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Influence of the variability of the operational parameters in obtaining cane syrup in sensorial attributes

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Abstract: Problems of variability in the design of equipment, the availability of equipment, the changes in the environment and in future changes which have been extensively investigated in order to determine the chances of success in environmental, technological and economic matters. This research considers the variability of the operational parameters in the quality of the final product, as an element in the process design, this approach is not an usual activity. Some previous studies on the production of sugarcane syrup were related to sensory attributes (viscosity, flavor and presence of crystals) with operational parameters (pH and °Brix).
It was generated the pH and °Brix using different probability distributions and the results were plotted by control charts. It was determined the influence of the variability of the °Brix in the sensorial acceptance of the final product.

Keywords: process design; quality control; uncertainly

1. Introduction

Uncertainty plays a very important role when it comes to whether or not a product meets certain specifications. For this, it must be verified whether the analytical result is within or without a "tolerance" or range of values defined in the specifications [2]. In this case, the first step will be the characterization of the probability distributions of the values of the variables and, the second is the study of the spread of uncertainties of the values of the variables, through the calculation process, using analytical methods (First-order Taylor series) or by numerical methods (Monte Carlo simulation)[5]. These models to optimization resulting will follow a stochastic system, which reflects the initial conditions plus the generated noise [6]. The Monte Carlo method is one of the many methods for the analysis of propagation of uncertainty, where the objective is to determine how a random variation in the amount of input or error affects the sensitivity, performance or reliability of the system being modeled [7].

The mathematical models proposed by [10] allow to-predict the viscosity, flavor and presence of crystals in cane syrup. These models correlate three pH levels (3.5, 4.0 y 4.5) y °Brix (74, 76 y 78) with the above quality attributes. The experimental data were obtained by sensory evaluation.

Six Sigma methodology is based on the normal distribution curve to know the level of variation of any activity. The drivers of this tool define Six Sigma as an applied quality methodology to offer a better product or service, faster and at lower cost, focusing its focus on the elimination of defects and customer satisfaction [14].

The sensorial evaluation of a goat milk yogurt with pineapple semi-fluid jelly, for which they used a hedonic scale of 5 points, (From 5: "I like it very much", going through 3: "I do not like or dislike me", Until 1: "I dislike much") was performed by [15].The sensorial analysis is one of the most important activities in the different stages of the process of manufacture of a product, development, maintenance, improvement and optimization, as well as the potential market evaluation [16] and is a scientific discipline that is used to measure, analyze, evoke and interpret reactions to some characteristics of food and materials, which are perceived by the senses of sight, smell, flavor, touch and hearing [17].

In the case of cane syrup, the viscosity, flavor, and possible presence of crystals, considered as defect, have a significant importance in the parameters of quality perceived by the consumer, at the same time as they identify and personalize the cane syrup. Determining these sensorial parameters could be subjective, so it is considered a certain degree of uncertainty. To calculate uncertainty with the approximation of ISO has the advantage that, as it has had to identify and quantify all sources of uncertainty of the analytical method, it can reduce the uncertainty of the results improve those parts of the method that contribute more to the final uncertainty of the result [19]. The objective of the present work was to determine the variability of the operating variables as an element of control of the organoleptic quality perceived by consumers.

2. Results and Discussion

The methodology was applied to the cane syrup processing process, and the following results: Were obtained: Reference was made to the publication of [10], which correlated the operational parameters °Brix and pH (coded values) with the response parameters viscosity, flavor and presence of crystals in sugarcane syrup.

The experiments performed by [10] were performed with the help of experimental design 3^2, taking as operational parameters the pH and concentration of sugars, In which obtained 3 mathematical models were for the response parameters as viscosity, flavor and presence of crystals that were measured by a sensorial analysis that is the emotional response of the consumer that is preceded by the cognitive evaluation that the user performs from what he perceives [16].

These models could be applied only using the encoding established by the author. With the experimental data reported we used the statistical tool RSM (response surface methodology). With the STATISTICA 8.0 program and with this statistical technique three statistical models were obtained (Table 1) for each of the response parameters mentioned above.

Tabla 1. Statistical models of response parameters - pH (X_1), °Brix (X_2) -

Response Parameters	Statistical Models
Viscosity	$-10806.86-37.56*X_1+0.33*X_1^2+287.14*X_2-1.90*X_2^2+0.45*X_1*X_2$
Flavor	$144.68+115.69*X_1-13.13*X_1^2-9.98*X_2+0.06*X_2^2-0.04*X_1*X_2$
Presence of crystal	$-4092.39+22.46*X_1-3.79*X_1^2+108.38*X_2-0.72*X_2^2+0.07*X_1*X_2$

With the software Arena 7.01 the probability distribution of the operational parameters was established, it was obtained that they are better adjusted distribution to the uniform probability This analysis revealed that the parameters also fit the beta distribution. The Monte Carlo method is classified as a sampling method because the quantities of inputs are randomly generated from a probability distribution in order to simulate the sampling process of a real population [7]. This method was used to generate random values of the operational parameters with the two probability distributions mentioned above. According to [19], the scalar control test in the sensory evaluation panels establishes a value of 6 for "I like very little", and 10 for "I like it very much", thus establishing the upper and lower limits of the control chart.

The beta and uniform probability distribution was applied in the Monte Carlo method to generate a thousand combinations of pH and ° Brix within the ranges 3.5 to 4.5 and 76 to 78 as proposed by [10].

With this procedure was predicted behavior of the variables response viscosity, Flavor and presence of crystals and the percentage of defects was quantified and a 30% (Fig. 1A), 48 % (Fig. 1B) y 30 % (Fig. 1C) respectively in the values generated with the distribution to probability beta.

In calculating the six sigma quality of the process we considered the simulation of the response parameters under the conditions set by [10] (Table 2) for each of the response parameters mentioned above.

Tabla 2. Sigma of the process

Response Parameters	Value
Viscosity	1.13
Flavor	1.44
Presence of crystal	1.51

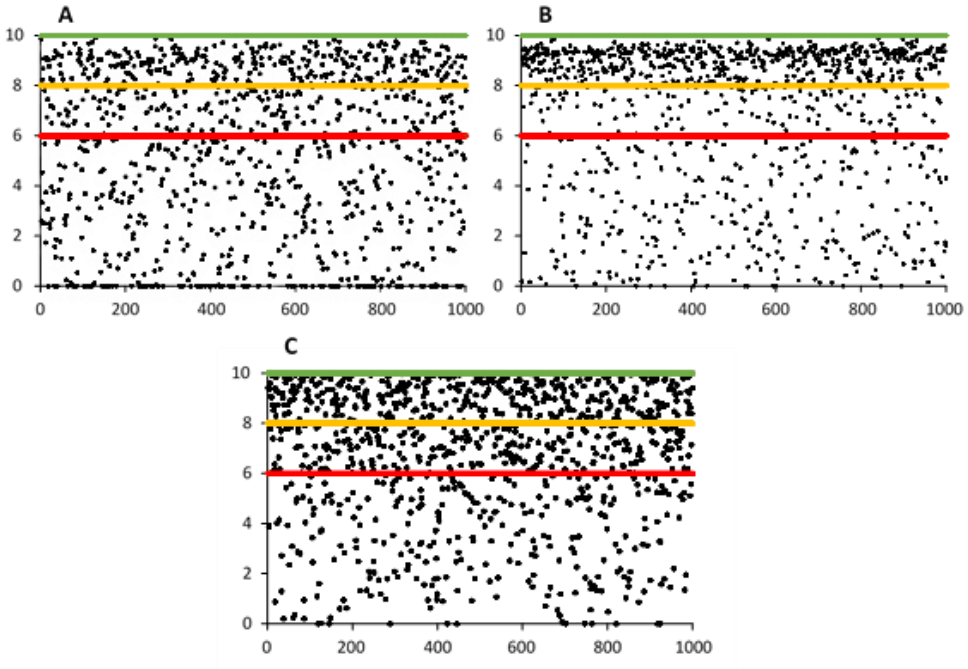

Figure 1. Control Chart of Sensory Attributes of Response Parameters. Random data generated with beta probability distribution. The data of the graphs on the left were generated with the limits of the parameters proposed by the author [10] .The data of the right graphs were generated from the limits obtained after the calculation of the uncertainty. A: Viscosity, B: Flavor, C: Presence of crystals. Hedonic scale of acceptance of the product. Maximum limit, midpoint Lower limit.

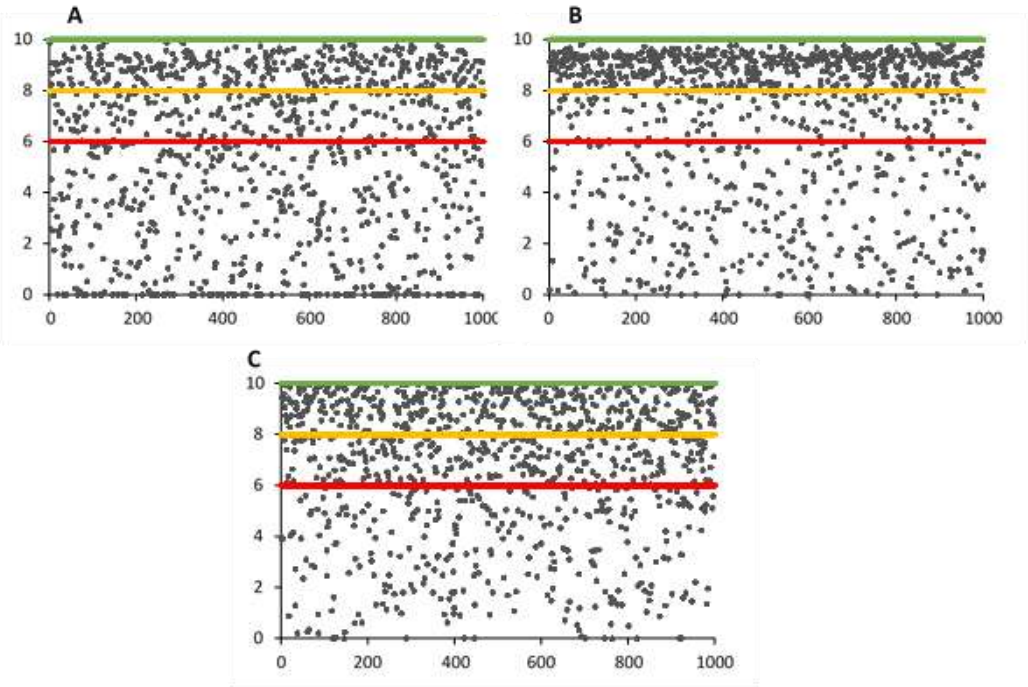

Figure 2. Control Chart of Sensory Attributes of Response Parameters. Random data generated with Uniform Probability Distribution. The data of the graphs on the left were generated with the limits of the parameters proposed by the author [10]. The data of the right graphs were generated from the limits obtained after the calculation of the uncertainty. A: Viscosity, B: Flavor, C: Presence of crystals. Hedonic scale of acceptance of the product. Maximum limit, midpoint Lower limit.

3. Materials and Methods

The experimental results obtained by [10] are used in the present work as starting point for the working procedure shown in Figure 3

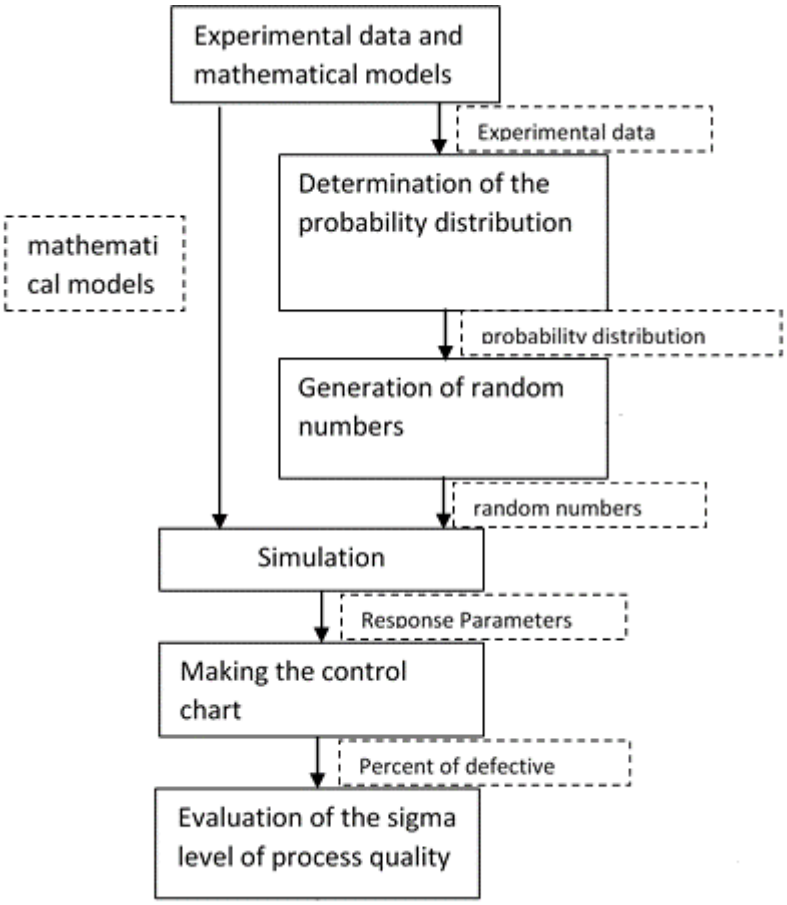

Figure 3. Scheme of applied methodology.

4. Conclusions

- On average 31% of the sensory attributes are outside the values defined as acceptable in the hedonic scale (From 6 to 10). This shows that a small variation in the operational parameters significantly affects the response parameters.
- The percentage of rejections when generating random values with Uniform distribution within the upper and lower limits of an average of (31%).
- The process of obtaining sugarcane syrup under the conditions defined in the operational parameters of pH between 3.5 to 4.5 and ° Brix between 74 to 78 establishes a sigma of the process less than 2, which causes a quantity of defective greater than 30%.

Author Contributions

All the authors contributed equally for the execution of the work and the writing of the manuscript

Conflicts of Interest

The authors declare no conflict of interest.

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