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Néctar de jambolão: propriedades físicas e químicas em função dos ingredientes da formulação

Jambolan nectar: physical and chemical properties due to formulation ingredients

Néctar de Jambolan: propiedades físicas y químicas dependiendo de los ingredientes de la formulación

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Resumo

O objetivo deste trabalho foi avaliar a influência de diferentes proporções de polpa de jambolão, açúcar e água nas características físicas e físico-químicas para obter informações que permitam o uso do jambolão e a consequente avaliação desse fruto. Seis formulações de

néctar jambolão foram estabelecidas através do design Simplex. Os ingredientes afetaram significativamente a luminosidade (32,14-34,24), viscosidade aparente (7,8-73,8 cP), sólidos solúveis totais (8,87-26,43 °Brix), acidez titulável (0,55-0,83g de ácido cítrico $100g^{-1}$) e a relação SST / AT (16.05-34.96) em néctares de jambolão. O néctar de jambolão com 55 g de 100 g^{-1} de polpa de jambolão, 15 g de 100 g^{-1} de açúcar e 30 g de 100 g^{-1} de água teve a maior desejabilidade em relação às propriedades físicas e físico-químicas, 85,1 % de inibição de DPPH, 10526,12 µg TE mL^{-1} e 27014,25 µmol TE mL^{-1} pelo método ABTS e ORAC, respectivamente. Conclui-se que é possível produzir néctar de jambolão, o que pode aumentar as possibilidades de aplicação da fruta como ingrediente na indústria de alimentos.

Palavras-chave: *Syzygium cumini*; Simplex; Desejabilidade; Flavonoides; DPPH; ABTS; ORAC

Abstract

The objective of this work was to evaluate the influence of different proportions of jambolan pulp, sugar and water on the physical and chemical characteristics to obtain information that allows the use of jambolan and, consequently, the evaluation of these fruits. Six jambolan nectar formulations were established through Simplex design. Ingredients significantly affected luminosity (32,14-34,24), apparent viscosity (7.8-73.8 cP), total soluble solids (8.87-26.43 °Brix), titratable acidity (0.55 -0.83g citric acid $100g^{-1}$) and the TSS / TA ratio (16.05-34.96) in jambolan nectars. Jambolan nectar with 55g $100g^{-1}$ of jambolan pulp, 15g $100g^{-1}$ of sugar and 30g $100g^{-1}$ of water has the highest desirability in relation to physical and physicochemical properties, 85.1% DPPH inhibition, 10526.12 µg TE mL^{-1} and 27014.25 µmol TE mL^{-1} by ABTS and ORAC method, respectively. It could be concluded that it is possible to produce jambolan nectar which can increase the possibilities of applying fruit as an ingredient in the food industry

Keywords: *Syzygium cumini*; Simplex; Desirability; Flavonoids; DPPH; ABTS; ORAC.

Resumen

El objetivo de este trabajo fue evaluar la influencia de diferentes proporciones de pulpa de jambolan, azúcar y agua sobre las características físicas y químicas para obtener información que permita el uso de jambolan y, en consecuencia, la evaluación de estas frutas.Seis formulaciones de néctar de jambolan se establecieron a través del diseño Simplex. Los ingredientes afectaron significativamente la luminosidad (32,14-34,24), la viscosidad aparente (7.8-73.8 cP), los sólidos solubles totales (8.87-26.43 °Brix), la acidez titulable (0.55-0.83g de

ácido cítrico 100g$^{-1)}$ y el SST / AT ratio (16.05-34.96) en néctares jambolan. El néctar de Jambolan con 55 g de 100 g^{-1} de pulpa de jambolan, 15 g de 100 g^{-1} de azúcar y 30 g de 100 g^{-1} de agua tiene la mayor deseabilidad en relación con las propiedades físicas y fisicoquímicas, 85.1% de inhibición de DPPH, 10526.12 μg de TE mL^{-1} y 27014.25 μmol TE mL^{-1} por el método ABTS y ORAC, respectivamente. Se podría concluir que es posible producir néctar de jambolan que puede aumentar las posibilidades de aplicar la fruta como ingrediente en la industria alimentaria

Palabras clave: *Syzygium cumini*; Simplex; atractivo; Flavonoides; DPPH; ABTS; ORAC

1. Introduction

Studies have shown that regular consumption of fruits provides beneficial effects for health maintenance and disease prevention. This fact is mainly due to the presence of phenolic compounds in some fruits (Alam et al., 2013).

Jambolan fruit (*Syzygium cumini*) belongs to the *Myrtacea* family and has aroused interest due to its nutritional properties of high concentration of phenolic compounds, such as ellagic acid; flavonoids, such as quercitin and rutin; and anthocyanins, such as delphinidin-3-glycoside, petunidine-3-glycoside, and malvidin-3-glycoside (Singh et al., 2018). These compounds have high antioxidant capacity and may reduce the risk of noncommunicable diseases, such as chronic degenerative diseases, cardiovascular disease, premature aging, obesity, diabetes and neurodegenerative diseases (Kolniak-Ostek & Oszmiański, 2015).

Jambolan also has pleasant taste, although a little astringent, with purple pulp due to the presence of anthocyanins, which are important sources of phenolic compounds with antioxidant properties (Coelho et al., 2016; Singh et al., 2016). In addition to these advantages, jambolan also has favorable characteristics for the beverage industry due to the presence of natural pigments, since color is an important sensory attribute of nectars, being highly attractive for consumers (Soares et al., 2019).

Among the research demands on jambolan, adequacy of conventional technologies and the development of new technologies for processing are emphasized, in order to promote a more profitable use, by adding value to the fruit. The beverage market has been on the rise, with tendency to increase production and consumption of healthier and more functional foods aiming at disease prevention. In this way, the industry has been investing in the production of ready-to-drink juices and nectars (Santos et al., 2018).

Due to the scarcity of scientific and technological information, the objective of the work was to elaborate nectars and evaluate their physical and chemical characteristics in order to obtain information that allows the use of jambolan pulp and the consequent valorization of the fruits.

2. Methodologies

This is a field survey for the collection of jambolan fruits that were collected in the region of Goiás, Brazil (latitude 16 ° 39'29.560 " S, longitude 49 ° 11'51.752'W and altitude of 732, 53 m, north direction). The fruits were pulped and used as raw material for the production of nectars. The nectars were quantitatively evaluated, laboratory research (physical, physical-chemical characteristics, total flavonoids and antioxidant activity) (Pereira et al., 2018).

2.1 Obtaining and processing of jambolan pulp

Jambolan (*Syzygium cumini*) were collected in Goiania city, the own maturation stage for consumption, taken to the Vegetable Products Processing Plant, in low density polyethylene (LDPE) bags. After the selection, which eliminated damaged fruit, attacked by pests and diseases, they were washed in tap water, sanitized with a sodium hypochlorite solution (200 mg L^{-1}) for 20 min, dried at 25 °C and mechanically pulped. Jambolan pulp portions of 1 kg were packed in LDPE bags, frozen, and stored at -18 °C.

2.2 Processing of jambolan nectars

To formulation of nectars were used granulated sucrose (Cristal®) (5-15g $100g^{-1)}$, jambolan pulp (30-50g $100g^{-1}$) and potable water (30-65g $100g^{-1}$), through the use of Simplex Design, with six mixtures and three repetitions at the center point. Jambolan pulp was thawed at 25 °C and homogenized with sucrose and water in industrial blender. Each sample was filled in a 1 L glass bottle, previously sanitized in boiling water for 20 min. Then the nectar bottles were pasteurized at 90 °C for 60 s, cooled in tap water, closed with metal lids and stored at 5± 1 °C until analysis.

2.3 Physical and physicochemical characteristics

The luminosity (L*) of samples was determined by means of colorimeter (Hunter-Lab, Color Quest II, Reston, USA); apparent viscosity (AV) at 25°C was measured in a viscometer

(Brookfield, DV-II +, Middleboro, USA) at speed of 50 cP, spindle 2 (LV2); titratable acidity (TA) was obtained by titration according to AOAC method No. 942.15 (2012), expressed as citric acid concentration; and the TSS content was read in digital refractometer (Reichert, R^2mini, New York, USA), expressed in ºBrix, according to AOAC method No. 932.12 (2012). The TSS / TA ratio was also calculated. All analyses were performed in triplicate.

2.4 Total flavonoids and antioxidant activity

Total flavonoids (TF) were determined according method by Zhishen et al. (1999). A know volume of sample was placed in a 10 mL volumetric flask. Distilled water was added to make 5 mL, and 0.3 m, $NaNO_2$ (1:20) were added. 3 mL $AlCl_3$ (1:10) were added 5 min later. After 6min, 2 mL mol L^{-1}NaOH was added and the total was made up to 10 mL with distilled water. The solution was mixed well again and the absorbance was measured against a blank at 510 nm in spectrophotometer (DU-640 ™, Beckamn-Coulter – Brea, CA, USA). Catechin it was used as the standard for a calibration curve and the results were expressed as milligrams of catechin equivalents of 100g of nectar.

Free radical-scavenging by DPPH (2,2-difenil-1-picrilhidrazila) activity was measured using a method by Brand-Williams et al. (1995). ABTS activity was measured using ABTS cation ($ABTS^+$) stock solution obtained by 5 mL of ABTS (2,2-azino-bis(3-etilbezotiazolina)-6-ácido sulfônico) (7 mM) with 88 µL of 2.45 mM potassium persulfate (final concentration) and allowing the mixture to stand in the dark overnight. After, the $ABTS^{\bullet+}$ solution was diluted with ethanol to an absorbance of 0.70 ± 0.01 at 734 nm and equilibrated at 30°C, according method described by Re et al. (1999). The assay was conducted on 1 mL of the $ABTS^{\bullet+}$ solution and 0.2 mL of sample and mixed for 30s measurements were taken immediately at 734 nm after 1 min. The antioxidant activity of the sample was calculated by determining the decrease in absorbance at different concentrations and was expressed as equivalent for µg of trolox equivalent per mL of *Syzygium cumini* nectar (µg TE mL^{-1}).

The $ORAC_{FL}$ assay was described by Ou et al. (2002) and modified by Dávalos et al. (2004). Reaction was carried out in 75 mM phosphate buffer (pH 7.4), and the final reaction mixture was 200µL. Antioxidant sample (20 µL) and fluorescein (120 µL; 70µM in final concentration) solutions were mixed in one of the 96 wells of a black microplate. Then, 60 µL of an AAPH solution (final concentration 12 mM) was added and fluorescence as checked every cycle of 60 s for 80 cycles. The automated ORAC assay was performed on a Novo Star Microplate reader (BMG Labtech, Offenburg, Germany) with fluorescence filters (excitation, λ 485 nm; emission λ 520 nm). The experiment was conducted at 37 ºC under pH 7.4

condition with a blank sample in parallel. The result was calculated using the differences of areas under FL decay curves between the blank (net AUC) and sample and was expressed as equivalent for µmol of trolox equivalent per mL of *Syzygium cumini* nectar (µmol TE mL^{-1}), as described in the following equation 1:

$$AUC1 + \Sigma fi\ /f0 \quad (1)$$

In which: f0 is the initial fluorescence (t=0); and fi is the fluorescence obtained at t=i (minutes).

Net AUC (equation 2) was plotted against sample concentration and results were compared to the standard curve (Net AUC versus Trolox concentration). The equivalence of Trolox was given by the angular coefficient of trolox curve concentration (µmol) versus sample concentration (mL). All assay was performed in three independent replicates.

$$\text{Net AUC} = \text{AUCsample} - \text{AUCblank} \quad (2)$$

2.5 Analysis of results

Polynomial models were adjusted to each response through the canonical models Scheffe to three components: linear and interactions. From analysis of variance (ANOVA), was estimated level of significance, coefficient of determination and lack of fit. To obtain the experimental design, data analysis and graphics, was usedt he Statistica 7.0 (Statsoft, version 7.0, Tulsa, USA). The physical and physicochemical responses determined were jointly optimized using a multi-response function, the desirability function (Derringer & Suich, 1980).

3. Results and Discussion

3.1 Phisycal and physicochemical characteristics

The physicochemical characteristics evaluated were influenced by components of mixture, as seen in Table 1. All polynomial models were significant ($p \leq 0.01$) and explained 86-99% of the responses, as seen in Table 1. The lack of fit was significant only for chrome and apparent viscosity. However, according to Waszczynskyj et al. (1981), if the mean square for the experimental error is low, the significance tests for the lack of adjustment have to be considered irrelevant, in this way all models can be used for predictive purposes.

Table 1. Luminosity (L*), apparent viscosity at 25 °C (AV), titratable acidity (TA), total soluble solids (TSS) and ratio titratable acidity/total soluble solids (TA/ TSS) of nectars in function of real proportion content of jambolan pulp, sucrose and water, and in function of pseudocomponent values, defined by the Simplex Design.

Mixture	Real Ingredients Ratio			Pseudocomponent[1]			L*	AV[2]	TA[3]	TSS[4]	TA/TSS
	Pulp	Sucrose	Water	Pulp (X_1)	Sucrose (X_2)	Water (X_3)					
N1 (A)	0.44	0.13	0.43	0.4	0.229	0.371	33.30±0.04	9.01±0.01	0.64±0.08	19.10±0.03	29.97±0.89
N1 (B)	0.44	0.13	0.43	0.4	0.229	0.371	32.83±0.21	12.02±0.01	0.69±0.00	18.87±0.01	27.33±0.10
N1 (C)	0.44	0.13	0.43	0.4	0.229	0.371	33.42±0.03	13.20±0.01	0.69±0.00	18.97±0.01	27.47±0.10
N2	0.55	0.05	0.40	0.714	0	0.286	33.29±0.10	49.83±0.02	0.74±0.08	11.77±0.13	16.10±2.10
N3	0.50	0.20	0.30	0.571	0.429	0	32.37±0.12	73.82±0.03	0.78±0.08	26.43±0.04	34.04±0.00
N4	0.30	0.20	0.50	0	0.429	0.571	33.12±0.06	13.81±0.01	0.69±0.00	24.13±0.02	34.96±0.10
N5	0.55	0.15	0.30	0.714	0.286	0	32.14±0.29	21.64±0.01	0.83±0.00	22.07±0.03	26.64±0.09
N6	0.30	0.05	0.65	0	0	1.0	34.24±0.09	7.83±0.00	0.55±0.00	8.87±0.03	16.05±0.13

[1] $X_1 + X_2 + X_3 = 1$; [2] Centipoise (Cp), [3] $g_{citricacid}$ $100g_{nectar}^{-1}$; [4] °Brix

Source: Own authorship, physicochemical laboratory UFG / GO.

The effects of jambolan pulp, sugar and water contents were significant for all responses, except jambolan pulp for AV. Interactions between jambolan pulp and sugar are significant for AV and TSS, while interaction between jambolan pulp and water for AV, and sugar and water for TSS, as seen in Table 2.

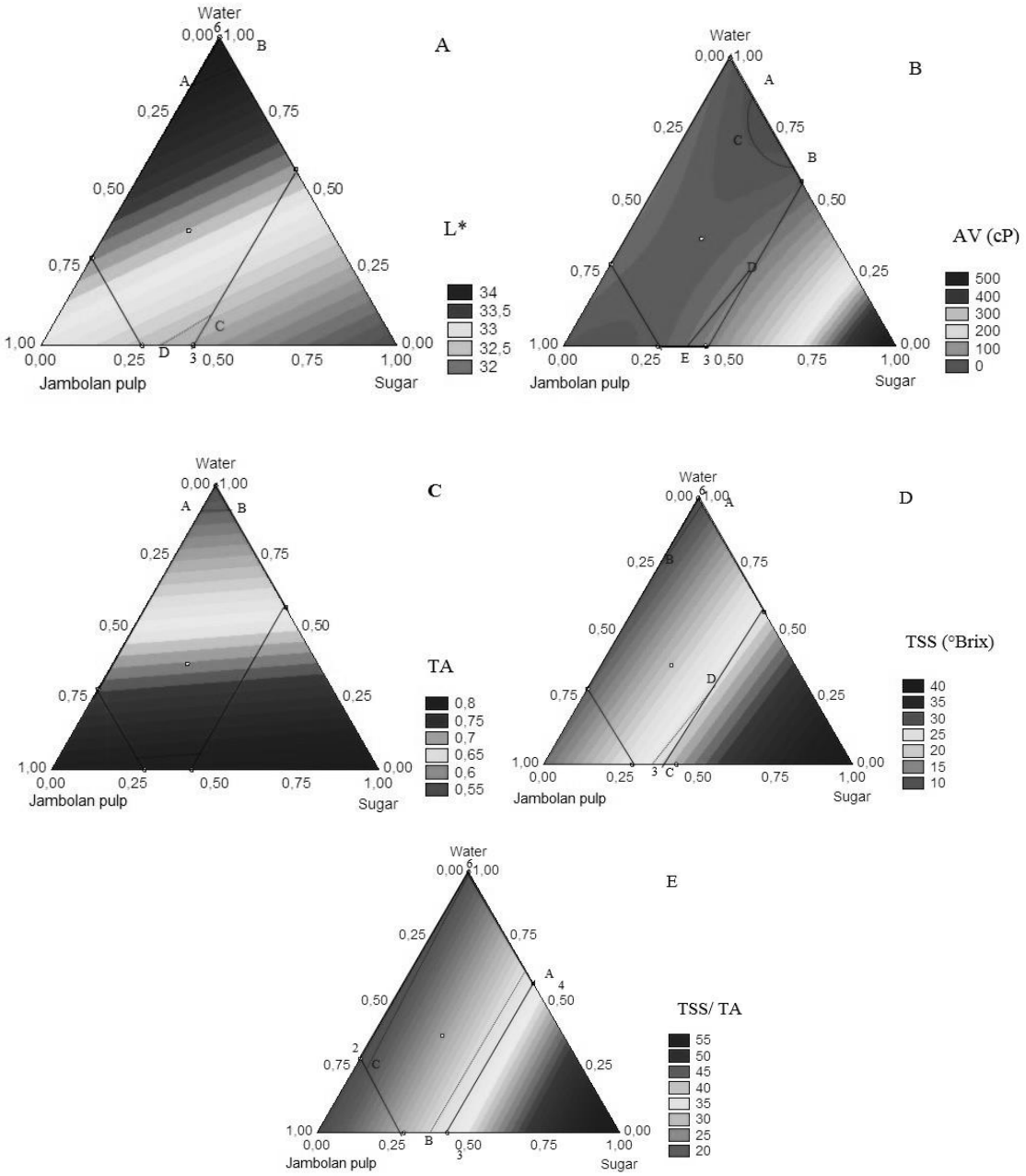
Table 2. Polynomial model, lack of fit (LF), level of significance (p) and determination coefficient (R^2) for luminosity, apparent viscosity, titratable acidity, total soluble solids and ratio titratable acidity/total soluble solids of nectars in function of pseudocomponents, jambolan pulp (x_1), sucrose (x_2) and water (x_3).

Parameter	**Model[1]**	**p**	**LF**	**R^2**
Luminosity	$Y = 32.78\ X_1 + 31.60\ X_2 + 34.34\ X_3$	0.01	0.72	0.88
Apparent viscosity at 25 °C[2]	$Y = \textit{20.36}\ X_1 + 625.03\ X_2 + \textit{7.80}\ X_3 - 840.81\ X_1X_2 + 161.75\ X_1X_3 - 1056.46\ X_2X_3$	0.01	0.01	0.99
Titratable acidity (TA)[3]	$Y = 0.79\ X_1 + 0.8086\ X_2 + 0.5461\ X_3$	0.01	0.31	0.86
Total soluble solids (TSS)[4]	$Y = 12.91\ X_1 + 40.43\ X_2 + 8.89\ X_3 + 6.61\ X_1X_2 + 7.13\ X_2X_3$	0.01	0.38	0.99
TSS/TA	$Y = 16.03\ X_1 + 15.87\ X_2 + 17.46\ X_3$	0.01	0.32	0.94

[1] Effects in italics were not significant (p> 0.05), but were maintained for the better fit of the model.; [2]Centipoise (Cp), [3]$g_{citric\ acid}$ 100 g_{nectar}^{-1}; [4] ºBrix.
Source: Own authorship, physicochemical laboratory UFG / GO

Nectars with minimum L * values (less than 33), that is, less amount of reflected light, were observed in the area of the graph between points 3, C, D, as seen in Figure 1A, in formulations with jambolan pulp concentration from 44 to 52g $100g^{-1}$, sugar from 18 to 23g $100g^{-1}$ and water from 30 to 33g $100g^{-1}$. The presence of pigments such as anthocyanins in jambolan pulp attributed lower luminosity to nectars, which was attractive for consumers in the sensory analysis. Color is directly influenced by the raw materials used in food formulations (Guimarães et al., 2014).

Figure 1. Luminosity e (L*) (A), apparent viscosity at 25 °C (AV) (B), titratable acidity (TA)$g_{\text{citric acid}}$ $100g^{-1}$) (C), total soluble solids (TSS) (D) and TSS/TA (E) in relation to jambolan pulp, sugar, and water contents (in pseudocomponents). Area demarcated between the numbered points demonstrate the experimental space analyzed.



Source: Own authorship, physicochemical laboratory UFG / GO.

Soares et al. (2014) evaluated the color of the epicarp of jambolan fruits from different trees in the city of Goiânia-GO, and obtained L* of 14.18, 56.9% lower than the highest value found in this study. Therefore, jambolan nectars were lighter than fresh fruits due to the fact that the pulp color is white and the epicarp color is between purple and black (Ayyanar & Subash-Babu, 2012). Therefore, the pulping process might have removed part of the epicarp.

The highest AV values were obtained between points 3, D and E, as seen in Figure 1B, in formulations with jambolan pulp concentration between 41 and 51g $100g^{-1}$, sugar from 19 to 20g $100g^{-1}$, and water from 30 to 38g 100g $^{-1}$. The highest jambolan pulp concentrations used in formulations provided an increase in TSS and consequently a decrease in the amount of free water in the mixture, thus increasing AV. AV is highly affected at concentrations higher than 20 °Brix (Magerramov et al., 2007), which explains the fact that N3 has higher sugar content (20g $100g^{-1}$) and the highest viscosity compared to the other experimental formulations. Molecular movement in a solution is affected by the amount of molecules present and their interaction with water molecules. The effect of solution concentration on AV is an important factor in industrial applications (Haminiuk et al., 2007).

Benítez, Genovese and Lozano, (2009) showed that the viscosity of a colloidal dispersion of solids in syrups is increased by increasing the particle-sugar interaction and by lowering the water activity of syrups. Sucrose, with higher molecular weight than that of glucose or fructose, has higher AV for solution of the same concentration (Šimunek et al., 2013).

Glucose and fructose are present in jambolan pulp (Lago, Gomes & Silva, 2006) and have lower influence on the AV of the nectar, since it has higher sucrose concentration, but regardless of pulp and sugar concentrations, all jambolan nectar formulations presented non-Newtonian and pseudoplastic fluid behavior, since AV decreased as a function of the applied shear rate (Schramm, 2006).

The highest TA values were found in the diagram area formed between points 3,5, C, and D, as seen in Figure 1C, in formulations containing 49 to 55g $100g^{-1}$ of pulp, 14 to 20g $100g^{-1}$ of sugar and 30 to 31g of 100g $^{-1}$ of water. Therefore, the highest TA values were obtained with the highest jambolan pulp and sugar concentrations and lowest water contents. Fruit pulps are composed of organic acids, so the higher the jambolan pulp concentration in the nectar formulation, the greater the amount of acids present. TA is an important quality parameter, since it is involved in hydrolysis, oxidation and fermentation reactions, which generate more acidic compounds that, consequently, increase the medium acidity (Chim et al., 2013), increasing the shelf life and reducing the microbial risk of foods and beverages.

Higher TSS values (higher than 25º Brix) were verified in the area between points 3, C, D (Figure 1D), in formulations containing 40 to 51g $100g^{-1}$ of jambolan pulp, 19 to 20g $100g^{-1}$ of sugar, and 30 to 40g of $100g^{-1}$ of water. The increase of pulp and sugar contents in nectars increased the TSS content. In jambolan pulp, the high TSS content is attributed to starch hydrolysis, according to the interconversion of carbohydrates during fruit ripening

(Jiménez et al., 2011). In experimental jambolan nectars, sucrose was the predominant sugar and the main factor responsible for their increased TSS content, as seen in Table 2.

Barcia et al. (2005) reported that TSS content in jambolan pulp ranged from 13.8 to 19º Brix, similar to that found in N1 (44, 13 and 43g $100g^{-1}$ of jambolan pulp, sugar and water, respectively), as seen in Table 1. The increased TSS content in jambolan nectars was a consequence of the incorporation of commercial sucrose and higher jambolan pulp contents, which is source of fructose and glucose. The decrease in TSS content occurred with the increase of water content, that is, dilution of nectars.

The highest TSS / TA ratio was obtained between points 3,4, A and B, as seen in Figure 1E, that is, formulations with jambolan pulp content from 30 to 51g $100g^{-1}$, sugar from 19 to 20g $100g^{-1}$ and water from 30 to 50g $100g^{-1}$. The TSS / TA ratio is an indicator used to determine the sweet / acid flavor balance (Couto & Canniatti-Brazaca, 2010). The increase of jambolan pulp in experimental formulations negatively influenced the TSS / TA ratio, decreasing the TSS / TA ratio because the pulp present acidic characteristic, as seen in Figure 1C. Gurak et al. (2008) evaluated whole grape juices and found TSS / TA values from 15.31 to 24.44, which are 4.42% to 30.09% lower than those found in this work. Therefore, jambolan nectars presented sweeter and more acidic flavor compared to grape juice, which can be an advantage for the beverage industry.

3.2 Model validation with the selected nectar

For the selection of the highest desirability experimental nectar, a comparison with commercial standard (Dell Valle guava nectar) was considered for each response; for L *, it was desired to highlight the dark color (lower values), matching with the chosen fruit (purple color); while for TA, TSS, TSS / TA, and AV at 25 ° C and 50 rpm, the highest values were selected. For the validation test of models, the formulation of highest desirability was used.

The result of the desirability test indicated as the most desirable, jambolan nectar formulation with 0.71: 0.29: 0 in pseudo components, jambolan pulp, sugar and water, respectively, or with real proportion of 55g $100g^{-1}$ of jambolan pulp, 15g $100g^{-1}$ of sugar and 30g $100g^{-1}$ of water. Thus, N5 was the most desirable formulation, as seen in Table 1.

It could be concluded that the predicted model corroborated values analytically found, since the percentage variation between these results varied little, between 0.56 and 7.5%, as seen in Table 3. Differences between analyzed and calculated values can be related to the determination coefficients of equations of each parameter evaluated and to standard deviations among triplicates of each analysis.

Table 3. Physicochemical characterization of selected nectar (N5). Data obtained in the validation test, estimated by the model, and percentage variation between the determined and estimated responses.

Parameter	Determined in the validation test	Estimated by model	Variation (%)
Luminosity[1]	33.57 ± 0.04	32.44	3.48
Apparent viscosity[2]	22.05 ±1.08	21.60	2.08
Titratable acidity (TA)[3]	0.86 ± 0.03	0.80	7.50
Total soluble solids (TSS)[4]	22.42 ± 0.05	22.13	1.31
TSS/TA[1]	16.07 ± 0.7	15.98	0.56

[1] dimensionless; [2]centipoise (Cp), [3]g $_{citric\ acid}$ 100 g $_{nectar}^{-1}$; [4] °Brix
Source: Own authorship, physicochemical laboratory UFG / GO

3.3 Total flavonoids and antioxidant activity

Jambolan nectar selected (N5) showed high TF content (14.05 mg 100g^{-1}of cathecin), as seen in Table 4, when compared to fresh fruit (7 mg 100g^{-1}of cathecin) obtained by Banerjee, Dasgupta and De (2005). Flavonoids are composed of various anthocyanins and also include other flavonols. Flavonoids have several physiological functions, such as antioxidant and UV protective effects (Ke et al., 2015).

Table 4. Total flavonoids and antioxidant activity (obtained by the DPPH, ABTS and ORAC methods) of the selected nectar formulated with 55g 100g^{-1} jambolon pulp, 15g 100g^{-1} sugar and 30g 100g^{-1} water.

Parameter	**Value[1]**
Total flavonoids (TF)[2]	14.05 ± 0.43
DPPH[3]	1620.25 ± 0.00ou 85.09%
ABTS[4]	10526.12 ± 0,00ou 95.06%
ORAC[5]	27014.25 ± 1.24

[1] Values are mean ± standard deviation of three original replicates and three triplicates
[2] mg of cathecin 100g^{-1}; [3] µg TE mL^{-1} ou 85,09%; [4] µg TEmL^{-1}; [5]µmol TE mL^{-1}; TE= trolox equivalent.
Source: Own authorship, physicochemical laboratory UFG / GO

For the DPPH method, jambolan nectar obtained 1620.25 µg TE mL^{-1} and 85.09% DPPH discoloration (Table 4), but in frozen blackberry nectars at zero storage time, 75.95 % DPPH discoloration was observed (de Araújo et al., 2009). Therefore, jambolan nectar had higher antioxidant capacity than blackberry nectar. Jambolan nectar presented higher antioxidant capacity by the ABTS method compared to blueberry nectar (3499.24 µg TE mL^{-1}) (Castagnini et al., 2015).

In relation to the antioxidant activity, it was observed that the ORAC method obtained higher values compared to the other methodologies used, being more effective for the determination of the antioxidant capacity of jambolan nectar, since it measures the lipophilic

and hydrophilic antioxidant activity of the sample. The ORAC method can be considered one of the most appropriate methods for biological systems. This is because it measures the ability of the sample to inhibit oxidation reactions induced by reactive oxygen species belonging to the group of free radicals called "peroxyl" (Prior et al., 2005).

Thus, we can observe that the jambolan nectar showed high antioxidant activity, enabling the use of jambolan pulp in food processing.

4. Final considerations

It could be concluded that the physical and physicochemical properties vary according to the nectar formulation. The highest desirability nectar (55g $100g^{-1}$ of jambolan pulp, 15g $100g^{-1}$ of sucrose and 30g 100g $^{-1}$ of water) presents high antioxidant activity, so it can promote health benefits for consumers, and its consumption can be recommended. It is possible to produce jambolan nectar with desirable physical and chemical characteristics, which may increase the possibilities of applying jambolan as an ingredient in the food industry.

It is suggested that in future work the development of new jambolan products and identified of bioactive compounds.

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