ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 11, Issue, 09, pp. 49967-49971, September, 2021
https://doi.org/10.37118/ijdr.22853.09.2021

RESEARCH ARTICLE OPEN ACCESS

PROXIMATE, MINERAL AND CAROTENOID COMPOSITION OF COQUINHO-AZEDO FLOUR

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ARTICLE INFO

Article History:
Received 10th June, 2021
Received in revised form
27th July, 2021
Accepted 06th August, 2021
Published online 27th September, 2021

Key Words:

Bioactive compounds,
Cerrado, Drying,
Lipids, Nutritional Value.

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ABSTRACT

The objective of this work was to elaborate and characterize the flour of this fruit. Whole fruits were sanitized, their pulp removed and sent for drying and later grinding and sifting, giving rise to flour. The product was evaluated for its proximal composition, mineral and carotenoid content. The coquinho-azedo flour showed that it was rich in fibers, source of magnesium and manganese and high contents of copper, carotenoids and vitamin A. Its high lipid content, has a prevalence of unsaturated fatty acids, which can contribute energetically and sensorially in formulations of food products.

Citation: ***Gabriel Sthefano Lourenço Pereira, Renata Nolasco Braga Souto, Mariuze Loyanny Pereira Oliveira, José Fábio Soares, Elisângela Elena Nunes Carvalho, Caroline Liboreiro Paiva and Juliana Pinto de Lima.*** "Proximate, mineral and carotenoid composition of coquinho-azedo flour", *International Journal of Development Research*, 11, (09), 49967-49971.

INTRODUCTION

The coquinho-azedo (*Butia capitata* Mart. Beccari) is a palm tree native to the Brazilian Cerrado with fruits that stand out for their intense use in regional food, in natura and for preparation of jams, liqueurs, juices and ice cream (Aguiar *et al.*, 2014; Moura *et al.*, 2010). The fruits of coquinho-azedo (*Butia capitata var. capitata*) have an elongated and oval shape, with a high pulp yield and predominantly one seed per fruit (Moura *et al.*, 2010). Its mesocarp has about 85.40% moisture, 2.60% lipids and 10.80% carbohydrates (Faria *et al.*, 2008), in addition to 36.10 µg/g carotenoids (45.80% of β-carotene) and provitamin A activity (Faria *et al.*, 2011). The pulp has a prevalence of unsaturated fatty acids (between 62.78 and 63.78% in relation to its lipid content) and high levels of linolenic acid (between 3.13 and 3.66%), fatty acids essential and with hypocholesterolemic effect (Lopes *et al.*, 2012).

The use of fruits from the Brazilian Cerrado is an alternative to introduce regional products on the market, nationally and internationally. However, even with the increase in research related to the development of new products, there is still low scientific investment and low commercial exploitation in this biome (Silva *et al.*, 2017), making it difficult to add value to the fruits due to the lack of understanding of their real value nutritional status or its applicability. An alternative to encourage and facilitate the consumption and application of regional fruits is the preparation of flour. Processing reduces occupied volume, water activity, chemical reactions and microbiological activity. The cost of the process is low and the final product can be incorporated into recipes such as cakes, cookies, pasta, bread, drinks, among others (Izidoro *et al.*, 2008). Few studies report the use of sour coconut flour in food. Pereira *et al.* (2017) incorporated this ingredient in fresh pasta and pointed out that there was an increase in the nutritional value of the product due to its high lipid content, high post-cooking performance and low loss of soluble solids compared to conventional pasta. Likewise, it is important to highlight that, so far, no studies have been found on the chemical evaluation of this fruit's flour, therefore, and it is a field of research to be explored. Based on this information, reinforcing the originality of the proposal, the objective of this work was to elaborate and characterize the coquinho-azedo flour in terms of its proximate composition, mineral and carotenoids.

MATERIALS AND METHODS

Coquinho-azedo flour processing: Fruits of coquinho-azedo (*Butia capitata var. capitata*), in natura and mature (completely yellow epicarp), were collected manually in the orchard of the Institute of Agricultural Sciences of the Federal University of Minas Gerais, in Montes Claros (Minas Gerais) (16°40'52" S, 43°50'22" W and altitude 628 m). The climate type of this region, according to Köppen's classification, is tropical semi-arid, with high average temperatures (25 to 35°C). After obtaining, the fruits were transported to the Laboratory of Vegetable Products, where they were selected according to the degree of ripeness, health and absence of mechanical damage. The coquinho-azedo flour was processed on a pilot scale (Figure 1). According to the methodology adapted from Yuyama*et al.* (2008), the fruits were washed, sanitized in a sodium hypochlorite solution (100ppm for 10 minutes) and dried at room temperature. Then, grinding was done in a food processor and sieved in a 40 mesh sieve. The coquinho-azedo flour obtained was placed in a glass container protected from light and stored under refrigeration (7°C) until the analysis was carried out.

Proximal composition: Proximal composition of the flour was performed in six replicates and according to the methods recommended by the Association of Official Agricultural Chemists - AOAC (1990). Moisture was determined by standard method 934.06 in an oven at 105°C until constant weight; protein content by the Kjeldahl method 920.152, considering 5.75 as the nitrogen conversion factor; lipids by method 920.85 with Soxhlet type extractor and ash according to method 940.26 with material incineration at 550°C. The soluble and insoluble fiber fractions were determined by the gravimetric-enzymatic method 991.43 using enzymes (α-amylase, protease and amyloglucosidase). Available carbohydrates was calculated by the difference between 100 and the proximal composition obtained previously. The energy (in kcal) was determined from the calculation established by Atwater andBryand (1900), where each gram of protein or carbohydrate releases about 4 kcal of energy, while for each gram of fat this value is 9 kcal.

Mineral characterization: Mineral composition was based on the methodology proposed by Kumari and Platel (2017) by flame atomic absorption spectrophotometry (Varian 240FS AA) using commercial standards for measurement calibration and the results expressed in mg/100g.

Carotenoid profile: Preparation and analysis of carotenoids followed the methodology adapted from Rodriguez-Amaya (2001) in a High Performance Liquid Chromatography system with a diode array detector (HPLC-DAD). The identification of carotenoids was based on commercial standards with high purity retention and UV-Vis spectrum. Quantification was performed by comparing the peak areas with those obtained in the analytical curve constructed from the injection of concentrations of standard solutions. Carotenoids were expressed in mg/100g of sample as single compounds and as total carotenoids (sum of contents). Vitamin A content (in mg of retinol equivalent - RE in 100g) was calculated considering the conversion rate of beta-carotene and alpha-carotene in retinol according to Codex Alimentarius (FDA, 2020).

Statistical analysis: The results of all analyzes were expressed as mean ± standard deviation, with three repetitions for each variable studied, using the statistical software SISVAR 5.6 (Ferreira, 2011).

RESULTS AND DISCUSSION

The coquinho-azedo flour was compared with data on the proximal composition and energy of flours from other Cerrado fruits found in the literature: jatobá (*Hymena eacourbaril*), juazeiro (*Ziziphus joazeiro*), pequi (*Caryocar brasiliense*) andburiti (*Mauritia flexuosa*) (Table 1). The coquinho-azedo flour showed moisture content according to Brazilian legislation, which establishes that the flours must have a maximum content of 15.00 g/100g (Brasil, 2005). This content, related to the time and temperature used in drying, hinders microbial growth and chemical reactions such as lipid oxidation and color loss, favoring stability during storage. Comparatively, the moisture and dry matter contents of the coquinho-azedo flour were similar to those reported in the jatobá and buriti flour. The lipid content of coquinho-azedo flour was higher when compared to jatobá and juazeiro flours. According to Lopes *et al.* (2012), the lipid fraction of coquinho-azedo has a predominance of unsaturated fatty acids, especially linoleic and linolenic acids. In addition to promoting energy, the lipid content plays an important role in improving the texture and appearance of food products, and can be used in formulations as a partial substitute for wheat flour. The distinct and characteristic volatile compounds present in the oleic phase also directly influence the flavor of the product, however, from a technological point of view; the high amount of lipids in the flour has the disadvantage of making it susceptible to fatty acid oxidation, causing a possible reduction in shelf life of foods (Damodaran and Parkin, 2017).

The protein content was considerably low, superior only to buriti flour, probably due to the drying process and concentration of this nutrient. Still evaluating other flours presented in the literature, it can be seen that the ash content of the coquinho-azedo flour was lower only for the jatobá and juazeiro flours. A more detailed description of the mineral fraction of coconut flour will be seen later in this article. Dietary fiber of coquinho-azedo flour had a total content of 62.84 g/100g (adding the soluble and insoluble fraction), and can be classified as a fiber-rich product according to Brazilian legislation (Brasil, 2012). According to McRae (2018), this component, present in vegetables, is considered functional, as it is associated with a reduction in the incidence of several chronic diseases, such as colorectal and breast cancer, when included in a healthy diet. Soluble fibers, with a lower flour content, are completely fermented by the intestinal microbiota, causing a differential effect on blood plasma cholesterol levels, while insoluble fibers, in greater quantities, play a significant role in fecal volume, retaining water in the gastrointestinal tract and prevention of pathological changes in the intestine (Jha *et al.*, 2017).

Regarding the available carbohydrates, coquinho-azedo flour showed a low value compared to the jatobá flour. According to Wang *et al.* (2018), a diet with foods low in carbohydrates is effective in the treatment of obesity, significantly reducing weight and improving blood glucose and lipid regulation in patients with type 2 diabetes. The incorporation of coquinho-azedo flour in foods with high carbohydrate content such as bakery products and its consumption, on the other hand, can play a relevant role in the regulation of postprandial metabolism, with a beneficial effect on the composition of the microbiota and on the production of short-chain fatty acids (Giacco *et al.*, 2016). According to Brazilian legislation, in relation to its energy content, of a diet of 2000 kcal per day, the consumption of 100 g of coquinho-azedo flour represents 24.78% of the daily caloric consumption (Brasil, 2003). The mineral composition of coquinho-azedo flour was compared with that found in the literature for corn, rice, broad bean and pea flour (Table 2). The calcium content was higher than that found for traditional flours such as corn and rice, indicating the possibility of partial replacement of these flours by coquinho-azedo flour. The content of the products produced in relation to this mineral and reducing the deficiency due to lack of others micronutrients in the diet, since the mineral is an important mineral for bone structure and bodily functions (Cozzolino, 2007).

Table 1. Proximal composition and energy value of coquinho-azedo, jatobá, juazeiro, pequi and buriti flours

Composition (g/100g)	Coquinho-azedo	Jatobá[a]	Juazeiro [b]	Pequi[c]	Buriti[d]
Moisture	12.80 ± 0.26	12.46 ± 0.48	8.53 ± 1.15	5.89 ± 0.00	12.06 ± 0.05
Dry matter	87.20 ± 0.26	87.54 ± 0.48	91.47 ± 1.15	94.11 ± 0.00	87.94 ± 0.05
Lipids	21.71 ± 0.46	3.03 ± 0.05	1.13 ± 0.06	35.36 ± 0.31	51.67 ± 0.02
Proteins	4.58 ± 0.19	7.60 ± 0.22	5.57 ± 0.91	29.62 ± 0.53	3.39 ± 0.03
Ashes	3.72 ± 0.03	4.60 ± 0.06	4.32 ± 0.03	3.50 ± 0.50	1.64 ± 0.04
Soluble fibers	3.81 ± 0.04	11.01 ± 0.50	nd*	nd*	nd*
Insoluble fibers	59.03 ± 0.61	42.86 ± 0.27	nd*	nd*	nd*
Avaliable carbohydrates	7.16	30.9	nd*	9.86	nd*
Total carbohydrates	69.99	84.77	80.45	31.52	31.24
Energy (kcal)	495.51	396.75	354.25	631.79	603.55

Values on dry basis and expressed as mean ± standard deviation. * nd = not determined. Sources: [a] Silva *et al.*(2001); [b] Cavalcanti *et al.* (2011); [c] Ramos *et al.*(2021); [d] Carneiro and Carneiro (2011).

Table 2. Mineral composition of coquinho-azedo, corn, rice, broad bean and pea

Minerals	Coquinho-azedo	Corn [a]	Rice [a]	Broad bean [b]	Pea [b]
Calcium (Ca)	0.22 ± 0.07	0.01	0.01	1.73 ± 0.47	1.14 ± 0.36
Magnesium (Mg)	0.46 ± 0.01	0.31	0.04	1.02 ± 0.04	1.03 ± 0.06
Copper (Cu)	3.62 ± 0.08	2.70	nd*	nd*	nd*
Iron (Fe)	11.97 ± 0.71	23.00	314.40	54.80 ± 8.40	33.10 ± 3.60
Manganese (Mn)	5.05 ± 0.13	nd*	0.40	nd*	nd*
Zinc (Zn)	2.08 ± 0.38	6.00	85.00	41.80 ± 9.00	38.80 ± 12.80

Macronutrients (Ca e Mg) expressed in g/kg and micronutrients (Cu, Fe, Mn e Zn) expressed in mg/kg. Values on a dry basis and expressed as mean ± standard deviation. * nd = not determined. Sources:[a] NEPA (2011); [b] Millar *et al.*(2019).

Table 3. Carotenoids and vitamin A from coquinho-azedo, araticum, cajá, pequi e tucumã flour

Components (mg/100g)	Coquinho-azedo	Araticum [a]	Cajá [b]	Pequi [c]	Tucumã [d]
α-carotene	60.11 ± 19.88	1.98 ± 0.07	0.34 ± 0.00	nd*	nd*
β-carotene	55.95 ± 14.56	1.58 ± 0.14	0.31 ± 0.01	4.24 ± 1.26	10.29 ± 0.72
Lutein	0.06 ± 0.02	nd*	0.63 ± 0.00	nd*	nd*
Total carotenoids	116.12	3.55	4.87	8.10	10.29
Vitamin A (mg RE/100g)	14.39	0.43	0.08	0.71	1.72

Values on a dry basis and expressed as mean ± standard deviation. * nd = not determined. Sources: [a]Silva *et al.* (2015); [b]Tiburski *et al.*(2011); [c]Cardoso *et al.* (2013); [d]Yuyama et. al (2008).

Magnesium content was only lower than that of the bean and pea flours coquinho-azedo flour can be considered a source of this mineral as it presents more than 15% of the Recommended Daily Intake for adults (Brasil, 2012). An important fact that deserves to be highlighted is that coquinho-azedo flour, presents more than 30% of the Recommended Daily Intake of copper for adults, being considered a product with a high content of this mineral (Brasil, 2012). Essentially acquired through diet, Martínez *et al.* (1999) indicate that the incorporation of foods with iron sources is an alternative to increase the nutritional value of products and prevent iron deficiency anemia in children and adolescents. In this sense, coquinho-azedo flour can be used as a complement to other flours with higher levels of this mineral. The manganese content in the coquinho-azedo flour indicates that the product is a source of this micronutrient (Brasil, 2012).

Zinc, associated with growth, reproduction, tissue repair and cellular immunity (Millar *et al.*, 2019) is low in coquinho-azedo flour compared to other flours. As mentioned before, the incorporation of this flour in other products could improve the final product and complement its nutrient content. The carotenoids and the equivalent content of vitamin A in coquinho-azedo flour were compared with other vegetables, such as araticum (*Annona crassiflora*), cajá (*Spondias mombin*), pequi (*Caryocar brasiliense*) andtucumã (*Astrocaryum vulgare*), found in the literature (Table 3). The α-carotene and β-carotene content of the coquinho-azedo flour was highly superior to all compared vegetables, however, its lutein content was lower. From the sum of the detected carotenoid fractions, the coquinho-azedo flour has a higher content than that of the vegetables in comparison and, consequently, a higher content of equivalent vitamin A. From the sum of the carotenoid fractions detected in the coquinho-azedo flour, the total was higher than the content of the foods in comparison.

While Chen *et al.* (2013) show that consumption of foods with α-carotene significantly inhibits cell metastasis and can act as a therapeutic adjuvant in cancer treatment, Ben Amara *et al.* (2015) demonstrate a favorable effect of β-carotene consumption on insulin sensitivity in obese individuals that may involve an up-regulation of adiponectin (appetite-regulating hormone). In diets containing the combination of these two carotenoids, there is evidence of a reduction in the occurrence of type 2 diabetes in healthy men and women (Sluijs *et al.*, 2015). The coquinho-azedo flour had a low lutein content, possibly due to the flour processing, as this carotenoid presents instability and chemical changes at high temperatures (Gouveia and Empis 2003). Results indicate that coquinho-azedo flour contains a high content of vitamin A (National Health Surveillance Agency, 2012), which allows it to be indicated as a possible supplement to fortify food products. The inclusion of this type of product in the diet can help combat vitamin A deficiency in the body, which is mainly responsible for blindness, poor growth and death in preschool-age children and pregnant women (Gurmu *et al.*, 2014).

CONCLUSION

The coquinho-azedo flour proved to be a viable option for the maintenance of this fruit from the Brazilian Cerrado and a potential for enriching other products in the area of bakery, confectionery and beverages. The results show that, in addition to being rich in fiber and a source of manganese and magnesium, has high contents of copper, carotenoids and vitamin A. The flour preparation process is in accordance with Brazilian legislation for commercialization due to its low moisture content, however, its high lipid content can lead to a possible reduction in the shelf life of the product in cases of lipid oxidation. Future studies should be carried out aiming at the stability of food products made with coquinho-azedo flour.

ACKNOWLEDGEMENTS

Authors would like to acknowledge the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CNPQ) and the Fundação de Amparo e Pesquisa do Estado de Minas Gerais (FAPEMIG) for partially funding this study. We also thanks the Federal University of Minas Gerais (UFMG) for making this research feasible and for all support provided.

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