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## Sustainability: Use of vegetables in their entirety or non-conventional food parts for flours preparation

*Sustentabilidade: utilização de vegetais na forma integral ou de partes alimentícias não convencionais para elaboração de farinhas*

### Abstract

**Introduction:** Waste is a great problem faced by Brazil, due to dietary habits, with a low use of fruit peels, leaves and stems of vegetables. However, it is known that the use of these parts traditionally not used can contribute to the production of healthier and more nutritious food with less negative impact on the environment. **Objective:** Take advantage of vegetables in their entirety or from their non-conventional food parts, and to characterize the flours obtained, for human consumption. **Methods:** Flours were obtained from green bananas (peel and pulp), tangerine peel, eggplant peel and pulp and grape marc from grape juice production, which were dried in a ventilated oven at 40 ° C for 48 hours. Physical-chemical and microbiological analyzes were realized. **Results:** Flours showed a high fiber (17.7 to 48.94 g/100g) and phenolic compounds (778.81 to 2708.11 mg EAG/100g) content, and low lipid content (0.70 to 3.40 g/100g). For the amount of proteins, eggplant flour was the one that stood out the most (13.81 g/100g), it can be an alternative to individuals who do not consume animal products. **Conclusions:** All flours are safe in a microbiological point of view, according to current legislation, and therefore they can be used in food to increase the supply of nutrients and reduce the impacts of pollution, contributing to the environment maintenance and income generating.

**Keywords:** Sustainability. Waste. Full use. PANC.

### Resumo

**Introdução:** O desperdício é um grande problema enfrentado pelo Brasil, em função dos hábitos alimentares, sendo o aproveitamento de cascas de frutas, folhas e talos de hortaliças ainda baixo. Sabe-se, no entanto, que a utilização dessas partes tradicionalmente não aproveitadas pode contribuir para a produção de alimentos mais saudáveis, nutritivos e com menor impacto negativo para o meio ambiente. **Objetivo:** Aproveitar os vegetais na sua forma integral ou de suas partes alimentícias não convencionais, e caracterizar as farinhas obtidas, com vistas à alimentação humana. **Métodos:** As farinhas foram obtidas de banana verdes (casca e polpa), casca de tangerina, casca e polpa de berinjela e bagaço de uva oriundo da produção de suco de uva, que foram secas em estufa ventilada a 40°C por 48 horas. Foram realizadas análises físico-químicas e microbiológicas. **Resultados:** As farinhas apresentaram alto teor de fibras (17,7 a 48,94 g/100g) e compostos fenólicos (778,81 a 2708,11 mg EAG/100g), e baixo teor de lipídeos (0,70 a 3,40 g/100g). Para a quantidade de proteínas, a farinha de berinjela foi a que mais se destacou (13,81 g/100g), podendo ser uma alternativa aos indivíduos que não consomem produtos de origem animal.

**Conclusões:** Todas as farinhas são seguras do ponto de vista microbiológico, de acordo com a legislação vigente, e portanto, podem ser utilizadas na alimentação humana para aumentar o aporte de nutrientes e diminuir os impactos da poluição, contribuindo para a manutenção do meio ambiente e gerando renda.

**Palavras-chave:** Sustentabilidade. Desperdício. Utilização integral. PANC.

## INTRODUCTION

Hunger and waste are among the biggest problems in Brazil. Due to the population's eating habits, there is no use of food in an Integral way, with the fruit clusters, leaves and stalks of vegetables thrown away.<sup>1-3</sup> According to data from the Food and Agriculture Organization (FAO), 28% of food reaching the end of the chain are wasted, on average, in Latin American countries,<sup>4</sup> and in Brazil it is estimated that waste is close to 26 million tons of solid waste per year.<sup>5,6</sup>

Organic residues utilization has been arousing interest of industry and science because it generates a significant volume of disposal and causes environment pollution. Researchers across the country are investing in the development of new products from these residues and non-conventional food parts, contributing to the production of healthy, nutritious food with lower negative impact on the environment.<sup>5</sup>

It is known that the full use of food is a way to contribute for the search of alternatives to offer products that comes from parts of high nutritional value and It is usually discarded, and its effectiveness is proven by studies. It also promotes a significant decrease in the volume of waste generated, in addition to strengthening food security and the sustainability of the agrifood system.<sup>7</sup>

The vegetable peels, as well as stems and leaves, are usually discarded, and they can often be considered a vitamins and minerals salts source that assist in treatment and prevent diseases - Therefore, the full use of food is necessary.<sup>8</sup>

As for the banana, in addition to the waste of the peels, in its green form, it still has a low consumption. The green banana is considered a non-conventional food plant (PANC), It means that They are plants or part of plants that are not habitually inserted in the daily menus, but they can be sources of nutrients and have technological characteristics to be inserted in preparations.<sup>8-11</sup>

The grape juice processing leads to the separation of grape marc, which is wasted, but It contains compounds that remain even after the juices preparation, such as antioxidants, dyes and other compounds with activities that are potentially functional.<sup>12</sup>

The tangerine peel has a high nutritional value. It is rich in vitamins, minerals, pectin and fibers that assist in intestinal functioning.<sup>13,14</sup> Gondim et al.<sup>2</sup> made a study in which It was proven that tangerine peel is indeed a good source of vitamin C and fiber.

As for eggplant, its consumption to reduce high cholesterol plasma level has already been consolidated, and researchers suggest that happen an inhibition in intestinal reabsorption of cholesterol due to the binding of soluble eggplant fibers with bile salts, also the presence of niacin and the amount of antioxidants.<sup>13,15</sup>

With the goal of promoting the reduction of food waste and the full use of food and/or non-conventional food parts. Whole green banana, tangerine peel, whole eggplant and grape marc flour were elaborated and characterized for human consumption.

## METHODS

### Raw material

The raw materials were obtained from the produce market in the Rio de Janeiro is municipality. Green banana peel and pulp (*Musa spp. Cv Silver*), tangerine peel (*Citrus reticulata* Blanco); eggplant skin and pulp (*Solanum melongena*) and grape marc (*Vitis labrusca* 'Isabella') were used.

## Flour preparation

Before processing, the fruits that still whole (pulp and peel) were weighed, washed under running water and neutral detergent, sanitized with a solution of chlorinated water at 150 ppm for 15 minutes, rinsed under running water and dried. They were cut into approximately 3mm slices.

The grape marc was obtained on laboratory scale. Composed by seed, peel, marc and grape pulp remained as a result of crushing the grain through a separating process of the juice or must.

Subsequently, the tangerine peel (CaT), whole eggplant - peel and pulp (BeJ), green banana - peel and pulp (BaV) and grape marc (BaU) were dehydrated in a forced air circulation oven at 40 °C for 48 hours. The conditions of the drying process were established from results obtained in preliminary tests. They were then ground in a hammer mill (TECNAL TE-360). In the end of process, fine flours with a characteristic color and odor were obtained, that were packed in polyethylene bags, labeled and kept under room temperature.

## Chemical, physical-chemical and physical analysis

The proximate composition of the flours was determined through the following analysis: humidity in an oven at 105°C until constant weight is obtained,<sup>16</sup> The ash by muffle incineration at 550°C until complete elimination of organic material<sup>16</sup>. Lipids according to the methodology recommended by Soxhlet.<sup>16</sup> The total nitrogen content by the Kjeldahl method and crude protein by multiplying the content of total nitrogen by the conversion factor 5,75.<sup>16</sup> The insoluble and soluble fiber fractions were determined according to the method of Prosky et al., which appears in the AOAC (1995).<sup>17</sup> Total dietary fiber was obtained by adding the insoluble fractions and soluble, as recommended by the same method. The total carbohydrate content was estimated by difference.<sup>18</sup> The total energy value (TEV) was obtained based on the Atwater factor, adopting the 4kcal / 1g protein and carbohydrate content, and the 9Kcal/1g content of lipid.<sup>18</sup>

Total acidity was determined by titration with 0.1 M NaOH solution in presence of phenolphthalein, and the results expressed in g of NaOH /100g of sample.<sup>16</sup> Water activity was determined using a water activity meter Aqualab, model Series 3 TE.<sup>15</sup> The pH was measured with the aid of a potentiometer with automatic temperature adjustment, duly standardized with pH 7 and pH 4 buffers solution.<sup>16</sup>

The total phenolics determination of the samples followed the methodology described by Singleton & Rossi.<sup>19</sup> A 500µL aliquot was mixed with 2.5ml of the reagent Folin Ciocalteu 10%, kept at rest in temperature for 2 minutes, after 2ml of sodium carbonate solution were added, the tubes were homogenized in a vortex and taken to a water bath at 50°C for 15 minutes. Then, the tubes were taken to the ice bath for 30 seconds, and the absorbance was measured at 760nm. The time between adding the Folin solution and reading the spectrum did not exceed 30 minutes. The total phenolic content was calculated by standard curve of gallic acid. The results were expressed in milligrams equivalent of gallic acid per 100g of sample (mg of EAG / 100 g of sample).

## Statistical analysis

The results obtained were subjected to analysis of variance, and the comparison of means between treatments was performed by Variance Analysis (ANOVA), Tukey test and t test with a 5% of significance level, using the XLSTAT program (2019).

## Microbiological analysis

To study the hygienic-sanitary quality of the flours, a search for *Salmonella sp*, *Bacillus cereus*, thermotolerant coliforms, *Staphylococci positive* coagulase, total mesophilic bacteria was made, according to the Compendium of Methods for the Microbial Examination of Food.<sup>20</sup> Although there are no standards for elaborated flours, the results were interpreted based on the RDC/ANVISA nº12/2001, the Technical Regulation on Microbiological Standards for Food, for group 2, which includes flours traditionally used in food.<sup>21</sup>

## RESULTS

Table 1 shows the data obtained from the physical-chemical characterization of elaborated flours, with emphasis on the contents of fibers, phenolic compounds and protein. The data from the microbiological analyzes are presented in the table 2. The results showed that all flours are within legislation standard therefore they are safe in a hygienic-sanitary point of view.

**Table 1.** Tangerine peel flour (CaT), grape marc (BaU), whole green banana (BaV) and eggplant (Bej) Characterization. Rio de Janeiro, Brasil, 2020.

Sample	CaT	BaU	BaV	Bej
TEV (Kcal/100g)*	115.92±0.00 <sup>d</sup>	195.54±0.00 <sup>b</sup>	263.22±0.00 <sup>a</sup>	173.10±0.00 <sup>c</sup>
Humidity	14.23±0.50 <sup>a</sup>	10.30±0.36 <sup>c</sup>	12.30±0.00 <sup>b</sup>	9.2±0.00 <sup>d</sup>
Ash (g/100g)	2.84±0.27 <sup>c</sup>	4.02±0.38 <sup>b</sup>	6.32±0.54 <sup>a</sup>	7.54±0.26 <sup>a</sup>
Carbohydrate (g/100g)	15.85±0.00 <sup>b</sup>	34.78±0.00 <sup>c</sup>	61.52±0.00 <sup>a</sup>	27.89±0.00 <sup>d</sup>
Fat (g/100g)	3.40±0.2 <sup>a</sup>	1.90±0.6 <sup>b</sup>	1.70±0.1 <sup>c</sup>	0.70±0.03 <sup>d</sup>
Crude protein (g/100g)	5.48±1.16 <sup>c</sup>	9.83±3.22 <sup>b</sup>	0.46±0.00 <sup>d</sup>	13.81±0.82 <sup>a</sup>
Soluble fiber (g/100g)	9.26±0.46 <sup>b</sup>	2.90±0.15 <sup>d</sup>	10.4±4.6 <sup>a</sup>	6.64±0.40 <sup>c</sup>
Insoluble fiber(g/100g)	48.94±0.05 <sup>a</sup>	36.27±2.00 <sup>b</sup>	7.3± 0.20 <sup>d</sup>	34.22±2.01 <sup>c</sup>
Total fiber (g/100g)	58.2±0.00 <sup>a</sup>	39.17±0.0 <sup>b</sup>	17.7±0.00 <sup>d</sup>	40.86±0.00 <sup>c</sup>
pH	5.31±0.05 <sup>b</sup>	3.78±0.06 <sup>c</sup>	5.88±0.08 <sup>a</sup>	5.26±0.16 <sup>b</sup>
Total acid (mL de NaOH 1N/100g)	1.34±0.25 <sup>d</sup>	3.71±0.4 <sup>b</sup>	2.48±0.26 <sup>c</sup>	2.58±0.47 <sup>a</sup>
Aw	0.29±0.00 <sup>d</sup>	0.55±0.0 <sup>a</sup>	0.39±0.00 <sup>c</sup>	0.48±0.0 <sup>b</sup>
Phenolic compounds (mg EAG/100g)**	2347.80±81.34 <sup>b</sup>	2223.03±21.08 <sup>c</sup>	778.81±43.98 <sup>d</sup>	2708.11±56.30 <sup>a</sup>

Equal letters on the same line indicate that there was no significant difference at the 5% level. \*TEV - total energy value. \*\* milligrams of gallic acid equivalent per 100g - mg of EAG / 100g. Table 2

**Table 2.** Mean values of *Salmonella sp*, *Bacillus cereus*, Thermotolerant coliforms, *Positive Coagulase staphylococci*, total mesophilic bacteria and the ANVISA standard values, Tangerine Peel (CaT) flours, Grape Macr (BaU), Whole green banana (BaV) and Eggplant (Bej). Rio de Janeiro, Brasil, 2020.

Microrganismo	CaT	BaU	BaV	Bej	Standard Legislation
<i>Salmonella sp</i> (UFC/g)	Absence	Absence	Absence	Absence	Absence
<i>Bacillus Cereus</i> (UFC/g)	< 10 <sup>2</sup>	< 10 <sup>2</sup>	< 10 <sup>2</sup>	< 10 <sup>2</sup>	3x10 <sup>3</sup>
Thermotolerant coliforms (UFC/g)	< 10	< 10	< 10	< 10	10 <sup>2</sup>
Positive Coagulase staphylococci (UFC/g)	< 10 <sup>2</sup>	< 10 <sup>2</sup>	< 10 <sup>2</sup>	< 10 <sup>2</sup>	-
Total Mesophilic bacteria Count (UFC/g)	3.8x10 <sup>4</sup>	1.0x10 <sup>4</sup>	1.7x10 <sup>4</sup>	1.4x10 <sup>4</sup>	-

Result: Product in satisfactory sanitary conditions Brazil, 2001 <sup>39</sup>

## DISCUSSION

### Chemical, physical and physical-chemical characterization

Regarding the moisture analyzed in the flours, the levels were satisfactory considering the maximum content of 15%, recommended by Anvisa in Administrative Rule nº354, of July 18, 1996,<sup>22</sup> for wheat flour, since there is no legislation that determines the maximum humidity for elaborated flours. The water activity present in the analyzed flours was adequate, as it contributes to its microbiological stability, since they had values below 0.6<sup>23</sup>

The pH is a very important parameter in food, as it defines the rigor of industrial treatments, being selective in the control of microbial presence and the occurrence of chemical interactions, besides it is a basic component of food taste. Depending on the pH value, foods are classified as: little acids (pH>4.5); acids (pH between 4 and 4.5) and very acids (pH<4).<sup>24</sup>

Therefore, the pH value of the prepared flours varied from 3.78 to 5.88. Grape marc flour is considered a very acid (3.78), with a value close to those found by Ferreira<sup>25</sup> and Bender et al.,<sup>26</sup> - 3.50 and 3.51, respectively. The BaV can be considered low acid, with a pH value (5.88), a value close to the found in unpeeled green banana flour by Borges, Pereira & Lucena<sup>20</sup> study. The CaT and BeJ flours had a pH of 5.31 and 5.26, respectively, showing no significant difference between them. As well as the BaV, low acid.

Acidity, as well as pH, is an important quality parameter, and in Flours it can indicate the kind of fermentation process that the product has gone through. The higher the acidity, the higher the fermentation intensity.<sup>24</sup> As there is no specific resolution for the analyzed flours, a comparison was made with the Brazilian legislation for cassava flour (maximum 2.0 mL 1 N NaOH /100g), and only BaU was within the recommended standard for cassava flour.<sup>22</sup>

Among the ash contents found, those belonging to the BaV and BeJ flours, proved to be above the other flours analyzed. In a study by Borges, Pereira, & Lucena,<sup>27</sup> evaluating the ash content of the whole green banana flour, the result was 2.59 lower than that found in this one. However, in this study, the use of green bananas was integral (peel and pulp). As for eggplant flour, Soares et al.<sup>28</sup> found a content of 3.67g/100g sample, below the present study; and Perez & Germani<sup>29</sup> found results similar, with 6.4g/100g of sample.

For the protein, the highest levels were in whole eggplant flours. Perez & Germani,<sup>29</sup> in a study on eggplant flour without the peel, found 16.27g/100g protein content, above the found in this study. Such results suggest that different methods and processes conducted in the raw materials can interfere in the protein content, since in this study the eggplant was used in its entirety, with peel. This protein content is important, especially for individuals who exclude animal products of the diet, and it can even be a way to increase the protein content of the meals.

Regarding the lipids content, these ranged from 0.70g/100g in BeJ to 3.40g / 100g in CaT. To the total carbohydrate values, excluding fiber, a great difference was observed between the analyzed flours. The values had a variation from 17.7g/100g for BeJ at 40.86g/100g for BaV. These differences are related to food matrices used and it directly interfere in the TEV, therefore the BaV is the flour with the highest value (263.22 Kcal / 100g of sample), followed by BaU flours (195.54 Kcal / 100g of sample), BeJ (173.10 Kcal / 100g of sample) and CaT (115.92 Kcal / 100g of sample), respectively.

According to RDC nº 54, of November 12, 2012,<sup>30</sup> a food can be considered with a high dietary fiber content, when in the finished product there is 6g/100g fiber for solid foods and 5g per serving. Therefore, one can consider that all the flours presented have high total fiber content. Whole green banana flours

(10.4g/100g) and tangerine peel (9.26g/100g) stood out in soluble fiber content; and for insoluble fibers, flours that presented greater quantities were tangerine bark (48.95g/100g) and grape marc (36.27g / 100g).

## Characterization of phenolic compounds

In a study by Machado, Pereira & Marcon,<sup>23</sup> aiming at quantification of phenolic compounds using the Folin-Ciocalteu,<sup>31,32</sup> the value found for fresh eggplant (*Solanum melongena*) was 85.08±3.39 mg of EAG/100g, significantly lower than the one found in the present study. This result is probably explained by the fact that, after the preparation of the flour, the compounds are concentrated, including due to the quantity of water present in fresh vegetables.

In relation to CaT, there is a variation influenced by the part of the fruit analyzed and also a difference in solute concentration, this study presented significantly higher content than found by Dutra et al.,<sup>33</sup> who evaluated the content of total phenolic compounds in tangerine juice (*C. reticulata* Blanco X *C. sinensis* Osbeck), with 52.32 ± 5.97mg of EAG/100g. Also noteworthy is the difference of the variety of cultivars analyzed. Therefore, in addition it is considered rich in phenolic compounds, due to its intermediate radicals which can prevent oxidation of various food ingredients, particularly lipids,<sup>34</sup> there is a possible contribution to the increase in shelf life, if flour is added to certain food products.

When evaluating the phenolic compounds content in grape marc and flour, Jacques et al.<sup>34</sup> found the values of 1,086 mg of EAG / 100g and 439 mg of EAG / 100g of dried fruit, respectively. Despite the full use of the fruit for obtaining flour, the content was lower compared to the present study.

Regarding the content of phenolic compounds in green banana flour the present study found a lower value than that found by Guiné et al.,<sup>35</sup> who evaluated the content of these compounds in banana flour cultivates *Musa nana* lyophilized mature, with 1570±0.07mg of EAG/100g. The lyophilization process is able to better preserve original properties than convective drying with hot air, which justifies the lower result found in the present study, despite the difference in maturity of the raw material.<sup>35</sup>

According to Siger et al.,<sup>36</sup> the interesting in natural antioxidants has increased considerably in recent years, due to its beneficial effects of prevention and reduction of various diseases risk. Epidemiological studies and clinical trials pointed a direct relationship established between fruit and vegetable intake and decreased of disorders related to oxidative stress occurrence, which happen due to the imbalance between the antioxidant and pro-oxidant balance, causing damage in biomolecules. These damages are attributed to a large number of pathologies, including cardiovascular or aging-related diseases, and even certain types of cancer.<sup>37</sup>

## Microbiological analysis

Safe foods are those that accomplish microbiological quality standards recognized and recommended by health agencies.<sup>38</sup> By the growing demand from the consumer market for safer food and the safety requirements established for food by regulatory agencies. A previous microbiological analyze is necessary for new products integrity.

In the present study, the analyzes carried out on the flours, showed absence of microorganisms capable of inflicting risk and showing no hygienic and sanitary deficiency. Therefore, these flours were considered satisfactory, as far as respect to microbiological quality.<sup>39</sup> (table 2).

## CONCLUSIONS

The elaborated flours had a high content of fibers and total phenolic compounds, and the quantity of protein in tangerine flour stood out for the possibility of being used by vegetarian individuals. These flours presented adequate microbiological characteristics, according to the current legislation.

The properties of those flours have a huge potential in the foods industry, and they can be used naturally and / or added to preparations or enriching foods and products. Furthermore, as it is a PANC and / or waste from processes, it can produce income, reduce waste and add nutritional value of the preparations.

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