INNOVATION AND DEVELOPMENT OF NEW FOOD PRODUCTS

VIRGÍNIA MIRTES DE ALCÂNTARA SILVA
NEWTON CARLOS SANTOS
VICTOR HERBERT DE ALCÂNTARA RIBEIRO

INNOVATION AND DEVELOPMENT OF NEW FOOD PRODUCTS

Cataloging International Data in Publication (CIP)

I584 Innovation and development of new food products / Silva et al.

— Campina Grande: EPTEC, 2022.
104 f.: il. color.

Format: PDF
System requirements: Adobe Acrobat Reader
Access mode: World Wide Web
Includes bibliography

ISBN: 978-65-00-38275-4

1. Awakened foods. 2. Proximate composition. 3. Agro-industrial residues. 4. Tropical fruits. 5. Powdered foods. I. Silva, Virgínia Mirtes de Alcântara. 2. Santos, Newton Carlos. 3. Ribeiro, Victor Herbert de Alcântara. II. Title.

CDU 62

Cover and Chapter Image Credits
Pixabay/Freepick

Editing, Proofreading and Cover Art
Paulo Roberto Megna Francisco

Virgínia Mirtes de Alcântara Silva
Newton Carlos Santos
Victor Herbert de Alcântara Ribeiro

INNOVATION AND DEVELOPMENT OF NEW FOOD PRODUCTS

Eptec
editora portal tecnológico
1.a Edition
Campina Grande-PB
2022

Realization

Support

Summary

Acknowledgments ***6***

PREPARATION OF ALBEDO OF PASSION FOUR (Passiflora edulis) AND ITS APPLICATION IN THE DEVELOPMENT OF COOKIE BISCUITS ***13***

OBTAINMENT OF FLOUR FROM THE PEEL OF THE GREEN BANANA (Musa spp.) AND ITS APPLICATION IN THE DEVELOPMENT OF SLICED BREAD ***31***

ELABORATION AND CHARACTERIZATION OF ICE CREAM ADDED FROM JABUTICABA (Myrciaria Cauliflora) LYOPHILLED HULL FLOUR ***50***

DEVELOPMENT AND CHARACTERIZATION OF GREEK YOGHURT WITH DIFFERENT CONCENTRATIONS OF PUMPKIN JELLY AND CORN STARCH ***69***

CARROT FLOUR (Daucus carota subsp. sativus) AS A FOOD INGREDIENT IN CAKE FORMULATION ***87***

Curriculum dos autores e organizadores ***102***

Acknowledgments

We would like to thank the Federal University of Rio Grande do Norte - Chemical Engineering Program for the unconditional support to our research. The Food Engineering Unit of the Center for Technologies and Natural Resources of the Federal University of Campina Grande for using the laboratories and providing all the equipment for the execution of this work.

Our special thanks to Professor Renato Ferraz de Arruda Veiga for his guidance throughout the work and for the strategic choice of all the raw materials for the development of all this research. We highlight in particular, Prof. Vania Moda Cirino for her orientations during the development of each chapter of this work.

To the National Council for Scientific and Technological Development (CNPq) and to the Coordination for the Improvement of Higher Education Personnel (CAPES) for the master's and doctoral scholarships for the authors.

The book entitled Innovation and development of new food products is the result of the work of our team of researchers in line with the guidelines carried out during the Food Systems Summit, held in September 2021 by the UN and FAO, whose main goal is the reform of food systems, avoiding loss and waste of food products, promoting the reuse and encouraging the development of new products.

Our inspiration for the realization of this work was the reading of the book: “Noah's Ark of Brazilian Native Fruits” released by the Brazilian Agricultural Research Corporation (EMBRAPA) in November 2021, with support from the Brazilian Society of Genetic Resources (SBRG) and the Northeast Plant Genetic Resources Network (RGVNE). It mainly highlights the conservation of genetic resources and the improvement of native fruit species, envisioning the huge and competitive real and potential market that presents itself, with several niches for fresh and dried fruits, as well as for their products and by-products.

Our country is the third largest producer of fruit in the world, with around 45 million tons per year. Among the main fruits produced are tropical ones, especially mangoes, avocados and pineapples, as well as oranges, bananas, melons, grapes and apples.

Orange, banana and pineapple account for an average of 57.4% of the production obtained by the Brazilian fruit industry, with the Northeast region playing a very important role in the cultivation of most tropical fruit species, especially pineapple, avocado, banana, cashew, coconut, papaya, mango, passion fruit, grapes, acerola and guava.

However, large amounts of waste are generated as by-products of fruits and vegetables are mainly constituted by: husks, bagasse fractions and seeds, which can be a good source of bioactive compounds and dietary fiber.

Therefore, this book represents the continuous effort of our group in the production of different formulations of new products using different fruit peel flours generating functional foods. In addition, we use efficient mathematical models in processing these emerging techniques.

Thinking about these aspects and the importance of the techniques used to obtain functional products, this work presents, in each chapter, research in a comprehensive way exemplifying most unit operations, conservation techniques and their used mathematical models.

We are grateful to all who contributed to the realization of this work and we hope that it can contribute more and more to the technological and productive development of the country in the definitive implementation of an efficient and clean model for the production of safe food for the world.

The authors

Presentation

Dr. Renato Ferraz de Arruda Veiga
Administrative Director of Fundação de Amparo à Pesquisa Científica - FUNDAG

Thinking about the issue of climate change, which is increasingly visible on the planet, the year 2022 could become the year of transformation of food systems, through the implementation of models of "regenerative agriculture" - which restore what was explored and reconstitute the that has been damaged - that will ensure food and nutrition security on the planet. Sustainable and regenerative agriculture that prioritizes increasing crop productivity, without the need to expand agricultural areas (a tradition of Brazilian agriculture that is also provided for in the UN's 2030 Agenda), can be promoted using digital technologies for optimization of production processes.

This ensures the preservation of natural resources with safer and more nutritious food, and also allows the use of soil and water conservation management practices, with intelligent irrigation systems, automation and a network of local sensors, among other traditional technologies.

The pandemic caused by SARS-CoV-2 and its variants showed the fragility of food systems in each country, highlighting the immediate need for reform of these systems. Recent data published by The State of Food Security and Nutrition in the World/2021, estimates that between 720 and 811 million people in the world suffered from hunger in 2020 - up 161 million more than in 2019.

Almost 2.37 billion of people did not have access to “adequate food” in 2020 – an increase of 320 million people in just one year where no region of the world was spared.

However, according to the World Food Waste Index about 17% of food is thrown away and about 14% of food is lost between harvest and sale, and in the case of fruits and vegetables, more is lost. 20% (UNEP,2021).

Brazil has the potential to be number one in the transformation of its food systems, due to its diversity and quantity of fruits, vegetables, grains and seeds. It is currently the second largest agricultural producer in the world and third in the ranking of world fruit production (INSTITUTO DE ECONOMIA AGRÍCOLA, 2019).

Still dealing with fruits, the country stands out with the production of about 45 million tons per year. Among its main fruit trees produced are those in a tropical climate, especially avocado, pineapple and mango, in addition to bananas, oranges, apples, melons and grapes. The trio pineapple, banana and orange account, on average, for 57.4% of the production obtained by all Brazilian fruit growing, and pineapple alone contributes with 7.3% of the total volume - with 1.8 million tons.

The Northeast region is of great importance in the cultivation of most tropical fruit species, especially acerola, avocado, pineapple, banana, cashew, coconut, guava, papaya, mango, passion fruit and grape (IBGE, 2016).

The world production of fruit reached the volume of 929.6 million tons, obtained in about 80.4 million hectares, in 2018 alone. In the processing of juices carried out by the agro industry, a significant amount of important by-products such as husks and seeds are generated (FAO, 2019).

These by-products represent a strategic matrix for the development of new products, through extraction and fermentation processes, with a high content of bioactive compounds and dietary fiber. Industrial by-products of fruits and vegetables consist mainly of: peel, bagasse fractions and seeds, which can be a good source of bioactive compounds, in addition to containing carbohydrates, dietary fibers, flavoring compounds and photochemical in their composition (COMAN et al., 2019).

Fruit trees represent a great natural reserve of vitamins and antioxidants. Its antioxidant activities have anti-cancer, anti-inflammatory, anti-allergic, anti-microbial properties, among others, promoting beneficial physiological effects, preventing or reducing the risk of numerous diseases in humans.

The development of new foods, using specific food matrices, will guarantee nutrition and disease prevention. In addition, it will allow the development and interaction of production chains with quality and with less use of natural resources (BRASIL, 2013).

In this scenario, this work certainly represented a challenge to the authors, whose goal was the development of new functional products with fruits from the Northeast. They centered their work on the use of organic waste, through the elaboration of flours, due to the ease of obtaining them and their high amount of nutrients.

Therefore, the choice of specific food matrices was fundamental for the development of products, such as passion fruit albedo, green banana peel, jabuticaba peel, among others.

Good examples come from several scientific works, developed in recent years, with passion fruit residues whose fruit can have 26.78% juice, 3.59% seeds and 69.63% husk, with a high content of pectin, fibers and carbohydrates, used for jellies as desserts.

The banana, whose heart is used as a PANC plant (non-conventional food plant), has fruits with high nutritional value, consisting of fiber, proteins, starches, sugars, vitamins A, B6, C and minerals such as potassium, phosphorus, calcium, sodium and magnesium, among others (SILVA et al., 2013; MONTEIRO, 2019). Its bark presents 1.99% of fibers and in the pulp 1.5% of fibers (GONDIM et al., 2005).

It is the most produced fruit tree worldwide, with 17.4% of the volume of fruit production, while in Brazil it occupies the second position, accounting for 16.7% of the volume of commercialized fruit, second only to the production of oranges (SAA, 2016). On the world stage, it ranks fourth in production, just behind India, China and Indonesia.

Practically everything produced is destined for the domestic market, with only 1% being exported since it is one of the most consumed fruits in the country. The processing of these becomes an alternative in order to take advantage of their nutritional value and at the same time reduce their waste (GONÇALVES et al., 2016).

About jabuticaba, it has a wide range of nutrients, such as carbohydrates, minerals, amino acids, lipids and vitamins (WU; LONG; KENNELLY, 2013). However, its highest levels of nutrients and phytochemicals are present in the bark.

In view of this, considering the high fiber content found in the flour of the peels of several fruits, the peel becomes a great option to add nutritional value to food products and in the development of new products. This can be seen in this work, in each chapter, such as cookies using flour obtained from passion fruit albedo, loaves using green banana flour, ice cream using jabuticaba peel flour, among others.

Anyway, two of these fruits are native to Brazil (passion fruit - known for the constitution of its beautiful flower that is related to the crucifixion of Christ - and jabuticaba - traditionally present in the backyards of our houses), the other is exotic (although our eternal muse “Carmem Miranda” has promoted a lot of banana) native to Southeast Asia and very well acclimated to the country. Anyway, the three team up to help our sustainable and regenerative agriculture, especially in terms of nutrition.

Bibliographic

BRASIL. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. Política Nacional de Alimentação e Nutrição. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. 1. ed. Brasília: Ministério da Saúde, 2013. 84p.

COMAN, V.; TELEKY, B. E.; MITREA, L.; MARTAU, G. A.; SZABO, K.; CALINOIU, L. F.; VODNAR, D. C. Bioactive potential of fruit and vegetable wastes. Advances in Food and Nutrition Research, v. 91, p.157-225, 2019.

FAO. Faostat. Desperdício de alimentos tem consequências no clima, na água, na terra e na biodiversidade. 2019. Disponível em: http://www.fao.org.br/daccatb.asp. Acesso em: 10 jan 2021.

GONÇALVES, J. Q. et al. Secagem da casca e polpa da banana verde (*Musa acuminata*): propriedades físicas e funcionais da farinha. Global Science and Technology, v.9, n.3, 2016.

GONDIM, J. A. M. et al. Composição centesimal e de minerais em cascas de frutas. Ciência e Tecnologia de Alimentos, v.25, n.4, p.825-827, 2005.

IBGE. Levantamento sistemático da produção agrícola. 2017. Disponível em: https://www.ibge.gov.br/estatisticas/economicas/agricultura-e-pecuaria/9201-levantamento-sistematico-da-producao-agricola.html?=&t=downloads.

MARSIGLIA, W. I. M. L.; SANTIAGO, Â. M.; ALVES, H. G.; ALMEIDA, R. L. J.; SANTOS, N. C.; DE SOUSA MUNIZ, C. E.; DE ALMEIDA, M. M. Modelagem e simulação do processo de secagem das cascas de jabuticaba (*Myrciaria cauliflora*). Research, Society and Development, v.10, n.3, e21510313214, 2021.

MONTEIRO, C. S. Sorbetto de maracujá enriquecido com fibras extraídas dos resíduos do maracujá amarelo. Revista Engenho, v.11, n.1, p.127-143, 2019.

SILVA, E. C.; SILVA, W. P. D.; GOMES, J. P.; SILVA, C. D. D. S.; SOUTO, L. M. D.; COSTA, Z. R. Physico-chemical characteristics of passion fruit flour under removal of flavedo and of maceration. Revista Brasileira de Engenharia Agrícola e Ambiental, v.23, p.869-875, 2019.

SILVA, L. M. de S. et al. Aproveitamento da casca de banana para produção de farinha destinada à formulação de biscoitos. 56f. Dissertação (Mestrado em Ciência e Tecnologia em Alimentos). Universidade Federal da Paraíba. Paraíba, 2013.

WU, S.; LONG, C.; KENNELLY, E. J. Phytochemistry and health-benefits of jaboticaba, an emerging fruit crop from Brazil. Food Research International, v.54, n.1, p.148-159, 2013.

ANDRADE, P. D. S. Secretaria de Agricultura e do Abastecimento. Análise da Conjuntura Agropecuária SAFRA 2016/17. 2016. Disponível em: http://www.agricultura.pr.gov.br/arquivos/File/deral/Prognosticos/2017/Fruticultura_2016_17.pdf.

PREPARATION OF ALBEDO OF PASSION FOUR *(Passiflora edulis)* AND ITS APPLICATION IN THE DEVELOPMENT OF COOKIE BISCUITS

Virgínia Mirtes de Alcântara Silva

Newton Carlos Santos

Raphael Lucas Jacinto Almeida

Victor Herbert de Alcântara Ribeiro

Juliana Cruz Albuquerque

Rosenildo dos Santos Silva

Jonnathan Silva Nunes

Introduction

Brazil is the world's largest producer and consumer of yellow passion fruit (*Passiflora edulis*), accounting for 50 and 60% of total world production, respectively (ARAÚJO et al., 2020). It is considered one of the most important fruits for the processing agroindustry in Brazil, being the variety of greatest commercial interest, as it presents high productivity, fruit quality and high pulp yield and resistance or tolerance to diseases and pests (GOMES et al., 2021).

According to Silva et al. (2019) passion fruit has a large amount of peel and its components can reach 26.78% juice, 3.59% seeds and 69.63% peel, which is composed of flavedo (yellow part) and albedo (part white).

Among the main co-products generated during the processing of fruit pulp are the skins, which have nutrients and low caloric content (FEITOSA et al., 2019). Passion fruit bark is composed of the flavedo (epicarp), which corresponds to the outer layer, with colors ranging from green to yellow, and is rich in insoluble fibers (cellulose, hemicellulose and lignin), and the albedo (mesocarp), which corresponds to the white inner layer, and is rich in soluble fibers, mainly pectin, with small amounts of hemicelluloses, gums and mucilage (SILVA et al., 2016).

Pectin is a polysaccharide acid that occurs naturally in fruits, especially citrus fruits and apples, most commercial pectins are extracted from citrus peels such as lemon and orange. It is an excellent supporting technology for its addition to fluid systems due to its gelling characteristics, consistency and texture, and can be applied to different types of products. Several researches have been carried out using by-products of different fruits: pequi mesocarp (SIQUEIRA et al., 2019); watermelon bark (FILHO et al., 2020); mango peel (KOUBALA et al., 2008); orange bagasse (FILHO et al., 2020); fig seed (LIANG et al., 2012) and guava pulp (MUNHOZ et al., 2010).

According to Decree No. 6,286, of November 22, 2007, of the Ministry of Agriculture, Livestock and Supply (BRASIL, 2007), what results from the processing, industrialization or economic improvement of a vegetable product is classified as a by-product.

Thus, several alternatives have been studied for the use of these agro-industrial residues (FEITOSA et al., 2019). According to Gaspar et al. (2020) the production of food flours can be a viable alternative for their use. According to RDC

Resolution No. 263, flours are products obtained from edible parts of one or more species of cereals, legumes, fruits, seeds, tubers and rhizomes by milling and or other technological processes considered safe for food production (BRASIL, 2005).

Recent studies have revealed significant levels of antioxidant activity associated with extracts of fruit by-products such as passion fruit, orange, bacupari, acerola, buriti, feijoa and mango (MELO et al., 2021; ALBUQUERQUE et al., 2019; REZENDE et al., 2019).

According to Oliveira et al. (2020) in the national and international market, there are bakery products for celiac patients, however, without functional appeal and low sensory quality, for this reason, the food industry has been striving to create products, as well as reformulate conventional recipes, using flour from unconventional sources, as in the case of the present study, passion fruit albedo flour.

Among the bakery products, the cookie stands out, which a product is obtained by kneading and baking dough prepared with flour and other ingredients. In addition, the cookie type cookie is a product that is easy to incorporate with alternative ingredients (MORETO et al., 2020). In this context, the present study aimed to elaborate and characterize the passion fruit albedo flour and to develop cookies with different concentrations of the passion fruit albedo flour.

Methodology

Flour elaboration

Passion fruit (*Passiflora edulis*) albedo was used to prepare the flour. The steps for its production can be seen in Figure 1.

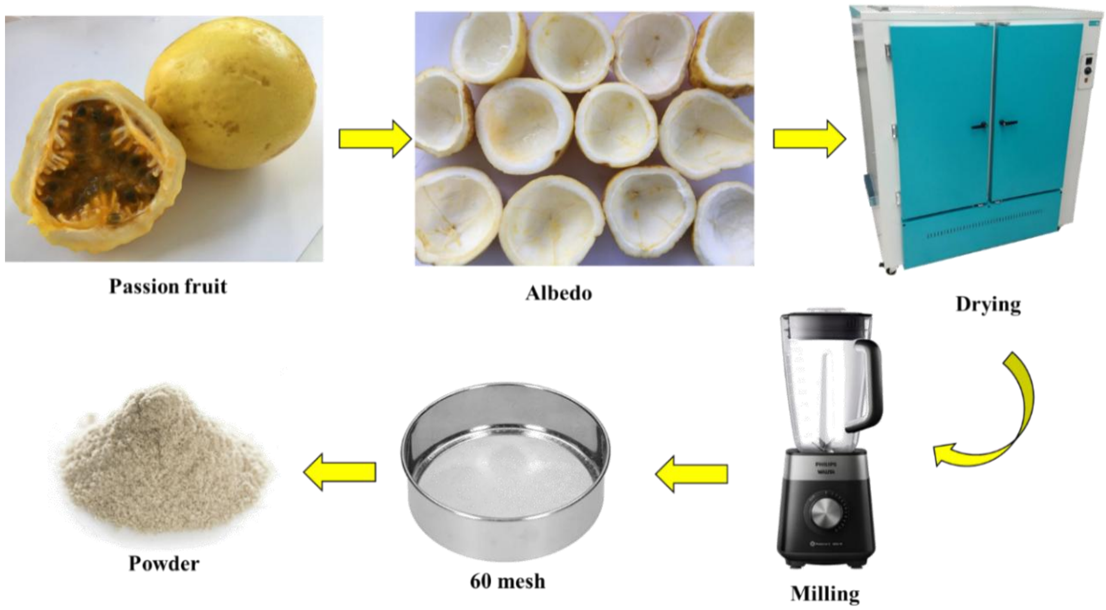

Figure 1. Main steps to produce passion fruit albedo flour.

Initially, the passion fruit were sanitized, sanitized (200ppm sodium hypochlorite) and washed in running water. After this stage, they were manually pulped, and the albedos were separated from the other fractions. The albedos were submitted to a convective drying step at a temperature of 65 °C and an air velocity of 2 m s-1 until obtaining a constant mass. After drying, the dehydrated albedo was crushed in a domestic blender and the powder obtained was standardized, using a 60-mesh sieve.

Characterization of passion fruit albedo flour

Centesimal composition

(1) Moisture content was determined by drying in an oven at 105 °C until constant weight (BRASIL, 2008);

(2) Ash content was determined by incineration in a muffle (BRAZIL, 2008);

(3) Total protein content was quantified by the Micro-Kjeldahl method, which consisted of the determination of total nitrogen according to the methodology described by Brasil (2008);

(4) Lipid content was quantified by the modified method of Blig and Dyer (1959);

(5) Crude fiber content was quantified by digestion with an acid solution by the method of Silva and Queiroz (2002);

(5) Total carbohydrate content was calculated by difference to obtain 100% of the total composition (FAO, 2003).

Mineral profile

The mineral profile was determined through the ash using an Energy Dispersive X-Ray Fluorescence Spectrometer, model EDX-720 (Shimadzu, Kyoto, Japan) using liquid nitrogen.

Morphological analysis (SEM)

The passion fruit albedo flour was processed at normal temperature using a scanning electron microscope. The sample was covered with a thin layer of gold. The SEM image was obtained at 2000x magnification with an acceleration potential of 10kV (ATROUS et al., 2016).

Cookie biscuit making

The cookies were made using passion fruit albedo flour, the ingredients used are described in Table 1.

Table 1. Formulations for making cookies with the addition of passion fruit albedo flour

Ingredients	A	B	C
Sugar	62.7%	62.7%	62.7%
Yeast	1.5%	1.5%	1.5%
Soybean Oil [1]	35.8%	35.8%	35.8%
egg [2]	1	1	1
Flour	100%	90%	80%
Passion fruit albedo flour	0%	10%	20%

Note: [1] expressed in mL; [2] expressed in units. Source: Adapted from Almeida et al, (2019).

The mixture of ingredients was carried out using a planetary mixer, the mixing time was 12 min, until obtaining a homogeneous mass. Then, the cookies were molded into a circular shape, being arranged in rectangular shapes. The baking was carried out in a preheated domestic oven at 180°C, for approximately 25 min. After baking, the cookies were packed in hermetic laminated packages.

Characterizations of prepared cookies

Cookies made with passion fruit albedo flour were characterized according to the centesimal parameters described. In addition, they were also characterized regarding the parameters of:

(1) Water activity (Aw) was determined using the Decagon® Aqualab CX-2T device at 25°C;

(2) The firmness of the cookies was evaluated in a universal texturometer model TA-XT plus - Texture Analyzer from the manufacturer Stable Micro Systems, equipped with the Exponent Stable Micro Systems software. The parameters used in the tests were: pre-test speed = 1.0 mm/s, test speed = 3.0 mm/s, post-test speed = 10.0 mm/s, 5.0 mm distance, with measure of force in compression. Firmness results were expressed in newtons (N).

Statistical analysis

The experimental data were analyzed in triplicate and the results were submitted to the analysis of variance of a single factor (ANOVA) of 5% probability and the significant qualitative responses were submitted to the Tukey test, adopting the same level of 5% of significance. For the development of statistical analysis, the software Assistat 7.7 (SILVA & AZEVEDO, 2016) was used.

Results and discussion

Table 2 shows the mean values obtained for the proximate composition and water activity of the passion fruit albedo flour, obtained by convective drying at a temperature of 65°C.

Table 2. Proximate composition and water activity of passion fruit albedo flour

Parameters (%)	Passion fruit albedo flour
Moisture	5.22 ± 0.03
Ash	6.36 ± 0.42
Lipids	0.12 ± 0.01
Proteins	4.81 ± 0.55
Raw fiber	36.72 ± 0.21
Carbohydrates	46.77 ± 0.14
Water activity (a_w)	0.214 ± 0.02

The passion fruit albedo flour had low moisture content (5.22%) and low water activity (0.214), being therefore considered a product with good stability. Rybka et al. (2018) when preparing mango peel factories at a temperature of 60°C, they obtained moisture values ranging from 6.90 to 8.30% among the varieties in the study. The ash content obtained was 6.36% and low lipid content 0.12%. Costa et al. (2018) when producing passion fruit peel flour, they obtained 4.93% of ash and 0.51% of lipids.

The protein value obtained for flour in the present study was 4.81%, lower values were reported in the literature for pineapple peel flour by Erkel et al. (2015) who observed 3.10%. As for the crude fiber content (36.72%), it indicated that the passion fruit albedo flour has potential for application in the development of new products.

Silva et al. (2016) while also preparing passion fruit albedo flour, however, the albedo was macerated and dried at 70 °C, obtaining a higher crude fiber content than in the present study (58.80%). The prepared flour presented 46.77% for the total carbohydrate content, showing that the passion fruit albedo flour can improve the nutritional quality of food products and their palatability, making them more accepted by consumers (CARVALHO et al., 2013).

Table 3 shows the mean values obtained for the mineral profile of the passion fruit albedo flour, obtained by convective drying at a temperature of 65 °C.

Table 3. Mineral content of passion fruit albedo flour

Mineral (mg/100)	Passion fruit albedo flour
K	2734.42 ± 0.01
Ca	652.69 ± 0.00
P	146.69 ± 0.02
S	28.31 ± 0.01
Fe	39.87 ± 0.03
Zn	7.14 ± 0.02
Br	3.91 ± 0.00
Cu	3.61 ± 0.01
Zr	0.22 ± 0.01

The highest mineral content was the potassium (K) content (2734.42 mg/100g) following the order: K>Ca>P>S>Fe>Zn>Br>Cu>Zr. Gondim et al. (2005), analyzed the presence of minerals in passion fruit peels and obtained, after drying in an oven at 60°C, levels of 44.51, 27.82, 178.40, 0.89, 0.32 and 0.04 mg/ 100g for calcium, magnesium, potassium, iron, zinc and copper, respectively. In Figure 2, the scanning electron microscopy image of the passion fruit albedo flour at 2000 times magnification is shown.

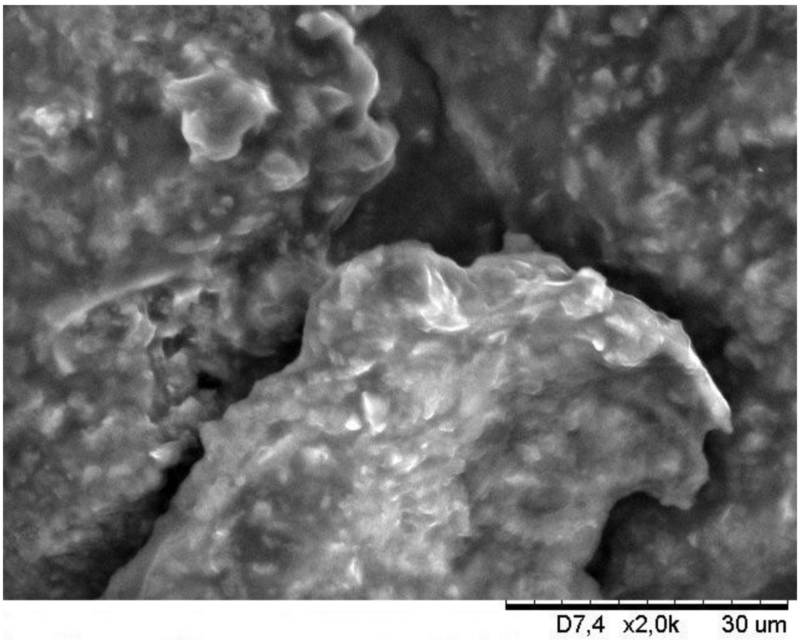

Figure 2. Scanning electron micrograph of passion fruit albedo flour with 2000x magnification.

Through image analysis, it is possible to observe that the passion fruit albedo flour presented an irregular structure of undefined shapes with cavities and spaces, in addition to a spongy appearance. In Figure 3, it is possible to observe the cookie type cookies made with the passion fruit albedo flour, in which the flour composition is shown in Table 2.

Figure 3. Cookies made with passion fruit albedo flour.

The image shows the cookies made with different percentages of passion fruit albedo flour, the control formulation being 0% passion fruit albedo flour and the formulations with the addition of 10 and 20% of the flour and consequently a reduction in the percentage of wheat flour. Visually it was noticeable changes in the color of the cookies, however, the color analysis was not performed. Through the tables below, it will be possible to visualize the composition of the cookies created. Table 4 presents the values obtained for the moisture content.

Table 4. Moisture content of cookies made with passion fruit albedo flour

Formulation	**Moisture (%)**
0%	3.98 ± 0.04c
10%	4.20 ± 0.08a
20%	4.12 ± 0.05b

Note: Different letters in the same column differ significantly by Tukey's test.

The prepared cookies had low moisture contents ranging from 3.98 to 4.20% and the increase in the percentage of passion fruit albedo flour did not show a direct relationship for this parameter. Statistically, the moisture values were significantly different from each other (p>0.05), with the highest content obtained for the formulation containing 10% of passion fruit albedo flour. Values close to those of the present study were reported by Costa et al. (2012) who obtained values ranging from 4.51 to 5.31% for cookies made with passion fruit peel flour. In Table 5, it is possible to visualize the mean values obtained for the ash content of cookies made with passion fruit albedo flour.

Table 5. Ash content of biscuits made with passion fruit albedo flour

Formulation	Ashes (%)
0%	1.78 ± 0.09c
10%	2.71 ± 0.10b
20%	3.96 ± 0.06a

Note: Different letters in the same column differ significantly by Tukey's test.

As for the ash content, there is a direct relationship with increased concentration of passion fruit albedo flour. These values ranged from 1.78 to 3.96%, which when compared with each other showed significant differences according to the Tukey test. Values lower than those in the present study were reported by Lupatini et al. (2011), who obtained ash contents ranging from 1.14 to 1.16% for cookies made with passion fruit and okara peel flour. Table 6 shows the mean values obtained for the lipid content of cookies made with passion fruit albedo flour.

Table 6. Lipid content of biscuits made with passion fruit albedo flour

Formulation	Lipids (%)
0%	9.76 ± 0.21c
10%	12.41 ± 0.15b
20%	15.20 ± 0.32a

Note: Different letters in the same column differ significantly by Tukey's test.

Relatively high values were observed for the lipid content of cookies made with passion fruit albedo flour. This variation was up to 5.44% when the passion fruit albedo flour content varied by up to 20%. Statistically the values were significantly different from each other (p>0.05). Values close to those of the present study were reported by Oliveira (2019), who obtained lipid content ranging from 6.48 to 14% for cookies made with passion fruit peel flour and whey protein. And by Orloski et al. (2016), who found 14.4% of lipids in a cream cracker biscuit added to flaxseed flour. However, Novaes et al. (2015) obtained lipid values higher than those in the present study, ranging from 19.56 to 22.41% in butter cookies enriched with different fruit peel flours.

In Table 7, it is possible to observe the results obtained for the protein content of cookies made with passion fruit albedo flour.

Table 7. Protein content of biscuits made with passion fruit albedo flour

Formulation	Proteins (%)
0%	3.90 ± 0.04c
10%	4.28 ± 0.01b
20%	5.01 ± 0.07a

Note: Different letters in the same column differ significantly by Tukey's test.

Protein content increased with increasing addition of passion fruit albedo flour, with values ranging from 3.90% (Control formulation) to 5.01% (Formulation with 20% passion fruit albedo flour). Statistically all formulations showed significant differences when compared to each other. Values close to those of the present study were reported by Silva et al. (2021), when preparing cookies with the addition of acerola residue flour, which obtained protein content ranging from 4.45 to 6.99% and by Albuquerque et al. (2016), who obtained 5.56% protein in cookies with the addition of seriguela flour. In Table 8, it is possible to visualize the mean values obtained for the total carbohydrate content of cookies made with passion fruit albedo flour.

Table 8. Carbohydrate content of biscuits made with passion fruit albedo flour

Formulation	Carbohydrates (%)
0%	80.58 ± 0.15a
10%	76.40 ± 0.19b
20%	71.77 ± 0.10c

Note: Different letters in the same column differ significantly by Tukey's test.

Regarding the content of total carbohydrates, values ranging from 71.77 to 80.58% were observed. Increasing the concentration of passion fruit albedo flour provided statistically significant reductions (p>0.05) for this parameter. Values lower than those in the present study were reported by Santos et al. (2019), which obtained values ranging from 62.10 to 64.78% for cookies with kiwi peel flour. Table 9 shows the values obtained for the parameters of water activity and firmness of cookies made with the addition of passion fruit albedo flour.

Table 9. Water activity and texture of cookies made with passion fruit albedo flour

Formulation	Water activity (aw)	Firmness (N)
0%	0.305 ± 0.02c	69.98 ± 0.37c
10%	0.362 ± 0.01a	74.21 ± 0.26b
20%	0.345 ± 0.00b	78.14 ± 0.41a

Note: Different letters in the same column differ significantly by Tukey's test.

Low water activity values ranging from 0.305 to 0.345 were observed between the developed formulations that showed statistically significant differences (p>0.05). Values lower than those in the present study were reported by Gusmão et al. (2018) when preparing cookies with mesquite flour, they obtained values ranging from 0.263 to 0.271 on day 0 of storage.

Regarding the texture parameter, it is observed that the firmness of the cookies was higher (78.14%) when there was a higher percentage of passion fruit albedo flour (20%), from a statistical point of view the values obtained were significantly different between each other, when applying the Tukey test. Values lower than those in the present study were reported by Ramos et al. (2020), when preparing cookies with flours from different fruit residues (pineapple peel, mango, banana, orange, watermelon husk and mango almonds), they obtained values ranging from 26.22 N to 52.37 N.

Conclusion

Through the results obtained, it could be concluded that:

The passion fruit albedo flour had low moisture content and high crude fiber content;

In the mineral profile, potassium (K) was the constituent with the highest content;

Through scanning electron micrographs, it was visible that the passion fruit albedo flour had an irregular structure;

The visually prepared cookies showed differences in color and the increase in the concentration of the passion fruit albedo flour promoted an increase in the ash, lipids and carbohydrates contents.

Furthermore, cookies also have low water activity values.

References

ALBUQUERQUE, J. G.; DUARTE, A. M.; CONCEIÇÃO, M. L.; AQUINO, J. S. Integral utilization of seriguela fruit (*Spondias purpurea* L.) in the production of cookies. Revista Brasileira de Fruticultura, v.38, n.3, p.1-7, 2016.

ALMEIDA, R. L.; SANTOS, N. C.; DOS SANTOS PEREIRA, T.; DE ALCÂNTARA SILVA, V. M.; DE ALCANTARA RIBEIRO, V. H.; SILVA, L. N.; LIMA, S. E. R. Composição físico-químicas de cookies adicionados de resíduos do arroz vermelho. Research, Society and Development, v.9, n.1, e151911852, 2020.

ALMEIDA, J. S. O; DIAS, C. O; ARRIOLA, N. D.; FREITAS, B. S. M.; FRANCISCO, B. S. M. A., PETKOWICZ, C. D.; ARAÚJO, L.; GUERRA, M. P.; NODARI, R. O.; AMBONI, R. D. M. C. Farinhas de casca de Feijoa (*Acca sellowiana*): Uma fonte de fibras dietéticas e compostos bioativos. Food Bioscience, v.38, p.100789, 2020.

ARAUJO, M. E. V.; BARBOSA, E. G.; DE OLIVEIRA, A. C. L.; MILAGRES, R. S.; DE CARVALHO PINTO, F. D. A.; CORRÊA, P. C. Physical propertyes of yellow passion fruit seeds (*Passiflora edulis*) during the drying process. Scientia Horticulturae, v.261, e109032, 2020.

ATROUS, H.; BENBETTAIEB, N.; CHOUAIBI, M.; ATTIA, H.; GHORBEL, D. Changes in Wheat and Potato Starches Induced by Gamma Irradiation: A Comparative Macro and Microscopic Study. International Journal of Food Properties, v.20, p.1532–1546, 2017.

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

BRASIL. Instituto Adolfo Lutz. Métodos físico-químicos para análise de alimentos .4th ed. v.1, São Paulo: Instituto Adolfo Lutz, 2008. 1020p.

BRASIL. Agência Nacional de Vigilância Sanitária. Resolução RDC nº 263, de 22 de setembro de 2005.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Decreto nº 6.286, de 22 de novembro de 2007. Institui a classificação de produtos vegetais, seus subprodutos e resíduos de valor econômico, e dá outras providências. Diário Oficial da República Federativa do Brasil, Brasília.

CARVALHO, K. D.; BOZATSKI, L. C.; SCORSIN, M.; NOVELLO, D.; PEREZ, E.; DALLA SANTA, H. S.; BATISTA, M. G. Development of the cupcake added flour banana peel: sensory and chemical characteristics. Alimentos e Nutrição Araraquara, v.23, n.3, p.475-482, 2013.

COSTA, B.; DE LIZ, F. R.; FERREIRA, J.; SANTOS, R.; GONÇALVES, T.; BALBI, M. Uso da farinha da casca do maracujá amarelo (*Passiflora edulis F. Flavicarpa deg*. Família Passifloraceae) na formulação de macarrão caseiro. Visão Acadêmica, v.19, n.4, p.32-45, 2019.

COSTA, J. N.; SOARES, D. J.; CARNEIRO, A. P. G.; MOURA, S. M.; RODRIGUES, C. S.; FIGUEIREDO, R. W. Composição centesimal e avaliação sensorial de biscoito tipo cookies acrescido de maracujá em pó. Revista Brasileira de Produtos Agroindustriais, v.14, n.2, p.143-147, 2012.

ERKEL, A.; DE ÁVILA, C. A.; ROMEIRO, M. M.; DOS SANTOS, E. F.; SARMENTO, U. C.; NOVELLO, D. Utilização da farinha da casca de abacaxi em cookies: caracterização físico-química e aceitabilidade sensorial entre crianças. Revista Uniabeu, v.8, n.19, p.272-288, 2015.

FAO. Food and Agriculture Organization of the United Nations. Food Energy: Methods of Analysis and Conversion Factors. Report of a Technical Workshop. Food and Nutrition Paper. v. 77. FAO: Rome, Italy, 2003.

FEITOSA, B. F.; DE OLIVEIRA, E. N. A.; DE OLIVEIRA NETO, J. O.; DE OLIVEIRA, D. B.; FEITOSA, R. M. Cinética de secagem dos resíduos da agroindústria processadora de polpa de frutas. Energia na Agricultura, v.34, n.1, p.134-141, 2019.

FILHO, A. C.; CASTRO, C. F. Produção, extração e análise físico-química de pectina do bagaço de laranja através do modelo de área superficial por Box-Behnken. Revista Arquivos Científicos, v.3, n.2, p.137-145, 2020.

GOMES, T. R.; FREITAS, E. R.; WATANABE, P. H.; FERREIRA, A. C. S.; TAVARES, L. M. D. S. Passion fruit peel in growing rabbit's feed. Revista Ciência Agronômica, v.52, n.4, e20207591, 2021.

GONDIM, J. A. M.; MOURA, M. D. F. V.; DANTAS, A. S.; MEDEIROS, R. L. S.; SANTOS, K. M. Composição centesimal e de minerais em cascas de frutas. Food Science and Technology, v.25, p.825-827, 2005.

GUSMÃO, R. P. D.; GUSMÃO, T. A. S.; MOURA, H. V.; DUARTE, M. E. M.; CAVALCANTI-MATA, M. E. R. M. Caracterização tecnológica de cookies produzidos com diferentes concentrações de farinha de algaroba durante armazenamento por 120 dias. Brazilian Journal of Food Technology, v.21, e2017116, 2018.

KOUBALA, B. B.; MBOME, L. I.;, KANSCI, G.; MBIAPO, F. T,.; CREPEAU, M. J,.; THIBAULT, J. F.; RALET, M. C. Physicochemical properties of pectins from amberella peels (*Spondias cytherea*) obtained using different extraction conditions. Food Chem, v.106, p.1202-1207, 2008.

LIANG R. H.; CHEN, J.; LIU, W.; YU, W.; YUAN, M.; ZHOU, W. Q. Extraction, characterization and spontaneous gel-forming property of pectin from creeping fig (*Ficus pumila* Linn.) seeds. Carbohydrate Polymers, 2012.

LUPATINI, A. L.; FUDO, R. M.; MESOMO, M. C.; DOS SANTOS CONCEIÇÃO, W. A.; COUTINHO, M. R. Desenvolvimento de biscoitos com farinha de casca de maracujá-amarelo e okara. Revista Ciências Exatas e Naturais, v.13, n.3, p.317-329, 2011.

MELO, A.M.; BARBI, R.C.T.; COSTA, B.P.; IKEDA, M.; CARPINÉ, D.; RIBANI, R.H.; Valorização de subprodutos agroindustriais do bacupari *(Garcinia brasiliensis (Mart.))* por meio da produção de farinha com propriedades bioativas. Food Bioscience, p.101343, 2021.

MORETO, V. O.; DA SILVA BRUNI, A. R., .; CZAIKOSKI, A.; CZAIKOSKI, K. Desenvolvimento e análise sensorial de biscoito acrescido de farinha de Guavirova. Brazilian Journal of Development, v.6, n.8, e58580, 2020.

MUNHOZ, C. L.; SANJINEZ-ARGANDOÑA, E. J.; SOARES-JUNIOR, M. S. Extraction of dehydrated guava pectin. Food Sci Technol, v.30, p.119-125.

NOVAES, M. D. S.; OLIVEIRA, A. P.; HERNANDES, T.; RODRIGUES, E. C; SIGARINI K. S.; PEDRO, F. G. G. Composição proximal e mineral de biscoitos tipo amanteigado enriquecidos com diferentes farinhas de casca de frutas. Revista Instituto Adolf Lutz, v.74, n.4, p.390-8, 2015.

OLIVEIRA, N. D. D. Desenvolvimento, caracterização física, físico-química e avaliação sensorial de cookie com farinha da casca de maracujá adicionado de Whey Protein. 51f. Trabalho de Conclusão de Curso (Graduação em Nutrição). Universidade Federal de Campina Grande. Cuité, 2019.

OLIVEIRA, P. V. C.; QUEIROZ, B. C. A.; PIOVESAN, N.; DE OLIVEIRA, P. V. C.; DE CARVALHO LIMA, M. H.; PEREIRA, A. S.; DE OLIVEIRA LIMA, W. Substituição da farinha de trigo por farinha de banana verde na elaboração de biscoito tipo cookie. Brazilian Journal of Development, v.6, n.10, e75662, 2020.

ORLOSKI, A. R.; BEZERRA, J. R. M. V.; ROMEIRO, M. M.; CANDIDO, C. J.; SANTOS, E. F.; NOVELLO, D. Elaboração de biscoito cream cracker adicionado de farinha de linhaça e com teor reduzido de sódio: avaliação físico-química e sensorial. Revista do Instituto Adolfo Lutz, v.75, p.01-12, 2016

RAMOS, S. A.; DAS DORES PEREIRA, R.; ANDRESSA, I.; SCHMIELE, M.; AMARAL, T. N. Desenvolvimento de cookies com coprodutos de frutas Development of cookies with fruit co-products Desarrollo de cookies con coproductos de frutos. Research, Society and Development, v.9, n.10, e5799108918, 2020.

RESENDE, L. M.; FRANCA, A. S.; OLIVEIRA, L. S. Buriti (*Mauritia flexuosa* L. f.) Farinhas de subprodutos de frutas: Avaliação como fonte de fibras dietéticas e antioxidantes naturais. Química alimentar, v.270, p.53-60, 2019.

RYBKA, A. C.; LIMA, A.; DE CÁSSIA NASSUR, R. Caracterização da farinha da casca de diferentes cultivares de manga. Enciclopédia Biosfera, v.15, n.27, p.12-21, 2018.

SANTOS, N. C.; SANTOS, E. R. M.; BARROS, S. L.; ALMEIDA, R. D.; ALMEIDA, R. L. J.; SILVA, V. M. A.; NASCIMENTO, A. P. S. Technological use of kiwi (cv. hayward) shell for elaboration of cookie-type biscuits. International Journal of Development Research, v.9, n.7, e28852, 2019.

SILVA, D. J.; QUEIROZ, A. C. Análise de alimentos: Métodos químicos e biológicos. 3.a ed. Universidade de Viçosa, 2002. 235p.

SILVA, E. C. O.; DA SILVA, W. P.; DE ALMEIDA, M. E. T.; LOPES, J. D.; DE GUSMÃO, R. P. Obtenção e caracterização da farinha do albedo de maracujá, Passiflora edulis f. Flavicarpa, para uso alimentício. Revista Verde de Agroecologia e Desenvolvimento Sustentável, v.11, n.3, p.69-74, 2016.

SILVA, E. C.; SILVA, W. P. D.; GOMES, J. P.; SILVA, C. D. D. S.; SOUTO, L. M. D.; COSTA, Z. R. Physico-chemical characteristics of passion fruit flour under removal of flavedo and of maceration. Revista Brasileira de Engenharia Agrícola e Ambiental, v.23, p.869-875, 2019.

SILVA, V. M. A.; SANTOS, N. C.; ALMEIDA, R. L. J; RIBEIRO, V. H. A.; SILVA, G. M.; QUEIROGA, A. P. R. de.; BRITO, A. C. O. de. Development of cookies with acerola (*Malpighia emarginata DC*) waste flour: central composition, texture, and water activity. In: SILVA, V. M. A.; SANTOS,N.C.;RIBEIRO,V.H.A. (Org.). Acerola thermophysical properties, drying and new product development. 1. ed .Campina Grande: EPTEC, 2021, 104 p.

SIQUEIRA, R. A. Características tecnológicas e aplicabilidade de embalagens biodegradáveis de pectina do mesocarpo do pequi na conservação de cenouras minimamente processadas. 2019.

SPILLER, S. H. Modificações nos métodos de extração de pectina de goiabas cv. Pedro Sato durante o amadurecimento. Revista Brasileira de Tecnologia de Alimentos, v.21, 2018.

OBTAINMENT OF FLOUR FROM THE PEEL OF THE GREEN BANANA *(Musa spp.)* AND ITS APPLICATION IN THE DEVELOPMENT OF SLICED BREAD

Virgínia Mirtes de Alcântara Silva
Newton Carlos Santos
Raphael Lucas Jacinto Almeida
Victor Herbert de Alcântara Ribeiro
Juliana Cruz Albuquerque
Rosenildo dos Santos Silva
Jonnathan Silva Nunes

Introduction

Banana (*Musa spp.*) is the main fruit in international trade and one of the most consumed fruits in the world. Today, bananas are the fourth most widespread fruit crop in the world, being produced mainly in tropical and subtropical regions. In addition, banana production is an important source of income and employment for the main banana exporting countries, such as Brazil (CASTELO-BRANCO et al., 2017).

Only in recent years has green bananas aroused interest in the consumer market and, consequently, several studies have been developed to assess its technological properties as a functional ingredient, mainly in the form of flour, including that produced from its peel (SARAWONG et al., 2014).

The retention of the bioactive compounds present in the green banana peel are preserved due to the drying process used, ensuring the nutritional and functional quality of the flour developed, making it a strategic ingredient to be used in several products. Several research have already been developed using flour to formulate functional foods, with emphasis on coconut residues (HANAFI et al., 2022); poncã bark (MARCON et al., 2021); melon seeds (MIRANDA et al., 2021); umbu (OLIVEIRA et al., 2021); pumpkin (MORAIS, 2019); papaya (OLIVEIRA, 2020) and cashew (PEREIRA et al., 2016).

A food can be considered functional if, in addition to its basic nutritional functions, it positively affects one or more physiological functions of the body, favoring health, better quality of life and helping to reduce the risk of diseases (SILVA et al., 2016).

According to Borges et al. (2009), bananas have a variable source of minerals, being an important component in food worldwide. Its flavor is one of the most important quality attributes, the green pulp is characterized by a strong astringency determined by the presence of soluble phenolic compounds, mainly tannins.

As the banana matures, these compounds polymerize, with a consequent decrease in astringency, increase in sweetness and reduction in acidity. In the green ripening stage, bananas are not consumed, due to their hardness and astringency, due to the presence of phenolic compounds. However, it has a longer shelf life, and has been considered an ideal product to be industrialized (SARAWONG et al., 2014; DINIZ, 2019).

The search for healthier food alternatives is leading the food industry to explore the incorporation of new ingredients in the development of bakery products, such as bread, for example, as it is a product consumed worldwide (ALVES et al., 2021).

Bread (from the Latin "panis") is currently considered the most consumed product by humanity, mainly by western populations. This product originated in the beginnings of the population, a period when man was still nomadic. However, Brazil only came to know bread from the 19th century onwards, through the baking activities of Italian immigrants, who were responsible for the introduction of bakeries in the country, especially in São Paulo.

The Brazilian's per capita consumption is, on average, 22.61 kg of bread per year, being consumed in the form of snacks or with meals. In the case of sliced bread, in addition to being practical, the growth in its consumption may be related to the sale of several types, especially those that cover the market of products with reduced caloric content (LIMA, 2019).

Breads are products obtained from wheat flour or from the addition of several flours, added with liquid, resulting from the process of fermentation or not and cooking, and may also contain other ingredients, as long as they do not detract from the product. They can have different coverage, filling, format and textures (BRASIL, 2005). It is considered a popular and well-accepted product, usually consumed as snacks or with meals, highly appreciated due to its appearance, aroma, flavor, price and availability (BATTOCHIO et al., 2006; NASCIMENTO et al., 2019; OLIVEIRA & ANDRADE, 2020).

Given the above, this study aims to prepare green banana peel flour and characterize the proximate parameters, mineral profile, bioactive compounds and antioxidant activity. After obtaining the banana peel flour, it will be applied in the preparation of breads with different concentrations of green banana peel flour.

Methodology

Preparation of green banana peel flour

To prepare the flour, green banana (*Musa spp.*) was used. The steps for its production can be seen in Figure 1.

Figure 1. Main steps for the preparation of green banana peel flour.

Initially, the bananas in the fully green maturation stage were sanitized, sanitized (sodium hypochlorite 200ppm) and washed in running water. After this step, they were manually peeled. The husks were submitted to a drying step in an electric oven with a power of 1200W until obtaining a constant mass. After drying, the dry husks were crushed in a knife mill and the powder obtained was standardized, using a 60 mesh sieve.

Characterization of green banana peel flour

Centesimal composition

(1) Moisture content was determined by drying in an oven at 105°C until constant weight (BRASIL, 2008);

(2) Ash content was determined by incineration in a muffle (BRAZIL, 2008);

(3) Total protein content was quantified by the Micro-Kjeldahl method, which consisted of the determination of total nitrogen according to the methodology described by BRASIL (2008);

(4) Lipid content was quantified by the modified method of Blig and Dyer (1959);

(5) Crude fiber content was quantified by digestion with an acid solution by the method of Silva and Queiroz (2002);

(6) Total carbohydrate content was calculated by difference to obtain 100% of the total composition (FAO, 2003).

Mineral Profile

The mineral profile was determined through the ash using an Energy Dispersive X-Ray Fluorescence Spectrometer, model EDX-720 (Shimadzu, Kyoto, Japan) using liquid nitrogen.

Total phenolic compounds and antioxidant activity

Total phenolic compounds were quantified by the Folin-Ciocalteau method described by Waterhouse (2006), using gallic acid as a standard. Water and methanol were used as extraction solvents. The calculations performed for the determination of phenolic compounds were based on a standard curve with gallic acid, and the readings were made in a spectrophotometer at 765 nm, with results expressed in mg/100 g of gallic acid. The antioxidant activity of DPPH• was performed according to the methodology described by Maria do Socorro et al. (2010) with adaptations.

Preparation of loaves of bread

Loaf type breads were made using whole wheat flour and green banana peel flour, the proportions of flour used are described in Table 1. The other ingredients used were: sodium chloride (2%), sucrose (5%), Dry biological yeast (3%), water (60%) and fat (3%) the bread preparation followed the procedures described by Andrade et al. (2018).

Table 1. Proportions of whole wheat flour and green banana peel flour for whole-wheat bread making

Ingredients	A	B	C	D
whole wheat flour	100%	90%	85%	75%
Green banana peel flour	0%	10%	15%	25%

Breads were prepared by the direct method. Initially, the dry ingredients were mixed in a mixer for 3 minutes. Then, the ingredients water, fat and biological yeast were added, mixing until obtaining a consistent mass. The dough was left to rest for 10 minutes, then cut into pieces. The pieces were rounded and molded, after molding they were placed in metallic containers and taken to the fermentation oven, where they remained at 30°C for 1 hour and 30 minutes. After fermentation, the formulations (0, 10, 15 and 25%) were baked at 200°C for 20 minutes (ANDRADE et al., 2018).

Characterizations of loaf breads

The breads made with green banana peel flour were characterized according to the parameters described in the following items.

Centesimal composition

The proximate parameters were determined as described in item 2.2.1.

Firmness

The firmness of the breads was evaluated in a universal texturometer model TA-XT plus - Texture Analyzer from the manufacturer Stable Micro Systems, equipped with the Exponent Stable Micro Systems software. The parameters used in the tests were: pre-test speed = 1.0 mm/s, test speed = 3.0 mm/s, post-test speed = 10.0 mm/s, 5.0 mm distance, with measure of force in compression. Firmness results were expressed in newtons (N).

Microbiological assessment

Microbiological analyzes of the formulations included the determination of the most probable number (MPN) of coliforms at 35°C and thermotolerant coliforms, and detection of Salmonella spp. according to APHA (2001).

Statistical analysis

The experimental data were analyzed in triplicate and the results were submitted to the analysis of variance of a single factor (ANOVA) of 5% probability and the significant qualitative responses were submitted to the Tukey test, adopting the same level of 5% of significance. For the development of statistical analysis, the software Assistat 7.7 (SILVA & AZEVEDO, 2016) was used.

Results

Table 2 shows the mean values obtained for the proximate composition of green banana peel flour, obtained by drying in an electric oven.

Table 2. Proximate composition of green banana peel flour

Parameters (%)	Green banana peel flour
Moisture	7.41 ± 0.08
Ashes	3.01 ± 0.20
Lipids	0.44 ± 0.11
Proteins	4.03 ± 0.91
Raw fiber	2.02 ± 0.23
Carbohydrates	83.09 ± 0.16

The green banana flour had a moisture content of 7.41%, a value within the maximum established by the Brazilian legislation for flour, which establishes a maximum moisture content of 15% for flour obtained from fruits and seeds (BRASIL, 2005). Carneiro et al. (2020) when evaluating the moisture content of green banana flours with application of antioxidants, they obtained levels ranging from 7.81 to 9.21%. The ash content obtained was 3.01%, which was higher than that obtained by

Borges et al. (2009), also for green banana peel flour, however, dried at 70°C (2.59%).

Regarding the lipid content, the green banana peel flour had a low content (0.44%), a value close to that found by Torres et al. (2005), who found a value of 0.53% in green banana flour (*Musa acuminata*) used in extruded products. The protein content obtained was 4.03% and the fiber content 2.02%.

Andrade et al. (2018) when preparing green banana flour from cultivars Prata and cockatiel, they obtained protein contents ranging between 3.0 and 5.2% and crude fiber content of 0.6% for the two varieties under study.

The green banana peel flour also had a high carbohydrate content of 83.09%, close to that reported by Castelo-Branco et al. (2017) for green banana pulp flour (84.4%) and for green banana peel flour (70%).

Table 3 shows the mean values obtained for the mineral profile of green banana peel flour, obtained by drying by drying in an electric oven.

Table 3. Average mineral content of green banana peel flour

Mineral (mg/100g)	**Green banana peel flour**
K	1096,47 ± 0,08
Zn	622,78 ± 0,03
Ca	202,03 ± 0,01
P	134,09 ± 0,04
S	99,47 ± 0,02
Mg	81,87 ± 0,1
Fe	27,11± 0,03
Cu	4,91 ± 0,00
Mn	3,20 ± 0,01

The potassium value quantified in this study was 1096.47 mg/100g, thus the green banana peel flour is considered a rich source of this mineral.

The highest concentrations of minerals present in the green banana peel flour followed the following order: K>Zn>Ca>P>S>Mg>Fe>Cu>Mn. Manganese being the mineral present in lower concentrations (3.20 mg/100g). Sabino et al. (2017), evaluated the macromineral content of flours produced from fruit peel, finding 427.0 for pineapple peel flour; 43.55 and 22.80 mg/100g, respectively for K, Ca and Mg.

For papaya peel flour the contents were 485.00; 86.80 and 29.60 mg/100g, respectively for K, Ca and Mg. Table 4 shows the mean values obtained for the total phenolic compounds and for the antioxidant activity of the green banana.

Table 4. Total phenolic compounds and antioxidant activity of green banana peel flour

Parameters	Green banana peel flour
Total phenolic compounds (mgGAE/100g)	59.31 ± 2.54
DPPH antioxidant activity (μmol Trolox/g)	19.82 ± 6.21

The green banana peel flour had a phenolic content of 59.31 mgGAE/100g. Values lower than those in the present study were reported by Castelo-Branco et al. (2017) in their studies with green banana pulp flour (32.90 mgGAE/100g) and for green banana peel flour (40.30 mgGAE/100g), this difference can be explained by the banana varieties used and the Phenolic extraction method. The antioxidant activity by free radical capture (DPPH) for the flour in the present study was 19.82 μmol Trolox/g. Kotovicz et al. (2021) when evaluating the antioxidant activity of dwarf banana peel extracts obtained by maceration, they observed that the extracts obtained presented good total antioxidant activity, and the hydroalcoholic extracts presented greater activity.

In Figure 2, it is possible to observe the breads made with green banana peel flour in which the flour composition is shown in Table 2.

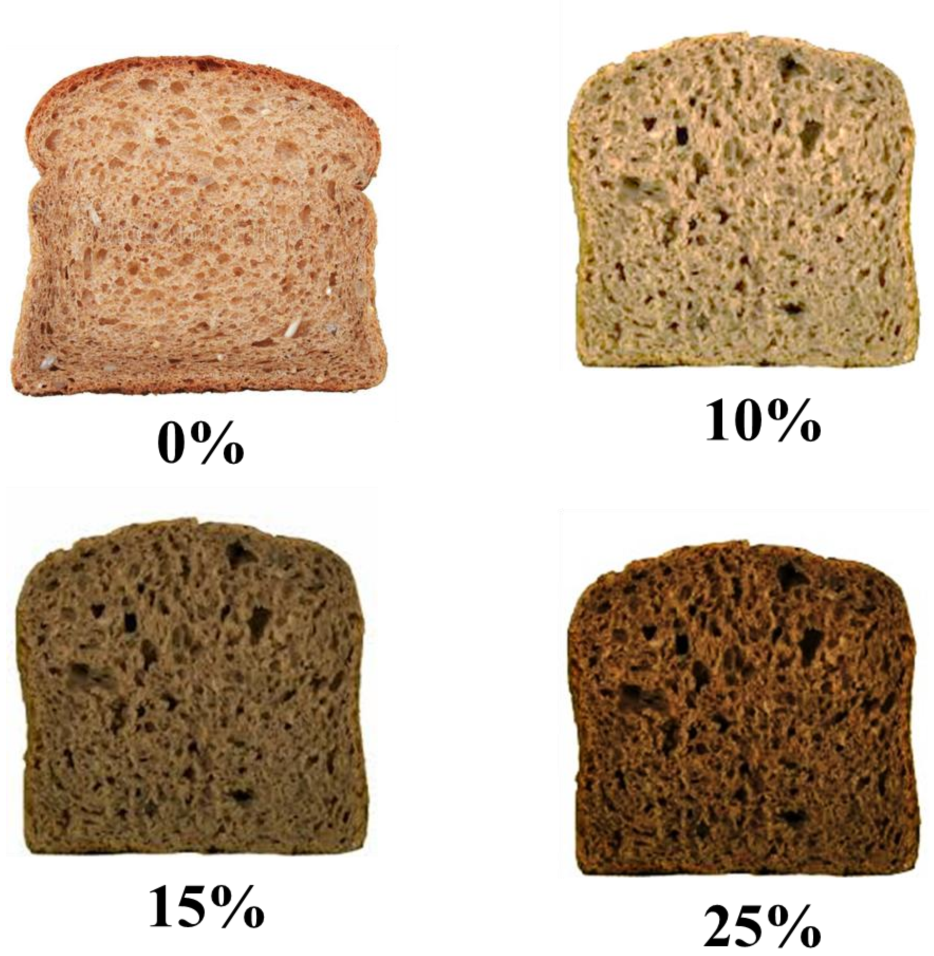

Figure 2. Loaf of bread made with green banana peel flour and whole wheat flour.

Through Figure 2, it is possible to visualize differences in the colors of the breads when there was an increase in the concentration of green banana peel flour. In which, the darkest crumb was bread with 25% banana flour. The characterizations of the loaves made with whole wheat flour and green banana peel flour are presented in the following Tables.

In Table 4, the results obtained for the moisture content can be seen.

Statistically significant differences were obtained for the moisture content, when compared to the formulations among themselves, which presented mean values ranging from 28.14 to 36.42%. Values close to those of the present study were reported in the literature by Alves et al. (2021) when making loaves with palm flour, they obtained moisture content ranging from 28.29 to 30.47% and by Santos et al. (2018) when they made whole breads enriched with papaya by-product flour, which had a moisture content of 33.66%.

Table 4. Moisture content of loaf breads made with green banana peel flour and whole wheat flour

Formulation	Moisture (%)
0%	28.14 ± 0.10d
10%	30.76 ± 0.09c
15%	33.63 ± 0.04b
25%	36.42 ± 0.02a

Note: Different letters in the same column differ significantly by Tukey's test.

Table 5 shows the results obtained for the ash content of the developed bread formulations.

Table 5. Ash content of sliced breads made with green banana peel flour and whole wheat flour

Formulation	Ashes (%)
0%	1.21 ± 0.01d
10%	1.77 ± 0.12c
15%	2.34 ± 0.04b
25%	2.98 ± 0.02a

Note: Different letters in the same column differ significantly by Tukey's test.

The ash content showed an increase in its values from 1.21 to 2.98% when there was an increase of up to 25% in the green banana peel flour. These values obtained were significantly different when the Tukey test was applied. Values close to those of the present study were reported by Castelo-Branco et al. (2017), which obtained ash content ranging from 1.51 to 2.96% for pasta made with green banana pulp and peel flour. And by, Vilhalva et al. (2011), in cassava flour-based breads, which reported an average ash content of 3.0%. Table 6 shows the results obtained for the lipid content of the developed bread formulations.

Table 6. Lipid content of sliced breads made with green banana peel flour and whole wheat flour

Formulation	Lipids (%)
0%	3.15 ± 0.11a
10%	2.76 ± 0.09b
15%	2.13 ± 0.03c
25%	1.36 ± 0.04d

Note: Different letters in the same column differ significantly by Tukey's test.

Regarding the lipid content, a reduction in the values of this parameter was observed when there was an increase in the concentration of green banana peel flour. In which, the control formulation (0%) presents 3.15% and the formulation with 25% green banana peel flour presents 1.36%, presenting a 1.79% reduction in the lipid content.

The values obtained were statistically different from each other. Constantino and Lopes (2019), when preparing loaf breads with different concentrations of a mixed flour composed of passion fruit albedo and jabuticaba peel, obtained lipid contents ranging from 2.26 to 3.66%. Table 7 shows the results obtained for the protein content of the developed bread formulations.

Table 7. Protein content of loaf breads made with green banana peel flour and whole wheat flour

Formulation	Proteins (%)
0%	6.91 ± 0.12c
10%	7.02 ± 0.21c
15%	7.93 ± 0.03b
25%	8.33 ± 0.04a

Note: Different letters in the same column differ significantly by Tukey's test.

The protein content showed values ranging from 6.91 to 8.33%, however, statistically, the control formulations did not show significant differences when compared to the formulation with 10% green banana peel flour.

Values higher than those in the present study were reported by Borges et al. (2013), in which they reported protein levels between 12.43 and 14.32% in their studies with breads made with mixed wheat and quinoa flour and by Santos et al. (2018) who, when making whole breads enriched with papaya by-product flour, obtained a protein content of 12.71%. Table 8 shows the results obtained for the total carbohydrate content of the elaborate breads.

Table 8. Total carbohydrate content of sliced breads made with green banana peel flour and whole wheat flour

Formulation	Carbohydrates (%)
0%	60.59 ± 0.11a
10%	57.69 ± 0.21b
15%	53.97 ± 0.16c
25%	50.91± 0.09d

Note: Different letters in the same column differ significantly by Tukey's test.

Regarding the content of total carbohydrates, it is observed that the values were reduced when there was an increase in the concentration of banana flour, these values were reduced from 60.59 to 50.91% when the percentage of flour increased by up to 25%.

Statistically the reduction of this parameter was significantly different. This same behavior was also observed by Constantino and Lopes (2019) when making loaves with different concentrations of a mixed flour composed of passion fruit albedo and jabuticaba peel, where the carbohydrate content reduced from 65.30% to 48.60%.

In Table 9, it is possible to observe the results obtained for the parameter of firmness of the elaborate breads.

Table 9. Firmness of loaf breads made with green banana peel flour and whole wheat flour

Formulation	Firmness (N)
0%	15.54 ± 0.73d
10%	19.30 ± 0.62c
15%	25.31 ± 0.31b
25%	29.17 ± 0.44a

Note: Different letters in the same column differ significantly by Tukey's test.

It is observed that and the addition of banana flour gave greater firmness to the breads, where the higher the percentage of banana flour in the formulation, the greater the firmness of the bread. Firmness values ranging from 15.54 to 29.17 N were statistically significantly different at the 5% probability level.

Constantino and Lopes (2019) when making loaf breads with different concentrations of a mixed flour composed of passion fruit albedo and jabuticaba peel, obtained firmness values ranging from 24.20 to 107.42N and after 7 days of bread production these values were from 31.10 to 131.75N. According to Santos et al. (2018), the texture for baked products is dependent on the formulation, with regard to the quality of the flour; amount of sugars, fats, emulsifiers, enzymes and even the addition of gluten and flour improvers; dough moisture, and conservation.

Table 10 shows the results obtained for the microbiological evaluation of the breads, in relation to the parameters of coliforms at 35 and 45°C, E. coli and Salmonela spp.

Table 10. Results of the microbiological evaluation of buns made with green banana peel flour and whole wheat flour

Parameters	**Formulations**			
	0%	**10%**	**15%**	**25%**
Coliforms 35 °C (NPM/g)	<3.0	<3.0	<3.0	<3.0
Coliforms 45 °C (NMP/g)	<3.0	<3.0	<3.0	<3.0
E. *coli*	Absence	Absence	Absence	Absence
Salmonella spp.	Absence	Absence	Absence	Absence

Note: NMP: Most Likely Number of Microorganisms.

The addition of green banana peel flour to bread was shown to be safe from a microbiological point of view. In all formulations, the presence of E. coli and Salmonella spp. Lima et al. (2021) when making breads enriched with eggshell flour, they also obtained an absence of E. coli and Salmonela spp. in your products. Thus, breads made with green banana peel flour are safe for consumption and acceptable in terms of hygienic-sanitary quality parameters.

Conclusion

Through the results obtained, it can be concluded that:

The drying of green banana peels in an electric oven was efficient, since the flours had low moisture content;

Potassium (K) and zinc (Zn) were the minerals present in the highest concentration in the flour;

The replacement of whole wheat flour by green banana peel flour significantly increased the parameters of: moisture, ash, proteins and firmness, on the other hand, promoted a reduction in total lipids and carbohydrates;

The replacement with 25% of green banana peel flour promoted a greater dark tone to the bread crumb;

Through microbiological analysis, the breads made are microbiologically safe for consumption.

References

ALVES, S. A.; CONSTANT, P. B. L.; TELES, A. R. S. Avaliação físico-química e sensorial de pão de forma elaborado com farinha de palma forrageira (*Opuntia ficus-indica*). Research, Society and Development, v.10, n.11, e14101119433, 2021.

APHA. American Public Health Association. Compendium of methods for the microbiological examination of foods. 4th ed. Washington: APHA, 2001. 516p.

ANDRADE, B. A.; PERIUS, D. B.; MATTOS, N. V. D.; LUVIELMO, M. D. M.; MELLADO, M. S. Produção de farinha de banana verde (*Musa spp.*) para aplicação em pão de trigo integral. Brazilian Journal of Food Technology, v.21, e2016055, 2018.

BATTOCHIO, J. R.; CARDOSO, J. M. P.; KIKUCHI, M.; MACCHIONE, M.; MODOLO, J. S.; PAIXÃO, A. L.; PINCHELLI, A. M.; DA SILVA, A. R.; DE SOUSA, V. C.; WADA, J. K. A.; WADA, J. K. A.; BOLINI, H. M. A. Perfil sensorial de pão de forma integral. Ciência e Tecnologia de Alimentos, v.26, n.2, p.428-433, 2006.

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

BORGES, J. T. S.; VIDIGAL, J. G.; SILVA, N. A. S.; PIROZI, M. R.; PAULA, C. D. Caracterização físico-química e sensorial de pão de forma contendo farinha mista de trigo e quinoa. Revista Brasileira de Produtos Agroindustriais, v.15, n.3, p.305-319, 2013.

BRASIL. Instituto Adolfo Lutz. Métodos físico-químicos para análise de alimentos. 4th ed. v.1, São Paulo: Instituto Adolfo Lutz, 2008. 1020p.

BRASIL. Agência Nacional de Vigilância Sanitária. Resolução RDC nº 263, de 22 de setembro de 2005.

CARNEIRO, T. S.; DE OLIVEIRA, G. L. S.; DOS SANTOS, J.; CONSTANT, P. B. L.; CARNELOSSI, M. A. G. Avaliação da farinha de banana verde com aplicação de antioxidantes. Brazilian Journal of Development, v.6, n.5, e28634, 2020.

CASTELO-BRANCO, V. N.; GUIMARÃES, J. N.; SOUZA, L.; GUEDES, M. R.; SILVA, P. M.; FERRÃO, L. L.; ZAGO, L. Uso da farinha de polpa e de casca de banana verde (*Musa balbisiana*) como ingrediente para a elaboração de massa tipo talharim. Brazilian Journal of Food Technology, v.20, n.2, e2016119, 2017.

CONSTANTINO, J. S. F.; LOPES, J. D. Desenvolvimento de pão de forma contendo farinha mista de maracujá e jabuticaba. As Ciências Biológicas e da Saúde na Contemporaneidade. 2, p. 137-142, Atena Editora, 2019.

DINIZ, E. P. U. Caracterização físico-química da biomassa de banana verde, para aplicação em pão de forma. 39f. Trabalho de Conclusão de Curso (Graduação em Engenharia de Alimentos). Universidade Tecnológica Federal do Paraná. Campo Mourão, 2019.

FAO. Food and Agriculture Organization of the United Nations. Food Energy: Methods of Analysis and Conversion Factors. Report of a Technical Workshop. Food and Nutrition Paper Volume 77. FAO: Rome, Italy, 2003.

HANAFI, F. N. A; KAMARUDING, N. A.; SHAHARUDDIN, S. Influência da fibra alimentar de resíduo de coco na capacidade físico-química, probiótica (*Lactobacillus plantarum* ATCC 8014) e atributos sensoriais de sorvete probiótico. LWT, v.154, p.112725, 2022.

KOTOVICZ, V.; LEINECKER, R.; BARBOSA, M.; KRUGER, R.; MESOMO, M. C. Avaliação da atividade antioxidante de extratos de casca de banana nanica obtidos por maceração. Revista em Agronegócio e Meio Ambiente, v.14, n.2, p.269-275, 2021.

LIMA, A. R.; COSTA, J. C.; AMORIM, M. M. A.; ROCHA, I. T.; FARIA, R. C.; DA SILVA, J. F.; MONTEZE, N. M. Qualidade sensorial, nutricional e microbiológica do pão enriquecido com casca de ovo. Research, Society and Development, v.10, n.10, e579101019122, 2021.

MARCON, L. S. S. Elaboração e caracterização da farinha de cascas de poncã. Trabalho de Conclusão de Curso. Universidade Tecnológica Federal do Paraná. 2021.

MARIA DO SOCORRO, M. R.; ALVES, R. E.; DE BRITO, E. S.; PÉREZ-JIMÉNEZ, J.; SAURA-CALIXTO, F.; MANCINI-FILHO, J. Bioactive compounds and antioxidant capacities of non–traditional tropical fruits from Brazil. Food Chemistry, v.121, n.4, p.996–1002, 2010.

MIRANDA, P. S. M.; LIMA, R. L.; OLIVEIRA, V. T. L.; LUZ, A. B. S. Preparações culinárias elaboradas com farinha das sementes de melão cantaloupe: estudo piloto. Revista Ciência Plural, v.7, n.3, p.43-60, 26, 2021.

MORAIS, L. K. Desenvolvimento, caracterização físico-química e sensorial de biscoitos tipo “cookies” obtidos a partir da farinha da semente de abóbora (*Cucurbita maxima*). Monografia. Universidade Federal de Campina Grande. Cuité.

NASCIMENTO, A. C.; SANTIAGO, S.; SANTOS, M.; MESQUITA-BASTOS, J.; SILVA, J. G. D.; CALHAU, M. A. Pão do norte de Portugal: um estudo interventivo com vista a reduzir o teor de sal no pão. Alimentação e Nutrição, v.24, n.5, p.28-30, 2019.

OLIVEIRA, A. P. D.; DE OLIVEIRA, T. J. A.; SANTOS, T. M. B.; DIAS, F. S. Sorvete simbiótico de leite de cabra com umbu fortificado com bactérias ácido-lácticas de queijo de cabra autóctone. LWT, v.141, p.110888, 2021.

OLIVEIRA, D. R.; DE ANDRADE, A. P. C. Elaboração de pão de forma adicionado de yacon. Research, Society and Development, v.9, n.8, e230985481, 2020.

OLIVEIRA, M. C. Aceitabilidade sensorial de barras de cereais elaboradas com farinha da semente de mamão. Trabalho de Conclusão de Curso. Curso Superior de Tecnologia em Alimentos. Instituto Federal Goiano. Morrinhos, 2020.

PEREIRA, A. D. Desenvolvimento e avaliação sensorial de bolos e biscoitos utilizando como ingrediente a farinha de resíduo do caju (*Anacardium occidentale l.*). Tese (Doutorado). Curso de Nutrição. Universidade Federal do Rio Grande do Norte. Santa Cruz, 2016.

SABINO, L. B. S.; LIMA, A. C. S.; SOARES, D. J.; SILVA, L. M. R da; OLIVEIRA, L. S. de; FIGUEIREDO, R. W. de; SOUSA, P. H. M. de. Composição mineral de farinhas obtidas a partir de cascas de frutos tropicais baseado na ingestão diária recomendada. Brazilian Journal of Food Research, v.8 n.3, p.102-111, 2017.

SANTOS, C. M. D.; ROCHA, D. A.; MADEIRA, R. A. V.; QUEIROZ, E. D. R.; MENDONÇA, M. M.; PEREIRA, J.; ABREU, C. M. P. D. Preparação, caracterização e análise sensorial de pão integral enriquecido com farinha de subprodutos do mamão. Brazilian Journal of Food Technology, v.21, e2017120, 2018.

SARAWONG, C.; SCHOENLECHNER, R.; SEKIGUCHI, K.; BERGHOFER, E.; NG, P. K. Effect of extrusion cooking on the physicochemical properties, resistant starch, phenolic content and antioxidant capacities of green banana flour. Food Chemistry, v.143, p.33-39, 2014.

SILVA, A. C. C., SILVA, N. A., PEREIRA, M. C. S.,VASSIMON, H. S. Foods contendo ingredientes funcionais em sua formulação saudável: Uma revisão o artigo published em periódicos brasileiros. Revista Conexão Ciência, v.11, n.2, 2016.

SILVA, D. J.; QUEIROZ, A. C. Análise de alimentos: Métodos químicos e biológicos. 3a ed. Universidade de Viçosa, 2002. 235p.

TORRES, L. L.; EL-DASH, A. A.; CARVALHO, C. W.; ASCHERI, J. L.; GERMANI, R.; MIGUEZ, M. Efeito da umidade e da temperatura no processamento de farinha de banana verde (*Musa acuminata*, grupo AAA) por extrusão termoplástica. Boletim do Centro de Pesquisa de Processamento de Alimentos, v.23, n.2, p.273-290, 2005.

VILHALVA, D. A. A.; SOARES JUNIOR, M.; MOURA, C. M. A.; CALIARI, M.; SOUZA, T. A. C.; SILVA, F. A. Aproveitamento da farinha de casca de mandioca na elaboração de pão de forma. Revista do Instituto Adolfo Lutz, v.70, n.4, p.514-521, 2011.

WATERHOUSE, A. Folin-ciocalteau micro method for total phenol in wine. American Journal of Enology and Viticulture, v.48, p.357-363, 2006.

ELABORATION AND CHARACTERIZATION OF ICE CREAM ADDED FROM JABUTICABA *(Myrciaria Cauliflora)* LYOPHILLED HULL FLOUR

Virgínia Mirtes de Alcântara Silva

Newton Carlos Santos

Raphael Lucas Jacinto Almeida

Victor Herbert de Alcântara Ribeiro

Juliana Cruz Albuquerque

Rosenildo dos Santos Silva

Jonnathan Silva Nunes

Introduction

Jabuticaba (*Myrciaria cauliflora*) is a fruit of the Myrtaceae family, widely distributed in the Brazilian territory, and is presented in the form of a globose berry, with up to 3 cm in diameter, reddish almost black rind, whitish, mucilaginous, bittersweet pulp, tasty, commonly single seed (LEMOS et al., 2019).

The industrial by-products of fruits and vegetables consist mainly of: peel, bagasse fractions and seeds, which can be a good source of bioactive compounds, in addition to containing carbohydrates, dietary fibers, flavoring compounds and phytochemicals in their composition. Usually the peels are discarded, corresponding to about 30% to 43% of the fruit, generating large amounts of waste and causing environmental impact due to excessive release into the environment (MARSIGLIA et al., 2021).

According to Almeida et al. (2020), one of the ways of reusing this waste is its transformation into powder, through the freeze-drying process. Freeze drying is considered to be one of the best drying methods, as it allows the maintenance of the organoleptic and nutritional properties of foods. The method consists of freezing the product followed by dehydration, which occurs through the sublimation process, providing a reduction in the water content and consequently minimizing the occurrence of most reactions that cause the degradation of the product (DUARTE et al., 2017).

Research has advanced using fruit flour: mango peel flour (PEDROSA et al., 2015); pineapple peel flour (CARNEIRO et al., 2020); pumpkin peel flour (SILVA, 2019); umbu-cajá flour (SILVA et al., 2019).

The constant demand for healthier food is making food industries look for different ingredients to add to the food produced. Frozen dairy desserts, such as ice cream, are consumed worldwide and for this reason they can be added with functional ingredients, thus promoting their nutritional enrichment (LAMOUNIER et al., 2015).

Ice cream is a product with good sensory acceptance, appreciated by people of all ages and social classes, being considered a dessert widely consumed in Brazil. Despite these characteristics, it has a high energy density, with a high content of trans and saturated fatty acids, which limits its consumption in most diets prescribed by nutritionists. The quality of ice cream depends on the quality of the ingredients used and the balance between the components, including the amount of total solids, fats, sugars, stabilizers, emulsifiers and flavors. Other characteristics include cost, viscosity, freezing point, aeration rate, appearance, taste, texture and nutritional value (DUARTE et al., 2021).

In this context, the present study aims to elaborate and characterize the freeze-dried jabuticaba peel flour and to develop ice cream formulations added to this flour, in addition, the elaborated ice creams were also characterized in terms of physical and proximate parameters.

Metodology

Preparation of jabuticaba peel flour

To prepare the flour, jabuticaba (*Myrciaria cauliflora*) peels were used. The steps for its production can be seen in Figure 1.

Figure 1. Main steps for the preparation of freeze-dried jabuticaba peel flour

Initially, the jabuticabas were sanitized, sanitized (sodium hypochlorite 200ppm) and washed in running water. After this step, they were manually pulped. The husks were subjected to an initial stage of freezing in a freezer for 48 hours at a temperature of -18°C. After freezing, the husks were transferred to a benchtop lyophilizer and subjected to drying at a temperature of -50°C for 48 hours. The dried husks were crushed in a domestic blender for 3 min and the powder obtained was standardized, using a 60 mesh sieve.

Characterization of jabuticaba peel flour

Centesimal composition

(1) Moisture content was determined by drying in an oven at 105°C until constant weight (BRASIL, 2008);

(2) Ash content was determined by incineration in a muffle (BRAZIL, 2008);

(3) Total protein content was quantified by the Micro-Kjeldahl method, which consisted of the determination of total nitrogen according to the methodology described by Brasil (2008);

(4) Lipid content was quantified by the modified method of Blig and Dyer (1959);

(5) Crude fiber content was quantified by digestion with an acid solution by the method of Silva and Queiroz (2002); and

(6) Total carbohydrate content was calculated by difference to obtain 100% of the total composition (FAO, 2003).

Mineral profile

The mineral profile was determined through the ash using an Energy Dispersive X-Ray Fluorescence Spectrometer, model EDX-720 (Shimadzu, Kyoto, Japan) using liquid nitrogen.

Bioactive compounds

Total phenolic compounds totais

Total phenolic compounds were quantified by the Folin-Ciocalteau method described by Waterhouse (2006), using gallic acid as a standard. Water and methanol were used as extraction solvents. The calculations performed for the determination of phenolic compounds were based on a standard curve with gallic acid, and the readings were made in a spectrophotometer at 765 nm, with results expressed in mg/100 g of gallic acid.

Total anthocyanins

The method used to read total anthocyanins was the single pH method described by Francis (1982). The method consists of carrying out a quantitative transfer of an aliquot of the concentrated extract to a recipient and then this aliquot is diluted with an amount of Ethanol – HCl solution at 1.5 mol.L^{-1}, thus having a volume of diluted extract. The amount of total anthocyanins was calculated by Equation 1.

$$Ant_{mg} = \frac{Abs_{535} \times V_{ec} \times V_{ed} \times 1000}{V_{alq} \times m \times 982} \quad \text{(Eq.1)}$$

Where: Ant_{mg} is the amount of total anthocyanins expressed in mg of anthocyanins per 100 grams of sample (mg/100); Abs_{535} is the absorbance read from the diluted extract at 535 nm; V_{ec} is the volume of the concentrated extract (mL); V_{ed} is the diluted extract volume (mL); V_{alq} is the volume of the aliquot taken from the concentrated extract to make the diluted extract (mL); m is the mass of the beverage used to carry out the extraction; The value of 982 is the extinction coefficient for anthocyanins.

Antioxidant activity

The antioxidant activity of DPPH• was performed according to the methodology described by Maria do Socorro et al. (2010) with adaptations. Antioxidant activity (ABTS) was determined by the method proposed by Re et al. (1999), with modifications made by Rufino et al. (2007).

Ice cream making

The ice creams were prepared using freeze-dried jabuticaba peel flour, the proportions and ingredients used are described in Table 1. The ice cream production followed the procedures described by Detoni (2020).

Table 1. Formulations of ice cream added with freeze-dried jabuticaba husk flour

Ingredients	Control 0%	10%	20%
Crystal Sugar	14%	14%	14%
Emustab	0.1%	0.1%	0.1%
Neutral Alloy	0.03%	0.03%	0.03%
Vegetable fat	5%	5%	5%
UHT whole milk	100ml	100ml	100ml
glucose syrup	6%	6%	6%
Jabuticaba bark flour	0%	10%	20%

Note: Ingredients added based on 100 mL of whole milk. Source: Adapted from Detoni (2020).

To produce the ice cream, the first step was to heat the milk with vegetable fat. The dry ingredients (sugar and neutral alloy stabilizer) were mixed separately and added to the milk after the complete dissolution of the fat. Glucose was added, homogenizing the mixture.

The syrup was pasteurized at a temperature of 80ºC for 15 s and cooled in an ice-water bath to 30ºC. Afterwards, the emulsifier Emustab was added and homogenized in an industrial blender for 5 min. The syrup was placed in a container with a lid and aged for 12 h in a cooling chamber at a temperature of 10ºC. The mixture was placed in an ice cream maker to beat for approximately 25 min, until the point where the ice cream was consistent enough not to come off the spatula. The ice cream was removed from the ice cream maker, placed in a plastic container with a lid and taken to freeze in a freezer at –18 ºC until the analysis was performed (DETONI, 2020).

Overrun (%)

Overrun was determined according to the method described by Whelan et al. (2008). Equal volumes (50 mL) of ice cream were weighed and the overrun was calculated.

Water activity

Water activity (a_w) was determined using the Decagon® Aqualab CX-2T device at 25°C

Proximate composition

The proximate parameters were determined as described in item.

Statistical analysis

The experimental data were analyzed in triplicate and the results were submitted to the analysis of variance of a single factor (ANOVA) of 5% probability and the significant qualitative responses were submitted to the Tukey test, adopting the same level of 5% of significance. For the development of statistical analysis, the Assistat 7.7 software was used (SILVA & AZEVEDO, 2016).

Results

Table 2 shows the mean values obtained for the proximate composition of the jabuticaba bark flour obtained by freeze-drying.

The jabuticaba bark flour had 9.54% moisture. Ferreira et al. (2012), found a moisture content of 12.05% for jabuticaba flour. Oliveira et al. (2021) obtained 8.24% moisture for banana peel flour. The ash content obtained was 2.96%. A higher value than the present study was reported by Leite-Legatti et al. (2012) who found 4.23% for jabuticaba bark dried in a forced air oven and a value lower than that of the present study was observed by Constantino and Lopes (2019) who obtained 1.98%.

Table 2. Proximate composition of freeze-dried jabuticaba peel flour

Parameters (%)	Jabuticaba bark flour
Moisture	9.54 ± 0.14
ash	2.96 ± 0.21
Lipids	1.75 ± 0.18
proteins	5.87 ± 0.56
raw fiber	5.02 ± 1.03
Carbohydrates	74.86 ± 0.66

In relation to the contents of lipids and proteins, the freeze-dried jabuticaba peel flour presented 1.75 and 5.87%, respectively. The crude fiber content obtained was 5.02%. Almeida et al. (2020) obtained crude fiber content of 4.50% for bark dried at 60°C and 4.93% for freeze-dried bark. The lyophilized jabuticaba peel flour had carbohydrate as the main macronutrient (74.86%).

Table 3 shows the mean values obtained for the mineral profile of the jabuticaba peel flour, obtained by freeze-drying.

Table 3. Mean mineral content of freeze-dried jabuticaba peel flour

Mineral (mg/100g)	Jabuticaba bark flour
K	1963.34 ± 0.04
Ca	267.96 ± 0.02
P	184.09 ± 0.01
S	106.54 ± 0.03
Fe	21.67 ± 0.01
Zn	9.14 ± 0.02
Mn	8.65 ± 0.03
Cu	4.10 ± 0.01
Rb	3.17 ± 0.01

The mineral content found in greater quantity was K (1963.34 mg/100g), followed by Ca, P, S, Fe, Zn, Mn, Cu and Rb. Constantino and Lopes (2019) when producing jabuticaba peel flour at a temperature of 60°C, obtained the following mineral contents: potassium (1650mg/100g), calcium (144 mg/100g), phosphorus (93 mg/100g) and sulfur (71mg/100g). Asheri et al. (2006), when studying the characterization of jabuticaba bagasse, finding equivalent amounts of potassium (1273.12 mg/100 g).

Table 4 shows the results obtained for total phenolic compounds, total anthocyanins and antioxidant activity of freeze-dried jabuticaba peel flour.

Table 4. Total phenolic compounds, total anthocyanins and antioxidant activity of freeze-dried jabuticaba peel flour

Parameters	Jabuticaba bark flour
Total phenolic compounds (mgGAE/100g)	992.94 ± 5.12
Total anthocyanins (mg/100g)	102.38 ± 1.01
DPPH antioxidant activity (µmol Trolox/g)	213.08 ± 7.44
ABTS+ antioxidant activity (µmol Trolox/g)	264.97 ± 10.47

The jabuticaba bark flour had a high content of total phenolic compounds (992.94 mgGAE/100g) and 102.38 mg/100g of total anthocyanins. Values lower than those in the present study were reported by Almeida et al. (2020), who obtained the jabuticaba bark flour by means of convective drying at a temperature of 50°C, observed the following levels of 887.33 mgGAE/100g of total phenolic compounds and 84.83 mg/100g of total anthocyanins. These differences may be mainly related to the drying technique used.

The antioxidant activity of the flour produced was evaluated using two different methods, DPPH and ABTS+, through Table 4, it was possible to observe that the free radical capture method by ABTS+ had a higher mean value of 264.97 µmol Trolox/g compared to the DPPH method that presented 213.08 µmol Trolox/g. According to Beltran et al. (2021) the antioxidant activity is related to the concentration of bioactive compounds, such as the content of anthocyanins, ascorbic acid and other phenolic compounds.

In Figure 2, it is possible to visualize the formulations of ice creams made without addition (0%) and with the addition of freeze-dried jabuticaba peel flour (10 and 20%).

Figure 2. Ice cream prepared without addition (0%) and with the addition of freeze-dried jabuticaba peel flour (10 and 20%).

Through Figure 2, it is possible to visualize differences in the colors of ice creams when there was an increase in the concentration of freeze-dried jabuticaba peel flour. In which, the most intense and notorious coloration, mainly in the formulation with 20% flour. The characterizations of the ice creams made without addition (0%) and with the addition of freeze-dried jabuticaba peel flour (10 and 20%) are presented in the following Tables.

Table 5 shows the results obtained for the ice cream overrum.

Table 5. *Overrum* of ice cream formulations developed without addition (0%) and with addition of freeze-dried jabuticaba peel flour (10 and 20%)

Formulation	***Overrun* (%)**
0%	83 ± 0.25^{a}
10%	72 ± 0.64b
20%	69 ± 0.41c

The overrum percentages obtained for the developed formulations ranged from 69 to 83%, with statistically significant differences at the 5% probability level. The highest percentage of overrum was obtained for the formulation with 0% jabuticaba peel flour, however, it was observed that the increase in the concentration of flour in the formulations promoted a reduction in this parameter, according to

Lamounier et al. (2015), this behavior may be related to the decrease in free water available in ice cream.

Table 6 shows the results obtained for water activity (aw) of ice creams made without addition (0%) and with the addition of freeze-dried jabuticaba peel flour (10 and 20%).

Table 6. Water activity of ice cream formulations developed without addition (0%) and with addition of freeze-dried jabuticaba peel flour (10 and 20%)

Formulation	Water activity (a_w)
0%	0.920 ± 0.01[a]
10%	0.919 ± 0.02a
20%	0.915 ± 0.01a

Note: Different letters in the same column differ significantly by Tukey's test.

There was a non-significant reduction in the water activity of elaborate ice creams, this reduction being from 0.920 to 0.915. The lowest water activity value was observed for the formulation with 20% jabuticaba bark flour, corroborating the result obtained for the overrum shown in Table 5.

Table 7 shows the results obtained for the moisture content of ice creams made without addition (0%) and with the addition of freeze-dried jabuticaba peel flour (10 and 20%).

Table 7. Moisture content of ice creams made with freeze-dried jabuticaba peel flour

Formulation	Moisture (%)
0%	71.34 ± 0.20a
10%	69.26 ± 0.04b
20%	62.15 ± 0.13c

Note: Different letters in the same column differ significantly by Tukey's test.

The moisture content of the developed formulations showed a reduction in its values from 71.34% to 62.15% when there was an increase in the concentration of freeze-dried jabuticaba peel flour from 0% to 20%, this reduction was statistically significant. Values lower than those in the present study were reported by Oliveira et al. (2019) who, when developing ice cream added with orange albedo flour, observed moisture content ranging from 58.9 to 60.80%.

Table 8 shows the results obtained for the ash content of ice creams made without addition (0%) and with the addition of freeze-dried jabuticaba peel flour (10 and 20%).

Table 8. Ash content of ice creams made with freeze-dried jabuticaba husk flour

Formulation	Ashes (%)
0%	0.51 ± 0.01c
10%	0.96 ± 0.06b
20%	1.74 ± 0.02a

Note: Different letters in the same column differ significantly by Tukey's test.

The increase in jabuticaba peel flour in ice cream formulations significantly increased the ash content, which varied from 0.51 to 1.74%. Values lower than those in the present study were reported by Morzele et al. (2012), when developing ice creams with fruits from the cerrado, they obtained ash contents of 0.42% (araticum ice cream), 0.49% (mangaba ice cream), 0.55% (pequi ice cream) and 0.44% (curriola ice cream).

Table 9 shows the results obtained for the lipid content of ice creams made without addition (0%) and with the addition of freeze-dried jabuticaba peel flour (10 and 20%). According to Oliveira et al. (2019) the lipid, found in conventional ice cream, guarantees greater softness, creaminess, durability and reduced cold sensation.

Table 9. Lipid content of ice creams made with freeze-dried jabuticaba peel flour

Formulation	Lipids (%)
0%	10.22 ± 0.29a
10%	8.06 ± 0.13b
20%	6.91 ± 0.15c

Note: Different letters in the same column differ significantly by Tukey's test.

The lipid content of the developed formulations decreased when there was an increase in the concentration of jabuticaba peel flour. This reduction was up to 3.31%

when the percentage of flour varied by up to 20%. Statistically, this reduction was significant when the Tukey test was applied. This same behavior was also reported by Boff et al. (2013) who, when developing chocolate ice cream using orange peel fiber as a fat substitute, obtained lipid levels ranging from 5.29 to 18.53% (control). Rodrigues et al. (2018) obtained lipid content ranging from 5.35 to 5.75% for ice cream made with açaí pulp and whey protein.

Table 10 shows the results obtained for the protein content of ice creams made without addition (0%) and with the addition of freeze-dried jabuticaba peel flour (10 and 20%).

Table 10. Protein content of ice creams made with freeze-dried jabuticaba peel flour

Formulation	**Proteins (%)**
0%	4.25 ± 0.01c
10%	4.98 ± 0.10b
20%	5.36 ± 0.04a

Note: Different letters in the same column differ significantly by Tukey's test.

The protein content of the formulations was significantly different from each other. It showed an increase trend, ranging from 4.25 to 5.36% when there was an increase of up to 20% in jabuticaba peel flour. Silva et al. (2021) when preparing ice cream with different concentrations of acerola pulp and goat milk, they obtained protein contents ranging from 6.12 to 4.88%. Melo et al. (2021) obtained protein content ranging from 3.34 to 5.80% for ice cream made with umbu and mangaba pulp.

Table 11 shows the results obtained for the total carbohydrate content of ice creams made without addition (0%) and with the addition of freeze-dried jabuticaba peel flour (10 and 20%).

Table 11. Total carbohydrate content of ice creams made with freeze-dried jabuticaba peel flour

Formulation	Carbohydrates (%)
0%	13.68 ± 0.17c
10%	16.74 ± 0.23b
20%	23.84 ± 0.11a

Note: Different letters in the same column differ significantly by Tukey's test.

The formulation with 20% of jabuticaba bark flour had the highest amount of total carbohydrates (23.84%), which may be associated with the proximate composition of this formulation, since it had the lowest moisture content. Statistically the formulations when compared to each other were significantly different at the 5% probability level. Fernandino et al. (2021) when preparing 4 ice cream formulations with 20 and 30% yellow tamarillo pulp and 20 and 30% with purple tamarillo pulp, they obtained carbohydrate contents of 24.75 and 26.33% for the ice cream with tamarillo pulp yellow and 27.44 and 23.55% for ice cream with purple tamarillo pulp, results superior to those found in the present study.

Conclusion

Through the results obtained, it could be concluded that:

The preparation of freeze-dried jabuticaba peel flour was viable for the reuse of residues from agribusiness;

The jabuticaba bark flour showed high levels of total phenolic compounds and good antioxidant activity;

Potassium and calcium were the minerals present in greater amounts;

The increase in the concentration of jabuticaba husk flour reduced moisture, water and lipid activity in the elaborate ice creams, in addition to promoting an increase in the content of ash, proteins and total carbohydrates;

The ice cream made met the requirements of healthier products, in addition to having added value to an agro-industry residue. .

References

ALMEIDA, R. L.; SANTOS, N. C.; DOS SANTOS PEREIRA, T.; DE ALCÂNTARA SILVA, V. M.; CABRAL, M. B.; BARROS, E. R.; DA SILVA, L. R. I. Determinação de compostos bioativos e composição físico-química da farinha da casca de jabuticaba obtida por secagem convectiva e liofilização. Research, Society and Development, v.9, n.1, e157911876, 2020.

ASCHERI, D. P. R.; ASCHERI, J. L. R.; CARVALHO, C. W. P. Caracterização da farinha de bagaço de jabuticaba e propriedades funcionais dos extrusados. Ciência e Tecnologia de Alimentos, v.16, n.4, 2006.

BELTRAN, L. B.; SOUZA, A. C.; MELONI, C. E. P.; MAGIERO, P. E.;BERGAMASCO, R.; VIEIRA, A. M. S. Avaliação da capacidade antioxidante e propriedades tecnológicas da farinha do fruto da Palmeira *Aiphanes Aculeata*. Brazilian Journal of Development, v.7, n.4, p.36868-36884, 2021.

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

BOFF, C. C.; CRIZEL, T. D. M.; ARAUJO, R. R. D.; RIOS, A. D. O.; FLÔRES, S. H. Desenvolvimento de sorvete de chocolate utilizando fibra de casca de laranja como substituto de gordura. Ciência Rural, v.43, p.1892-1897, 2013.

BRASIL. Instituto Adolfo Lutz. Métodos físico-químicos para análise de alimentos. 4th ed. v. 1. São Paulo: Instituto Adolfo Lutz, 2008. 1020p.

BRASIL. Agência Nacional de Vigilância Sanitária. Resolução RDC nº 263, de 22 de setembro de 2005.

CARNEIRO, W. S. F. R. Aproveitamento da farinha de casca de abacaxi *Ananas comosus* (L.) Merril para a elaboração de sorvete funcional probiótico. Dissertação (Mestrado em Nutrição).Universidade Federal de Pernambuco. Recife, 2020.

CONSTANTINO, J. S. F.; LOPES, J. D. Desenvolvimento de pão de forma contendo farinha mista de maracujá e jabuticaba. As Ciências Biológicas e da Saúde na Contemporaneidade 2, p. 137-142, Atena Editora, 2019.

DETONI, E. Sorvete próbiotico de guabijú (*myrcianthes pungens*): desenvolvimento, caracterização, avaliação de compostos bioativos e viabilidade de *lactobacillus paracasei*. 87f. Dissertação (Mestrado em Tecnologia de Alimentos). Universidade Tecnológica Federal do Paraná. Medianeira, 2020.

DUARTE, E. L.; CARLOS, L. A.; GONÇALVES, C. R.; DE ANDRADE, R. M.; DE OLIVEIRA, K. G. Influência da liofilização sobre os carotenoides de frutos do cerrado e comportamento higróscopico dos pós-liofilizados. Biológicas & Saúde, v.7, n.23, p.22-33, 2017.

DUARTE, Y. G.; DE REZENDE, A. J.; FORTES, R. C.; DA PAZ, R. D. C.; DA SILVA, B. N. Desenvolvimento e análise sensorial de sorvete de morango enriquecido com suplemento proteico (Whey Protein Isolado): um estudo experimental analítico. Brazilian Journal of Development, v.7, n.8, p.85185-85200, 2021.

FAO. Food and Agriculture Organization of the United Nations. Food Energy: Methods of Analysis and Conversion Factors. Report of a Technical Workshop; Food and Nutrition Paper Volume 77. FAO: Rome, Italy, 2003.

FERNANDINO, C. M.; NEPOMUCENO, A. T.; FONSECA, H. C.; BASTOS, R. A.; LIMA, J. P. D. Propriedades físico-químicas da polpa de tamarillo (*Solanum betaceum*) e sua aplicabilidade na elaboração de sorvetes. Brazilian Journal of Food Technology, v.24, e2020090, 2021.

FERREIRA, A. E.; FERREIRA, B. S.; LAGES, M. M. B.; RODRIGUES, V. A. F.; THÉ, P. M. P.; PINTO, N. A. V. D. Produção, caracterização e utilização da farinha de casca de jabuticaba em biscoitos tipo cookie. Alimentos e Nutrição, v.23, n.4, p.603-607, 2012.

LAMOUNIER, M. L.; DAS CHAGAS ANDRADE, F.; DE MENDONÇA, C. D.; MAGALHÃES, M. L. Desenvolvimento e caracterização de diferentes formulações de sorvetes enriquecidos com farinha da casca da jabuticaba (*Myrciaria cauliflora*). Revista do Instituto de Latícinios Cândido Tostes, v.70, n.2, p.93-104, 2015.

LEITE-LEGATTI, A. V.; BATISTA, Â. G.; DRAGANO, N. R. V.; MARQUES, A. C.; MALTA, L. G.; RICCIO, M. F.; JÚNIOR, M. R. M. Jaboticaba peel: Antioxidant compounds, antiproliferative and antimutagenic activities. Food Research International, v.49, n.1, p.596-603, 2012.

LEMOS, D. M.; ROCHA, A. P. T.; GOUVEIA, J. P. G.; OLIVEIRA, E. N. A.; SOUSA, E. P.; SILVA, S. F. Elaboration and characterization of jabuticaba and acerola prebiotic jelly. Brazilian Journal of Food Technology, v.22, e2018098, 2019.

MARIA DO SOCORRO, M. R.; ALVES, R. E.; DE BRITO, E. S.; PÉREZ-JIMÉNEZ, J.; SAURA-CALIXTO, F.; MANCINI-FILHO, J. Bioactive compounds and antioxidant capacities of non –traditional tropical fruits from Brazil. Food Chemistry, v.121, n.4, p.996–1002, 2010.

MARSIGLIA, W. I. M. L.; SANTIAGO, Â. M.; ALVES, H. G.; ALMEIDA, R. L. J.; SANTOS, N. C.; DE SOUSA MUNIZ, C. E.; DE ALMEIDA, M. M. Modelagem e simulação do processo de secagem das cascas de jabuticaba (*Myrciaria cauliflora*). Research, Society and Development, v.10, n.3, e21510313214, 2021.

MELO, C. S.; FERREIRA, I. M.; OLIVEIRA, A. M.; DE CARVALHO, M. G. Sorvete de umbu e mangaba com propriedade funcional: processamento e caracterização. Segurança Alimentar e Nutricional, v.28, e021028, 2021.

MORZELLE, M. C.; LAMOUNIER, M. L.; SOUZA, E. C.; SALGADO, J. M.; DE BARROS VILAS-BOAS, E. V. Caracterização físico-química e sensorial de sorvetes à base de frutos do cerrado. Revista do Instituto de Laticínios Cândido Tostes, v.67, n.387, p.70-78, 2012.

OLIVEIRA, F. B.; SANTIAGO, Â. M.; DE LIMA MARSIGLIA, W. I. M.; BARBOSA, A. G. A.; DOS SANTOS SILVA, M. C.; GOUVEIA, A. G. M.; DE ALMEIDA MOTA, M. M. Produção e caracterização da farinha da casca da banana. Research, Society and Development, v.10, n.8, e0910817017, 2021.

OLIVEIRA, N. A. D. S.; WINKELMANN, D. O. V.; TOBAL, T. M. Farinhas e subprodutos da laranja sanguínea-de-mombuca: caracterização química e aplicação em sorvete. Brazilian Journal of Food Technology, v22, e2018246, 2019.

PEDROSA, J. R.; SILVA, C. C. A.; SILVA, F. A; TERAN-ORTIZ, G. P. Avaliação sensorial do uso da farinha de casca da manga "Tommy Atkins" em sorvetes. In: Simpósio Latino Americano de Ciências de Alimentos, 2015, Campinas. Anais... Campinas, 2015.

RE, R.; PELLEGRINI, N.; PROTEGGENTE, A.; PANNALA, A.; YANG, M.; RICE-EVANS, C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radical Biology and Medicine, v.26, p.1231-1237, 1999.

RODRIGUES, J.; BEZERRA, J.; TEIXEIRA, A.; RIGO, M. Avaliação sensorial e físico-química de sorvete com polpa de açaí e proteína do soro do leite. Ambiência, Guarapuava, v.14, n.2, p.225-236, 2018.

RUFINO, M. S. M.; ALVES, R. E.; BRITO, E. S.; MORAIS, S. M.; SAMPAIO, C. D. G.; JIMENEZ, J. P.; CALIXTO, F. D. S. Metodologia científica: determinação da atividade antioxidante total em frutas pela captura do radical livre $ABTS^{o+}$. Embrapa Agroindústria Tropical-Comunicado Técnico (INFOTECA-E). 2007.

SILVA, L. G. O. C. Sorvete de iogurte sabor mangaba com adição de semente de abóbora. 36 f. Trabalho de Conclusão de Curso (Graduação de Tecnólogo em Alimentos). Instituto Federal de Sergipe. São Cristóvão, 2019.

SILVA, R. H. F. Elaboração e caracterização de farinha do resíduo de umbu-cajá (*spondias spp*.). 57f. Trabalho de Conclusão de Curso (Bacharelado em Engenharia de Alimentos). Universidade Federal Rural de Pernambuco. Garanhuns, 2019.

SILVA, V. M. A.; SANTOS, N. C.; ALMEIDA, R. L. J.; RIBEIRO, V. H. A.; SILVA, G. M.; QUEIROGA, A. P. R. de; BRITO, A. C. O. de. Preparation, physicochemical, bioactive and microbiological characterization of acerola (*Malpighia emarginata DC*) ice cream with goat's milk. In: SILVA, V. M. DE A. et al. (Org.). Acerola thermophysical properties, drying and new product development. 1ed. Campina Grande: EPTEC, 2021. p.40-53.

WATERHOUSE, A. Folin-ciocalteau micro method for total phenol in wine. American Journal of Enology and Viticulture, v.3, n.5, p. 357-363, 2006.

WHELAN, A. P. et al. Physicochemical and sensory optimisation of a low glycemic index ice cream formulation. International Journal of Food Science and Technology, v. 43, n. 9, p. 1520-1527, 2008.

DEVELOPMENT AND CHARACTERIZATION OF GREEK YOGHURT WITH DIFFERENT CONCENTRATIONS OF PUMPKIN JELLY AND CORN STARCH

Virgínia Mirtes de Alcântara Silva

Newton Carlos Santos

Raphael Lucas Jacinto Almeida

Victor Herbert de Alcântara Ribeiro

Juliana Cruz Albuquerque

Rosenildo dos Santos Silva

Jonnathan Silva Nunes

Introduction

Yogurt is the product obtained from the fermentation of milk, using mainly protosymbiotic cultures of Streptococcus salivarius subsp. Thermophilus and Lactobacillus delbrueckii subsp. Bulgaricus. Greek yogurt differs by having higher concentrations of proteins and fats and greater firmness and viscosity when compared to other similar products.

This distinction is due to the technological drainage process to which the product is submitted (SILVEIRA et al., 2016; BEZERRA et al., 2019). The consumption of yogurt is associated with several benefits to human health, such as facilitating the action of proteins and digestive enzymes and improving the absorption of calcium, phosphorus and iron. It is also considered an indirect alternative to milk consumption (MUNHOZ et al., 2018).

Therefore, the increase in yogurt consumption can be attributed to the growing concern of people with ingesting natural products and the benefits that food brings to the human body. There is also a tendency to add fruits and vegetables to dairy foods with the aim of improving the nutritional and sensory value of the final product, since fruits and vegetables are rich in bioactive compounds, such as vitamins, antioxidant compounds and fiber (BARBOSA & GALLINA, 2017).

Some researchers have already been carried out using fruit jelly: pitanga jelly (SILVA et al., 2020); passion fruit jelly (SILVIO et al., 2020); Cajá jelly (BRAGA et al., 2020) and pineapple jelly (VALADARES et al., 2017).

Among the existing vegetables, the pumpkin (*Cucurbita moschata Duch*) stands out for presenting in its composition several nutrients, such as B vitamins, vitamin C, dietary fiber and many minerals, such as potassium, phosphorus, calcium, sodium, magnesium, iron and chlorine. In addition, it also stands out for being considered a source of carotenoids, especially beta-carotene, which has provitamin A activity and gives the product a reddish-orange color and antioxidant properties (ANJOS et al., 2017).

Pumpkin is widely accepted in Brazil, especially in the Northeast region, where the vegetable is most consumed, in various ways: cooked or used as raw material in the preparation of products such as sweets, jams, jellies, purees, cakes and cookies. Jams represent an excellent alternative for the processing of fruits and vegetables, also allowing the development of new flavors and the preservation of the product for a long time (BARROS et al., 2019a; SANTOS et al., 2015; OLIVEIRA et al., 2016).

In addition to the nutritional composition, texture is one of the parameters that most interferes with the sensory acceptance of yogurts, being influenced by factors such as the addition of solids and heat treatment. In order to improve the firmness of Greek yogurt, thickening agents are often used in the production process, such as powdered milk, whey or whey protein concentrate, caseinate, modified starch, pectin, gelatin and gums (BEZERRA et al., 2019).

In agribusiness, the use of solids and stabilizers as ingredients in the production process of various foods aims to optimize this process, providing greater yield, higher quality and longer shelf life of the final product (MENDES et al., 2015). According to Wang et al. (2012), the addition of polysaccharides such as corn starch in the preparation of yogurts directly influences the texture of the product, especially in terms of consistency, viscosity and firmness.

Methodology

Pumpkin jelly making

Pumpkin (*Cucurbita moschata Duch*) was purchased from local businesses in the city of Campina Grande-PB. They were sanitized using a 200 ppm sodium hypochlorite solution for 15 minutes. The pumpkin was peeled with the aid of a knife, the seeds were removed and the pulp was processed in a blender.

Pumpkin pulp (50%), crystal sugar (30%), water (18.5%) and pectin with high methoxylation power (1.5%) were mixed. Citric acid was added to the mixture until it reached a pH of 3.2. Subsequently, cooking was carried out in an open pan under heating with continuous manual stirring until it had a soluble solids content of 65 °Brix. The jellies were filled hot, in previously sterilized glass containers (100°C/30 min), and they were stored under refrigeration at 5 °C until the moment they were added to the yoghurts.

Preparation of Greek yogurts

The yogurts were prepared using the 22 factorial planning method with 3 repetitions in the central point, resulting in the formulations F1, F2, F3, F4, F5, F6 and F7 (Table 1), in order to assess the influence of the variables independent (concentrations of cornstarch and pumpkin jelly) on the response variables (physicochemical and textural characteristics, as well as the interactions between the independent variables). The effect of independent variables on the response variables was evaluated through statistical analysis, using the computer program Statistica® version 7.0.

Table 1. Planning matrix for the preparation of Greek yogurts with pumpkin jam, with their respective independent variables and their real and coded levels

Experiments	**Independent variables**	
	Maize starch (%)	**Pumpkin jelly (%)**
F_1	-1 (15)	-1 (5)
F_2	-1 (15)	+1 (15)
F_3	+1 (25)	-1 (5)
F_4	+1 (25)	+1 (15)
F_5	0 (20)	0 (10)
F_6	0 (20)	0 (10)
F_7	0 (20)	0 (10)

For the production of Greek-style yoghurts, the following steps were taken:

I) Preparation of the inoculum using reconstituted commercial whole milk powder, as described on its packaging;

II) Thermicization of milk at 80ºC for 15 minutes and subsequent cooling to 45 ± 1ºC;

III) Addition of corn starch at the levels shown in Table 1;

IV) After cooling the milk, addition of bacterial culture (natural Greek yoghurt) and incubation at 45 °C until fermentation occurs;

V) Addition, over the yogurt, of a layer of pumpkin jelly (levels shown in Table 1) in a previously sterilized container, obtaining the final product, which is then stored under refrigeration.

The procedures described in the steps above were performed for each formulation referred to in the experimental planning.

Characterizations of prepared yogurts

Prepared yogurts were characterized in triplicate according to the following parameters:

Physicochemical characterization

(1) Moisture content and total solids were determined by drying in an oven at 105 °C until constant weight (BRASIL, 2008);

(2) pH was determined through direct reading on the digital pH meter (Brasil, 2008);

(3) Total titratable acidity (TT) determined by titration with sodium hydroxide (BRASIL, 2008);

(4) Total Soluble Solids (TSS) determined by direct reading in a digital refractometer (BRASIL, 2008);

(5) Ratio (SST/ATT) determined by the relationship between the contents of total soluble solids and total titratable acidity;

(6) Ash content was determined by incineration in a muffle (BRAZIL, 2008);

(7) Water activity (aw) was determined using the Decagon® Aqualab CX-2T device at 25°C;

(8) Reducing sugars, non-reducing sugars and total sugars were determined by the method of Lane and Eynon (1934).

Texture profile

All elaborated formulations were submitted to texture profile analysis (TPA). This analysis was performed using a universal texturometer, model TA-XT plusC Texture Analyzer, from the manufacturer Stable Micro Systems, equipped with the Exponent Stable Micro Systems software, using the P-36R probe to obtain the attributes of firmness and consistency.

Statistical analysis

The experimental data were analyzed in triplicate and the results were submitted to the analysis of variance of a single factor (ANOVA) of 5% probability and the significant qualitative responses were submitted to the Tukey test, adopting the same level of 5% of significance. For the development of statistical analysis, the software Assistat 7.7 (SILVA & AZEVEDO, 2016) was used.

Results

Table 2 shows the mean values of the response variables for the physicochemical characteristics of Greek yogurt formulations with different percentages of pumpkin jelly and corn starch.

Table 2. Results of the physicochemical analysis of Greek yogurt added with pumpkin jam

	Answers				
Experiments	**Moisture content (%)**	**A_w**	**ATT (%)**	**pH**	***Ratio***
F_1	81.69	0.947	0.83	4.39	26.86
F_2	82.10	0.954	0.88	4.38	26.13
F_3	86.10	0.989	1.19	4.29	21.59
F_4	85.24	0.983	1.24	4.16	22.75
F_5	83.93	0.960	0.96	4.33	25.34
F_6	83.88	0.963	0.95	4.32	25.96
F_7	83.91	0.965	0.99	4.32	24.24

	Answers					
Experiments	**ANR (%)**	**AR (%)**	**AT (%)**	**ST (%)**	**SST (°Brix)**	**Ashes (%)**
F_1	0.98	4.53	5.51	18.31	22.30	0.76
F_2	1.15	4.97	6.12	17.90	23.00	0.83
F_3	3.06	6.66	9.71	13.90	25.70	1.09
F_4	3.13	6.92	10.05	14.76	27.30	1.21
F_5	2.63	5.84	8.47	16.07	24.33	0.88
F_6	2.64	5.83	8.47	16.12	24.67	0.89
F_7	2.65	5.86	8.51	16.09	24.00	0.90

It is observed in Table 2 that the moisture content varied from 81.69% to 86.10%, and the formulations (F1 and F2) containing the lowest level (-1) of jelly had the lowest percentages of moisture. However, it was notorious the increase of this parameter as the levels of jelly and corn starch increased. Antunes et al. (2015) obtained a moisture content of 77.76 to 83.29% for semi-skimmed yoghurts added with whey protein concentrate.

All formulations had values above 0.9 with respect to the water activity parameter (Aw), which varied from 0.947 to 0.989; higher values were observed for the formulations containing the highest level (+1) of pumpkin jelly.

The influence of the addition of pumpkin jelly was also observed in relation to the moisture content parameter. According to Barros et al. (2019b), reduced moisture content and water activity values indicate greater stability of the product during storage, and foods that have a moisture content greater than 20% and water activity greater than 0.60 are subject to deterioration processes caused by molds and yeasts, requiring the application of conservation methods such as refrigeration.

For total titratable acidity (TT), there was a small variation from 0.83 to 1.24% of lactic acid; the highest percentages were obtained by the formulations that had the highest level (+1) of jelly. Values close to those of the present study were reached by Magalhães and Torre (2018), who obtained, for Greek yogurt, acidity indices ranging from 1.07 to 1.37% of lactic acid. Regarding the pH values, the prepared yogurts varied from 4.16 (F4) to 4.39 (F1), with a slightly acidic character.

Modesto Júnior et al. (2016), when evaluating the pH of Greek-style yoghurts made with buffalo milk and different concentrations of sour sour syrup, they obtained a pH variation from 3.63 to 4.13. Silveira et al. (2016), when evaluating the quality of Greek yogurt, obtained pH values between 4.2 and 4.3.

The total solids content (TS) varied from 13.90% to 18.31%, these values being inversely proportional to the moisture content. As for the content of total soluble solids (TSS), it is observed that the F1 formulation had the lowest value (22.30 °Brix) and the F4 formulation, the highest value (27.30 °Brix). The high value in the soluble solids content is related to the higher levels (+1) of jelly and cornstarch in the preparation of yogurts. Oliveira et al. (2019), when producing jabuticaba flavored yoghurt sundae, obtained values of 24 and 30 °Brix in their formulations.

Regarding the ratio, a variation from 21.59 (F3) to 26.86 (F1) was observed. According to Morgado et al. (2019), this parameter is able to indicate the degree of sweetness of the product. It appears that yogurts containing a lower percentage of pumpkin jelly had greater sweetness.

The non-reducing sugar content (ANR) obtained between the formulations ranged from 0.98% (F1) to 3.13% (F4), and the reducing sugar content (AR) ranged from 4.53% (F1) at 6.92% (F4); as expected, the highest values were verified in the formulations with the highest percentage of jelly. The total sugar content (TA) obtained in the present study varied from 5.51% (F1) to 10.05% (F4); this higher percentage of the F4 formulation is due to the presence of the highest percentages of jelly and corn starch. Oriente et al. (2019), when developing plum yoghurts added with chia flour, they obtained the following results: 7.72 to 10.08% of reducing sugars, 1.01 to 3.23% of non-reducing sugars and 10.09 to 13 .26% of total sugars.

The values found for the ash content ranged from 0.76 to 1.21%; the highest percentage obtained was for the F4 formulation, which contains the highest levels (+1) of jelly and corn starch. Values close to those of the present study were observed by Bezerra et al. (2019), who obtained ash contents ranging from 0.86 to 0.92% for natural Greek yogurts made with different concentrations of sucrose. Ribeiro et al. (2016), when developing a yoghurt added with jabuticaba bark jelly, they obtained ash content ranging from 0.53 to 0.67% during 30 days of storage.

Table 3 shows the mean values of the response variables for the textural characteristics of Greek yogurt formulations with different percentages of pumpkin jelly and cornstarch.

Table 3. Texture profile results of Greek yogurts with added pumpkin jam

	Answers	
Experiments	**Firmness (N)**	**Consistency (Nos)**
F_1	1,027	13,950
F_2	1,103	14,026
F_3	1,961	20.623
F_4	2,049	25,883
F_5	1,245	15,676
F_6	1,265	15,823
F_7	1,258	15,790

The instrumental firmness ranged from 1.027 to 2.049 N, being observed that greater forces were necessary to cause deformation in the product in the formulation containing the highest percentage of starch. According to Garrido, Lozano and

Genovese (2015) and Barros et al. (2019b), firmness is defined as the force necessary to achieve a given deformation; in the context of sensory analysis, it represents the force needed to compress food between the molars in the first bite.

Regarding the consistency of the yogurts, Table 3 shows a variation from 13,950 to 25,883 N.s; the lowest values of this parameter were obtained for the formulations that required a lower applied force. According to Almeida et al. (2019), once the product presents a lower firmness, consequently its consistency will be lower.

Table 4 presents the analysis of variance (ANOVA) and the F test with 95% ($p<0.05$) reliability only for the variables that were predictive, that is, with coefficients of determination greater than 90% in processing of Greek yogurts with added pumpkin jam.

From the analysis of the results obtained in relation to the parameters of pH, humidity, total solids and reducing sugars, it was found that the coefficients of determination (R^2) of these parameters greater than 98%, an excellent fit to the experimental data. The individual effects of the independent variables (pumpkin jam and corn starch) as well as the interaction between them on the response variables (physical-compounds and textural) dissipation statistically significant model ($F_c > F_{tab}$).

It can be seen, in Pareto diagrams (Figure 1), the factors that had the greatest influence on the preparation of yogurts.

Table 4. Analysis of variance (ANOVA) for the analyzed responses

Parameter	Source of variation	SQ	GL	QM	$F_{calculated}$	R^2 (%)
pH	Regression	0.0341	3	0.0114	53,044	98.15
	Residue	0.0006	3	0.0002		
	lack of fit	0.0006	1	0.0006	17,286	
	pure error	0.0001	two	3.3×10^{-5}		
	Total	0.0347	6			
Moisture content (%)	Regression	14.6539	two	7.3269	374.1977	99.47
	Residue	0.0783	4	0.0196		
	lack of fit	0.0771	two	0.0385	60.8327	
	pure error	0.0013	two	0.0006		
	Total	14.7322	6			
Total solids (%)	Regression	14.6539	two	7.3269	374.1977	99.47
	Residue	0.07832	4	0.0196		
	lack of fit	0.07705	two	0.0385	60.8327	
	pure error	0.00127	two	0.0006		
	Total	14,73217	6			
Total soluble solids (°Brix)	Regression	16,1450	two	8.0725	61.2614	96.84
	Residue	0.52709	4	0.1318		
	lack of fit	0.30262	two	0.1513	1.3482	
	pure error	0.22447	two	0.1122		
	Total	16.67209	6			
Total Titratable Acidity (% lactic acid)	Regression	0.1314	1	0.1314	57.4857	91.99
	Residue	0.011429	5	0.0023		
	lack of fit	0.010563	3	0.0035	8,1252	
	pure error	0.000867	two	0.0004		
	Total	0.142836	6			
Total sugars (%)	Regression	16.5242	1	16.5242	88.0846	94.63
	Residue	0.93798	5	0.1876		
	lack of fit	0.93691	3	0.3123	585.5677	
	pure error	0.00107	two	0.0005		
	Total	17.46220	6			
Reducing sugars (%)	Regression	4.2841	two	2.1421	481.7462	99.59
	Residue	0.017786	4	0.0044		
	lack of fit	0.017319	two	0.0087	37.1122	
	pure error	0.000467	two	0.0002		
	Total	4.301886	6			

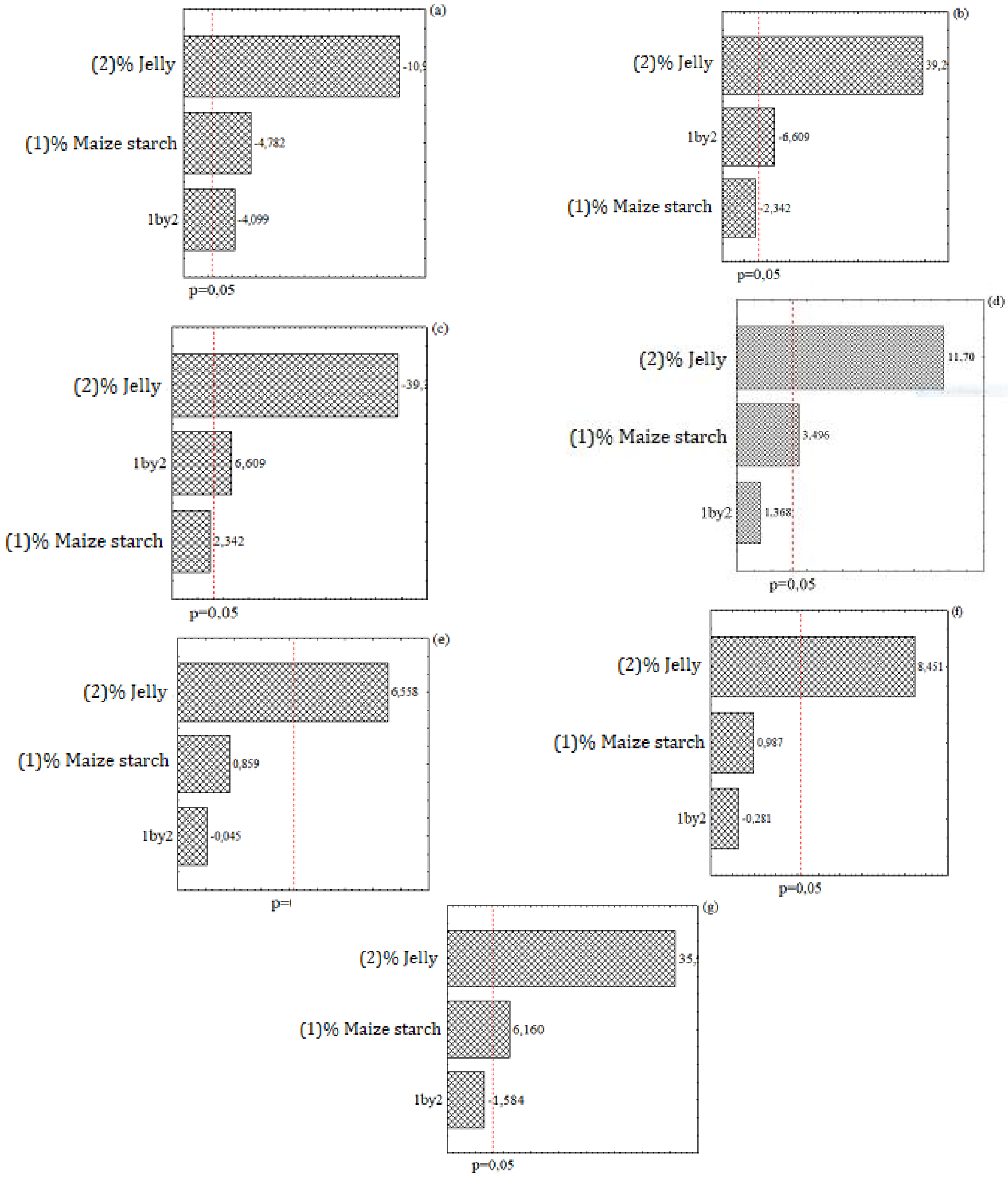

Figure 1. Pareto diagrams for the influence of corn starch concentration and pumpkin jelly concentration factors in the parameters: a) pH; b) humidity; c) total solids; d) total soluble solids; e) total titratable acidity; f) total sugars; and g) reducing sugars.

Given the statistical significance of the results presented (Figure 1), it was possible to observe that the percentage of jelly had the greatest influence on the response variables, followed by the percentage of cornstarch. For the parameters in which the $\mathbf{F_{calculated}}$ was greater than the $F_{tabulated}$, a polynomial model was fitted to the experimental data (Table 5), since the regression was statistically significant.

Table 5. Polynomial model adjusted to the yogurt experimental data

Parameters	Polinomial model
pH	pH = 4,463 + 0,017 × AM - 0,004 × G - 0,0012 × AM × G
Moisture (%)	U = 76,286 + 0,396 × G - 0,0018 × AM × G
Total solids (%)	ST = 23,714 - 0,396 × G - 0,0018 × AM × G
Total soluble solids (°Brix)	SST = 15,621 + 0,115 × AM + 0,385 × G
Total Titratable Acidity (% lactic acid)	ATT = 0,281 + 0,036 × G
Total sugars (%)	AT (%) = - 0,010 + 0,4065 × G
Reducing sugars (%)	AR = 1,371 + 0,035 × MS + 0,204 × J

Note: AM = % corn starch; G = % pumpkin jelly.

In Figure 2, the response surfaces obtained for the physical and chemical analyzes (response variables) that presented statistically significant models (Fc>Ftab) are represented.

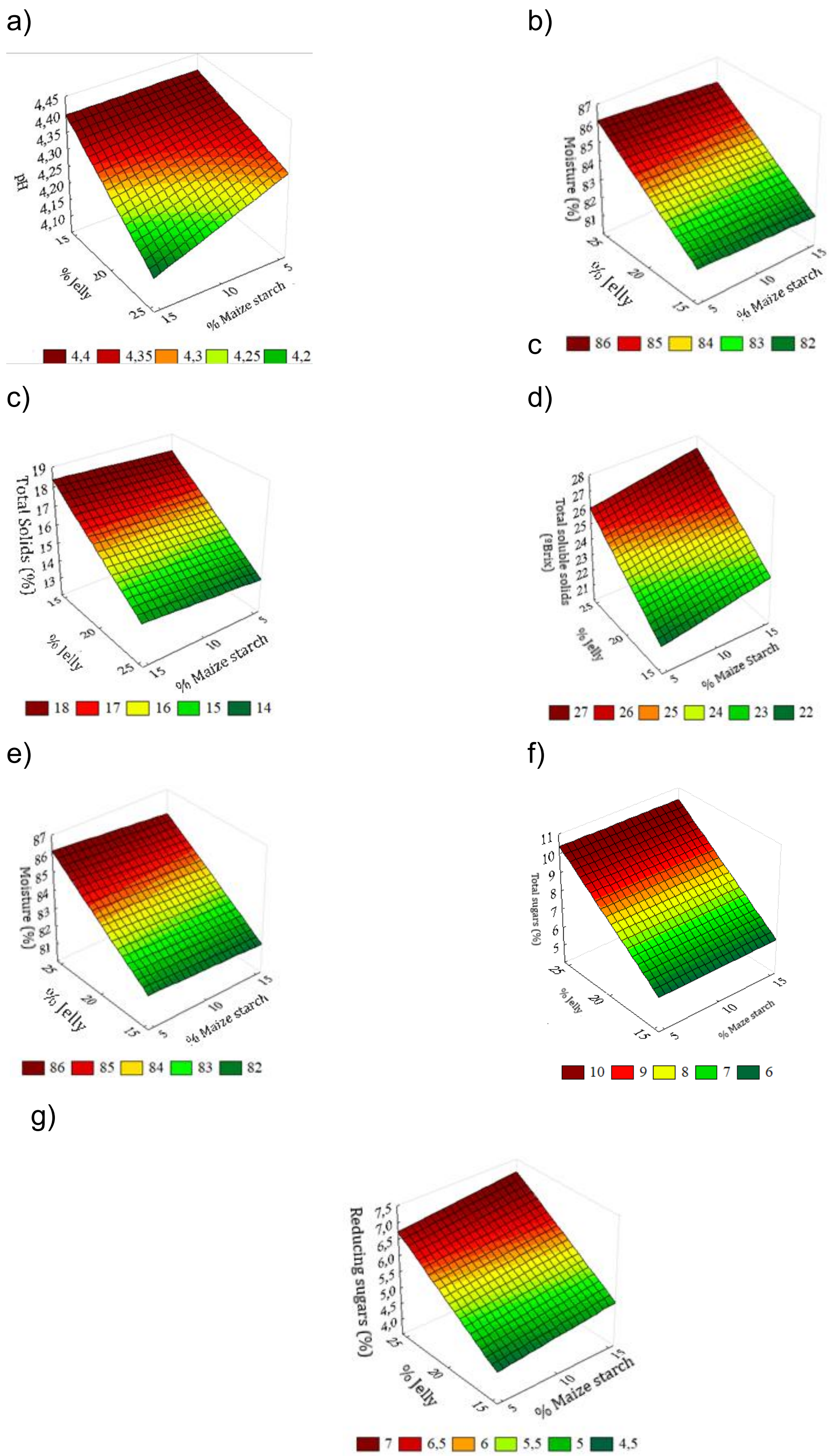

Figure 2. Response surfaces for the parameters of: a) pH; b) humidity; c) total solids; d) total soluble solids; e) total titratable acidity; f) total sugars; g) reducing sugars in Greek yoghurts, as a function of the percentages of corn starch and pumpkin jelly.

Final considerations

When analyzing the seven formulations, it was observed that:

All parameters evaluated showed an increase directly proportional to the addition of pumpkin jelly and corn starch to the product, so that, when considering the statistical significance of the results;

The jelly percentage showed the greatest interference on the response variables;

The addition of pumpkin jelly and cornstarch has a significant influence on the final yoghurt composition;

As a suggestion for future work, it is necessary to pay attention to the stability of the product during storage, due to its high moisture content and water activity.

References

ALMEIDA, R. L. J.; SANTOS, N. C.; BARROS, S. L.; NASCIMENTO, A. P. S.; SILVA, V. M. A. Caracterização físico-química e textural de iogurtes tipo grego comercializados na cidade de Campina Grande-PB. Revista Higiene Alimentar, v.33, n.288/289, p.983-987, 2019.

ANJOS, C. N.; BARROS, B. H. S.; SILVA, E. I. G.; MENDES, M. L. M.; MESSIAS, C. M. B. O. Desenvolvimento e aceitação de pães sem glúten com farinhas de resíduos de abóbora (*cucurbita moschata*)**.** Arquivos de Ciências da Saúde**, v**.24, n.4, p.58-62, 2017.

ANTUNES, A. R.; FARINÃ, L. O.; KOTTWITZ, L. B. M.; PASSOTTO, J. A. Desenvolvimento e caracterização química e sensorial de iogurte semidesnatado adicionado de concentrado proteico de soro. Revista do Instituto de Laticínios Cândido Tostes, v.70, n.1, p.44-54, 2015.

BARBOSA, P. P. M.; GALLINA, D. A. Viabilidade de bactérias (starter e probióticas) em bebidas elaboradas com iogurte e polpa de manga. Revista do Instituto de Laticínios Cândido Tostes, v.72, n.2, p.85-95, 2017.

BARROS, S. L.; SANTOS, N. C.; ALMEIDA, R. L. J.; SILVA, S. N.; NASCIMENTO, A. P. S.; ALMEIDA, R. D.; RIBEIRO, V. H. A.; SILVA, W. P.; GOMES, J. P.; SILVA, V. M. A.; PEREIRA, T. S.; SANTIAGO, A. M.; LUIZ, M. R. Influence of pulp, sugar and maltodextrin addiction in the formulation of kiwi jellies with lemon grass tea. Journal of Agricultural Science, v.11, n.15, p.124-134, 2019a.

BARROS, S. L.; SILVA, W. P.; FIGUEIRÊDO, R. M. F.; ARAÚJO, T. J.; SANTOS, N. C.; GOMES, J. P. Efeito da adição de diferentes tipos de açúcar sobre a qualidade físico-química de geleias elaboradas com abacaxi e canela. Revista Principia, v.1, n.45, p.150-157, 2019b.

BEZERRA, K. C. A.; OLIVEIRA, E. N. A.; FEITOSA, B. F.; FEITOSA, R. M.; MATIAS, J. K. S. Perfil físico-químico e sensorial de iogurtes grego naturais elaborados com diferentes concentrações de sacarose. Revista Engenharia na Agricultura, v.27, n.2, p.89-97, 2019.

BRAGA, A. C. C.; SANTANA, A. L.; DA SILVA, B. A.; AMORIM, D. S.; AMORIM, I. S.; DE PAIVA LIMA, J. M.; DA SILVA, J. B. Composição nutricional de iogurte grego com geleia de cajá (*Spondia Mombin* L.) e pólen apícola. In: Equidade e sustentabilidade no campo da segurança alimentar global. (Org) SILVA, F. F. Ponta Grossa: Atena, p.1-388-416, 2020.

BRASIL. Métodos físico-químicos para análise de alimentos. 4. ed. São Paulo: Instituto Adolfo Lutz, 2008. 1020 p.

GARRIDO, J. I.; LOZANO, J. E.; GENOVESE, D. B. Effect of formulation variables on rheology, texture, colour, and acceptability of apple jelly: Modelling and optimization. Food Science and Technology, v.62, n.1, p.325-332, 2015.

GONÇALVES, N. M.; FERREIRA, I. M.; SILVA, A. M. O.; CARVALHO, M. G. Iogurte com geleia de cajá (*Spondias mombin L.*) adicionado de probióticos: avaliação microbiológica e aceitação sensorial. Revista Brasileira de Higiene e Sanidade Animal, v.12, n.1, p.54-63, 2018.

GUIMARÃES, D. H. P.; SILVA, F. R. S. R; LÊNTHOLA, N. M. Iogurte elaborado à base de leite de búfala sabor queijo com geleia de goiaba. Brazilian Journal of Food Technology, v.18, n.1, p.57-61, 2015.

LANE, J. H.; EYNON, L. Determination of reducing sugars by Felhling's solution with methylene blue indicador. London: Normam Rodge, 1934. 8p.

MAGALHÃES, A. U.; TORRE, A. C. G. D. Composição química e análise sensorial do iogurte grego comercializado no sul do estado de Minas Gerais. Revista do Instituto de Laticínios Cândido Tostes, v.73, n.1, p.10-18, 2018.

MENDES, M. L. M.; RIBEIRO, A. P. L.; ALMEIDA, E. C. Efeito da acidificação nas propriedades físico-químicas e funcionais do amido de sementes de manga (*Mangifera indica L.*), variedade Tommy Atkins. Revista Ceres, v.62, n.3, p.225-232, 2015.

MODESTO JÚNIOR, E. N.; SOARES, S. S.; SOUSA, D. D. F.; CARMO, J. R.; SILVA, R. M. V.; RIBEIRO, C. F. A. Elaboração de iogurte grego de leite de búfala e influência da adição de calda de ginja (*Eugenia uniflora* L.) no teor de ácido ascórbico e antocianinas do produto. Revista do Instituto de Laticínios Cândido Tostes, v.71, n.3, p.131-143, 2016.

MORGADO, C. M. A.; GUARIGLIA, B. A. D.; FAÇANHA, R. V.; TREVISAN, M. J.; JACOMINO, A. P.; CORRÊA, G. C.; CUNHA JUNIOR, L. C. Avaliação da qualidade de jabuticabas (cv. sabará), submetidas ao armazenamento e acondicionadas em diferentes embalagens. Desafios, v.6, n.2, p.18-25, 2019.

MUNHOZ, C. L.; BORGES, G. S.; SILVA, M. L. F.; OLIVEIRA, R. F. Avaliação sensorial de iogurtes de jambo vermelho. Revista Inova Ciência & Tecnologia, v.4, n.1, p.25-31, 2018.

OLIVEIRA, C. D.; PAULO, F. J.; OLIVEIRA, J. C. C.; FERREIRA, B. A.; RIBEIRO, B. P.; FAGUNDES, K. R. M.; CLAUDINO, T. O. Caracterização físico-química do iogurte tipo *sundae* sabor jabuticaba. Brazilian Journal of Development, v.5, n.6, p.5091-5097, 2019.

OLIVEIRA, J. M. S. P.; NASCIMENTO, A. L. S.; VITÓRIA, M. F.; RAMOS, S. R. R.; SILVA, A. V. C. Alterações em abóbora após cocção. Nucleus, v.13, n.2, p.167-171, 2016.

ORIENTE, S. F.; SILVA, P. I. S.; GOUVEIA, D. S.; MOTA, M. M. A.; DANTAS, R. L.; SANTIAGO, Â. M. Elaboração e caracterização físico-química de iogurtes de ameixa adicionados da farinha de chia. Magistra, v.30, p.78-85, 2019.

RIBEIRO, L. R.; MATIAS, T. G.; MARTINS, E. M. F.; MARTINS, M. L.; MARTINS, A. D. O.; BITTENCOURT, F.; CAMPOS, R. C. A. B. Desenvolvimento e caracterização de iogurte adicionado de geleiada da casca de jabuticaba e de cultura probiótica. Revista Higiene Alimentar, v.30, n.262/263, p.136-141, 2016.

SANTOS, I. V.; IENSEN, D.; QUAST, E.; QUAST, L. B.; RAUPP, D. S. Doce de abóbora com leite contendo alta proporção de abóbora – avaliação da textura e aparência. Revista Nutrir, v.1, n.2, p.1-12, 2015.

SILVA, F. A. S.; AZEVEDO, C. A. V. The Assistat Software Version 7.7 and its use20 in the analysis of experimental data. African Journal of Agricultural Research, v.11, n.39, p 3733-3740, 2016.

SILVA, R. T.; ASSIS, B. B. T.; COSTA MONÇÃO, É.; MOURA, F. J.; SANTOS SILVA, M. E.; SOUZA GRILO, M. M;, CONCEIÇÃO, M. M. Análise microbiólogica e fisico-química de iogurte tipo grego adicionado de geleia de pitanga (*eugenia uniflora* L.). Revista Brasileira de Desenvolvimento, v.6, n.5, p.24660-24677, 2020.

SILVIO, V. M.; FARIAS, L. C. B.; MEDEIROS, J. S.; DOS SANTOS, L. S.; LEÃO, P. V. T.; DE OLIVEIRA, L. A.; DA SILVA, M. A. P. Parâmetros físicos e químicos do açafrão e uso como corante em iogurte grego saborizado com geleia de maracujá. Pesquisa, Sociedade e Desenvolvimento, v.9, n.5, e117953244, 2020.

SILVEIRA, M. P.; ROCHA, L. O. F.; CASTRO, A. L.; BRANDÃO, D. C.; GUEDES, T. J.; FERNANDES, M. K. O. Avaliação da qualidade de labneh (iogurte grego): estudo com consumidores. Revista do Instituto de Laticínios Cândido Tostes, v.71, n.2, p.65-74, 2016.

SOUSA, K. S. M.; ABREU, A. K. F.; ARAÚJO, H. R. R.; CARDOSO, R. C.; COELHO, B. E. S.; SILVA, V. P. Elaboração de iogurte probiótico de leite de cabra adicionado de polpa de manga. Revista Craibeiras de Agroecologia, v.4, n.1, p.1-5, 2019.

WANG, W.; BAO, Y.; HENDRICKS, G. M.; GUO, M. Consistency, microstructure and probiotic survivability of goats' milk yoghurt using polymerized whey protein as a co-thickening agent. International Dairy Journal, v.24, n.2, p.113-119, 2012.

CARROT FLOUR *(Daucus carota subsp. sativus)* AS A FOOD INGREDIENT IN CAKE FORMULATION

Virgínia Mirtes de Alcântara Silva

Newton Carlos Santos

Raphael Lucas Jacinto Almeida

Victor Herbert de Alcântara Ribeiro

Juliana Cruz Albuquerque

Rosenildo dos Santos Silva

Jonnathan Silva Nunes

Jonnathan Silva Nunes

Introduction

Carrots are considered one of the best-known and most cultivated root vegetables in the world. It is a crucial source of certain phytonutrients such as vitamins, carotenoids and dietary fiber. Fresh carrot root contains more than 86% water on a wet basis and is easily prone to quality deterioration during storage, which causes great economic losses to growers. Due to its perishable nature, the selection of a suitable method of conservation of carrots is vital to retain the nutritional values for better marketing (GUO et al., 2020).

Dewatering or drying operations is one of the most common preservation approaches for fruits and vegetables among the various preservation methods, and its basic objective is the removal, in whole or in part, of water to a level where microbial growth is minimized (SILVA et al., 2009).

Drying is a complex operation involving simultaneous heat and mass transfer, along with variations in material processes, such as physical or chemical transformations, which, in turn, can cause changes in the quality of the material as well as in the transfer mechanisms. of heat and mass (MUJUMDAR, 2006).

Studies on the transport phenomena that occur during drying are of great technological interest for the chemical, food and pharmaceutical industries, and of technical-scientific interest due to the complexity that the process presents (ALBINI et al., 2019)

Among the various types of dryers, the fixed bed dryer provides adequate support to understand the simultaneous phenomena of heat and mass transfer that occur within each material in the bed and the phenomena of transfer between the solid and fluid phases of the packed bed (ALBINI et al., 2019).

Numerous studies have been carried out on the natural bioactive compounds present in by-products of fruits and vegetables widely consumed in Brazil due to their biological properties and applicability in the development of new functional foods, such as: mango (CHEN et al., 2019); banana (KHOOZANI et al., 2019; pineapple (RODA et al., 2019); coffee husks (ATEŞ et al., 2019); apple, pineapple and melon (TOLEDO et al., 2019).

They are important species, not only because of their taste, aroma and appearance, but also because they are functional and have nutritional and pharmaceutical properties of great interest to the population, to the economy and to science. (SILVA JUNIOR et al., 2021).

According to Ozores et al. (2015), the transformation of the vegetable into flour can be a way to make better use of it and ensure an even longer shelf life. Flour can be used in various preparations as a substitute for wheat flour in cake formulations.

Cake is a bakery product produced on a large scale in Brazil (MAIA et al., 2018). They are confectionery products that are very popular as a dessert or in snacks. They come in different formats, flavors and texture, varying with the formulation or the method used in the manufacture (GUTOKOSKI et al., 2011).

Therefore, the objective of the present work was to elaborate a carrot flour through the process of drying in a fixed bed and to develop cake formulations with different percentages of the elaborated flour. In addition, the flour prepared was characterized in terms of parameters: centesimals, mineral profile, bioactive compounds and antioxidant activity; And the formulations developed were characterized as to the physical parameters of moisture, water activity and firmness.

Methodology

Preparation of carrot flour

Carrots (*Daucus carota subsp. sativus*) were used to prepare the flour. The steps for its production can be seen in Figure 1. Initially, the carrots were sanitized, sanitized (200ppm sodium hypochlorite) and washed in running water. After this step, they were peeled and cut into slices (thickness not defined).

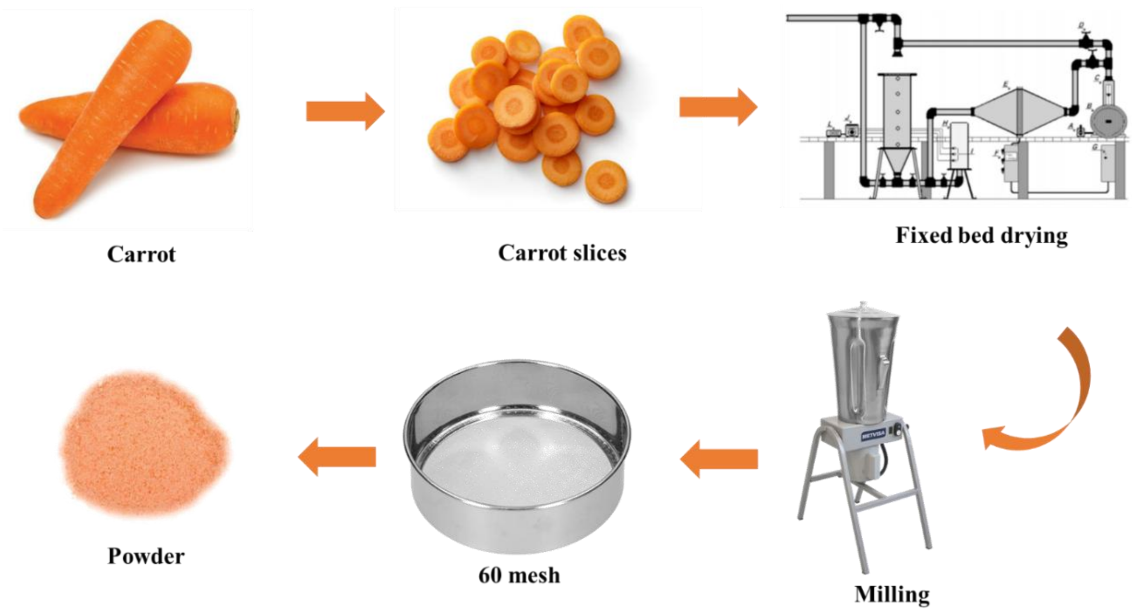

Figure 1. Main stages for the preparation of carrot flour.

The slices were subjected to the drying process in a fixed bed dryer at a temperature of 50°C, until they reached constant mass. The dried slices were ground in an industrial blender and the powder obtained was standardized using a 60 mesh sieve.

Characterization of carrot flour

The carrot flour obtained by drying in a fixed bed at 50°C was characterized in terms of the following parameters described below:

Centesimal composition

(1) Moisture content was determined by drying in an oven at 105°C until constant weight (BRASIL, 2008);

(2) Ash content was determined by muffle incineration (BRASIL, 2008);

(3) Total protein content was quantified by the Micro-Kjeldahl method, which consisted in the determination of total nitrogen according to the methodology described by BRASIL (2008);

(4) Lipid content was quantified by the modified method of Blig and Dyer (1959);

(5) Crude fiber content was quantified by digestion with an acid solution by the method of Silva and Queiroz (2002);

(5) Total carbohydrate content was calculated by difference to obtain 100% of the total composition (FAO, 2003).

Mineral profile

The mineral profile was determined through the ash using an Energy Dispersive X-Ray Fluorescence Spectrometer, model EDX-720 (Shimadzu, Kyoto, Japan) using liquid nitrogen.

Bioactive compounds

Total phenolic compounds

Total phenolic compounds were quantified by the Folin-Ciocalteau method described by Waterhouse (2006), using gallic acid as a standard. Water and methanol were used as extraction solvents. The calculations performed for the determination of phenolic compounds were based on a standard curve with gallic acid, and the readings were made in a spectrophotometer at 765 nm, with results expressed in mg/100 g of gallic acid.

Total carotenoids

The determination of total carotenoids was performed according to Lichtenthaler (1987).

Antioxidant activity

The antioxidant activity of DPPH• was performed according to the methodology described by Maria do Socorro et al. (2010) with adaptations. Antioxidant activity (ABTS) was determined by the method proposed by Re et al. (1999), with modifications made by Rufino et al. (2007).

Making the cake

The cake formulations produced are shown in Table 1. Carrot flour was used instead of wheat flour in different proportions.

Table 1. Formulations of cakes made with carrot flour

Ingredients	A	B	C
Flour	100%	50%	25%
Carrot flour	0%	50%	75%
Sugar	20%	20%	20%
Chocolate powder	16%	16%	16%
Baking powder	5%	5%	5%
Milk	20%	20%	20%
Egg	14%	14%	14%
Oil	9%	9%	9%
Oat flakes	10%	10%	10%

Source: adapted from Pires et al. (2020).

For processing the cakes, the methodology proposed by Pires et al. (2020), using an oven at a temperature of 235ºC for 30 minutes

Characterizations of the elaborate cake

The prepared cake formulations A, B and C were characterized in terms of the parameters described in the following items.

Moisture content

Moisture content was determined by drying in an oven at 105°C until constant weight (BRASIL, 2008).

Water activity

Water activity (aw) was determined using the Decagon® Aqualab CX-2T device at 25°C.

Firmness

The firmness of the cakes was evaluated in a universal texturometer model TA-XT plus - Texture Analyzer from the manufacturer Stable Micro Systems equipped with the software Exponent Stable Micro Systems. The parameters used in the tests were: pre-test speed = 1.0 mm/s, test speed = 3.0 mm/s, post-test speed = 10.0 mm/s, distance of 5.0 mm, with measure of force in compression. Firmness results were expressed in Newtons (N).

Statistical analysis

The experimental data were analyzed in triplicate and the results were submitted to a 5% probability single-factor analysis of variance (ANOVA) and the significant qualitative responses were submitted to the Tukey test, adopting the same 5% significance level. For the development of statistical analyses, the Assistet 7.7 software was used (SILVA & AZEVEDO, 2016).

Results

Table 2 shows the average values obtained for the proximate composition of carrot flour obtained by drying in a fixed bed.

The carrot flour prepared in the present study presented values close to those reported by Corrêa et al. (2018) who, when producing carrot flour at an advanced stage of maturation, obtained the following contents: moisture (9.17%), ash (6.99%), lipids (0.75%), proteins (1.13%), crude fiber (13.23%) and total carbohydrates (81.96%).

Table 2. Centesimal composition of carrot flour

Parameters (%)	Carrot flour
Moisture	8.44 ± 0.21
Ashes	7.06 ± 0.33
Lipids	0.81 ± 0.11
Proteins	1.58 ± 0.44
Raw fiber	15.01 ± 0.78
Carbohydrates	67.10 ± 0.90

Table 3 shows the average values obtained for the mineral composition of carrot flour obtained by drying in a fixed bed at a temperature of 50°C.

Table 3. Average mineral content of carrot flour

Mineral (mg/100g)	Carrot flour
K	5263 ± 0.54
Here	821 ± 0.26
mg	497 ± 0.66
P	466 ± 0.37
Faith	6.08 ± 0.04
Zn	3.34 ± 0.03
Mn	2.09 ± 0.01
Ass	1.05 ± 0.01

The mineral content found in greater quantity was K (5263 mg/100g), followed by Ca, Mg, P, Fe, Zn, Mn and Cu. Schiavon et al. (2016) when producing freeze-dried flour from vegetable residues composed of pumpkin peels, carrots, chayote and cabbage stalks, obtained the following mineral contents: Ca (671 mg/100g), Mg (451 mg/100g), K (3862mg/100g), P (432mg/100g), Cu (0.431mg/100g), Fe (4.01mg/100g), Mn (1.58mg/100g) and Zn (2.88mg/100g). Table 4 presents the results obtained for the total phenolic compounds, total carotenoids and antioxidant activity of the carrot flour.

Table 4. Total phenolic compounds, total carotenoids and antioxidant activity of carrot flour

Parameters	Carrot flour
Total phenolic compounds (mgGAE/100g)	121.84 ± 6.24
Total carotenoids (mg/100g)	44.68 ± 0.19
DPPH antioxidant activity (µmol Trolox/g)	53.67 ± 5.31
ABTS+ antioxidant activity (µmol Trolox/g)	81.49 ± 9.11

The carrot flour, obtained by drying in a fixed bed at a temperature of 50°C, presented a phenolic compound content of 121.84 mgGAE/100g. Values higher than those of the present study were reported by Pereira et al. (2018), who when producing flours from carrot and beet residues dried in an oven at 45°C obtained phenolic compounds contents of 375.3 mgGAE/100g and 484.2 mgGAE/100g, respectively, performing the extraction in an ultrasound bath. for 1 h 50% ethanol is used as solvent. The total carotenoid content obtained for the flour of the present study was 44.68 mg/100g. Medeiros et al. (2011) when determining the total carotenoid content in fresh and blanched carrots, they obtained average levels of 79.26 mg/100g and 47.96 mg/100g, respectively.

Regarding the antioxidant activity, it can be seen in Table 4 that the capture method by DPPH presented a value of 53.67 µmol Trolox/g and the ABTS+ method presented a value of 81.49 µmol Trolox/g, which is the method that showed the highest value.

Table 5 presents the values obtained for the moisture content of the cake formulations made with different percentages of carrot flour. According to Corrêa et al. (2018) the evaluation of the moisture content is of great importance, as they directly influence the shelf life of the products.

The moisture content of the elaborated formulations showed a reduction when the percentage of carrot flour was increased, in which, this reduction was from 23.75 to 22.72% when the percentage of carrot flour increased from 0% to 75%. Statistically, the moisture contents were significantly different when compared to each other. Andrade et al. (2015) when producing different cake formulations using demucilated taro flour, they obtained moisture content ranging from 23.22 to 25.87%.

Table 5. Moisture content of cakes made with carrot flour.

Formulation	Moisture (%)
A	23.75 ± 0.06a
B	23.06 ± 0.02b
C	22.72 ± 0.03c

Note: Different letters in the same column differ significantly by Tukey's test.

Table 6 presents the values obtained for the water activity of the cake formulations made with different percentages of carrot flour.

Table 6. Water activity of cakes made with carrot flour

Formulation	Water activity
A	0.843 ± 0.05c
B	0.901 ± 0.02a
C	0.896 ± 0.01b

Note: Different letters in the same column differ significantly by Tukey's test.

The water activity of the formulated cakes varied significantly between the formulations prepared according to the Tukey test at a 5% significance level. The mean values of this parameter presented values greater than 0.8 (aw > 0.8). Gutkoski et al. (2011) when making English-style cakes, the water activity values ranged from 0.85 to 0.89 between the formulations developed. According to Santos et al. (2020) the water activity indicates the amount of free water available for molecular movement, transformations and microbial growth in the product.

Table 7 shows the values obtained for the firmness parameter of the cake formulations made with different percentages of carrot flour.

Table 7. Firmness of cakes made with carrot flour

Formulation	Firmness (N)
A	6.47 ± 0.37a
B	4.11 ± 0.17b
C	3.75 ± 0.35c

Note: Different letters in the same column differ significantly by Tukey's test.

The firmness of the elaborate cakes showed a reduction in their values when there was a reduction in wheat flour and an increase in carrot flour, in which their values ranged from 3.75 N (Formulation C) and 6.47 N (Formulation A) . Statistically, the formulations elaborated were statistically different from each other. Esteller et al. (2006) when making chocolate cake produced with cupuaçu powder and kefi obtained firmness values ranging from 3.81 to 4.67 N.

The maximum strength evaluated, for foods of this nature, is dependent on the formulation (flour quality, amount of sugars, fats, emulsifiers and eggs), dough moisture and conservation (product manufacturing time and packaging).

In the process of beating the dough, despite the strong agitation and speed of the blades, the ingredients are not completely solubilized. Carbon dioxide is released before and during baking.

During cooking, the water vapor of the dough also volatilizes and forms a complex matrix of gelatinized starch and proteins, which trap the volatile material and form alveoli of varying sizes. These “cushions” of air, distributed unevenly, may represent, in the same sample, variations in firmness values and influence other texture parameters (ESTELLER et al., 2006).

Conclusions

Through the results obtained, it can be concluded that:

Carrot flour presented technological potential to be used as a food ingredient in the formulation of new products;

The mineral composition of carrot flour showed potassium (K) as the highest fraction, however, the following minerals were also quantified in order of decrement: Ca > Mg > P > Fe > Zn > Mn > Cu;

The free radical capture method (ABTS+) had the highest mean value;

The parameters evaluated in the elaborated cakes were significantly ($p<0.05$) influenced by the percentage of carrot flour.

References

ALBINI, G. Estudo da secagem de grãos em leito fixo, com e sem escoamento reverso do ar de secagem. Tese (Doutorado em Engenharia Química). Universidade Federal de São Carlos. São Carlos, 2019.

ANDRADE, L. A.; NAGATA, C. L. P.; ASSUMPÇÃO, G. M. P.; GONÇALVES, G. A. S.; PEREIRA, J. Demucilated taro corm flour used in cake preparation. Científica (Jaboticabal), v.43, n.3, p.203-214, 2015.

ATEŞ, G.; ELMACI, Y. Características físicas, químicas e sensoriais de bolos enriquecidos com fibras elaborados com casca de café em substituição à farinha de trigo. Journal of Food Measurement and Characterization, v.13, n.1, p.755-763, 2019.

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

BRASIL. Instituto Adolfo Lutz. Métodos físico-químicos para análise de alimentos 4th ed. v.1. São Paulo: Instituto Adolfo Lutz. 2008. 1020p.

CHEN, Y.; ZHAO, L.; HE, T.; OU, Z.; HU, Z.; WANG, K. Efeitos do pó da casca de manga na digestão do amido e nas características de qualidade do pão. Jornal Internacional de Macromoléculas Biológicas, v.140, p.647-652, 2019.

CORRÊA, I. M.; DE ARAÚJO PERFEITO, D. G.; MORENO, V. J.; DE LIMA DUTRA, M. B. Farinha de cenoura em estágio de maturação avançada como alternativa à redução do desperdício de alimentos. Multi-Science Journal, v.1, n.10, p.61-68, 2018.

ESTELLER, M. S.; ZANCANARO JÚNIOR, O.; LANNES, S. C. D. S. Bolo de chocolate produzido com pó de cupuaçu e kefir. Revista Brasileira de Ciências Farmacêuticas, v.42, n.3, p.447-454, 2006.

FAO. Food and Agriculture Organization of the United Nations. Food Energy: Methods of Analysis and Conversion Factors. Report of a Technical Workshop. Food and Nutrition Paper Volume 77. FAO: Rome, Italy, 2003.

GUO, Y.; WU, B.; GUO, X.; DING, F.; PAN, Z.; MA, H. Effects of power ultrasound enhancement on infrared drying of carrot slices: Moisture migration and quality characterizations. LWT, v.126, e109312, 2020.

GUTKOSKI, L. C.; DURIGON, A.; MAZZUTTI, S.; CEZARE, K. D.; COLLA, L. M. Influência do tipo de farinha de trigo na elaboração de bolo tipo inglês. Brazilian Journal of Food Technology, v.14, p.275-282, 2011.

KHOOZANI, A. A.; BIRCH, J.; BEKHIT.; AHMED. E. D. A. Produção, aplicação e efeitos na saúde da farinha de polpa e casca de banana na indústria alimentícia. Revista de Ciência e Tecnologia de Alimentos , v.56, n.2, p.548-559, 2019.

LICHTENTHALER, H. K. Chlorophylls and carotenoids: pigments of photosynthetic biomembranes. Methods in Enzymology, v.148, n.22, 1987.

MAIA, S. M. P. C.; PONTES, D. F.; GARRUTI, D. D. S.; OLIVEIRA, M. D.; ARCANJO, S. R. S.; CHINELATE, G. C. B. Farinha de maracujá na elaboração de bolo de milho. Embrapa Agroindústria Tropical, 2018.

MARIA DO SOCORRO, M. R.; ALVES, R. E.; DE BRITO, E. S.; PÉREZ-JIMÉNEZ, J.; SAURA-CALIXTO, F.; MANCINI-FILHO, J. Bioactive compounds and antioxidant capacities of non –traditional tropical fruits from Brazil. Food Chemistry, v.121, n.4, p.996–1002, 2010.

MEDEIROS, G. R.; KWIATKOWSKI, A.; CLEMENTE, E.; COSTA, J. M. C. Avaliação de carotenóides em cenoura e análise sensorial de barras de cereais elaboradas com cenoura desidratada. Revista Brasileira de Tecnologia Agroindustrial, v.5, n.1, p.306-313, 2011.

MUJUMDAR, A. S. Principles, classification and selection of dryers. In: MUJUMDAR, A. S. Handbook of Industrial Drying. CRC Press/Taylor & Francis Group. 2006, p.3 - 30

SANTOS, N. C.; BARROS, S. L.; ALMEIDA, R. L. J; MONTEIRO, SHÊNIA S.; NASCIMENTO, A. P. S.; SILVA, V. M. A; GOMES, J. P.; LUIZ, M. R; VIEIRA, D. M. Avaliação da degradação dos compostos bioativos do fruto physalis (P. peruviana) durante o processo de secagem. Research, Society and Development, v.9, e102911678, 2020.

OZORES, B.; STORCK, C. R.; DE OLIVEIRA FOGAÇA, A. Aceitabilidade e características tecnológicas de bolo enriquecido com farinha de maracujá. Disciplinarum Scientia, v.16, n.1, p.61-69, 2015.

PEREIRA, P. H. M.; BARRETO, B.; AGNES, F.; BACCAR, N. D. M.; ROHLFES, A. L. B. Quantificação de compostos fenólicos e flavonoides em vegetais, farinhas de vegetais e produtos de panificação. Seminário de Iniciação Científica, 188. 2018.

PIRES, E. B. R.; DE ALMEIDA, J. C.; VIEIRA, R. P.; GHERARDI, S. R. M. Obtenção, caracterização e incorporação de farinha de folha de cenoura em bolo de chocolate. Revista Científica Agropampa, v.1, n.1, p.73-89, 2020.

RE, R.; PELLEGRINI, N.; PROTEGGENTE, A.; PANNALA, A.; YANG, M.; RICE-EVANS, C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. Free Radical Biology and Medicine, v.26, p.1231-1237, 1999.

RODA, A.; LAMBRI, M. Usos alimentares de resíduos e subprodutos de abacaxi: uma revisão. Revista Internacional de Ciência e Tecnologia de Alimentos, v.54, n.4, p.1009-1017, 2019.

RUFINO, M. S. M.; ALVES, R. E.; BRITO, E. S.; MORAIS, S. M.; SAMPAIO, C. D. G.; JIMENEZ, J. P.; CALIXTO, F. D. S. Metodologia científica: determinação da atividade antioxidante total em frutas pela captura do radical livre $ABTS^{o+}$. 2007. Embrapa Agroindústria Tropical. Comunicado Técnico (INFOTECA-E).

SCHIAVON, M. V.; PEREIRA, E. S.; VIZZOTTO, M.; MENDONÇA, C. R. B.; GRANADA, G. G. Quantificação de minerais em farinha de resíduos de vegetais. In: Congresso Brasileiro de Ciência e Tecnologia de Alimentos, 25, Gramado. Anais... Gramado: SBCTA Regional, 2016.

SILVA, A. S. A.; DOS SANTOS MELO, K.; ALVES, N. M. C.; GOMES, J. P. Cinética de secagem em camada fina da banana maçã em secador de leito fixo. Revista de Biologia e Ciências da Terra, v.9, n.2, p.107-115, 2009.

DA SILVA JUNIOR, J. F.; SOUZA, F. V. D.; PÁDUA, J. G. A arca de Noé das frutas nativas brasileiras. Embrapa Tabuleiros Costeiros. 2021. 220p.

TOLEDO, N. M. V.; MONDONI, J.; HARADA-PADERMO, S. S.; VELA-PAREDES, R. S.; BERNI, P. R. A.; SELANI, M. M.; CANNIATTI-BRAZACA. Caracterização de subprodutos de maçã, abacaxi e melão e sua aplicação em formulações de biscoitos como alternativa para potencializar a capacidade antioxidante. Revista de Processamento e Conservação de Alimentos, v.43, n.9, e14100, 2019.

WATERHOUSE, A. Folin-ciocalteau micro method for total phenol in wine. American Journal of Enology and Viticulture, v.3, n.5, 2006.

Curriculum

Newton Carlos Santos: *Bachelor's Degree in Industrial Chemistry from the State University of Paraíba (UEPB); Professional Internship held at ASA Indústria e Comércio - Vitamilho, working in the Quality Control sector; Specialist in Food Science and Technology by the Federal Institute of Rio Grande do Norte (IFRN); Master in Agricultural Engineering from the Federal University of Campina Grande (UFCG), working in the area of Heat and Mass Transfer with an emphasis on Refrigeration and Drying of Food. He is currently a PhD candidate in Chemical Engineering at the Federal University of Rio Grande do Norte (UFRN). He has in related topics such as: Science, Technology and Food Engineering, working in the food processing area, with an emphasis on food preservation processes, kinetics and mathematical modeling of drying processes, physical properties, unconventional technologies in processing of food and new product developments.*
newtonquímicoindustrial@gmail.com

Juliana Cruz Albuquerque: *Has experience in Chemical Engineering, with an emphasis on Biochemical Process Operations. In research in the areas of Environmental Engineering: Conducting a study on the drying kinetics of coffee grounds in an air-circulated oven for subsequent oil extraction, developing an analysis of the research data using a 2^3 factorial design. Fruits by the Foam-Mat Process. - Analyze that among the processes for obtaining powdered fruit, Foam Mat is a relatively simple drying process, the general objective of this project was to study the drying of fresh fruit pulp using this technology. In the Agricultural Sciences Area: Elaboration of miniaturized Probiotic Milk Dessert of Jabuticaba Jelly - Evaluating the elaborated jabuticaba (Myrciaria cauliflora) milky desserts with probiotic potential - Evaluate making probiotic flan with a jabuticaba bark jelly.*
julianalbuquerquepb@hotmail.com

Raphael Lucas Jacinto Almeida: *Bachelor's Degree in Industrial Chemistry from the State University of Paraíba (2017), where he studied in the area of microbiology and production of probiotic dairy beverage and Degree in Chemistry from Cruzeiro do Sul (2021), Professional Internship (2017) held at the Garanhuns Beverage Industry - Jatobá LTDA, working in the Quality Control and Microbiology sectors; Specialist (2019) in Food Science and Technology at the Federal Institute of Rio Grande do Norte; Master in Chemical Engineering (2019) from the Federal University of Campina Grande, with experience in the Biotechnology area with an emphasis on enzymatic hydrolysis, starch extraction and processing of agro-industrial residues. He is currently a PhD student in Chemical Engineering at the Federal University of Rio Grande do Norte, with a hydrothermal and enzymatic starch modification project.*
raphaelqindustrial@gmail.com

Rosenildo dos Santos Silva: *Food Engineer at the Federal University of Campina Grande (UFCG), Campus de Pombal - PB. Ongoing Master's Degree in Agricultural Engineering in the area of Processing and Storage of Agricultural Products, by the Federal University of Campina Grande (UFCG). Specialization in progress in Food Science and Technology by the Federal Institute of Rio Grande do Norte (IFRN). Volunteer at CONSUALI Junior Food Company (2018/2019). He was a volunteer monitor of the disciplines of Food Analysis (2016.2) and Materials and Packaging Technology (2018.2). He was a Scientific Initiation Scholar (PIBIC)*

(2018/2019) and a volunteer at the company O Burgeratto Hamburgueria (2019). He has experience in the field of Food Science and Technology, with an emphasis on Technology of Products of Vegetal Origin and Drying and Storage of Agricultural Products.
rosenildo.sb@gmail.com

Jonnathan Silva Nunes: *Degree in Food Engineering from the Federal University of Campina Grande (UFCG), post-graduate (latu sensu) in Food Science and Technology from IFRN and post-graduate (latu sensu) in Quality from FAVENI. During graduation, he acted as Monitor of the discipline of General Biochemistry and was part of the extension project entitled "Good manufacturing practices and transfer of minimal processing technology to add value to fruits and vegetables to small rural producers in the municipality of Pombal" PB He worked on the following topics: food analysis, hygienic and sanitary conditions, labeling, preparation of alcoholic beverages, baking, preparation of meat products and minimal processing of fruits and vegetables. He was part of the research group of the Laboratory of Food Analysis (LAA) conducting research in the area of post-harvest fruit and vegetables.*
jonnathan.s.n@hotmail.com

Victor Herbert de Alcântara Ribeiro*: Graduated in Agroecology from the State University of Paraíba (2016). Master in Agricultural Sciences (Agroecology) by the Center for Human, Social and Agrarian Sciences of the Federal University of Paraíba - Campus III, Bananeiras. Doctoral candidate in Engineering and Natural Resources Management with emphasis in the area of Heat and Mass Transfer linked to Food Refrigeration and Drying (drying, osmotic dehydration, lyophilization, food enrichment and new products (development of food for fish with mesquite residues Prosopis)) juliflora (Sw) DC) also works with topics related to biofertilizers, organomineral substances and sesame (Sesamum indicum L.). Doctoral Student of the Postgraduate Program in Engineering and Natural Resources Management at the Federal University of Campina Grande, UFCG / CTRN / Campus Campina Grande-PB.*
victor_herbert_cg@hotmail.com

Virgínia Mirtes de Alcântara Silva*: Graduated in Biological Sciences at the University of Vale do Acaraú-CE in 2010, Doctor and Master in Natural Resources Engineering at the Federal University of Campina Grande - UFCG, Specialist in Geoenvironment and Semi-arid Water Resources at the Federal University of Campina Large - UFCG. State University of Paraíba - UEPB, Specialist in Geography and Environmental Management by the Integrated University of Patos - FIP. Working in the areas of Remote Sensing and GIS, Desertification, Ecological Restoration, Recovery of Degraded Areas and Climatological Characteristics of Brazil, Extreme Rain Events and Environmental Disasters. Doctor in Natural Resources Engineering working in the area of Cryoconservation of Plant Genetic Resources with Peanut, Wedge and Sorghum Seeds. Currently works with related research in the area of Heat and Mass Transfer related to Refrigeration and Drying of Foods (drying, osmotic dehydration, lyophilization, food enrichment and new products). She is part of the editorial board of the EPTEC publisher. Reviewer of the African Journal of Plant Sciences; African Journal of Food Science; Journal of Agricultural Economics and Development, Journal of Plant Breeding and Crop Science, Journal of Horticulture and Forestry (JHF), Journal of International Pharmaceutical Research, Journal of Medicinal Plant Research, and African Journal of Agricultural Research. Member of the São Paulo Association of Rural Extension - APAER / SP. Member of the International*

Research Network for the Development of Climate Resilience - RIPEDRC- Climate Resilience Network, created in 2019, in an international partnership, approved by CNPQ / Araucária Foundation notice: PI 06/2018 Researcher Links Program (United Kingdom), which provided for the organization of the "Brazil-United Kingdom Workshop on Financing for Climate-Resilient Urban Development", held from 9-13 September 2019.
virginia.mirtes2015@gmail.com; virginia.m.alcantara@gmail.com

®Eptec
editora portal tecnológico

978-65-00-38275-4