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Fruit Waste as Natural Pectin Source for Jam Production in Rural Communities

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Abstract

A study was carried out to elaborate and monitor the shelf life of a pineapple jam with ingredients using, as “gelatinizing agent”, the pectin extracted from passion fruit residues from a rural community of Amazonas State, Brazil. The product was always maintained at a temperature of 25 ℃ and studied for 4 months, with the results showing physical-chemical and microbiological stability. We concluded that passion fruit residue can be used in pineapple jam production while still meeting legal standards for commercialization, reducing environmental waste, and being an alternative source of income in rural communities.

Keywords: *Passiflora edulis, Ananas comosus*, food waste

1. Introduction

Fresh fruit production, both in crude and processed form, has increased significantly around the world. Rising incomes and growing consumer interest in product variety, freshness, convenience, and year-round availability are among the main reasons for this increased demand (Feliciano, 2016). Consumers today demand foods that are sustainably produced and processed, deemed safe, fresh, and natural, and have nutritional value (Putnik et al., 2018). Food industries are looking for sustainable technologies that provide better preservation of native nutrients in fruits and vegetables, and they can be applied to the exploitation of by-products while remaining eco-friendly (Granato et al., 2020). Fruit waste has become one of the main sources of municipal solid wastes, which have been an increasingly tough environmental issue, in addition to the urgent need to seek resources and use of benefit for fruit waste (Deng et al., 2012).

In Brazil, the sustainable production and consumption of food have faced constant challenges, as serious problems may arise in the future due to postharvest losses and food waste. Traditional farming systems will face increasing challenges to maintain and expand their current levels of food production due to climate change, intensive use of inputs and natural resources and, above all, changes in the eating habits of the Brazilian population (Henz & Porpino, 2017). In Brazil, post-harvest losses of vegetables can reach up to 30-45% (Henz, 2017), thus, finding ways to mitigate such damage is vital.

Increased fruit crop farming and diversity in many tropical countries coupled with the risk of post-harvest losses have given rise to alternative means of processing these fruits into valued products. Tropical fruits such as, oranges, grapes, pineapples, cherries, guavas, cashews, lemons, and watermelons have increased and gained global importance due to their medicinal and nutritional values, flavors, exotic aromas, and colors. In this context, jams are examples of useful by-products that can contain the high nutritional levels of some fruits and their bioactive compounds. A jam is an intermediate moisture content (Mc) product that is prepared with fruit pulp, sugar, pectin, acid, and other ingredients that allow it to be conserved for prolonged periods and greater with added value to the product. For example, the *Passiflora edulis* pectin has been extracted and evaluated as ingredient for the fruit industry (Seixas et al., 2014).

Pectin is a natural hydrocolloid that exhibits a wide spectrum of functional properties. Furthermore, the gelatinizing ability of pectin enables its use as a viscosity enhancer (Vanita & Khan, 2017). One natural source of pectin is passion fruit, which is cultivated and commercialized in Brazil, especially in beverage production. The passion fruit peel consists essentially of the mesocarp (albedo), rich in pectin and highly useful in industrial and technological processes (Casagrande et al., 2017). The P. edulis pectin is applied in jam production, such as in tamarind jam without pectin and pectin from the albedo of yellow passion fruit (Souza et al., 2016). Garcia et al. (2020) showed the viability of optimized production of alternative flour (30% of passion fruit peel flour) from agro-industrial waste and the potential of the flour as an ingredient for the nutritional enrichment of dietary foods.

In this context, the objective of this study was to elaborate and characterize a pineapple jam with natural pectin of passion fruit and pineapple residues from a Brazilian rural community. Additionally, the study sought to increase the source of family income in the production of new products for commercialization without chemical additives and a way to use waste and monitor product shelf life.

2. Method

2.1 Raw Materials

Samples of fully mature yellow passion fruits (*Passiflora edulis*) and ‘Turiaçu’ pineapples (*Ananas comosus*) were purchased in July of 2019 at the rural community of “Vila do Engenho” in Amazonas State, Brazil. The pineapple peel was removed using a scraper or sharpened knife. Fruits that did not contain deterioration, insect bites or foreign materials were obtained and those that had a "non-standard" size or shape were discarded. After selection, the fruits were sent to the Food and Pilot Plant Laboratory of the Federal University of Amazonas, Brazil.

2.2 Pectin Extraction

The passion fruit pulps were manually separated from the peels with a sanitized spoon. Then, the peels were cooked until translucent to obtain the albedo and the pineapples cut into pieces and processed in a blender to obtain the pulp that was subsequently sifted.

2.3 Jam Preparation

The product was formulated as follow: pineapple peel (85%) + natural pectin (1%) + sugar (14%) were used to form a single batch. Even with low pectin content, pineapples are suitable for jams due to their naturally high acid content, which meets the requirements to manufacture jams that requires the presence of acids for the formation of the gel. Cooking took place in an open pan using an electric shovel mixer. The products were packed in glass containers previously sterilized at 100 ℃/15 min with capacity for 250 g and closed with a metal lid. Heating was performed in a water bath at 100 ℃ for 15 min. Then, the products were cooled by adding cold water for 15 min and stored at room temperature (approximately 25 ℃) for 4 months. The shelf life of the product was monitored every 20 days through physical, chemical, and microbiological analysis. The process was carried out in triplicate from 3(three) different lots of passion fruits for pectin extraction and pineapples for jam preparation. The control sample was produced with commercial pectin according Lima et al. (2017). On the other hand, the control sample was produced only with the orientation purpose.

2.4 Assays

Proximate composition and physicochemical properties: samples were evaluated for pH, total solid soluble (°Brix), and water activity by AQUALAB 4TE. The proximate composition (moisture content (Mc), crude protein, lipids, crude fiber, and ash) was determined by the methods described by AOAC (2016). Microbiology: coliform 45 ℃, *Salmonella* sp. and Molds and Yeasts were evaluated according to APHA (2011).

2.5 Statistical Analysis

The means of the physicochemical analyses were evaluated by variance analysis (ANOVA) and f-test at 5% probability using the statistical package Statistical Analyses System (SAS, 2001).

3. Results

3.1 Proximate Composition

The proximate composition values obtained in the study are displayed in the table below (Table 1), compared to the results obtained by Aina et al. (2015) and Santos et al. (2014) with pineapple jam, where our carbohydrate values (63.0%) were close to Santos et al. (2014), but some of the other values were a lot closer to Aina et al. (2015).

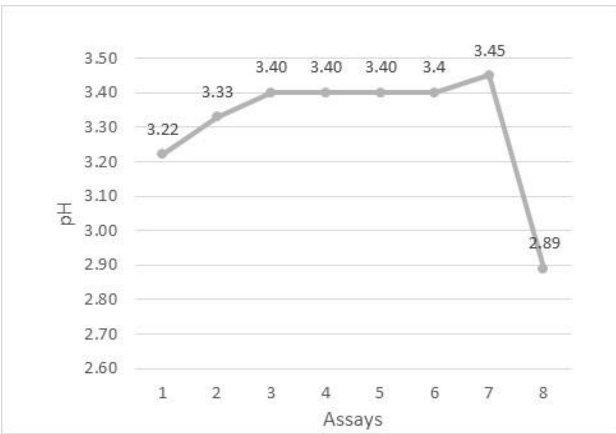
Table 1. Proximate composition of pineapple jam

Variables (g%)	Results (mean ±SD)	Aina et al. (2015)[a]	Santos et al. (2014)[a]
Moisture Content	19.9±0.05	30.0±0.08	35.34±0.10
Carbohydrates	70.7±0.05	58.6±0.30	63.99±0.15
Lipids	3.0±0.05	3.40±0.26	0.10±0.04
Protein	1.0±0.01	0.08±0.008	0.73±0.08
Ash	2.4±0.01	5.0±0.08	0.60±0.02
Crude Fiber	3.0±0.02	2.2±0.08	0.35

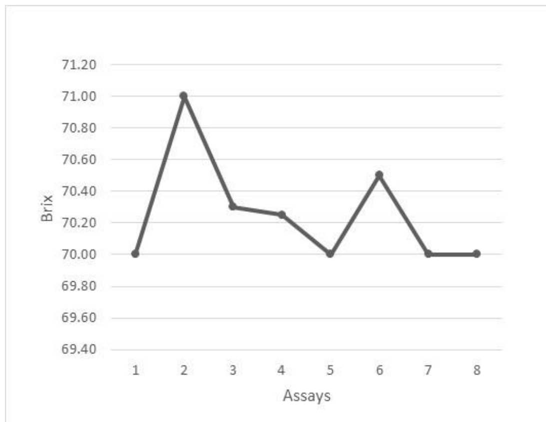
a Aina et al. (2015) and Santos et al. (2014) evaluated pineapple jams but it was not clear the pineapple cultivar of the raw material.

3.2 Physicochemical Properties of Pineapple Jam and Microbiological Analysis

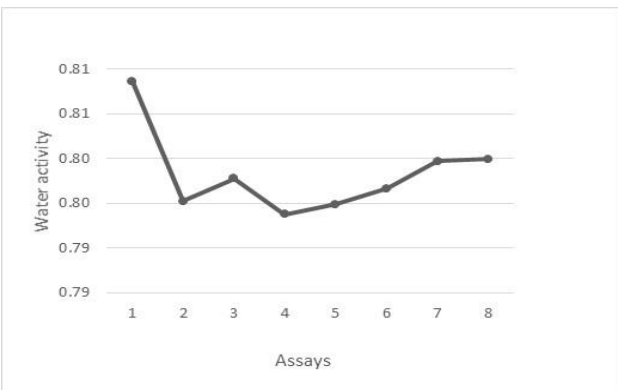
The values obtained regarding the physicochemical properties of the pineapple jam are displayed in the image below (Figure 1), where they are separated in four graphs: (a) pH showed mean of 3.31, (b) total soluble solids (°Brix) mean was 70.20%, (c) Water activity values showed mean of 0.8, and (d) mc mean was 15.90%; (e) the titrable acidity mean was 0.4%. The microbiological analysis showed: absence of *Salmonella* sp. (in 25g), total coliform (<3 MPN/g), and molds and yeasts (<104 CFU/g).



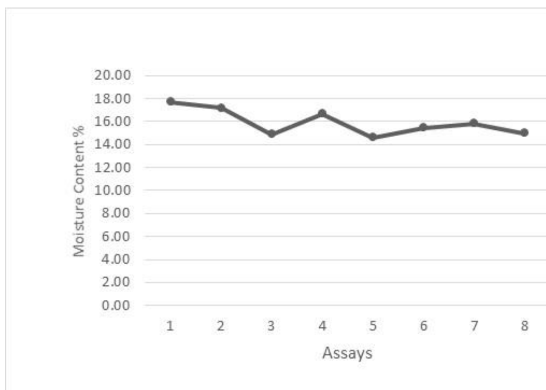
(a) pH



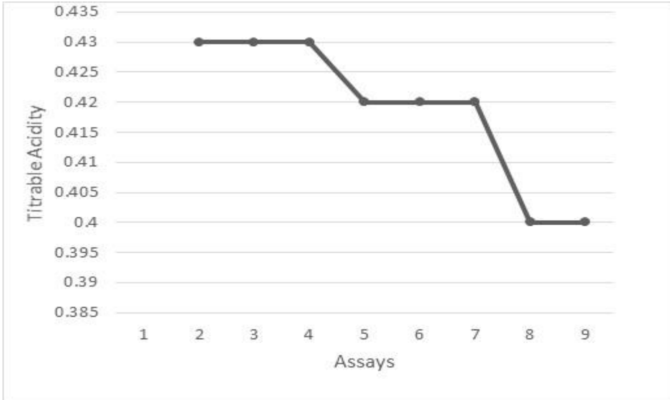
(b) °Brix



(c) Water activity



(d) Moisture content %



(e) Titrable Acidity %

Figure 1. Physicochemical properties of pineapple jam. The assays were carried out biweekly, concerning: (a) pH, (b) °Brix, (c) water activity, (d) moisture content% and (e) titrable acidity%

4. Discussion

The results of the pineapple jam with natural pectin were compared to a previous study by Aina et al. (2015) of a pineapple jam despite the authors not describing its preparation, source of pectin or the cultivar as raw material of the product. The carbohydrate content found in our work was 70.7% higher than 63.9% reported by Santos et al. (2014). The 'Turiaçu' cultivar is known for being a sweet pineapple with a high amount of carbohydrates and Lopes Neto et al. (2015) reported the lipid value of 0.10g%, which is much lower than our results of 3.0g%. This may be explained by the fact that the authors reported food fiber and no crude fiber. The value of crude fiber (3.0%) was similar to Lima et al. (2017) of 3.02%. In this context we can consider the use of pineapple peel an important ingredient, such as some seeds, stalks and leaves of other vegetables to be discarded. They can add economic and environmental value, in addition to the nutritional aspect, especially with increased value of dietary fibers (Vieira et al., 2017).

For pH, the mean was 3.31, which lower than Vieira et al. (2018) who produced a jam without citrus pectin and with 'Turiaçu' pineapples and found pH 3.77 and titratable acidity of 0.22%. The authors considered that the gel formed was considered weak because the total acidity of the jam should be between 0.50 and 0.80%, as there is exudation of the jam liquid (syneresis) in values above 1.00%. In low acidity, which are in values below 0.50%, the gel net becomes weak. In our work, the acidity value was 0.40%, although levels slowly decreased in 25 °C of storage. The 'Turiaçu' is a low acidity pineapple cultivar according Lopes Neto et al. (2015) and it may explain the low level of acidity.

Regarding Total Soluble Solids (°brix), we found an average of 70.20%. The results were higher than values reported by Granada et al. (2005) of 65.10%. Here, the °brix value meets Brazilian legislation that requires a minimum of 62% (Brazil, 2000). The jam was composed of 'Turiaçu' pineapples that, according to Araújo et al. (2012), the fruit had on average 16.1% soluble solid content, which is higher than other Brazilian cultivars such as 'Pearl', 'Cayenne' or 'Vitória'. The passion fruit pectin seems to contribute to the gelation process, strongly influenced by the pectin esterification degree (DM). For commercial pectin, there are two different procedures of pectin gelation that can be distinguished. High-methoxylated pectins (DM > 50%) and low-metoxylated pectins (DM < 50%) (Robledo & Vasques, 2018). In this context, the natural pectin from passion fruit was able to keep the product Brix stable for 4 months. Licodiedoff et. al. (2010) studied high values of °Brix in pineapple jam with different levels of pectin metoxylation and observed that the highest content of total soluble solids (69.67%) was obtained with the use of high metoxylation pectin and rapid gelling at a concentration of 0.50%. Pereira et al. (2015) elaborated a pear-type pineapple jam with commercial pectin and found an average pH of 3.94, °Brix of 37.94, and titratable acidity of 0.24, however, the authors did not specify whether they used commercial pectin and only mentioned the formulation (pulp, sugar, preservatives, and acid). The physicochemical properties seem to keep a product safe against some microorganisms. The microbiological analysis showing absence of *Salmonella* sp., total coliform, and molds and yeasts, are in accordance with the Brazilian microbiological standards for jam (Brazil, 2001).

According to Oliveira et al. (2012), low relative humidity values leave the product exposed to yeast deterioration processes when associated with a water activity value of approximately 0.6. In the present study, we found an average of 0.80 that can prevent the growth of molds, yeasts and mycotoxigenic species. The Mc level was lower than the values reported by Lima et al. (2017) of 36.81%. Despite the different findings, there was no significant syneresis in our product or negative visual aspects. More studies are necessary to understand the role of natural pectin of passion fruit in moisture content of the product using different ingredient concentrations.

The product met the nutritional aspects required by Brazilian legislation and presented stability throughout the study period, proving its feasibility for commercialization by the rural community to add value to "non-standard" fruits that would normally be discarded. Furthermore, we also suggest that further studies focus on the aspects of antioxidant activity, vitamins, and dietary fibers of the future potential products. We also suggest the use of other regional fruits such as bananas and oranges. Other conservation processes can be tested, including natural sources of sugars to obtain sustainable food products.

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