JAMBOLAN LIQUOR PRODUCTION: INFUSION AND CLARIFICATION INFLUENCE

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ABSTRACT

Liqueurs are obtained by the infusion or maceration of the vegetable in alcoholic solvent when its flavour compounds are extracted, as well as those that cause turbidity, a quality problem for this beverage. In this context, clarification is considered a necessary step to improve clarity and add value to the liquor. In this work, the influence of the maceration was evaluated, using or not a previous thermal treatment on the fruit, different maceration and aging times, and different ways of clarifying the jambolan liquor. The clarification methods chosen were sedimentation, with and without the clarification agent bentonite, followed by cotton sieving and vacuum filtration. Physicochemical evaluations demonstrated that the pH value, total phenolic compounds and gallic acid concentrations varied during maceration, with a reduction in the pH value and an increase in the total phenolic and gallic acid concentrations. There was also a predominance of the yellow colour of the liquor, regardless the heat treatment of the fruits. The total soluble solids and titratable acidity parameters did not change, regardless the clarification method used. However, it was observed that the clarification method that used bentonite produced a jambolan liqueur with the lowest turbidity and highest tone, being the clearest obtained.

KEYWORDS: *Syzygium cumini (L)* Skeels*, beverage, solid–liquid extraction, phenolic compounds*

I. INTRODUCTION

Jambolan (Syzygium cumini (L) Skeels), a plant of the Myrtaceae family originally from India, is a large tree well adapted to Brazilian growing conditions that is found wildly throughout almost the entire country [1, 2]. Its fruit is small and has attractive characteristics, such as high monomeric anthocyanin and phenolic compound levels, which confer to the peels an intense purple colour in the ripe fruit, and antioxidant power to its pulp [3, 4, 5, 6]. However, the jambolan fruit has been commercially neglected, and the plant has been mainly used as an ornamental and shadow provider plant, with the fruit being mostly consumed in natura.

According to the Brazilian regulations, the liquors must be prepared with an appropriate ethanol or a simple distilled alcohol, or even other alcoholic beverages with added vegetable or animal substances or extracts, flavouring substances, pigments, etc., have a sugar content over 30 $g \cdot L^{-1}$, and present an alcoholic graduation between 15 and 54% $v \cdot v^{-1}$, at 20 °C [7].

According to Silva et al. [8], notwithstanding the technological advances in the beverage production field, basic liquor processing remains the same as that used in the past, with an undetermined period of

infusion and a further addition of alcohol, sugar, or syrup, resulting in a sweet alcoholic beverage. To obtain this vegetable extract, a solid–liquid extraction similar to that used in tea production is conducted [9], in which, traditionally, the vegetables are previously cut, smashed, or broken to increase the superficial area and improve contact with the extractant (alcohol), at room temperature [10]. At the end of this process, it is common to obtain a turbid beverage as a result of different factors, such as the quality of the sugar used, the presence of pectin and several carbohydrates, and the formation of a complex tannin-protein, all transferred from the vegetable source during the infusion step [11, 12, 13, 14].

According to Teixeira et al. [15], the maceration time is a critical point to obtain a high-quality liquor, since in this step, the complete extraction of the essential compounds, such as the sensorial and the phenolic compounds, which have antioxidant activities, is guaranteed. They also affirmed that the best maceration time for extraction varies with the vegetable source.

Even though, not being an indispensable step in general liquor production, a clarification step it is necessary for those made from fruits, before they are conditioned into bottles, to avoid the spontaneous sedimentation of these particles, and improve their final quality by offering a beverage with a better visual appearance. Thereby, turbidity is an important sensorial parameter that influences consumer acceptance, and the simplest process to achieve its reduction is to let the liquor naturally decanter and then filtrate the supernatant. However, it is a slow process that demands a modification that could speed it up [15, 16].

Most of the liquor consumed in Northeast Brazil is made in a craft mode by small producers at their homes [11,17]. Several methods of clarification are used in that way of production, which includes tissues, cotton and paper sieving, the use of egg white and unflavoured gelatine as bonding agents, and either activated charcoal or natural sedimentation. Thus, this work aimed to evaluate different infusion and clarification processes on some physical-chemical parameters of the liquor of jambolan to understand the visual quality aspects of this product, since this fruit presents elevated phenolic compound concentrations that are transferred from the fruit to the liquor, which could influence the colour variation of the product over time. As jambolan is a rich fruit that has not been deeply studied, this work has a relevant role in future works in this area, especially for those that will consider phenolic compound extraction from jambolan fruit.

This paper is structured into four sections: Section I presents the introduction. The methodology, which describes compositions, mixing procedures, and analysis methods, is presented in section II. The results and discussion are presented in Section III and the main conclusions drawn from the study are presented in Section IV.

II. METHODOLOGY

2.1. Material

Jambolan fruits (Syzygium cumini) were harvested at the State University of Feira de Santana, Bahia-Brazil, located at a latitude of 12º11'30.60" South, and a longitude of 38º57'59.99" W. The alcoholic beverage used to produce the liquor was cane brandy with an alcoholic graduation of 41.1% $v \cdot v^{-1}$, at 20 °C, acquired also in Feira de Santana, as well as the sugar used to prepare the syrup, and the bentonite bonding agent (Ever Brasil Ind. e Com. LTDA, Fort Benton). For the filtration step, a paper filter (80 $g \cdot m^{-2}$, 0.02 mm of thickness, pore of 25m), and a vacuum pump (Olidef C-71) were used.

Spectrophotometric analyses were carried out in a UV/Vis spectrophotometer (Femto, model 600 Plus), and chromatographic analysis was carried out in an HPLC (Varian) coupled to a diode array detection (DAD) and manual injector (Varian ProStar). For the separation of compounds, the column used was a LiChroCART Purospher StaR® RP8-e (250 mm x 4.6 mm i.d.) (5 µm) (Merck®, Darmastad, Germany) combined with a suitable precolumn also acquired from Merck®, PTFE 0.45 µm membrane and an ODS C18 cartridge.

For the physical-chemical analysis, gallic acid standard (Merck®, Darmastad, Germany), NaOH 0.1 N, and phenolphthalein 1% were used. The total soluble solids (TSS) were determined by a digital

refractometer (Reichert, model AR200), and the pH value was determined by a digital potentiometer (Nova Instruments, model NI PHM).

2.2. Physical-chemical evaluation

The total phenolic compounds were evaluated by the spectrophotometric Folin-Ciocalteu method [18] using a wavelength of 760 nm for measurement of the absorbance. The gallic acid standard was used to construct the standard curve, and the results were expressed in milliequivalents of gallic acid by 100 g of alcoholic extract or liquor (mg·EAG 100 g^{-1}).

The analysis of the total acidity (TA) was performed using 0.1 N sodium hydroxide as titrant, with a 1:10 sample dilution in distilled water, using 1% phenolphthalein as an indicator, expressed as a percentage of citric acid (m/v). The TSS was determined by refractometry, and the pH was determined by straight determination in a digital pH meter. All these analyses were conducted as described by IAL - Instituto Adolfo Lutz [19].

Colour spectrophotometric analysis was performed at wavelengths of 420, 520 and 620 nm using the methodology described by Glories [20], and the turbidity was measured by transmittance at a wavelength of 660 nm, as described by Reed; Hendrix; Hendrix [21].

2.3. Liquor processing

The raw material preparation consisted of selection, washing in potable water and sanitation with chlorine solution (50 ppm), and a subsequent increase in the contact surface area by kneading it with a pestle. Liquor processing was conducted in two steps: alcoholic extraction and clarification.

2.3.1. Alcoholic extraction

Two alcoholic extraction methodologies were used: with and without a thermal treatment (60 °C/10 min) before simple alcoholic maceration with brandy, which occurred at ambient temperature (approximately 25 °C). The extraction was evaluated at different times, 9, 15 and 30 days, in the proportion of 500 g of fruit for 600 mL of brandy, in closed glass jars, protected from light, under occasional stirring of the jars, without changing the extractor. The samples were filtered at the end of the maceration time, and submitted to physical-chemical analysis (pH, TSS, TA and total phenolics).

2.3.2. Liquor clarification

Once the maceration time and temperature treatment were defined, the liquor was prepared by adding a sucrose syrup, produced under a hot process, to obtain a liquor with a TSS of approximately 30 °Brix.

The study included four clarification treatments: addition of bentonite or sedimentation, both followed by filtration in a cotton sieve, sedimentation followed by vacuum filtration, and the control. In the first treatment, hydrated bentonite, which was prepared with 10% distilled water for 24 h, was added to the liquor in a proportion of 1 g/L. The samples were left for 30 days in contact and then filtered through cotton sieves. The sedimentation samples were rested for three months, and then filtered in a cotton sieve and vacuum filtered with qualitative paper. The control corresponded to the crude liquor.

The physical-chemical analyses conducted at this step were pH, TSS, TA, turbidity, and colour. They were all conducted in triplicate.

2.4. Gallic acid quantification by HPLC

The methodology used was adapted from that described by Silva et al. [22]. The samples, the jambolan alcoholic extracts and liquors were evaluated for their gallic acid concentration. The analysis conditions of the chromatograph analysis were injection volume of 20 µL, elution range with an aqueous phase A of 2% acetic acid and a mobile phase B of 100% methanol, runs of 42 minutes in a wavelength range of 200-600 nm, with the chromatograph acquisition at 280 nm, considering the number of peaks and resolution. The columns were operated at 25 °C.

III. RESULTS AND DISCUSSION

3.1. Jambolan characterization

The physical-chemical evaluation indicates that the processed fruits were ripe, rich in total soluble solids (15.90 ± 0.01 °Brix), with an average pH value of 4.79 ± 0.01, and total phenolic compounds of 423.09 ± 43.12 mg·EAG 100 g^{-1}, which differs from those found by Brandão et al. [23] in their work, who found a pH value of 3.75 ± 0.17, total soluble solids of 12.78 ± 0.02 °Brix and total phenolic compounds of 664.04 ± 0.03 mg·EAG 100 g^{-1}. Soares & Pereira [24] also found a total soluble solids content of 15.2 ± 0.6 °Brix, and Brito et al. [25] found a pH value of 3.79 ± 0.01, which was similar and smaller than those found in the present work, respectively.

The slight difference obtained could be explained by the species, environmental conditions, growth conditions, soil, harvest, and maturation period [26, 27]; however, the biochemical, structural, and physiological changes evolved in this process are not yet well known [27, 28]. Regarding the phenolic compound content, it is necessary to consider that the presence of seeds in the fruit exerts some influence on its total content, as observed by Luzia and Jorge [29] in their work, in which they found a concentration of phenolic compounds of 130.56 mg·EAG 100 g^{-1} of jambolan seed extract.

3.2. Alcoholic extraction

3.2.1. Physical-chemical parameters

The pH evolution over the liquor maceration time (0, 9, 15 and 30 days) and aging (0, 30, 60 and 90 days) is shown in Figure 1. According to Souza et al. [30], the pH value is mainly influenced by the maceration time during liquor processing; however, in this work, it was observed that syrup addition, which caused a decrease in the pH value, and the aging period had a major influence on this parameter, with values varying between 4.25 and 4.27 during maceration time, and between 3.85 and 4.20 at the aging time. All the values were under the limiting pH value for most of the deterioration/pathogenic microorganisms, which grows at a pH value over 4.5, making this product stable at all production steps [31, 32]

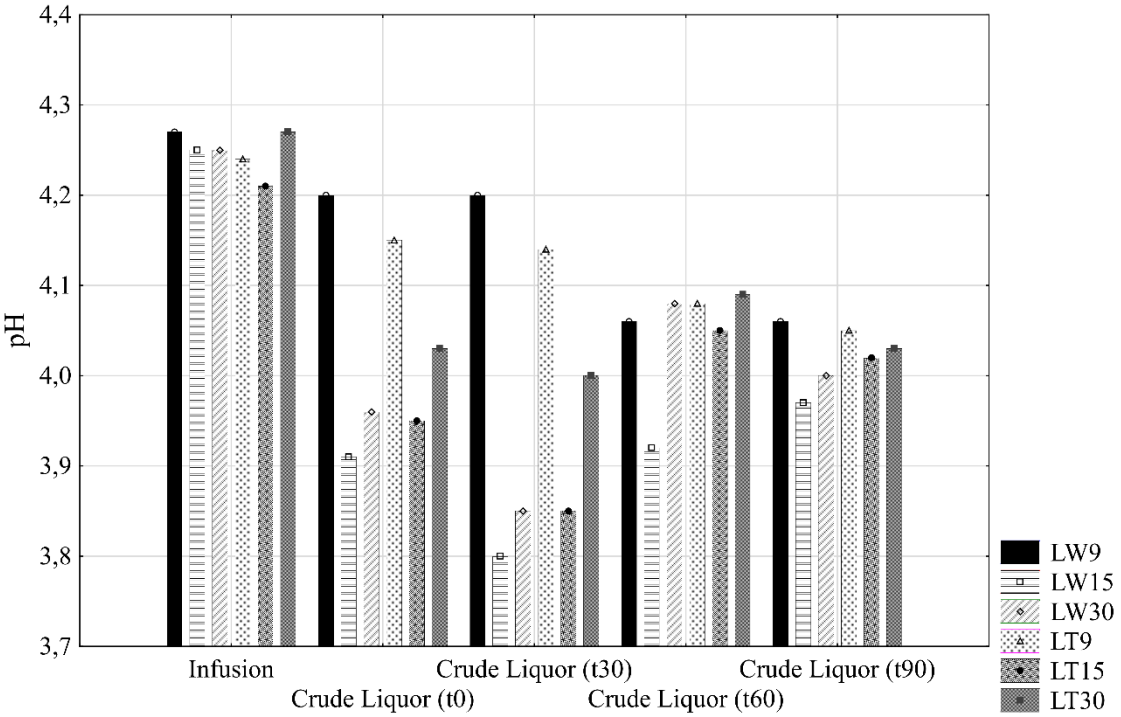

Figure 1: pH values of the jambolan extracts under different maceration and aging times. LW represents the liquor without thermal treatment; LT represents the liquor with thermal treatment; and tn represents the liquor aging time (n = 0 to 90 days).

According to Santos, Machado and Gomes [33], the total soluble solids constitute one of the best sweetness evaluation parameters. At the jambolan liquor processing the TSS decreased, when compared to the TSS fruit, from 15.9 ± 0.22 °Brix to 12.10 ± 0.48 °Brix in the liquor produced with a previous

hot treatment, and to 11.91 ± 0.42 °Brix in the liquor without the hot treatment, remaining constant over the maceration time, which was expected since the fruit TSS was diluted in the alcoholic source. It was also verified that, for the infusions and the liquors, the TSS values did not differ statistically from each other, at a 5% significance level (data not shown). The TSS did not vary over the aging liquor time (32.73 ± 0.50 °Brix), and, considering the TSS values obtained, it is possible to classify the liquor as a fine liquor because their limits were between 100 g·L^{-1} and 350 g·L^{-1} [34].

3.2.2. Total phenolic compound content

The evaluation of the total phenolic compounds was carried out considering the standard curve of gallic acid (R^2 = 0.997), and the results obtained are shown in Figure 2, in which is possible to observe an increase in the total phenolic compounds over the maceration time. This extraction process is influenced by the extractant used, as observed by Gámez-Meza et al. [35], who found that a higher phenolic compounds extraction may be obtained by solvents with higher polarity. In other studies, where the content of polyphenols in extracts of red fruit residues was evaluated, it was observed that it was higher in methanolic and ethanolic extracts than in aqueous extracts over time [18].

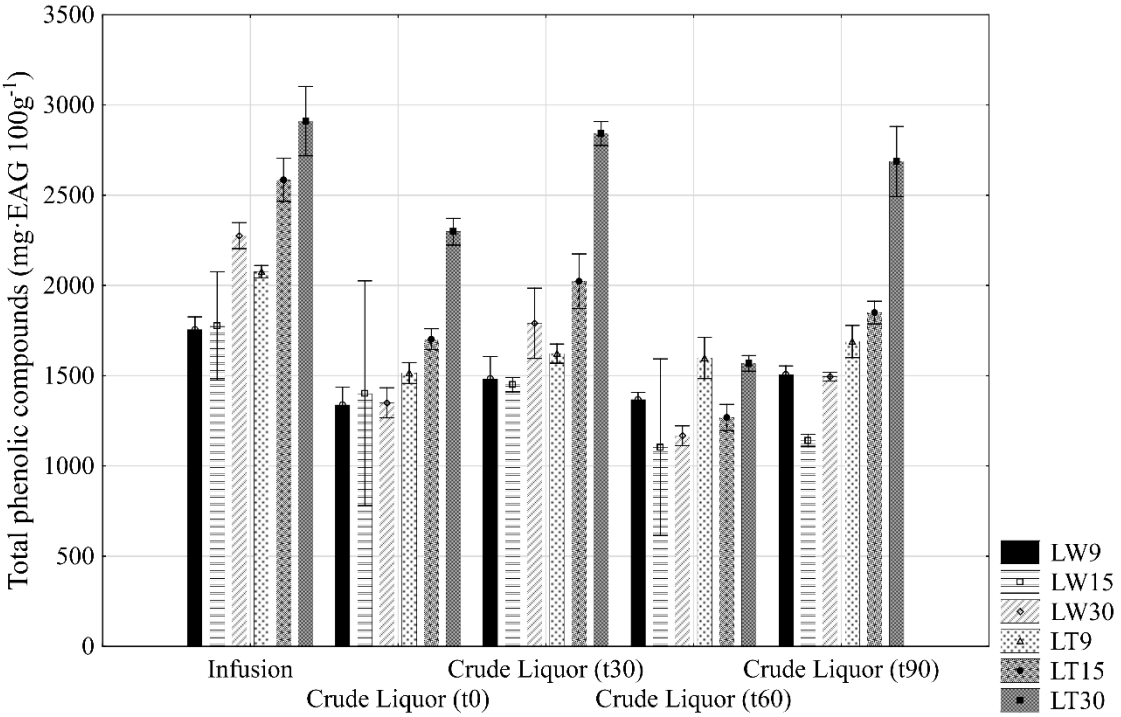

Figure 2: Total phenolic compounds of the liquors under different maceration and aging times. LW represents the liquor without thermal treatment; LT represents the liquor with thermal treatment; and tn represents the liquor aging time (n = 0 to 90 days).

It is possible to verify that the phenolic compound content was higher in the liquors elaborated from the fruits that were submitted to thermal treatment before maceration (Figure 2). Falcão et al. [36], in a study in which the phenolic compounds in grape wort were quantified, observed a positive correlation between the increase in the thermal treatment time, at 70 °C, and the increase in the half lifetime and the percentage of the colour retention of the anthocyanin pigments, since an increase in the temperature leads to better pigment transfer from the grape peel. Considering that the anthocyanins are phenolic compounds from the flavonoid group, the same group of natural pigments that give the characteristic colour of jambolan, it can be assumed that the thermal treatment also contributed to a higher extraction of the phenolic compounds during the maceration process. Jeong et al. [37] and Jeong et al. [38], in previous works with sesame seeds, showed that thermal treatment promoted the cleavage of bonds of phenolic compounds, making them soluble.

However, the phenolic content over time for the same liquor was neither stable nor constant. The first observed variation can be attributed to the extracted dilution caused by the addition of syrup after the

maceration time. The following decrease observed may be explained by the sweet solution stabilization at 60 days, leading to a smaller phenolic compound content, since some reducing substances, such as sugars, amino acids, and ascorbic acid, could have interfered with the method used [39, 40]

As observed for the phenolic compound content, the liquor obtained from the fruits that had been thermally treated before maceration presented a higher gallic acid content compared to the others that were not treated, with values varying from 35.30 µg.mL^{-1} to 82.31 µg.mL^{-1} for liquors of simple maceration and for liquors of maceration after thermal treatment, respectively. The gallic acid concentrations are shown in Figure 3.

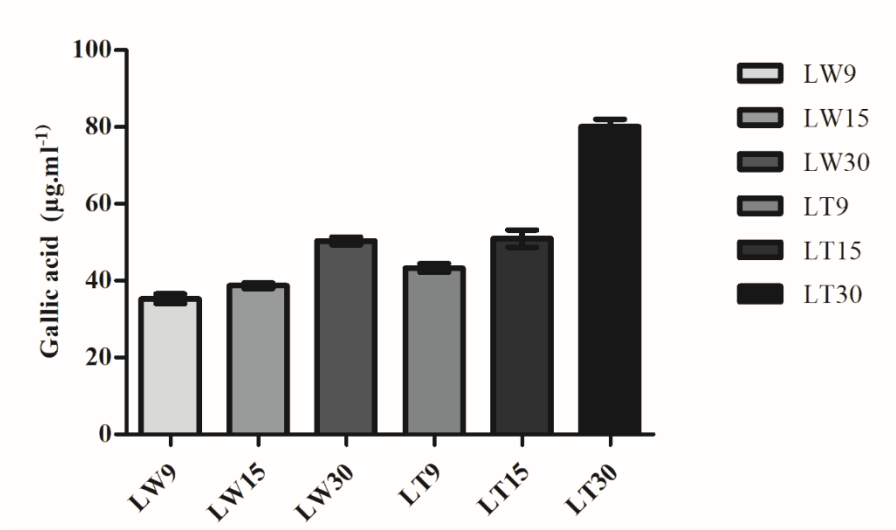

Figure 3: Gallic acid concentration of the liquors. LW represents the liquor without thermal treatment, and LT represents the liquor with thermal treatment.

3.2.3. Liquor colour and turbidity

The results for the liquor colour and turbidity (Table 1) showed a prominence of the yellow colour in the liquors during maceration times, wherever the treatment was applied to the fruit before it. The red colour percentage decreased over time, and the blue colour was discreet during all aging times. The increase in the yellow percentage and reduction in the red percentage, prevalent in acidic solutions, are related to the stability of anthocyanins, since these pigments can degrade due to pH, temperature, and oxygen presence, depending on their structure and concentration [41].

Table 1: Colour and turbidity of the crude liquors.

Treatment	Colour					Turbidity
	Intensity	Tonality	% Yellow	% Red	% Blue	% T
LW9	2.18 ± 0.05	1.91 ± 0.01	57.79 ± 0.08	30.31 ± 0.04	11.90 ± 0.04	48.20 ± 1.25
LW15	2.16 ± 0.03	1.36 ± 0.01	51.03 ± 0.17	37.45 ± 0.22	11.52 ± 0.10	70.40 ± 0.20
LW30	2.25 ± 0.01	1.26 ± 0.01	48.37 ± 0.11	38.52 ± 0.16	13.12 ± 0.20	63.60 ± 0.87
LT9	1.83 ± 0.06	2.29 ± 0.01	62.15 ± 0.15	27.17 ± 0.08	10.68 ± 0.06	48.20 ± 1.25
LT15	2.24 ± 0.01	1.49 ± 0.02	51.11 ± 0.27	34.42 ± 0.51	14.47 ± 0.75	60.57 ± 0.92
LT30	2.01 ± 0.01	1.61 ± 0.02	53.42 ± 0.30	33.13 ± 0.13	13.45 ± 0.22	66.30 ± 0.56

Turbidity occurs essentially due to the presence of colloidal particles in the liquid phase and can be quantified by their effect on the dispersion of light in the liquor [15, 42]. In this way, the results showed that the turbidity generally varied under a huge range for all the liquors produced, not presenting, however, any difference for the thermal treatment applied to the fruit. Turbidity in liquors can occur for several causes, including the use of dry sugar during its elaboration and the presence of pectin from the

fruits used in their formulation [12, 39]. The efficiency of the infusion filtrations as well as the sugar dissolution during the syrup preparation can contribute to variations in this parameter.

3.2.4. Clarification

It could be observed that the liquor produced with the thermal treatment of the fruit had a higher total phenolic content, and that its extraction was better at a maceration time of 30 days. Based on those results, jambolan liquors were prepared in a maceration period of 30 days, in brandy, after a thermal treatment of the fruit, at 60 °C for 10 minutes, and submitted to a clarification study.

3.2.5. Physical-chemical parameters

The liquors were submitted to three clarification experiments and a control: 1. the control (without treatment); 2. liquor clarified with the bonding agent bentonite; 3. liquor clarified with sedimentation followed by filtration in a cotton sieve; and 4. liquor clarified with sedimentation followed by vacuum filtration. The values for the physical-chemical parameters, pH, TSS and TA, of the clarified liquors are shown in Table 2. It was not possible to find similar studies of liquor clarification to compare with the results obtained by this work. However, it reinforces its importance.

Table 2: Total soluble solids, pH and titratable acidity of the extract, the crude liquor (CL), the liquor clarified with bentonite (BL), and the liquor clarified by sedimentation followed by filtration in cotton sieve (CS) and vacuum filtration (VF).

Treatment	pH	TA	TSS (°Brix)
Extract	4.31 ± 0.01	2.29 ± 0.02 [a]	12.00 ± 0.00
CL	4.20 ± 0.01	1.83 ± 0.05 [b]	31.00 ± 0.00
BL	4.26 ± 0.02	1.83 ± 0.02 [b]	31.00 ± 0.00
CS	4.15 ± 0.01	1.87 ± 0.02 [b]	31.00 ± 0.00
VF	4.15 ± 0.01	1.88 ± 0.02 [b]	31.00 ± 0.00

Values with the same letter do not differ statistically by the Tukey test at 5% significance.

Through the results obtained, it was possible to observe that the pH values for all the treatments varied from 4.15 to 4.26, being the lowest for those clarified by sedimentation. However, it was not possible to distinguish a significant difference between the values since they did not present a normal distribution. The slight difference observed in the pH value can be attributed to the retention properties of the different clarification methods used. It can also be observed that, even without passing for a clarification process, the control liquor presented a smaller pH value than the extract because of the dilution promoted by the addition of the syrup. Furthermore, the lower pH values for clarification with sedimentation followed by filtration on a cotton sieve or vacuum filtration are probably due to the removal of insoluble solids, especially pectin, by those filtration methods [43].

As bentonite is a mineral characterized by the presence of thin particles with high surface areas and charges, elevated cation exchange capacity, and swelling in the presence of water, it is widely used in clarification processes based on adsorption, acting by adsorbing the positive charges of the particles in suspension [44], which explains the highest pH value of the liquor clarified with bentonite.

The titratable acidity for all the liquors evaluated were similar, with no significant difference among them, varying between 1.83 and 1.88 g·100 mL^{-1}, with the results obtained for the control and clarified by adding bentonite being the lowest, followed by sedimentation plus cotton sieve filtration, and sedimentation plus vacuum filtration. As the liquor acidity depends on the fruit used, as well as on the method of flavouring compound extraction, and considering that the same fruit and infusion process was used, the results obtained were expected.

As the TSS corresponds to the soluble solid as sugars, salts, proteins, acids, etc., in a water solution, and as the clarification methods used did not interfere in this constitution, they remained constant for all the liquors evaluated and above the minimum determined by the Brazil regulation for this kind of beverage, which is 30 g·L^{-1} [12, 45].

3.2.6. Liquor colour and turbidity

The clarification process corresponds to the removal of suspended insoluble particles, such as cellular fragments from the pulp, pectin, starch, or other solids not completely dissolved, from the beverage [46]. They affect the turbidity and colour of the liquor and depend on the physical-chemical characteristics of the fruit used, which causes different degrees of natural haze on their juices. Table 3 shows the results obtained for turbidity after the clarification methods evaluated.

The transmittance values showed that the turbidity of the liquors clarified by all the methods evaluated did not differ statistically among them; for the same reason explained for the pH values found, the small data variation led to a distribution out of the statistical normality, with values varying between 73.63 ± 0.11 and 78.93 ± 0.06. However, it can be noticed that the liquor clarified using bentonite as a bonding agent presented the highest transmittance and thus the lowest turbidity among them.

According to [47], the colour tonality is related to how luminous or bright the sample is, varying from 0 to 100, with those with the highest values presenting brighter colours. Taking this into account, and the fact that the results did not present a statistical normal distribution, even with the liquor clarified by the use of bentonite presenting the highest tonality (2.92 ± 0.05), this value is not much superior to that found for the darkest one, which was 1.81 (± 0.07), which is enough to affirm that they are the brightest among the liquor evaluated but does not have a high significance for the quality parameter.

The colour intensity varied from 1.12 ± 0.05 to 1.32 ± 0.10, with the control presenting the higher value for this parameter. Considering the clarified liquor, they did not differ significantly among them, with the liquor clarified with bentonite having the same intensity as the control, which could be related to the surficial charges of the bentonite, and its interaction with the suspended particles. The predominant colour was yellow, followed by red and blue, for all the clarified liquors evaluated. Furthermore, the control and the liquors clarified by sedimentation presented a similar percentage value for all the colours, yet the liquor clarified by adding bentonite presented a predominance of the yellow colour when compared to the others.

Table 3: Turbidity and colour of the crude liquor (CL), the liquor clarified with bentonite (BL), and the liquor clarified by sedimentation followed by filtration in cotton sieve (CS) and vacuum filtration (VF).

	Colour					Turbidity
Treatment	**Intensity**	**Tonality**	**% Yellow**	**% Red**	**% Blue**	**% T**
CL	1.32 ± 0.10 [a]	1.81 ± 0.07	55.51 ± 1.62	30.72 ± 0.27	13.77 ± 1.35 [a]	73.63 ± 0.11
BL	1.22 ± 0.05 [ab]	2.92 ± 0.05	67.95 ± 0.55	23.25 ± 0.23	8.80 ± 0.32 [b]	78.93 ± 0.06
CS	1.15 ± 0.03 [b]	1.91 ± 0.01	57.92 ± 0.16	30.27 ± 0.05	11.81 ± 0.12 [c]	75.73 ± 0.11
VF	1.12 ± 0.05 [b]	1.91 ± 0.01	57.99 ± 0.26	30.43 ± 0.09	11.58 ± 0.19 [c]	74.73 ± 0.11

Values with the same letter do not differ statistically by the Tukey test at 5% significance.

Jambolan is a fruit characterized by its composition of bioactive compounds, especially anthocyanins, as verified by Santos et al. [48] in their work, which allowed the identification of six different anthocyanins in this fruit: delphinidin 3,5-diglucoside/digalactoside (Del3,5D (1) and Del3,5D (2)), petunidin 3,5-diglucoside/digalactoside (Pet3,5D (1) and Pet3,5D (2)), malvidin 3,5-diglucoside (Mal3,5D) and petunidin 3-glucoside (Pet3G). They are responsible for the colours of the fruits, flowers, and leaves, varying between the tones of red and blue, according to the environment in which they are grown. Among the clarification methods applied for the jambolan liquors, the percentage of blue was higher in the control. According to Lopes et al. [41], under acidic conditions, anthocyanins present a red colour; however, the predominance of the yellow colour is related to their stability since anthocyanins can be degraded due to factors such as pH value, temperature, presence of solvents, oxygen, light and enzymes [49].

Considering this, the processing of jambolan to obtain its liquor could cause an increase in the percentage of yellow colour and a reduction of the red and blue colour due to the thermal treatment applied, which can be corroborated by Schiozer & Barata [49], who reported in their work that the rate of degradation of anthocyanins increases during handling and storage due to the increase in temperature.

In their work, the temperature was greater than 25 °C, which may have contributed as the main factor to the prevalence of the yellow colour, since in that condition, the degradation of anthocyanins is higher [41]. Chemical modifications, such as the synthesis of 3-deoxyanthocyanins, can also be conducted to increase their stability; however, it also modifies the anthocyanins from red to yellow [49]. In addition, at pH values between 4 and 5.5, carbinol, which has no colour, and chalcone, which is yellowish, are predominant.

The results have shown the existence of a relation between tonality and turbidity, especially for clarification with bentonite, which was the clearest liquor produced and the one with the lowest turbidity.

3.2.7. Gallic acid composition

As shown in Figure 4, the control treatment, which consisted of vacuum filtration just after the addition of the syrup to the jambolan infusion, led to a higher gallic acid concentration, which could be explained by its removal caused by dragging or coagulation together with other particles in suspension or even by some undesirable reaction, that may have occurred during the clarification time with other compounds.

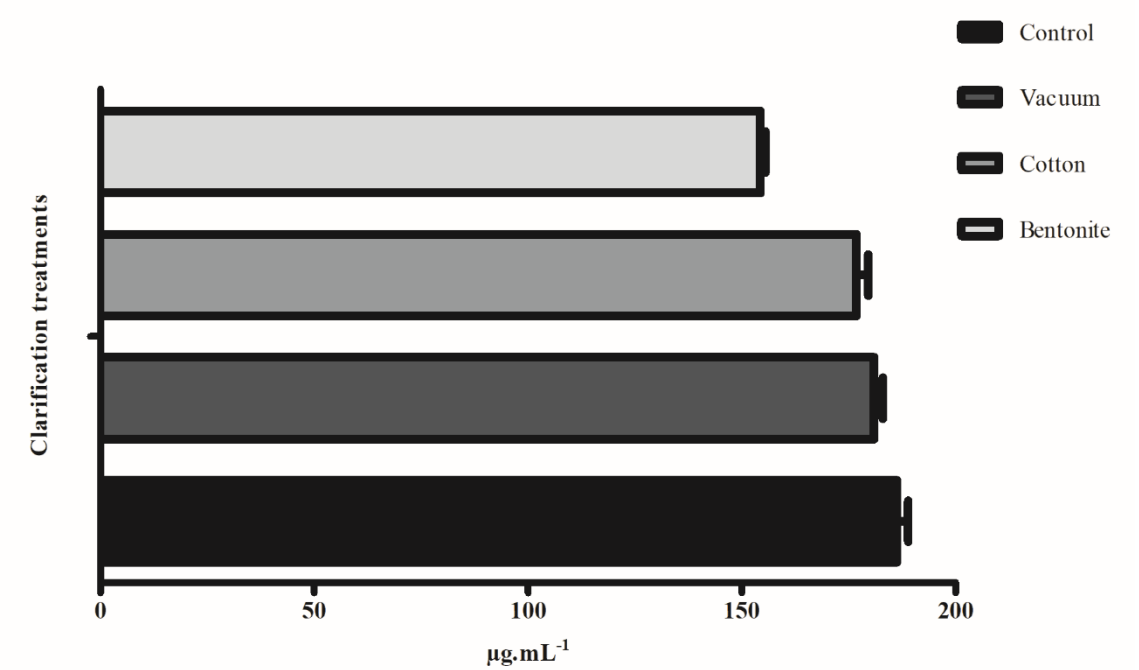

Figure 4: Gallic acid concentration of the clarified liquors.

The results indicate that the phenolic content varies with the clarification method used, as could be observed for the gallic acid content, the target molecule chosen, which presented the lowest level in the clarification using bentonite. This can be explained by the fact that, in addition to attracting proteins, other compounds with a positive charge, such as anthocyanins, phenolic compounds and nitrogen compounds, can also be attracted by bentonite [44].

IV. CONCLUSIONS

The thermal treatment improved the phenolic compound extraction from the jambolan; the physical-chemical parameters were independent of the clarification method used, with expected levels for the liquor. The use of bentonite at the clarification step produced a brighter jambolan liquor; however, the phenolic compound content, a remarkable characteristic of this fruit, and desired for the final product, was higher when sedimentation followed by filtration in cotton sieves was used as a clarification method, producing a higher-quality product.

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