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Characterization and Potential Application of Blend of Passion Fruit Peel with Rice Flour in an Extruded Product for Fiber Enhancement

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Abstract By-products from the production of passion fruit juices can be a raw material for the formulation of foods with higher added value. Rice, characterized by being hypoallergenic and gluten-free, can be used with the passion fruit peel. The objective of this study was to prepare a precooked mixture by extrusion of rice flour (Rf) and passion fruit peel (Pfp) for the subsequent formulation of cookies with high fiber content and to determine the physicochemical, microbiological and sensorial characteristics of the flour and processed biscuits obtained. Experimental design of 20 treatments with (Pfp:Rf) percent ratios of 1.6/99.4, 5/95, 10/90, 15/85, and 18.4/81.6%; with moisture percentages of 14.64, 16, 18, 20 and 21.36%; and temperatures of 99.6, 120, 150, 180, and 200.4°C. The extrudates were characterized relative to the centesimal composition, dietary fiber, water absorption index (WAI), water solubility index (WSI), radial expansion index (REI), Ray-X diffraction (DRX), and microbiological stability. The results were subjected to analyses of variance and tests of comparisons of means (Tukey, $p < 0.05$). Of three treatments, the best was chosen for use in obtaining the cookies. For ready-to-eat cookies, the formulation with 18.4% of Pfp flour showed 6.75% acceptability with the judges with an average score of 6.5, which is equivalent to I liked it slightly. For gluten-free cookies stored with microbiological stability for 120 days, the presence of microorganisms was not observed. From the technological point of view, the development of cookie formulations is a viable alternative for human consumption of precooked Pfp and Rf.

Keywords: *dietary fiber, functional properties, by-product, extrusion-cooking, blends, cookies*

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1. Introduction

Passion fruit peel (Pfp) (Passiflora edulis f. flavicarpa Degener) is a co-product resulting from the fruit juice industry, which can reach between 65 and 70% of the weight of the fruit. At present, minimal notice is taken of this important resource, which is, for the most part, discarded [1]. To find alternative uses, in the form of Pfp flour, the extrusion processing of the mixture of this resource with rice flour was proposed, aiming to add value.

Many plant sources with high dietary fiber content are not always suitable for direct consumption due to low sensorial preference. In this sense, it is necessary to create alternatives that, through appropriate processing, demonstrate greater acceptability, preference, and nutritional benefit for the consumer [2,3]. Food extrusion technology is a high-temperature and short time heat treatment (HTST), which causes significant transformations in the materials, leaving them with altered nutritional and functional characteristics and, in general, ready for consumption [4]. According to Kosińska-Cagnazzo, et al. and Ascheri and Carvalho [5,6] showing the application of extrusion technology for items for human consumption, such as breakfast cereals, biscuits (salted and sweet), instant soups, pasta (noodles) and mixed flours. Considering these important technological resources, foods containing high fiber content can be processed along with others that exhibit unique characteristics, in which nutritional benefits, sensorial quality, and even economic aspects that allow their introduction into the consumer market can be considered [7]. The conclusion of the work of Raju et al. [3] regarding Pfp potential for the use of the purple Pfp extract in diabetes subjects with high blood pressure. Because the purple Pfp extract did not show any clinical toxicity, it is possible to consider purple passion fruit as a supplement to antihypertensive medications, such as angiotensin-converting enzyme inhibitors.

According to Chandalia et al. [8], a high-fiber diet improved glycemic control, as evidenced by decreases in the mean daily pre-prandial and 24-hour plasma glucose concentrations. Urinary glucose excretion was also lowered by a high-fiber diet, and the diet lowered glycosylated hemoglobin values slightly but not significantly. A high-fiber diet also lowered 24-hour plasma insulin concentrations. Another conclusion of the Post et al.[9] study about dietary fiber showed that, overall, an intervention involving fiber supplementation for type 2 diabetes mellitus could reduce fasting blood glucose and HbA1c, suggesting that increasing dietary fiber in the diet of patients with type 2 diabetes is beneficial and should be encouraged as a disease management strategy. According to Coqueiro et al. [10] found similar results showing efficacy in the supplementation with the flour of the yellow Pfp, referring to the hypoglycemic and hypolipidemic action. The results found by Lima et al. [11] showed that Pfp flour has an inhibitory effect on the absorption of sucrose in normal rats and a hypoglycemic effect in alloxan-induced diabetic rats. In this sense, the study clearly demonstrated that the hypoglycemic effect of this Amazonian fruit should be exploited biotechnologically, for example, in the control of type II diabetes [12,13].

Several researchers have used starchy cereals to allow the extrusion of other materials that, if processed independently, would have problems of extrudability, as well as sensorial unacceptable characteristics [14,15,16,17,18].

In this sense, considering that the extrusion process promotes the fusion of one or more ingredients (depending on the chemical composition and its particle size in the extrusion system), mainly carbohydrates and proteins, extrusion allows the formation of new structures and physical functional characteristics in the food, including: water absorption and solubility, textures and peculiar sensory properties, making it possible to take advantage of food properties that are beneficial to human health.

The objective of this work was to prepare precooked Pfp and Rf mixed flours by extrusion and to determine the physicochemical characteristics of the extrudates for later use in the formulation of cookies and the sensorial evaluation and stability of the cookies.

2. Materials and Methods

2.1. Raw Material Preparation

Polished rice grains, Tio João brand, long thin class type 1 from a local market, was milled in a disc mill with a 1 mm aperture sieve and the rice flour was obtained. The yellow passion the fruit was purchased from a local commerce site in Rio de Janeiro City, Brazil. After sanitization the passion fruit was divided into four parts, the pulp was removed, and the bark and albedo were ovens dried at 70°C for 24 hours. After drying, the peels and albedo were weighed and packed in plastic bags to be ground. The dried samples were ground in a TREU™ hammer mill (Rio de Janeiro, Brazil) with a 1 mm sieve and then a 2 mm aperture disk mill and a Perten™ mill (Hägersten, Sweden) with a 0.8 mm sieve to obtain the peel and albedo flour (Pfp) with adequate granulometry. Both flours were packed in airtight containers for later use.

2.2. Chemical Composition

Moisture content was determined according to AOAC [19] Method 925.09. The fat content was determined according to AOAC Method 945.38, using petroleum ether as the solvent. The total protein content was determined following the methodology from AOAC, 2001.11 (Kjedahl), factor conversion 5.75. The ash content was determined according to AOAC, 923.03 methodologies. The dietary fiber content of extruded Pfp and Rf blends was determined using the methodology described by AOAC method 985.29.

The mineral composition (sodium, potassium, magnesium, calcium, iron, and phosphorus) was determined following the AOAC. The mineralization was performed by cavity microwave, Method 999.10, Item 9.1.08 AOAC. The quantification was performed using Method 990.08, item 9.2.39, AOAC. All minerals were quantified in duplicate.

2.3. Extrusion Trials and Experimental Design

The extrusion process was carried out with a Brabender® DSE model 19/20DN, single-screw extruder, (Duisburg, Germany), using a 3:1 compression ratio screw, 3mm die diameter and a screw speed of 140rpm. The feed rate was fixed at approximately 2.5 $kg{\cdot}h^{-1}$, operating at a screw speed of 180 rpm, fitted to a torque rheometer DCE330 (Brabender, Duisburg, Germany) provided with a cooling system via compressed air for the three barrel sections. The barrel temperature profile of the first zone at 60°C and the second zone at 100 °C was fixed, and the third zone varied according to the experimental design (Table 1).

The experiment was conducted in a complete factorial design 2^3 [20] with three independent factors or variables (moisture, temperature, and formulation and three coded levels. Thus, in this experiment, 20 treatments were used, eight factorial (combinations of levels -1 and +1), six axial (one variable at level ± α and another at level 0) and six central, serving as an estimate of experimental error and determining the accuracy of the mathematical model [21].

2.4. Physical Characteristics of Extrudates

The radial expansion index (REI) was evaluated by measuring the extrudates diameter with a manual 150-mm pachymeter (Vonder®, Curitiba, Brazil), and the calculation, with an average of 20 determinations for each treatment, was performed according to Equation (1) [22]

$$\mathrm{REI} = \left(\frac{\mathrm{D}}{\mathrm{D}_0}\right)^2 \quad (1)$$

Where D is the diameter of the die bore (D_0 = 3.0 mm) and D is the diameter of the extrudates after cooling.

The apparent density of the extrudates (ρ) was calculated using Equation (2)

$$\rho = \frac{4\mathrm{m}}{\pi \times \mathrm{D}^2 \times \mathrm{L}} \quad (2)$$

Where m is the mass of extrudates of length L. 20 readings for both D and L were recorded for each type of extrudates. The D readings averaged three measurements: at the extremes and in the middle along L.

Water activity (A_w) determination of flour and cookies was performed using the Aqualab® model CX-2 (Pullman, Washington, USA) digital at a temperature of 25 °C, and the sample was then weighed and the weight recorded. The water activity results were expressed as the mean of three measurements for each treatment.

Extrudates instrumental texture was determined using a TA-XT2 Texture Analyzer (Stable Micro Systems Ltd. (Surrey, England), and the test conditions were pre-test speed 5 mm·s-^{1},posttest 10 mm, and 50 g contact force [23].The results were expressed with the mean of 20 determinations for each treatment.

Pasting viscosity was determined using a Rapid Visco Analyzer (RVA, Newport Scientific Pty Ltd., Warriewood, NSW, Australia). A sample (3g) of extruded blend flour was weighed into a dried empty canister, which was filled with 25ml of distilled water into the canister containing the sample. The solution was thoroughly mixed, and the canister was well fitted into the RVA. The slurry was heated from 50 to 95°C with a holding time of 2 minutes followed by cooling to 50°C with 2 minutes holding time. The rate of heating and cooling were at a constant rate of 14°C/min. Peak viscosity, trough, breakdown, final viscosity, setback, peak time and pasting temperature were read from the pasting profile with the aid of Thermocline Software for Windows connected to a computer.

The determination of water absorption index (IAA) and water solubility (ISA) in extruded flour were performed using the methodology described by [24]. For the calculation of WSI, Equation 3 was used.

$$\text{WSI} = \frac{\text{water soluble solids}(\text{g})}{\text{dry sample}(\text{g})}. \quad (3)$$

After removal of the supernatant liquid, the tubes were weighed, and thus, along with the weight of the sample and the weight of the residue that solubilized in the distilled water, the WAI of the extruded material was found, according to Equation 4.

$$\text{WAI} = \frac{\text{absorbed water}(\text{g})}{\text{dry sample}(\text{g}) \times \left[1 - \text{fraction soluble}(\text{g})\right]}. \quad (4)$$

2.5. Microbiological Evaluation of Extruded Mixed Flour and Cookies

The microbiological analyses of the mixed flours were performed in duplicate with three replicates (true replicates) to determine the useful life of the flours. The methodology described by the Compendium of Methods for the Microbiological Examination of Foods [25] was utilized: Salmonella sp, Thermotolerant coliforms, molds and yeasts during the periods of 0, 15, 30 and 45 days.

For the cookie analyses, evaluations of Salmonella, Coliforms at 45 °C, molds and yeasts, Bacillus cereus and Staphylococcus coagulase positive were performed according to the methodology described by the Compendium of Methods for the Microbiological Examination of Foods (25)f or the periods of 0, 60 and 120 days.

2.6. Preparation and Physical Evaluation of the Cookies

Among the 20 factors designated in the experimental design, three were chosen according to physical property criteria (WAI, WSI and REI): T8 with 5% Pfp and 95% Rf; T12 with 10% Pfp and 90% Rf; and T13 with 18.4% Pfp and 81.6% Rf, respectively.

To obtain cookies with Pfp and Rf extruded mixed flours, a completely randomized design was used, considering the variation of corn starch in the cookie formulation: (a) corn starch (T8: 160g, T12: 120g, T13: 80g); (b) corn starch (T8: 40g, T12: 80g, T13: 80g) and other fixed ingredients for T8, T12 and T13 with added refined sugar (80g), palm oil fat (60g), sodium bicarbonate (2g), refined salt (1g), soya lecithin (2ml), vanilla (2ml), whey (4g), two egg yolks and ammonia bicarbonate.

Cookies were obtained in two stages, where a cream was prepared with soy lecithin, refined sugar, palm fat, whey, salt and eggs. This phase, where the cream was produced, was carried out for three minutes. In the second phase, the flour was added to cream (extruded Pfp and Rf, corn starch, ammonia bicarbonate, vanilla and yeast) and homogenized in the planetary mixer (Arno Deluxe SX80, Brazil) for five minutes to obtain the mass. After the mixing process, the laminar mass was opened at two cm and then extended with the aid of a roll on a marble surface and molded in a rectangular form. After this step, the mass was cut. The formatted dough was provided and baked (220°C, for 10 minutes) using a prefilled pan with butter paper. After cooking, the biscuits were cooled to room temperature for one hour and then stored in sealed containers for further analysis.

2.7. Sensory Evaluation

The acceptability of cookies was determined by sensory evaluation using a panel of 100 untrained judges from both sexes and age groups at Embrapa Food Technology. Acceptability was evaluated in terms of appearance, aroma, taste and texture among the different types of cookies, using the structured hedonic scale of 9 points, according with Stone & Sidel, 1985 [26]. To evaluate the texture among the different types of cookies, a seven-point scale ranged from 1 "very hard" to 7 "very soft".

Before the sensory evaluation, all the judges were informed about the methodology of the applied test, using individual cabins under white lighting for the realization of the sensorial analysis. For the test, the samples (~ 5.56 to 9.22 g) were randomly coded with three digits and served on porcelain dishes. For the participation in the research, all the judges signed the Free and Informed Consent Form submitted and approved by the Research Ethics Committee of the Federal Rural University of Rio de Janeiro (protocol number 379/2013).

The extrudates color in the cookies was determined using the Hunter LAB (Virginia, USA) colorimeter, model Color Quest XE, performed by reflectance in the CIELAB and CIELCH Color apparatus, aperture 0.375 mm in diameter, luminance D65/10 in the extruded mixed flour from Pfp and Rf and cookies. Samples were placed in a 10 mm quartz cuvette in four replicates for each sample.

3. Results and Discussion

After the evaluation of the experimental dates (Table 1) expansion, absorption and solubility in water, and pasting properties, three treatments were chosen as the most appropriate for use in the preparation of cookies, T8, T12 and T13, containing the following respective proportions of Pfp and Rf),: 5:5 (T8). 10:90 (T12) and 18.4:81.6 (T13). The composition centesimal, content of dietary fiber and minerals are, shown in Table 2.

3.1. Dietary Fiber

According to the results of Table 2, the protein values of the mixtures are related to the rice flour content in the blend. Likewise, the fiber content of the formulation will be greater as Pfp fiber is used 5:95 (T8), 10:90 (T12) and 18.4: 81.6 (T13). Treatment T13 contains 18.4% Pfp and 81.6% Rf. In this sense, the resulting extruded flour may have uses, as the formulation of a novel food is required for a given functionality. Of course, as a higher Pfp content is added into the formulation, the dietary fiber (DF) content will be higher, ranging from 1.39 to 5.66%. The results show that the T13 treatment received the highest concentration of dietary fiber of Pfp and Rf. The peel of the passion fruit, including albedo and flavedo, has considerable value of pectin. According to Martinez et al. [27], Pfp presented a high content of total dietary fiber (57.36%), soluble (19.20%) and insoluble fiber (38.05%).

In the work of Chawla and Patil and Sharma et al. [28,29], a wide variety of foodstuffs naturally loaded with soluble dietary fiber (SDF) are available, with their intact potential properties capable of providing significant physiological benefits. High-quality SDF isolated from various sources can be incorporated into a wide variety of commercial beverages, solid foodstuffs such as bakery goods, dairy products, and fruit- and vegetable-based products, which all provide potential benefits to the food industry with their consequent increased demand owing to their potent health claims. In this work, the form of fiber incorporation, soluble and insoluble, for the derived Pfp was through the extruded Pfp blending with rice flour.

Adequate daily intake (up to 35 g dietary fiber/day) of DF is largely recommended, according to Maphosa and Jideani [29]. According to Fungwe et al. [30] from Institute of Medicine (IOM), dietary reference intake (DRI), an adequate intake for total fiber, is set at 38 and 25 grams (g) per day for young men (age 14-50 years) and women (age 19-50 years), respectively. Thus, by the present study, the treatments T12 and T13 have moderate and high amounts of fiber, respectively. Therefore, the preparations with extruded mixed Pfp and Rf flour have the potential to promote enrichment through the production of bread products (biscuits, cakes and breads). In another study performed by Leoro et al. [31] all the extrudates (6, 15, 24, and 30% Pfp) that were produced showed a reduction in the in vitro glycemic index of approximately 50% when compared to white bread. Could be considered an interesting alternative to be used as extruded breakfast cereals in weight and glycemic control diets, in which a slower liberation of glucose is desired. Second Li et al., [32] mention the extrusion as a way to modify and promote a certain degree of functionality in the raw materials containing fibers. After extrusion, an increase in solubility of the cell wall pectin polymers and hemicelluloses was observed along with swelling of the cell wall material, while carbohydrate composition of the cell wall material remained unaffected. With such modifications in solubility and apparent viscosity, onion waste material, for example, can be used as a potential source of DF, leading to added values when applied to new formulations to produce extruded foods (29) and (6).

Table 1. Factorial design 2^3 with three independent variables and three levels and experimental design and responses for radial expansion

	Independent Variables			Dependent Variables					
Test	Temperature (T °C)	Moisture (M, %)	Passion fruit peel (Pfp, %)	Radial expansion index (REI)	Water Absorption index WAI g/g	Water Solubility index WSI (%)	Initial Pasting Viscosity VI (cP)	Maximum pasting viscosity VM (cP)	Final Pasting Viscosity VF (Cp)
1	180	20	15	2.64967	8.7985	7.1121	1439	1156	706
2	120	20	15	3.06744	9.3765	6.9108	904	1001	858
3	180	16	15	4.70133	9.4185	10.0843	7749	5477	4683
4	120	16	15	4.434	5.7802	6.5178	1386	1363	663
5	180	20	5	2.92972	9.9818	6.6198	837	783	630
6	120	20	5	4.27528	9.8831	8.2868	2044	1751	880
7	180	16	5	5.12711	9.5966	10.7185	1484	1446	916
8	120	16	5	5.4705	7.08	10.7507	505.5	875	904.5
9	200.5	18	10	4.71039	9.1131	8.1688	1253	1424	561
10	99.5	18	10	5.2035	9.7797	9.183	657	860	789
12	150	21.4	10	3.12056	8.7709	5.7193	860	912	652
13	150	14.6	10	3.56679	6.621	10.2191	1465	1572	700
14	150	18	18.4	6.59394	7.0209	7.9867	6144	5598	3726
15	150	18	1.6	4.9645	9.419	11.0239	1339	1362	858
16	150	18	10	4.09739	9.3931	9.1993	1412	1322	769
17	150	18	10	4.50017	8.77	8.1324	1222	1320	702
18	150	18	10	4.61267	9.5936	9.5043	1120	1271	730
19	150	18	10	4.52272	9.6431	9.8626	1371	1381	679
20	150	18	10	4.03611	9.5287	6.8428	1375	1378	675

Table 2. Proximate composition of extrudates from three main treatments with passion fruit peel (Pfp) and rice flour (Rf) blends

Composition (%)	Selected trials of Pfp and Rf rates*		
	T8	T12	T13
Moisture	6.66	7.33	8.69
Ash	0.82	1.16	0.66
Nitrogen Total	1.22	1.16	0.66
Protein	7.62	7.25	4.12
Ether Extract	0.00	0.00	0.00
Carbohydrates*	83.68	82.1	85.87
Dietary fiber	1.39	2.75	5.66
Sodium (mg)	217.62	451.74	88.18
Potassium (mg)	2447.70	4118.10	1468.58
Magnesium (mg)	372.89	445.68	342.76
Calcium (mg)	183.40	379.50	113. 44
Iron(mg)	32.61	19.87	6.77
Phosphorus (mg)	1269.06	1300.52	1213.63

3.2. Radial Expansion Index (REI)

The radial expansion index is one of the main responses resulting from the extrusion process. This index can be high, low, or ideal, according to how the process parameters, raw material characteristics, and extrusion system configuration, among others, are monitored [33]. For starchy products, many jobs have been reported showing their effects. In the same way, a series of products was evaluated considering mixtures, to find new forms and characteristics of products. To the extent that other no starch materials are substituted for the starch, it is evident that the expansion of the starch is related to the degree of substitution. In this case, the substitution of Pfp for Rf, promoted interesting results for the possibility of using these precooked mixtures.

For REI (Table 2),the highest values found (6.59 mm, 5.47 mm and 5.35 mm for T13, T8 and T12, respectively) were determined when the Pfp and Rf were 18.4, 5 and 10% of Pfp (the difference corresponds to Rf) extruded at the moisture of 18, 16 and 14.64% and temperatures of 150, 120 and 10 °C, respectively. On the other hand, if the moisture is high, the final product will have a lower degree of cooking, will exert less pressure on the matrix, and will reduce the generation of heat, and the transformation of the product will be decreased. Second Brennan [34] mention that the expansion index is also related to the amount of water inserted in the sample to be extruded.

According to Capriles and Arêas [35] state that higher starch content is related to higher values of expansion index using raw material with lower lipid content (rice) and low moisture extrusion. In this way, these authors verified that the extrudates with greater expansion, according to their structure, could be crunchier.

Thus, the experimental study showed that the lowest value of the expansion index was in the treatment T1 at 2.63 mm in diameter, when the test was processed with the highest moisture content of 20%, temperature in the third zone of extrusion of 180°C and 15%Pfp formulation. This result shows that high moisture contributed to the reduction in the extrudates expansion, since, according to Capriles and Arêas [35], the high moisture decreases the amount of gelatinized starch in the mass.

A higher moisture extrusion processing (20%) was used in the T1, T2, and T5 tests. A low expansion index was observed. Under these conditions, there is a lower degree of degradation of the material, thus reducing the degree of material cooking because of a lower friction in the extrusion system. In another study, Carvalho [36] mixed 70% rice flour and 30% residual bean material with 17% of dietary fiber, obtaining a high REI value of 7.75 and, showing that this combination with high fiber content did not hamper the expansion. The percentage of Pfp used in this study did not influence the expansion of the expanded ones. The objective was to use the highest possible Pfp incorporation; consequently, the samples that obtained higher values of the radial expansion index were used. The values of the Pfp content of the T8 (5%), T12 (10%) and T13 (18.4%) tests contributed to the expansion of the extrudates, because the rice flour, naturally by the starch content, provides high levels of expansion. Studies by Pai et al. (37, 38) reported that the presence of fibers impairs the expansion of the extrudates. Obviously, in this case, the expansion is believed to be related to the type of fiber present, with higher percentages of cellulosic fiber and lower levels of soluble fibers.

The standardized effects of the variable radial expansion index (REI) shows that it is the parameters, moisture (both linear and quadratic), Pfp percentage and process temperature that are significant. Without doubt, the insertion of material containing fibers causes a drop in the values of expansion. Considering that Pfp flour contains pectin, this component may interact in the system at the moment of heat fusion in the structure of the starchy rice.

3.3. Water Absorption Index (WAI)

By the analysis of Table 1, we observed that, the higher temperature results in higher water absorption values. However, high levels of moisture in processing favoured higher values of the water absorption index. The mixture of Pfp and rice flour would have a greater fusion between its components according to the proportionality of the mixture. Thus, temperature and moisture variations would show WAI, according to Pfp percent. Because the Pfp composition is approximately 30% cellulose, 27% pectin, 1.6% hemicellulose and 1.1% lignin, dry basis [37], the high cellulose content can be considered as a blockage to the formation of structures better organized with the starch material from Rf. This blockage may explain the differences between the treatments assigned in the experimental design and the reason for choosing three of them as being the most suitable for formulating the biscuits. In Table 1, can be observe the existing correlations between the properties of the exudates. The WAI does not prove to be significant.

3.4. Water Solubility Index (WSI)

In general, for extruded products, high solubility values in water imply severe treatments during extrusion because the amylaceous structure is diminished to polymer fractions around the dextrin. In this state, there is very low hydrogen bonding, which allows the paste formation. Numerous papers have been reported indicating that, if the incorrect parameters are not corrected, low processing moisture, high temperatures, and screw configurations with high shear rate can lead to starchy products, high expansion results or even severe degradation where material burning occurs. Table 1 shows that the treatments with 16% moisture exceeded 10% WSI.

The values determined for the WSI variable (Table 2) show that the highest and lowest average values were obtained for treatments T14 and T11, respectively, at a temperature of 150°C, with 18% and 21.36% moisture, 140 rpm as the rotation of the screw inside the extruder, and flour water solubility of 11.02 and 5.71%. In Table 2, the water solubility of the extruded Pfp and Rf was positively correlated with lower moisture and higher temperature, showing the higher solubility WSI for the T7, T8, T12 and T3 treatments.

3.5. Pasting Properties

The results of pasting properties are presented in able 1. The initial viscosity (VI), maximum viscosity at 95°C and final viscosity (VF), in cP, were considered. The treatment T3, containing 15% Pfp, extruded at 180°C with 16% moisture, reached the highest initial viscosity value, 7740 cP, a value considered high, which shows that the processed material, although having 15% Pfp, shows a flour with excellent cold paste-forming characteristics. In the same way, the T13 treatment, containing 18.4% Pfp, extruded at 150 °C and with 18% moisture, reached6144 cP, a value also considered high in cold pasting. The higher peak viscosity, suggests that the starch, from rice flour, was characterized by a high water-holding capacity and ability to swell the granules.

However, to verify the water activity values of the processed samples, the treatments, T8, T12 and T13 had 0.276 ± 0.015, 0.227 ± 0.005 and 0.259 ± 0.034 Aw, respectively, determined at 24°C, values that indicate very low possibilities for the development of microorganisms.

3.6. Sensory Evaluation of Cookies

The sensory evaluation of the cookies (Table 3) shows that the formulations Fb13 and Fb8 had a higher acceptability index. The biscuits obtained through the incorporation of Pfp to Rf, in the proportion of 18.4% of the formulation in Fb13, was the most sensorial accepted, with a mean score of 6.75, which corresponds to the note interval 6, representing, respectively, “liked slightly", which generated greater acceptability on the part of the judges.

Table 3. Means and standard deviation of the sensory acceptance test of cookie biscuits using different concentrations of Pfp and Rf

Attribute	Fb8 5%*	Fb_{12} 10%*	Fb_{13} 18.4%*
Appearance	6.26±1.91b	5.82±1.97^{b}	6.98±1.50^{a}
Aroma	6.91±1.44a	5.91±1.74^{b}	6.75±1.45^{a}
Flavor	6.70±1.55a	5.41±2.11^{b}	6.63±1.62^{a}
Texture	6.90±1.50a	4.72±1.95^{b}	7.06±1.49^{a}
Acceptance	6.68±1.50a	5.26±1.95^{b}	6.75±1.49^{a}

Different letters in each row means that the samples were significantly different (p<0.05) *Percentage of extruded flour Pfp and Rf on the biscuits formulation. Fb: biscuit elaborate with extruded flour from treatment 8, 12 or 13.

The formulation Fb12 with 10% Pfp had the lowest acceptability index with respect to the formulations Fb13 and Fb8. Therefore, the formulation Fb12 was considered by the judges with an average score of 5.26 that corresponds to the Likert score of 5 representing, "I neither liked nor disliked". The treatments differed statistically from each other (p<0.05) with respect to appearance, and the sample that obtained the highest acceptance by the judges was the formulation Fb13 (6.98), which was a product with a general appearance significantly superior to the formulations Fb8 (6.26) and Fb12 (5.82). The one with the lowest score in this issue was the Fb12 formulation. Formulations Fb8 and Fb12 had similar general appearances, which were inferior to the appearance of Fb13. These indices were much higher if compared to the biscuits made with soybean meal and rice bran meal developed by Mariani [38], which obtained a mean score (5) for the appearance attribute.

The results presented (Table 3) indicate biscuits formulated with Pfp and Rf presented better marks for the appearance attribute than those obtained by Mariani [38]. However Giovanella [39] elaborated several formulations of gluten-free biscuits using quinoa flour and potato starch, where they verified that the highest acceptance in the appearance attribute was formulation B (7.68) followed by formulations D and C (7.63 and 7.29). In this study, we found higher values regarding the appearance for cookies formulated with 18.4% Pfp and Rf. Table 3 shows that the aroma differences of the treatments differed statistically from each other (p<0.05). The Fb12 formulation presented less aroma than the others. However, the formulations Fb8 and Fb13 presented similarities in their aromatic characteristics.

Regarding the flavour attributes shown in Table 3, a significant difference (p<0.05) between the treatments was demonstrated. The Fb12 formulation presented (5.41) less flavour than the others did, obtaining the lowest mean of evaluation. The Fb8 and Fb13 (6.70 and 6.63) presented similarities in this attribute. However, the biscuits with gluten-free flour (quinoa and potato starch) elaborated by Giovanella [39] presented greater acceptability for formulation attribute B (7.05).

Regarding texture, the sample showing high acceptability was the fb13 formulation (7.06), and less preferred in this regard was the formulation fb12 (4.72). The formulation Fb12 presented a very soft texture in relation to the others. Formulations Fb13 (7.06) and Fb8 (6.90) presented similar textures. According to Giovanella (39) elaborated four formulations of cookies with gluten-free flour, using quinoa flour and potato starch, and obtained a higher acceptance value in formulation B (7.41), followed by C and D (7.23 and 7.21). Thus, the present study shows that the results presented for the texture of biscuits with flour of cashew and albedo of passion fruit and rice were inferior when compared to the three formulations of biscuit processed with gluten-free flour and flour of quinoa and potato starch.

3.7. Shelf life and Microbiological Analyses of Mixed Flours

Molds and Salmonella sp. did not show any growth in Pfp and Rf, thus complying with current legislation, since the limit according to ANVISA - Resolution 12/2001 is the absence detected in 25 g.

The storage times (0, 15 and 45 days) of the Pfp and Rf were in compliance with the ANVISA-Resolution 12/2001 and CNNPA-Resolution 12/1978 regulations regarding microbiological standards.

4. Conclusions

Passion fruit peel is an important coproduct from the juice industry. The flour Pfp, including flavedo and albedo, was mixed with rice flour and processed by extrusion to result in an important new product that can be used as a supplier of dietary fiber in the elaboration of other foods. From the different percentages used (1.6, 5, 10, 15 and 18.4% Pfp, with the balance to 100% from rice flour), all of them had excellent extrudability in a single-screw extruder system (3:1), providing extruded flours with different properties according to the treatment followed in the experimental design. Although the total fiber content of Pfp was high, the extrusion process was able to fuse Pfp into a single material with the rice flour. In this way, extrudates with different degrees of expansion, absorption and solubility in water were obtained, with characteristics of color and texture according to the applied mechanical effort. As a test of use of these extruded flours, three treatments were chosen to compose the cookie form, which had a good acceptance rate by the tasters. Consequently, this extruded Pfp and RF flour is considered as an alternative for the insertion of fibers in the formulation of other foods such as porridges, beverages, and bread products, in general. The sensory evaluation of the cookies shows a higher acceptability index. The biscuits obtained through the incorporation of Pfp to Rf, in the proportion of 18.4% of the formulation was the most sensorially accepted.

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Declarations of Interest

The authors attest that there are no interests that competed with the objective, interpretation, and presentation of the results.

Compliance with Ethical Standards

According with Ethical Commission –UFRRJ/COMEP, by protocol n°. 379/2013, the research met ethical principles whose acceptance process by number 23083.007762/2012-10.

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