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Avaliação do perfil sensorial de geleia de jambolão (*Syzygium Cumini*) utilizando análise descritiva quantitativa

Evaluation of the sensory profile of jambolan jam (*Syzygium Cumini*) using quantitative descriptive analysis

Evaluación del perfil sensorial de la jalea de jambolan (*Syzygium Cumini*) mediante análisis descriptivo cuantitativo

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Jamayle Silva Teles
ORCID: https://orcid.org/0000-0002-7894-5376
Universidade Federal do Tocantins, Brasil
E-mail: jamayle1@gmail.com
Rômulo Alves Morais
ORCID: https://orcid.org/0000-0003-3069-283X
Universidade Federal do Tocantins, Brasil
E-mail: romuloitallo2505@gmail.com
Cecília Marques Tenório Pereira
ORCID: https://orcid.org/0000-0001-7340-4637
Universidade Federal do Tocantins, Brasil
E-mail: tenorioctn@gmail.com
Silvia Myrelly Tavares da Silva
ORCID: https://orcid.org/0000-0003-2558-9942
Universidade Federal do Tocantins, Brasil
E-mail: silvinha.my@gmail.com
Rodolfo Castilho Clemente
ORCID: https://orcid.org/0000-0002-0766-9968
Universidade Federal do Tocantins, Brasil
E-mail: castilho@uft.edu.br
Caroline Roberta Freitas Pires
ORCID: https://orcid.org/0000-0002-1427-7276
Universidade Federal do Tocantins, Brasil

E-mail: carolinerfpires@mail.uft.edu.br

Resumo

A caracterização sensorial de um produto serve como ferramenta para melhorar a sua qualidade e observar os efeitos do seu processamento quanto aos atributos de sabor, aroma, textura e aparência. Este trabalho teve como objetivo utilizar a Análise Descritiva Quantitativa (ADQ) para traçar o perfil sensorial das geleias de jambolão. Para a otimização das geleias adotou-se a metodologia de superfície de resposta com planejamento fatorial completo 2^3. Em relação às características das geleias foram obtidos doze descritores, que mostraram as similaridades e diferenças entre as geleias. Foram selecionados 9 julgadores com base na habilidade de discriminar e reproduzir a avaliação. Para definição da intensidade de cada termo descrito pelos provadores foi utilizada uma escala não estruturada de 9 cm. Os dados foram analisados por ANAVA e teste de Tukey a 5% de significância. A partir dos resultados obtidos pelo perfil sensorial e teste afetivo observaram-se diferenças significativas entre as formulações propostas, sendo a formulação F2 (com razão polpa/açúcar 40/60, sem adição de ácido cítrico e com 3% de albedo de maracujá) a que apresentou as melhores médias nos atributos sensoriais, com níveis mais altos de brilho, aroma, sabor doce, cor e viscosidade.

Palavras chaves: ADQ; Jambolão; Descritores sensoriais de geleia.

Abstract

The sensory characterization of a product serves as a tool to improve its quality and observe the effects of its processing on the attributes of taste, aroma, texture and appearance. This work was intended to use the Quantitative Descriptive Analysis (QDA) to trace the sensory profile of jambolan jams. For the optimization of jams, the response surface methodology was used with complete factorial planning 2^3. Regarding the characteristics of the jellies, twelve descriptors were obtained, which showed the similarities and differences between the jams. Nine evaluators were selected based on the ability to discriminate and reproduce the assessment. The data were analyzed by ANAVA and Tukey's 5% significance test. From the results obtained by the sensory profile and affective test, significant differences were observed between the proposed formulations, with the F2 formulation (with a pulp/sugar ratio of 40/60, without addition of citric acid and with 3% of passion fruit albedo) presenting the best averages in sensory attributes, with higher levels of brightness, aroma, sweet taste, color and viscosity.

Keywords: QDA; Jambolan; Sensory jam descriptors.

Resumen

La caracterización sensorial de un producto sirve como una herramienta para mejorar su calidad y observar los efectos de su procesamiento en términos de atributos de sabor, aroma, textura y apariencia. Este trabajo tuvo como objetivo utilizar el Análisis descriptivo cuantitativo (ADC) para rastrear el perfil sensorial de las jaleas de jambolán. Para la optimización de las jaleas, se adoptó la metodología de superficie de respuesta con diseño factorial completo 2^3. En cuanto a las características de las jaleas, se obtuvieron doce descriptores, que mostraban las similitudes y diferencias entre las jaleas. Se seleccionaron nueve jueces en función de la capacidad de discriminar y reproducir la evaluación. Para definir la intensidad de cada término descrito por los catadores, se utilizó una escala no estructurada de 9 cm. Los datos fueron analizados por ANAVA y la prueba de Tukey con una significancia del 5%. A partir de los resultados obtenidos por el perfil sensorial y la prueba afectiva, se observaron diferencias significativas entre las formulaciones propuestas, con la formulación F2 (con una relación pulpa / azúcar 40/60, sin agregar ácido cítrico y con 3% de albedo de maracuyá) a que presentó los mejores promedios en atributos sensoriales, con mayores niveles de brillo, aroma, sabor dulce, color y viscosidad.

Palabras claves: ADC; Jambolán; Jalea descriptores sensoriales.

1. Introduction

Jambolan (*Syzygium Cumini*), originally from the Indian subcontinent, is a perennial crop that produces fruit of the same name (Baliga et al., 2011). They are ovoid in shape, with a green to purple or black colored peel after maturation and flesh ranging from white to pink, with a sweet and astringent taste (Lestario et al., 2017).

In Asian countries the consumption of the fruit is mainly in its natural form, due to its nutritional content and the high content of natural bioactive compounds with therapeutic effects, also present in seeds, leaves and bark. Although the fruit of jambolão has characteristics inherent to marketing it is cultivated only for urban purposes for afforestation (Ayyanar et al., 2012).

These substances have antibacterial, antifungal, anti-diabetic, antioxidant, anti-inflammatory and anti-mutagenic, antitumor and neuroprotective effects (Sharma et al., 2014; Zielinski et al. 2014; Singh et al., 2016). In addition, *Syzygium Cumini* pulp is rich in minerals (potassium, calcium, phosphorus, iron and zinc), water-soluble vitamins (such as ascorbic acid, thiamine and niacin) and carbohydrates (glucose, mannose, sucrose, maltose, fructose) (Baliga et al., 2011).

The main limitation for the use of this fruit on an industrial scale is its astringent taste. Thus, the processing of this fruit allows its consumption outside the production season and still favors consumption because it makes the taste more pleasant. As an example of products obtained from pulp, we have juice, yogurt, wine and jam (Veigas et al., 2007).

Fruit pulp, sugar, acid and pectin are needed to obtain a jam. All these ingredients are submitted to the cooking process so that the sugar dissolves in the pulp and consequently the union with pectin and acid to form the gel. This concentration process lasts until the jam reaches the range of 64 to 71 °Brix (Maia, 1997).

For each new product, sensory evaluation is indispensable to discover the opinion of the consumer about attributes such as color, shape, taste, aroma, texture and the interaction between them (Penna, 1999). Thus, sensory analysis aims to present information that promotes the improvement of product quality, verify the effects of its processing or storage and also allows characterizing the product (Amerine et al., 1965).

The descriptive analytical methods score the perceived characteristics (using vision, smell, taste, touch and hearing) and their respective intensities. These methods are based on the concept that an individual can be trained to perceive and recognize individual sensory characteristics of a product and the degree of its intensity, and thus achieve agreement with the other members of the group (Silva, 1992).

The quantitative descriptive analysis (QDA) is a method of sensory analysis that allows the detailed description of the product, evaluating it through points the appearance, color, aroma, taste and texture according to the order that these attributes are perceived. With this analysis we have a complete sensory description of the product under test and also allows the improvement of the product through the information collected by the judges (Stone et al., 1985). Thus, the objective of this study was to evaluate through quantitative descriptive analysis the sensory properties of eleven jambolan jam formulations, in which the concentration of pulp/sugar, citric acid and passion fruit albedo (natural source of pectin) was varied, and to compare them sensorially in order to trace the sensory profile of each sample.

2. Materials and Methods

This is a quantitative research, part of which was conducted in the field, with urban collect in the city of Palmas, Tocantins (collect of jambolan fruits) and the other part was performed in a laboratory (optimization of jams and Quantitative Descriptive Analysis) (Perreira et al., 2018).

2.1. Raw material

The fruits were harvested in the municipality of Palmas -TO and selected according to the stage of maturity, physiological quality and absence of injuries. They were sanitized with 3% chlorinated water for 20 minutes, then rinsed, pulped and ground in domestic processor. The pulps were then frozen at -18ºC until the day of preparation of the jams.

2.2. Experimental planning and fruit processing

The pulp was defrosted in a refrigerator (10ºC) for three hours, and then the ingredients were weighed. Eleven jambolan jam formulations containing different proportions of pulp (40%, 50%, 60%) and sugar (40%, 50%, 60%), passion fruit albedo as source of natural pectin, as descriptors by Silva et al. (2012) (0%, 1.5% and 3%) and citric acid (0%, 0.5% and 1%) were developed, and the concentration was performed in an open pan at atmospheric pressure until reaching a minimum soluble solid content of approximately 65ºbrix. After the cooking process was completed, the jams were hot-filled into previously sterilized flasks, closed and stored under refrigeration at 4ºC. For the optimization of the jams, the response surface methodology with complete factor planning 2^3 was used according to the methodology descriptors by Box and Draper (1987), which aims to evaluate the influence of three factors according to the experimental design proposed in Table 1.

Table 1- Experimental line 2^3, for the jambolan jam elaboration tests.

Tests	Coded variables			Real variables		
	X_1	X_2	X_3	X_1 (%)	X_2 (m/m)	X_3 (%)
1	+1	+1	+1	1	60/40	3
2	-1	-1	+1	0	40/60	3
3	+1	-1	+1	1	40/60	3
4	-1	+1	+1	0	60/40	3
5	+1	+1	-1	1	60/40	0
6	-1	+1	-1	0	60/40	0
7	+1	-1	-1	1	40/60	0
8	-1	-1	-1	0	40/60	0
9	0	0	0	0,5	50/50	1,5
10	0	0	0	0,5	50/50	1,5
11	0	0	0	0,5	50/50	1,5

*__Real variables__: X1= Citric acid concentration (%); X2= Pulp/sugar ratio (m/m) and X3= Albedo concentration (%). Source: The author (2020).

2.3. Sensory analysis

The following steps were followed to perform the quantitative descriptive analysis (QDA): recruitment of judges, development of descriptive terminology, training and selection of judges and evaluation of samples.

2.3.1. Recruiting the team

The QDA was carried out by recruiting guests who expressed interest in participating in the sensory evaluation of jambolan jam. Judges were pre-selected who were evaluated by the flavor recognition test, in which the judges had to match 70% of the flavors selected in the test to be approved.

Then, the judges were submitted to the basic taste test which was represented by a series of three samples, using aqueous solutions of NaCl, sucrose and citric acid, and the candidates who obtained 100% of the answers were successful.

The successful judges proceeded to the triangular test (two equal samples and one different one) carried out in 6 repetitions, in which the candidates who obtained 60% of hits in the evaluation were approved. After these tests, the 14 selected judges participated in the creation of the jambolan jam sensory attributes form.

2.3.2. Development of descriptive terminology

After the selection of the tasters, they were trained to draw the sensory profile of jambolan jams. For the training of the tasters, samples 9,10 and 11 were used, which represent the central point of the variables (Table 1). About 20 grams of jambolan jam samples were served to the judges in disposable white cups, coded with three-digit numbers and randomly presented for the description of the sensory attributes.

The survey of attributes was done through the traditional method, in which each judge analyzed the sample offered and then issued an opinion on each attribute. The judges were arranged around a table for team involvement and survey of the descriptors. The jams were placed in the central position of the table allowing the interaction of the group. The sensory attributes were determined after several sessions. The ambient temperature was kept at 20ºC.

A list of descriptors was used by the leader, only for orientation of the group, however, the session was conducted in order to obtain as many descriptors as possible that could trace the sensory profile of jambolan jams. With the suggested attributes the synonyms, doubtful or redundant terms were eliminated and those that appeared with low frequency. After intense debate and by consensus, the team selected the attributes that were listed in the Quantitative Descriptive Analysis protocol.

2.3.3. Training and selection of tasters

For each attribute selected in agreement with the team, where possible, reference material was presented, as well as reference from the end of the scale to standardize the use of each descriptive term by the tasters. After this, a list was generated with all the descriptive terms with the respective ends of the scale used. The descriptive terms that were listed by the tasters were: appearance (purple color, brightness, grain size); aroma (astringent, sweet and jambolan); taste (jambolan, acid, sweet, astringent) and texture (viscosity and grain size).

The intensity of each attribute was fixed on an unstructured 9 cm scale, anchored by extremes varying from light to dark, low to high, less to more and weak to strong (Table 2), in which it was possible to prepare the evaluation sheet for the samples. This phase started with 14 tasters and at the end only 12 were able to participate effectively in the training.

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Table 2 - Unstructured 9 cm scale anchored by ends.

Name:		
Appearance		
Purple color	Ligth	Dark
Brightness	Low	High
Granularity	Low	High
Aroma		
Astringent	Weak	Strong
Sweet	Weak	Strong
Jambolan	Weak	Strong
Taste		
Jambolan	Weak	Strong
Acid	Weak	Strong
Astringent	Weak	Strong
Sweet	Weak	Strong
Texture		
Viscosity	Low	High
Granularity	Low	High

Source: The author (2020).

For the selection stage of the dressing rooms, the samples were served according to the design of randomized complete blocks, and each dressing room experienced 11 samples with 3 repetitions, using an evaluation sheet with the extremes of scale for the selected attributes (Table 2). Thus, it was possible to select the tasters with higher discrimination power, repeatability and agreement with the team.

2.3.4. Sensory analysis

The jambolan jam samples were evaluated in six repetitions by the selected tasters in relation to the attributes identified by the tasters.

2.3.5. Affective Sensory Analysis

Three samples of the formulations with the best averages for the sensory attributes favorable to obtaining the jams were evaluated for acceptance in relation to the attributes of flavor, aroma, texture and overall impression using the structured nine point hedonic scale, varying between the terms "disgusted extremely (score 1)" and "enjoyed extremely (score 9)".

The intention to purchase was also evaluated using a scale that varies between the extremes: (5) would certainly buy from (1) would certainly not buy (Meilgaard et al., 1988). The analysis was performed in individual booths at the Sensory Analysis Laboratory of the Federal University of Tocantins, with fifty untrained tasters of both sexes, aged between twenty and forty years. The samples with approximately 20g of jam were coded with three-digit numbers and distributed in a random and balanced way.

2.4. Statistical analysis

The data obtained in the sensory analysis were analyzed through the analysis of variance (ANAVA) using the SISVAR statistical program and, identifying significant differences between the means ($p \leq 0{,}05$), they were submitted to Tukey's test at a 5% significance level.

3. Results and Discussions

In the flavor test, out of the 20 participants, 14 reached the minimum of hits, which is 70% of the flavors with normal degree of difficulty. For the basic taste tests, 14 tasters participated, and all of them obtained the 100% hit criteria. For the triangular tests of tastes and aromas, out of the 14 tasters who participated only 12 remained on the team of qualitative sensory analysis.

3.1. Development of descriptive terminology

With the adoption of the traditional method of defining descriptors, an initial list of 18 terms was obtained among the attributes of appearance, aroma, taste and texture. The tasters' team when discussing in open discussions eliminated the synonyms, dubious or redundant terms and those that appeared with very low frequency. In this way, a new list was arrived at with 12 terms that best descriptors the analyzed samples (Table 3).

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Table 3- Definitions of attributes and benchmarks used during the evaluation of jambolan jams.

Attributes	Reference
	Appearance
Purple colour	Purple colour characteristic of the fruit **Light-** jam with 30% pulp, 70% sugar and 1.5% acid. **Dark-** jam with 70% pulp and 30% sugar.
Brightness	Shiny surface appearance **Low** - jam with 60% pulp and 40% sugar. **High** – caramel
Granularity	Surface with the presence of granules **High** - jam with 30% pulp and 70% sugar. **Low** - jam with 40% pulp and 60% sugar.
	Aroma
Astringent	Aroma associated with green fruits **Weak** - jam with 30% pulp, 70% sugar. **Strong** - jam with 70% pulp and 30% sugar.
Sweet	Aroma associated with sugars in jam **Weak** - jam with 70% pulp and 30% sugar. **Sweeter** - jam with 30% pulp, 70% sugar.
Jambolan	Characteristic aroma of the fruit **Weak** - jam with 30% pulp, 70% sugar. **Strong** - jam with 70% pulp and 30% sugar.
	Taste
Jambolan	Characteristic taste of the fruit **Weak** - jam with 30% pulp, 70% sugar. **Strong** - jam with 70% pulp and 30% sugar.
Acid	Taste stimulated by the presence of organic fruit acids **Weak** - Geleia com 40% de polpa e 60% de açúcar. **Strong** - Geleia com 30% de polpa, 70% de açúcar e 1,5% de ácido.
Astringent	Taste resulting from the action of phenolic compounds that cause "pungency" **Weak** - jam with 30% pulp, 70% sugar. **Strong** - jam with 70% pulp and 30% sugar.
Sweet	Sweet taste perceived after ingestion of the jam **Weak** - jam with 70% pulp and 30% sugar. **Strong** - jam with 30% pulp and 70% sugar.
	Texture
Viscosity	Jam consistency **Low** - jam with 60% pulp and 40% sugar. **High** - jam with 40% pulp and 60% sugar.

Granularity	Sensation resulting from the perception of insoluble solids present in the jam **Low** - jam with 70% pulp and 30% sugar **High** - jam with 30% pulp and 70% sugar.

Source: The author (2020).

3.2. Selection of tasters

In relation to the capacity of discrimination, repeatability and agreement with the team it was possible to select 09 of the 12 tasters that composed the group in the training stage. The tasters who were eliminated committed some of the errors: they identified the sample, but applied a higher or lower score than the average of the team; they identified the sample, but reversed the values, applying a higher score for the sample that the team evaluated with a lower score and vice versa. Based on the results, was eliminated the tasters 1, 4 and 7.

3.3. Descriptive analysis of jambolan jam samples

Table 4 presents the average values of the twelve descriptors of the eleven jambolan jam formulations.

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Table 4 - Table with averages per attribute evaluated.

F	**Appearance**			**Aroma**		
	Color	**brightness**	**Granularity**	**Astringent**	**Sweet**	**Jambolan**
F1	6,96 ±0,12 ^{b}	3,02 ±0,02 ^{d}	7,48 ±0,37 ^{a}	6,89 ±0,21 ^{a}	3,38 ±0,21 ^{e}	6,37 ±0,44 ^{a}
F2	7,77 ±0,08 ^{a}	7,39 ±0,30 ^{a}	2,04 ±0,04 ^{d}	2,50 ±0,16 ^{e}	7,03 ±0,19 ^{ab}	3,84 ±0,39 ^{c}
F3	2,84 ±0,19 ^{d}	7,22 ±0,22 ^{a}	2,36 ±0,24 ^{cd}	4,46 ±0,20 ^{b}	7,31 ±0,20 ^{a}	2,45 ±0,09 ^{f}
F4	7,22 ±0,20 ^{ab}	4,23 ±0,27 ^{c}	6,11 ±0,28 ^{b}	6,98 ±0,20 ^{a}	3,53 ±0,07 ^{e}	6,33 ±0,05 ^{a}
F5	5,27 ±0,11 ^{c}	5,21 ±0,19 ^{b}	5,76 ±0,12 ^{b}	7,10 ±0,20 ^{a}	3,35 ±0,30 ^{e}	3,66 ±0,22 ^{cd}
F6	7,24 ±0,08 ^{ab}	4,78 ±0,35 ^{bc}	6,39 ±0,41 ^{b}	6,87 ±0,06 ^{a}	4,20 ±0,10 ^{d}	5,54 ±0,09 ^{b}
F7	1,91 ±0,27 ^{e}	7,24 ±0,26 ^{a}	2,1 ±0,19 ^{d}	2,84 ±0,07 ^{de}	6,93 ±0,05 ^{ab}	2,84 ±0,27 ^{ef}
F8	7,32 ±0,19 ^{ab}	7,16 ±0,14 ^{a}	2,47 ±0,12 ^{cd}	3,28 ±0,19 ^{cd}	6,72 ±0,14 ^{c}	3,28 ±0,15 ^{cde}
F9	5,09 ±0,19 ^{c}	6,94 ±0,08 ^{a}	2,91 ±0,20 ^{c}	3,45 ±0,13 ^{c}	6,90 ±0,15 ^{ab}	3,71 ±0,26 ^{cd}
F10	5,16 ±0,38 ^{c}	6,98 ±0,18 ^{a}	2,53 ±0,32^{cd}	3,56 ±0,09 ^{c}	6,79 ±0,13 ^{ab}	3,33 ±0,28 ^{cde}
F11	4,96 ±0,35 ^{c}	6,84 ±0,07 ^{a}	2,67 ±0,05^{cd}	3,62 ±0,28 ^{c}	6,89 ±0,30 ^{ab}	3,03 ±0,14 ^{def}

F	**Taste**				**Texture**	
	Jambolan	**Acid**	**Astringent**	**Sweet**	**Viscosity**	**Granularity**
F1	6,7 ±0,42 ^{a}	7,33 ±0,09 ^{a}	7,26 ±0,02 ^{ab}	3,05 ±0,21 ^{f}	2,46 ±0,35 ^{c}	7,98 ±0,24 ^{a}
F2	2,42 ±0,27 ^{d}	2,19 ±0,13 ^{e}	3,07 ±0,11 ^{f}	8,22 ±0,19 ^{a}	7,85 ±0,09 ^{a}	2,11 ±0,03 ^{g}
F3	2,98 ±0,10 ^{d}	6,65 ±0,18 ^{b}	3,70 ±0,24 ^{e}	6,64 ±0,28 ^{de}	7,65 ±0,27 ^{a}	2,39 ±0,28 ^{fg}
F4	6,92 ±0,20 ^{a}	2,67 ±0,28 ^{e}	7,03 ±0,06 ^{ab}	6,69 ±0,22 ^{de}	2,75 ±0,05 ^{c}	6,88 ±0,07 ^{b}
F5	5,80 ±0,19 ^{b}	7,70 ±0,18 ^{a}	7,10 ±0,10 ^{ab}	3,28 ±0,10 ^{f}	2,73 ±0,12 ^{c}	6,32 ±0,09 ^{c}
F6	6,72 ±0,07 ^{a}	3,79 ±0,07 ^{d}	7,36 ±0,12 ^{a}	6,40 ±0,10 ^{e}	2,60 ±0,09 ^{c}	7,03 ±0,20 ^{b}
F7	2,92 ±0,11 ^{d}	6,67 ±0,17 ^{b}	5,98 ±0,15 ^{cd}	7,46 ±0,24 ^{bc}	7,67 ±0,05 ^{a}	2,58 ±0,05 ^{ef}
F8	3,01 ±0,17 ^{d}	2,58 ±0,05 ^{e}	5,44 ±0,35 ^{d}	7,87 ±0,08 ^{ab}	7,48 ±0,25 ^{a}	2,91 ±0,21 ^{e}
F9	3,81 ±0,25 ^{c}	5,46 ±0,29 ^{c}	6,79 ±0,33 ^{bc}	7,33 ±0,04 ^{cd}	6,65 ±0,20 ^{b}	3,50 ±0,26 ^{d}
F10	3,78 ±0,10 ^{c}	5,6 ±0,14 ^{c}	6,80 ±0,12 ^{bc}	7,35 ±0,33 ^{cd}	6,14 ±0,04 ^{b}	3,49 ±0,20 ^{d}
F11	3,69 ±0,15 ^{c}	5,3 ±0,36 ^{c}	6,77 ±0,05 ^{bc}	7,34 ±0,21 ^{cd}	6,10 ±0,28 ^{b}	3,53 ± 0,14 ^{d}

Source: The author (2020).

According to Table 4 for the color attribute, the tasters assigned average values ranging from 1.91 to 7.77, with the first value corresponding to sample F7 and the second to sample F2. Higher means were observed in formulations without the addition of citric acid. According to Martynenko & Chen (2016) the addition of citric acid promotes the reduction of the pH of the medium culminating in the formation of color tending towards red in foods with the presence of anthocyanins.

As for the gloss attribute, no significant difference was observed between the formulations F2, F3, F7 and F8 that presented the highest averages, being also the formulations with higher sugar contents. According to Jackix (1988), sugar is responsible for providing brightness to sweets and jams.

The granularity was defined as the surface with the presence of granules. According to the tasters, the F1 formulation differed significantly from the other samples, presenting a higher mean (7.48). The F2 formulation also differed significantly from the other samples with lower granularity values. The formulations with higher pulp content were evaluated with higher means, since their surface was characterized as more granular. This is related to the particles of the pulp, especially the part corresponding to the fruit rind.

As for aroma, an attribute resulting from the volatile content of chemical compounds, it is one of the most important factors in the sensory quality of fruits and their respective products. These constituents are mostly thermolabile phenolic compounds that are directly influenced when subjected to heat treatment (Correa et al., 2010).

The tasters listed three descriptor terms: astringent aroma, sweet aroma and characteristic jambolan aroma. For the descriptor astringent aroma, it was observed that the samples that presented the highest averages without significant difference were the formulations F1, F4, F5 and F6, which is related to the pulp/sugar ratio of 60/40, varying the addition of citric acid and albedo.

As for the sweet aroma, F4 and F5 formulations showed significantly lower values, with averages of 3,53 and 3,35, respectively. It should be noted that both formulations have a pulp/sugar ratio of 60/40, which is related to the low perception of sweet aroma.

For the characteristic aroma of jambolan, the formulations F1 and F4 had the highest values, differing significantly from the other samples, while the formulations F3 and F7 had the lowest values, which can be justified by the pulp/sugar ratio of 60/40 in the first two formulations and 40/60 in the last two.

Kapoor et al. (2015) when studying jambolan pulp dried in hot air and freeze-dried observed that the process with high temperatures promoted significant changes in physicochemical characteristics and also in the content of phenolic compounds, and consequently the volatile compounds also underwent changes during the evaporation process, thus changing the perception of the aroma of the products. However, it is known that the fruit concentration process promotes considerable losses of volatile compounds responsible for aroma and taste, leading to a decline in the sensory quality of the final product (Garruti et al., 2008).

According to RDC Nº 12 (1978) jam must have a color and aroma appropriate to the fruit of origin, in addition the taste must be sweet, semi-acid, according to the fruit used.

Metha et al. (2018) when analyzing the volatile constituents in three stages of jambolan maturation verified that maturation is a preponderant factor for the quantification of these compounds. The green jambolan had more volatiles (80) than ripe fruits (70), the most identified volatile compounds being trans-β-ocimene, β-ocimene, caryophyllene, humulene, D-α-pinene, L-β-pinene, β-pinene, α-terpineol, and D-limonene.

As for the taste attribute, four descriptors were listed: characteristic taste of jambolan, acidic taste, astringent and sweet taste. According to table 3, samples with higher percentage of pulp/sugar ratio (60/40) had higher characteristic jambolan flavor and higher astringency. This fact can be justified by the higher amount of pulp present in these samples.

According to Veiga et al. (2007) the main limitation of jambolan consumption is its astringent taste resulting from the presence of phenolic compounds, especially condensed tannins. Taste arises from the integrated response of olfactory stimuli, taste and mouth sensations of texture perceived by nerve endings taken to the trigeminal nerve (Biasoto, 2013). As for the acid taste, F1 and F5 formulations showed mean values significantly higher than the other samples. It is worth mentioning that in both samples the pulp/sugar ratio was 60/40 and citric acid was also added.

As for the sweet aroma, the formulations F1 and F5 showed lower average values for this attribute with averages of 3,05 and 3,28, respectively. Both samples showed lower sugar concentrations in their composition, which justifies the behavior presented.

Viscosity, related to the flow resistance of a fluid, is an important variable in jam production and can be influenced by type of fruit, processing and temperature. In jams, pH, acid, pectin and sugar also influence, and in formulations with higher sugar concentration tend to be more viscous (Javanmard & Endan, 2010). As for this attribute for jams it was observed that the average values varied between 2.46 and 7.84.

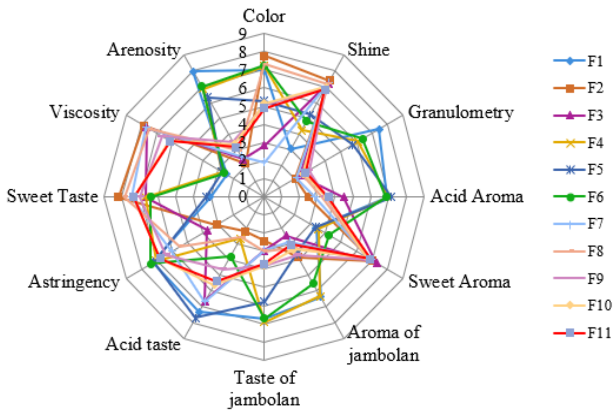
The formulations F2, F3, F7 and F8 showed mean values significantly higher than the other samples. It should be noted that in all these formulations the pulp/sugar ratio was 40/60, i.e., higher sugar content.

For the granularity attribute, the F1 formulation presented a higher mean value differing significantly from the other samples with a mean of 7.98. The tasters attributed these values considering the sandy sensation in the mouth imposed by the higher pulp/sugar ratio, coming from the peel of the fruit changing the perception of smooth jam.

The data collected were projected in a spider graph (Figure 1) to better visualize the differences in the descriptors of each jam formulation.

It can be observed that formulation 2 presented the highest average for brightness, purple color, sweet flavor and viscosity and the lowest average for particle size in appearance as well as for acid aroma, acid flavor and astringent.

Figure 1 - Spider graph for the descriptors. Source: The author (2020).



Fonte: Authors.

These values are consistent because this formulation has a higher sugar content, which is responsible for the sweet taste, thus reducing astringency, and responsible for brightness to the jam, in addition to the lower amount of pulp that influences a lower perception of granules from the fruit pulp.

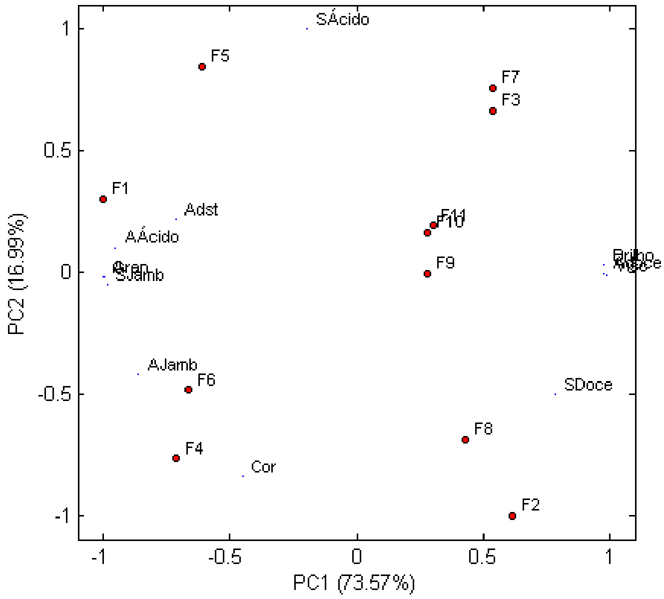
The F1 sample presents opposite characteristics to F2, since it has a higher percentage of pulp, which intensifies the flavor and aroma of jambolan, acidic flavor, higher astringency, more pronounced perception of granules due to higher concentration of pulp. However, this formulation has lower sugar content resulting in lower averages for the descriptors sweet taste and aroma and brightness.

The formulations of the 60/40 pulp/sugar ratio group showed similar behaviors, differing only in the acidic flavor and sweet flavor where formulations F1 and F5 obtained higher averages for acidic flavor and formulations F4 and F6 obtained higher averages for sweet flavor when compared in their 60/40 pulp/sugar ratio group, which can be justified by the absence of citric acid in their composition, allowing the perception of the descriptor sweet flavor.

The samples of the pulp/sugar ratio group 50/50 showed high values for the sweet aroma attribute and low values for the acid aroma, granularity in appearance and texture.

As a form of global visualization of these results, the analysis of main components is presented in Figure 2.

Figure 2 - Principal Component Analysis (PCA): SÁcido= acid taste; AÁcido= acid aroma; Gran= granularity; Aren= granularity in the appearance; AJamb= jambolan aroma; SJamb= taste of jambolan; Adst= astringency; SDoce= sweet taste; Brilho= brightness; Visc= Viscosity; Adoce= sweet aroma; Cor=color. Source: The author (2020).



Fonte: Authors.

The Figure 2 shows both the scores, in which the first two main components were responsible for explaining 90.56% of the total variability present in the data set; it also shows the weights that bring the relationship between the samples and the sensory attributes.

The analysis of the data by the PCA technique allowed us to separate the samples in order to express and highlight their similarities and differences, according to the sensory attributes. Thus, the F1 sample is clearly distinguished from the other samples by its higher astringency, acid aroma, granularity in the texture and characteristic taste of jambolan.

Samples F5, F7 and F3 remained in the upper quadrant due to the similarity of the mean values of the acid taste attribute, represented by the code SÁcido.

The formulations F2 and F8 distanced themselves from the others due to the higher values of the sweet taste attribute.

3.4. Affective Sensory Analysis

From the analysis of the sensory profile of jambolan jams, three formulations with the best averages were chosen for the sensory attributes favorable to obtaining the jams. F1 represents the 60/40 sugar pulp ratio group, with higher jambolan taste, F2 represents the 40/60 sugar pulp ratio group with higher brightness and F9 represents the 50/50 sugar pulp/ sugar ratio group with high viscosity. Table 5 shows the averages for each attribute of the three formulations.

Table 5 - Mean values of sensory attributes for jambolan jam.

Formulations	**Aroma**	**Taste**	**Texture**	**Global impression**	**Intention to buy**
F1	6,18 ^{a}	5,54 ^{b}	5,96 ^{b}	6,12 ^{b}	2,86 ^{b}
F2	6,24 ^{a}	7,1 ^{a}	7,58 ^{a}	7,32 ^{a}	3,78 ^{a}
F9	6,62 ^{a}	5,76 ^{b}	6,02 ^{b}	6,36 ^{ba}	3,06 ^{ba}

*Averages followed by the same letter in the same column do not differ by Tukey's test at 5% significance. Source: The author (2020).

As for the aroma, the samples did not differ significantly. With respect to taste and texture the F2 sample had an average value significantly higher than the formulations F1 and F9 which did not differ statistically from each other. For overall impression the sensory evaluation showed that the F2 formulation (7,32) had the best average, however it did not differ significantly from the F9 formulation.

Three regions were plotted in relation to the hedonic scale, where scores of 1-4 correspond to the region of rejection, score 5 corresponds to the region of indifference to the affective relationship of the taster with the product and scores of 6-9 correspond to acceptance of the product.

The highest percentages of jams were in the 6-9 grade region indicating acceptance of the product in all attributes. Regarding the aroma, the F9 sample stood out with 80% of the tasters giving marks between 6-9. Regarding texture, taste and overall impression, the F2 sample stood out as the best formulation, obtaining the highest averages of 88%, 90% and 86%, respectively (Figure 3).

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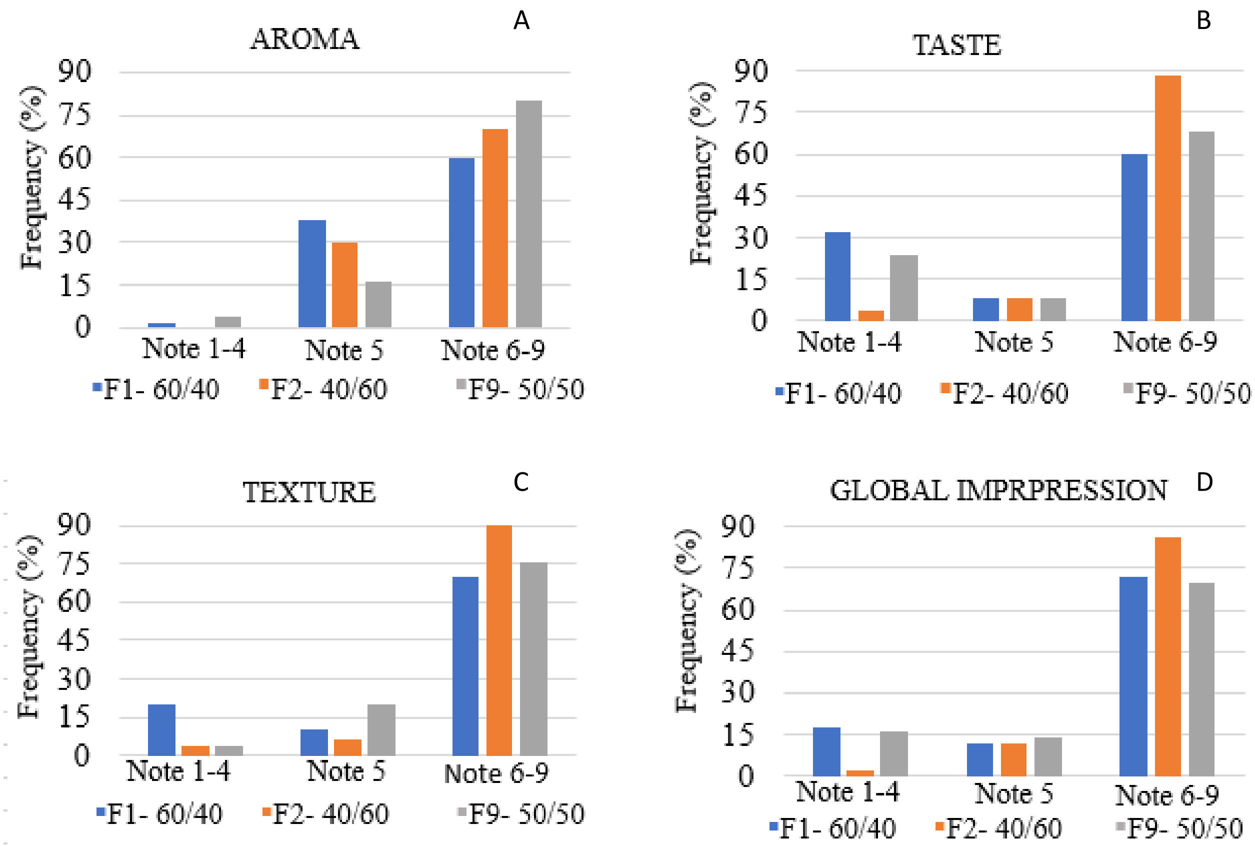
Figure 3 - Histogram frequency for aroma (A), taste (B); texture (C) and global impression (D).

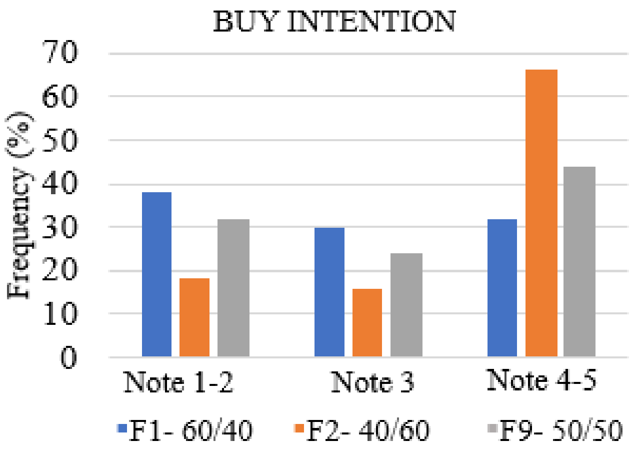


Source: Authors.

Regarding the intention to purchase (Table 5) the formulations F2 and F9 did not differ significantly with higher values, however, the formulation F2 differed significantly from the formulation F1 that obtained the lowest means.

In Figure 4 we have the histogram for purchase intent.

Figure 4- Histogram of frequency of responses to buy intention. Source: The author (2020).



Source: Authors.

Three regions were plotted regarding the intention to buy, where grades 1 and 2 correspond to the region of rejection (would not buy), grade 3 corresponds to the region of doubt if I would buy the product and grades 4 and 5 correspond to certainly buy the product. It was observed that only 32% of tasters would buy F1 jam (60/40 pulp/sugar), 66% would buy F2 jam (40/60 pulp/sugar) and 44% would buy F9 jam (50/50 pulp/sugar).

In general, it was observed that the increased concentration of jambolan pulp promoted the decrease of sensory notes.

4. Final Considerations

With the application of the QDA methodology it was possible to obtain twelve attributes descriptors the 11 jambolan jams formulations. The formulations with higher sugar contents were best evaluated in terms of the descriptors brightness, color, sweet aroma, sweet taste and viscosity, all of which are directly related to the characteristics that sugar provides.

However, it was observed that a greater addition of jambolan pulp had a negative impact on several sensory characteristics of jams, such as brightness, granularity, viscosity and sweet taste, because the main characteristic of the fruit is astringency, so its higher concentration is not satisfactory from the consumer's point of view.

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Porcentagem de contribuição de cada autor no manuscrito

Jamayle Silva Teles – 30%

Rômulo Alves Morais – 20%

Cecília Marques Tenório Pereira – 10%

Silvia Myrelly Tavares da Silva – 10%

Rodolfo Castilho Clemente – 10%

Caroline Roberta Freitas Pires – 20%