



Standardization of Pasteurized Sugarcane Juice

Ivana Morais Geremias de Andrade; Isabele Valichelli Matos; Ana Cláudia Rocheto;
Natali Knorr Valadão; Rodrigo Rodrigues Petrus*

Department of Food Engineering
College of Animal Science and Food Engineering
University of São Paulo/SP – Brazil
*Corresponding Author's Email: rpetrus@usp.br

Abstract – This study targeted the standardization of sugarcane juice based on the identification of the ratio (soluble solids/titratable acidity) of greater sensory acceptance. For this purpose a rotational central composite design with eleven treatments was used. The formulations (treatments), prepared with pasteurized sugarcane juice, were submitted to nine-point hedonic scale tests to assess the overall impression, at a temperature of about 12 °C, by a team of 52 panelists. The independent variables were the total soluble solids (SS), in the range between 13.1 and 25.9 °Brix, and titratable acidity (TA), between 0.02 and 0.09 g citric acid /100 mL of juice. The dependent variable was the average scores assigned to the overall impression for each of the eleven formulations. The average scores of the hedonic scale tests ranged from 6 (“like slightly”) to 7 (“like moderately”). The Tukey test showed no significant difference ($p > 0.05$) among the means of the formulations. Applying the model of hierarchical classification for statistical analysis, the effects of TA and SS content within TA were tested. It was found that only TA effect was significant ($p < 0.05$) for juice's acceptance. The statistical comparison among the levels of TA revealed that only 0.055% level was significantly different from the others. The 19.5 °Brix and TA 0.09% formulation was considered the best one, with a pH near 3.9. It was concluded that all formulations of sugarcane juice were well accepted by the team of panelists in a wide range of SS and TA.

Keywords – Factorial Design, Processing, Sugarcane Juice, Ratio, Aseptic Filling.

I. INTRODUCTION

The sugarcane, genus *Saccharum*, is a raw material of great versatility and economic feasibility. Its successful production is justified by the easy adaptation to Brazilian climate and soil while it is cultivated in much of the national territory [14]. This raw material is mainly composed of juice (composed of water, sugars, ash and nitrogen materials) and bagasse (consisting mainly of fibers) [2], [4] - [11].

Sugarcane juice is resulted of the sugarcane crushing in electric or manual grinders and is characterized as a drink of low acidity, with pH ranging between 5.0 and 5.5, high water activity (0.98-0.99), coloring in brown and dark green tones, variable composition depending on the variety, maturity stage, soil, climatic and agricultural conditions [6] - [11].

The market for cane juice for final consumption is part of the informal food sector and consists, mainly, by street vendors, often in precarious sanitary conditions [7]. On the other hand, its sale in kiosks located in coastal areas and shopping centers in Brazil is increasing [2]. However, this

practice has required the installation of mills in retail outlets, often poorly sanitized, the need for decontamination of sugarcane before grinding (procedure often omitted) and the generation of large volumes of waste (bagasse).

Moreover, the juice composition, especially the soluble solids content and yield obtained in the extraction are variable throughout the year, highlighting the need for standardization of juice ratio [2], [11] - [12]. The titratable acidity, soluble solids, reducing and total sugars, vitamin C and pH are important parameters for standardization of food products and to analyze changes during processing and storage of products of plant origin [10].

Some studies have been carried out aiming the preparation of sugarcane juice with fixed values of pH, soluble solids, titratable acidity and the content of acid fruit pulp [4] - [13].

In the study of [9], the authors produced three formulations of partially clarified-stabilized sugarcane juice, each formulation, added a fruit juice as follows: 5% of passion fruit juice, 10 % pineapple juice and 7.5% lemon juice. The formulations were standardized to pH 4 by addition of citric acid. Sensory analyses results indicated that the preferred mixture was that one formulated with 5% passion fruit juice, then the mixture containing 10% pineapple juice.

Despite of the popularity of sugarcane juice in some countries, the industrialization of this product is not well explored. The advantages provided by the industrialization of sugarcane juice refers to the possibility of providing a safe and high-quality drink at any time of the year, regardless of harvest time; the longer self-life, commercialization that extends to sites distant from the planting regions and smaller volume of transported raw material.

The present study targeted the preparation and sensory evaluation of eleven formulations of pasteurized sugarcane juice, prepared with different soluble solids and titratable acidity levels. For this purpose a central composite rotational design (CCRD) was used.

II. MATERIAL AND METHODS

Sugarcane Juice Extraction

The raw material (*Saccharum officinarum*, cultivar SP 3250) was donated by Tecnocana Tecnologia em Cana Ltda (Santa Cruz das Palmeiras/SP, Brazil). The sugarcane stalks were scraped and cleaned by immersion in chlorinated water containing 50 mg/L of free residual chlorine (FRC) at 25°C, for 30 minutes. Subsequently, the

juice was extracted by an electric mill that consisted of stainless steel cylinders, manufactured by MAQTRON (Joaçaba/SC, Brazil).

Fig. 1 illustrates the flowchart used in the processing of sugarcane juice that preceded the preparation of formulations.

Thermal Processing of Sugarcane Juice

The freshly extracted juice was pasteurized at 95 °C/30 s in an electric plate heat exchanger (Sumá, Campinas/SP, Brazil).

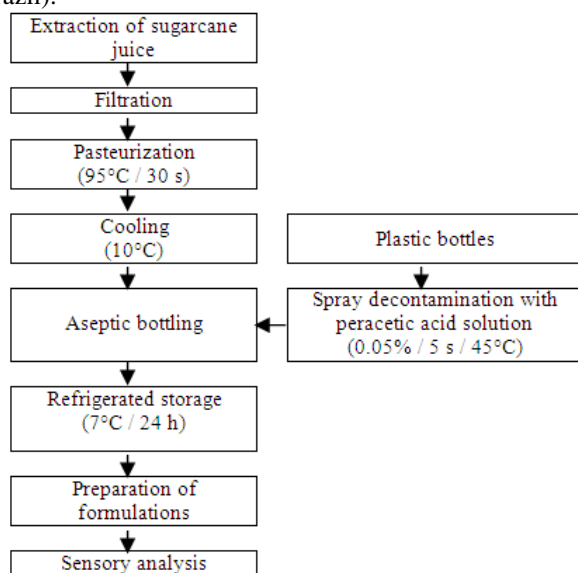


Fig.1. Flowchart of sugarcane juice processing for the preparation of formulations.

After thermal treatment, the juice was cooled at a temperature of about 10°C and aseptically bottled in 250 mL polyethylene terephthalate (PET) bottles, with polypropylene screw caps.

The bottles were decontaminated by spraying peracetic acid solution (PAA) (Thech Desinfecção, São Paulo/SP, Brazil) 0.05% (v/v) / 5 s / 45°C.

Bottling was performed using a gravimetric filler (Polienva-Movitron, São Paulo/SP, Brazil) in an unidirectional airflow cabin (ISO Class 5) (Veco do Brasil, Campinas/SP, Brazil).

The processed juice was stored at 7 ± 0.5°C for approximately 24 h, before being used for the preparation of the formulations.

Physico-Chemical Characterization of the Whole Pasteurized Sugarcane Juice

The physico-chemical tests were performed according to the methodology described by [1]. The pH values were measured using the pHmeter Analyser Model 300 M (Hanna Instruments, Romania). The soluble solids content was determined by the handset digital refractometer model AR200 (Reichert, Depew, USA). Titratable acidity was determined by quantifying the volume of 0.1 M NaOH required to raise the pH value to 8.3.

Microbiological Analysis of Pasteurized Sugarcane Juice

Aerobic mesophilic counts in the fresh and pasteurized juice were carried out in order to quantify the microbial

population before and after heat treatment according to the methods described in [8]. Additionally, coliforms at 45 °C and Salmonella tests were performed in pasteurized juice.

Standardization of Pasteurized Sugarcane Juice

In order to prepare and identify the more palatable formulation, a Central Composite Rotational Design (CCRD) with eleven treatments was performed, considering the titratable acidity TA (expressed as % citric acid) and soluble solids SS (expressed in °Brix) as the independent variables while sensory acceptance was the dependent variable. The TA levels were set between 0.02 and 0.09 g citric acid/100 mL of juice, and SS, between 13.1 and 25.9°Brix, according to Tables 1 and 2. Levels of AT and SS were established based on previous research, described in [15], who reported wide variation in soluble solids and titratable acidity for raw sugarcane juice.

Table 1: Coded and uncoded theoretical independent variables

Variable/Code	- α	-1	0	+1	+ α
Titratable acidity (% citric acid)	0.020	0.030	0.055	0.080	0.090
Soluble solids (° Brix)	13.1	15.0	19.5	24.0	25.9

(-α) lower axial point, (-1) lower level, (0) central point, (+1) higher level, (+α) higher axial point, α = 1.4142

Table 2: Matrix of the central composite design used to prepare the formulations of pasteurized sugarcane juice.

Formulation	Factors (independent variables)		Response (dependent variable)
	Titratable Acidity (% citric acid)	Soluble Solids (° Brix)	
01	(-1)	(-1)	Sensory acceptance (Mean score for overall impression)
02	(+1)	(-1)	
03	(-1)	(+1)	
04	(+1)	(+1)	
05	(0)	(0)	
06	(0)	(0)	
07	(0)	(0)	
08	(-α)	(0)	
09	(+α)	(0)	
10	(0)	(-α)	
11	(0)	(+α)	

The processed juice was divided into eleven parts for the preparation of pre-defined formulations. The masses of drinking water, sucrose and citric acid to be added were calculated by a mass balance.

Sensory Analysis

The sensory tests were applied according to the procedure described in [5]. Samples of pasteurized standardized sugarcane juice were submitted to the nine-point hedonic scale test for the overall impression evaluation. A team of 52 panelists, 22 years average age, expressed their overall impression about the eleven formulations. The samples were monadically served (about 40 mL) at a temperature of about 12°C, with a glass of water and evaluation form. The sensory analysis was divided into three sessions to avoid fatigue of panelists.

Statistical Analysis

To determine the best formulation of sugarcane juice, a statistical approach was taken by applying the model of hierarchical classification. Analyses were performed using the MIXED of SAS, considering the repeated measures of panelists. The results were statistically treated at 5% significance level using SAS 9.2 software.

III. RESULTS AND DISCUSSION

The mass of previously scraped sugarcane received was close to 73 kg and the volume of juice extracted was 35 L. The results obtained in the physico-chemical characterization of the pasteurized sugarcane juice can be seen in Table 3.

Table 3: Extraction Yield and physico-chemical characteristics of whole sugarcane juice freshly pasteurized.

Yield ¹ (%)	48
pH	5.32
Soluble solids (°Brix)	18.4
Titrateable Acidity (% w/v citric acid)	0.05

¹by mass of scraped raw material.

The aerobic mesophilic counts in whole fresh juice was 4.0×10^4 CFU/mL while the mesophilic and psychrotrophic microorganisms counts for refrigerated pasteurized juice were less than 1.0 CFU/mL.

Table 4 shows the mass of added components to each formulation, as calculated by the mass balance.

Table 5 shows the matrix of CCRD with the actual values of the dependent variables as well as ratios and mean scores obtained in the sensory tests. Bold values highlight the highest and lowest means obtained in assessing the overall acceptability. Mean scores for overall impression ranged from 6 (“like slightly”) and 7 (“like moderately”).

Reference [7] applied a factorial design to assess the sensory acceptance of hot filled sugarcane juice, with varying pH (3.6 and 5.3) and soluble solids content (12.2 and 17.8°Brix). The best score for sensory acceptance was observed for pH above 4.0 and soluble solids above 15°Brix.

In [4] the authors obtained averages close to 8 (“like very much”) for overall impression determined by a sensory acceptance test on a nine-point hedonic scale for sugarcane juice pasteurized at 90°C / 5 min, with pH adjustment (addition of citric acid) to 4.3; soluble solids equivalent to 21.2°Brix and titrateable acidity 0.63%.

The statistical comparison among the mean scores for overall impression (Table 5) showed that they did not differ statistically ($p < 0.05$), despite the wide range of SS and TA studied.

In order to determine the best formulation of sugarcane juice, the hierarchical classification model was used. For this purpose the effects of TA as the main factor grouping was considered. Thus, the effects (levels) of the SS content were considered as subgrouping factor, i.e., the SS content was within the TA.

Table 4: Mass M (Kg) of components used to prepare the formulations of sugarcane juice.

Formulation	M _{juice}	M _{water}	M _{citric acid} (10 ⁻⁴ Kg)	M _{sucrose}
01	1.785	0.400	0.362	0
02	1.802	0.408	5.259	0
03	1.505	0.010	0.000	0.116
04	1.807	0	6.708	0.133
05	1.801	0	3.100	0.029
06	1.802	0	2.121	0.025
07	1.802	0	2.126	0.025
08	1.638	0.029	0.000	0.025
09	1.795	0.000	5.517	0.025
10	1.794	0.726	0	0
11	1.818	0	1.511	0.184

Table 5: Actual values for the studied factors in the sugarcane juice standardization and sensory acceptance response.

Formulation	Factors (independent variables)		Ratio	Response ¹
	Titrateable Acidity (% citric acid)	Soluble Solids (° Brix)		
01	0.029 (-)	14.9 (-)	513.8	6.3 a
02	0.078 (+)	18.1 (-)	232.0	6.8 a
03	0.030 (-)	23.9 (+)	796.7	6.4 a
04	0.082 (+)	24.3 (+)	296.3	7.0 a
05	0.057 (0)	19.8 (0)	347.4	6.5 a
06	0.057 (0)	19.0 (0)	333.3	6.9 a
07	0.052 (0)	19.4 (0)	373.1	6.3 a
08	0.022 (-α)	19.6 (0)	890.9	6.3 a
09	0.084 (+α)	19.4 (0)	230.9	6.5 a
10	0.060 (0)	13.3 (-α)	221.7	6.0 a
11	0.054 (0)	25.7 (+α)	475.9	6.1 a

¹Mean scores for overall impression in nine-point hedonic scale tests. Means followed by the same letter do not differ at 5 % significance.

The panelist was also considered as a factor of variation. It is noteworthy that the choice of TA as a major grouping factor was arbitrary. The same consideration could have been made regarding the content of SS. Statistical tests were carried out using the MIXED of SAS, considering the repeated measures of panelists.

Table 6 shows the results of the analysis of hierarchical classification model considering the 572 scores (judgments) assigned for the overall impression of pasteurized standardized sugarcane juice, referring to eleven formulations.

Table 7 shows the analysis of variance (ANOVA) considering the sources of variation TA and SS within TA of the hierarchical classification model.

The ANOVA in Table 7 revealed that only TA source of variation was significant at $p < 0.05$. The source of variation SS within TA was not significant.

This statistical analysis revealed that the effect of the variation of soluble solids was not significant ($p > 0.05$) for the panelists in evaluating the overall impression of sugarcane juice with different ratios. To determine the best formulation of standardized sugarcane juice a statistical

comparison of different levels of TA (Table 1) was made (Table 8).

The results presented in Table 8 show that only the level 0 of TA (0.055%) differed from the other levels except from the level +1. In order to favor the enzymatic and microbiological stability of the sugarcane juice, the 0.09% TA level (pH near to 3.9) was chosen. Therefore, the formulation 9 (with 0.084% titratable acidity and 19.4°Brix) was considered the best one.

Table 6: Results of the analysis of hierarchical classification model for the formulation of pasteurized standardized sugarcane juice test.

Numbers of judgments	Average score for overall impression	Standard deviation	Coefficient of variation
572	6.5	1.6	25.5

Table 7: Analysis of variance.

Effect	Degrees of freedom	F value	p value > F
TA	4	3.01	0.0189*
TA (SS)	4	1.67	0.1610 ns

* significant (p value < 0.05). ns: not significant.

Table 8: Statistical comparison among different levels of titratable acidity.

Level	TA theoretical (% citric acid)	Average score (overall impression)	Standard error
-α	0.020	6.3 a	0.23
-1	0.030	6.4 a	0.16
0	0.055	6.2 b	0.12
+1	0.080	6.9 ab	0.16
+α	0,090	6.5 a	0.23

Means followed by the same letter are not different at 5% of significance.

IV. CONCLUSIONS

All sugarcane juice formulations achieved good acceptance among the panelists in a wide range of soluble solids and acidity titratable. The soluble solids content did not influence the sensory acceptability of the formulations. The formulation with 0.09% titratable acidity and 19.5°Brix soluble solids was presented as one that would best serve the aspects of juice stabilization due to its higher acidity (pH ~ 3.9).

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AUTHOR'S PROFILE

Rodrigo R. Petrus

was born in Mariana/MG, Brazil. He received his degree in Food Engineering in 1997 from Federal University of Viçosa/MG, his master degree in 2000, and PhD degree in 2004, in Food Technology from State University of Campinas/SP. Dr. Petrus is Assistant Professor since 2005 at Department of Food Engineering at University of São Paulo, in Pirassununga. His field of research concerns processing and shelf-life of liquid food products.