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CENTESIMAL COMPOSITION AND MAIN CHEMICAL CHARACTERISTICS OF RESIDUE FLOUR FROM THE AGRO-INDUSTRIAL PROCESSING OF PSDIUM GUAJAVA L

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Henrique Ferreira de Assis[1], Daniela Barros de Oliveira[2], Luana Pereira de Moraes[3], Frederico de Castro Figueiredo[4] and Marcus Vinicius Sandoval Paixão[5].

ABSTRACT

An estimated 30% of food produced globally is lost annually, totaling about 77 million tons in Latin America, with 28% of this waste occurring at the end of the agro-industrial process. During the extraction of guava pulp, a residue composed of seeds and pulp, which represents up to 19% of the total mass of the fruit, is generated. This residue is rich in proteins, lipids, polyphenols and vitamin C, showing potential for animal feed. Proximate analysis is essential in the nutritional assessment of feed, allowing a detailed analysis of key nutrients and promoting animal health. This study was carried out with the objective of evaluating the centesimal composition of a flour produced from the agro-industrial residue of guava, obtained in the agroindustry of Ifes - Campus Itapina, in Colatina, ES. The residue was dehydrated at 60°C until it reached a moisture content below 13%, crushed in a knife mill and stored under refrigeration. NDF, crude protein (CP), moisture, ash, lipids, total and non-fibrous carbohydrates, titratable acidity and total tannins were analyzed. The results showed 37% NDF, 9.37% CP, 2.04% ash and 5.76% lipids. The humidity was 11.94%, and the pH was 3.59, below the risk limit of 4.5. The flour has advantageous nutritional properties, and can improve animal health and performance.

Keywords: Food. Vitamins. Metabolites.

[1] Dr. in Plant Production,
Federal Institute of Education, Science and Technology of Espírito Santo
E-mail: Henrique.assis@ifes.edu.br
ORCID: https://orcid.org/ 0000-0007-3157-1403
[2] Dr. in Natural Products Chemistry
North Fluminense State University, Campos, RJ
Email: dbarrosoliveira@uenf.br
ORCID: https://orcid.org/ 0000-0003-2266-1822
[3] Dr. in Food Engineering,
North Fluminense State University, Campos, RJ
Email: luana@uenf.br
ORCID: https://orcid.org/ 0000-0001-8180-098x
[4] Dr. in Animal Science,
Federal Institute of Education, Science and Technology of Espírito Santo
Email: Frederico.figueiredo@ifes.edu.br
ORCID: https://orcid.org/ 0009-0000-1985-1356
[5] Dr. in Plant Production,
Federal Institute of Education, Science and Technology of Espírito Santo
Email: mvspaixao@gmail.com
ORCID: https://orcid.org/000-0003-3262-9404

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INTRODUCTION

The guava tree, of the plant species *Psidium guajava* L., is known for being one of the most resistant tropical fruit trees, standing out for its ability to adapt to diseases and a variety of climatic conditions. In terms of productivity, it surpasses several other fruit species. It belongs to the Myrtaceae family, which includes 142 species and more than 6700 species of trees and shrubs (DE MALTA et al., 2018).

In 2020, Brazil ceded 22,025 hectares for guava cultivation, with the effective harvest of 21,914 hectares, which resulted in a total production of 566,293 kilograms, which is equivalent to an average of 25,842 kilograms per hectare (IBGE, 2022) The creation of this crop is especially relevant for Brazilian agribusiness, especially in the northeast region and the state of São Paulo, contributing significantly to the generation of jobs and directly influencing the Gross Domestic Product (GDP) (CNA; ESALQ/USP, 2021).

In the state of Espírito Santo, guava production reached 9,162 tons in 2020, with an average productivity of 19,288 kilograms per hectare. This production was approximately 1.6% of the national production of guava (IBGE, 2022).

It is estimated that about 30% of the food produced on the planet is wasted or lost annually, which results in 1.3 billion tons, with about 77 million tons in Latin America alone. Of this total, 28% is wasted at the end of production, 22% during management and storage, 17% in the distribution market (wholesale) and 28% in final consumers (FAO, 2021).

During the extraction of guava pulp, a residue with seeds and residual pulp is produced, which represents up to 19% of the total mass of the fruit. This material has great potential to be used in animal feed (BROCHADO et al., 2018) The waste produced by the agro-industrial processing of guava has great potential to be used in the formulation of feed for animal feed, since it is rich in proteins, lipids, polyphenols, and vitamin C (NOBRE et al., 2020).

In addition to its value as an industrial by-product, guava is recognized for its great nutritional value. In addition to being a very productive crop, it has a large number of fruits and a large amount of solids, as observed by De Malta et al. (2018) Although guava is widely consumed in its natural form, most national productions are destined for agro-industrial processing, including the production of juices, pulps and sweets (LANDAU; MARTINS; DA SILVA, 2020).

Brazil has the greatest biodiversity in the world, being responsible for approximately 20% of the world's flora. In this way, it is recognized for the development of new therapeutic techniques based on natural products. Among these technologies are plants with medicinal properties, which are all plant species that have chemical substances capable of performing pharmacological activities, helping to cure and/or treat various diseases (ROCHA et al., 2021).

The metabolism of plants results in two types of metabolites: primary (proteins, carbohydrates and fats) and secondary (phenolic compounds, essential oils and hormones), secondary metabolites are used as plant defense, that is, the greater the adversity found for their reproduction, the higher the concentration of these metabolites. And it is the various secondary metabolites that give plants their phytotherapeutic functions (SANTANA et al., 2015).

Centesimal analysis is an indispensable technique to evaluate the nutritional composition of foods. It allows for a more in-depth analysis of the main nutrients present in food, such as proteins, lipids, carbohydrates, fiber, vitamins, and minerals. This assessment is essential to understand the nutritional value of a food and its contribution to the human diet (LEMOS et al., 2022).

The objective of this study was to evaluate the antioxidant efficacy of flour obtained from guava agro-industrial residues.

MATERIAL AND METHODS

The guava residue was obtained from the fruit processing agroindustry of Ifes – Itapina Campus, located in the city of Colatina – ES. For the production of flour. The residue was dehydrated at a temperature of 60°C in a continuous air stream dehydrator until it reached a humidity below 13%, and then taken to the knife mill to be crushed, when ready, the flour was packed in plastic silage bags, sealed and stored in a refrigeration chamber at 8°C until the analysis was carried out.

The quantities of Neutral Detergent Fiber (NDF) were determined according to the protocols described by Silva & Queiroz (2009), in the detergent system the sample is first exposed to neutral detergent (pH 7). After exposure to neutral detergent, a filtration was carried out that separates the soluble cell content from the cell wall or neutral detergent fiber.

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The characterization of the cell content was detected starch, proteins, lipids and other compounds with high digestibility, and the neutral detergent fiber hemicellulose, cellulose and lignin.

The crude protein concentration was determined using the Kjeldahl method according to the methodology described by Silva and Queiroz (2009). After digestion, the samples were alkalized by adding a 50% sodium hydroxide solution and distilled and the nitrogen extracted from them was reserved in an erlenmeyer containing boric acid, after distillation the samples were titrated in a solution with hydrochloric acid at 0.1 mol/L thus obtaining the nitrogen content. After determining the total nitrogen content of the samples, the crude protein content was calculated by multiplying the value obtained in the analyses by 6.25, considering that the proportion of nitrogen in the plant proteins is 16% (CAMPOS et al., 2004).

Moisture was evaluated by drying in an oven, where the sample was transferred to an oven preheated to 105°C, kept at constant temperature for an approximate period of 4 hours. After the drying period, the sample was removed from the oven and allowed to cool in a desiccant chamber to prevent moisture absorption from the environment, and then the sample was weighed again. The moisture content of the sample was calculated by the difference in weight between the initial sample and the sample after drying, divided by the initial weight of the sample, and multiplied by 100 to express the result as a percentage (equation 1) (SILVA and QUEIROZ, 2009).

$$\% \text{ Moisture} = (\text{Initial Weight} - \text{Ending Weight}) / (\text{Initial Weight}) \times 100 \quad \text{eq. 1}$$

To determine the ash content, method 920.93 (AOAC, 2005) was used, which is based on the determination of the weight loss of the material submitted to incineration in muffle furnace at 550°C for 8 hours. It was weighed 1.0 g of the sample, and placed in the muffle and then weighed again. Equation 2 was used to calculate the percentage of ash and because the samples did not have the same moisture content, the moisture correction calculation was performed (equation 3). The results were expressed as a percentage (%).

$$\% \text{ Ash} = (\text{Ash mass (g)}100)/(\text{Sample mass (g)}) \quad \text{eq. 2}$$

$$\% \text{ of corrected ash} = (\% \text{ Ash} \times 12)/\text{moisture} \quad \text{eq. 3}$$

For lipid analyses, the method of Bligh and Dyer (1959) was used. This method uses a mixture of three solvents, chloroform, methanol, and water. The sample was mixed with methanol and chloroform forming a single phase with the sample, then more chloroform and water were added, promoting the formation of two distinct phases, one of chloroform, containing lipids, and another of methanol plus water, containing non-lipidic substances. The chloroform phase with the fat was isolated and after evaporation of the chloroform in a rotary evaporator, the ether extract content will be obtained by weighing.

The total titratable acidity was performed by titrating the sample with 0.1N NaOH solution, using phenolphthalein as an indicator and the results expressed as a percentage of malic acid. The pH analysis was performed by direct measurement in a calibrated phmeter with pH buffer solutions 4 and 7 (AOAC, 2005).

The carbohydrate content was determined by difference, subtracting from 100% the sum of the values obtained in the previous determinations Silva and Queiroz (2009).

The total tannins were quantified according to Pansera (2003). The samples were diluted in distilled water (1mg/mL). In the test tube, 1mL of the diluted extract and 1mL of the Folin Denis reagent were added. The solution was homogenized and, after 3 minutes, 1mL of 7.5% sodium carbonate solution was added and the mixture was stirred in a vortex. After 1 hour of rest away from light, the reaction tubes were centrifuged at 2000RPM for 5 minutes. Then, the absorbance reading was submitted to the supernatant in a spectrophotometer at 750nm. Gallic acid was used as standard to construct a calibration curve. From the equation of the line obtained, the total tannin content expressed in ug EAG/mg extract (micrograms of gallic acid equivalent per milligram of extract) was calculated.

RESULTS AND DISCUSSION

Table 1 shows the centesimal composition of the agro-industrial guava residue flour.

A relatively high value of Neutral Detergent Fiber - NDF (37.42%) was found, well above the carbohydrate source generally used in pig and poultry diets, (Corn <10%, Wheat 15 to 20%), according to Rostagno et al. (2017), however, although it is more studied in ruminant diets, Neutral Detergent Fiber (NDF) is an important component in the nutrition of non-ruminants. They control intestinal transit, stimulate chewing, collaborate in the regulation of glucose and lipids in the blood, and are fermented in the large intestine, producing short-chain fatty acids, which are beneficial for intestinal health, stimulating the growth of beneficial bacteria, and maintaining a healthy intestinal environment (SILVA JUNIOR et al., 2022).

Guava flour had a crude protein content of 9.37%. The content found has a good possibility of replacing corn (8%) (ROSTAGNO et al., 2017) traditionally used in zootechnical diets. The value found is important because proteins are essential for a healthy and balanced diet, playing several important roles in the body, including the construction and repair of tissues, enzymes, hormones, immunity, nutrient transport, fluid balance (SILVA JUNIOR et al., 2022). In addition to their nutritional importance, proteins are of great financial importance, so it is necessary to have stock availability and variability, to be cost-effective, to carry out good food planning so that there are no losses or unnecessary inclusion, and to use cheaper sources of protein in diets (YANG et al., 2024).

The moisture content was 11.94%, within the standard established by the National Health Surveillance Agency (ANVISA), which requires a maximum of 13% moisture in flours (BRASIL, 2005). Maintaining moisture content is crucial for preserving food quality and safety. This level of humidity is essential to inhibit the growth of microorganisms, such as fungi and bacteria, which can lead to the deterioration of products and the occurrence of food diseases. According to Oliveira and Silva (2018), the reduction of moisture in dry foods not only extends shelf life, but also preserves the organoleptic and nutritional characteristics of the product.

The value found in the ash analysis, 2.04%, was close to the values found for araçá-boi residue food powders, 2.28% (BERNARDINA et al., 2020), which highlight the association of the high ash rates found with a higher concentration of minerals present in the residues analyzed after the drying process. The ash content presents the mineral fraction of food, including essential minerals such as calcium, phosphorus, potassium, magnesium, sodium and traces of other minerals, minerals that are important in the animal mineralization process, acting on bone health and body functioning (GONÇALVES et al. 2016).

The physicochemical analyses revealed a lipid content of 5.76%. Macagnan et al. (2014) also studied various flours made from fruit by-products and found similar lipid contents in orange pomace meal of the Rubi and Hamlin varieties.

Lipids are key in non-ruminant nutrition as they offer a concentrated source of energy, providing more than twice the energy per gram compared to carbohydrates and protein (YANG et al., 2023). This is particularly relevant for growing pigs, which have high

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energy requirements. In addition, fat-soluble vitamins, such as A, D, E, and K, require the presence of lipids for their absorption and use by the body (YANG et al., 2023). A diet that contains adequate lipids is essential to ensure the effective absorption of these vitamins. Lipids can also increase the palatability of feed, which is especially beneficial in situations where feed quality varies or when animals are under stress, which can impact their feed intake. Finally, lipids act as precursors to important hormones, such as steroids, which play crucial roles in animal reproduction, growth, and metabolism (YANG et al., 2023).

Regarding the evaluation of carbohydrates, 76.65% of total carbohydrates and 2.18% of non-fiber carbohydrates were found. Total carbohydrates include all types of carbohydrates present in the food, while non-fiber carbohydrates refer only to the part of total carbohydrates that are quickly digested and absorbed by the body. Both are of nutritional importance, but the analysis of non-fiber carbohydrates is particularly useful in formulating diets for farm animals, as it provides a more accurate estimate of the immediate energy availability of feed (GAO et al., 2023).

The value of hydrogen potential (pH) found was 3.59, being below the limit for the risk of developing microorganisms, which is 4.5, thus, it becomes an alternative that is difficult to attack microbially, as cited by Bernardina et al. (2020). According to ANVISA, pH is important because, in addition to sensory quality, it affects food safety and food stability. Inadequate pH can favor the growth of unwanted microorganisms, such as pathogenic bacteria and fungi, which can compromise quality, as well as all the other results presented here.

5.51 g/kg of total tannins were found. Tannins are phenolic compounds found in a variety of plants, including fruits, vegetables, grains, herbs, and trees. These perform several important functions and have various applications in the food, pharmaceutical and other areas. Among these functions, tannins have antioxidant, antimicrobial, anti-inflammatory properties and improvements in digestion (SANTOS et al., 2023).

Table 1 - Centesimal composition of guava agro-industrial residue flour

Physicochemical analysis	Results (%)
FDN	37.42 ± 0.244
Crude Protein	9.37 ± 0.103
Moisture	11.94 ± 0.58
Ashes	2.04 ± 0.109
Lipids	5.76 ± 0.328
Total carbohydrates	76.65 ± 0.301
Non-fiber carbohydrates	2.18 ± 0.283
Total Tannins	0.0051 ± 0.175

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Source: Author's research data

CONCLUSION

The centesimal evaluation of feeds is essential both in nutrition and in the economy of animal production, providing essential information for the formulation of balanced, efficient and economical diets.

Flour from agro-industrial guava residues has advantageous nutritional properties, with potential to improve animal health, promote performance and improve nutritional quality.

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