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Bioethanol production with different dosages of the commercial Acrylamide polymer compared to a Bioextract in clarifying sugarcane juice

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ABSTRACT

One of the most important steps is to clarify the juice, which are added synthetic polymer acrylamide base, aiming the fast settling of impurities present in the juice. However, this input is expensive and may have carcinogenic and neurotoxic actions to humans. The search for new natural flocculants that have similarity with the commercial product is of great value. A bioextract that may be promising and has coagulant action is the *Moringa oleifera* Lam. In this context, the objective of the research was to evaluate the consequences of the use of moringa seed extracts and various concentrations of commercial polymer, such as sedimentation aids in clarifying sugarcane juice in the ethanol production, comparing the efficiency of the bioextract moringa. In the treatment of the juice, excessive addition of flocculants can result in reduction of sugars. The bioflocculant moringa was similar in technological features and the fermentative viability compared to usual dose of commercial polymer in Brazil. The fermentation efficiency was also higher for this flocculant, followed by moringa extract. The results obtained in this research indicate potential to the moringa bioextract, particularly in countries where the doses of flocculants are higher than 5 $mg.L^{-1}$.

Key words: Biofuels, Biopolymers, Juice treatment, *Moringa oleifera* Lam.

INTRODUCTION

The production of sugarcane in Brazil is growing, the projection of the harvest 2016/2017 indicates a grinding about 630 million tons, an increase of 18.66 million over the total processed in the current season (2015/2016), which totaled 617 million tons (UNICA 2016).

This increase mainly results from grinding the expected greater ethanol productivity, whose importance has increased in recent years, as a renewable fuel less polluting than oil products and relatively low cost (UNICA 2016).

These attributes were taken into consideration when Brazil, signed the agreement of the 21^{th} Conference of Parties to the United Nations Convention on Climate Change, which set a goal of 10 billion gallons of ethanol by 2025, thus reducing 37% of greenhouse's gases. However, to achieve this mark will be necessary to advance in cane crushing, find complementary biomass and ensure

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the improvement of the production process of the first generation ethanol (ABBI 2016).

With such a growth forecast, an essential step and costly for the industry is the treatment of the juice, in order to remove inhibiting compounds of the yeast to produce ethanol. Today this process is carried out with addition of synthetic polyelectrolytes (polymers) which has in its acrylamides constitution, this compound may exhibit neurotoxic and carcinogenic actions to human. Studies report that there is no tolerable intake, but this should be as low as possible, with an average intake of 1 mg.kg^{-1} (0.001 ppm) portion per day, to 4 mg.kg^{-1} (0.004 ppm) portion per day JECFA, FAO, OMS 2011). Since the yeast in the fermentation process is often recycled and its surplus is used for manufacturing some food and even animal feed (Girotto et al. 2015, Mendes 2016). However, it is important to point that studies or reports that identify this compound in the yeast or mud from the settling process are not found in the literature.

However, this is not the only crucial point, as already mentioned the cost of this product is US $ 6.00 / L, for which it uses 1.5 ml.L^{-1}, totaling approximately US$ 9,000.00 a ton. This dosage is used in Brazil, but in Canada this value can reach 20 ml.L^{-1}. Rein 2012, quote that more than 5 mg.L^{-1} of polymer could be agent of dispersant and it would not be useful for coagulation.

From this perspective, seeking to obtain results through quality gains, natural products are presented as an important alternative that will enable the production process.

Among natural products, extracted plants are highlighted, such as *Moringa oleifera* Lam. seed, which is widely used as flocculants in water treatment for human consumption (Egbuikwem and Sangodoyin 2013).

In addition, the *Moringa oleifera* can be produced on site that will be used since it is an easily adaptable plant and fast growing in the first year, the plant can now reach 4 meters high, with flowers and fruits becoming a safe and inexpensive alternative (Awad et al. 2013).

The composition of your protein is a 2S albumin, which is the storage of seeds, the main sources of carbon and nitrogen and are involved in plant defense. These properties make moringa seeds with flocculant potential and widely used in water treatment. It is also interesting to note the possible development of antifungal drugs and transgenic crops. Recent studies have shown that Moringa seed is composed of two alpha-helical chains stabilized by four disulfide bridges, which makes it stable and resistant to pH changes and temperature to 98 °C (Ullah et al. 2015).

This temperature is extremely important for the treatment of sugarcane juice, since this is heated to 105 °C, and then added flocculants, demonstrating the potential of moringa seeds.

This requires studies to prove the similarity of moringa extract with commercial polymer, aiming the treatment of sugar cane juice, with lower costs and without the presence of acrylamide molecules.

MATERIALS AND METHODS

INSTALLATION AND CONDUCTION OF THE EXPERIMENT

The experiment was conducted at the Laboratory of Sugar and Alcohol Technology and Fermentation Microbiology - FCAV/UNESP, Jaboticabal-SP campus, in the 2015/2016 harvest. Colms from the CTC5 sugarcane variety were used.

The stems were harvested in the month of June, in their useful period of industrialization, with approximately 14 months of cultivation, due to the fact that the variety used was precocious and and without previous burns of the straw. Moringa seeds and leaves were obtained from an adult plant cultivated in the Horto Florestal at FCAV / UNESP.

The commercial synthetic flocculant used was Kemtalo Sep A3XL (Powdered Anionic Polymers), widely used in the power plant of Brazilian midwest.

The broth remained in the laboratory decanter for 20 minutes.

The dosages of the flocculant were:

- 1.5 mg.L^{-1} of the commercial synthetic flocculant, Kemtalo Sep A3XL;
- 5 mg.L^{-1} of commercial synthetic flocculant, Kemtalo Sep A3XL;
- 10 mg.L^{-1} of commercial synthetic flocculant, Kemtalo Sep A3XL;
- 20 mg.L^{-1} of commercial synthetic flocculant, Kemtalo Sep A3XL;
- 13 mg.L^{-1} of seed extract *Moringa oleifera* Lam (Costa et al. 2016).

PREPARATION OF BIOEXTRACT COAGULANT OF *Moringa oleifera* LAMARCK

The moringa seeds were collected between May and July 2016. Then, the seeds were placed in a greenhouse at 55 ºC for 12 hours, peeled and macerated manually in a porcelain dish.

For the extraction of the active principle of the seed, 1 gram of seed was added to 100 gram of 1 mol.L^{-1} CaCl solution and water. The mixture was stirred for 10 minutes followed by vacuum filtration using qualitative filter paper for the retention of coarse insoluble particles (Okuda et al 2001).

OBTAINING CLARIFIED JUICE

The juice was obtained by milling. The Brix was adjusted to 16 ° and then subjected to a simple calcination process with pH up to 6.0 and then heating to boiling, adding the flocculation auxiliaries in the decanter prior to the addition of the heated juice.

CHARACTERIZATION OF CLARIFIED JUICE

The clarified calculations were submitted to analyzes of Brix, Pol, Purity, pH, Total Acidity, Turbidity, Total Ash (CTC 2011) and Total Phenolic Compounds (Folin and Ciocalteu 1927).

PREPARATION AND CHARACTERIZATION OF MUST

The clarified juice and molasses were standardized at Brix 16 ° and pH 4.5 by the addition of 10N sulfuric acid. Then, the Total Acidity and Total Reducing Sugars (TRS) (CTC 2011) were quantified.

FERMENTATION PROCESS

The must was standardized at 28-32 ºC and inoculated with *Saccharomyces cerevisiae* yeast at the concentration of 10^8 colony forming units. It should be noted that yeast presented cell viability greater than 85%.

They were fermented in 500 mL erlenmeyers, which were placed in a B.O.D. with controlled temperature of 30 ºC, where it remained until decreasing of the Brix to values below 1, or stabilization in half-hour period.

The must feeding was carried out in two stages, firstly 100 mL of must was added with the previously adapted yeast, and after 1 hour the volume was supplemented with a further 150 mL.

After 40 minutes of this second feed and at the end of the fermentation process, aliquots were determined to determine cell viability, budding index and viability sprouts (Lee et al. 1981).

At the end of the process, the fermented material was centrifuged at 2500g / 30 ºC for separation of yeast and wine.

CHARACTERIZATION OF WINE

The wine was submitted to Brix, Total Residual Reduction Sugars (TRRS), pH, Total Acidity (CTC 2011), glycerol (CTC 2011) and alcohol content analysis (reading in Digital Densimeter Antoon-Paar DMA 500).

EXPERIMENTAL DESIGN AND DATA ANALYSIS

To characterize the results obtained, a randomized block design was used, with 4 replicates. The main treatments consisted of clarified juice with 1 commercial flocculant with 4 different concentrations (Commercial Synthetic Polyelectrolyte) and a Bioextract of Moringa Seeds, in addition to Control treatment (in which no flocculant was added).

The results were submitted to analysis of variance by the F test, and the means obtained were compared according to the Tukey test (5%), using the program Assistat version 7.7 beta.

RESULTS AND DISCUSSION

QUALITY OF RAW MATERIAL

Table I presents the average results obtained for the technological characteristics of the juice extracted from the CTC5 sugarcane variety. Table I shows the analyzes performed for Brix, pH, Pol, Purity and TRS (Total Reducing Sugar), indicating that the sugarcane was within the quality parameters established by the industry, being in the order of 5.0 to 5.5 for H_2SO_4 for acidity (Ripoli and Ripoli 2009), Pol ≥ 14% (Amorim 2006), Purity ≥ 85% (Amorim 2006) and TRS ≥ 15% (Amorim 2006), except the acidity which was slightly above ≤ 0.80 g. L^{-1} H_2SO_4, but this is not a parameter that should be analyzed in isolation.

The Soluble Ash content (Table I) was 0.82% higher than that reported in the literature of 0.2 to 0.7% (Delgado and Cesar 1977), this high content may be associated with supplementation of the soil with vinasse, since such an analysis may be indicative of the presence of potassium and calcium in the extracted juice. However, this is a problem for sugar and not to ethanol production, because potassium and calcium can be used as nutrient in the fermentative process (Yang et al. 2016).

Another characteristic determined was Turbidity (Table I), this analysis determines exactly the suspended particles contained in the juice. The stem was harvested in an integral way, what means, with the impurities that were present in the soil, and the value obtained was 1089 NTU. The clarification process interferes directly in this technological parameter, because after the juice treatment these particles should be removed as much as possible to avoid interfering in the fermentation process.

As for the Reducing Sugars (RS) presented in Table I, they were within the established ≤ 0.8% (Amorim 2006). To maintain plant physiology, there must be the inversion of the sucrose molecule in glucose and levulose (Ripoli and Ripoli 2009). The lower these sugars, the higher will be the metabolic activity of the plant and the greater will be the conversion of these sugars.

Phenolic compounds are biomolecules synthesized by plants, mainly through the acetate pathways. They are one of the most widespread classes of secondary metabolites, being known for their great importance in the soil-plant system. In general, they can be related to metabolic stress, but they are interfering in the alcoholic fermentation, the extracted juice presented values of 406.7 mg.L^{-1}. An efficient fermentative process requires values close to 400 mg.L^{-1}, indicating that the phenolic compounds in the juice was close to the expected one (Costa et al. 2014a, Novoa et al. 2006).

CHARACTERIZATION OF CLARIFIED JUICE

The evaluation of the chemical-technological characteristics (Brix, pH, Pol, Purity, TRS Acidity, Ashes, Turbidity and Phenolic Compounds) of the clarified juice, aimed to know the effect of the treatments on the process of clarification of the juice and the reflexes on the quality of the juice produced, for industrial processing, for ethanol production. These are presented in Tables II and III.

TABLE I
Average values obtained for Brix, pH, Acidity, Pol, Purity, TRS, Ash, Turbidity, RS and Phenolic Compounds of extracted juice. Jaboticabal-SP. 2015/2016 crop year.

Brix	pH	Acidity g/L H_2SO_4	Pol (%)	Purity (%)	TRS (%)	Ash (%)	Turbidity (NTU)	RS (%)	Phenolic ($mg.L^{-1}$)
20.2	5.1	0.89	18.20	90.09	19.32	0.82	1089	0.69	406.7

TABLE II
Mean values obtained for Brix, pH, Pol, Purity and TRS of the clarified juice with 5 different sedimentation aids, from CTC5 sugarcane variet. Jaboticabal-SP. 2015/2016 crop year.

Treatments	Brix	pH	Pol(%)	Purity(%)	TRS (%)
Flocculant (F)	468.0**	6.8**	0.53ns	2.52ns	52.26**
Control	15.72e	5.9a	14.13a	82.59a	13.43ab
Polimer 1.5	16.50b	5.9a	14.47a	85.23a	13.85a
Polimer 5.0	16.30c	5.9a	14.57a	85.77a	12.57b
Polimer 10	16.20d	5.9a	14.43a	85.62a	10.12c
Polimer 20	16.20d	5.9a	14.37a	85.30a	10.49c
Moringa Extract	16.65a	5.7b	14.29a	85.22a	14.54a
DMS	0.06	0.08	0.95	3.49	1.15
CV	0.18	0.66	2.88	1.80	4.03

The averages followed by the same letter do not differ statistically from each other (Tukey test 5%). The letters compare averages in the column. ** significant at the 1% probability level ($p <0.1$) * significant at the 5% probability level ($0.1 = <p <0.5$). DMS - Significant Deviation. CV - Coefficient of Variation.

For the Brix of the clarified juice (Table II), significant differences between treatments were observed, although the values were very close, the lowest value was for the control treatment. It should be noted that the values detected are lower than the extracted juice because prior to the juice clarification process, standardization was done for 16º Brix for all treatments, but it can be concluded that the use of a treatment in juice, independent of the used flocculant, conserves more sugars than its non-use.

There has also been standardized pH (Table II), adjusted to 6.0, with the purpose of conserving nutrients which will be available in the fermentation process for yeasts. The values in this parameter had a significant difference, where the lowest value treatment was the moringa extract, reducing only 5%, but this fact is already expected since there were reactions of ions drag between the calcium molecules and the phosphate of the juice. This reduction can be considered insignificant by keeping nutrients available.

For Pol and Purity (Table II) no significant difference was observed, all were above the values expected by the industry, except for the purity of the control that was 2.83% below the recommended value (Amorim 2006).

In the technological parameter TRS (Table II), it was observed that there were considerable reductions when the dosages of 10 and 20 $mg.L^{-1}$ were used, being 30% and 27.85% respectively, this drop can cause lower fermentation yields, when uses the polymers, these accelerate the process of drag of impurities, however, the high amount of this flocculant may have caused the drag of sugars as well.

Evaluating the acidity levels (Table III), it was observed reduction in all treatments, such removal is a result of treatment juice by liming, which adsorbs acid molecules and drag to the bottom of the decanter along with the calcium phosphates formed through the reactions between the added lime milk and the phosphates present in the raw material (Albuquerque 2011).

The ash contents (Table III) showed reductions in all treatments, and the control removed low contents of the order of 3.65% in relation to the extracted juice, followed by the seed extract with 13.41%, the polymer with dosage of 1.5 ml.L^{-1}, with 24.31% and the other three treatments the reduction was approximately 32%, these values are close to another author when evaluated ash reduction with treatment of polymer, with reductions of 37%. Another studies verified that the presence of ash did not reduce the efficiency of the fermentation process (Huang et al. 2017, Martins et al. 2016).

Comparing the effects of flocculants on turbidity (Table III), it was found that the use of the polymer with higher dosage resulted in a juice more translucent than the other treatments, achieving a removal rate of 62%. The moringa extract removed approximately 43%, being close to the other dosages. Turbidity removal is one of the main parameters for the clarification ability, as the higher turbidity is due to the presence of non-sugars in the juice, and the reduction of these sugars may indicate the removal of these components (gums, starch, protein) (Eggleston 2000, Freita et al. 2014). As for the phenolic compounds of the clarified juice (Table III), there were significant differences between the Control and the other treatments, where for this one, there was a smaller reduction being 15% and for the others approximately 35%. Other authors obtained results similar to those observed in this research, noting the removal of phenols by the simple chalking process with the addition of flocculants**.** Some authors mention that this physico-chemical process is unable to reduce the content of these molecules in the juice and others believe that such removal of total phenolic compounds is directly related to the raw material processed, which varies not only the content of these compounds but also the characteristics of each one (Ravaneli et al. 2011, Costa et al. 2014b).

CHARACTERISTICS AND FERMENTATION OF MUST

Table IV established the mean values obtained for Total Acidity and Total Reducing Sugars (TRS) of the must prepared from clarified juice with the use of different flocculants.

TABLE III
Mean values obtained for Acidity, Ash, Turbidity and Phenol of the juice clarified with 5 sedimentation aids. Jaboticabal-SP. 2015/2016 crop year.

Treatments	Acidity	Ash	Turbidity	Phenol
Flocculant (F)	**g/L H_2SO_4**	**%**	**NTU**	**mg/L**
Control	0.64bc	0.79a	876a	345a
Polimer 1.5	0.84a	0.62c	775a	287b
Polimer 5.0	0.75ab	0.58cd	823a	259b
Polimer 10	0.60c	0.57cd	763a	261b
Polimer 20	0.65bc	0.52d	413b	259b
Moringa Extract	0.81a	0.71b	615ab	295b
DMS	0.14	0.06	266.31	49.02
CV	8.75	4.23	16.31	7.50
F	10.23**	56.23**	8.57**	9.84**

The averages followed by the same letter do not differ statistically from each other (Tukey test 5%). The letters compare averages in the column. ** significant at the 1% probability level (p <0.1) * significant at the 5% probability level (0.1 = <p <0.5). DMS - Significant Deviation. CV - Coefficient of Variation.

Brix and pH were adjusted to 16 ± 1 and 4.5 ± 0.3 respectively, the reason for which there was no significant difference between these parameters and is not in the and are not presented in any table.

Analyzing the Total Acidity of the must, it was observed that there was no significant difference for the treatments, which all presented an increase, precisely due to the correction of the pH, which is made through the addition of acid.

For the TRS, it was observed that the treatments had a slight reduction in relation to the clarified juice, emphasizing that the treatments with 10 and 20 $mg.L^{-1}$ are what are with low sugar contents.

The initial viability represents the amount of live yeast cells (%), with Budding Index and Feasibility of the sprouts and adapted to compose the inoculum, yeast or foot of vat, destined to the accomplishment of the fermentative process. The results obtained are shown in Table V.

Considering that for ferments with high yields, the yeast must have cell viability greater than 85%, it was observed that the yeast used in this test met the recommendations stipulated by the sector, being 98% viable.

TABLE IV
Results for TRS and Total Acidity of the must obtained from clarified juice with 5 sedimentation aids. Jaboticabal-SP. 2015/2016 crop year.

Treatments	Acidity	TRS
Flocculant (F)	**g/L H_2SO_4**	**%**
Control	1.07a	13.12bc
Polimer 1.5	1.09a	13.68ab
Polimer 5.0	1.06a	12.40c
Polimer 10	1.04a	9.96d
Polimer 20	1.04a	10.35d
Moringa Extract	1.05a	14.45a
DMS	0.22	0.99
CV	23.22	3.52
F	0.25ns	69.78**

The averages followed by the same letter do not differ statistically from each other (Tukey test 5%). The letters compare averages in the column. ** significant at the 1% probability level (p <0.1) * significant at the 5% probability level (0.1 = <p <0.5). DMS - Significant Deviation. CV - Coefficient of Variation.

At the beginning of the fermentation process the lowest index was for the control treatment without addition of flocculants. The treatments with 10 $mg.L^{-1}$, 20 $mg.L^{-1}$ and moringa extract were the highest rates of initial viability. In this sense it was verified that all the treatments were in the recommended percentage.

Evaluating the Budding Index and Feasibility of the sprouts, It was observed that sprouting did not differ as the viability of shoots differed for the control treatment with a viability 10% lower than the others. It is important for the industrial process that is feasibility of the largest possible, which can be reused for many cycles of fermentation. At the end of the fermentation, the percentage of live cells, bud index and shoot viability were again quantified, to better evaluate the impacts of the must submitted to different flocculants and the fermentation on the yeast. These results are presented in Table V.

The results obtained for the viability of cells and shoots at the end of the fermentation process did not present a significant difference; for the final viability of the cells, the control group presented a 14.74% reduction to the other treatments, and it is a highlight for the treatment with moringa extract where the viability of shoots was superior to all other treatments.

When comparing the beginning of shoot viability with the end of the process, it was noticed that this parameter increased, this fact is due to the decrease in the amount of sugars present in the substrate as the yeast consumes it to perform its metabolic processes.

When this concentration reaches values lower than 6%, the yeasts metabolize sugars through their respiratory tract, which results in the production of ATP, glucose breakage in addition to new yeast cells (Venturini Filho et al. 2013).

TABLE V
Results obtained for Cell Viability, Budding and Feasibility of Sprouts at the beginning and at the end of the fermentative process of musts obtained from clarified juice with 5 sedimentation aids. Jaboticabal-SP. 2015/2016 crop year.

Treatments Flocculant (F)	Cell Viability Beginning	Cell Viability The end	Budding Beginning	Budding The end	Feasibility of Sprouts Beginning	Feasibility of Sprouts The end
	%					
Control	87.33d	84.82c	12.37d	25.45a	90.19b	84.83b
Polimer 1.5	95.92b	95.04ab	21.80a	25.74a	100a	96.77a
Polimer 5.0	92.73c	92.14b	18.30c	20.28a	97.06a	97.04a
Polimer 10	98.37a	94.34b	23.83a	24.57a	97.31a	96.33a
Polimer 20	98.16a	95.45ab	21.08a	25.23a	98.84a	97.83a
Moringa E.	97.94a	96.06a	20.65a	23.48a	100a	99.50a
DMS	1.44	3.33	0.06	11.81	6.08	4.31
CV	0.66	1.56	4.23	21.34	2.73	1.96
F	192.19**	39.52**	56.23**	0.63ns	7.66**	36.39**

The averages followed by the same letter do not differ statistically from each other (Tukey test 5%). The letters compare averages in the column. ** significant at the 1% probability level ($p < 0.1$) * significant at the 5% probability level ($0.1 = < p < 0.5$). DMS - Significant Deviation. CV - Coefficient of Variation.

CHARACTERIZATION OF WINE

Table VI shows the values obtained for pH, Total Acidity, TRRS and Glycerol of the wine resulting from the fermentation process.

The brix of all treatments were ≤ 1.0, evidencing that the fermentation had already been consumed. For the pH of the wines, it was observed that the sedimentation aids had a reduction. However, the lowest pH reduction was for the 20 $mg.L^{-1}$ polymer, however this is not an interferer of the process.

Evaluating the Total Reducing Residual Sugars (TRRS), it was observed that the control treatment had the highest percentage of the order of 0.1%, while the others had close values, in this parameter values lower than 0.2% were expected, which all treatments were below this value.

For the acidity the contents varied from 2.33 to 2.62 $mg.L^{-1}$, these results are close to those determined in another study that evaluated the Total Acidity of 12 fermentative cycles in an industrial unit, verified maximum levels of 2.2 $mg.L^{-1}$ (Mutton et al. 2012).

Glycerol is typically produced by yeasts with an inverse correlation with fermentative efficiency (Maiorella et al. 1983). In the present study the highest value was for the control, as expected, as soon as the juice had no treatment, with interferences in which it changes the metabolic route of the yeasts.

This fact is clearly observed in the alcoholic content and fermentative efficiency which, for the control, the alcohol content was 33% lower than the 1.5 $mg.L^{-1}$ polymer treatment, it is must mentioning that this content is the one used in Brazil by all the producing units and in spite of the treatment with moringa extract obtained values significantly close to this flocculant, similar fact occurred for fermentative efficiency. However, we must mention another study that evaluated the sedimentation velocity of the moringa extract in the same concentration used in this study, and obtained 0.3 $cm.min^{-1}$ and also 0.5 of coagulant activity, values lower than the polymer (Costa et al. 2016).

The treatments with higher polymer contents remained statistically close, but below 80%,

TABLE VI
Results for pH, Total Acidity, TRRS, Glycerol, Alcohol Content and Fermentation Efficiency of the wine resulting from the fermentation process using the most prepared from clarified juice with 5 sedimentation aids.

Treatments	pH	Total Acidity	TRRS	Glycerol	Alcohol Content	Fermentation Efficiency
Flocculant (F)		g/L H_2SO_4	(%)	(%)	(%)	(%)
Control	3.37b	2.62a	0.10a	0.13ª	4.96c	57.70d
Polimer 1.5	3.37b	2.25e	0.07b	0.09b	7.00a	87.02a
Polimer 5.0	3.57a	2.26de	0.06bc	0.08b	6.21ab	78.01bc
Polimer 10	3.45b	2.33cd	0.05c	0.08b	5.66bc	77.40c
Polimer 20	3.69a	2.45b	0.05c	0.10b	5.63bc	77.05c
Moringa Extract	3.35b	2.35c	0.07b	0.08b	6.83a	83.57ab
DMS	0.11	0.07	0.01	0.02	0.87	5.61
CV	1.46	1.44	11.49	13.27	6.27	3.18
F	18.75**	67.01**	23.85	7.65**	16.91**	69.15**

The averages followed by the same letter do not differ statistically from each other (Tukey test 5%). The letters compare averages in the column. ** significant at the 1% probability level (p <0.1) * significant at the 5% probability level (0.1 = <p <0.5). DMS - Significant Deviation. CV - Coefficient of Variation.

demonstrating that higher levels of flocculants did not improve the fermentation process.

CONCLUSIONS

In the treatment of the juice, the excessive addition of flocculants can lead to a decrease in sugars.

The moringa bioflocculant was similar in the technological characteristics and also in the fermentative viability compared to the usual commercial polymer dose in Brazil.

The alcohol content was greater for the treatment of flocculant polymer 1.5 mg.L^{-1}, but bioflocculant moringa had similar values.

The fermentative efficiency was also higher for this flocculant, followed by the moringa extract.

The results obtained in this research indicate potential to bioextract moringa, especially in countries where the doses of flocculants are greater than 5 mg.L^{-1}.

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