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MANGO FRUIT BY-PRODUCT AS A POTENTIAL SOURCE OF NUTRIENTS AND CAROTENOIDS FOR FOOD

[1]Renata N.B. Souto, [2]Lara A. Borges, [1]Enele T.B. Gonçalves, [1]Mariuze L.P. Oliveira, [1]José F. Soares, [3]Caroline R.F. Pires and [1,*]Juliana P. Lima

[1]Institute of Agricultural Sciences, Federal University of Minas Gerais, 39404-547 Montes Claros, Minas Gerais, Brazil; [2]Department of Food Technology, School of Food Engineering, University of Campinas, 13083-862 Campinas, São Paulo, Brazil; [3]Department of Food Science and Technology, Federal University of Tocantins, 77001-090 Palmas, Tocantins, Brazil

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Corresponding author:
Juliana P. Lima

ABSTRACT

The aim of this study was to develop and chemically characterize mango kernel flour, variety “Ubá”. The flour was submitted to analysis of proximal composition, mineral content and carotenoids profile. The means and the standard deviations were calculated for all data. Mango fruit by-product presented relevant levels of digestible carbohydrates (56.99%), dietary fibers (14.85%), lipids (10.86%), total carotenoids (9682.95 µg 100 g^{-1}), vitamin A (1246.38 µg RE 100 g^{-1}), in addition to having representative mineral content for food, such as magnesium (135.47 mg 100 g^{-1}), manganese (3.39 mg 100 g^{-1}) and iron (3.31 mg 100 g^{-1}). Therefore, mango kernel flour can add nutritional value to food products, being a promising option for the food industry, in addition to reducing environmental impacts due to the inadequate disposal of agro-industrial waste.

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INTRODUCTION

The increase of fruits and vegetables in the diet is extremely important and has been expanding in recent years due to the dietary recommendations, which intensifies the demand for foods with high nutritional value and appreciable sensory characteristics (Pereira *et al.,* 2020). On the other hand, when thinking about these vegetables, it is also necessary to mention their whole structure. Although the consumption of traditional parts of the plant is common, the most of substances of interest are generally found in fractions considered “undesirable”, such as peels, seeds and bagasses (Alañón *et al.,* 2021). In this way, the full use of food would expand the diversity of products that could be produced from a single culture, culminating in economic benefits to the producers, in addition to environmental gains (Resende and Franca, 2019). Mango (*Mangifera indica* L.) is an important tropical fruit known for its succulence, taste and pleasant flavor, being consumed *in natura* and widely used by the food industry (Jahurul *et al.,* 2015). The fruit has a yellow pulp (mesocarp) and a solitary almond covered with a fibrous, rigid and long structure (integument or endocarp), being that the junction of the almond and integument gives rise to the kernel (Nadeem *et al.,* 2016). It is important to point out that mango is considered a rich source of ascorbic acid, β-carotene and phenolic compounds, substances that are beneficial to health due to its high antioxidant activity (Gentile *et al.,* 2019). However, several authors have shown that mango residues, represented by peels and kernels, have even higher values of certain nutrients compared to the traditional edible part (Alañón *et al.,* 2021). In this sense, if processed at low cost and insert in human food, could add benefits to the health of the individual, in addition to reducing the environmental impact caused by the inadequate disposal of agro-industrial waste. Most current studies emphasize the use of peel or almond from the mango kernel in the development of food products, but until the end of this work, no studies were found with the flour obtained from the whole kernel (integument and almond) of the variety “Ubá”. Therefore, this work aimed to use the kernel originated from the processing of mango pulp, more specifically, to elaborate and chemically characterize the kernel flour.

MATERIALS AND METHODS

***Mango kernel flour processing*:** The mango fruits (*Mangifera indica* L., Ubá variety) were harvested in the municipality of Montes Claros, state of Minas Gerais, Brazil. The kernels (integument and almond) were dried by natural convection in a ventilated environment (only to remove excess water). Subsequently, to obtain the flour, the kernels were crushed in a mechanical press (model MPE-100, PI 10CV, Ecirtec), dehydrated in an over with forced air circulation at 60 °C and ground in a cutting mill (model MF32150, Scott Tech) until size desired. Mango kernel flour (MKF) was packed in low density polyethylene plastic bag and kept under refrigeration (5 ± 2 ºC) until use.

***Proximal composition*:** Moisture, ash, protein, lipids, soluble and insoluble fibers were performed according to the methods described by the Association of Official Analytical Chemists (AOAC, 2016). The digestible carbohydrates were obtained by the difference between 100 and the sum of the moisture content, ashes, proteins, lipids, soluble fibers and insoluble fibers. The energy value was estimated using the Atwater conversion factors for carbohydrates, lipids and proteins.

***Mineral characterization*:** The minerals calcium (Ca), copper (Cu), magnesium (Mg), manganese (Mn), iron (Fe) and zinc (Zn) were determined according to the methodology described by Kumari and Platel (2017). The extract and standard solutions for each mineral were analyzed using a Varian atomic absorption spectrophotometer (AA 240 FS).

***Determination of the carotenoid profile*:** Carotenoid extraction was performed according to the protocol proposed by Rodriguez-Amaya (2001) and the analysis followed the chromatographic conditions developed by Pinheiro-Sant'ana *et al*. (1998). A high performance liquid chromatografy (HPCL) with a diode array detector (DAD) at 450 nm was used. Vitamin A content was measured from each precursor carotenoid as recommended by Codex Alimentarius (FDA, 2020).

***Statistical analysis*:** Analytical determinations were performed in triplicate (n = 3) and the results expressed as arithmetic mean ± standard deviation, using the statistical software SISVAR 5.6 (Ferreira, 2011).

RESULTS AND DISCUSSION

MKF presented moisture content compatible with Brazilian legislation (maximum 15% for flours) (Brasil, 2005) (Table 1). The ash content reflects the total amount of minerals present in MKF and further considerations regarding the minerals representing this fraction will be discussed in more detail later. The percentage of lipids determined in MKF is high, considering that in 100 g of MKF can supply 13.92% of RDI for adults and children aged 4 years and older (FDA, 2020). On the other hand, thinking about the nutritional aspect and quality, Wu *et al*. (2015) reported that the mango seed has an attractive fatty acid profile in the lipid fraction, with stearic acid and oleic acid. The protein content of MKF is low (Table 1) when compared to commercial flours, such as wheat and rye (NEPA, 2011). Although mango almond seeds have a small amount of protein, their quality is high, because it is rich in essential amino acids, such as leucine and valine (Abdalla *et al.,* 2007). It should also be noted that the protein content in 100 g of MKF supplies 13.16% of RDI for adults (FDA, 2020). The value of total dietary fiber present in MKF was much higher than that found for wheat, corn and rice flours (NEPA, 2011). The content of dietary fiber in 100 g of MKF supplies 53.04% of RDI (FDA, 2020), revealing that MKF provides more than half of the recommended daily value. In view of this, including mango kernel flour in the diet can be a great option for ingesting this important component. It is suitable to emphasize that the particularities of dietary fibers promote several advantages in the physiology of the human body (Espirito Santo *et al*., 2020).

Table 1. Centesimal composition of mango kernel flour

Composition	Mango kernel flour[a]
Moisture (%)	8.55 ± 0.05
Ash (%)	2.17 ± 0.03
Lipids (%)	10.86 ± 0.62
Proteins (%)	6.58 ± 0.11
Total dietary fiber (%)	14.85 ± 1.9
Soluble dietary fiber (%)	5.52 ± 0.04
Insoluble dietary fiber (%)	9.33 ± 0.07
Digestible carbohydrates (%)	56.99
Energy value (kcal 100 g^{-1})	352.03

[a]Values expressed as mean (n=3) ± standard deviation, except digestible carbohydrates and energy value. With the exception of moisture and energy value, all data are represented on a dry basis

The content of digestible carbohydrates is high (Table 1), in this case, MKF consumption should be more moderate, as according to Bemfeito *et al.* (2020), high levels of sugars can cause high glycemic peaks in the blood. It should be added that the considerable fiber content in MKF can favor the reduction of the product's glycemic index. As it is a flour that presented considerable values of proteins, lipids and carbohydrates in its composition, a high energy value was to be expected. Among the minerals studied from MKF (Table 2), those with the highest representative content for food were manganese, copper, magnesium and iron. MKF can be considered as having a high content of Mn, Cu and Mg, because they have values that supply al least 30% of the nutrient reference values (NRVs) (FAO, 1997). In addition, MKF can be considered a sorce of Fe (supplies 15% NRV per 100 g) (FAO, 1997). It is importante to point out that these micronutrients play a fundamental role in the proper functioning of the body (Gupta and Gupta, 2014).

Table 2. Mineral content of mango kernel flour and representation of the percentage of reference daily intake for adults

Mineral	(mg 100 g^{-1}) Mango kernel flour[a]	% RDI [b] in 100 g (Mango kernel flour)
Manganese (Mn)	3.39 ± 0.15	147.39
Copper (Cu)	0.64 ± 0.05	71.11
Magnesium (Mg)	135.47 ± 11.26	32.25
Iron (Fe)	3.31 ± 0.44	18.39
Calcium (Ca)	7.63 ± 1.17	0.59
Zinc (Zn)	0.39 ± 0.08	3.54

[a]Values expressed as mean (n=3) ± standard deviation. Data are represented on a wet basis. [b]FDA (2020)

It can be observed that these structures, commonly discarded by the consumer or by the industry, presented similar or higher mineral contents than that observed in mango pulp.

Table 3. Carotenoids and vitamin A content in mango kernel flour

Evaluation	Mango kernel flour[a]
Total carotenoids (µg 100 g^{-1})	9682.95 ± 0.84
Lutein (µg 100 g^{-1})	2.95 ± 2.91
β-carotene (µg 100 g^{-1})	5220 ± 3.11
α-carotene (µg 100 g^{-1})	4460 ± 2.70
Vitamin A (µg RE 100 g^{-1})	1246.38 ± 2.49

[a]Values expressed as mean (n=3) ± standard deviation. Data are represented on a wet basis

These results reinforce the potential application of MKF in the fortification of food preparations. MKF presented good content of carotenoids (Table 3). According to Rodriguez-Amaya *et al.* (2008), for a food to be considered as source of this compounds, it is necessary to have a minimum content of 20 µg g^{-1}. Therefore, MKF can be considered a rich source of these food constituents. Quantification of carotenoids is importante because thesey have antioxidant properties, and provide photoprotection and provitamin A activity (Resende and Franca, 2019). It is interesting to note that the presence of this class of bioactive compounds in MKF becomes extremely interesting, because conventional flours generally do not have these substances. As for vitamin A (Table 3), MKF provides more than the daily recommended value (900 µg RE 100 g^{-1}) (FAO, 2020). Furthermore, it is important to mention that MKF has a significantly higher content of this vitamin compared to the edible parts of the following fruits: plum, banana apple, pineapple and jamel (NEPA, 2011).

CONCLUSIONS

The mango kernel flour had considerable levels of digestible carbohydrates, dietary fiber, lipids, in addition to the high content of minerals, especially manganese, magnesium and iron. Moreover, MKF can be considered a rich source of total carotenoids and vitamin A. Therefore, it is possible to use an agro-industrial by-product, such as mango kernel, to turn it into flour, which is beneficial for human health, environment and food industry.

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