Study on Guapeva (*Pouteria gardneriana Radlk*) Shelf Life and Physical-Chemical Characterization of the Fruit Peel Flour

Estudo de Vida Útil do Fruto e Caracterização Físico-Química de Farinha de Casca de Guapeva (*Pouteria gardneriana Radlk*)

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ABSTRACT
The Brazilian Cerrado is considered one of the most representative biomes because of the great diversity of regional fruits with great agricultural potential and applications in fresh or processed products for consumption. One of the most typical fruits of such biome is

guapeva (*Pouteria gardneriana* Radlk), a fruit with a sweet flavor that has applications in the medical field and in the production of fresh and industrialized foods. Despite these attractive characteristics, only a few studies involving this fruit can be found in the literature. Therefore, this work aims to evaluate the shelf life of this fresh fruitas well as the use of its residues to add value to the final product through the production of a flour. From the results obtained, it was possible to conclude that the production of guapeva peel flour is a viable alternative for the use of this residue due to its high nutritional value and high content of bioactive compounds that may be favorable to the development of new productsas well as human nutrition.

Keywords: cerrado fruit, physical-chemical analysis, guapeva flour, phenolic compounds, *Pouteria gardneriana*.

RESUMO
O cerrado brasileiro caracteriza-se como um dos biomas de maior representatividade, visto que uma grande diversidade de frutas regionais com grande potencial agrícola, bem como na utilização em produtos para o consumo in natura ou processados podem ser encontradas. Um dos principais representantes deste bioma é a guapeva (*Pouteria gardneriana* Radlk), fruto do cerrado que apresenta um sabor adocicado e que apresenta aplicações no campo medicinal e na produção de produtos in natura e industrializados. Apesar destas características atrativas poucos estudos envolvendo esta fruta que podem ser encontrados na literatura. Diante do exposto, este trabalho tem como objetivo avaliar a vida útil deste produto in natura e também ao uso de seus resíduos para agregação de valor via produção de uma farinha. A partir dos resultados obtidos foi possível concluir que a produção de farinha de casca de guapeva configura-se como uma alternativa viável para aproveitamento deste resíduo tendo em vista seu alto valor nutritivo e elevado teor de compostos bioativos que podem ser favoráveis à elaboração de novos produtos e nutrição humana.

Palavras-chave: fruto do cerrado, análise físico-química, farinha de guapeva, compostos fenólicos, *Pouteria gardneriana*.

1 INTRODUCTION

The Cerrado is a biome that occupies a considerable part of Brazil's territory, extending over 12 states, including all from the Midwest region (Goiás, MatoGrosso, Mato Grosso do Sul and the Federal District). This biome stands out for its biological diversity. Particularly, considering the flora there are records of a great diversity of endemic fruits with agricultural and medicinal potential.

Among these native fruits, baru (*Dipteryx alata*), gabiroba (*Campomanesia cambessedeana* Berg), murici (*Byrsonoma verbascifolia* Rich), pequi (*Caryocar brasiliense* Camb.) and mangaba (*Hancornia speciosa* Gomes) stand out in terms of economic potential, nutritional importance and social interest due to their unique flavor and nutrient contributions for recommended dietary intake. In addition, these fruits have a considerable content of sugar, proteins, minerals and fatty acids, being such functional properties attributed to the presence of bioactive substances that have antioxidant action and can contribute to beneficial health effects (Siqueira, Pacheco & Naves, 2015; Morzelle, Bachiega, Souza, Vilas Boas & Lamounier, 2015; Perfeito, Corrêa & Peixoto, 2017).

Despite all the documented richness of native fruits from the Cerrado, we must consider that many fruits have not been properly studied and/or recognized yet–although having nutritional and commercial benefits. Besides, it is worth noting the lack of studies regarding their potential applications. One example of this niche of fruits with little market applicability is the guapeva (*Pouteria gardneriana* Radlk). This fruit is produced by a large tree found in places with plenty of water; it has a sweet taste and its pulp has a slightly yellow color and soft texture, in addition to a high nutritional and bioactive load. This fruit can be consumed fresh or processed, and its peel is, as a general rule, discarded (Siqueira, Oliveira, Machado, Lourenço, 2017; Cabral, Sales, Silva, Branquinho & Oliveira, 2013; Malta, 2011). Figures 1 (a) and (b) show the external and internal appearances of the guapeva.

Figure 1: Guapeva(a) external and (b) internal appearances.

(a) Fresh guapeva. (b) Guapeva interior.

In the literature, there are few studies on this fruit, which are divided into two large groups, namely, those that evaluate the fruits and those that evaluate the peel of the tree and leaves. In the first group, we can cite the work developed by Malta (2011), who studied biological activities through the identification and quantification of phenolic compounds from Cerrado fruits, including guapeva. The author also investigated the antioxidant, anti-inflammatory, anti-mutagenic, anti-genotoxic, anti-proliferative and cytotoxic activities of guapeva. Cabral et al (2013) evaluated the effects of drying, storage and insecticide treatment on the physiological quality of guapeva seeds. More recently, Siqueira et al. (2017) reported a study on the chemical and bioactive characterization of guapeva. As to the guapevapeel, Costa (2014) evaluated the levels of total phenols and flavonoids, and analyzed the antiradical and mutagenic activities of the hydroalcoholic extracts of its leaves.

Like most native fruits, guapeva has a short shelf life, mainly due to its high water activity and nutrient density. In this scenario, several mechanisms have been studied in order to increase its shelf life. One of the most efficient is the use of drying techniques. In general, the drying process allows the reduction of the moisture content in the food, creating an inappropriate environment for the growth of microorganisms and enzyme activity since they need water as a substrate or vehicle for the main reactions (Bontempo, Silva, Cardoso, Castejon & Santos, 2016). One of the direct applications of the drying process, in this case, is the production of fruit flours.

Flours are products obtained from edible parts of one or more species of fruits, seeds and rhizome tubers by grinding or other technological processes considered safe for food production (Storck, Basso, Favarin & Rodrigues, 2015). In the specific case of fruits, these flours can be included in human diet–not only as substitutes for the traditional flours used to produce other types of food, but also for nutritional supplementation given their high content of vitamins and bioactive compounds–as a way to minimize fruit waste due to its short shelf life (BONTEMPO et al., 2016). Currently, emphasishas been givento the use of fruit residues, such as peels, seeds, bagasse and pips, in the preparation of these flours since they can contribute to the nutritional density and be destined to human consumption after processing (Aranha, Negri, Martin & Spoto, 2017; Storck Et Al., 2015).

In the literature, several studies involving the production of flour can be found. Ogunsina, Radha & Singh (2010) studied full-fat and defatted *Moringa oleifera* kernel flours considering the effect of pH and NaCl concentrations on their functional properties. Schmiele, Jaekel, Patricio, Steel & Chang (2012) investigated the rheological properties of wheat flour and the quality characteristics of pan bread modified by partial additions of wheat bran or whole-wheat flour. Ding, Wang, Zhang, Shi & Wang (2015) reported the effect of ozone treatment on the physicochemical properties of waxy rice flour and waxy rice starch. Gunaratne et al. (2016) investigated the starch digestibility and thermal, pasting and gelling properties of *Caryotaurens* flour using wheat flour as reference. Nakhon, Jangchud, Jangchud & Prinyawiwatkul (2017) evaluated the physicochemical properties (pasting and thermal properties, swelling power, water solubility and antioxidant activities) and chemical composition of pumpkin flour and starch.

Therefore, this work aims to evaluate the shelf life of guapeva fruits stored at room temperature as well as to produce and evaluate the quality of the fruit peel flour. This work is structured as follows. The Material and Methods section presents the methodologies used to evaluate the guapevashelf life; the aspects related to bleaching and drying of the guapeva peel; and the procedure adopted to determine the quality and yield of the guapevapeel flour. In the Results and Discussion section, we show the results obtained with regard to the fruit shelf life and the composition of the guaveva peel flour. In the last section, Conclusion, our final considerations are presented together with proposals for future work.

2 METHODOS

2.1 FRUIT OBTENTION

The pieces of guapeva fruit were collected in the municipality of Morrinhos (Goiás, Brazil), in an area of the Cerrado natural formation, located at latitude 17°43'52" South and longitude 49°05'58" West, with an altitude of 771 m and Aw-type tropical climate. According to the Köppen-Geiger classification, this region is characterized by a rainy season (October to April) and a dry season (May to September), with an average annual temperature between 23 and 25ºC. The fruits used in this study were harvested ripe with an average soluble solid content of 20 °Bx and used while still fresh.

After harvesting, the pieces of fruit were selected in order to remove those with visible physical, chemical or biological injuries. Subsequently, they were washed with neutral detergent to eliminate physical dirt, and then sanitized with sodium hypochlorite solution with a concentration of 100 $mg.L^{-1}$for 20 minutes for superficial microbial removal.

2.2 EVALUATION OF THE FRUIT SHELF LIFE

After washing and sanitization, the pieces of fruit were stored in an air-conditioned room at a temperature of 25 ° C and evaluated every 2 days for 6 days. The physicochemical evaluations determined the content of soluble solids by refractometry, expressed in °Bx, the titratable total acidity by titration with 0.01 N NaOH, expressed in milligrams of citric acid per 100 g of sample, and the ascorbic acid content by the Tillmans method, expressed in milligram of ascorbic acid per 100 g of sample.

2.3 PEEL BLEACHING AND DRYING

After sanitization, the whole pieces of fruit were bleached in flowing steam for 5 minutes to assist in the final quality of the flour in relation to color, texture and nutritional value as well as to inactivate enzymes and remove gases.

For the quantification of fractions of the fruit, peel, pulp and seed, 40 pieces of fruit were selected, and the fractions were mechanically separated and weighed on a precision scale. The data were presented in percentage using the weight of the whole fruit as a reference. The peels were mechanically separated and cut into 10-mm thick slices to increase the contact surface with the drying air.

The guapevapeel slices were placed onto screened trays in a 65 ° C oven dryer for 12 hours. At the end of the drying process, the dried and cooled peels at room temperature were crushed in a food processor and refined using a 0.6-mm (30-mesh) sieve.

2.4 DETERMINATION OF THE QUALITY AND YIELD OF THE GUAPEVA PEEL FLOUR

The flour was physically and chemically evaluated with respect to: i) moisture by gravimetry in a drying oven at 105 °C; ii) fixed mineral residues by muffle furnace incineration; iii) lipids by ethereal extraction (Soxhlet method); and iv) proteins by the micro-Kjeldahl method, according to the Association of Official Analytical Chemists - AOAC (AOAC, 2010), whose results were expressed in $g.100g^{-1}$. For the quantification of the dietary fibers, the gravimetric-enzymatic method described by the AOAC (AOAC, 1995) was used, with results expressed in $g.100g^{-1}$. The carbohydrate content was obtained by difference, using the following relationship:

$$\%Carbohydrates=100-(\%Moisture+\%Proteins+\%Lipids+\%Asches+\%Fibers)$$

The total caloric value was estimated using the conversion factors: 4 kcal for proteins, 4 kcal for carbohydrates and 9 kcal for lipids, as suggested by Merril and Watt (1973). For the analysis of the phenolic compounds, the ethanolic extract from the sample was used. The phenolic compounds were determined by the Folin–Ciocalteou method (Zielinski and Kozlowska, 2000) using a spectro photometer at 700 nmand a standard curve of Gallic Acid (GA), and the results were expressed in mg of $AG.100g^{-1}$of sample.

The yield was calculated by subtracting the weight of the peel after drying and grinding from the weight of fresh fruit peel before drying (equivalent to 100%).

In the next section, we present the results of the procedures described above for each analysis.

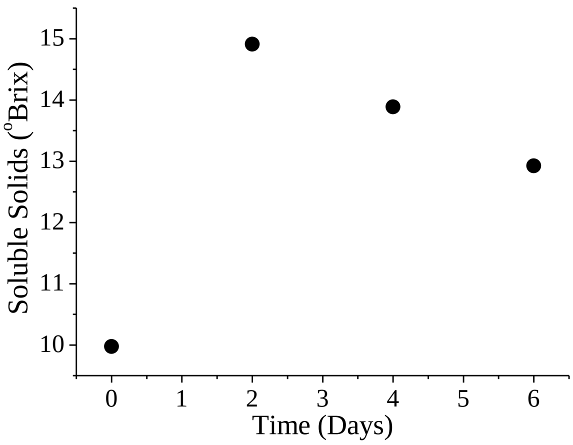
3 RESULTS

3.1 ANALYSIS OF THE GUAPEVA SHELF LIFE

The pieces of fruit stored at room temperature lasted 6 days. After this period, they were inadequate to be evaluated due to the presence of phytopathogens and the fact that they were withered and with external browning.

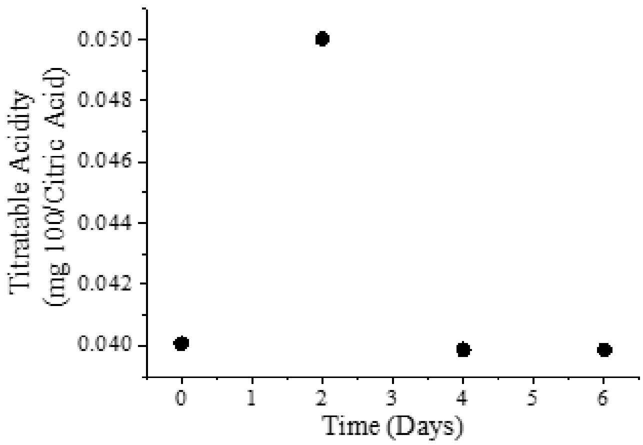
The content of soluble solids was higher on the second day of evaluation, increasing from 10 to 15 °Bx (see Fig. 2), followed by a decrease during the fruit storage.

Figure 2: Content of soluble solids in guapeva stored at 25°C.



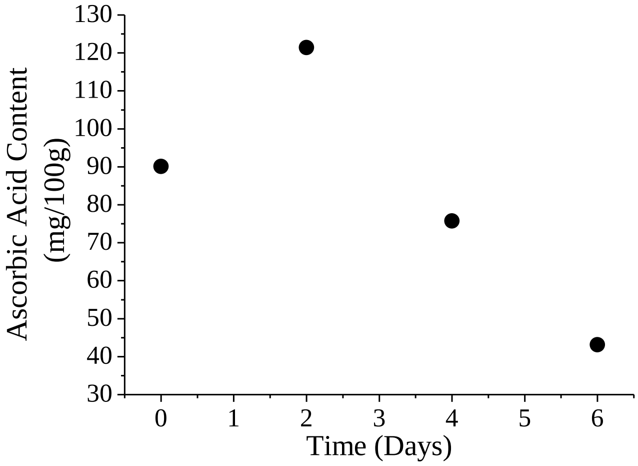
Similar to the behavior observed for the soluble solids, the titratable acidity also peaked after two days of storage, as seen in Fig. 3.

Figure 3: Titratable acidity in guapeva stored at 25°C.



The content of ascorbic acid in the fruit also increased after two days of evaluation, according to Fig. 4.

Figure 4: Ascorbic acid content in guapeva stored at 25°C.



3.2 COMPOSITION OF THE GUAPEVA PEEL FLOUR

The fractions (in percentage) that compose the mass of guapeva fruit were: 64% of peel, 24% of pulp and 12% of seed.

Table 1-Proximal composition and content of phenolic compounds in the guapeva peel flour.

Parameters	Contents (g .100g^{-1})
Moisture	7.11
Proteins	7.86
Lipids	10.07
Carbohydrates	22.41
Total dietary fibers	50.5
Soluble fibers	8.2
Insoluble fibers	42.3
Fixed mineral waste	2.05
Total caloric value (kcal)	240.15
Total phenolic compounds (mg.AG)	3286

4 DISCUSSION

4.1 ANALYSIS OF THE GUAPEVA SHELF LIFE

The content of soluble solids was higher on the second day of evaluation, increasing from 10 to 15 °Bx (see Fig. 2), followed by a decrease during the fruit storage. This behavior was already expected since the fruit was harvested from the mother plant, and despite having characteristics such as physiological maturity color and size, it still had substrate for better sweetness. However, with the intensification of respiratory activity during storage enabled by storage temperature, the fruit most likely made use of these substrates to continue its metabolic activities.

Similar to the behavior observed for the soluble solids, the titratable acidity also peaked after two days of storage, as seen in Fig. 3. The predominant organic acid in guapeva is citric acid, quite common in fruits. From the contents found, we could note that guapeva is a low-acid fruit, which affects its shelf life and storage stability since low-acid foods are more prone to microbiological attacks, mainly by fungi and bacteria (Pinheiro et al., 2006). These acids can also be used as a respiratory substrate by the fruit (Chitarra & Chitarra, 2005).

The content of ascorbic acid in the fruit also increased after two days of evaluation, according to Fig. 4. Also known as vitamin C content, the ascorbic acid suffered a very sharp drop in its contents, which is common and already reported in the literature for other fruits that are source of this acid (Cunha et al., 2014; Silva, Martins & Deus, 2009). Moreover, it is well known that the time-temperature binomial influences the preservation of vitamin C content in fruits, that is, those refrigerated ret a in better this content (Mercali, Schwartz, Marczaka, Tessaroa & Sastryc, 2014; Muniz, Pelizza, Fernandes, Gonçalves & Rufato, 2017).

In general, we can state that it is extremely important to know the best harvest time and the moment the fruit has its best physical-chemical parameters in order to determine the best time to use it and its purpose. Guapeva is a very perishable fruit, as observed in the results obtained from the post-harvest physical-chemical analyses, being necessary to adopt a procedure for its better use and processing. For this purpose, the next section shows the results regarding the characterization of the guapeva flour.

4.2 COMPOSITION OF THE GUAPEVA PEEL FLOUR

During the fruit processing for the obtention of juices, jellies and ice creams, only the pulp is generally used, as is the case for most fruits. Thus, we can determine that most of the raw material is discarded, justifying the study and characterization of this fruit peel flour. The flour obtained had a brown color, in addition to a characteristic aroma. The yield of the final product was around 30%, which is interesting from a technological point of view since the raw material would be discarded in case of processing.

The composition of the guapeva peel flour showed a moisture content of about 7%, which is in accordance with the Collegiate Board Resolution (RDC) No. 263, from September 22, 2005, of the Brazilian Health Regulatory Agency (ANVISA), which states that the maximum moisture content for flours should be 15% (see Table 1). The moisture content in foods is related to the product stability during storage since water is essential for microbiological growth and chemical and enzymatic reactions. The moisture content found can be compared to other fruit flours, such as blueberry flour with 6.78% (Goldmeyer, Penna, Melo & Rosa, 2014), green banana flour with 7.54% (Oliveira, Muller, Franco, Kotovicz & Waszczynskyj, 2015) and seriguela (*Spondiaspurpurea*) flour with 8.48% (Albuquerque, Duarte, Conceição & Aquino, 2016).

The protein content found classifies this product as a food that is a source of protein, according to RDC No. 54, from November 12, 2012 (BRASIL, 2012). This adds value to the final product since flours are usually sources of carbohydrates and fibers, but not commonly of proteins. The percentage of proteins in the composition of this flour (see Table 1) was higher than that found in the blueberry and blueberry bagasse flours, which were 2.81% and 5.27%, respectively (Goldmeyer et al., 2014). It was also higher than the percentage found inflours obtained from fruit residues (3.87%) (Aranha, Negri, Martin & Spoto, 2017) and jabuticaba (*Pliniacauliflora*) peel (2.88%) (Micheletti et al., 2018).

As shown in Tab. 1, the lipid content of the guapeva peel flour was high, contributing to a higher energy value of the final product. It is known that lipids have important functions in human nutrition, such as metabolism regulation, hormonal composition and protection. Allied to the predominantly unsaturated profile of plant-derived lipids, the higher content of lipids adds nutritional value to the product. The guapeva peel flour presented a high lipid density compared to other fruit flours, which ranged from 0.2 to 5.23% (jabuticaba peel and acerola (*Malpighiaglabra*) residues, respectively) (Micheletti et al., 2018; Aquino, Móes, Leão, Figueiredo & Castro, 2010).

Regarding the carbohydrates, the guapevapeel flour showed a considerable percentage. However, this value was significantly low in relation to other fruit flours, such as jabuticaba peel flour with 90.04% (Micheletti et al., 2018), seriguela flour with 71.77% (Albuquerque et al., 2016), and blueberry and blueberry bagasse flours with 86.78 and 85.15%, respectively (Goldmeyer et al., 2014). This lower valuecan be associated with the significantly large amount of other nutrients, such as lipids and proteins, found in this product.

The guapeva peel flour can be considered a food with a high fiber content since it contains 50.5% of dietary fibers in its composition, with 8.2% of soluble fibers and 42.3% of insoluble fibers, as established by Resolution No. 54, from November 12, 2012 (Brasil, 2012). This amount is larger than that found in the flour produced fromfruit residues (39.36%), jaboticaba peel (33.86%) and acerolaresidues (37.9%). Fibers are characteristic of this type of food given the biological nature of its structure. In daily diet, fibers are important for satiety and for the production of stool bulk, collaborating with the gastroinstestinal transit.

The fixed mineral residues tend to be high for flours of this type since they represent the minerals in the food, and notably minerals are important components of fruits and vegetables. According to Tab. 1, the guapeva flour presented fixed mineral residues, similar to those in the acerola residue flour (2.03 $g.100g^{-1}$) (Storck et al., 2015) and higher than the contents found in the blueberry flours (0.87 $g.100g^{-1}$) (Goldmeyer et al., 2014).

Despite having a relevant lipid contribution, in terms of caloric value the guaveva peel flour proved to be less caloric than the seriguela flour (313.21 kcal/100g) (Albuquerque et al., 2016) and the jabuticaba peel flour (382.88 kcal/100g) (Micheletti et al., 2018).

Additionally, the guapeva flour presented 3286 mg of gallic acid per 100 g of sample, a significant value compared to some fresh fruits, such as acai (*Euterpeoleracea*) (3268 mg) and jabuticaba (3584 mg), which are reference fruits in terms of content of phenolic compounds (Rufino, Alves, Brito, Jiménez & Calixto, 2010). In foods, phenolic compounds have an influence on the sensory quality (color, bitterness and astringency), and when in large quantities they can cause enzymatic browning. These compounds are important for the prevention of diseases due to their antioxidant capacity (Rocha et al., 2011).

In comparison with the results presented by Siqueira et al. (2017), who studied the fresh guapeva, we can consider that the production of guapeva peel flour was effective in preserving the physicochemical characteristics of the fruit. As expected, these attributes were found in greater quantities in the guapeva flour than in the fresh fruit as the drying process leads to the occurrence of an apparent concentration of these nutrients.

5 CONCLUSION

The present work evaluated the shelf life of the guapeva fruit stored at a temperature of 25 °C. Taking into account that its shelf life is 6 days and as a suggestion to extend the use of this fruit for longer periods of time, we presented the production of guapeva peel flour as a viable alternative for the better use of this residue, considering not only its high nutritional value and high content of bioactive compounds, but also the compliance with the specific legislation for food flour. Therefore, this product was considered satisfactory to be used in the preparation of new products and in human nutrition.

As proposals for future work, we can cite: i) the constitutive and phenomenological modeling of the drying process of guapeva from the formulation and resolution of inverse problems; ii) the evaluation of the fruit drying process considering other types of dryers; and iii) the evaluation of the drying process and flour preparation for other fruits of interest in the region.

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