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Short Communication

Chemical characterization of passion fruit (*Passiflora edulis* f. *flavicarpa*) seeds

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The aim of this study was to determine the chemical characteristics of passion fruit seeds and their oil for possible use in human food and reduction of organic waste from fruit industrialization. Passion fruit seeds were analyzed for moisture, lipids, proteins, ash, fibers, titratable acidity, pH, soluble solids and antioxidant activity. The oil was characterized for parameters such as acid value, saponification, iodine and peroxide. The content of oil extracted demonstrates that it has good potential for industrial utilization. According to analyses, the oil has characteristics similar to conventional edible oils such as soybean, and may be a new source of human consumption. Passion fruit seeds have high nutritional value, proving to be a promising product, mainly because it contains significant amounts of proteinase. Therefore, passion fruit seeds and their oil should be used as raw material in the food, chemical and pharmaceutical industry, as they have beneficial features.

Key words: Industrial utilization, characterization, by-products.

INTRODUCTION

Brazil stands out as the world's largest producer of passion fruit (*Passiflora edulis flavicarpa*), and produced in 2010 approximately 920,000 tones of the fruit (IBGE, 2012), and there is a worldwide trend toward consumption of passion fruit due to its great nutritional value, that is, the consumption of exotic tropical fruits with distinctive flavor is increasing.

Passion fruit is native to tropical America and widely grown in Brazil. It is rich in vitamin C, calcium and phosphorus. The most economically importance of passion fruit is in the form of concentrated juice (Ferrari et al., 2004); however, for industrialization, passion fruit bark and seeds are usually discarded, and these represent over 60% of the fruit and are almost always treated as organic waste.

An alternative to by-products from passion fruit industrialization would be its use in human food. The seeds of these fruits are rich in fiber, minerals and lipids, with good amount of proteins (Oliveira et al., 2011). Chau and Huang (2004) reported that passion fruit seeds are

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rich in crude lipids and insoluble dietary fiber. Passion fruit seed oil has pleasant taste and mild odor and compares with the cottonseed oil in nutritional value and digestibility (Ferrari et al., 2004). Passion fruit seeds contain large amounts of oil and fiber and are generally removed after being crushed. These residues imply in operating costs for industries and may become an environmental problem. Thus, the extraction of oil from passion fruit seeds can add value to this agroindustrial residue (Malacrida and Jorge, 2012).

Passion fruit seed oil has physicochemical characteristics similar to some common edible oils; may be a new source for human consumption (Kobori and Jorge, 2005). Passion fruit seed oil has high contents of polyunsaturated fatty acids that can be and successfully used, for example, in the production of margarine, which are consumed without heat treatment and therefore less susceptible to oxidation (Lopes et al., 2010).

Many substances present in fruits, pulp, seeds and bark can contribute to beneficial effects such as antioxidant activity (Zeraik et al., 2010). The action of antioxidants present in plant extracts plays an important role in reducing lipid oxidation in plant and animal tissues, because when incorporated in human food not only preserves the quality of food, but also helps reduce the risk of the development of diseases such as arteriosclerosis and cancer (Namiki, 1990; Ramarathnam et al., 1995).

Passion fruit seed oil, extracted by Soxhlet, has significant antioxidant quantity and can serve as a source of natural antioxidants preventing the development of diseases or as a food additive, increasing the stability and quality of food products (Malacrida and Jorge, 2012). The aim of this study was to determine the chemical characteristics of passion fruit seeds and their oil for possible use in human food and reduction of organic waste from fruit industrialization.

MATERIALS AND METHODS

Passion fruit seeds were obtained in a farm in the municipality of Santa Helena de Goiás, GO, with an altitude of 525 m and coordinates 17° 37' 58"S and 50° 33' 20" W.

Passion fruits were sent to the Laboratory of Fruits and Vegetables, Food Engineering Unit, Federal Institute of Education, Science and Technology of Goiás, Rio Verde Campus, Goiás, where seeds were extracted. Subsequently, the wet samples were dried in the sun for 6 hours to remove the residual moisture from fruits.

The physical and chemical composition of fresh pequis was determined as follows: moisture according to methodology No. 925.09 of AOAC (2000), until constant weight was achieved; ether extract according to methodology No. 925.38 of AOAC (2000); crude protein content according to micro-Kjeldahl method No. 920.87 of AOAC (2000); ash, according to the gravimetric method of AOAC (2000) No. 923.03, and calcined at 550°C, with permanence of the sample inside the FORNITEC oven, model 1926, Brazil; crude fiber according to methodology of AOAC (1995). The titratable acidity contents were obtained by titration of the filtered juice with NaOH solution (0.01 N), and the results were expressed as % citric acid (IAL, 2005). The content of soluble solids, expressed in °Brix, was determined by reading the filtered juice in refractometer model Atago N-2E (IAL, 2005). The pH was determined using a Bel Engineering pH meter; model W3B, according to the technique of IAL (2005).

Table 1. Chemical and nutritional propertied and antioxidant activity of passion fruit seeds.

Component	Value*
Soluble solids (°Brix)	3.50 ± 0.27
pH	6.36 ± 0.08
Titratable acidity (%)	0.90 ± 0.05
Proteins (%)	11.80 ± 0.20
Lipids (%)	30.22 ± 1.42
Moisture (%)	7.45 ± 0.16
Ash (%)	2.05 ± 0.35
Dietary fiber (%)	67.23 ± 1.69
Antioxidant activity (EC_{50})	108 ± 1.58

*****Mean and standard deviation.

The acid, peroxide, iodine and saponification values were determined by adapted official methodology described by “Institute Adolfo Lutz” (IAL, 2008).

The measure of the scavenging activity of DPPH free radical was performed according to methodology described by Brand-Williams and Berset (1995). Passion fruit seed samples were ground (10 g) extracted into tubes with methanol (40 ml) and centrifuged for 5 min; the supernatant was stored for further use. The extracts were diluted in three different concentrations for subsequent spectro-photometric reading.

The reaction mixture consisted of adding 0.5 ml sample, 3 ml of absolute ethanol and 0.3 ml of DPPH free radical solution and 0.3 mM of ethanol. The reduction of the DPPH free radical was measured by reading the absorbance at 517 nm in 100 min of reaction. The antioxidant activity was expressed according to Equation 1 of Mensor et al. (2001) described below:

$$\% AA = 100 - \{[(Ab_{ssample} - Abs_{blank}) \times 100] / Abs_{control}\} \quad (1)$$

Where, Aa = sample absorbance; Ab = blank absorbance; Ac = control absorbance. Thus, the specific blank of extracts in various concentrations used for each sample was taken into account. The specific sample blank was determined using 3.3 ml of ethanol and 0.5 ml of sample in each concentration and the absorbance was read at 517 nm after 100 min of reaction. A tube containing 3 ml of absolute ethanol, 0.5 ml of 70% ethanol and 0.3 ml of 0.5 mM DPPH served as a negative control.

RESULTS AND DISCUSSION

The results for the passion fruit seeds studied are shown in Tables 1 and 2. Soluble solids are composed of water-soluble compounds, including sugars (Chitarra and Chitarra, 2005). The passion fruit seeds used in this study had average soluble solids content of 3.5 °Brix.

The moisture content of seeds was 7.45%. The moisture reported in this study was higher than the value found by Jorge et al. (2009) of 6.89%; however, is within

Table 2. Chemical characteristics of the passion fruit seed oil.

Component	Value*
Acidity value (mg KOH g^{-1})	1.63 ± 0.08
Iodine index (g I/100 g oil)	109.48 ± 5.02
Peroxide index (meq/Kg)	1.54 ± 0.12
Saponification Index (mg KOH g^{-1})	173.95 ± 1.48

***Mean and standard deviation.

the recommended limit for plant flours established by law, which is 15% (ANVISA , 2005), which ensures higher quality, because the drier the flour, the higher its microbiological stability.

The titratable acidity is consistent with expectations, and passion fruit seeds have low acidity and pH near neutral, with 0.90% and 6.36, respectively.

The amount of lipids was found to be 30.22%, which indicates that passion fruit seeds are good source of oils, especially when compared to soybean seeds, which contains according to Costa et al. (2005), about 20% in oil. Togashi et al. (2007) used passion fruit seeds in the diets for broilers and found about 24.5% of lipid content. Passion fruit seed oil has high contents of unsaturated fatty acids, which indicates that this product has good potential for use in both human and animal feed, as in the cosmetics industry (Ferrari et al., 2004).

Passion fruit seeds have high amounts of dietary fiber, equal to 67.23%. Fiber intake is associated with lower concentrations of cholesterol, lower risk of coronary heart disease, reduced blood pressure, increased weight control, improved glycemic control, reduced risk of certain forms of cancer, and improved gastrointestinal function (Anderson et al., 1994).

The high fiber and protein content of passion fruit seeds suggests that these can be used as animal and human feed due to their significant nutritional value since as long as there are no toxic or allergenic substances (George, 2009).

The antioxidants present in passion fruit seed extracts react with DPPH, which is a stable radical and converts it into 2,2- diphenyl - 1 - picryl hydrazine, where the degree of discoloration indicates the antioxidant potential of the extract (Roesler, 2007). Plants, particularly fruits, are rich in several compounds with antioxidant activity, which include ascorbic acid, polyphenols and carotenoids (Melo et al., 2008). The EC_{50} for passion fruit extract was 108 $\mu g.mL^{-1}$. Roesler (2007) studied the antioxidant activity of fruits from the cerrado regions and obtained results similar to those of this study in relation to the seeds of fruits studied, obtaining 162.97 $\mu g.mL^{-1}$ for lobeira pulp + seed and 30.97 $\mu g.mL^{-1}$ for araticum seeds. Since passion fruit seeds are often treated as industrial waste, its antioxidant activity reveals that this seed can and should be considered extremely significant material for consumption, as the antioxidant activity is related to the reduction of diseases. The study of bioactive substances is of great importance and these studies reveal the importance of the consumption of plant products due to their high antioxidant activity.

The chemical characteristics of passion fruit seed oil are shown in Table 2. The acidity index provides important data on the condition of the oil conservation. The Codex Alimentarium Commission (2008) determines the maximum value of the acidity index of 4.0 mg $KOHg^{-1}$ as a quality parameter. The value found in this study (1.63 mg KOH g^{-1}) indicates that the studied oil can be used for food purposes, since it lies within the stipulated quality values.

The iodine index is related to the amount of unsaturation present in the oil. Passion fruit seed oil is mostly composed of unsaturated fatty acids (Ferrari, 2004), with iodine value of 109.48 g/2/100 g of oil. Industrially, this parameter is used as a way to control the hydrogenation of oils. Malacrida and Jorge (2012) found in their work iodine index for passion fruit seed oil of 128.0 gI2/100 g of oil. With iodine index above 100, the oil can be considered as semi-drying (Bello et al., 2011).

The determination of the peroxide value is used as an indicator of lipid oxidation. The Codex Alimentarium Commission (2008) establishes for refined and crude oils maximum peroxide values between 10 and 15 meq O_2kg^{-1}. The oil under study showed 1.54 $meqO_2$ kg $^{-1}$ peroxide value. Ferrari et al. (2004) found higher peroxide value working with passion fruit seeds, of 4.7 meq O_2 kg^{-1}. High peroxide values indicate that, somehow, the oil was exposed to oxidative process either during the preparation of the raw material, extraction or oil storage (Jorge and Luzia, 2012).

The saponification index indicates the mean molecular weight of fatty acids esterified to glycerol in the triacylglycerol molecule; a high saponification index indicates fatty acid of lower molecular weights and vice-versa (Jorge and Luzia, 2012). The value found for the saponification index of the sample analyzed was 173.95 mg $KOHg^{-1}$, which is compatible with values found by Kobori and Jorge (2005) when working with tomato, orange, passion fruit and guava oil samples of 172.86, 181.05, 174.97 and 189.91 mg KOH g^{-1} oil, respectively.

Conclusion

The disposal of industrialization products is a problem and adding value to these products, in this case passion fruit seeds, have a great economical, scientific or technological importance.

The content of oil extracted demonstrates that it has good potential for industrial utilization. According to the analyses, it has features similar to conventional edible oils such as soybean oil, and may be a new source for human consumption.

Passion fruit seeds have high nutritional value, proving to be a promising product, mainly due to their significant amounts of protein and fiber. The use of seeds and their oil should be encouraged, as they provide the development of clean technology, reducing organic waste and increasing food production for containing high nutritional values.

Conflict of interests

The authors did not declare any conflict of interest.

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