Effect of the addition of *pinhão* flour and bagasse generated after starch extraction on the formulation of cookie

Stéphanie Schiavo Romko¹, Cleoci Beninca², Camila Delinski Bet¹,
Radla Zabian Bassetto Bisinella¹, Egon Schnitzler¹

1 – State University of Ponta Grossa – UEPG, Ponta Grossa, Brazil

2 – Federal Institute of Education, Science and Technology of Santa Catarina – IFSC,
Canoinhas, Brazil

Abstract

Keywords:

Bagasse
Flour
Araucaria
angustifolia

Article history:

Received
16.09.2019
Received in revised
form 22.11.2019
Accepted
28.11.2019

Corresponding author:

Egon Schnitzler
E-mail:
egons@uepg.br

DOI:

10.24263/2310-
1008-2019-7-2-3

Introduction. After the process of the starch extraction from *pinhão* seeds, the generated residues are discarded. The aim of this study was to add these by-products as a potential substitute for wheat flour in a cookie formulation.

Materials and methods. *Pinhão* seed were purchased from local businesses in Ponta Grossa-PR (Brazil), and after the aqueous extraction of starch, the residues retained in the sieve were milled to produce a flour. The cookies were elaborated from a simplex-centroid experimental planning using wheat flour, whole *pinhão* flour and residual flour after the extraction of the *pinhão*.

Results and discussion. The flours produced with both *pinhão* and the bagasse obtained after the extraction of starch had high fibre content, and consequently, this was also seen in the cookies produced with the addition of these flours. Wheat flour had a higher protein ($13.59 \pm 0.38\%$) and lipid ($2.00 \pm 0.02\%$) content than *pinhão* and bagasse flours. Formulations using wheat flour and bagasse; or *pinhão* and bagasse had high lipid content ($18.44 \pm 0.32\%$ and $18.82 \pm 0.09\%$, respectively). After cooking, the added bagasse biscuits showed a decrease in apparent and specific volume. The addition of *pinhão* flour to the biscuits provided greater softness, unlike the addition of bagasse. Differences were observed in the colour of the flours, especially in the luminosity and chromaticity a^* . The wheat flour showed lower brightness possibly due to its higher ash content, impacting directly on the low brightness of biscuits produced with its addition. Besides making it difficult to grow the dough, the bagasse flour from starch extraction also made the cookies harder. The addition of the three flours, in equal proportion, showed interesting results for application in biscuits.

Conclusions. Both *pinhão* flour and bagasse obtained after starch extraction are potential sources of replacement for wheat flour, allowing adding value to this raw material considered endangered, as well as to the elaborated product.

Introduction

The trees of the so-called "Paraná pine" (*Araucaria angustifolia* or *Araucaria brasiliensis*, *Araucariaceae* family, order *Coniferales*) grow in mixed forests of southern Latin America: mainly in Brazil (south), Paraguay, Chile and Argentina. These trees can reach up to 35–60 m in height and up to 2 m in diameter and their wood has great value [1, 2]. The seeds of these trees are called *pinhão*. They have a high caloric value and can be consumed cooked or roasted by humans and domestic animals. Naturally they are eaten by birds and rodents [3].

In addition to proteins, lipids, fibres, complex carbohydrates, minerals and phenolic compounds, *pinhão* seeds contain about 68–72% starch [2, 4], which can be used in its native form or after modifications for industries such as pharmaceutical, food, cosmetic and textile [5, 6, 7, 9].

During the extraction of the amylaceous fraction, a fibrous by-product called bagasse is generated, which can still have a high content of starch and proteins [7]. This residue could be used in the formulation of some foods such as flour, in order to enrich the nutrition or replace wheat flour.

Thus, the objective of this study was to evaluate the effect of the addition of *pinhão* flour and bagasse generated after starch extraction on the formulation of cookies using the centroid-simplex design for experiments. Proximal analysis, colorimetry (L, a* and b*), analysis of physical properties and hardness were performed to characterise the biscuits.

Objectives of research:

- Produce a *pinhão* seed flour;
- Extract the starch and recover the bagasse;
- Formulate biscuits with whole wheat, *pinhão* flour and starch extraction bagasse;
- Analyse the proximal composition of biscuits;
- Determine the physical properties, colour and hardness of raw and baked cookie.

Materials and methods

Raw materials

Paraná pine seeds, whole wheat flour (F. Venturelli, F18), salt (L 317826), refined sugar, hydrogenated vegetable fat (Delicia Supreme, with salt, L 317826) and yeast (Royal, L.CC 32717 35 3) were acquired in the local commerce of Ponta Grossa (Paraná, Brazil).

Pinhão seeds were acquired in June (2018), and the skin and embryo were removed. The almonds were then kept at -18 °C in plastic bags for four months. After this period, the seeds were thawed (22 °C).

Production of *pinhão* flour and aqueous starch extraction

For the production of *pinhão* flour, the seeds were initially submitted to aqueous grinding (1:1. m / v) in a mixer (Siemens, model SL-08) and the product obtained was dried at 40 °C for 18 h.

Starch extraction was performed by the aqueous method, starting with the aqueous grinding of the *pinhão* seeds as previously described, and passing the ground material through a sieve (150 mesh). The material retained in the mesh (bagasse) was resuspended in water and homogenized again with a blender to improve the extraction yield. After the second washing, the bagasse was recovered and dried in an oven at 40 °C for 24 h, and the permeate was centrifuged to separate the starch.

After drying, the *pinhão* flour and the starch extraction bagasse were ground in a knife mill (Ika Werke M20 - 620 W) for 5 minutes and sieved (42 mesh) to homogenise the size of the particles.

Cookie formulation

The basic formulation of cookies is presented in Table 1.

Table 1

Basic formulation for standard integral cookies

Ingredients	Standard	% (m/m) ¹
Refined salt (g)	0.9	0.5
Yeast (g)	2.2	1.2
Refined sugar (g)	44.0	24.8
Hydrogenated vegetable fat (g)	30.0	16.9
Flour (g)	100.0	56.5
Distilled water (ml)	qsp ²	-

¹mass %;

²disregarding the volume of water;

²amount sufficient to reach the mass point

Centroide-simplex design for experiments was used to define the formulations, using 3 main components: (a) wheat flour, (b) *pinhão* nut flour, and (c) bagasse flour obtained after starch extraction (Figure 1).

Fig. 1. Preview formulation after experimental planning:

F1 – wheat flour (A); F2 – *pinhão* flour (B); F3 – bagasse flour (C)

Thus, 7 assays were tested with different proportions of ingredients as shown in Table 2.

Experimental planning for three compounds recipe

Table 2

Formulation	Ratio of flour in ternary mixture					
	Pseudo-compounds			Real concentration (g)		
	A (X1)	B (X2)	C (X3)	A (C1)	B (C2)	C (C3)
1	1.00	0.00	0.0	100	0	0
2	0.00	1.00	0.00	0	100	0
3	0.00	0.00	1.00	0	0	100
4	0.50	0.50	0.00	50	50	0
5	0.50	0.00	0.50	50	0	50
6	0.00	0.50	0.50	0	50	50
7	0.33	0.33	0.33	33.3	33.3	33.3

(A) wheat flour, (B) *pinhão* flour and (C) bagasse flour obtained after starch extraction

All the ingredients were weighed, and the dough was mixed by hand. Water was added to obtain a uniform mixture. Then, the dough with a height of approximately 0.7 cm was cut with an aluminium baking sheet (4 x 4 cm) and kept in an industrial oven for 20 min at 180 °C.

Centesimal composition

A centesimal composition of 3 flours and 7 formulations was performed. The protein content was performed by Kjeldahl and Soxlet [8].

The crude fibre content was performed by the sachet method (AOAC BA 6A-05). All determinations were performed in triplicate. The moisture and ash content were determined by thermogravimetry (TG) using the TGA-50 equipment (Shimadzu) under the following conditions: sample mass of approximately 7.0 mg; air atmosphere at a flow rate of 150 mL min⁻¹; heating ratio of 10 °C.min⁻¹, from 30 °C to 650 °C [3, 19]. The mass losses were calculated using the TA-60 software.

Physical properties

The length, width, thickness of the cookies were measured with a pachymeter. This analysis was performed on six randomly chosen biscuits before and after roasting. The ratio between the length and thickness of the biscuits after roasting results in the expansion factor. The mass of the raw and baked biscuits was determined with the aid of an analytical balance. The apparent volume (cm³) of the baked biscuit was obtained by means of the method of displacement of birdseeds and the specific volume was calculated, dividing the apparent volume by the mass of the baked biscuit (cm³ g⁻¹).

Colorimetric analysis

The MiniScan (Hunter) reflectance spectrophotometer was used to determine the colour parameters of the flours and raw and baked biscuits of the formulations. The equipment used was the portable colorimeter (Miniscan XE Plus, model 45/0-L, Hunter Associates Laboratory Inc., Reston, VA, USA) with CIE L*a*b* system [18]. Calibration was performed in accordance with the colour standards provided by the manufacturer. The biscuit was placed inside an opaque support in order to exclude the interference of external light in the sample. Colour measurements were initiated in six positions, totalling six colour readings of each biscuit.

Cookie hardness

The texturometer (TA.XT Plus Texture Analyser) and Texture Exponent Lite software was used to evaluate the hardness of the samples.

Seven days after baking, six biscuits were randomly selected and the experiment was performed in the 'Measure force in compression' mode (Ref BIS2/KB), under the following conditions: probe Knife Edge (HDP/BS) in base (HDP/90), velocities: pre-test of 1.5 mm s^{-1} ; test of 2.0 mm s^{-1} and post-test of 10.0 mm s^{-1} , trigger force of 25g, distance of 5 mm, restarting in original position.

Statistical analysis

The results of the analyses were expressed as mean followed by standard deviation. Analysis of variance (ANOVA) and Tukey's test were used to compare the means between the samples with 95% confidence ($p < 0.05$).

Results and discussion

Centesimal composition

Flour is the product obtained from edible parts of one or more species of cereals, pulses, fruits, seeds, tubers and rhizomes by grinding and/or other technological processes considered safe for food production. The product is called "flour" followed by the name of the plant [10].

Pinhão flour can be produced from its edible parts, aiming at better utilization of its nutrients, adding value and as an alternative to the replacement of wheat flour, since it does not present gluten [11].

In the literature it is possible to find the production of *pinhão* flour from drying the endosperm at a temperature of 70°C for 4 h, in order to apply it to bread and biscuits [11, 12].

The centesimal composition of the wheat flour, *pinhão* and bagasse are presented in Table 3.

Pinhão flour (B) and flour obtained from starch extraction bagasse (C) can be classified as "rich" or with high fibre content in accordance with current national legislation [13], because they have a content greater than 6 g of fibre per 100 g of product. From the increase in fibre concentration, the flour (C) retained a greater amount of water, consequently, presenting higher moisture content.

Pinhão flour has higher carbohydrate content than wheat flour, while the amount of lipids, proteins and ashes is lower. The lipid content of flour (B) was similar to the values found in the literature [4, 14].

Table 3

Centesimal composition of (A) wheat flour, (B) *pinhão* flour and (C) bagasse flour obtained after starch extraction (% m/m)

Sample	Moisture	Carbohydrate ¹	Protein	Lipid	Total fibre	Ash
A	8.00±0.11 ^b	67.71±0.33 ^c	13.59±0.38 ^a	2.00±0.02 ^a	4.74±0.01 ^b	8.70±0.11 ^a
B	6.32±0.12 ^c	82.05±0.16 ^a	6.04±0.27 ^b	1.33±0.09 ^b	6.35±0.54 ^{ab}	4.27±0.16 ^c
C	8.64±0.03 ^a	79.87±0.03 ^b	4.53±0.03 ^c	1.47±0.04 ^b	8.49±0.06 ^a	5.50±0.02 ^b
p-value	<0.001	<0.001	<0.001	0.002747	0.029319	<0.001

^{abc}Different letters in the same column represent significant differences according to Tukey's Test (p<0.05).

The extraction of *pinhão* starch confers a reduction in the protein content and higher concentration of lipids, ashes and fibres in the bagasse.

These differences between the flours influenced the centesimal composition of the elaborated cookies, as shown in Table 4.

Table 4

Centesimal biscuit composition (% m/m)

Sample	Moisture	Carbohydrate ¹	Protein	Lipid	Total fibre	Ash
1	8.00±0.11 ^a	59.70±0.38 ^e	8.38±0.30 ^a	15.23±0.00 ^{bc}	5.95±0.86 ^{ab}	8.70±0.11 ^b
2	5.74±0.05 ^c	68.58±0.69 ^b	3.65±0.13 ^d	14.88±0.77 ^c	7.26±1.78 ^{ab}	7.15±0.12 ^c
3	6.39±0.06 ^b	72.25±0.27 ^a	3.05±0.24 ^e	14.95±0.04 ^c	8.04±0.61 ^a	3.36±0.03 ^f
4	6.33±0.06 ^b	67.99±0.25 ^b	5.77±0.15 ^b	15.36±0.21 ^{bc}	5.36±0.36 ^{ab}	4.55±0.05 ^e
5	4.33±0.23 ^d	63.08±0.14 ^d	5.67±0.11 ^b	18.44±0.32 ^a	7.52±1.87 ^a	8.49±0.24 ^b
6	8.05±0.05 ^a	60.00±0.16 ^e	3.32±0.04 ^{de}	18.82±0.09 ^a	4.48±0.31 ^b	9.81±0.14 ^a
7	5.50±0.04 ^c	66.64±0.25 ^c	4.93±0.13 ^c	16.40±0.18 ^b	5.79±0.65 ^{ab}	6.53±0.05 ^d
p-value	<0.001	<0.001	<0.001	<0.001	0.01	<0.001

¹Calculated by difference

^{abc}Different letters in the same column represent significant differences according to Tukey's Test (p<0.05).

According to the Brazilian legislation, biscuits are the products obtained by the mixture of flour(s) and/or starch(es) with other ingredients, submitted to kneading and cooking processes, fermented or not. They may have different coverage, filling, shape and texture [13]. The biscuits made with bagasse had a higher content of carbohydrates, differing significantly from the other formulations. The protein content was higher in the formulation made only with wheat flour. The combination of wheat flour and bagasse flour, as well as bagasse flour and *pinhão* flour provided the highest lipid content in the cookies.

Higher ash content was obtained with the combination of *pinhão* flour and bagasse. The lowest content was found for the formulation with bagasse only.

The assay with the use of the three flours in equal proportion gave an interesting result for proximal composition, with a good content of fibres, proteins and lipids.

Physical properties

Regarding the evaluation of physical properties of the samples before and after cooking, the results are presented in Table 5.

Table 5
Evaluation of the physical properties of cookies before and after cooking

Raw cookie	1	2	3	4	5	6	7	p-value
Length (cm)	3.8 ±0.1 ^c	3.8 ±0.1 ^{bc}	3.9 ±0.1 ^{bc}	4.0 ±0.1 ^{ab}	3.9 ±0.1 ^{abc}	4.0 ±0.0 ^a	4.0 ±0.1 ^{ab}	<0.001
Width (cm)	3.8 ±0.1 ^b	3.9 ±0.1 ^{ab}	4.1 ±0.1 ^a	3.9 ±0.2 ^{ab}	3.9 ±0.1 ^{ab}	3.8 ±0.1 ^b	3.9 ±0.1 ^b	<0.001
Thickness (cm)	0.7 ±0.0 ^b	0.6 ±0.1 ^c	0.8 ±0.0 ^a	0.8 ±0.1 ^{ab}	0.8 ±0.0 ^a	0.8 ±0.1 ^{ab}	0.8 ±0.0 ^a	<0.001
Mass (g)	11.5 ±0.4 ^b	10.7 ±0.8 ^b	13.7 ±1.0 ^a	14.0 ±0.4 ^a	14.1 ±0.5 ^a	14.7 ±0.5 ^a	13.6 ±0.9 ^a	<0.001
Baked cookie	1	2	3	4	5	6	7	p-value
Length (cm)	3.9 ±0.1 ^c	4.5 ±0.2 ^a	4.0 ±0.1 ^{bc}	4.4 ±0.2 ^a	4.0 ±0.1 ^{bc}	4.2 ±0.1 ^b	4.1 ±0.1 ^{bc}	<0.001
Width (cm)	4.0 ±0.1 ^b	4.4 ±0.1 ^a	4.0 ±0.1 ^b	4.5 ±0.1 ^a	4.1 ±0.1 ^b	4.1 ±0.2 ^b	4.1 ±0.1 ^b	<0.001
Thickness (cm)	1.0 ±0.1 ^c	1.1 ±0.1 ^{bc}	0.9 ±0.1 ^c	1.2 ±0.0 ^a	1.2 ±0.0 ^a	1.1 ±0.1 ^{bc}	1.2 ±0.1 ^{ab}	<0.001
Expansion factor	4.0 ±0.4 ^{ab}	4.3 ±0.5 ^a	4.3 ±0.2 ^a	3.6 ±0.1 ^{bc}	3.3 ±0.1 ^c	4.0 ±0.4 ^{ab}	3.6 ±0.4 ^{bc}	<0.001
Mass (g)	9.2 ±0.2 ^c	8.7 ±0.6 ^c	11.2 ±0.7 ^b	12.0 ±0.5 ^{ab}	11.6 ±0.3 ^{ab}	12.4 ±0.4 ^a	12.4 ±0.9 ^a	<0.001
Apparent volume (cm ³)	15.0 ±0.0 ^b	15.0 ±0.0 ^b	10.2 ±0.1 ^c	20.0 ±0.0 ^a	15.0 ±0.0 ^b	21.3 ±1.0 ^a	16.0 ±0.0 ^b	<0.001
Specific volume (cm ³ g ⁻¹)	1.6 ±0.0 ^a	1.7 ±0.1 ^a	0.9 ±0.1 ^c	1.7 ±0.1 ^a	1.3 ±0.0 ^b	1.7 ±0.0 ^a	1.3 ±0.1 ^b	0.44

^{abc}Different letters in the same line represent significant differences according to Tukey's Test (p<0.05).

The raw biscuits showed slight differences in their measurements during their modelling. Bagasse flour seems to interfere with the weighing of biscuits when compared to wheat and *pinhão* flours.

After baking the biscuits, a more significant increase was observed in the length, width and thickness of the biscuits for the formulation with *pinhão* flour. The balanced mixture between wheat and *pinhão* was influenced by the characteristics of *pinhão* flour, leaving it

lighter, and with width, length and thickness similar to formulation 2. So, *pinhão* flour made the dough lighter than wheat flour. Perez and Germani [15] also found lower weight for biscuits formulated with eggplant flour before and after roasting. Bagasse flour, which already had a higher dough in the raw cookie, seems to have resulted in a denser dough, hindering the growth of the dough, since its parameters were practically maintained after baking the biscuits.

The expansion factor is related to the quality of dough, evaluating the ability of the ingredients to absorb water, especially flour. Thus, biscuits formulated with higher fibre content are associated with higher water retention. With this, the expansion factor generally decreases. This was not observed in this study, as reported by other authors [16] with elaboration of cookies using pumpkin seed flour. These authors suggested that due to the high amount of insoluble fibres in pumpkin seeds this may not interfere with water absorption. Thus, the presence of fibres may favour a greater availability of water in the mass, allowing the gelatinisation of starch, and consequently, cause an increase in the expansion of the elaborate biscuits.

A reduction in apparent and specific volume was observed after the addition of bagasse. On the other hand, the mixture between wheat and *pinhão*, as well as *pinhão* and bagasse showed higher apparent volume.

As the biscuits with added bagasse flour showed higher mass after roasting, this affected their specific volume, being the lowest value found.

Colorimetric analysis

The results for the flours' colour parameters are presented in Table 6.

Table 6

Colour parameters of (A) wheat flour, (B) *pinhão* flour and (C) bagasse flour obtained after starch extraction

Flours	L	a*	b*
A	77.88±0.74 ^c	2.85±0.26 ^a	11.08±0.40 ^a
B	83.38±0.06 ^b	2.30±0.01 ^b	10.70±0.04 ^a
C	85.95±0.06 ^a	0.79±0.02 ^c	10.21±0.06 ^b
p-value	<0.001	<0.001	<0.001

^{abc}Different letters in the same column represent significant differences according to Tukey's Test (p<0.05).

Wheat flour showed higher ash content in the proximal analysis, and this reflected in lower luminosity. The chromaticity a* that evaluates the trend from green (-) to red (+) was lower for bagasse flour, thus a lower trend to red, unlike wheat flour. This may be related to the leaching of pigments during starch extraction. And for the chromaticity b* that evaluates the trend from green (-) to yellow (+), there was no significant difference between wheat flour and *pinhão* flour, with a greater tendency to yellow.

Tables 7 and 8 present the colour parameters for the raw and baked cookies, respectively.

Table 7

Colour parameters of raw cookies

Formulation	L	a*	b*
1	47.94±0.55 ^g	9.46±0.35 ^a	22.49±0.54 ^a
2	67.61±0.07 ^a	4.68±0.03 ^e	17.24±0.12 ^e
3	64.9±0.56 ^b	6.34±0.19 ^d	17.69±0.46 ^{de}
4	57.28±0.85 ^e	7.00±0.30 ^c	19.2±0.57 ^c
5	55.12±0.59 ^f	7.68±0.16 ^b	20.24±0.51 ^b
6	61.8±0.13 ^c	6.83±0.04 ^c	20.25±0.12 ^b
7	60.58±0.07 ^d	6.37±0.09 ^d	18.39±0.89 ^{cd}
p-value	<0.001	<0.001	<0.001

^{abc}Different letters in the same column represent significant differences according to Tukey's Test (p<0.05).

The colour of the cookies before being submitted to the oven, reflected the colour of the flours, with a higher luminosity, or tendency to white for *pinhão* flour and bagasse, and a higher tendency to red and yellow for wheat flour. Thus, the presence of wheat in the formulations decreased the luminosity of the samples and the chromaticity a* and b*.

Table 8

Colour parameters of baked cookies

Formulation	L	a*	b*
1	59.16±0,17 ^f	8.56±0.10 ^a	23.26±0.18 ^c
2	68.17±0,16 ^c	8.31±0.08 ^b	26.16±0.26 ^a
3	71.93±0,09 ^a	6.23±0.06 ^f	20.48±0.08 ^e
4	64.96±0,41 ^e	8.24±0.04 ^b	24.79±0.11 ^b
5	66.40±0,13 ^d	7.02±0.07 ^c	22.79±0.07 ^c
6	69.97±0,56 ^b	6.77±0.11 ^d	23.20±0.35 ^c
7	69.03±0,34 ^c	6.51±0.13 ^e	21.98±0.15 ^d
p-value	<0.001	<0.001	<0.001

^{abc}Different letters in the same column represent significant differences according to Tukey's Test (p<0.05).

Corroborating with the colorimetric analysis of the flours, after baking, the biscuits formulated with wheat presented darker and with greater tendency to red, approaching these results the biscuit with pinion flour, which presented greater tendency to yellow. This may be related to the occurrence of non-enzymatic reactions such as the caramelization reaction of sugar present in the mixture and also to the Maillard reaction, since the mixture presents a high amount of carbohydrates and a significant amount of proteins [17].

Cookie hardness

The hardness corresponds to the force over a maximum distance of a compression cycle and is plotted as the maximum peak height of this cycle during the test. The hardness values varied from 6.68 to 25.68 kg as shown in Table 9.

Table 9

Cookie hardness

Formulation	Hardness (kg)
1	18.80±1.29 ^b
2	8.30±0.97 ^d
3	25.68±3.14 ^a
4	6.72±1.15 ^d
5	7.03±0.49 ^d
6	11.41±1.39 ^c
7	6.68±0.80 ^d
p-value	<0.001

^{abc}Different letters in the same column represent significant differences according to Tukey's Test ($p < 0.05$).

The greatest hardness was found for the formulation of biscuit produced only with the bagasse flour obtained after the starch extraction from *pinhão* seeds (3) possibly due to lower starch content, followed by the sample with whole wheat flour (1). The lowest values were observed for formulations with added *pinhão* flour.

The gluten protein network, present in wheat flour, is one of the factors responsible for the hardness of the biscuits. *Pinhão* does not present gluten in its composition, and the starch present in the flours, as well as its higher fibre content, collaborates in the absorption of water and consequent reduction of the hardness values.

Thus, the *pinhão* flour gave less hardness to the biscuits, bringing an interesting sensory characteristic to the formulation defined as the central point of the experimental design. This allows adding value to the by-product of starch extraction and taking advantage of the nutritional value of both wheat flour and *pinhão* flour.

Conclusions

Bagasse flour from the extraction of *pinhão* starch is a good alternative as a substitute for wheat flour, presenting a rich nutritional value, especially as a source of fibre. The production of flour allows extending the useful life of the *pinhão*, expanding its industrial applications and breaking the barrier of its seasonality.

In addition, the biscuit made with the mixture of the three flours stands out, with a good nutritional balance, colour and less hardness.

The bagasse flour together with the wheat flour also presented interesting values except for the higher lipid content of the biscuit.

Thus, the effect of replacing whole wheat flour by *pinhão* flour and by-product of starch extraction in the preparation of biscuits proved promising and other applications can be explored in future work.

References

- Costa F.J.O.G., Leivas C.L., Waszczynskyj N., Godoi R.C.B., Helm C.V., Colman T.A.D., Schnitzler E. (2013), Characterisation of native starches of seeds from *Araucaria angustifolia* from four germplasm collections, *Thermochimica Acta*, 565, pp. 172–7.
- Pinto V.Z., Vanier N.L., Deon V.G., Moomand K., El Halal S.L.M., Zavareze E.R., Lim L-T., Dias A.R.G. (2015), Effects of single and dual physical modifications on pinhão starch, *Food Chemistry*, 187, pp. 98–5.
- Ribeiro L.S., Cordoba L.P., Colman T.A.D., Oliveira C.S., Andrade M.M., Schnitzler E. (2014), Influence of some sugars on the thermal, rheological and morphological properties of “pinhão” starch, *Journal of Thermal Analysis and Calorimetry*, 117, pp. 935–42.
- Cordoba L.P., Bet C.D., Schnitzler E. (2015), Study by thermal methods of pinhão starch modified with lactic acid, *Carpathian Journal of Food Science and Technology*, 7(4), pp. 41–7.
- Daudt R.M., Kulkamp-Guerreiro I.C., Caldera-Oliveira F., Thys R.C.S., Marczak L.D.F. (2014), Determination of properties of pinhão starch: analysis of its applicability as pharmaceutical excipient, *Industrial Crops and Products*, 52, pp. 420–9.
- Gonçalves P.M., Norena C.P.Z., Silveira N.P., Brandelli A. Characterization of starch nanoparticles obtained from *Araucaria angustifolia* seeds by acid hydrolysis and ultrasound, *LWT – Food Science and Technology*, 58, pp. 21–7.
- Thys R.C., Aires A.G., Marczak L.D.F., Norena C.P.Z. (2013), The effect of acid hydrolysis on the technological functional properties of pinhão (*Araucaria brasiliensis*) starch, *Ciência e Tecnologia de Alimentos*, 33(1), pp. 89–94.
- INSTITUTO ADOLFO LUTZ (2008), Normas Analíticas do Instituto Adolfo Lutz. Métodos físico-químicos para análises de alimentos. 4ª ed. (1ª Edição digital).
- Pinto V.Z., Vanier N.L., Klein B., Zavareze E.R., Elias M.C., Gutkoski L.C., Helbig E., Dias A.R.G. (2012), Physicochemical, crystallinity, pasting and thermal properties of heat-moisture-treated pinhão starch, *Starch-Stärke*, 64, pp. 855–63.
- BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. Resolução - RDC nº 263, de 22 de setembro de 2005. Aprova o regulamento técnico para produtos de cereais, amidos, farinhas e farelos, *Diário Oficial da República Federativa do Brasil*, Brasília, 23 de setembro de 2005.
- Bezerra J.R.M.V., Gonzáles S.L.; Kopf C., Rigo M., Bastos R.G. (2006), Elaboração de pães com farinha de pinhão, *Revista Ciências Exatas e Naturais*, 8(1), p. 70–81.
- Thyz R.C.S., Noreña C.P.Z., Marczak L.D.F., Aires A.G., Cladera-Oliveira F. (2010), Adsorption isotherms of pinhão (*Araucaria angustifolia* seeds) starch and thermodynamic analysis, *Journal of Food Engineering*, 100, pp. 468–473.

13. ANVISA - Agência Nacional de Vigilância Sanitária. RDC Nº 54, de 12 de novembro de 2012 - Regulamento Técnico Sobre Informação Nutricional Complementar.
14. Cordenunsi B. R., Menezes E. W, Genovese M. I., Colli C., Souza G. A, Lajolo F.M. (2004), Chemical Composition and Glycemic Index of Brazilian Pine (*Araucaria angustifolia*) Seeds, *Journal of Agricultural and Food Chemistry*, 52 (11), pp. 3412–3416.
15. Perez P.M.P., Germani R. (2007), Elaboração de biscoitos tipo salgado, com alto teor de fibra alimentar, utilizando farinha de berinjela (*Solanum melongena*, L.), *Ciência e Tecnologia de Alimentos*, Campinas, 27(1), pp. 186–192.
16. Moura F.A.de, Spier F., Zavareze E.da.R., Dias A.R.G., Elias M.C. (2010), Biscoitos tipo “cookie” elaborados com diferentes frações de semente de abóbora (*Curcubita maxima*), *Alimentos e Nutrição Araraquara*, 21(4), pp. 579–585.
17. Moraes K.S. et al. (2010), Avaliação tecnológica de biscoitos tipo cookie com variações nos teores de lipídio e de açúcar, *Food Science and Technology*, 30(1), pp. 233–242.
18. Hornung P.S., Oliveira C.S., Lazzarotto M., Lazzarotto S. R. S., Schnitzler E. (2016), Investigation of the photo-oxidation of cassava starch granules, *J. Therm. Anal. Calorim.* 123(3), pp. 2129–2137.
19. Malucelli L. C., Lacerda L. G., Filho M. A. S. C., Fernández D. E. R., Demiate I. M., Oliveira C. S., Schnitzler E. (2015), Porous waxy maize starch, *J. Therm. Anal. Calorim.*, 120(1), pp. 525–532.