Elaboration of star fruit jam (Averrhoa carambola) with the addition of chilli pepper (Capsicum frutescens)

Elaboração de doce de frutas estrela (Averrhoa carambola) com adição de pimenta-do-reino (Capsicum frutescens)

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ABSTRACT
Star fruit (Averrhoa carambola) is an exotic food with high productivity that can be cultivated in tropical and subtropical regions. The chili pepper (Capsicum frutescens) produces capsaicinoids that give the sensation of pungency when consumed. Both fruits have high perishability, requiring industrialization alternatives. Thus, the objective is to elaborate and characterize star fruit jam formulations with different pepper contents, in addition to verifying their acceptance by the consumer. Three samples star fruit jam were formulated: standard, medium and hot spicy with variation in the concentration of chilli pepper being 0.0%, 1.0% and 1.6%, respectively. After filling, they were subjected to physicochemical characteristics of moisture, pH, titratable acidity and soluble solids. For the sensory analysis, a nine-point hedonic scale was used to assess flavor, texture, global acceptance, ranging from 1 "I disliked it very much" to 9 "I liked it very much" and another purchase intention scale, ranging from 1 to 5, with 50 tasters not trained. The jams had good physical-chemical characteristics, acidic pH, in addition to sensory acceptance with an approval rate above 75% of the product.

Keywords: Capsaicinoids, Sensory Analysis, Oxalidaceae, Carambola.

RESUMO
A fruta estrela (Averrhoa carambola) é um alimento exótico com alta produtividade que pode ser cultivado em regiões tropicais e subtropicais. A pimenta (Capsicum frutescens) produz capsaicinóides que dão a sensação de pungência quando consumida. Ambas as frutas têm alta perecibilidade, exigindo alternativas de industrialização. Assim, o objetivo é elaborar e caracterizar formulações de doce de frutas estreladas com diferentes conteúdos de pimenta, além de verificar sua aceitação pelo consumidor. Três amostras de doce de frutas estrelado foram formuladas: padrão, médio e picante, com variação na concentração de pimenta malagueta em 0,0%, 1,0% e 1,6%, respectivamente. Após o envase, elas foram submetidas às características físico-químicas de umidade, pH, acidez titulável e sólidos solúveis. Para a análise sensorial, foi utilizada uma escala hedônica de nove pontos para avaliar o sabor, a textura, a aceitação global, variando de 1 "eu não gostei muito" a 9 "eu gostei muito" e outra escala de intenção de compra, variando de 1 a 5, com 50 provadores não treinados. As geléias tinham boas características físico-químicas, pH ácido, além de aceitação sensorial com uma taxa de aprovação acima de 75% do produto.

Palavras-Chave: Capsaicinoides, Análise Sensorial, Oxalidaceae, Carambola.

1 INTRODUCTION

Star fruit (*Averrhoa carambola.)* belongs to the Oxalidaceae family and is easily adaptable to hot and humid climates and tropical and subtropical regions with high

production (BABU *et al.*, 2006). The fleshy fruit, with a sweet and sour flavor, with a juicy pulp (MUTHU *et al.*, 2016) is edible freshly and has a star shape when cut transversely (FERRARA, 2018).

It is rich in vitamins C, A and B complex, minerals such as magnesium, potassium and phosphorus, carotenoids, gallic and oxalic acid (FERRARA, 2018). In addition, it has a low caloric value (34 kcal / 100 g), due to its high humidity, which leads to its perishability and can be stored only for a few days (MOHD SUHAIMI; MAT ROPI; SHAHARUDDIN, 2021) at room temperature (MUTHU *et al.*, 2016), because there is rapid dehydration and browning of the pulp (DAS CHAGAS LAMEIRA *et al.*, 2020). It can also be industrialized in the form of fruit juice, jellies, canned, yogurts, dehydrated and dried (BARMAN; BADWAIK, 2017; CHAKRABORTY; BUDHWAR, 2018; GREGÓRIO *et al.*, 2020; LEIVAS *et al.*, 2016).

However, some conservation methods such as conventional drying or the use of modified atmosphere cause shrinkage due to moisture loss and subsequent cell collapse with changes in color, texture, flavor and nutritional composition (FERRARA, 2018). One of the options to extend shelf life is industrialization. Jam making is the common method of preserving fruit, the main factor being the high concentration of sugar that helps in preservation (DISHA. *et al.*, 2017). As it contains soluble fibers such as gums, pectins and mucilages, it is ideal for the production of jams or creamy sweets (GHAZALI; LEONG, 1987).

The addition of ingredients that can bring benefits to the consumer's health and/or add some flavor different from the traditional version increases acceptability and commercialization (STRØM-ANDERSEN, 2020). The elaboration of star fruit jam with the addition of chilli pepper (*Capsicum frutescens*, Solanaceae) can add financial value and present an exotic and spicy product to the food market.

Red peppers, such as chilli peppers, contain capsaicin, such as capsaicin, dihydrocapsaicin, nordihydrocapsaicin and other compounds that give the sensation of pungency (heat on the tongue) when consumed (SANATI; RAZAVI; HOSSEINZADEH, 2018) n addition to having antimicrobial, antioxidant, antihyperglycemic effects , antihypertensive and anti-inflammatory (RIVERA et al., 2019; SANATI; RAZAVI; HOSSEINZADEH, 2018). It should be noted that peppers are highly perishable, with the need to study alternatives to reduce post-harvest losses (ALMEIDA ALVES *et al.*, 2019). It enhances the flavor of preparations and industrialized products reaching audiences who like this spice.

Considering the high added value of star fruit and pepper, in addition to the fact that they are sources of several compounds beneficial to health, combined with the fact that they are perishable to the point of seeking alternatives for their post-harvest use, this study aimed to elaborate and characterize star fruit jam formulations with different pepper contents, in addition to verifying their acceptance by the consumer.

2 MATERIALS AND METHODS

Materials

Star fruit with crunchy and adequate texture, without stains or defects, in grade 3 maturation (25-75% yellow, visually evaluated) were acquired in Mato Grosso do Sul (23º 03' 54" S 54º 11' 26" W), central region of the Brasil. The chilli pepper samples were also acquired in Mato Grosso do Sul, as well as pectin, sugar (sucrose) and food grade citric acid. All materials were transferred to the Food Technology Laboratory of the State University of Mato Grosso do Sul, where the analyzes were conducted.

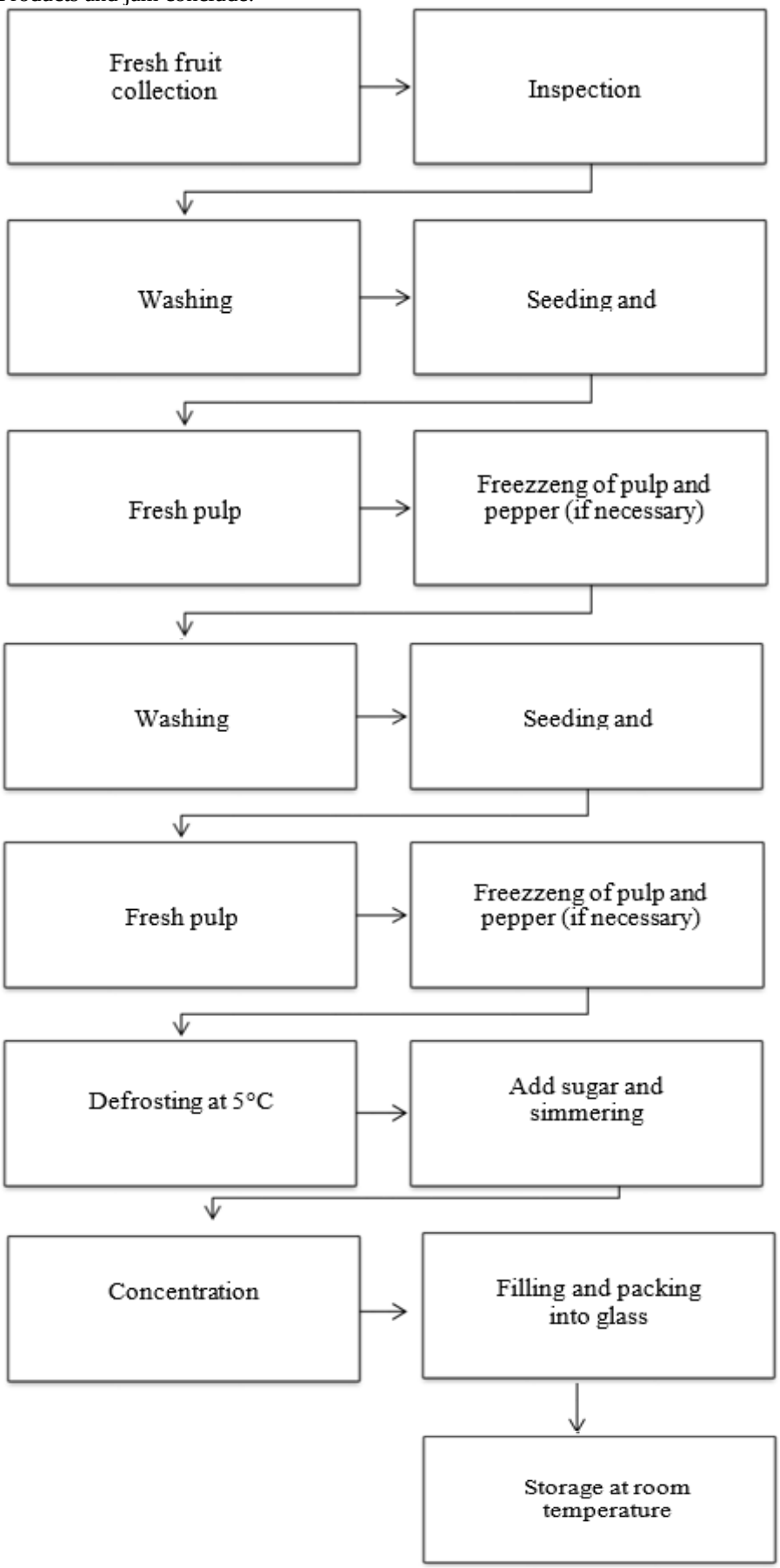
Methods

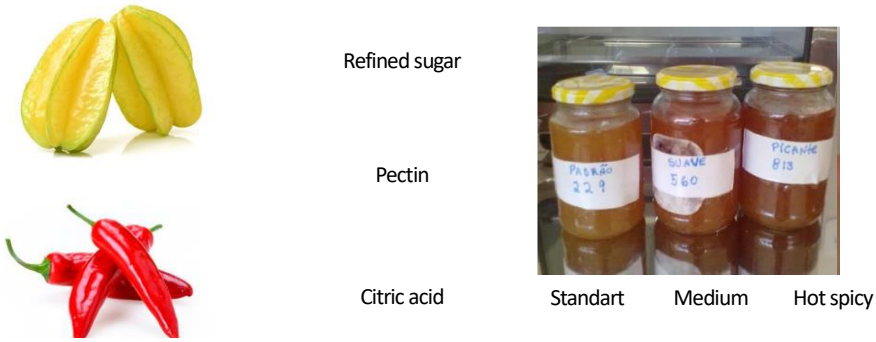
Elaboration of star fruit jams with and without pepper addition

Initially, the fruits were washed in chlorinated water (250 ppm) and the excess water removed with non-recyclable paper towels. To prepare the jam, the star fruit seeds were removed to be crushed in a blender. Then, they were sieved to obtain the pulp, which was frozen (-15º C) until preparation. Pepper samples were frozen whole and before preparing the jam, they were minced and added as shown in Figure 1.

Three jams formulations were prepared, namely: a) Standard jam, without pepper; b) Medium jam (with the addition of 1% chili pepper); and c) Hot spicy jam (with the addition of 1.6% chili pepper). The other ingredients added were sugar, pectin and citric acid. Pectin was added after defining, by preliminary ethanol precipitation test, that the amount of pectin present in the fruit was insufficient for gel formation. The complete formulation of the jellies, as well as the proportion of ingredients, is shown in Table 1.

Figure 1. Elaboration of the jam. A) Flowchart of the elaboration of star fruit jams with pepper and without pepper. B) Products and jam conclude.





Processing started with the pulp thawing, adding it in a stainless pan (1500g of pulp), added 10% of the total sugar, keeping it under continuous manual stirring, and submitted to cooking in an industrial stove. For the medium formulations 15g of pepper was added and for the hot spicy formulation 24g. Still under cooking, 15g of pectin diluted in water and the remainder of the sugar were added to the final concentration of 53ºBrix (measured with the aid of a refractometer) and then 9.75 g of citric acid diluted in water was added to finish gel formation (INSTITUTO ADOLFO LUTZ, 2008).

Table 1. Formulation of star fruit jams with and without the addition of chilli pepper.

Ingredients (g)	**Tips of the jams**		
	Standart[a]	**Medium[b]**	**Hot spicy[c]**
Pulp of star fruit	1500,0	1500,0	1500,0
Chilli pepper	-	15,0	24,0
Refined sugar	1500,0	1500,0	1500,0
Pectin	15,0	15,0	15,0
Citric acid	9,5	9,5	9,5

[a] without chilli pepper; [b]1% of the chilli pepper; [c]1,6% of the chilli pepper.

After the concentration step, the jellies, at a temperature of 85ºC, were placed in sterilized glass containers with a capacity of 300 mL, with metal lids, and subjected to inversion for 4 minutes (to sterilize the lids). They were cooled by immersion in cold water until reaching a temperature of approximately 25 °C and placed protected from light, at room temperature (± 25 °C) for 8 days, until they were submitted to physicochemical analyses. Figure 1 shows the flowchart of the preparation of the jam.

Physicochemical characterization of jams

Para a determinação da umidade, as amostras foram acondicionadas em cápsulas de porcelana, For the determination of moisture, the samples were placed in porcelain capsules, previously tared, and heated in an oven at 105ºC, until obtaining a constant weight. Total Titratable Acidity was estimated by titration in 0.1M sodium hydroxide (NaOH) solution. The soluble solids

content was determined by refractometry (with the aid of a portable refractometer model RT-82, at a temperature of approximately 25°C) and the pH by potentiometry. The physicochemical analyzes of acidity, pH, moisture, soluble solids were carried out in the three jams formulations in triplicate (INSTITUTO ADOLFO LUTZ, 2008).

Sensory analysis was conducted in an acclimatized laboratory (23°C), in individual booths, under white fluorescent light by 50 volunteer tasters, aged between 24 and 50 years, untrained. An affective acceptance test was performed for flavor, texture and global acceptance attributes using a 9-point hedonic scale (1 = very much disliked, 9 = very much liked) (STONE; SIDEL, 2004) and a 5-point purchase intention scale (1 = certainly wouldn't buy, 5 = certainly would buy) (MEILGAARD; CIVILLE; CARR, 2016). For each taster, three samples of jams of around 20 g were served in 50 mL disposable cups, at room temperature, coded with three-digit random numbers, so that, visually, there was no way to identify the difference between the samples. The order of presentation was served in balanced complete blocks, softening the sample position effects. Evaluators were instructed to taste and evaluate each set of samples from left to right and clean the palate with water between samples. In addition, testers were instructed on the use of the hedonic scale. They were given an informed consent form, informing the research objectives.

Statistical analysis was performed in five phases. From the first to the third phase, the data were explored by descriptive statistics, in the first, the profile of the evaluators, in the second, the rating scale assigned by the evaluators in the hedonic scale and in the purchase intention and in the third, the means were presented (standard deviation) of the scores obtained for each item. In the fourth and fifth phases, the data were studied by experimental statistics, in the fourth, the preferred public for each sample was determined using the t test with Welch criterion (5% probability). Finally, the fifth phase consisted of the comparison between samples for each of the items evaluated by the tasters (taste, texture, global acceptance and purchase certainty), through the analysis of variance by the F test at the level of 5% probability. When the F test indicated significance between treatments, the means were compared by Fisher's LSD test at the 5% probability level. All statistical analyzes and all graphs were obtained in the “R” statistical environment (R CORE TEAM, 2012).

3 RESULTS AND DISCUSSION

Jam is a product widely used by different populations(DISHA. *et al.*, 2017). Those prepared with star fruit had a yellowish color and flavor similar to that of the fruit with different levels of pungency due to the addition of pepper. When evaluating the data from this experiment

(Table 2), the standard jam had the highest moisture content (42%), followed by the medium (40%) and the hot spicy (39%) and with lower total titratable acidity (0.7%) , when compared to medium (0.90%) and hot spicy (1.0%) formulations. All samples had pH below 1.5, probably because the star fruit pulp is naturally acidic. *Averrhoa bilimbi* L. jam, from the same family as the star fruit, had 34% moisture, and a pH higher than the star fruit jam, however, with good product stability and high consumer acceptance (ANUAR; SALLEH, 2019). Regarding the soluble solids content, the hot spicy jam (69.3ºBrix) had a higher content compared to the standard (53.6ºBrix) and the medium (64.1ºBrix). In another study, star fruit jam had 73.5ºBrix and a pH of 4.3 (VICENTE *et al.*, 2014).

Table 2. Physicochemical parameters of star fruit jams with and without pepper addition.

Tips os jams	**Parameters**			
	pH	Acidity (% acid citric)	Total soluble solids (°Brix)	Umidade (%)
Standart	1,4	0,70	53,60	42
Medium	1,4	0.90	64,10	40
Hot spicy	1,2	1,00	69,30	39

The formulations showed physical and sensory characteristics typical of jam and the results obtained in the sensory analysis were expressed for each item evaluated (taste, texture, global acceptance and purchase certainty). The judges were 70% female, and most were aged up to 35 years.

In the sensory analysis, for standard jam, 88% of the evaluators gave scores between 7 and 9 for flavor, 86% of the evaluators gave these marks to the medium flavor and 90% to the hot spicy, referring to "I liked it moderately, very or very much" . Star fruit has a unique and sweet flavor coming from terpenes named as norisoprenoids, which are derived from carotenoids (JIA et al., 2019), however, the pungency content seems to have positively interfered in the assessment of this item.

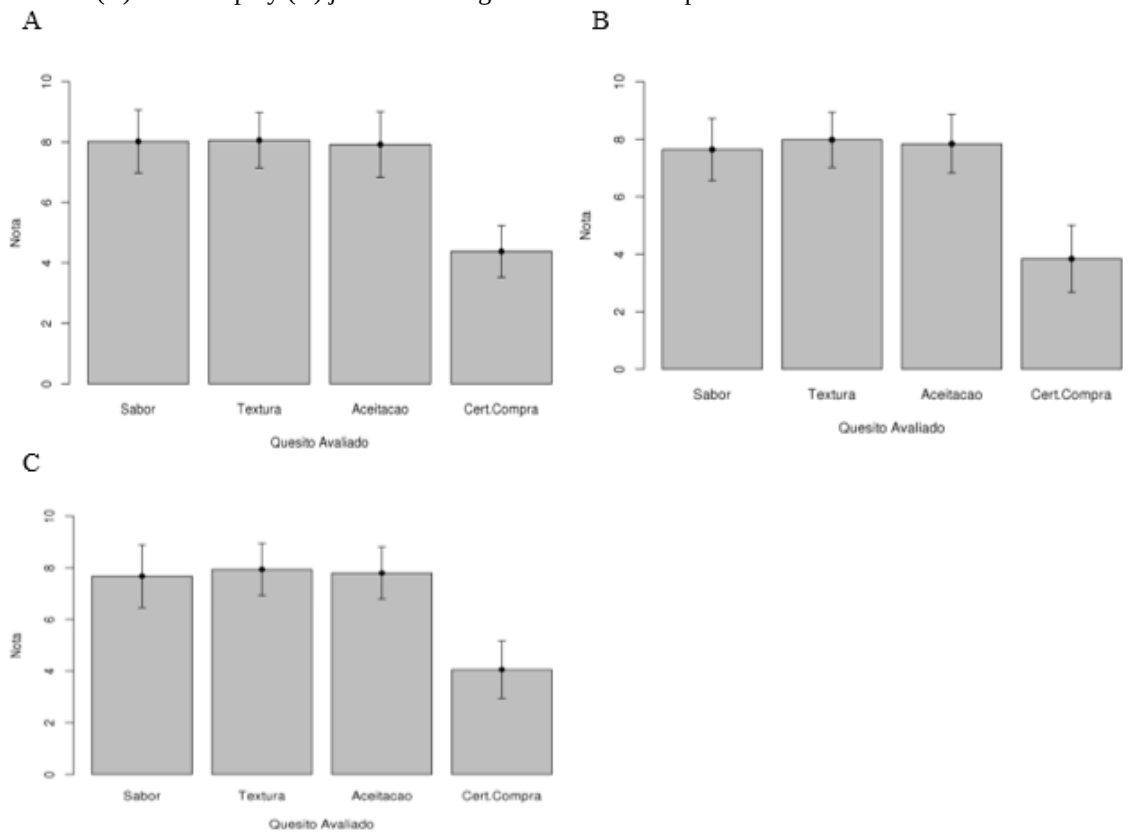
Among the evaluators, 93% gave between 7 and 9 points for the standard jam texture, 94% for the smooth jam and 96% for the spicy texture. In a study by Disha et al. (2017), the texture and flavor of star fruit jam without the addition of pectin were well accepted by the evaluators (DISHA. *et al.*, 2017). In this study, all formulations had good texture acceptance and the jam with the greatest addition of pepper was the best evaluated.

In the evaluation of the global acceptance of the jellies, 72% of the evaluators scored between 8 and 9 points for the standard, 70% for the medium jam and 60% gave the same score for hot spicy, referring to “I liked it very much or very much”.

In terms of purchase intent, 58% of the raters gave the highest score on the scale for standard jam, 40% of the raters gave the highest rating to the smooth jam, and 46% of them would certainly buy the hot spicy jam.

Figure 2 shows the average of the grades of the evaluated attributes and the purchase intention of the three jams formulations with or without pepper addition, according to the evaluators' preferences. The overall average of the notes for flavor (8.0), texture (8.0), global acceptance (7.9) were high for standard jam. For smooth jam, the averages were 7.8 for flavor, 8.0 for texture and 7.9 for global acceptance. As for spicy jam, the average of notes for flavor was 7.6, texture was 8.0 and global acceptance of 7.7. The flavor of standard jam was better evaluated compared to jams with added pepper. In passion fruit jellies, the judges preferred the passion fruit jam with a lower percentage of pepper in relation to flavor, color, odor and texture (RESOSEMITO et al., 2020).

Figure 2. Average of the grades of the evaluated attributes and purchase intention of the standard (A), medium (B) and hot spicy (C) jams according to the evaluators' preferences.



The results in table 3 showed good sensory acceptability in the evaluated samples of jellies, where the standard presented for the items taste, texture and global acceptance average above 7.92, ranging from 7.92 to 8.06 and showing certainty of purchase of 4.38 with a 78.6% approval rating for the product. The jellies with the addition of pepper also had great acceptance for the items flavor, texture and global acceptance, with an average above 7.64 for the medium jam, ranging from 7.64 to 7.98, and for the spicy jam the average was above 7.68, ranging from 7.68 to 7.94, with an acceptability of 75.8%.

For the preparation of jellies composed only of peppers, the less spicy species have a reddish color, characteristic pepper flavor and aroma, sweet taste and low pungency and were better evaluated when compared to jams made with more pungent peppers (ALMEIDA ALVES *et al.*, 2019). It is known that the capsaicin present in peppers has a different effect in terms of the burning sensation or pungency after consumption, which quickly dissipates (RESOSEMITO *et al.*, 2020).

On the purchase intention, the standard jam received an average of 4.3 points, the medium of 3.9, referring that maybe they bought or perhaps not bought the product and the hot spicy one received an average of 4.0 points ("Possibly I would buy"). Unlike the current study, when adding chilli pepper to passion fruit jellies, acceptance was better evaluated by the judges, both for sensory properties and for purchase intent, when the product had a lower pungency content(RESOSEMITO et al., 2020).

Table 3. Comparison of preferences between samples, depending on the item evaluated.

Average of grades received*				
Tips of the jams	**Flavor**	**Texture**	**Global acceptance**	**Purchase intention**
Standart	8.02 [2]	8.06 [2]	7.92 [2]	4.38 a [3]
Medium	7.64	7.98	7.84	3.84 b
Hot spicy	7.68	7.94	7.80	4.06 ab
Fcalc	1.75^{ns}	0.2^{ns}	0.17^{ns}	3.32^{*}
CV(%)	14.4	12.1	13.2	25.7

*Grades received ranging from 1 to 9 for flavor, texture and global acceptance, and from 1 to 5 for purchase certainty; 2 means do not differ according to the F test at 5% probability; 3 means followed by the same letter do not differ, according to Fisher's LSD test, at the 5% probability level.

In general, the results of the comparisons between the samples in function of the evaluated items (taste, texture and global acceptance), showed that the averages of the grades received do not differ from each other, according to the F test at 5% probability. With regard to purchase certainty, medium jam had lower acceptance than standard jam

and hot spicy jam, in turn, was as accepted as standard jam, and as rejected as jam with mild pepper, according to the test Fisher's LSD, at the 5% probability level. Star fruit jam with added sugar was better accepted than without added sugar (DISSANAYAKE; SARANANDA; PRASANNA, 2008).

According to Lakmal et al., 2021, star fruit extracts demonstrated several potentially beneficial medicinal properties, including antioxidant, hypoglycemic, hypocholesterolemic, anti-inflammatory, cardiovascular, antitumor and immune-boosting effects, both in in vitro and in vivo studies (LAKMAL *et al.*, 2021). On the other hand, star fruit ingestion has also been shown to cause nephrotoxicity and neurotoxicity, especially in individuals with chronic kidney disease, due to caramboxin and oxalate compounds (DE OLIVEIRA; DE AGUIAR, 2015). Caramboxin is inactivated when mixed with water and stored at room temperature (DE OLIVEIRA; DE AGUIAR, 2015) and the Oxalate is eliminated by bacteria from the gastrointestinal tract and urine (CRIVELLI *et al.*, 2021). Large oxalate content can also be found in other fruits and vegetables (AVILA-NAVA *et al.*, 2021). However, so far, there are no reports that these foods are toxic for patients with chronic kidney disease (DE OLIVEIRA; DE AGUIAR, 2015). In addition, the thermal processing undergone by the jam during its preparation should cause a considerable reduction in these compounds.

Table 4. Preferential audience estimate (sex of the evaluators), through the grades given to the jams, by question judged.

Point	**Standard jam**		**Medium jam**		**Hot spicy jam**	
	Woman*	**Man***	**Woman***	**Man***	**Woman***	**Man***
Flavor	7.91	8.27	7.63	7.67	7.69	7.67
Texture	7.97	8.27	8.00	7.93	8.03	7.73
Global acceptance	7.86	8.07	7.80	7.93	7.89	7.60
Purchase intention	4.31	4.53	3.89	3.73	4.11	3.93

*Results expressed as an evaluation average according to the sex of the evaluators;

When comparing the scores given by the female and male judges. it is noticed that men gave higher marks than women in all items for standard and lower for hot spicy, but without statistically significant differences. Currently, there are 22 naturally occurring capsaicinoids that can cause the sensation of heat when consumed and each person has a different effect of feeling hot in the mouth (GUZMÁN; BOSLAND, 2017). Authors investigated the appreciation of pungency after consuming peppers and the variables that influence the taste and intake of spicy foods among men and women. They found that

they approach this sensation differently, while the search for a poignant sensation was more important in women, the sensitivity to reward was more important in men (BYRNES; HAYES, 2015).

4 CONCLUSIONS

In the physicochemical analyses, the spicy jam had lower moisture content when compared to standard and medium jam. All jams had acidic pH and were well accepted, reaching over 75% of purchase intent. Although with statistical difference in the evaluated attributes, it was not possible to define the formulation with the lowest acceptance, since all the jam had an overall acceptance above 75%. This result was promising, as it adds value to the jam, there was the development of a new product as a new alternative to the use of carambola and the differential pungency was obtained when desired, obtained through the addition of chilli pepper.

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