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Physicochemical and sensory analyses of sequilhos produced with non-conventional food plants: arrowroot, licuri and wild passion fruit shell

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Abstract

The presented study aimed to produce sequilhos with Non-Conventional Food Plants (arrowroot and licuri), using different proportions of wild passion fruit shell powder (PFP). These products were analyzed with regards to the proximal composition (ash, moisture, proteins, lipids and dietary fiber) and water activity. The sensory aspects were evaluated by acceptability and purchase intention tests, in which 118 non-trained adult panelists participated of the study. All formulations produced in this study (containing 5, 10 and 15% of PFP) presented higher values for ash and dietary fiber, when compared with the control formulation (without PFP). However, all formulations presented a lower but acceptable performance in sensory analyses when compared with the control formulation, probably due to the flavor and aroma of wild passion fruit shell. Despite of that, the addition of 5 and 10% PFP is still encourage due to the increase of nutrients in the product, and as an strategy to expand and disseminate the knowledge on NCFP.

Keywords: food composition; edible plants; bakery foods.

Practical Application: Valorization of traditional foods with arrowroot, licuri and wild passion fruit.

1 Introduction

Tubers, roots, rhizomes and bulbs of Non-Conventional Food Plants (NCFP) are emerging and alternative food sources that can be exploited in the market of starch industry and consequently in bakery products (Silveira & Francisco, 2020). In addition, the use of NCFP may increase the socioeconomic influence and visibility of the consumption of agroecological products (Moura et al., 2021).

The Cerrado and Caatinga are Brazilian biomas with a wide diversity of vegetables and unknown varieties of spontaneous food plants, which may have nutritional, environmental and commercial relevance. However, there are few studies about the benefits of using these plants as food. Thus, it is important to explore the application of disused species, as well as explore the advantages of using these plants (Nascimento et al., 2015).

Arrowroot (*Maranta arundinacea L.*) is a NCFP with an important source of resistant starch, which provides important sensory features to bakery products. This gluten-free vegetable has many functional properties and may contribute to increase the income of small-scale agricultural producers (Santos, 2017). On the other hand, the licuri (*Syagrus coronata* M. Beccari) has attracted the consumers interest due to good nutritional value, but this NCFP also preset a socioeconomic potential (Gomes & Aplevicz, 2021). Moreover, the oil extract from this plant is very appreciated and it has a great economic value (Santos et al., 2020).

The wild passion fruit *(Passiflora cincinnata* Mast.) presents high nutritional value, high content of phenolic compounds, and it has a high commercial potential (D'Abadia et al., 2019). Among the benefits of this fruit, it is possible to cite the anti-inflammatory, antihypertensive, and sedative properties (Silva et al., 2020). In this sense, the wild passion fruit flour has potential to be used in bakery because it has higher values of ash and dietary fiber when compared to traditional wheat flour. In addition, this flour has lower moisture content, which shows the potential to be used as food or even as a food supplement (Lima et al., 2019). Thus, bakery products produced with wild passion fruit flour are characterized by the high content of dietary fiber, and by the sustainable approach, considering the fruit wastes are frequently discarded (Lima et al., 2022).

Considering the relevance and benefits of the use of NCFP, the presented study aimed to produce sequilhos with arrowroot and licuri, using different proportions of wild passion fruit shell flour (PFP). These products were further analyzed with regards to the proximal composition, water activity and sensory aspects.

2 Methods

2.1 Materials and product formulation

The NCFP (3 kg of arrowroot, 0.5 kg of licuri and 1 kg of wild passion fruit) were purchased in a traditional open market in Brazil, and they were used to produce the formulations of

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sequilhos presented in Table 1. Arrowroot was purchased as a powder obtained by grinding the dried plant, and licuri were ground before incorporation into the recipes. The wild passion fruits were sanitized and the pulps were removed, while the fruit shells were frozen at -18 °C for 24 h. After that, these shells were freeze-dried and ground into a powder.

2.2 Production of sequilhos

The ingredients of the formulations presented in Table 1 were weighed on a semi-analytical scale and mixed manually to obtain the dough. Thus, the sequilhos were molded, placed in baker trays with butter paper, and baked in a preheated industrial oven for 7 min at 180 °C. After that, the sequilhos were slowly cooled at room temperature and properly stored for further analyses.

2.3 Physicochemical analyses

Moisture and water activity

These parameters are related to the stability and sensorial characteristics of the product. Thus, the water activity was measured in a water activity analyzer by the dew point, and the results were expressed ass values between 0 and 1. Following, the moisture content was evaluated by drying *ca.* 2 g of sequilhos at 105 °C until constant weight. The mass lost in the process was calculated, and the results were expressed as % (w/w) of moisture (Instituto Adolfo Lutz, 2008).

Ash

The ash content is related to the amount of minerals in a product, and provides important information about the nutritional aspects of the food. To evaluate this parameter, *ca.* 2 g of sequilhos were incinerated at 600 °C until constant weight and the results were expressed as % (w/w) of ash (Instituto Adolfo Lutz, 2008).

Proteins

The protein content is a parameter related to the food structure and to the nutritional value of a product, and it was evaluated using the micro Kjeldahl method (Instituto Adolfo Lutz, 2008). Thus, *ca.* 0.5 g of sequilhos and 1.5 g of catalyst powder (copper sulphate and potassium sulphate 1:10) were added to a Kjeldahl digestion tube, along with 3 mL of sulfuric acid, and heated at 350 °C until complete digestion of the sample. Thus, a Kjeldahl apparatus was used to distillate the nitrogen as ammonia, which was collect in 5 mL of 2% (w/v) boric acid solution with methyl red as indicator. Total nitrogen titres were quantified using standard 0.1 M hydrochloric acid solution, and the protein content was calculated using a correction factor of 6.25, expressed in % (w/w) of proteins.

Lipids

Lipids play an important role in the nutritional value of the product and in the sensory characteristics. Thus, lipid content in sequilhos was evaluated using the Bligh-Dyer method (Bligh & Dyer, 1959) with modifications, in which *ca.* 0.5 g of sample were mixed with 1.6 mL of water, 2 mL of chloroform and 4 mL of methanol (0.8 : 1 : 2 ratio) into a glass tube. The mixture was stirred for 30 min, followed by the addition of 2 mL of chloroform and 2 mL of 1.5% (w/v) aqueous sodium sulfate solution (1.8 : 2 : 2 water/chloroform/methanol ratio). Next, the chloroform phase was transferred to a tube containing sodium sulfate and filtered through a filter paper. After that, the final volume of the lipid extract was measured and the liquid was dried at 105 °C, so the residual solids were used to calculate the lipid content by mass difference. The results were expressed in % (w/w) of lipids.

Dietary fiber

The consumption of dietary fiber is important due to innumerous physiological benefits and, thereby, this parameter was evaluated using the methodology proposed by Van Soest et al. (1991) with modifications described by Souza et al. (1999), for the quantification of neutral detergent fiber (NDF - cellulose, hemicellulose and lignin). Thus, *ca.* 0.5 g of sequilhos were mixed with 50% (v/v) aqueous ethanol solution and heated at 50 °C for 20 min, followed by filtration, to defat the samples. Next, the residual material was added to 5 mL of water and 0.2 mL of thermostable amylase (Termamyl - Novozymes, Araucária, Brazil), followed by heating at 80 °C for 20 min. After that, 35 mL of neutral detergent solution were added to the mixture and boiled under reflux for 1 h. Finally, the dietary fiber in the mixture was collected by filtration on a quantitative filter paper, with two washing steps using 10 mL of acetone. The dried filter papers with dietary fiber residues were dried at 105 °C, followed by incineration at 600 °C until constant weight (ash quantification). Thus, the NDF content was calculated by the difference between the filter paper mass and the filter paper mass with residues (without ash), and the results were expressed as % (w/w) of dietary fiber.

Table 1. Formulations of sequilhos produced with non-conventional food plants.

Ingredients	Formulations			
	Control	5% PFP	10% PFP	15% PFP
Arrowroot (g)*	600	570	540	510
Wild passion fruit shell (g)*	-	30	60	90
Licuri (g)*	100	100	100	100
Sugar (g)	235	235	235	235
Egg (g)	250	250	250	250
Margarine (g)	40	40	40	40

*Arrowroot and wild passion fruit shell were dried and ground into a powder, and licuri was only ground.

Carbohydrates and total energy

The carbohydrate content was determined by difference, that is, by subtracting from 100% the percentage of moisture, ash, proteins, lipids and dietary fiber, and it was expressed as % (w/w) of carbohydrates. Total energy was calculated considering 9 kcal per gram of lipid, 4 kcal per gram of protein and 4 kcal per gram of carbohydrate.

2.4 Sensory analysis

The sequilhos formulations were subjected to an acceptability test, as proposed by Hough et al. (2006), with 118 non-trained adult panelists composed by students and staff of Universidade Federal do Oeste da Bahia. The test was composed by a 9-point hedonic scale for the evaluation of color, flavor, aroma, texture and overall acceptance. The panelist were also enquired about the purchase intention using a 5-point hedonic scale raging from "certainly would not buy" to "certainly would buy" (Santana et al., 2006). Throughout the test, the panelists received each formulation one by one, in randomly coded cups, and they were asked to clean the palate between each tasting using water and unsalted crackers. The results of acceptability tests were analyzed as described in the section 2.5, and the results for purchase intention were analyzed by the frequencies among panelists for each formulation.

2.5 Statistical analysis

The physicochemical analyses were performed in triplicates and the statistical differences were calculated by analysis of variance (ANOVA) followed by Tukey's means comparison test, both at the 5% significance level (Sisvar software version 5.6). The results of acceptability tests were also analyzed as previously described, using the same parameters.

3 Results and discussion

The NCFP are characterized by a regional and nutritional diversity, but the consumption of these plants has been decreasing in the last years. Considering that some NCFP are rich in micronutrients and bioactive compounds, it is important to explore their potential in the production of traditional and new functional food, thereby being a cheap and accessible source of nutrients (Folharini et al., 2019).

Another characteristic of NCFP is that they are sensory-rich plants, due to the color, texture, aroma, and flavor, which attract consumers who are interested in alternative food sources. These plants also represent a cultural heritage in Brazil that contributes as an important tool to encourage family farming, sustainability and biodiversity aspects. On the other hand, NCFP also have a great economic potential because they can be used as a source of income for small-scale agricultural producers, but they are still very undervalued and unknown by the population (Moura et al., 2021).

In this context, easily accessible foods such as bakery products may be an interesting vehicle to propitiate and encourage the consumption of NCFP. According to Roriz et al. (2020), biscuits are bakery products with recognized commercial value due to their high demand in the market, with a long shelf life and good acceptability. Moreover, it is important to identify the variation of each ingredient in the shape, appearance, and acceptance of the product, since consumers have become more exigent in the recent years. Thus, it is necessary to modify the ingredients to improve sensory characteristics, especially using healthier alternatives, and NCFP may play a role in this context. Thus, the development of new food products using these traditional plants is a good alternative for the high demand of products that are less expensive, healthy, with several nutrients, and that reach consumers' interest.

3.1 Physicochemical analyses

Food composition analyses are important to evaluate the quality, production, and storage strategies of food. In this sense, the NCFP arrowroot, licuri and wild passion fruit were applied in the production of sequilhos, which were analyzed with regards to the proximal composition, as presented in Table 2. The results indicate that the incorporation of NCFP significantly increased the values of ash, protein and dietary fiber in almost all formulations, indicating a positive effect on the nutritional composition of these products.

Moisture values for sequilhos were below the limits recommend by the Resolution nº 12, of 1978 from the National Commission of

Table 2. Proximal composition, water activity and total energy value of sequilhos produced with arrowroot, licuri and wild passion fruit.*

Physicochemical parameters	Formulations			
	Control	5% PFP****	10% PFP****	15% PFP****
Water activity	0.510	0.511	0.509	0.506
Moisture (%)	11.25 ± 0.21^{a}	8.36 ± 0.01^{b}	8.57 ± 0.01^{b}	7.94 ± 0.05^{c}
Ash (%)	0.37 ± 0.02^{a}	0.58 ± 0.01^{b}	0.79 ± 0.03^{c}	0.98 ± 0.06^{d}
Lipids (%)	6.29 ± 0.17^{a}	6.46 ± 0.43^{a}	6.95 ± 0.46^{a}	6.85 ± 0.29^{a}
Protein (%)	3.98 ± 0.38^{a}	4.14 ± 0.06^{a}	4.93 ± 0.24^{b}	5.01 ± 0.15^{b}
Dietary fiber (%)	8.76 ± 0.18^{a}	9.08 ± 0.14^{b}	10.61 ± 0.35^{b}	12.20 ± 0.61^{c}
Carbohydrates (%)**	69.35^{a}	69.38^{a}	68.15^{b}	67.02^{b}
Total energy (kcal/100 g)***	349.93	352.22	358.87	349.77

*Mean ± standard deviation. Means followed by the same letter in the same row do not differ at 5% significance level. **The carbohydrate content was determined by difference, that is, by subtracting from 100% the percentage of moisture, ash, proteins, lipids and dietary fiber. ***Total energy was calculated considering 9 kcal per gram of lipid, 4 kcal per gram of protein and 4 kcal per gram of carbohydrate. ****PFP: wild passion fruit powder.

Norms and Standards for Foods (CNNPA) (1978), which establishes the maximum value of 14% of moisture for biscuits. Similarly, the water activity values indicated that all formulations would be stable with regard to the multiplication of microorganisms. According to Cecchi (2003), the water content of a food is crucial for the speed of deterioration or in the occurrence of reactions that may alter the organoleptic characteristics of the food. Thus, the results presented in Table 2 for moisture and water activity suggest that these products may have a long shelf life.

According to the results presented in Table 2, the addition of PFP significantly increased the ash content in sequilhos, indicating a higher mineral content in this product when compared to the control without PFP. In 2005, Cordova et al. reported almost 9% of ash for the dried wild passion fruit powder (obtained with the fruit shell), corroborating the correlation between addition of PFP and the increase in the ash content. Similarly, He et al. (2020) reported that the common passion fruit (*Passiflora edulis*) seed, pulp and shell are rich in Fe, Zn, Mn, B, Cu, K, N, Ca, P, Mg, S, and Mo, which shows the potential of these species for the increase of minerals in new foods.

Lipid content in sequilhos did not present significant differences among the formulations, while protein content significantly increased when the proportion of PFP was higher in the formulation. Lipids in passion fruit are mainly located into the seeds, thereby it is expected that the addition of PFP (obtained with the fruit shell) would not increase the lipid content in these formulations (He et al., 2020). On the other hand, protein content in formulations with 10 and 15% of PFP were significantly higher when compared to the control and formulation with 5% of PFP. Considering that the increase in proteins was not linear according to the amount of PFP in the formulation, this fact may be attributed to variations in the proportion of other ingredients.

The dietary fiber content in formulations enriched with PFP presented higher values when compared to the control, which is corroborated by the high content of dietary fiber in the dried fruit shell, representing almost 26% of the mass (Córdova et al., 2005). In 2013, López-Vargas et al. (2013) reported 72% of total dietary fiber in the dried albedo of *P. edulis* (common passion fruit), indicating the high potential of this material for application in the production of new functional foods. Considering the increasing interest of population for healthier diets, food products with higher amounts of dietary fiber may attract the attention of such consumers (Campidelli et al., 2021). Among the main benefits, dietary fibers act by decreasing the risk of Chronic Noncommunicable Diseases (NCDs), promoting better digestion and acceleration of intestinal transit, assisting in the formation of the fecal bolus, and reducing dysbiosis of the intestinal microbiota (Cui et al., 2019; Mateos-Marcos et al., 2017).

All the sequilhos formulations presented predominance of carbohydrates in proximal composition, and such result is attributed to the arrowroot powder, which is rich in carbohydrates, especially resistant starch (Santos, 2017). As a result, all formulations presented very similar energy values (kcal), considering the high content of carbohydrates in all formulations, and low content of lipids.

3.2 Sensory analyses

Three formulations of sequilhos were produced using the NCFP arrowroot, licuri and wild passion fruit and they were submitted to an acceptance test (texture, flavor, aroma, color, and global acceptability), and the results are presented in Table 3. The same panelists were also inquired about the purchase intention, and the results are presented in Figure 1.

Considering the results of the acceptability test, it was observed that the formulations with 5 and 10% of PFP did not differ statistically among all the attributes that were analyzed. Moreover, the control formulation did not differ statistically from the formulations with 5 and 10% of PFP for the attribute aroma, and it was showed that the control formulation presented higher scores for all other attributes, indicating a higher acceptability when compared to the other formulations. Similarly, the sequilhos with 15% of PFP differed statistically from the other formulations, with lower mean values and higher standard deviation values for all the evaluated attributes, indicating lower acceptability of this formulation.

The purchase intention test (Figure 1) was performed once, that is, each panelist tasted the formulations only once, so it was not possible to obtain the standard deviation for more detailed statistical analyses. Thus, these values represent only the frequency of purchase intention for each formulation throughout the scale of attitude. As a result, it was observed that the formulations with 5 and 10% PFP obtained good results (certainly and probably would buy), when compared to the control formulation, which reached higher scores. This result indicate the low perception of panelists with regard to the incorporation of PFP into the formulation, encouraging the use of NCFP to increase the nutritional value of food and to spread the use of NCFP among the population.

Table 3. Sensory analysis of sequilhos produced with arrowroot, licuri and wild passion fruit. The values represents the results of an acceptability test with 118 non-trained adult panelists and using a 9-pions hedonic scale.*

Formulations	Attributes				
	Aroma	Color	Texture	Flavor	Global acceptability
Control	7.23 ± 1.32^{a}	7.49 ± 1.23^{a}	7.66 ± 1.23^{a}	7.57 ± 1.34^{a}	7.72 ± 1.14^{a}
5% PFP**	6.99 ± 1.54^{a}	6.73 ± 1.75^{b}	6.65 ± 1.83^{b}	7.09 ± 1.77^{b}	6.99 ± 1.54^{b}
10% PFP**	7.06 ± 1.46^{a}	6.76 ± 1.62^{b}	6.66 ± 1.58^{b}	6.91 ± 1.70^{b}	6.91 ± 1.55^{b}
15% PFP**	6.41 ± 1.67^{b}	6.23 ± 1.87^{c}	6.02 ± 1.89^{c}	5.44 ± 2.05^{c}	5.84 ± 1.81^{c}

*Mean ± standard deviation. Means followed by the same letter in the same column do not differ at 5% significance level. **PFP: wild passion fruit powder.

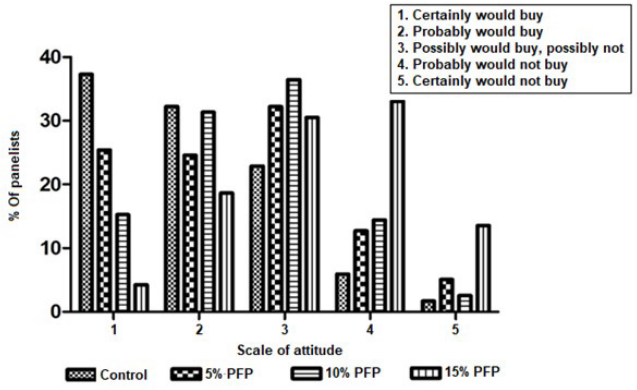

Figure 1. Purchase intention of sequilhos produced with arrowroot, licuri and wild passion fruit. The values represents the results of a purchase intention test with 118 non-trained adult panelists and using a 5-pions hedonic scale. PFP: wild passion fruit powder.

To the best of our knowledge, this is the first study about the application of wild passion fruit shell in the production of bakery products. Despite of that, some studies have evaluated the application of other NCFP in this type of food (Ramos et al., 2021). In 2020, Nascimento et al. (2020) evaluated the application of a powder produced with the shells of common passion fruit (*P. edulis*) in the production of biscuits. Those authors reported a decreasing acceptability and purchase intention of biscuits when the proportion of powder was increased in the formulations. Similar results were reported by Ozores et al. (2015) for cakes produced with a common passion fruit powder (*P. edulis*), where the formulations with a higher proportion of the powder presented lower acceptability and purchase intention. Thus, it is expected a lower acceptability and purchase intention of bakery products added of wild passion fruit shell powders, or similar ingredients, probably due to the flavor and aroma that is not common to the consumers. To overcome these negative results, other NCFP may be added to the formulations to improve flavor and aroma of the sequilhos in future studies. Despite of that, the addition of PFP is still encourage due to the increase of important nutrients in the products (minerals and dietary fiber), considering that the sequilhos with 5 and 10% PFP also presented acceptable scores in the sensory analysis.

4 Conclusions

The sequilhos produced with the NCFP arrowroot, licuri, and wild passion fruit shell powder presented potential to be an alternative for the supplementation of minerals and dietary fiber in human nutrition. In addition, due to the low values of moisture and water activity, the sequilhos may have higher microbiological stability and, consequently, a longer shelf life. The formulations with higher percentages of wild passion fruit flour were those that presented higher fiber contents, which are important components for healthier bakery products. Despite the lower acceptability and purchase intention, the addition of 5 and 10% of PFP is still encourage due to the increase in the nutrients of the product and as an alternative to stimulate the consumption of NCFP by the population. In this sense, the present study may contribute to expand and disseminate the knowledge on NCFP, which is still a subject without recognized importance in the area of Food Science and Technology.

Ethical approval

This study was approved by the Research Ethics Committee of the Universidade Federal do Oeste da Bahia (No. 3.449.038). The participation of individuals in the study was voluntary by signing the Consent Form.

Conflict of interest

The authors declare that they have no conflict of interest.

Author contributions

The authors Marcos Vidal Martins and Carolina Couto Ribas conceived and designed experiments, and prepared the draft of the manuscript. Bárbara Reges Feitosa assisted in the execution of the sensorial analysis, and prepared and revised the manuscript. Fabrício Luiz Tulini conducted the physicochemical analysis experiments and reviewed the manuscript. Volnei Brito de Souza coordinated the sensory analysis and reviewed the manuscript.

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