

Physicochemical characterization of fruits of *Campomanesia guazumifolia* (Cambess.) O. Berg (Myrtaceae)

Jonas Goldoni^{1*}, Clevison Luiz Giacobbo¹, Leandro Galon², Caroline Zarzeka¹, Alison Uberti¹ and Adriana Lugaresi¹

¹Universidade Federal da Fronteira Sul, Rodovia SC-484, km 02, 89815-899, Chapecó, Santa Catarina, Brazil. ²Universidade Federal da Fronteira Sul, Erechim, Rio Grande do Sul, Brazil. *Author for correspondence. E-mail: jonas.goldoni@uffs.edu.br

ABSTRACT. Belonging to the family Myrtaceae, '*sete capotes*' is a plant native to the Atlantic Forest biome. It produces yellow-green fruits between February and May. Although used for consumption by local populations, studies of the fruit are rare. The present work aimed at characterize the fruit in terms of physicochemical properties. We quantified mass, volume, moisture, pulp yield, pH, titratable acidity, soluble solids/titratable acidity, proteins, lipids, total sugars, reducing sugars, ash, macronutrients, micronutrients, pectin, vitamin C and phenolic compounds. Compared with commercial fruits and other native fruit trees, *sete capotes* is unusual for its pulp yield, vitamin C levels, total phenolic compound content, protein levels, calcium content, potassium levels and iron content. Through the results it is verified of the fruit as a functional food, mainly because of its nutritive content and because of its bioactive compounds. Our data emphasize the importance of study of the constituents of native flora.

Keywords: native fruits; vitamin C; antioxidants in fruits; pomology.

Received on December 19, 2018.

Accepted on August 9, 2019.

Introduction

Brazil has the richest flora in the world, with more than 46 thousand species currently cataloged. Such diversity, in addition to presenting challenges in terms of conservation, presents a vast field for botanical and pharmacological research (Flora, 2017).

The territorial dimensions and ecological diversity of the country is also reflected in fruticulture. Occupying third place in the world in terms of production of commercial fruits, Brazil stands out for her variety of native fruits. (Raseira, Antunes, Trevisan, & Gonçalves, 2004).

Among native Brazilian fruit trees are those belonging to the family Myrtaceae. In general, their fruits potentially provide great nutritional and medicinal value, because of the presence of vitamins, minerals and antioxidant compounds, being consumed *in natura* or in the form of jellies, sweets and liqueurs (Reynertson, Yang, Jiang, Basile, & Kennelly, 2008).

Campomanesia guazumifolia (Cambess.) O. Berg, popularly known as *sete capotes*, *sete cascas* or *capoteira* belongs to the family Myrtaceae. It is a fruit tree plant found in Brazil from Bahia to Rio Grande do Sul, being found in soaked soils. It is consumed strictly by local populations. Its leaves are used in the production of teas (Lorenzi, 1998). The fruits mature between the months of February to May, a season characterized by low supply of commercial fruits. Even with this wide distribution, studies of the fruit remain scarce.

In light of the importance of studies that consider regional flora and the lack of bibliographical information related to *sete capotes*, the objective of this work was to characterize its fruits in terms of their physicochemical properties.

Material and methods

These experiments were conducted in the fruticulture and post-harvest laboratory at the *Universidade Federal da Fronteira Sul*-UFFS, Chapecó campus. The fruits used were collected from *sete capotes* (*C. guazumifolia*) located in the municipality of Guatambú, State Santa Catarina.

The fruits were collected in February 2017, at ideal maturation stage, when there was a yellow-green coloration of the skin. After collection, the fruits were selected, cleaned in running water, dried on

absorbent paper, packed in polyethylene bags and frozen at -20°C until analysis. Prior to analysis, the fruits were removed from refrigerator, and juice was extracted by manual pressing through a sieve. We also obtained flour from pulped and oven-dried fruits at 55°C that were ground in a mill. The variables analyzed are described below, taking into account that humidity, pH, SS/AT ratio, lipids, total sugars, ash and vitamin C were quantified according to the methodology proposed by the *Instituto Adolfo Lutz* (2008).

Volume and mass: For mass determination, we used a semi-analytical balance (Mars AD430). The volume was measured by an indirect method: Fruits were immersed in a known quantity of distilled water, using graduated cylinder to observe the displacement of the liquid. The mean value of mass and volume of the samples were expressed as grams and cm^3 .

Humidity: Was used to determine the percent moisture content, and the percentage humidity was calculated by the loss of water by desiccation of fruits after 48 hours in an oven at 55°C .

Pulp yield and number of seeds per fruit: The calculation of pulp yield was performed according to the methodology of Santos, Lima, Petkowicz, and Candido (2013), comparing fruit weight before and after seed removal. The mean value of yield was expressed as a percentage, as was the mean number of seeds in fruits.

pH: The pH of the juice diluted 1:10 in distilled water was measured with the aid of a calibrated pH meter (MSTecnopon-MPA210).

Titrateable acid – TA: Consisting of titrating juice diluted 1:10 with a standard solution of 0.1 N NaOH to pH 8.2. The results were expressed as grams of citric acid per 100 mL.

Determination of soluble solids by refractometry – SS: The analysis of soluble solids by refractometry was performed on an Abbé-type bench refractometer (BEL-RTM). Readings were performed on fruits at the same maturation stage, and the results were expressed in Brix degrees.

SS/TA ratio: Based on the calculation of the SS/TA ratio (Brix degrees divided by the value of Titrateable acid), to verify the indication of the degree of maturation of the raw material in organic acid.

Protein: Quantification of the protein content was based on the spectrophotometric. Bovine albumin was used as the standard, and results were expressed as g of protein per 100 mL of the sample.

Lipids: Lipid content was measured by extraction in n-hexane on a Soxhlet apparatus for 8 hours. After extraction, the solvent was distilled and the lipid content was defined by the residual mass present in the flask. The results were expressed as grams of lipids per 100 g of sample.

Reducing sugars: Reducing sugar content was evaluated using the methodology of Vasconcelos, Pinto, and Aragão (2013), using 3,5-dinitrosalicylic acid (DNS). The absorbance was measured at 540 nm in samples diluted at 1:100, with equal volumes of DNS reactive solution, compared to data obtained on a calibration curve prepared with glucose. Results were expressed as g per 100 mL.

Total sugars: The quantification of total sugars was performed according to the colorimetric. Juice samples were passed through filter paper and diluted in distilled water at a ratio 1:100, then added to a solution of 5% phenol and sulfuric acid. Absorbance of the sample was read at 490 nm, and the calibration curve was prepared with glucose. Results were expressed as g per 100 mL.

Ash: By incinerating the samples of fruit in a muffle furnace at 550°C . The results were expressed as g of ash per 100 g of fruit.

Macro and micronutrients: We quantified N, P, K, Ca, Mg, Fe, Mn, Zn, Cu and B according to the methodology proposed by Schweitzer and Suzuki (2013). After digestion of the samples, the elements were quantified, and were expressed as mg per kg of fruit.

Pectin: The extraction of pectin was carried out according to the methodology described by Kliemann et al. (2009), using a reflux system in a Soxhlet extractor, with samples of fruit pulp in 0.086% citric acid solution. The system was refluxed for 60 min. at 97°C . Subsequently, the solvent was added in ethanol in the ratio 1:2 v:v, filtered and oven-dried. The results were expressed as the ratio between the initial weight of the sample and pectin obtained after drying, expressed as percentage yield.

Vitamin C: Vitamin C content was quantified using Tillman's reagent. Diluted in 2% solution of oxalic acid, the juice samples were titrated with 0.02% dichlorophenol-indophenol solution that had been previously standardized with ascorbic acid solution. The results were expressed as mg of ascorbic acid per 100 mL of juice.

Total phenolic compounds: We used the methodology proposed by Singleton, Orthofer, and Lamuela-Raventós (1999). After extracting 57% ethanol solution, fruit samples were added to Folin-Ciocalteu reagent (1:5, v:v). After the reaction period, the absorbance of the samples was read in a spectrophotometer

at 760 nm. The average result of the total phenolic compound content was expressed as gallic acid equivalent (GAE) per gram of sample (mg GAE per 100 g).

Experimental design: The evaluation of mass, volume, moisture, yield, seeds per fruit and SS were performed with 10 replicates, while the other tests were performed in triplicate. The results were expressed through the mean obtained in the tests, followed by their respective standard deviations, and the results were analyzed in Microsoft Excel 2010.

Results and discussion

A mean of 14.32 ± 2.29 g was verified by measuring fruit mass. Mean volume was 12.9 ± 2.28 cm³. The pulp yield was $97.39 \pm 0.73\%$. Mean number of seeds per fruit was 10.9 ± 0.87 , and mean moisture content was $77.16 \pm 1.30\%$.

The values of pulp yield described in other fruits of the same genus of the species were 68% for the perfume guava (*Campomanesia lineatifolia*) and 46% in the guavira (*Campomanesia adamantium*) (Pelloso, Vieira, & Zárate, 2008; Morzelle, Bachiega, Souza, Boas, & Lamounier, 2015). In other native species of the Myrtaceae family, the following values have been recorded: 72% for the camu-camu (*Eugenia cibrata*), 79% for the pitanga (*Eugenia uniflora*), 45% for the araçá-do-campo (*Psidium guineense*) and 75% for the araçá-pêra (*Psidium acutangulum*) (Diniz, Araújo-Neto, Novalli, Nogueira, & Silva, 2017; Batista, Fonseca, Carvalho, & Bittencourt, 2017). When comparing pulp yield data obtained in the present study with those of other referenced species, we may confirm that *sete capotes* is outstanding. This is good for industry, where high yields imply large amounts of final product, including sweets and jams, with balanced input/output ratios.

As for the number of seeds per fruit, our data were similar to those described for the same species in Santos, Ferreira, and Áquila (2004), in which an average number of 11 seeds per fruit were reported. Nevertheless, these authors reported moisture content in the fruits, after desiccation, of 78%. Thus, it can be stated that in both studies, the values found in these variables were similar.

The pH readings of the juice samples had an average value of 3.38 ± 0.045 . In analyses performed with gabirola (*Campomanesia xanthocarpa*), guavira and cambuci (*Campomanesia phaea*) species belonging to the same genus as *sete capotes*, the average values of pH were, 3.77, 4.50, and 2.9, respectively (Vallilo, Garbelotti, Oliveira, & Lamardo, 2005; Scalon, Oshiro, & Dresch, 2012; Santos et al., 2013). In addition to varying species, the pH in fruits is influenced by environmental factors and degree of maturation, among factors (Scalon et al., 2012). The Brazilian consumer has a preference for *in natura* consumption of sweet fruits with low acidity. Thus, acidic fruits are commonly employed in prepared foods such as jellies and jams. The fruits of *sete capotes* have acidity similar to those of other fruits of the same genus referenced here.

Regarding titratable acidity, the average result obtained from the samples evaluated was 1.591 ± 0.16 g of citric acid per 100 mL. When analyzing the TA in other species, it was found that the orange (*Citrus* sp.), the Myrtaceae most consumed in Brazil, and the guava (*Psidium guajava*), the most commercially-cultivated fruit, presented TA values of 1.14 and 0.51 g per 100 mL, respectively. In other Myrtaceae, including the uvaia (*Eugenia pyriformis*), gabirola and guavira, the values described were 0.46, 1.39 and 0.33 g of citric acid per 100 mL, respectively (Scalon et al., 2012; Krumreich, D'Avila, Freda, Chim, & Chaves, 2016).

According to Instituto Adolfo Lutz (2008), although non-linear, the acid content in citric acid present in fruits varies proportionally according to their vitamin C content. Thus, the high content of citric acid found in *sete capotes* fruits, compared to the species mentioned, highlights its potential as a source of organic acids.

On determination of soluble solids by refractometry, we recorded values of 13.18 ± 1.10 Brix degrees. The SS/TA ratio was 1.59. This relationship expresses fruit maturation, flavor and texture index, and more specifically, sugar/acid content, defining the characteristic fruit flavor (Instituto Adolfo Lutz, 2008). This is parameter is specific to each species and variety in terms of flavor. In fruits grown on a commercial scale [e.g., orange, apple (*Malus domestica*), grape (*Vitis vinifera*), among others] this ratio is used as a standard. However, native species do not present such values, making comparisons difficult. Nevertheless, the higher the ratio, the sweeter the fruit. For a comparison, the pineapple varies between 19 - 28 and in citrus the ratio is 0.5 - 0.7 (Lessa, Ledo, Amorim, & Oliveira, 2014).

On determination of protein content, we recorded an average value of 1.904 ± 0.006 g per 100 mL of juice. Compare this value to that of other Myrtaceae, such as 1.1% in the gabirola, 0.46 in the pitanga, 0.44

in the *cambuci* and 0.50% in the *araçá* (*Psidium cattleianum*) (Vallilo et al., 2005; Silva, Cavalcante, Gebrim & Martins, 2008; Santos et al., 2013; Batista et al., 2017). In commercial cultivars, values of 0.3% for apples and 1% for peaches have been reported (Cunha, Durigan, & Mattiuz, 2010). Note that, compared to other fruits, *sete capotes* stands out in terms of protein content.

Although proteins of plant origin do not present the same biological value as those derived from animals, the consumption of fruits rich in these compounds, especially unconventional fruits, may represent an alternative for those populations with food restrictions (Kinupp & Barros, 2007). Therefore, given its protein content, the consumption of *sete capotes* can supplement the diet of its consumers.

On lipid quantification, we recorded a value of 0.67 ± 0.063 g per 100 g. This was lower than that described in fruits of *gabioba*, *cambuci* and *guavira*, which gave 1.31, 1.53, and 0.12%, respectively. All these fruits belong to the same genus as that of the study species (Vallilo et al., 2005; Vallilo, Lamardo, Gaberlotti, Oliveira, & Moreno, 2006; Silva et al., 2008). In other Myrtaceae, values were 0.11, 0.41, 0.35, 0.49, 0.82, and 1.22% in *goiaba serrana* (*Acca sellowiana*), *cereja-do-mato* (*Eugenia aggregata*), *pessegueiro-do-mato* (*Eugenia myrcianthes*), *araçá amarelo*, *cagaita* (*Eugenia dysenterica*) and *araticum* (*Annoma crassiflora*), respectively (Kinupp & Barros, 2007; Silva et al., 2008).

Lipids are highly energetic molecules, found in high amounts in seeds, mainly oilseeds. However, in fruits and vegetables, lipids are only available in reduced amounts (Santos et al., 2013), explaining the low lipid content found in *sete capotes*.

Reducing sugar analysis revealed an average value of 2.86 ± 0.01 g per 100 mL of juice. In the study by Santos et al. (2013), the content of reducing sugars found in *gabioba* was 6.77%. In the study of Oshiro, Dresh, and Scalon (2013), who studied *guavira*, the value described was 3.14%. In addition, in analyses performed with fruits of the *pitangueira*, Oliveira, Figueiredo, and Queiroz (2006) reported content of 3.82, with 13.2 in apple and 2.5% in peach (Cunha et al., 2010).

The content of reducing sugars in fruits is generally higher than that of non-reducing sugars (Oshiro et al., 2013). In terms of nutrition, the varied consumption of fruits represents, among other benefits, an important source of carbohydrates. Substitution of sugars from industrialized foods can be accomplished by consuming fruits. These habits have been highlighted by investigators in the field as important for maintaining a healthy diet.

With our data, we may conclude that the reference values for reducing sugars vary according to the species, even when comparing fruits belonging to the genus *Campomanesia*. Therefore, despite the lack of concentration of reducing sugars, the consumption of *sete capotes* may represent an supplement to the diet.

The quantification of total sugars in glucose by phenol-sulfuric method revealed 7.57 ± 0.19 g of sugar per 100 mL of juice. In a similar trial performed with *gabioba*, Santos et al. (2013) reported a 7.88% content. In a study carried out by Oshiro et al. (2013), a content of 12.26% was reported. Regarding the chemical characterization of the red arachnid, the values were 6.79% (Santos, Petkowicz, Wosiacki, Nogueira, & Carneiro, 2007). The values were 10.5 in apple and 9.5% in peach (Rizzon, Bernardi, & Miele, 2005).

The difference in total sugar content in terms of glucose compared to that of related species was similar to that found in samples of *sete capotes* with respect to reducing sugars.

Ash content, obtained after incineration of the fruit samples, gave an average of 0.46 ± 0.02 g per 100 g fruit. In other species of the genus *Campomanesia*, including *gabioba*, *gabioba-do-cerrado* (*Campomanesia cambessedeanana*) and *cambuci*, the ash percentages reported were 0.68, 0.04, and 2.66%, respectively (Silva et al., 2008; Santos et al., 2013), while values in apple and persimmon (*Diospyros kaki*) were 0.23 and 0.37%, respectively (Rizzon et al., 2005; Elias et al., 2008).

The quantification of ash content is only a complementary datum, since ash content does not necessarily express all the inorganic matter present in the sample. In addition to organic compounds, certain salts can also be volatilized (Instituto Adolfo Lutz, 2008). However, although secondary in terms of characterization, the ash content of *sete capotes* is a notable physicochemical property.

The quantification of the macro and micronutrients evaluated in *sete capotes* in this study, as well as the levels observed in fruits of some *Myrtaceae*, compared to the data obtained in the seven layers, are displayed in Table 1.

Table 1. Quantification of macro and micronutrients described in fruits of *sete capotes*, *gabirola*, *guavira*, *pitanga*, apple and *guava* expressed as mg per kg of fruit.

Macro and micronutrients	Sete capotes	Gabirola ¹	Guavira ²	Apple ³	Guava ⁴
N	1872	–*	–	–	36,4
P	23	149	170	55,7	5,7
K	2443	2084	1304	1019	74,2
Ca	388	101	165	14,6	2,8
Mg	114	135	175	31	3,6
Fe	27	6,4	11,3	0,8	74
Mn	1,3	1,2	2,1	0,7	41
Zn	2,7	4	4,9	0,7	55
Cu	1,6	3,3	1,9	0,5	33
B	7,5	–	–	–	43

¹Vallilo, Moreno, Oliveira, Lamardo, and Garbelotti (2008); ²Vallilo et al. (2006); ³Rizzon et al. (2005); ⁴Souza, Amorim, Rozane, and Natale (2017). *Elements not quantified by the authors in the trials.

Compared to the other fruits referenced, *sete capotes* stands out in terms of its high levels of potassium, calcium and iron.

The consumption of foods rich in minerals is fundamental for their replacement in the human body to ensure complete homeostasis (World Health Organization [WHO], 2003). Fruits and vegetables are known to be primary sources of these compounds. Therefore the inclusion of native fruits in the diet, among them, *sete capotes*, can potentiate the supplementation of these and other indispensable nutrients in the maintenance of the quality of life of the population.

The pectin quantification assays extracted from fruits of *sete capotes* showed an average percentage of $5.28 \pm 0.49\%$ of pectin in dry mass. In similar studies, contents of 5.89, 5.7, and 0.72% of pectin in dry mass were reported for *gabirola*, *guava* and *araçá-do-campo*, respectively. In addition, 0.258% was reported for *gabirola-do-cerrado*, the latter being evaluated in fresh mass content (Santos, Petkowicz, Haminiuk, & Cândido, 2010; Abreu, Santos, Abreu, Corrêa, & Lima, 2012; Morzelle et al., 2015).

Present in the cell wall of plant tissues, pectins represent about one third of the dry matter weight in fruits. Due to their gelling properties, they have been used since ancient times in the production of fruit jellies and industrially as thickening and stabilizing agents. It can be observed that *sete capotes* had an average pectin content similar to some fruits of the same family. According to Torrezan (1998), about 1% of pectin is sufficient to make jellies with a firm appearance, not necessarily in the case of *sete capotes*.

The evaluation of the vitamin C content in the fruits of *sete capotes* showed an average of 198.33 ± 12.58 mg of ascorbic acid per 100 mL of juice. In a study carried out by Giacobbo, Zanuzo, Chim, and Fachinello (2008) with *araçá*, a mean value of 38.85 mg per 100 mL was reported. In similar trials with fruits of the same family, contents of 313.21 mg per 100 mL were described for *gabirola*, 234 mg per 100 mL in *guavira*, and 33 mg per 100 mL in *cambucius*, while 43 mg per 100 mL were reported for *jambolão* (*Syzygium cumini*) and 27 mg per 100 mL for *uvaia* (Vallilo et al., 2005; Vallilo et al., 2006; Santos et al., 2013).

Hummer and Barney (2002) demonstrated a disparity in vitamin C content between different fruits, as in the case of apple having 5.7 mg per 100 g and blackberry (*Rubus spp*) having 181 mg per 100 g. Similarly, it can be stated that such variation occurs in fruits from the same family, including individuals from the family Myrtaceae.

Since vitamin C is an essential compound for proper homeostasis, participating in several cellular mechanisms, the *sete capotes* presents itself as a viable alternative in the supply of this and other bioactive compounds.

The quantitative analysis of total phenolic compounds in *sete capotes* showed an average value of 312.13 ± 3.11 mg of gallic acid equivalents (GAE) per 100 g of fruit.

In a phytochemical study, Stuelp-Campelo, Arruda, Bianchini, and Rosa (2016) verified the presence of phenolic compounds in capoeira stem tissues, however, he did not report the content found.

In a study of optimization for extraction of bioactive compounds in *gabirola*, *pitanga-do-cerrado* (*Eugenia punicifolia*) and *pêra-do-cerrado* (*Eugenia klotzschiana*) phenolic compounds indices of 385, 364, and 271 mg GAE per 100 g, respectively, were reported (Rocha et al., 2011). Alves, Alves, Fernandes, Naves, and Naves (2013) performed extraction in methanol, and reported that fruits of *gabirola* had an average value of 1222 mg GAE per 100 g. In addition, Lima, Castro, Sabino, Limas, and Torres (2016) reported indices of 229 and 511 mg GAE per 100 g for yellow *gabirola* (*Campomanesia lineatifolia*) and myrtle (*Blepharocalyx salicifolius*), respectively.

Infante, Rosalen, Lazarini, Franchin, and Alencar (2016), in tests of fruits from the genus *Eugenia*, reported levels of 151, 183, 266 and 178 mg GAE per 100 g for *araçá-pitanga* (*Eugenia leitonii*), cherry-grove, grumixama (*Eugenia brasiliensis*) and *pessegueiro-do-mato*, respectively. The author also emphasized the difference in the contents of these compounds in fruits of the same species when collected in different locations, revealing the influence of environmental factors on the production of these substances.

As in other Myrtaceae fruits, the content of phenolic compounds found with *sete capotes* enhances the nutritional and functional potential of the fruit.

Conclusion

The physicochemical characterization of *sete capotes* revealed the potential of this fruit as a nutritious and functional food.

The fruit harvest period (February to May) coincides with the season of low supply of fruits in the national market (Brazil).

The fruit stood out in relation to other Myrtaceae in terms of pulp yield, vitamin C, total phenolic compounds, protein and calcium content, potassium and iron.

The diffusion of knowledge about the constituents of the fruit, in addition to appreciating the diversity of the regional flora, can stimulate interest and can increase its addition in the diet.

References

- Abreu, J. R., Santos, C. D., Abreu, C. M. P., Corrêa, A. D., & Lima, L. C. O. (2012). Sugar fractionation and pectin content during the ripening of guava cv. Pedro Sato. *Food Science and Technology*, 32(1), 156-162. doi: 10.1590/S0101-20612012005000029
- Alves, A. M., Alves, M. S. O., Fernandes, T. O., Naves, R. V., & Naves, M. M. V. (2013). Caracterização física e química, fenólicos totais e atividade antioxidante da polpa e resíduo de gabioba. *Revista Brasileira de Fruticultura*, 35(3), 837-844. doi: 10.1590/S0100-29452013000300021
- Batista, A., Fonseca, A., Carvalho, M., & Bittencourt, S. (2017). Caracterização física, físico-química e química de frutos de pitangueiras oriundas de Cinco Municípios Baianos. *Magistra*, 26(3), 393-402.
- Cunha Jr, L. C., Durigan, M. F. B., & Mattiuz, B. (2010). Conservação de pêssegos “Aurora-1” armazenados sob refrigeração. *Revista Brasileira de Fruticultura*, 32(2), 386-396. doi: 10.1590/S0100-29452010005000041
- Diniz, G., Araújo-Neto, S., Novalli, D., Nogueira, N., & Silva, I. (2017). Quality index and harvest maturity of *Eugenia cibrata* fruits. *Revista Brasileira de Fruticultura*, 39(spe.), e-859. doi: 10.1590/0100-29452017859
- Elias, N. F., Berbert, P. A., Molina, M. A. B., Viana, A. P., Dionello, R. G., & Queiroz, V. A. V. (2008). Avaliação nutricional e sensorial de caqui cv. Fuyu submetido à desidratação osmótica e secagem por convecção. *Food Science and Technology*, 28(2), 322-328. doi: 10.1590/S0101-20612008000200009
- Flora, B. (2017). 2020 (in construction) *Jardim Botânico do Rio de Janeiro*. Rio de Janeiro, RJ: Eletronic version.
- Giacobbo, C. L., Zanuzo, M., Chim, J., & Fachinello, J. C. (2008). Avaliação do teor de vitamina C em diferentes grupos de araçá-comum. *Current Agricultural Science and Technology*, 14(1), 155-159. doi: 10.18539/CAST.V14I1.1899
- Hummer, K. E., & Barney, D. L. (2002). Currants. *HortTechnology*, 12(3), 377-387. doi: 10.21273/HORTTECH.12.3.377
- Infante, J., Rosalen, P. L., Lazarini, J. G., Franchin, M., & Alencar, S. M. (2016). Antioxidant and anti-inflammatory activities of unexplored Brazilian native fruits. *PLoS One*, 11(4), e0152974. doi: 10.1371/journal.pone.0152974
- Instituto Adolfo Lutz. (2008). *Normas analíticas do Instituto Adolfo Lutz. 1a edição digital*. In: *Métodos físico-químicos para análise de alimentos*. São Paulo, SP: Electronic version.
- Kinupp, V. F., & Barros, I. B. I. (2007). Riqueza de plantas alimentícias não-convencionais na região metropolitana de Porto Alegre, Rio Grande do Sul. *Brazilian Journal of Biosciences*, 5(S1), 63-65.
- Kliemann, E., Simas, K. N., Amante, E. R., Prudêncio, E. S., Teófilo, R. F., Ferreira, M. M. C., & Amboni, R. D. M. (2009). Optimisation of pectin acid extraction from passion fruit peel (*Passiflora edulis* flavicarpa)

- using response surface methodology. *International Journal of Food Science and Technology*, 44(3), 476-483. doi: 10.1111/j.1365-2621.2008.01753.x
- Krumreich, F., D'Ávila, R. F., Freda, S. A., Chaves, F. C. & Chim, J. F., (2016). Análises físico-químicas e estabilidade de compostos bioativos presentes em polpa de uvaia em pó obtidos por métodos de secagem e adição de maltodextrina e goma arábica. *Revista Thema*, 13(2), 4-17. doi: 10.15536/thema.13.2016.4-17.351
- Lessa, L. S., Ledo, C. A. S., Amorim, E. P., & Silva, S. O. (2014). Estimativa de repetibilidade de híbridos diploides (AA) de bananeira. *Pesquisa Agropecuária Brasileira*, 49(2), 109-117. doi: 10.1590/S0100-204X2014000200005
- Lima, J. S. S., Castro, J. M. C., Sabino, L. B. S., Limas, A. C. S., & Torres, L. B. V. (2016). Physicochemical properties of gabioba (*Campomanesia lineatifolia*) and myrtle (*Blepharocalyx salicifolius*) native to the mountainous region of Ibiapara-CE, Brazil. *Revista Caatinga*, 29(3), 753-757. doi: 10.1590/1983-21252016v29n327rc
- Lorenzi, H. (1998). *Arvores Brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil* (vol. 2). Nova Odessa, SP: Plantarum.
- Morzelle, M. C., Bachiega, P., Souza, E. C., Vilas Boas, E. V. B., & Lamounier, M. L. (2015). Caracterização química e física de frutos de curriola, gabioba e murici provenientes do Cerrado brasileiro. *Revista Brasileira de Fruticultura*, 37(1), 96-103. doi: 10.1590/0100-2945-036/14
- Oliveira, F. M. N., Figueiredo, R. M. F., & Queiroz, A. J. M. (2006). Análise comparativa de polpas de pitanga integral, formulada e em pó. *Revista Brasileira de Produtos Agroindustriais*, 8(1), 25-33. doi: 10.15871/1517-8595/rbpa.v8n1p25-33
- Oshiro, A. M., Dresh, D. M., & Scalón, S. P. Q. (2013). Atmosfera modificada e temperaturas de armazenamento na conservação pós-colheita de guavira (*Campomanesia adamantium* Camb.). *Bioscience Journal*, 29(S1), 1421-1430.
- Pelloso, I. A. O., Vieira, M. C., & Zárate, N. A. H. (2008) Avaliação da diversidade genética de uma população de guavira (*Campomanesia adamantium* Cambess, O. Berg., Myrtaceae). *Revista Brasileira de Agroecologia*, 3(SI), 49-52.
- Raseira, M. do C. B., Antunes, L. E. C., Trevisan, R., & Gonçalves, E. D. (2004). *Espécies Frutíferas Nativas do Sul do Brasil*. Pelotas, RS: Embrapa.
- Reynertson, K. A., Yang, H., Jiang, B., Basile, M. J., & Kennelly, E. J. (2008). Quantitative analysis of antiradical phenolic constituents from fourteen edible Myrtaceae fruits. *Food Chemistry*, 109(4), 883-890. doi: 10.1016/j.foodchem.2008.01.021
- Rizzon, L. A., Bernardi, J., & Miele, A. (2005). Características analíticas dos sucos de maçã Gala, Golden Delicious e Fuji. *Ciência e Tecnologia de Alimentos*, 25(4), 750-756. doi: 10.1590/S0101-20612005000400020
- Rocha, W. S., Lopes, R. M., Silva, D. B., Vieira, R. F., Silva, J. P., & Agostini-Costa, T. S. (2011). Compostos fenólicos totais e taninos condensados em frutas nativas do cerrado. *Revista Brasileira de Fruticultura*, 33(4), 1215-1221. doi: 10.1590/S0100-29452011000400021
- Santos, C. M. R., Ferreira, A. G., & Áquila, M. E. A. (2004). Características de frutos e germinação de sementes de seis espécies de Myrtaceae nativas do Rio Grande do Sul. *Ciência Florestal*, 14(2), 13-20. doi: 10.5902/198050981802
- Santos, M. S., Lima, J. J., Petkowicz, C. L. O., & Candido, L. M. B. (2013). Chemical characterization and evaluation of the antioxidant potential of gabioba jam (*Campomanesia xanthocarpa* Berg). *Acta Scientiarum. Agronomy*, 35(1), 73-82. doi: 10.4025/actasciagron.v35i1.14389
- Santos, M. D. S., Petkowicz, C. L. O., Wosiacki, G., Nogueira, A., & Carneiro, E. B. B. (2007). Caracterização do suco de araçá vermelho (*Psidium cattleianum* Sabine) extraído mecanicamente e tratado enzimaticamente. *Acta Scientiarum. Agronomy*, 29(5), 617-621. doi: 10.4025/actasciagron.v29i5.737
- Santos, M. S., Petkowicz, C. L. O., Haminiuk, C. W. I., & Cândido, L. M. B. (2010). Polissacarídeos extraídos da gabioba (*Campomanesia xanthocarpa* Berg), propriedades químicas e perfil reológico. *Polímeros*, 20(5), 352-358. doi: 10.1590/S0104-14282010005000056
- Scalón, S. P. Q., Oshiro, A. M., & Dresch, D. M. (2012). Conservação pós-colheita de guavira (*Campomanesia adamantium* Camb.) sob diferentes revestimentos e temperaturas de armazenamento. *Revista Brasileira de Fruticultura*, 34(4), 1022-1029. doi: 10.1590/S0100-29452012000400008

- Schveitzer, B., & Suzuki, A. (2013). *Métodos de análise foliar utilizados no laboratório de ensaio químico da Epagri/EECd*. Florianópolis, SC: Epagri.
- Silva, M. R., Lacerda, D. B. C. L., Santos, G. G., & Martins, D. M. O. (2008). Caracterização química de frutos nativos do cerrado. *Ciência Rural*, 38(6), 1790-1793. doi: 10.1590/S0103-84782008000600051
- Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. *Methods in Enzymology*, 299, 152-178. doi: 10.1016/S0076-6879(99)99017-1
- Souza, H. A., Amorim, D. A., Rozane, D. E., & Natale, W. (2017). Quantificação de nutrientes nos frutos de goiabeiras adubadas com subproduto da agroindústria processadora de goiabas. *Revista de Ciências Agrárias*, 40(2), 80-90. doi: 10.19084/RCA16126
- Stuelp-Campelo, P. M., Arruda, M. F. C., Bianchini, L. F., & Rosa, E. A. (2016). Contribution of Ethnopharmacology for the mouth ulcer healing. In A. M. T. Grégio, P. V. C. Bettega, M. Rinaldi, A. C. B. R. Johann (Org.), *Phytotherapy approaches for oral ulcers treatment* (Chapter 5, p. 83-90). New York, NY: Nova Sciences Publishing.
- Torrezan, R. (1998). *Manual para a produção de geleias de frutas em escala industrial*. Rio de Janeiro, RJ: Embrapa.
- Vallilo, M. I., Garbelotti, M. L., Oliveira, E., & Lamardo, L. C. A. (2005). Características físicas e químicas dos frutos do cambucizeiro (*Campomanesia phaea*). *Revista Brasileira de Fruticultura*, 27(2), 241-244. doi: 10.1590/S0100-29452005000200014
- Vallilo, M. I., Lamardo, L. C. A., Gaberlotti, M. L., Oliveira, E. D., & Moreno, P. R. H. (2006). Chemical composition of *Campomanesia adamantium* (Cambessédes) O. Berg'fruits. *Food Science and Technology*, 26(4), 805-810. doi: 10.1590/S0101-20612006000400015
- Vallilo, M. I., Moreno, P. R. H., Oliveira, E., Lamardo, L. C. A., & Garbelotti, M. L. (2008). Composição química dos frutos de *Campomanesia xanthocarpa* Berg-Myrtaceae. *Ciência e Tecnologia de Alimentos*, 28(suppl.), 231-237. doi: 10.1590/S0101-20612008000500035
- Vasconcelos, N. M., Pinto, G. A. S., & Aragão, F. A. S. (2013). *Determinação de açúcares redutores pelo ácido 3, 5-dinitrosalicílico: histórico do desenvolvimento do método e estabelecimento de um protocolo para o laboratório de bioprocessos*. Brasília, DF: Embrapa.
- World Health Organization [WHO]. (2003). *Diet, nutrition and the prevention of chronic diseases*. Retrieved from http://whqlibdoc.who.int/trs/WHO_TRS_916.Pdf