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Physicochemical properties, mineral and fatty acids composition of Jackfruit seeds flour of two varieties from Brazilian Midwest

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ABSTRACT. Jackfruit seeds are usually discarded as waste. Therefore, this work aimed at obtaining the Jackfruit seeds flour of two varieties (soft and firm) from Brazilian Midwest and to evaluate its physicochemical characteristics, mineral and fatty acids composition (FA). Seeds were dried at 45°C for 72h and ground (40-mesh). Both flours revealed high protein content, varying from 13.43% to 16.28%. It also revealed excellent insoluble fibers (4.16% for soft Jackfruit seeds flour [SJF] and 4.68% for firm Jackfruit seeds flours [FJF]) content. Plus, it was good sources of minerals, especially magnesium (approximately 200 mg $100g^{-1}$). Oleic acid was predominant in FJF (47.03%) and linoleic acid (30.81%) in SJF. The flour from both seeds presented minor contents of acid α-linolenic acid (approximately 5%). Consequently, both seeds flours are strongly indicated for formulating new food products, improving its nutritional value and promoting beneficial effects on human health.

Keywords: Fatty acids; jackfruit; residue; seeds flour; seeds processing.

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Introduction

Jackfruit (*Artocapus heterophyllus* L.) is a flowering tree of the Moraceae family, native of the tropical forests of Southwestern India, being widely distributed in other Asian countries such as Thailand, Indonesia, Filipinas, Malaysia, China, and others (Ranasinghe, Maduwanthi, & Marapana, 2019). It adapted very well to Brazil, spreading over an extensive area from the Southeast to the North of the country. The most common varieties of jackfruit in Brazil are the firm variety, with larger fruits and more consistent buds; the soft variety, with smaller fruits, softer and sweeter buds; and the butter variety, with intermediary consistence (Oliveira, Godoy, & Borges, 2011). Generally, the fruit has a green to yellow brown exterior rind that is composed of hexagonal, bluntly conical carpel apices and, is composed of three principal regions: the fruit axis; the persistent perianth and the true fruit (Ranasinghe et al., 2019).

Despite its great potential as a raw material for the industry, a large part of jackfruit production is wasted in the post-harvest period, mainly due to its low commercialization and high perishability (Oliveira et al., 2011). Jackfruit seeds, which represent 8 to 15% of the fruit total weight, are commonly discarded as waste with the peel and other parts. Moreover, jackfruit seeds contain approximately 55% of moisture, thereby decreasing the possibility of conservation for a long time (Ranasinghe et al., 2019). However, it can be cooked or toasted for human consumption, or even transformed into food powders or flours for use in the manufacture of food products, such as breads, cookies, cakes and pasta (Madruga et al., 2014).

Flours are products obtained from edible parts of one or more species of cereals, legumes, fruits, seeds, tubers and rhizomes, and may previously undergo appropriate technological processes considered safe for food production. The product can be named 'flour' followed by the name of the vegetable of origin. Flours are classified as simple, once obtained from a single vegetable species, and mixed, once obtained by mixing flours of different vegetable species (Brazil, 2005a). In Brazil, there is no specific legislation for jackfruit flour regarding the classification according to the processing, the granulometry, the color and the quality (Brazil, 2005a).

Numerous advantages arise from the use of flours other than wheat, including the socioeconomic, as it may favor a possible cost reduction in the food industry by using raw materials of lower commercial cost. Moreover, there is the advantage of a possible increase in the nutritional value of the final product, since several studies show that e.g. jackfruit flour has considerable amounts of carbohydrates, proteins, fibers and bioactive components, including phenolic compounds and antioxidants (Mohamad, Said, Munaim, Mohamad, & Sulaiman, 2019), beyond antibacterial, antifungal and anticarcinogenic properties attributed to the jacalin and the artocarpine lectins (Ranasinghe et al., 2019).

Therefore, considering the importance of the new products development, the search for alternative food sources and the marginal use of jackfruit seeds, this work aimed at evaluating the physicochemical properties, mineral and fatty acids composition of jackfruit (*Artocarpus heterophyllus* L.) seeds flours of two varieties from Brazilian Midwest.

Material and methods

Raw materials

Jackfruits (*Artocapus heterophyllus* L.) of firm and soft varieties were harvested from fruit trees in the city of Dourados, Mato Grosso do Sul State, Midwest of Brazil (22°13'18.54" South and 54°48'23.09" West). Ten samples of each variety were collected.

The fruits were sanitized in sodium hypochlorite solution (50 ppm 15 min.$^{-1}$) and running water. Seeds were extracted and pulp removed manually before the characterization. Figure 1 (a,b) demonstrates the two varieties of jackfruits collected in Brazilian Midwest.

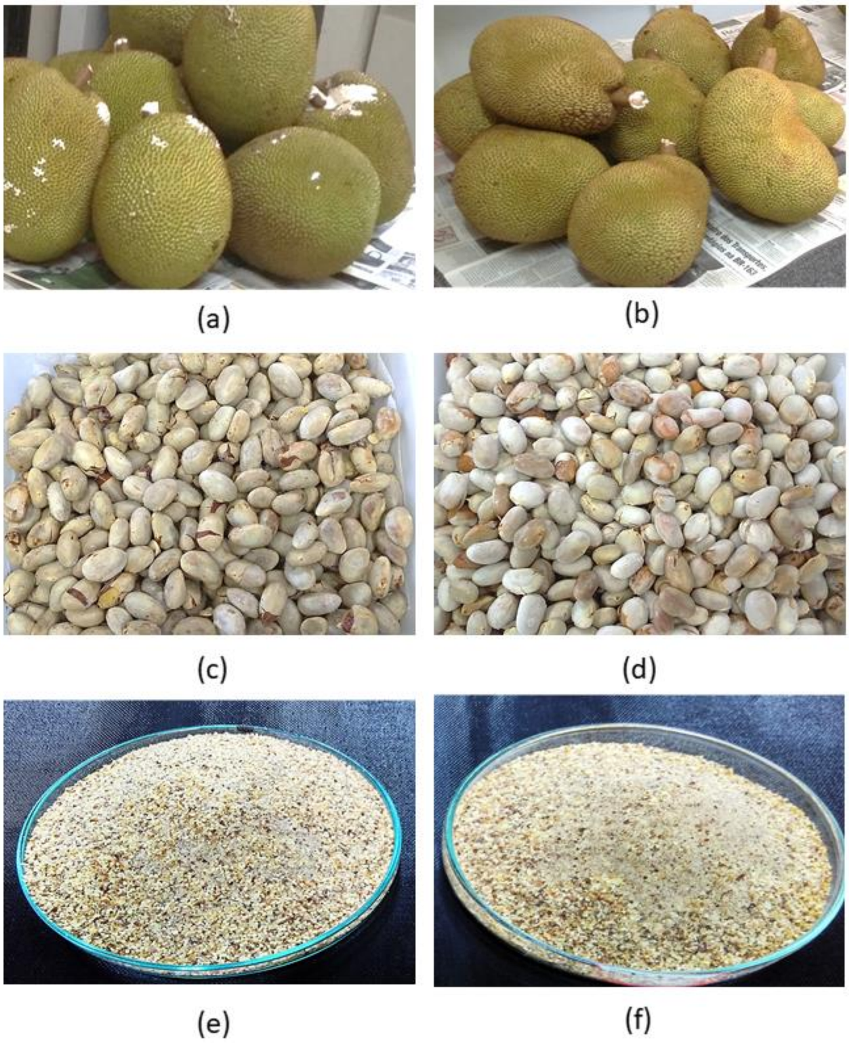

Figure 1. Fruits, seeds and flours of two varieties of jackfruit. (a) Soft jackfruit variety; (b) Firm jackfruit variety; (c) Seeds of soft jackfruit variety; (d) Seeds of firm jackfruit variety; (e) Soft jackfruit seeds flour; (f) Firm jackfruit seeds flour.

Seed characterization

Seeds (100 samples) of each variety were randomly selected. The averages length, width, thickness and diameter of individual seeds were determined using a digital caliper with a precision of 0.01 mm and expressed in mm. Mass was obtained by individually weighing the seeds in analytical balance and expressed in g. Moisture was determined by the gravimetric method in an air-circulating oven (Lucadema, Luca - 82/250) at 105°C (Association of Official Analytical Chemists [AOAC], 2012). Figure 1 (c,d) demonstrates the jackfruits seeds of two varieties studied.

Processing of seeds to obtain flour

The whole seeds (containing the white aryl and the brown spermoderm) were placed on trays and dried in air circulation oven (Marconi, MA 035) at 45°C for 72h and ground in a knife mill (Fortinox, Star FT 50). Subsequently, both jackfruit seeds flour of soft variety (SJF) and jackfruit seeds flour of firm variety (FJF) were sieved, selected at 40-mesh granulometry, portioned in polyethylene bags, and stored under freezing (-18°C) until use. Figure 1 (e, f) demonstrates the flours of both varieties obtained.

Proximate composition and energy value

The moisture, protein, crude fiber, and ash contents of both flours (SJF and FJF) were determined in triplicate according to the methods described by AOAC (2012). Moisture was determined by the oven drying method at 105°C until constant weight (method 950.46B), protein was determined by the Kjeldhal method (method 928.08), crude fiber content was determined by the gravimetric method using a fiber determiner (method 978.10) and ash was determined by the muffle oven technique (method 920.153). The total lipid content was determined by the Bligh and Dyer (1959) method. The carbohydrate content was estimated by difference. The energy value (kcal 100 g^{-1}) was theoretically estimated using the conversion factors of 4 Kcal g^{-1} for carbohydrate and protein and 9 Kcal g^{-1} for lipids (Brazil, 2003).

Starch and mineral composition

The determinations of starch and minerals were carried out as determined by Adolfo Lutz Institute (ALI, 2008).

Acidity, pH and water activity

Titratable acidity was expressed as a percentage of citric acid (method 942.15; AOAC, 2012). The pH was determined using a digital potentiometer (Instrutherm pH 2000). The water activity was determined using an Aqualab model BTE equipment (Decagon Devices, Inc.).

Fatty acids composition

The fatty acids composition was determined carried as described by Sinossaki et al. (2019). For this, 100 mg of sample of each flour were weighed in tubes for esterification, were added 2.0 mL of methanolic NaOH solution (1.25 mol L^{-1}). The mixture was sonicated for 5 min. in ultrasound bath (Elmasonic P, São Paulo, Brazil) with frequency of 37 kHz. Then, 2.0 mL of the methanolic H_2SO_4 solution (1.75 mol L^{-1}) was added to the mixture, which was sonicated for another 5 min. After that, 1.0 mL of *n*-heptane was added to the mixture, which was manually stirred for 30 s and then centrifuged for 5 min at 4.000 rpm. Finally, 500 μL of internal standard (PI, 23:0) was added and the upper phase was collected for gas chromatographic (GC) analysis.

The fatty acids methyl esters (FAME) were separated in GC (3300 Trace Ultra, Thermo Scientific) equipped with flame ionization detector (FID) and capillary column CP-7420 (100 m × 0.25 mm i.d., 0.25 μm cyanopropyl). Samples were injected in duplicate at a volume of 2.0 μL, using a 1:80 split ratio. Gas flow rates were: 1.2 and 30 mL min^{-1} for run and makeup gas, H_2 and N_2, respectively, and 35 and 350 mL min^{-1} for H_2 and synthetic air, respectively. The injector and detector temperatures were 240°C. The column temperature was maintained at 165°C for 7 min., increased to 185°C at a rate of 4°C $min.^{-1}$, maintained at 185°C for 3 min., and then increased to 235°C at a rate of 6°C $min.^{-1}$, totaling a 25 min. run.

FAMEs were identified by comparing the retention time of the samples constituents with analytical standards (FAME Mix, C4 - C24, Sigma-Aldrich). The retention time and peak areas were automatically calculated using the Chromquest™ 5.0 software. The values were expressed in mg g^{-1} of total lipids (Visentainer, 2012) and then converted to mass percentage.

Statistical analysis

Results were presented as mean ± standard deviation. Means were compared by Student's t test to evaluate significant differences between the two varieties of jackfruit seeds studied. The significance level used was 5% ($p < 0.05$). Data were processed using Statistica software, version 7.0 (http://www.statsoft.com).

Results and discussion

Physical characteristics of Jackfruit seeds and flour yield

Table 1 displays some physical characteristics of the two jackfruit seeds varieties. The moisture found was 53.84% and 59.71% for soft and firm jackfruit varieties seeds, respectively. Leite, Queiroz, and Figueirêdo (2019) reported moisture of 49.69% for fresh jackfruit seed and 57.04% for germinated seeds of soft jackfruit variety. These authors reported unit mass of fresh and germinated seeds were 4.91 g and 6.63 g, respectively, which were similar to results obtained in this study.

The dimension characteristics: length, width and thickness are on average similar to values reported by Kushwaha, Singh, Singh, and Kaur (2019) to five cultivars from India. These authors reported the length values varying from 2.30 for the Katahari cultivar to 2.93 for the Bhadaiyan cultivar. The geometric diameter varied from 1.72 to 2.04 for Hadiyava and Bhadaiyan cultivars, respectively. In this study, the cultivars studied revealed values similar or higher than the values reported by those authors.

Table 1. Characterization of jackfruit seeds of two varieties (soft and firm) collected in Brazilian Midwest and flour yield.

Properties [A]	Soft jackfruit seed	Firm jackfruit seed
Moisture (%)	53.84 ± 0.17^b	59.71 ± 0.29^a
Length (mm)	32.64 ± 1.38^a	27.81 ± 1.38^b
Width (mm)	20.11 ± 1.43^a	18.17 ± 1.71^b
Thickness (mm)	15.87 ± 1.83^a	14.71 ± 1.34^b
Average geometric diameter (mm)	22.87 ± 0.87^a	20.23 ± 0.84^b
Unitary mass (g)	6.72 ± 0.91^a	4.73 ± 0.61^b
Seed’s mass/fruit mass relation (%)	7.91 ± 0.03^a	6.80 ± 0.02^a
Flour yield (%)	44.89 ± 0.03^a	36.41 ± 0.03^b

[A]Different letter in the same line indicated significant difference by ‘Student's t test’. ($p < 0.05$).

The relation between seeds mass and fruit mass was 7.91 and 6.80% for soft and firm varieties, respectively (Table 1). These values were lower than 13.32% reported for unspecified varieties of jackfruit seeds (Santos, Bonomo, Fontam, Leite, & Santos, 2013a). The lower values observed could be associated to the maturation state, since the fruits samples were collected at the beginning of the harvesting season. Therefore, the fruits collected did not reach 100% of its development state and maturation. No considerable damage or waste during the extraction and handling of the seeds were observed in this study.

The yield of seeds processing into flour was higher for soft variety than for variety (Table 1), which could be related to the mass and moisture of seeds from firm jackfruit variety. These seeds revealed lower mass than seeds of soft variety and more moisture (Table 1). However, both varieties presented yields lower than values reported by other researchers, 46% (Chowdhury, Bhattacharyya, & Chattopadhyay, 2012) and 48.25% (Hossain et al., 2014) for unspecified varieties of jackfruit seed.

Characterization of jackfruit seed flours

Table 2 presents the physicochemical characteristics of the seed flours of two varieties of jackfruit (FJF) and (SJF).

Moisture content was higher than 6.09% (Ocloo, Bansa, Boatin, Adom, & Agbemavor, 2010) and 9.35% (Leite et al., 2019) reported elsewhere for jackfruit seed flours. There is no specific legislation for jackfruit seeds flour in Brazil. For comparison, a maximum moisture content of 9% is recommended for defatted soybean flour and 15% for wheat flour (Brazil, 2005b). In this sense, the obtained flours attend both Brazilians standards. Thus, differences in moisture content between this study and results reported by other studies may have resulted due to different methods of drying process, sample preparation and differences in seed sizes, according to the variety of the fruit.

A significant difference ($p < 0.05$) was observed in ash content between SJF and FJF flours (Table 2). Values of both flours (SJF and FJF) were similar to 2.41% and 2.70% reported for jackfruit seeds flour of soft variety by Mohamad et al. (2019) and Ocloo et al. (2010), respectively. The variation in ash content in different varieties of jackfruit could be related to geographical location and flours processing (Ocloo et al., 2010).

Table 2. Physicochemical characteristics of jackfruit seed flour of soft variety (SJF) and jackfruit seed flour of firm variety (FJF).

Parameters [A]	SJF [B]	FJF [C]
Moisture (%)	12.50 ± 0.13^a	10.84 ± 0.11^b
Ash (%)	2.61 ± 0.01^b	3.21 ± 0.03^a
Proteins (%)	13.43 ± 0.26^b	16.28 ± 0.42^a
Lipids (%)	1.21 ± 0.05^a	1.41± 0.05^a
Carbohydrates (%)	66.10 ± 0.59^a	63.58 ± 1.16^b
Starch (%)	46.03 ± 1.86^a	40.83 ± 2.22^b
Insoluble fiber (%)	4.16 ± 0.45^a	4.68± 0.74^a
Energetic value (kcal/100 g)	329.09 ± 1.98^a	332.22 ± 3.07^a
pH	4.84 ± 0.01^a	4.78± 0.01^b
Titratable acidity (%) [D]	2.11 ± 0.02^b	2.90 ± 0.01^a
Water activity (a_w) at 25°C	0.61 ± 0.01^a	0.51 ± 0.02^b

[A]Values are expressed as media ± standard deviation. Different letter in the same line indicated significant difference by 'Student's t test'. ($p < 0.05$). [B]SJF: jackfruit seed flour of soft variety; [C]FJF: jackfruit seed flour of firm variety. [D] Titratable acidity was expressed as a percentage of citric acid (g citric acid $100g^{-1}$ sample).

Regarding protein content, there was a significant difference ($p < 0.05$) between the flours of two varieties (Table 2). The values were close to that (13.67%) reported elsewhere for flours derived from seeds of different cultivars of the Mastura variety (Mohamad et al., 2019). However, the protein contents found were higher than those obtained for seed flours from cloned jackfruit varieties, such as, J29 (7.62%), J31 (8.46%) and J33 (8.24%) (Azeez, Lasekan, Jinap, & Sulaiman, 2015). The protein content of jackfruit seed flour of both varieties (SJF and FJF) was satisfactory for human growth and development. In addition, the results highlight the potential of these flours in reducing the incidence of protein malnutrition, mainly if combined with flours with lower protein levels, *e.g.* wheat flour, with approximately 11% of proteins (Brazil, 2005a).

No significant difference ($p > 0.05$) was noted in total lipid content between the two flours (Table 2). However, the results were inferior to the 1.27% reported for jackfruit seeds flours (Ocloo et al., 2010).

Carbohydrates presented a significant difference ($p < 0.05$) between flours, with higher values for SJF. The values were similar to the 66.20% reported for seeds flour of J33, a cloned jackfruit variety (Azeez et al., 2015) and, slightly lower than the 69.19% reported for jackfruit seed flour from cultivar Mastura (Mohamad et al., 2019). The insoluble fiber content presented no significant difference ($p > 0.05$) between the flours. Both flours presented contents higher than 3%, consequently both can be considered sources of dietary fiber (Brazil, 2012). These values are higher than the results reported for other jackfruit seed flours, such as 3.00% (Mohamad et al., 2019) and 3.19% (Ocloo et al., 2010). Flours rich in fiber have been used in the preparation of bakery and pasta products, expanding the offer of products with high fiber content for healthy consumers and those with chronic non-transmissible diseases. Dietary soluble and insoluble fibers provide benefits to the gastrointestinal tract from the ingestion up to the excretion, protecting against cardiovascular and colon diseases, such as constipation, diarrhea and colorectal cancer (Saueressig, Kaminski, & Escobar, 2016).

There was a significant difference ($p < 0.05$) in the levels of starch contained in seeds flours (Table 2). The jackfruit seed has a high amount (20 – 40%) of starches in its composition. The amylose content of jackfruit starch is around 24-32%, which is similar to potato starch (Ranasinghe et al., 2019; Madruga et al., 2014). Therefore, this characteristic makes seeds an important product that can be used at industrial level as raw material, avoiding its disposal after pulp utilization.

The theoretical energy values presented no significant difference ($p < 0.05$) between the flours of firm and soft varieties (Table 3). However, the obtained values were lower than the 345 kcal 100 g^{-1}(Mohamad et al., 2019) and 383 kcal 100 g^{-1} (Ocloo et al., 2010) reported for seed flour of the Mastura variety and an undetermined variety of jackfruit, respectively. Those authors reported minor values of total lipids and carbohydrates in seeds of jackfruits varieties evaluated.

The measurement of hydrogen potential (pH) and acidity are important for determining deterioration and quality maintenance of the food (Sandulachi, 2012). The titratable acidity and pH showed no significant difference ($p > 0.05$) between the seed flours of two jackfruit varieties (Table 3). Results of titratable acidity indicated that both flours were in accordance to the maximum established for rye and cornmeal flours (5.0%). However, those results are higher than the 2% of titratable acidity established for wheat flour by the Brazilian Health Regulatory Agency (Brazil, 2005a). Ocloo et al. (2010) reported minor values (1.12%) for seed flour of jackfruit collected in Ghana, Africa. Those authors also reported higher values of pH (5.78) than the values found in this study. These differences could be associated with the proximal composition and methods of flours production, since those authors used high temperature (60°C).

The water activity has been considered a fundamental property in food quality control, since values higher than 0.60 allow the development of microorganisms. Water activity influences the product shelf-life, since values close to 1 increases susceptibility to microbial growth and biochemical reactions responsible for spoilage (Sandulachi, 2012). In this study, values differed significantly ($p < 0.05$) between SJF and FJF, with SJF (0.611) showing higher water activity compared to FJF (0.513). This difference may be related to the variation in diameter and mass between the seeds (Table 2). However, temperature and time of drying are also important parameters to achieve different water activities. Leite et al. (2019) reported a water activity of 0.417 for jackfruit seed flour of unspecified variety dried at 75°C. This temperature is higher than that used in this study.

Table 3 displays the mineral content of flours of two jackfruit seed varieties (SJF and FJF). A significant difference ($p < 0.05$) was observed between the flours, and the SJF was superior in its mineral content than the SJF for seven of the nine minerals identified. However, both flours can be considered excellent sources of minerals.

Table 3. Mineral composition of seed flours obtained from two jackfruit varieties, SJF and FJF.

Minerals (mg $100g^{-1}$)[A]	FJF[B]	SJF[C]
Calcium	68.22 ± 0.46^b	88.10 ± 0.33^a
Magnesium	249.13 ± 0.21^a	215.09 ± 0.44^b
Phosphorous	93.78 ± 0.57^b	98.03 ± 0.41^a
Sodium	3.07 ± 0.16^b	4.86 ± 0.24^a
Iron	2.55 ± 0.21^b	2.93 ± 0.18^a
Copper	1.72 ± 0.13^a	1.45 ± 0.06^a
Zinc	2.88 ± 0.20^b	3.44 ± 0.16^a
Potassium	148.90 ± 0.58^a	151.09 ± 0.34^a
Manganese	1.02 ± 0.11^a	1.10 ± 0.10^a

[A]Different letter in the same line indicated significant difference by 'Student's t test'. ($p < 0.05$). [B]SJF: jackfruit seed flour of soft variety; [C]FJF: jackfruit seed flour of firm variety.

Magnesium represents the main element reported in both flours (Table 3). Thus, 100 g of both flour (SJF and FJF) provides about 95% of the 260 mg recommended daily intake for adults (Brazil 2005b). This mineral acts as cofactor in metabolic reactions, playing a fundamental role in glucose metabolism, insulin and glycemic homeostasis, and in the synthesis of adenosine triphosphate, proteins and nucleic acids (Elin, 2010). The potassium values were lower than values reported of 769.32 mg $100g^{-1}$ (Mohamad et al., 2019) and 2.348mg $100g^{-1}$ (Leite et al., 2019). All results are lower than the 3.5 g per day recommended for potassium consumption to avoid problems such as hypertension and cardiovascular diseases (World Health Organization [WHO], 2007).

The sodium values were lower than the 5.39 mg $100g^{-1}$ (Mohamad et al., 2019) and 6.07 mg $100g^{-1}$ (Ocloo et al., 2010) reported for seeds flours of Mastura jackfruit variety and an unspecified variety of jackfruit, respectively. The calcium values were higher than the 40.86 mg $100g^{-1}$ (Mohamad et al., 2019) reported for seeds flours of the Mastura jackfruit variety. Phosphorus levels were lower than 128.83 mg 100 g^{-1} (Mohamad et al., 2019) and 171.44 mg 100 g^{-1} (Leite et al., 2019). Both flours obtained in this study presented low levels of iron, which were lower than 9.32 mg 100 g^{-1} (Leite et al., 2019) and 12.55 mg 100 g^{-1} (Borgis & Bharati, 2020) reported for seed flour of soft jackfruit variety and for an unspecified jackfruit variety, respectively.

The levels of zinc and manganese present in FJF and SJF were lower of 4.65 mg $100g^{-1}$ and 2.40 mg 100 g^{-1} (Leite et al., 2019) reported for seeds flour of soft jackfruit variety, respectively. However, the content of both minerals in 100 g of SJF and FJF reaches around 60-70% of the recommended daily intake for children up to 10 years (Brazil, 2005a). All these differences in mineral content may be related to the different jackfruit varieties, maturity stages and other factors that influence the environment for jackfruit development, including soil, climate and agricultural practices (Mohamad et al., 2019; Ranasinghe et al., 2019).

Fatty acids composition

The fatty acid (FA) composition of the jackfruit seed flours (SJF and FJF) of two varieties are detailed in Table 4. Both flours (FJF and SJF) exhibited higher contents of saturated fatty acids (SFA), followed by monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA), which totalized minor values. The predominant SFA in FJF was lignoceric acid (24:0) with 51.55%, whereas in SJF the major SFA was (21:0) 24.84% followed by oleic acid (18:0) with 20.88%.

MUFA totalized 56.22% in FJF and 55.15% in SJF. The majors FA in the studied flours are 16:1n-9 (34%) and 18:1n-9t (47%), respectively. A significant difference ($p < 0.05$) was also noted between PUFA content, with higher values for FJF (Table 4). However, SFJ indicated greater diversity of PUFA than FJF, which concentrated FA as linoleic acid (18:2n-6; 30.8%). There are evidences that PUFA are beneficial in controlling risk factors for cardiovascular disease, with hypocholesterolemic effects when SFA are replaced for MUFA. This substitution in the diet can reduce LDL (low density lipoprotein) levels; improve the sensitivity of insulin performance, thereby reducing the risk of diabetes mellitus, which can also improve blood pressure control, reducing cardiovascular risks (Santos et al., 2013b).

Table 4. Fatty acids composition (% m/m) of seed flours of two jackfruit varieties (SJF and FJF).

Fatty acids [A]	FJF [B]	SJF [C]
14:0	0.83 ± 0.04^a	0.72 ± 0.08^b
15:0	1.21 ± 0.11^a	-
16:0	4.22 ± 0.14^a	3.62 ± 0.11^b
16:1	34.36 ± 0.21^a	-
17:0	-	0.32 ± 0.06^a
18:0	2.19 ± 0.10^b	20.88 ± 0.16^a
18:1n-9t	21.86 ± 0.34^b	47.03 ± 0.22^a
18:1n-9c	-	1.40 ± 0.09^a
18:2n-6	30.81 ± 0.30^a	16.74 ± 0.10^b
18:3n-6	-	0.14 ± 0.03^a
18:3n-3	4.88 ± 0.09^b	5.65 ± 0.16^a
20:0	-	0.31 ± 0.13^a
20:1n-9	-	6.72 ± 0.24^a
20:2n-6	-	1.20 ± 0.08^a
21:0	-	24.74 ± 1.01^a
24:0	51.55 ± 0.15^a	6.01 ± 0.13^b
SFA[D]	60.00 ± 0.18^a	56.61 ± 0.25^b
MUFA[E]	56.22 ± 0.21^a	55.15 ± 0.30^b
PUFA[F]	35.69 ± 0.30^a	30.45 ± 0.17^b
n-6[G]	30.81 ± 0.16^a	18.08 ± 0.09^b
n-3[H]	4.88 ± 0.08^b	5.65 ± 0.05^a
n-6/n-3[I]	6.31 ± 0.04^a	3.20 ± 0.02^b
PUFA/SFA[J]	0.59 ± 0.03^b	0.42 ± 0.08^a

[A]Different letter in the same line indicated significant difference by "Student's t test". ($p < 0.05$). [B] FJF: jackfruit seed flour of firm variety; [C] SJF: jackfruit seed flour of soft variety;[D] SFA: saturated fatty acids; [E] MUFA: monounsaturated fatty acids; [F] PUFA: polyunsaturated fatty acids; [G] n-6: total fatty acids of n-6 series; [H] n-3: total fatty acids of n-3 series; [I] n-6/n-3: ratio between n-6 and n-3 fatty acids; [J] PUFA/SFA: ratio between polyunsaturated fatty acids and saturated fatty acids.

The total n-6 FA were significant difference ($p < 0.05$) between the flours obtained from the two jackfruit varieties. FJF exhibited 30.81% of n-6 FA with the predominance of linoleic acid (18:2n-6), whereas SJF presented 18.08% of n-6 FA, also with predominance of linoleic acid (16.74%). The total n-3 FA were the minor contents of PUFA, with 4.88% for FJF and 5.65% for SJF, in both cases represented by α-linolenic acid (18:3n-3). Those results are higher than values reported by Azeez et al. (2015) to a cultivar of jackfruit (J33) collected in Malaysia. In that study, authors found 22.34% of linoleic acid and 1.54% of α-linoleic acid.

The benefits of consuming PUFA have been deeply studied and important physiological effects in the prevention and treatment of many chronic degenerative diseases in humans have been described for α-linoleic and linoleic acids, which are some of the most important essential FA for human consumption. The relevance of those fatty acids is related to its ability to be transformed into biologically active substances, with special functions in homeostatic balance, and in structural component of cell membranes, brain and nervous tissues (Simopoulos, 2008).

The PUFA/SFA value presented for SJF (Table 4) was higher than the reference value of 0.45 (Department of Health and Social Security [DHSS], 1994). This indicates that SJF is a beneficial food in relation to cholesterol metabolism. However, FJF presented a ratio lower than 0.45, indicating potential to induce an increase in blood cholesterol. On the other hand, regarding the n-6/n-3 ratio, the FJF would be the most indicated for consumption, since it showed values lower than 4.0, which are associated with reduction in coronary heart disease (Simopoulos, 2008).

Conclusion

Both varieties of jackfruit seeds provided flours with beneficial substances for human health, such as proteins, fibers and minerals. Both flours revealed preservation parameters (pH and a_w) according to recommendations. Essential fatty acids, although in low concentration, were present and the PUFA/SFA and n-6/n-3 ratios demonstrate that the consumption of the obtained flours (SJF and FJF) can promote beneficial effects on human health. Therefore, the flours are recommended and could be utilized in the formulation and enrichment of foods, improving its nutritional value and reducing environmental impacts due to irregular discard of seeds.

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