ABSTRACT - Strawberries are appreciated in our diet for their sensory and nutritional characteristics. The food industry has used these fruit for confectionery, ice cream, frozen pulps among others. It generates a great quantity of residue materials, which is rich in nutrients. Several studies suggest consuming this fruit in its entirety, in order to reduce the environmental impact caused by improper disposal, and the possibility of alternative food sources. This study aimed to produce flour from the frozen strawberry pulp co-products and to perform their proximate and mineral composition. The samples were collected at different times. For determination of protein, carbohydrates, lipids, ash, moisture, minerals, fiber, we have used the methodology proposed by the AOAC (2010). Through the analyzes, we can emphasize the high amount of lipids (20.90 g.100 g⁻¹), calcium (667.80 mg.100g⁻¹), total fibers (70.55 g.100 g⁻¹) which show that strawberry coproducts present an exploitation potential in food production.

KEYWORDS: Fragaria sp; residues; macronutrients; fruit; consume.

1. INTRODUCTION

The relationship between a high consumption of fruit and vegetables is inversely related to the incidence of various degenerative diseases. The relationship between a balanced diet and the maintenance of health have aroused the interest of various research centers in the world and called the consumer’s attention (Hong et al. 2012; Bertoia et al. 2015; Giampieri et al. 2015; Mazzoni et al. 2016). Brazil has a vast fruit production with a wide variety of species, and its forms of presentation and industrialization emphasize the fruit agribusiness (Anuário Brasileiro de Fruticultura, 2015). However, this growth has been generating an increasing co-products production that requires to be used (Silva and Silva, 2013; Sena et al. 2015).

The fruticulture co-products may result in environmental contamination, especially water resources and soil. The accumulation of these materials is a substrate for proliferation of vectors which transmit diseases when not properly treated (Sousa, 2011; Leonel et al. 2014; Macagnan et al. 2014; Silva and Silva, 2013; Sena et al. 2015).

Several studies have pointed out that the shells, pith and fruit seeds are good sources of nutrients. The fruitculture subproducts have been highlighted in recent years for its high nutritional

PROXIMATE COMPOSITION AND MINERAL CONTENT OF STRAWBERRY COPRODUCTS

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quality and for avoiding the environmental impacts caused by improper disposal. Studies suggest drying the skins, stems, seeds and pith, and its process for the production of flour for sale in bakeries, producing cakes, cookies and functional breads with high macrominerals and fiber content (Brennan et al. 2012; Siddhuraju, 2007; Oliveira et al. 2009; Sousa et al. 2011; Daiuto et al. 2014; Leonel et al. 2014; Sena et al. 2015).

Berries in general are important sources of nutrients for proper body functions. Studies show that the strawberry is rich in minerals, vitamins, lipids, antioxidants such as phenolic compounds, carotenoids, flavonoids and anthocyanins. All of these compounds play an important role in health promotion and disease prevention, some of which have the function of body detoxification through decreasing the action of reactive oxygen species, which reduces oxidative stress and leads to a decrease in cell damaging. They also help to protect and repair DNA damaging (Giampieri et al. 2015; Xia et al. 2015; Mazzoni et al. 2016; Naithani et al. 2016.). The aim of this study is to produce flour from the strawberry pulp coproducts and investigate its proximate and mineral composition.

2. MATERIALS AND METHODS

The strawberry coproducts were kindly provided by a processing frozen pulp company from the city of Vitoria da Conquista – BA. The strawberries residues, those remaining in the sieves, were routinely discarded by the company, so it was requested the immediate freezing of the material on three separate dates, which were divided and labeled as following: Lot 1 - strawberry (Sb-1); Lot 2 - strawberry (Sb-2); Lot 3 - strawberry (Sb-3). The company buys its fruits from different cities across the country; their strawberry comes from the city of Vitoria - ES. The samples were dried out for flour production in an oven with forced air circulation (Marconi, Model MA035/1) at 50 ± 2°C for 36 (± 1h). Then, the dried material was grounded in a Wiley mill (Polymix PX-MFC 90 D) and then in a ball mill (Marconi MA350), the standardized granulometry was done in an 80-mesh sieve for flour production. Each lot was analyzed in triplicate in all analyzes.

2.1 Moisture, protein, lipids, carbohydrates, fiber, ash and minerals determination

Moisture content was determined by the drying method in a convection oven, according to the procedures proposed by the AOAC (2010). For protein determination, we have used the Kjeldahl method proposed by the AOAC (1990). For total nitrogen determination, it was used the 5.75 factor for converting proteins according to Brazil (2003), since it has its origin in plant proteins. The total lipids were determined by the gravimetric method recommended by the AOAC (2010), in a Soxhlet extractor, by using ethyl ether as a solvent extractor. The carbohydrate content was determined by difference, according to the methodology proposed by ANVISA RDC nº. 360/2003. The soluble fiber content (FS), insoluble (FI) and total (FT) were determined by the enzyme-gravimetric method. This methodology is based on the determination of the residue weight resulting from the elimination of starch and protein by enzymatic hydrolysis (α-amylase, protease, and amyloglucosidase), and subsequent precipitation of the fibers in the presence of ethanol (AOAC, 1990). The analyzes were conducted at the Laboratory Amazile Biagioli Maia - LABM, located in Juiz de Fora, MG.

Ash analysis was determined according to the method AOAC (2010). Mineral analyses was conducted following the method proposed by the AOAC (2010). The elements sodium and potassium were determined by employing the flame photometry (Micronal b-262). The mineral elements calcium and magnesium were determined by atomic absorption spectrometry (brand and model). All results were expressed as g.100g⁻¹. To conduct the experiments we have used the Completely Randomized Design (CRD), with three replicates. The results are presented as mean and standard deviation (SD). The analysis of variance (ANOVA) and the multiple comparisons were done through the Tukey’s test at the significance level of 5%.
3. RESULTS AND DISCUSSION

3.1 Proximate composition

Proximate composition is the analysis of moisture, protein, lipids, carbohydrates and dietary fiber levels. The results from the strawberry flour analysis are presented in Table 1.

Table 1 – Proximate composition of strawberry flour coproducts.

<table>
<thead>
<tr>
<th>Lots</th>
<th>Unit (%)</th>
<th>Proteins (g.100(^{-1}))</th>
<th>Lipids (g.100(^{-1}))</th>
<th>Total carbohydrates (g.100(^{-1}))</th>
<th>SDF (g.100(^{-1}))</th>
<th>IDF (g.100(^{-1}))</th>
<th>TF (g.100(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sb-1</td>
<td>14.40±0.19(^{ab})</td>
<td>6.92±0.23(^{a})</td>
<td>20.90±0.28(^{a})</td>
<td>15.86±0.3(^{a})</td>
<td>9.10±0.20</td>
<td>61.54±0.15</td>
<td>70.55±0.05</td>
</tr>
<tr>
<td>Sb-2</td>
<td>15.50±0.72(^{a})</td>
<td>4.80±0.03(^{b})</td>
<td>10.25±0.02(^{c})</td>
<td>4.20±0.79(^{b})</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sb-3</td>
<td>14.10±0.35(^{b})</td>
<td>4.43±0.27(^{b})</td>
<td>11.01±0.28(^{b})</td>
<td>3.11±0.45(^{b})</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sb: Strawberry. Average of 03 repetitions each lot followed by a standard deviation ±. Average followed by the same letter in the columns do not differ statistically from each other. The Tukey test was applied at the level of 5% probability. SDF (Soluble Dietary Fiber); IDF (Insoluble Dietary Fiber). TF (Total Fibers).

For moisture analysis, we have found, in the flours of strawberry residues, values ranging from 10.70% to 14.79%. According to Resolution nº 263 from September 22, 2005, which presents moisture patterns in food products such as flour, this type of product should not have moisture exceeding 15.0% moisture g.100\(^{-1}\). Therefore, the flours from the strawberry residues were within the standard established by law. It is noteworthy that moisture values above 15% contribute to a further deterioration and a lower life of the analyzed product.

In relation to the protein content, we have found in the flours of strawberry residues, values ranging from 4.43 to 6.92 g.100\(^{-1}\). Higher protein values in the dry matter of various tropical fruit residues have been described for pineapple, acerola, guava, passion fruit and melon (respectively: 8.35 g.100\(^{-1}\); 10.54 g.100\(^{-1}\), 8.47 g .100\(^{-1}\); 12.36 g.100\(^{-1}\); 17.33 g.100\(^{-1}\)) (Junior et al. 2006). Thus, we can see that the flours from strawberry residues have moderate amounts of protein when compared to other fruits.

We have found significant amounts of lipids in strawberry flour (10.25 to 20.90 g.100\(^{-1}\)). Fruit and vegetables are generally good sources of lipids, since most of them contains between 0.1 and 1% of total lipids. Similar lipid values were described by Abud and Narain (2009), who found levels of 16.25; 10.75; 19.05 g.100\(^{-1}\) in fruits such as guava, umbu and passion fruit, respectively. When comparing the strawberry lipid content to the value recommended by the Dietary Reference Intakes - DRI (IOM, 2005) for healthy people aged 19-30 years old, if an individual consume 100g of strawberry flour, he/she will be reaching 59.71% of daily necessities. Therefore, we can say that the strawberry flour is rich in lipids.

The total number of carbohydrates present in the strawberry flour varied from 3.11 to 15.86 g.100\(^{-1}\). Abud and Narain (2009) found higher amounts of carbohydrates in the flour residues from guava, acerola, umbu and passion fruit, respectively: 29.52; 70.83; 53.92; 13.52 g.100\(^{-1}\), not differentiating between soluble and insoluble. According to the USDA (2012), for each frozen strawberry of 255g, we can find 4.8g of total dietary fiber, not differentiating between
soluble or insoluble. The current Brazilian law, when dealing with the amount of fiber in food products, in order for the product to be considered rich as a fiber source, advocates that it must contains 5g of fiber per 100g (Brazil, 2012). Therefore, we can consider that the flour from strawberry residue is a rich source of fiber.

3.2 Minerals

Ash consists of minerals, which are required on a daily diet value and are usually found in great quantity in different kinds of food. The results of mineral content found in the residues of strawberry flours are shown in Table 2.

<table>
<thead>
<tr>
<th>Lots</th>
<th>Ash (%)</th>
<th>Calcium (mg.100g⁻¹)</th>
<th>Magnesium (mg.100g⁻¹)</th>
<th>Potassium (mg.100g⁻¹)</th>
<th>Sodium (mg.100g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sb-1</td>
<td>3.08±0.08xiety</td>
<td>667.80±21.10</td>
<td>51.50±0.47</td>
<td>200±0.00</td>
<td>31.33±1.10</td>
</tr>
<tr>
<td>Sb-2</td>
<td>3.10±0.04</td>
<td>572.00±17.70</td>
<td>44.20±0.56</td>
<td>200±0.00</td>
<td>31.31±1.10</td>
</tr>
<tr>
<td>Sb-3</td>
<td>3.02±0.16</td>
<td>564.90±24.28</td>
<td>40.40±0.88</td>
<td>200±0.00</td>
<td>30.66±1.10</td>
</tr>
</tbody>
</table>

Sb: Strawberry. Average of 3 repetitions of each lot followed by a standard deviation ± Average followed by the same letter in the columns do not differ statistically from each other (p<0.05).

The amount of ash present in the strawberry flour ranged from 3.02% to 3.10% g.100 g⁻¹. Françoso et al. (2008) studied fresh strawberries and obtained an ash value of 0.44%. Taco (2012) presented 0.5% for fresh fruit. We can observe that the strawberry flour has more ash than the fresh fruit; this may have been due to the quantities of seeds present in the residues.

The amount of calcium found in the strawberry flour ranged from 572 to 667.8 mg. 100 g⁻¹. These results demonstrate that such residues can be considered as good sources of calcium, since it provides about 67% of DRI. Felipe et al. (2006) studied the mango and passion fruit peels and found low values, 39.8 and 58.65 mg.100 g⁻¹ of calcium, respectively. Gondim et al. (2005) analyzed the tropical fruit residues and found lower calcium levels in tangerine: 478.98 mg.100 g⁻¹. Marques et al. (2012) found 264.32 mg.100 g⁻¹ of calcium in agroindustrial residues of dehydrated acerola, lower than those found in the strawberry flour.

Magnesium content found in the strawberry flour ranged from 40.4 to 51.5 mg.100 g⁻¹, and may be regarded as a good source of magnesium, since it provides approximately 20% of DRI (RDC n°. 269/2005). Marques et al. (2012) studied the agroindustrial residues in dehydrated acerola and found higher values of magnesium (106.62 mg.100 g⁻¹). Marques et al. (2010) also found lower values of magnesium in dried mango’s peel (22.38 mg.100 g⁻¹). Comparing the above mentioned results, we can say that the strawberry flour has moderate amounts of magnesium in relation to other fruit residues. So far, we have not found mineral values in strawberries residues for comparison.

Potassium content in strawberry flour remained constant in all lots (200 mg.100 g⁻¹), which means that this is a poor source regarding such a mineral, since it provides only about 4% of the mineral DRI. Godim et al. (2005) found higher potassium values than the ones found in this study (598.36 mg.100 g⁻¹) for tangerine residues. Potassium results found in this study are higher than those presented in fresh fruits according to data presented by the TACO table (2012), which describes the amount of 184 mg.100g⁻¹. The sodium content found in the strawberry flour varied from 30.6 to 31.30 mg.100 g⁻¹, we considered these flours as poor sources of this mineral, since they provided 2.08% of DRI. Godim et al. (2005) found higher sodium values than those found in tangerine peel (77.76 mg.100 g⁻¹). Thus, we can consider that the strawberry flour is a good source of calcium and magnesium and poor in sodium and potassium when compared to some other fruit residues already published.
4. CONCLUSION

Considering the presented results, we can conclude that the residues from the strawberry pulp are an important source of lipids, calcium, magnesium and especially fibers. Therefore, we suggest new studies that enables the use of strawberry flour in the development of new products, since the fibers are related to prevention, treatment and control of diseases such as diabetes, dyslipidemia, constipation among others.

REFERENCES


