Analysis Of Factors Affecting The Level Of Sacrose In Manufacturing Sugarcane Panel (Saccharumofficinarum)

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Abstract: The objective of this article was to determine the factors that affect the% sucrose during the process of making sugar cane panela (Saccharumofficinarum). The sugarcane material used corresponded to variety V 78-1, harvested at the optimal time of maturity for the production of panela, using a fractional factorial design6-1, considering 32 observations, where the effect of 6 factors on the % sucrose: purity, investment time, cooling time, ° Brix, vacuum pressure and cooking temperature; applying the analysis of variance using the statistical program R. A significant effect ($p \leq 0.05$) of the purity and ° Brix factors was found, in addition to the interactions purity * ° Brix, inversion time * ° Brix and purity * pressure cooling vacuum; selecting the factors purity, investment time, ° Brix and vacuum pressure, as the predominant ones in the process of making panela from sugar cane. The application of the 2K-1 fractional factorial design allowed the selection of the factors purity, investment time, ° Brix and cooling vacuum pressure, from the total of factors initially addressed, which affect the% sucrose of sugar cane panela. sugar; In this way, it is proposed to consider these 4 factors when seeking to standardize the sucrose content in the final product and thus guarantee its quality, to reach higher value markets.

Index Terms: 2K-1 factorial design, controllable factors, interaction, sucrose, sugar cane panela.

1 INTRODUCTION

IN Venezuela, sugar cane (Saccharumofficinarum L.) is used as a raw material to obtain two main by-products such as raw or white sugar and panela. In this sense, panela represents a food product with a high carbohydrate content, also known as brown sugar and it differs by containing sucrose, glucose, fructose, minerals, vitamins, fats and protein compounds; which is obtained to a lesser extent in rural agroindustries through the evaporation of sugarcane juice by boiling; as described by García et al [1]. However, despite being processed in an artisanal way, there have been several studies in search of modernizing the production process to obtain panela, due to current trends in the consumption of high quality and healthy foods, as mentioned by Gutiérrez et al [2], who in turn highlight the relevance that panela deserves for providing levels of sucrose and minerals in amounts similar to those recommended for daily intake. For this reason, several authors have directed their efforts to study the factors that affect the quality of the final product, such as those carried out by García et al [1] and Vera et al [3], who demonstrated that sugarcane varieties for The production of panela exhibits yields and characteristics of juice composition, which are additionally affected by the production conditions and maturity of the cane at harvest time. This same study pointed out that operating conditions, such as pH, temperature and pressure, have a profound effect on the quality of the final product. Similarly, Prada [4], point out that the quality of the panela is affected by factors such as the presence of insoluble solids (impurities) and hardness. Other authors such as Jaffe [5] and Espitia et al [6] point out that another of the factors that influence the deterioration of panela are related to humidity, composition and environmental conditions; and as the moisture absorption increases, the panela softens, changes color, increases the reducing sugars and the sucrose content decreases; thus affecting the quality of the product. Consequently, food safety and organoleptic traits are the best criteria used by consumers to define the quality of sugar cane panela and despite being consumed as a drink, it is mostly marketed in blocks; For this reason, consumers will normally look for a product with a slightly sweet taste, a light brown color, and its typical aroma.In relation to the above and in order to determine the factors that affect the sucrose content during the sugarcane panela production process, a 26-1 fractional factorial design was applied and six (6) factors were evaluated on the% sucrose: purity, investment time, cooling time, cooking temperature and vacuum pressure; Given the importance that this has on the organoleptic characteristics and therefore on the quality of the final product.

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2 METHODOLOGY

This research was carried out in an artisanal agroindustry located on the "El Ángel" farm, specifically in the rural area of Mariara, Diego Ibarra Municipality, Carabobo state, Venezuela. The sugarcane material used corresponded to the V 78-1 variety, harvested at the optimum time of maturity for the production of panela. Through the application of brainstorming or "brainstorming", defined by García and Vanderslice [7] as a way to quickly obtain ideas regarding a topic; The factors evaluated in the process of elaboration of the panela based on sugar cane were identified, presented in Table 1. The response variable that was measured was the% sucrose present in the panela based on sugar cane, its determination was performed by the following calculation:

% Sucrose = Metric Refract Brix * Purity / 100

TABLE 2

ANALYSIS OF VARIANCE FOR % SUCROSE

Source	Df	SS	MS	F	P
Purity (A)	1	7,712	7,7126	11,49	0,0026 *
Investment time (B)	1	0,041	0,0413	0,06	0,8088 ns
Cooling time (C)	1	0,427	0,4279	0,64	0,4322 ns
°Brix (D)	1	8,394	8,3948	12,51	0,0019 *
Vacuum pressure (E)	1	0,487	0,4876	0,73	0,4021 ns
Cooking temperature (F)	1	0,346	0,3465	0,52	0,4784 ns
Purity* °Brix (A*D)	1	2,826	2,8263	4,21	0,0421 *
Investment time*°Brix (B*D)	1	3,747	3,747	5,58	0,0274 *
Purity*Vacuum pressure (A*E)	1	6,257	6,257	9,32	0,0038 *
Error	22	14,76	0,671		
		45,0			

2.1 2^{K-1} fractional factorial design

A 2^{6-1} fractional factorial design was used, where the effect of six (6) factors on the% sucrose was evaluated, this being one of the variables measured at the end of the process of making panelas based on sugarcane. The application of a 2^{6-1} fractional factorial design implied the use of the fraction ½, therefore, 32 combinations of the 64 possible combinations are required; To construct this fraction, a single design definition relationship was used, which was I = + ABCDE, obtained by selecting only the combinations of treatments that have a positive sign in the ABCDEF column, according to Lorenzen and Virgil [8].The treatment combinations of the 2^{6-1} design generated 31 degrees of freedom, which allowed estimating the main effects and first-order interactions. The resolution of the 2^{6-1} design is VI, which indicates that no main effect and first-order interaction are aliases of another main effect or first-order interaction, Montgomery [9], for the design used. the main effects are aliases of fourth-order interactions and the first-order interactions are aliases of third-order interactions, which allowed the restrictions regarding interactions that are insignificant to be low, allowing a good interpretation of the data.

3 RESULTS AND DISCUSSION

3.1 Interaction Purity (A) with degrees Brix (D)

Table 2 shows that the interaction purity (A) ° Brix (D) presented a significant effect (p≤ 0.05), establishing that the ° Brix are affected by the purity of the raw material and consequently simultaneously influence the sucrose content of the final product.

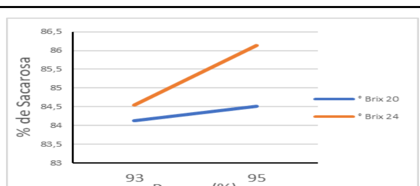

***Fig. 1**. Effect of the interaction between Purity (A)*

TABLE 1

FACTORS EVALUATED IN THE PROCESS OF MAKING PANELA BASED ON SUGARCANE.

Factor	Levels	Units
Purity (A)	93 y 95	%
Investment time (B)	25 y 60	Minutes
Cooling time (C)	16 y 18	Minutes
°Brix (D)	20 y 24	%
Vacuum pressure for cooling (E)	13 y 15	Hg
Cooking temperature(F)	123 y 124	°C

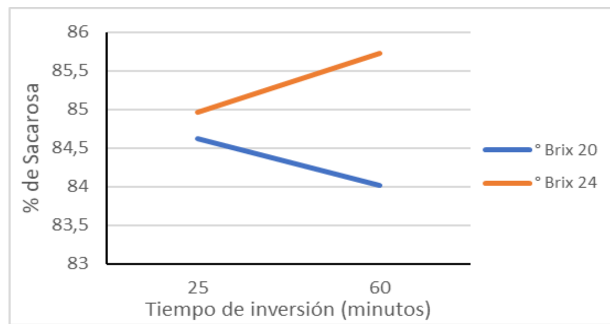

***Fig. 2**. Effect of the interaction between the Inversion time (B) and ° Brix (D) on % sucrose.*

The results obtained in the present investigation show the significant effects existing between some of the factors evaluated on the values of sucrose present in panela based on sugar cane.Figure 1 represents the probability graph of the residuals for the% Sucrose, observing a satisfactory behavior and fulfilling the assumption of normality, and random behavior of the data.In Figure 2 it is observed that when using the low level of 20 ° Brix, a decrease in the% sucrose is generated, as the investment time increases; on the contrary, with the high level of 24 ° Brix, the effect that sucrose levels generate in the inversion time is positive. With reference to the interaction between the investment time factors (B) and ° Brix (D); In the investigation carried out by Cárcamo [10] it was observed that there is indeed a relationship between the investment times used and the ° Brix presented by the raw material used; which significantly influences the production of sucrose. From this evidence, it is established that the best percentage of sucrose is obtained by using a raw material with a brix level of 24 and an inversion temperature of 60 minutes.

3.2Interaction of purity (A) with vacuum pressure on cooling (E)

Table 2 shows that the effect of these factors was significant (p≤0.05). Additionally, based on the information provided in Figure 3, it is established that when using the high level of vacuum pressure (15 hg), the effect it generates on the purity levels of the raw material is negligible, generating similar values of % sucrose; In contrast to this, when using the low value of vacuum pressure (13 hg) a positive effect is generated on the% sucrose, increasing as the level of purity of the raw material increases. Therefore, it is established that, to achieve the highest percentage of sucrose in the final product, a raw material with a purity level of 95% and a cooling vacuum pressure of 13 hg must be used. Regarding the interaction found between the purity factor with the vacuum pressure during cooling, no studies were found in which both factors were simultaneously evaluated; However, regarding the vacuum pressure Prada et al [11], determined that the sucrose values in the sugar cane panela showed differences when the vacuum pressure levels were varied; the same effect being reported by Quezada [12] who determined that the purity of the raw material significantly influences the% sucrose. Therefore, it is essential to take this information into consideration for future studies in the manufacturing process studied in this research.

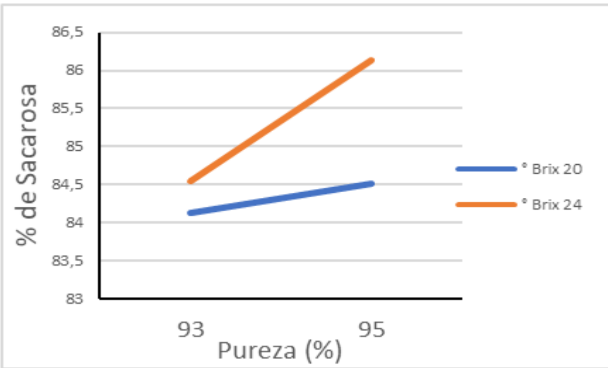

Fig. 3. *Effect of the interaction between Purity (A) and ° Brix (D) on% sucrose.*

In Table 2 it is observed that only the purity (A) and ° Brix (D) factors presented statistically significant differences ($p \leq 0.05$), so it is established that depending on the level that If these factors are used in the manufacturing process, this will be the% sucrose values that the final product will have. It is important to highlight that these two factors presented significance in their interaction, therefore, the use of raw material that has 95% purity and 24 ° Brix is recommended. For the rest of the evaluated factors, no statistically significant differences were observed between the levels studied for each factor, since the use of any of the two levels studied in the manufacturing process would generate the same% sucrose in the final product. At this point, it is important to highlight that despite the fact that the factors investment time (B) and vacuum pressure during cooling (E) did not show a significant effect, they were selected as factors that can influence in a certain way the% sucrose of the final product, due to its presence in two first order interactions that presented significant effect; being of vital importance when optimizing the process. Regarding the factors cooling time (C) and cooking temperature (F), the non-significance allows to establish the use of any of the two levels evaluated in the present investigation, leaving the choice of the level to use to a cost analysis. of the manufacturing process. In this sense, the information obtained in this research for the cooking temperature factor coincided with the results reported by Mujica et al [13], did not find significant differences when using different levels of cooking temperature, in the values of sucrose measured in the cane-based panela; Therefore, an economic analysis is recommended to decide which of the evaluated cooking temperatures should be used. Regarding the cooling time factor, the result obtained is corroborated with that obtained by Mosquera et al [14] determined that the average cooling time is over 17 minutes, with a range between 15 and 19 minutes respectively. The choice of the level of cooling time will depend on the cost-benefit ratio of the process.

4 Conclusions

The application of the 2K-1 fractional factorial design to determine the factors that affect the% sucrose during the sugarcane panela production process, allowed the selection of the factors purity, investment time, ° Brix and vacuum pressure cooling, of all the factors initially addressed.

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