesia xanthocarpa e Campomanesia xanthocarpa var. littoralis,* quanto à composição química e valor nutricional através da quantificação de carboidratos, lipídios, umidade, cinzas, proteínas e fibras; os minerais Ca, Mg, P, Cu, Zn, Mn, Fe, K, Na; teor de vitamina C e carotenoides. Essas variedades apresentaram características físico-químicas distintas, com pequenas diferenças principalmente quanto ao teor de cinzas e valores calóricos. No entanto, *C. xanthocarpa var. littoralis* apresentou maiores teores de fibra, sólidos solúveis totais e acidez total titulável. Espécies de *C. eugenioides* se destacam em relação ao teor de vitamina C e minerais, com exceção de *C. xanthocarpa var. litorais* que apresentaram maior teor de ferro. *C. xanthocarpa* apresentou o maior teor de carotenoides, confirmando que esses frutos apresentam propriedades funcionais e alto valor nutricional. Finalmente, este estudo fornecerá dados científicos importantes para apoiar a aplicação de frutos valiosos de três espécies de *Campomanesia* na produção de ingredientes bioativos e conservantes naturais para produtos alimentícios.
Palavras-chave: *Campomanesia eugenioides; Campomanesia xanthocarpa; Campomanesia xanthocarpa* var. *litorais;* Superfrutas; Guabiroba; Gabiroba.

Abstract

Campomanesia eugenioides, *Campomanesia xanthocarpa (Berg)* and *Campomanesia xanthocarpa* var. *littoralis* are native fruits plants distributed in Brazil, which are popularly recognized for their nutritional, economic and cultural values. Given the scarcity of the controlled scientific studies comparing native *Campomanesia* varieties, the objective of this study was to characterize the fruits of *Campomanesia eugenioides*, *Campomanesia xanthocarpa* and *Campomanesia xanthocarpa* var. *littoralis*, regarding chemical composition and nutritional value through the quantification of carbohydrates, lipids, moisture, ash, proteins and fibers; the minerals Ca, Mg, P, Cu, Zn, Mn, Fe, K, Na content; vitamin C and carotenoids content. These varieties showed distinct physicochemical characteristics with small differences mainly about ash content and caloric values. Nevertheless, *C. xanthocarpa* var. *littoralis* showed higher values for fiber content, total soluble solids, and total titratable acidity. *C. eugenioides* species highlighted in relation to the vitamin C and mineral contents, with an exception for *C. xanthocarpa* var. *littoralis* that showed higher iron content. *C. xanthocarpa* had the highest carotenoid content, confirming that these fruits have functional properties and high nutritional value. Finally, this study will provide important scientific data supporting the application of valuable fruits from three edible *Campomanesia* species for producing bioactive ingredients and natural preservatives for food products.

Keywords: *Campomanesia eugenioides; Campomanesia xanthocarpa; Campomanesia xanthocarpa var. littoralis;* Superfruit; Guabiroba; Gabiroba.

Resumen

Campomanesia eugenioides, Campomanesia xanthocarpa (Berg) y Campomanesia xanthocarpa var. littoralis son frutas nativas distribuidas en Brasil, reconocidas popularmente por sus valores nutricionales, económicos y culturales. Dada la escasez de estudios científicos controlados que comparen variedades nativas de Campomanesia, el objetivo de este estudio fue caracterizar los frutos de Campomanesia eugenioides, Campomanesia xanthocarpa y Campomanesia xanthocarpa var. littoralis, con respecto a la composición química y el valor nutricional a través de la cuantificación de carbohidratos, lípidos, humedad, cenizas, proteínas y fibras; los minerales Ca, Mg, P, Cu, Zn, Mn, Fe, K, Na; contenido de vitamina C y carotenoides. Estas variedades mostraron diferentes características físico-químicas, con pequeñas diferencias principalmente en términos de contenido de cenizas y valores calóricos. Sin embargo, C. xanthocarpa var. littoralis presentó mayores contenidos de fibra, sólidos solubles totales y acidez titulable total. Las especies de C. eugenioides se destacan en relación con el contenido de vitamina C y minerales, con la excepción de C. xanthocarpa var. littoralis que tenían mayor contenido de hierro. C. xanthocarpa mostró el mayor contenido de carotenoides, confirmando que estas frutas tienen propiedades funcionales y alto valor nutricional. Finalmente, este estudio proporcionará datos científicos importantes para respaldar la aplicación de frutas valiosas de tres especies de Campomanesia en la producción de ingredientes bioactivos y conservantes naturales para productos alimenticios.

Palabras clave: *Campomanesia eugenioides*; *Campomanesia xanthocarpa*; *Campomanesia xanthocarpa* var. *littoralis*; superfruta; guabiroba; gabiroba.

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1. Introduction

Fruits have a recognized role in human nutrition and disease prevention, because they are excellent sources of vitamins, minerals and dietary fiber (Vallilo et al., 2008). They are beneficial to the consumer's health not only as recognized sources of nutrients, but because they contain in their composition, different groups of chemical substances (such as phenolic and carotenoid compounds), which when ingested, reduce the risk of cardiovascular diseases, also act as potent anti-cancer agents and prevent premature aging (Murillo et al., 2010).

Brazil is among the world's largest fruit producers thanks to its territorial extension, geographical position, soil and climatic conditions (Pereira et al., 2012). Due to these conditions and the new existing technologies, it is possible to produce fruits practically during the entire year. The native tropical fruits have conquered the consumer's preference, mainly with regard to their sensorial characteristics, of unique character (Duarte et al., 2010). Based on this statement, several species of fruit, still little known, have been evaluated more recently, as an alternative to traditional species (Pereira et al., 2012).

Among the native plants in Brazil, those of the *Myrtaceae* family are among the ten families with the highest representation in flora and comprise 26 genera and approximately 1000 species (Landrum & Kawasaki, 1997). Among the fruits belonging to the family *Myrtaceae* is the genus *Campomanesia* sp. The species of this genus have diversified economic importance. Its fruits are consumed *in natura* only by the local population and by several species of animals and are also used in the production of homemade sweets, ice cream, brandy, liqueurs and soft drinks (Vallilo et al., 2005).

Thus, the characterization of little-known and consumed fruits native species contributes to the expansion of knowledge about their chemical composition, nutritional value and functional properties, favouring their inclusion in the population's diet. Therefore, the objective of this study was to characterize the fruits of *Campomanesia eugenioides*, *Campomanesia xanthocarpa* and *Campomanesia xanthocarpa* var. *littoralis*, regarding chemical composition and nutritional value through the quantification of carbohydrates, lipids, moisture, ash, proteins and fibers; the minerals Ca, Mg, P, Cu, Zn, Mn, Fe, K, Na content; vitamin C and carotenoids content.

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2. Material and Methods

A research is carried out to bring new knowledge to society, as stated by Pereira et al. (2018). For a research to be recognized and validated, it must rely on methodologies accepted by the scientific academic community. The present study reports a quantitative research with a qualitative bias that reports the laboratory characterization research that was done on fruits in focus.

2.1. Location description and collection of samples

Riped *C. eugenioides* (*Campomanesia eugenioides*), *C. xanthocarpa* (*Campomanesia xanthocarpa (Berg)*) and *C. xanthocarpa var. littoralis* (*Campomanesia xanthocarpa* var. *littoralis (D. Landrum)*) fruits were collected in the West region of Santa Catarina State, Brazil, at latitude 27°14′2″S and longitude 52°1′40″W of Greenwich. The vouchers specimens were deposited at the Herbário do Vale do Taquari (HVAT, Lageado, Rio Grande do Sul, Brazil) and at the Herbário Padre Balduíno Rambo (HPBR, Erechim, Rio Grande do Sul, Brazil) with the no. HVAT 2612, HPBR 11579 and HPBR 11580, respectively. All the samples were collected when fully mature and were preselected considering the absence of visible injury, infections and color uniformity. Moreover, the fruits were freeze-dried with all the edible parts (skin, pulp, and seeds) and processed in a knife mill (Tecator, Knifetec 1095 model). The powders obtained were vacuum sealed in plastic bags and stored at a temperature of −18 ± 0.2 °C until analyzed.

2.2. Physicochemical analysis

Moisture, ash, protein (N×6.25), fiber, lipid, total soluble solids content (ºBx) and the acidity (% citric acid) were determined according to AOAC (2005). Total carbohydrates (g $100g^{-1}$) were obtained by difference. The energy value (Kcal $100g^{-1}$) was obtained by a calorimetric bomb (Ika Werke, C2000 basic model). The measurements of the pH values were obtained using a pH meter (Hanna, model HI 223). All analyses were carried out in triplicate.

2.3. Mineral composition

The mineral composition was determined according to AOAC (2005). The samples

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were digested in HNO_3-$HClO_4$ 8:1 (v:v) at 160 ºC and heating was continued until the initial volume was reduced to about one mL. After decomposition, the volume was completed to a 25 mL with ultrapure water. Quantification of the Ca, Cu, Fe, Mg, Mn and Zn in the samples was carried out using an Acetylene Flame Atomic Absorption Spectrophotometer (VARIAN SpectrAA 220). The wavelengths (nm) used included the following: Ca 422.07; Cu 324.8; Fe 248.3; Mg 285.2; Mn 279.5; and Zn 213.9. For the quantification of K and N, the Atomic Emission Spectrometry in a Flame Photometer (Micronal B 262) was used. Moreover, the P element was quantified by using the molybdovanadate reagent method. The measures were carried out on a spectrophotometer (Varian Cary 50 Probe) at 400 nm. The analytical curves were prepared using metal standards in a 5% solution of HNO_3 (R^2 = 0.99).

2.4. Vitamin C content

The vitamin C was determined according to AOAC (2005), and the results were expressed as milligrams of ascorbic acid equivalent per 100 g of fresh fruit weight (mg AA $100g^{-1}$ fresh fruit weight). The analyses were carried out in triplicate.

2.5. Carotenoid content

Carotenoids were extracted from samples (0.5 g lyophilized mass, n = 3) with methanol (MeOH) added to 100 mg L^{-1} tertbutyl hydroxytoluene (TBH). Solutions were filtered through a cellulose membrane to remove particles. The samples (10 µL, n = 3) were injected into the liquid chromatograph (Shimadzu LC-10A) equipped with a C18 reverse-phase column (Vydac 218TP54; 250 9 4.6 mm Ø, 5 µm, 30°C). This column was protected by a 5^{-1} m C18 reverse-phase guard column (Vydac 218GK54) and a UV–Vis detector (450 nm). Elution was performed with MeOH: CH3CN (90:10, v/v) at a flow rate of 1 mL min^{-1}. Carotenoid identification was performed using retention times and co-chromatography of standard compounds. Carotenoid quantification was based on standard curve of lutein (0.5–45 µg mL^{-1}; y = 7044x; r^2 = 0.999) for quantification. Results were expressed on a fresh weight (fw) basis as mg of lutein equivalents per 100 g of sample (mg LE $100g^{-1}$ fresh fruit weight).

2.6. Statistical analysis

The significance of the differences between the means of the samples was determined by analysis of variance (ANOVA) followed by Tukey's test (5 % significance). All statistical analyses were performed using the software STATISTICA version 13.3 (StatSoft Inc., Tulsa, OK, USA).

3. Results and Discussion

The physicochemical compositions of *Campomanesia* fruits are described in Table 1.

Table 1. Chemical composition, vitamin C, and carotenoids contents of *Campomanesia eugenioides*, *Campomanesia xanthocarpa* (Berg) and *Campomanesia xanthocarpa* var. *littoralis* (D. Landrum) fruits*.

	C. eugenioides	***C. xanthocarpa* (Berg)**	***C. xanthocarpa* var. *littoralis***
Moisture (g $100g^{-1}$ fw)	73.96 ± 0.02^{c}	79.87 ± 0.01^{a}	75.16 ± 0.04^{b}
Ash (g $100g^{-1}$ fw)	0.78 ± 0.01^{a}	0.42 ± 0.04^{b}	0.76 ± 0.01^{a}
Lipid (g $100g^{-1}$ fw)	0.39 ± 0.07^{c}	1.56 ± 0.04^{a}	1.01 ± 0.09^{b}
Carbohydrate (g $100g^{-1}$ fw)	21.64 ± 0.20^{a}	15.33 ± 0.02^{c}	17.15 ± 0.12^{b}
Protein (g $100g^{-1}$ fw)	0.88 ± 0.02^{b}	1.04 ± 0.02^{c}	1.33 ± 0.08^{a}
Fiber (g $100g^{-1}$ fw)	2.36 ± 0.13^{b}	1.79 ± 0.02^{c}	4.56 ± 0.35^{a}
Caloric value (Kcal $100g^{-1}$)	116.8 ± 1.46^{a}	111.1 ± 0.04^{b}	114.9 ± 0.22^{a}
Total soluble solids (°Brix)	14.9 ± 0.31^{c}	17.8 ± 0.46^{b}	19.3 ± 0.01^{a}
Total titratable acidity (% citric acid)	0.51 ± 0.01^{b}	0.43 ± 0.01^{c}	0.84 ± 0.01^{a}
Total soluble solids content by the total titratable acidity ratio	29.24 ± 0.68^{b}	41.86 ± 1.57^{a}	22.98 ± 0.19^{c}
pH	4.13 ± 0.01^{b}	4.28 ± 0.02^{a}	3.71 ± 0.02^{c}
Vitamin C (mg AA $100g^{-1}$ fw)	1049.00 ± 26.66^{a}	170.67 ± 4.04^{b}	86.00 ± 5.57^{c}
Carotenoids (mg LE $100g^{-1}$ fw)	25.68 ± 2.85^{b}	32.03 ± 3.59^{b}	61.48 ± 3.44^{a}

* Results presented as mean ± SD, n=3 repetitions. The same letters in the same line indicate no significant difference ($P < 0.05$). AA – ascorbic acid; LE – lutein equivalent; fw – fresh weight. Source: Authors.

All the samples presented significant differences ($P < 0.05$) for all the variables analyzed, except for the ash and the caloric value of *C. eugenioides* and *C. xanthocarpa* var.

littoralis. Regarding the moisture values, despite the significant difference, the samples presented high moisture content, a common characteristic of the *Myrtaceae* family, falling into the class of fleshy and juicy fruits as described by Landrum and Kawasaki (1997). These three fruits studied in the present work also do not appear as a lipid and protein source. Similar values of lipid content were determined for *Campomanesia phaea* (Vallilo et al., 2005), and *Campomanesia adamantium* (Vallilo et al., 2006). On the other hand, Pereira et al. (2012) observed higher protein content (5.53 g $100g^{-1}$) for *C. xanthocarpa* than those found in the present work. The differences in the proximate composition of the fruits can be explained mainly by the seasonal variation, by the variation of climate, soil and by the intrinsic characteristics of each species of *Campomanesia* (Van Leeuwen et al., 2004). As expected, the three samples evaluated showed high carbohydrate content, which showed a high correlation (R= 0.915) with their caloric values. Thus, the carbohydrate content was the highest calorie contributor to the fruits. Moreover, *C. xanthocarpa* var. *littoralis* showed the higher fiber content ($P < 0.05$) between the samples analyzed. This genus also showed the highest value ($P < 0.05$) for total soluble solids and total titratable acidity than the others two samples evaluated. Pereira et al. (2012) reported that these values were in the range recommended for fruits destined for processing, certifying a better, and more natural flavor for the product. Also, the pH values showed a high correlation (R = - 0.997) with acidity values, indicating that *C. xanthocarpa (Berg)* has the lower acidity among the three fruits analyzed. Duarte et al. (2010) and Vallilo et al. (2006) reported similar pH values for *C. pubescens* and *C. adamantium* (4.14 and 4.30, respectively).

As reported by Pereira et al. (2012) the soluble solids content by the total titratable acidity ratio is a better indicator of acid flavor than both isolated measures, providing a good perception of the balance between these two components. Therefore, the ratio detected for *C. xanthocarpa (Berg)* indicated that this fruit could be classified as the sweetest and tasty when compared to the other two samples.

C. eugenioides demonstrated the higher vitamin C content ($P < 0.05$), when compared with the others two species evaluated (Table 1), reaching almost a 100 times these contents. Duarte et al. (2010) considered high the value equal to 1090 mg AA $100g^{-1}$ fw of vitamin C in their study. However, as cited by Villas Boas et al. (2018), if each 100 g of the fruit has vitamin C concentration higher than 33 mg, this content is considered higher than that recommended by Food and Agriculture Organization of the United Nations and World Health Organization (FAO/WHO) for the daily human nutrition. Vallilo et al. (2008) obtained lower vitamin C than those verified in the present work for *C. xanthocarpa* (18 mg AA $100g^{-1}$).

Pereira et al. (2012) affirmed that there are many factors which can influence in the fruits vitamin contents, as, the species; the maturity stage, when harvested; genetic variations, and the postharvest handling.

In contrast to the previous results obtained for the physicochemical composition and vitamin C content, the higher ($P < 0.05$) carotenoid content was found for *C. xanthocarpa* var. *littoralis* (Table 1). However, all carotenoid content values were higher than reported by Murillo et al. (2010) and by Pereira et al. (2012), for others wild fruits and guabiroba fruit, indicating that all samples of this work could be a good source of carotenoid content. The differences observed may be related to small differences in the maturation stages of the analysed fruits, since Yoo and Moon (2016) reported that ripening increased the total carotenoid in three citrus varieties (*Citrus junos Sieb* ex Tabaka, *Citrus unshiu* Marcow, and *Citrus grandis* Osbeck).

With regard to the mineral elements (Table 2), in general, *C. eugenioides* fruits showed higher ($P < 0.05$) minerals contents, with emphasis on potassium, calcium, magnesium, phosphorus, and zinc contents; which were similar ($P > 0.05$) to the magnesium and phosphorus content found for *C. xanthocarpa* var. *littoralis* fruits. This last one *Campomanesia* fruit species showed higher ($P < 0.05$) iron content, when compared with the three species evaluated.

Sodium, manganese, and copper contents showed the same behavior for the three species, i.e., demonstrated lower concentration equivalent to the quantification limit of the method. High potassium content was also observed by Vallilo et al. (2008) for *C. xanthocarpa*. Hofman et al. (2002) also stated that the potassium represents one of the most abundant minerals in fruits, generally followed by calcium which is frequently associated with the firmness and the fruit quality. It is noteworthy, that the iron content determined for three *Campomanesia* fruit types studied were higher than those found for *C. phaea* (0.36 mg $100g^{-1}$) (Vallilo et al., 2005), *C. adamantium* (1.13 mg $100g^{-1}$) (Vallilo et al., 2006), and *C. xanthocarpa* (0.64 mg $100g^{-1}$) (Vallilo et al., 2008). Pereda (2005) clarify that variations in the levels of these elements are dependent on several factors, but mainly on the composition of the soil where the plant is located.

Table 2. Mineral composition (mg 100 g^{-1} fresh matter) of *Campomanesia eugenioides*, *Campomanesia xanthocarpa* (Berg) and *Campomanesia xanthocarpa* var. *littoralis* (D. Landrum) fruits[†]**.**

Minerals	***C. eugenioides***	***C. xanthocarpa* (Berg)**	***C. xanthocarpa* var. *littoralis***
Potassium	331.36 ± 14.62[a]	209.25 ± 13.28[c]	276.44 ± 7.78[b]
Calcium	73.23 ± 3.88[a]	13.37 ± 0.53[c]	59.27 ± 2.99[b]
Magnesium	21.74 ± 0.76[a]	14.35 ± 0.36[b]	23.59 ± 0.03[a]
Phosphorus	32.96 ± 0.85[a]	26.44 ± 1.41[b]	32.69 ± 0.14[a]
Sodium*	<5.0	<5.0	<5.0
Iron	1.40 ± 0.04[b]	1.25 ± 0.07[b]	1.72 ± 0.08[a]
Zinc	0.40 ± 0.02[a]	0.18 ± 0.01[c]	0.31 ± 0.00[b]
Manganese*	<2.5	<2.5	<2.5
Copper*	<5.5	<5.5	<5.5

[†] Results presented as mean ± SD, n=3. The same letters in the same line indicate no significant difference ($P < 0.05$). * Concentration equivalent to the quantification limit of the method. Source: Authors.

4. Final Considerations

This study will provide important scientific data supporting the application of valuable fruits from three edible *Campomanesia* species for producing bioactive ingredients and natural preservatives for food products. *C. eugenioides*, *C. xanthocarpa (Berg)*, and *C. xanthocarpa* var. *littoralis* showed distinct physicochemical characteristics, with an exception for the ash content and for the caloric values which were higher for *C. xanthocarpa* (Berg).

The three fruits studied in the present work also do not appear as a lipid and protein source. As expected, the three samples evaluated showed high carbohydrate content, which showed a high correlation with their caloric values. *C. xanthocarpa* var. *littoralis* showed higher values for fiber content, total soluble solids, and total titratable acidity.

Total soluble solids content by the total titratable acidity ratio indicated that *C. xanthocarpa (Berg)* fruit is the sweetest and tasty. *C. eugenioides* species highlighted in relation to the vitamin C and mineral contents, with emphasis on potassium, calcium, and zinc contents, which were similar to the magnesium and phosphorus contents of *C. xanthocarpa* var. *littoralis*. *C. xanthocarpa* var. *littoralis* also excelled about the iron content.

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