

Characterization of Bioactive Compounds in Fruit and Vegetable Bagasse

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The use of agro-industrial residues is presented in food waste. The processing of them is an opportunity for the development of by-products, as well as the aggregation of lost value, and the sustainable use of these residues. The study aimed to characterize the bioactive compounds in grape, carrot, cocoa, and banana skins from the processing of juice, banana chips, and chocolate. The analyzed samples showed good moisture, satisfactory water activity value, with the highest flavonoid content in the grape sample (1.679 mg EQ/g) and the highest phenolic content in the cocoa epicarp sample (1.367 mg EAG/g). In this way, we verified the viability of using food peels in the food industry, enabling the use of waste generated. **Keywords:** Food Waste. By-products. Bioactive Compounds.

Introduction

The Food and Agriculture Organization of the United Nations – FAO, estimates that the world production of agro-industrial residues reaches 1.3 billion tons per year, since 1/3 of the food potentially destined for human consumption is wasted, either as residues, from processing or as a loss in the production chain [1].

The residues generated by the juice industry, fruit peels, and seeds can represent a loss of biomass and nutrients, in addition to the inadequate disposal causing the pollution of soils and water bodies, causing potential public health problems [2].

Studies show that these residues contain few calories, are a source of micronutrients, fiber and are rich in phenolic compounds and flavonoids in large amounts. These compounds can reduce the risk of cardiovascular disease and some cancers [3]. The use of agro-industrial residues, especially fruit peels and seeds, is an opportunity for the development of by-products, aggregation of lost value, and sustainable use of these residues [4].

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Thus, investigating as a way to minimize this disposal, aiming to know the nutritional quality of by-products generated by food processing industries located in Bahia, such as grape and carrot bagasse from the company PUDJA, mesocarp and cocoa epicarp from the company Mais do Cocoa, and banana peel from Bioalimentos land, this work aimed to analyze the proximate composition and quantify phenolic compounds and flavonoids from fruit residues from different processes.

Material and Methods

The systematic review selected keywords such as bioactive compounds, phenolics, flavonoids, and related terms. The research focused on the period from 2020 to 2021.

The techniques used to perform the characterization of bioactive compounds were following the literature [5, 6].

We received the bioactive compounds in fruit and vegetable peels (grape, carrot, cocoa, and banana peel), by the Bionutrition Laboratory of SENAI CIMATEC. They went through the milling process and stored in vacuum packaging until the moment of analysis. We collected the moisture and water activity of these products. The physical-chemical assessment was carried out concerning moisture content, using an infrared moisture balance (MOC-120H; Shimadzu), and concerning water activity, we used a decagon (Novasina, Lab Master aw).

For the analysis of bioactive compounds, extraction was performed by diluting the samples (flour) in 80% cereal alcohol. Afterward, filtration was performed in previously tared vials and the samples were dried in a concentrator (Genevac, DUC 22060 – N00). To prepare the mother solution, the dry material was dissolved with grain alcohol and then the solutions were stored under refrigeration for 24 hours.

The content of total phenolic compounds was determined based on the methodology proposed in the literature by using the sample's mother solution, aqueous folin solution, and sodium carbonate [5]. The absorbance evaluation was performed in a spectrophotometer (Femto, 600 plus) with a wavelength of 765 nm.

The quantifying of total flavonoids was performed according to the methodology described by Meda A. [6]. The origin solution of each sample and the methanolic aluminum chloride solution were used. Absorbance reading was performed using a spectrophotometer (Femto, 600 plus), with a wavelength of 415 nm.

Results and Discussion

We observed that the carrot peel had the highest moisture value, while the banana peel had the lowest value. Besides, the results are within the standards required by RDC 263/2005 and establish a maximum moisture content of 15% for flour obtained from fruits and seeds [7].

The results also showed low water activity for all analyzed bark samples, indicating values ranging between 0.389 and 0.426. So, we inferred that the flours used have satisfactory water activity since for the development of bacteria pathogens the value found must exceed 0.854 [8].

The phenolic compounds in a plant contribute to the growth and reproduction of vegetables. In food, they are responsible for the color and aroma, whereas, for humans, the consumption of foods rich in phenolic compounds reduces the risk of developing pathologies such as arteriosclerosis and cancer [9].

We found that the Epicarp of cocoa (1.367 mg EAG/g) and the Mesocarp of cocoa (1.088 mg EAG/g) were the husks that presented the highest levels of phenolic compounds. The carrot husks (0.310 mg EAG/g) and banana (0.638 mg EAG/g) had both the lowest levels, but still within the average established in the gallic acid behavior graph, which is 0.124 to 2.122 mg EAG/g (Table 1 and Figure 1) [7].

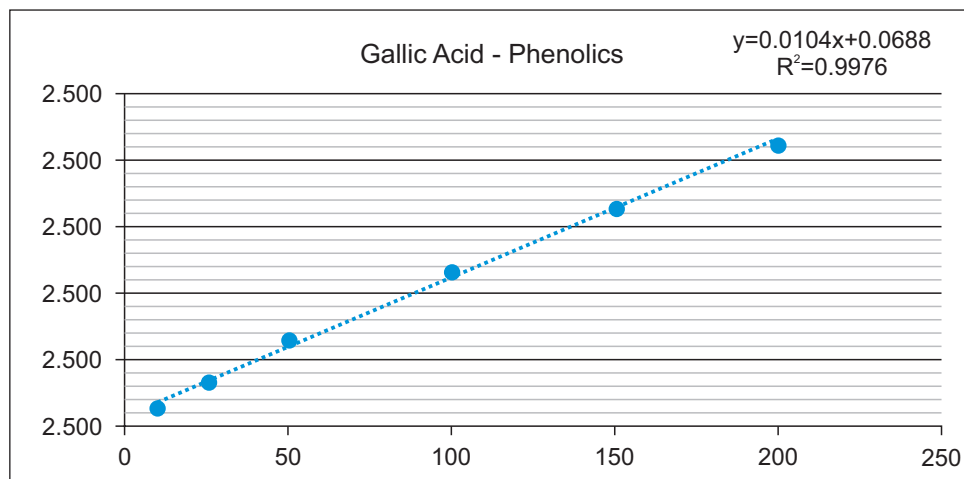
Flavonoids are bioactive compounds that can be found in many foods. In plants, it helps to protect against microorganisms and defend against the incidence of ultraviolet rays. In humans, the consumption of foods rich in flavonoids favors antioxidant reactions which act positively to delay aging and prevent inflammatory reactions, in addition to other benefits [10].

The samples showed that the highest levels of flavonoids found were from grape skins (1.679 mg EQ/g) and banana (0.640 mg EQ/g), while the

Table 1. Collected data in the phenolic test.

[] μ /mL (EAG)	ABS	ABS	ABS	Average	Standard deviation
10	0.124	0.123	0.124	0.124	0.000
25	0.316	0.321	0.320	0.319	0.002
50	0.631	0.625	0.65	0.635	0.011
100	1.143	1.161	1.155	1.153	0.007
150	1.640	1.636	1.636	1.637	0.002
200	2.092	2.125	2.149	2.122	0.023

Carbonate: Anhydrol Folin: Exodus

Figure 1. Gallic acid behavior graph.

lowest levels were from carrot skins (0.253 mg EQ/g) and mesocarp cocoa (0.320 mg EQ/g). They are within the mean variation established in the quercetin graph, which ranges from 0.037 to 1.859 mg EQ/g (Table 2 and Figure 2)[9].

Table 3 presents the values of the physico-chemical characterization of the samples of grape and carrot bagasse, cocoa mesocarp and epicarp, and banana peel.

Conclusion

The samples analyzed presented good moisture, satisfactory water activity, and phenolic compounds and flavonoids within the average. Bananas stand out as having lower moisture and

water activity, carrots with higher moisture but fewer phenolics and flavonoids, cocoa mesocarp with higher water activity, cocoa epicarp with higher phenolic content, and grape with the highest flavonoid content. Thus, the feasibility of using food peels in the food industry is reported in the study through enabling a waste reduction, helping to strengthen the immune system, and using the waste generated by food processing companies.

Acknowledgments

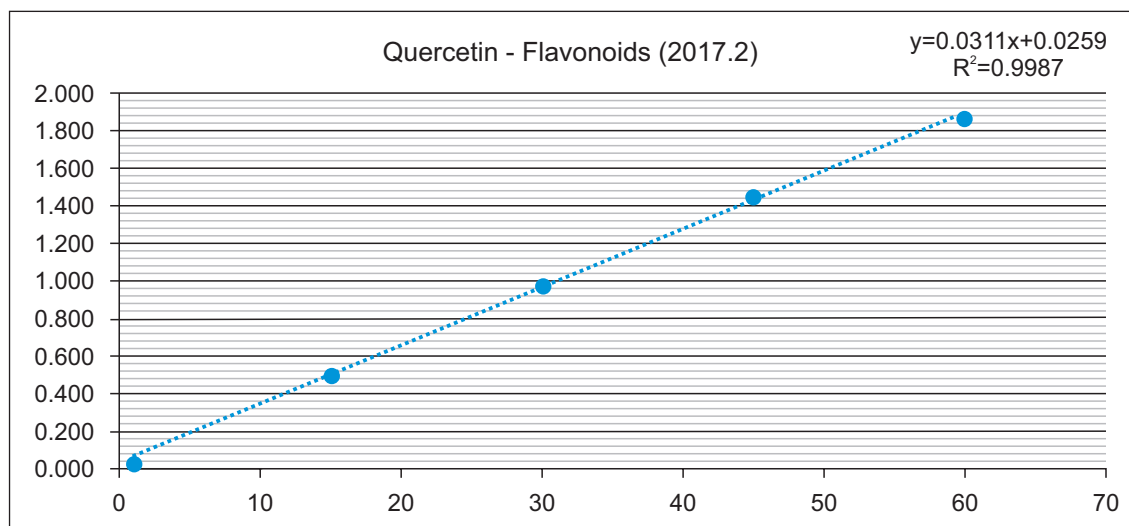
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Table 2. Collected data in the flavonoid test.

[] $\mu\text{g/mL}$ (EQ)	Abs 01	Abs 02	Abs 03	Average	Standard deviation
1	0.034	0.043	0.034	0.037	0.004
15	0.499	0.498	0.491	0.496	0.004
30	0.963	0.979	0.991	0.978	0.011
45	1.461	1.452	1.451	1.455	0.004
60	1.863	1.854	1.86	1.859	0.004
75	2.179	2.16	2.166	2.168	0.008

Chloride: Vetec

Methanol: Anhydrol

Figure 2. Quercetin behavior graph.**Table 3.** Physicochemical characterization, bioactive compounds from fruit and vegetable bagasse.

Tests	Grape	Carrot	Cocoa mesocarp	Cocoa epicarp	Banana
Moisture (%)	10.42±0.14	12.96±0.24	9.17±1.02	10.07±0.41	3.33±0.96
Water activity	0.390±0.01	0.403±0.01	0.426±0.03	0.396±0.01	0.389±0.01
Total phenolics (mg EAG/g)	0.679±0.68	0.310±0.03	1.088±0.01	1.367±0.05	0.638±0.04
Flavonoids (mg EQ/g)	1.679±0.06	0.253±0.03	0.320±0.11	0.521±0.03	0.640±0.03

EAG: equivalent in gallic acid; EQ: Quercetin equivalent.

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