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Physical, chemical, nutritional and antinutritional characterization of fresh peels of yellow pitaya (*Selenicereus megalanthus*) and red pitaya (*Hylocereus costaricensis*) and their flours[1]

Caracterização física, química, nutricional e antinutricional das cascas in natura de pitaia amarela (*Selenicereus megalanthus*) e vermelha (*Hylocereus costaricensis*) e suas farinhas

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ABSTRACT – The consumption of fruits has been growing worldwide due to the exigence of consumers for healthy eating habits, generating a significant volume of agro-industrial waste such as peels. The objectives of this work were the physical, chemical, nutritional, and antinutritional characterization of fresh peels of yellow and red pitaya, as well as the production, characterization, and study of technological properties of these flours of peels. The humidity values obtained for the peels were between 88.56% and 91.18% and between 5.25% and 9.62% for the flours. For water activity, the peels had values of 0.94 and the flours between 0.35 and 0.52, showing that flours are more indicated to develop new products, such as bread and cookies, besides presenting higher protein content and low lipid content. The flours present glucose, maltose, xylose, fructose as the main sugars, high fiber content, minerals, and antioxidant capacity. It was not detected the presence of cyanogenic compounds, condensed and hydrolyzed tannins. It was concluded that the flours presented an excellent alternative as an ingredient to be incorporated in food products, in which the yellow pitaya flour stands out compared with red pitaya flour regarding contents of proteins, ashes, potassium, phosphorus, zinc, vitamin C, absorption index in oil, and the red pitaya flour stands out in calcium, manganese, copper, absorption index and solubility in water, absorption index in milk.

Key words: Co-products. Flours. Food products. Waste.

RESUMO - O consumo de frutas tem crescido mundialmente, decorrente da exigência de consumidores por hábitos alimentares saudáveis, gerando significativo volume de resíduos agroindustriais como cascas. Os objetivos deste trabalho foram a caracterização física, química, nutricional e antinutricional das cascas *in natura* de pitaia amarela e vermelha, bem como a produção, caracterização e estudo das propriedades tecnológicas das farinhas destas cascas. Os valores obtidos de umidade para as cascas foram de 88,56% a 91,18% e para as farinhas de 5,25% a 9,62%. Para atividade de água, as cascas tiveram valores de 0,94 e as farinhas de 0,35 a 0,52, mostrando que as farinhas são mais indicadas para utilização no desenvolvimento de novos produtos como: pães, cookies entre outros, além de apresentarem maior teor proteico e baixo teor lipídico. As farinhas mostraram possuir glicose, maltose, xilose e frutose como principais açucares, alto teor de fibras, minerais e capacidade antioxidante. Não foi detectada presença de compostos cianogênicos, taninos condensados e hidrolisados. Conclui-se, que as farinhas apresentam excelente alternativa na incorporação de produtos alimentícios como ingrediente, na qual a farinha de pitaia amarela sobressai em relação a farinha de pitaia vermelha nos conteúdos de proteínas, cinzas, potássio, fosforo, zinco, vitamina C, índice de absorção em óleo e a farinha de pitaia vermelha em cálcio, manganês, cobre, índice de absorção e solubilidade em água, índice de absorção em leite.

Palavras-chave: Coprodutos. Farinhas. Produtos alimentícios. Resíduos.

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INTRODUCTION

Globally, the consumption of exotic fruits has attracted consumers, and among them can be cited pitaya. This fruit is from the Cactaceae family, considered wild and also known as Dragon Fruit. The pitaya is an average-sized fruit weighing between 300 to 600 grams, with peel with carmine or yellow coloration, depending on the variety, and shiny peel covered with scales, from which comes the name Dragon Fruit. Its pulp is smooth and slightly sweet, with white or purple coloration, according to the variety, and a pulp filled with small black seeds (MAHAYOTHEE *et al*., 2018; NURUL; ASMAH, 2014; WONG; SIOW, 2015; WU *et al*., 2006).

Pitaya presents nutritional and functional characteristics, in which the pulp is an important fiber source with attractive digestive attributes. Its physical and chemical characteristics can vary according to the species due to the high genetic diversity of this fruit (CORDEIRO *et al*., 2015; SANTOS *et al*., 2017). Furthermore, research carried out with pitaya emphasized its functional properties, which helps to reduce chronic diseases risk, such as preventing type 2 diabetes, colon cancer, reduction of bacterial infections and cardiovascular diseases (STINTZING; CARLE, 2004; STINTZING; SCHIEBER; CARLE, 2002; TRINDADE *et al*., 2019; WICHIENCHOT; JATUPORNPIPAT; RASTALL, 2010). The peel presents antioxidant components, especially betalains (LI-CHEN *et al*., 2006).

This species has favorable characteristics, providing health benefits that permit to identify it as one of the tropical fruits still little known but very promising, with high potential for Brazilian internal and external markets (JUNQUEIRA *et al*., 2002; LE BELLEC; VAILLANT; IMBERT, 2006; SILVA; MARTINS; ANDRADE, 2006; YAH *et al*., 2008).

According to Alves, Monteiro, and Pompeu (2018), the Pitaya peel represents about 33% of its total weight, which generates a big waste during pulp industrialization. The use of peels has enormous potential for pigment extraction or as a raw material in developing food products, presenting proven antioxidant capacity. Other factors to be considered are the environmental problems by the presence of high organic value and the nutrient sources for microorganisms (ABUD; NARAIN, 2010; AMID; MANAP, 2014; JAMILAH *et al*., 2011).

Studies are frequently conducted about the use of waste from the processing of plant-origin products, principally about their transformation in flours as a viable alternative of reuse, actuating in the development of new products nutritionally rich. These studies are relevant to determine their nutritional and antinutritional characteristics that can influence the safety of using these co-products (ZANATTA; SCHLABITZ; ETHUR, 2010).

The objectives of this work were physical, chemical, nutritional, and antinutritional characterization of fresh peels of yellow and red pitaya, as well as the production, characterization, and study of the technological properties of these flours of peels.

MATERIAL AND METHODS

Samples

For the conduction of this study, the Pitaya fruit of yellow peel (*Selenicereus megalanthus*) and of red peel (*Hylocereus costaricensis*), as can be observed in figure 1, were acquired matures at the Ceasa (S 16°37’35.8”, W 49°12’12.8”) from Goiânia –GO (Centrais de Abastecimento do Estado de Goiás - Supply Centers of the State of Goiás) – Brazil, from July 2018 to January 2019.

Figure 1 - Yellow Pitaya, whole with white pulp, and red peel pitaya with red pulp

Sample preparation

The fruits were selected based on the absence of defects, washed in running water, and sanitized with sodium hypochlorite solution at 100 ppm for 15 minutes to remove dirt and impurities. The fruits were manually opened, and the peels were separated from the pulp with a sanitized stainless-steel knife and spoon. Posteriorly, part of the fresh peels was submitted to physical, chemical, nutritional, and antinutritional analysis. Another part of the peels was submitted to the drying process at 55 ºC for 72 hours in a forced air circulation oven until the humidity was below 10%. Then, the dry peels were ground in a Willye knife mill (STAR FT 50, Brasil) to obtain the flours. They were put in a plastic bag of high-density polyethylene and sealed in a vacuum sealer (TecMaq TM-150, Brasil), as shown in figure 2, covered with foil to prevent the incidence of light, and stored in a freezer at a temperature of -12 ºC, until the physical, chemical, nutritional, and antinutritional analyses and evaluation of technological properties.

Methods

Physical analysis

The fruits were evaluated concerning fresh mass, using a balance (FILIZOLA CS-6, Brazil), as well as concerning longitudinal diameter (DL) and transversal diameter (DT), using a digital pachymeter (Vernier Caliper ive, 0-150 mm, Brazil), with results expressed in g or cm, respectively. The texture of the fruits was measured with a Texture Analyser TA-XT Plus (Surrey, England) using the P2 needle probe with a drilling speed of 1 mm s^{-1} for the pretest, test, and posttest. The drilling distance was standardized in 10 mm with 95 mm of medium height samples. The result of fruit peel breakage was expressed by force (N). The instrumental parameter of color was determined using a colorimeter (Color Quest, XE, Reston, USA), according to the CIELab system. The results were expressed in the values L*, a*, b*, being L* (luminosity or brightness), varying from black (0) to white (100), a* varying from green (-60) to red (+60), b* varying from blue (-60) to yellow (+60), and Chrome (C). The water activity (Aw) was evaluated with the portable analyzer (Novasina, Labswift-aw, Brazil), being color and Aw analyses performed both with the fresh peels and the flours.

Chemical analysis

The pH was performed using a potentiometer calibrated with pH 7.0 and 4.0 solutions. The total titratable acidity was performed through titration with a sodium hydroxide solution (NaOH) 0.1 M. The soluble solids content was performed through a dilution reading (1:9) of the sample in distilled water with a digital refractometer (Reichet ar200, Brasil). The humidity and ash content were determined by the gravimetry method, proteins by Kjeldahl Method, according to the Association of Official Analytical Chemists (2016), using a conversion factor of 6.25; total lipids through Bligh and Dyer method (1959); total carbohydrates calculated by difference (ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, 2016); calorific value using Atwater coefficients (carbohydrate = 4.0 Kcal/g; lipid = 9.0 Kcal/g; proteins = 4.0 Kcal/g) (MERRIL; WATT, 1973). The determination and quantification of carbohydrates in dry samples were performed by high-performance liquid chromatography – HPLC (Agilent, model 1260 infinity II), following Naegele (2016), being glucose, fructose, maltose, and xylose used as the standard. The soluble and insoluble fibers were determined by the gravimetric-enzymatic method using the α-amylase, protease, and amyloglucosidase following the methodology of the Association of Official Analytical Chemists (2012), being the results expressed in g/100g.

Figure 2 - Flour of red pitaya peels in the several phases of the processing (dry peel, crushed peel, and vacuum-packed)

The determination of the minerals (phosphorus, potassium, calcium, magnesium, iron, copper, manganese, and zinc) was performed by the method of nitro-perchloric digestion in dry samples, according to Malavolta, Vitti and Oliveira (1997). Vitamin C concentration was determined by the method described by Strohecker and Henning (1967), and the results were expressed in mg of ascorbic acid per 100 g of sample. All these analyses were made with the fresh peels and their respective flours.

Antinutritional Analysis

The content of condensed tannins was estimated by spectrophotometry following Price, Scoyoc and Butler (1978), with the adaptations proposed by Barcia *et al*. (2012). The analysis of cyanogenic compounds was performed following Araújo (2011).

Technological properties of flours

To determine the water absorption index (AIW), the methodology described by Okezie and Bello (1988) and the equation described by Anderson *et al.* (1969) were used. To determine the solubility in water index (SIW), the methodology described by Okezie and Bello (1988) was used according to the item AIW, and the SIW was measured by the equation described by Anderson *et al*. (1969); for the absorption and solubility in milk indices (AIM and SIM), the same procedures described above were performed. To determine the oil absorption index (AIO), the methodology described by Okezie and Bello (1988) was used.

Statistical analysis

The experiment was conducted in a completely randomized design for the technological properties of flours, minerals, dietary fiber, vitamin C, and a factorial 2x2 in other physical, chemical, nutritional, and antinutritional analyses, being two treatments (fresh peel and flour) and two peel colors (yellow and red). The analyzes were performed in triplicate with five repetitions. The data of the analyses performed were submitted to analysis of variance (ANOVA) and Tukey test at 5% probability with the SISVAR software (FERREIRA, 2011).

RESULTS AND DISCUSSION

The results found for the physical characteristics of the fresh peels of yellow and red pitaya and their respective flours are presented in Table 1.

The diameter and weight of pitayas presented a high variability in the values between the fruits, resembling the mandacaru fruit (*Cereus Jamacaru* P.), which can be attributed to not having standardized processes such as fertilization, crop irrigation, soil, among others to better management of the crop (SANTOS NETO *et al*., 2019). This study also observed a higher breakage force for yellow pitaya (14.72N) than the red pitaya (9.22N), demonstrating that yellow pitaya is more resistant to mechanical defects with a lower possibility of losses with fresh red pitaya. Anami *et al.* (2018), stated that a fruit's internal, external, and texture characteristics must be observed to define it as a quality fruit.

The yellow pitaya flour presented an Aw of 0.52, and red pitaya flour of 0.35, being more favorable to develop new products because they have lesser microbiological changes during storage, influencing significantly in this ingredient conservation. The water present in the food is a risk factor for quality and conservation during storage and manipulation because it can cause its deterioration by developing bacteria, fungi, and mycotoxin production (CORADI *et al.*, 2013).

Table 1 - Physical characteristics of fresh peels of yellow Pitaya (YP), red Pitaya (RP), and their respective flours (YPF and RPF)

	YP	RP	YPF	RPF
TD (mm)	77.04 ± 5.05 a	91.29 ± 5.78 b	-	-
HD (mm)	116.18 ± 9.17 a	94.82 ± 7.41 b	-	-
Whole fruit weight (g)	328 ± 52.22 a	442 ± 72.35 b	-	-
Texture (N)	14.72 ± 2.43 a	9.22 ± 1.65 b	-	-
Aw	0.94 ± 0.00 c	0.94 ± 0.00 c	0.52 ± 0.00 b	0.35 ± 0.00 a
L	32.57 ± 11.15 b	22.22 ± 9.44 a	60.08 ± 1.17 c	66.82 ±1.01 d
a*	15.05 ± 3.91 b	42.82 ± 10.04 a	7.85 ± 0.13 c	3.51 ± 0.06 d
b*	55.40 ± 16.85 a	31.66 ± 9.86 b	20.96 ± 0.63 c	17.90 ± 0.38 d

The values are expressed by the mean ± standard deviation. Equal letters on the same line do not differ statistically according to the Tukey test at 5% probability. DT (transversal diameter); DH (horizontal diameter)

When evaluating the color parameters, the peel of the fruits presented higher saturation for a* in red peel with values of 42.82 and b* for the yellow peel with values of 55.40, which was already expected.

In this study, the values found for YPF were 60.08, 7.85, 20.96, and RPF of 66.82, 3.51, and 17.90 for the parameter to L*, a*, and b, respectively, varying significantly with the values found in the peels of the fresh fruits. This fact can be justified by the different pigment degradation factors, the incidence of light, the temperature in the drying process, and the pH (WOO *et al*., 2011).

The peels of fresh pitaya presented high humidity with values of 91.18% for yellow and 88.56% for red pitaya. Such results can be compared with Jamilah *et al*. (2011) and Abreu *et al*. (2012), findings with values of 92.65% and 89.46%, respectively, for red pitaya peels. The humidity values found in YPF (9.62%) and RPF (5.25%) are within the current Brazilian legislation standard that requires the maximum humidity of 15% (BRASIL, 2005). The humidity content is essential because it is directly connected to food stability. The values found in the fresh peel are high, being conducive to microbial growth; in contrast, the flours are outside the humidity content necessary for the growth of microorganisms (CLEMENTE *et al*., 2012).

Table 2 - Proximal composition (g/100 g), energy value (kcal/100 g), carbohydrate profile (g/100 g), mineral profile (mg/100 g), and vitamin C (mg of ascorbic acid /100 g) of fresh peels of yellow Pitaya (YP), red Pitaya (RP) and their respective flours (YPF and RPF) on a dry basis

	YP	RP	YPF	RPF
Moisture	91.18 ± 0.09 d	88.56 ± 0.78 c	9.62 ± 0.47 b	5.25 ± 0.36 a
Ashes	14.45 ±0.31 b	18.21 ± 0.78 a	19.55 ± 3.03 a	19.23 ± 0.87 a
Proteins	6.77 ± 1.11 ab	6.16 ± 2.32 ab	7.48 ± 0.62 a	5.45 ± 0.26 b
Lipids	2.39 ± 0.49 b	4.13 ± 0.67 a	1.84 ± 0.14 c	1.56 ± 0.13 c
Glucose	-	-	0.73	0.26
Maltose	-	-	0.93	1.05
Xylose	-	-	0.72	0.06
Fructose	-	-	5.52	1.51
Total carbohydrates	76.38 ± 1.48 a	70.69 ± 2.64 c	70.60 ± 3.25 c	73.38 ± 0.76 b
TEV	357.96 ± 4.38 a	344.63 ±3.37 b	329.66 ± 9.77 c	329.58 ± 0.95 c
Insoluble fiber	33.25 ± 3.74 a	34.34 ± 0.25 a	36.79 ± 4.13 a	36.24 ± 0.27 a
Soluble fiber	29.16± 3.88 a	22.91 ± 4.65 a	32.27 ± 4.30 a	24.18 ± 4.91 a
TDF	62.42 ±3.90 a	57.25 ±7.12 a	69.0.6 ± 4.32 a	60.21 ± 8.15 a
pH	4.95 ± 0.08 c	5.03 ± 0.12 d	4.73 ± 0.00 b	4.45 ± 0.03 a
TTA	0.04 ± 0.00 a	0.35 ±0.02 a	0.20 ± 0.01 c	0.10 ± 0.01 c
TSS	0.9 ± 0.57 c	0.9 ± 0.37 c	22.5 ± 0.64 a	10 ±1.80 b
Phosphor	*	*	325 ± 0.02 a	232 ± 0.01 b
Potassium	*	*	5600 ± 1.08 a	4667 ± 0.05 b
Calcium	*	*	566.66 ± 0.05	966.66 ± 0.05 a
Magnesium	*	*	300 ± 0.00 a	333.33 ± 0.05 a
Iron	nd	nd	nd	nd
Copper	*	*	0.64 ±0.21 b	0.89 ± 0.04 a
Manganese	*	*	8.6 ± 0.14 b	14.67 ± 1.41 a
Zinc	*	*	8.45 ± 0.23 a	3.76 ± 0.41 b
Vitamin C	168.38 ±22.14 b	72.97 ± 1.90 c	186.30 ±11.27 a	77.02 ± 1.90 c
CT	nd	nd	nd	nd
Cyanogens	nd	nd	nd	Ng

Values expressed by mean ± standard deviation. TEV= Total energy value. TDF (total dietary fiber); TTA= Total titratable acidity (g citric acid /100g). TSS = total soluble solids (°Brix). CT (condensed tannins); nd (not detected) Equal letters in the same line do not differ statistically according to the Tukey test at 5% probability

RP, YPF, RPF presented ashes values of 19.23, 18.21, 19.55 (g/100 g), respectively, differing significantly from YP that had values of 14.45 (g/100 g). These results present good nutritional advantages in the samples because the ashes content evidence that the samples contain many minerals reinforced by the mineral profile.

In this work, the results for RP were 0.56 (g/100 g) for proteins and 0.45(g/100 g) for fats, being similar to Jamilah *et al*. (2011), who determined the physical-chemical characteristics of red pitaya peels (*Hylocereus Polyrhizus*) and found low contents of protein 0.95 (g/100 g) and fats 0.10 (g/100 g).

YP, RP, YPF (6.77, 6.16, and 7.48 g/100 g) can be considered ingredients that have a good protein content because, according to BRASIL (2012), a portion of food can be considered a protein source when presenting at least 6 g of protein per 100 g of product, while the RPF, even removing the humidity, has a value (5.45 g/100 g) lower than the recommended by BRASIL (2012).

Concerning lipid content, the values are low both for fresh peels and for their flours (2.39, 4.13, 1.84, and 1.56 g/100 g), and the highest value was found for red pitaya peels, which are higher than the findings of Abreu *et al*. (2012). These authors evaluated the chemical composition of the peels of red (0.66 g/100 g) and white (0.61 g/100 g) pitaya.

The caloric value of YP and RP were 357.96 and 344.63 Kcal/100 g, while YPF and RPF values were 329.66 and 329.58 Kcal/100 g. There was a significant difference between the peels, being the highest value in the yellow peel, probably due to the higher amount of carbohydrates, a fact reinforced by the amount of fructose (5.52 g/100 g). The main sugars found in samples of YPF and RPF were glucose, maltose, xylose, and fructose, similar to the findings of Jamilah *et al*. (2011). This study found that glucose, maltose, and fructose may occur due to high invertase activity, maturation, and cultivar (SOMBOONKAEW; TERRY, 2010).

The result found for RPF insoluble fiber was 36.79 g/100 g, similar to the value found by Madane *et al.* (2019), for the red pitaya peel (*Hylocereus undatus*), which was 49.22 g/100 g. The high contents of insoluble and soluble dietary fiber demonstrate that the flour of pitaya peels can be considered a promising source with sound physiological effects. Several studies state that foods with high fiber content can contribute to developing new products because they can provide texture, increasing cooking yield. Fibers contribute to water retention and consequently influence the technological properties, promoting physicochemical and sensory attributes (DAS; RAJKUMAR; VERMA, 2015; JIMENEZ COLMENERO *et al.*, 2003; SÁYAGO-AYERDI; BRENES; GOÑI, 2009; VERMA *et al.*, 2013).

For the pH, lower values for flours were obtained, YPF 4.73 and RPF 4.45, compared with their respective fresh peels that presented YP 4.95 and RP 5.03. These values followed by other factors, such as humidity, indicate higher stability in the flour, impeding the growth of microorganisms, such as bacteria that prefer pH close to neutrality, which is between 6.5 and 7.0 (ABUD; NARAIN, 2010).

YPF (22.5° Brix) and RPF (10° Brix) presented a higher concentration of soluble solids than fresh peels of yellow (0.9° Brix) and red pitaya (0.9° Brix). Thus, the higher the content of soluble solids, the more beneficial it is for the food industry because less sugar will be added to the product, and less energy expenditure will occur in processing (PINHEIRO *et al*., 1984).

It is observed that the peels and their flours present less acidity, which can be attributed to the process of transformation into sugars or the use as a substrate during the maturation in their respiratory process (FERREIRA *et al.*, 2017). Enciso *et al.* (2011), stated an 80% reduction in acidity during the storage process of red pitaya samples with white pulp (*Hylocereus undatus Haw.*).

Brazil (2005) presents recommended values of daily intake of vitamins and minerals to be used as parameters to answer the nutritional needs of population health. This study showed that 100 grams of YPF; 8.45 mg/100 g, 300 mg/100 g, and 8.6 mg/100 g of zinc, magnesium, and manganese, where the recommended is 7 mg, 260 mg, and 2.3 mg, respectively. The RPF presents 333.33 mg/100 g of magnesium, which fills the nutritional need, and 3.78 mg/100 g of zinc, which meets the nutritional need of 2.8 mg for children up to 06 months. Concerning the calcium content of YPF and RPF, the results obtained were: 566.66 mg/100 g and 966.66 mg/100 g/. The recommended calcium intake is 1000 mg. Thus, combined with a balanced diet, the ingestion of pitaya peels' flour complements the amount of calcium needed, noticing that the ingestion of minerals in the diet can bring benefits to blood pressure, glucose metabolism, and weight regulation (VAN MEIJL *et al*., 2008; WOO *et al*., 2019).

Most of the antioxidants present in citrus fruits are vitamin C and polyphenols, principally flavonoids. Vitamin C protects against uncontrolled oxidation in the aqueous medium of cells due to its high reducing power. Polyphenols are substances with great power of neutralizing free radical molecules (JAYAPRAKASHA; PATIL, 2007; KLIMCKAC *et al*., 2007). In this study, we found 72.91 mg/100 g of ascorbic acid for the RP, and 77.02 mg/100 g of acid for RPF, being these values lower than YP, which presented 168.4 g/100 g of ascorbic acid, and 183.3 mg/100 g of the same acid in the YPF. Besides, it was observed that for the red pitaya, there was no statistical difference between fresh peels and the flour, which is advantageous when considering the preservation of bio-compounds. Mahattanatawee *et al.* (2006), found values 55.8 mg/100 g for the pitaya *Hylocereus* sp., cv. Red Jaina (red pitaya and red pulp). Abreu *et al.* (2012), observed that the peel of red pitaya presented an excellent antioxidant capacity and that the content of vitamin C suffers variations according to the different species of cultivars and origins. Their study found values of 24.05 mg ascorbic acid /100 g, and 22.51 mg ascorbic acid 5/100 g for white pitaya peels (*Hylocereus undatus*) and red pitaya peels (*Hylocereus polyrhizus*), respectively.

Figure 3 shows the Guignard Test results to verify the presence of cyanogenic compounds in fresh peels of red pitaya and yellow pitaya.

The results showed that peels do not have toxic potential concerning this substance because they presented negative results for cyanogen glycosides since the plum is the positive control. As shown in figure 3, the sample strips do not present color alterations, as happened in the control. The Guignard test was made only with the fresh peels because the heat treatment process causes cyanogenic glycosides' toxicity inactivation. Condensed and hydrolyzed tannins were also not detected in the yellow and red pitaya peels nor their respective flours. According to Sena *et al*. (2017), the lower the content of hydrolyzed tannins, the more desirable are the fruit's sensory characteristics.

Figure 3 - Guignard Test to verify the presence of cyanogenic compounds in fresh peels of red (V) and yellow pitaya (A), and plum seed (C)

The results of the technological properties of yellow and red Pitaya peels' flours are presented in Table 3.

The flours presented the following values of AIW: 6.91 g.gel /100 g (yellow pitaya) and 9.72 g.gel/100 g (red pitaya). The results show that the flours of pitaya peels have chemical characteristics that influence this property. The content of fibers is responsible for absorbing water, making the flour desirable for application in meat products and baked goods, like cakes and bread, permitting the addition of water in the formulation of products, improving the handling, and reducing costs (PORTE *et al*., 2011; SILVA *et al*., 2020).

The SIW was 14.73 g/100 g for yellow peel flour, showing lower solubility power than the red peel flour, which presented values of 27.90 g/100 g. Flours with these characteristics are applicable in the food industry for instant foods, soups, sauces, which need low temperatures to give favorable sensory characteristics to the products more efficiently (LEONEL; FREITAS; MISCHAN, 2009).

The flours presented values of AIM of 6.00 g. gel/g for the YPF, and 9.47 g. gel/g for the RPF. These flours can be indicated as an ingredient because they present affinity in a liquid medium, being important when developing new products as an alternative for milk-based products, such as dairy desserts, cream cheese, candies, and instant baby food (BECKER *et al.*,2014).

Table 3 - Technological properties of flours of Pitaya peels

Parameters	YPF	RPF
AIW (g. gel/g)	6.91 ± 063 b	9.72 ± 1.12 a
SIW (g/100 g)	14.43 ± 2.41 b	24.89 ± 4.85 a
AIM (g. gel/g)	6.00 ± 0.31 b	9.47 ± 0.71 a
SIM (g/100 g)	29.04 ± 1.39 a	27.03 ± 0.94 b
AIO (g/100 g)	2.20 ± 0.20 a	1.85 ± 0.22 b

Values expressed by mean ± standard deviation. AIW= Absorption index in water. SIW= Solubility index in water. AIM= Absorption index in milk. SIM= Solubility index in milk. AIO= Absorption index in oil

For AIO, the values of 2.20 g/100 g were found for yellow peel flour and 1.85 g/100 g for red peel flour. This factor is of extreme importance because, through AIO, it is possible to determine the conditions of storage stability for new products to avoid oxidative changes, which influence the nutritional quality and sensory characteristics of food (SIDDIQ *et al*., 2010).

CONCLUSIONS

The flours are the most suitable to develop new products as an ingredient than the fresh peels because they present better results for water activity, humidity, pH, soluble solids. YPF stands out in the content of proteins, ashes, phosphorus, potassium, zinc, vitamin C, solubility in milk index, and absorption in oil index, and regarding RPF and RPF in the content of carbohydrates, caloric value, calcium, copper, manganese, absorption of water index, solubility in milk index. Based on everything discussed and presented, it can be affirmed that flours of pitaya peels are applicable in baked and meat products to replace other flours partially or totally.

REFERENCES

ABREU W. C. *et al.* Características físico-químicas e atividade antioxidante total de pitaias vermelha e branca. **Revista Instituto Adolfo Lutz**, v. 71, n. 4, p. 656-661, 2012.

ABUD, A. K. S.; NARAIN, N. Incorporação da farinha de resíduo do processamento de polpa de fruta em biscoitos: uma alternativa de combate ao desperdício. **Brazilian Journal of Food Technology**, v. 12, n. 4, p. 257-265, 2010.

ALVES, A. C. B.; MONTEIRO, L. B.; POMPEU, D. R. Otimização da extração sólido-líquido de compostos fenólicos totais e betalaínas da casca de frutos de pitaya (*Hylocereus polyrhizus*). **Revista Brasileira de Tecnologia Agroindustrial**, v. 12, n. 1, p. 2556-2577, 2018.

AMID, M.; MANAP, M. Y. A. Purification and characterisation of a novel amylase enzyme from red pitaya (*Hylocereus polyrhizus*) peel. **Food Chemistry**, v. 165, p. 412-418, 2014.

ANAMI, M. J. *et al.* Avaliação da textura com diferentes velocidades de teste em maçãs 'gala' armazenadas. **Congrega Urcamp: Educação e Desenvolvimento Regional**, v. 15, n. 15, p. 781-790, 2018.

ANDERSON, R. A. *et al.* Gelatinization of corn grits by roll- and extrusion-cooking. **Cereal Science Today**, v.14, p. 4-7, 1969.

ARAÚJO, J. M. A. **Química de alimentos**: teoria e prática. Viçosa, MG: UFV, 2011. 601 p.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. **Official methods of analysis**. 20th ed. AOAC internacional, 2016.

BARCIA, M. T. *et al*. Bioactive compounds, antioxidant activity and percent composition of jambolão fruits (Syzygium cumini). **The Natural Products Journal**, v. 2, n. 2, p. 129-138, 2012.

BECKER, F. S. *et al.* Incorporation of buriti endocarp flour in gluten-free whole cookies as potential source of dietary fiber. **Plant Foods for Human Nutrition**, v. 69, p. 344-350, 2014.

BLIGH, E. G.; DYER, W. J. A rapid method of total lipid extraction and purification. **Canadian Journal of Biochemistry and Physiology**, v. 37, n. 8, p. 911-917,1959.

BRASIL. Agência Nacional de Vigilância Sanitária. **RDC nº 54, de 12 de novembro de 2012**. Dispõe sobre o Regulamento Técnico sobre Informação Nutricional Complementar. Brasília, DF: ANVISA, 2012. Disponível em: http://portal.anvisa.gov.br/documents/%2033880/2568070/rdc0054_12_11_2012.pdf/c5ac23fd-974e-4f2c-9fbc-48f7e0a31864. Acesso em: 6 set. 2019.

BRASIL. Agência Nacional de Vigilância Sanitária. **Resolução RDC nº. 263, de 22 de setembro de 2005**. Aprova o Regulamento técnico para produtos de cereais, amidos, farinhas e farelos. Brasília, DF: ANVISA, 2005. Disponível em: http://portal.anvisa.gov.br/documents/33880/2568070/RDC_263_2005.pdf/d6f557da-7c1a-4bc1-bb84-fddf9cb846c3. Acesso em: 6 set. 2019.

CLEMENTE, E. *et al*. Características da farinha de resíduos do processamento de laranja. **RECEN-Revista Ciências Exatas e Naturais**, v. 14, n. 2, p. 257-269, 2012.

CORADI, C. P. *et al*. Identification of the critical control points in a feed mill: a case study. **Revista Brasileira de Tecnologia**, v. 7, n. 1, p. 977-992, 2013.

CORDEIRO, M. H. M. *et al.* Caracterização física, química e nutricional da pitaia-rosa de polpa vermelha. **Revista Brasileira de Fruticultura**, v. 37, n. 1, p. 20-26, 2015.

DAS, A. K.; RAJKUMAR, V.; VERMA, A. K. Bael pulp residue as a new source of antioxidant dietary fiber in goat meat nuggets. **Journal of Food Processing and Preservation**, v. 39, p. 1626-1635, 2015.

ENCISO, T. O. *et al.* Calidad postcosecha de frutos de pitahaya (*Hylocereus undatus Haw*.) cosechados en tres estados de madurez. **Revista Fitotecnia Mexicana**, v. 34, n. 1, p. 63-72, 2011.

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia**, v. 35, n. 6, p. 1039-1042, 2011.

FERREIRA, R. B. *et al.* Desenvolvimento fenológico de frutos de lichia (Litchi chinensis) em diferentes regiões. **Revista de Ciências Agrárias**, v. 40, n. 2, p. 397-404, 2017.

JAMILAH, B. *et al.* Physico-chemical characteristics of red pitaya (Hylocereus polyrhizus) peel. **International Food Research Journal**, v. 18, n. 1, 2011.

JAYAPRAKASHA, G. K.; PATIL, B. S. *In vitro* evaluation of the antioxidant activities in fruit extracts from citron and blood orange. **Food Chemistry**, v. 101, n. 1, p. 410-418, 2007.

JIMENEZ COLMENERO, F. *et al*. Physicochemical and sensory characteristics of restructured beefsteak with added walnuts. **Meat Science**, v. 65, n. 4, p. 1391-1397, 2003.

JUNQUEIRA, K. P.*et al*. Informações preliminares sobre uma espécie de pitaya do Cerrado. Planaltina-DF: **Embrapa Cerrados**, 2002. 18 p. (Documentos, 62).

KLIMCZAK, I. *et al*. Effect of storage on the content of polyphenols, vitamin C and the antioxidant activity of orange juices. **Journal of Food Composition and Analysis**, v. 20, n. 3/4, p. 313-322, 2007.

LE BELLEC, F.; VAILLANT, F.; IMBERT, E. Pitahaya (Hylocereus spp.): a new crop, a market with a Future. **Fruits**, v. 61, n. 4, p. 237-250, 2006.

LEONEL, M.; FREITAS, T. S.; MISCHAN, M. M. Physical characteristics of extruded cassava starch. **Scientia Agricola**, v. 66, n. 4, p. 486-493, 2009.

LI-CHEN, W. *et al*. Antioxidant and antiproliferative activities of red pitaya. **Food Chemistry**, v. 95, p. 319-327, 2006.

MADANE, P. *et al*. Dragon fruit (Hylocereus undatus) peel as antioxidant dietary fibre on quality and lipid oxidation of chicken nuggets. **Journal of Food Science and Technology**, v. 57, p. 1449-1461, 2019.

MAHATTANATAWEE, K. *et al*. Total antioxidant activity and fiber content of select Florida-grown tropical fruits. **Journal of Agricultural and Food Chemistry**, v. 54, n. 19, p. 7355-7363, 2006.

MAHAYOTHEE, B. *et al*. Influence of drying conditions on colour, betacyanin content and antioxidant capacities in dried red-fleshed dragon fruit (Hylocereus polyrhizus). **International Journal of Food Science and Technology**, p. 1-11, 2018.

MALAVOLTA, E.; VITTI, G. C.; OLIVEIRA, S. A. **Avaliação do estado nutricional das plantas**: princípios e aplicações. 2. ed. Piracicaba: Potafos, 1997, 319 p.

MERRILL, A. L.; WATT, B. K. **Energy value of foods**: basis and derivation, agriculture handbook. Washington, DC: United States Department of Agriculture, 1973.

NAEGELE, E. Analysis of lactose free dairy product susing the Agilent 1220 Infinity LC with evaporative light scattering detection. **Agilent Technologies**, Oct. 2016.

NURUL, S. R.; ASMAH, R. Variability in nutritional composition and phytochemical properties of red pitaya (Hylocereus polyrhizus) from Malaysia and Australia. **International Food Research Journal**, v. 21, n. 4, p. 1689-1697, 2014

OKEZIE, B. O.; BELLO, A. E. Physicochemical and functional properties of winged bean flour and isolate compared with soy isolate. **Journal of Food Sciences**, v. 53, p. 450-455, 1988.

PINHEIRO, R. V. R. *et al*. Produtividade e qualidade dos frutos de dez variedades de goiaba, em Visconde do Rio Branco, Minas Gerais, visando ao consumo ao natural e à industrialização. **Revista Ceres** v. 31, p. 360-387, 1984.

PORTE, A. *et al*. Propriedades funcionais tecnológicas das farinhas de sementes de mamão (*Carica papaya*) e de abóbora (*Cucurbita sp*). **Revista Brasileira de Produtos Agroindustriais**, v. 13, n. 1, p. 91-96, 2011.

PRICE, M. L.; SCOYOC, V. S.; BUTLER, L. G. A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. **Journal of Agricultural and Food Chemistry**, v. 26, p. 1214-1218, 1978.

SANTOS, F. S. *et al*. Drying kinetics and physical and chemical characterization of white-fleshed 'pitaya'peels. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v. 21, n. 12, p. 872-877, 2017.

SANTOS NETO, J. P. *et al*. Características físico-químicas de frutos de mandacaru (Cereus Jamacaru P. Dc.) cultivados no Sertão Alagoano. **Revista Craibeiras de Agroecologia**, v. 4, n. 1, p. e7741, 2019.

SÁYAGO-AYERDI, S.; BRENES, A.; GOÑI, I. Effect of grape antioxidant dietary fiber on the lipid oxidation of raw and cooked chicken hamburgers. **LWT - Food Science and Technology**, v.42, n.5, p.971-976, 2009.

SENA, D. N. *et al*. Farinhas provenientes do processamento de frutas: bioacessibilidade de compostos antinutricionais. **Arquivos Brasileiros de Alimentação**, v. 2, n. 3, p. 156-163, 2017.

SIDDIQ, M. *et al*. Physical and functional characteristics of selected dry bean (Phaseolus vulgaris L.) flours. **LWT – Food Science and Technology**, v. 43, n. 2, p. 232-237, 2010.

SILVA, J. S. *et al*. Nutritional characterization and technological functional properties of marolo pulp flour. **Research, Society and Development**, v. 9, n. 4, p. e51942826, 2020.

SILVA, M. T. H.; MARTINS, A. B. G.; ANDRADE, R. A. de. Enraizamento de estacas de Pitaya Vermelha em diferentes substratos. **Revista Caatinga**, v. 19, n. 1, p. 61-64, 2006.

SOMBOONKAEW, N.; TERRY, L. A. Altered physiology and biochemistry of imported litchi fruit held under different vapor pressure deficits. **Journal of Agricultural and Food Chemistry**, v. 58, n. 10, p. 6209-6218, 2010.

STINTZING, F. C.; CARLE, R. Functional properties of anthocyanins and betalains in plants, food, and in human nutrition. **Trends in Food Science & Technology**, v. 15, n. 1, p. 19-38, 2004.

STINTZING, F. C.; SCHIEBER, A.; CARLE, R. Betacyanins in fruits from red-purple pitaya *Hylocereus polyrhizus* (Weber) Britton & Rose. **Food Chemistry**, v. 77, n. 1, p. 101-106, 2002.

STROHECKER, R.; HENNING, H. M. **Analisis de vitaminas**: métodos comprobados. Madrid: Paz Montalvo, 1967.

TRINDADE, A. *et al*. Pitaia: perspectivas e dificuldades de uma "nova" cultura. **Agrotec**: **Revista Técnico-Científica Agrícola**, p. 32-34, mar. 2019.

VAN MEIJL, L. E. C. *et al*. Dairy product consumption and the metabolic syndrome. **Nutrition Research Reviews**, v. 21, n. 2, p. 148-157, 2008.

VERMA, A. K. *et al*. Guava (Psidium guajava L.) powder as an antioxidant dietary fibre in sheep meat nuggets. **Asian Australasian Journal of Animal Sciences**, v. 26, n. 6, p. 886-895, 2013.

YAH, A. R. C. *et al*. Sensorial, physical and chemical changes of pitahaya fruits (hylocereus undatus) during development. **Revista Fitotecnia**, v. 31, n. 1, p. 1-5, 2008.

WICHIENCHOT, S.; JATUPORNPIPAT, M.; RASTALL, R. A. Oligosaccharides of pitaya (dragon fruit) flesh and their prebiotic properties. **Food Chemistry**, v. 120, n. 3, p. 850-857, 2010.

WONG, Y.-M.; SIOW, L.-F. Effects of heat, pH, antioxidant, agitation and light on betacyanin stability using red-fleshed dragon fruit (*Hylocereus polyrhizus*) juice and concentrate as models. **Journal of Food Science and Technology**, v. 52, n. 5, p. 3086-3092, 2015.

WOO, H. W. *et al*. Prospective associations between total, animal, and vegetable calcium intake and metabolic syndrome in adults aged 40 years and older. **Clinical Nutrition**, p. 1-10, 2019.

WOO, K. K. *et al.* Stability of betalain pigment from red dragon fruit (Hylocereus polyrhizus). **American Journal of Food Technology**, v. 6, p. 140-148, 2011.

WU, L. *et al.* Antioxidant and antiproliferative activities of red pitaya. **Food Chemistry**, v. 95, n. 2, p. 319-327, 2006.

ZANATTA, C. L.; SCHLABITZ, C.; ETHUR, E. M. Avaliação físico-química e microbiológica de farinhas obtidas a partir de vegetais não conformes à comercialização. **Alimentos e Nutrição**, v. 21, p. 459-468, 2010.