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RESEARCH ARTICLE

EFFECT OF THE CONTENT OF SUGARS OF MUCYLAGUS DURING THE PRE-DRYING, PREVIOUS TO FERMENTATION, ON THE PHYSICAL AND SENSORIAL QUALITY OF COCOA (*Theobroma cacao* L.)

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ABSTRACT

In order to improve the quality of CCN-51 cocoa beans, this study was developed in which 5 concentrations of total sugars, defined by the Brix degrees (° Bx) and adjusted by pre-drying, were evaluated prior to the process of fermentation. A completely random distribution was used in the allocation of the treatments, which were defined by 1 ° Bx (T1), 1 - 5 ° Bx (T2), 5 - 10 ° Bx (T3), 10 - 15 ° Bx (T4) and more than 15 ° Bx (T5). The selected grains came from healthy cobs of the same farm, which after the pre-drying were subjected to the fermentation process in jute bags for three days; exposing them later to natural drying, until leaving them with 7% humidity. The proportion of fermented, violet and slate grains was evaluated, making the longitudinal cut of the grains and comparing them with a visual scale. Likewise, sensory acceptance was valued through a paste, using 5 trained judges and a hedonic scale of 6 points, in categories ranging from undesirable (0) to excellent (5). In addition, the temperature was evaluated in the 3 days of fermentation and the initial and final pH of this process. Properly fermented grains were obtained in more than 80% in the first 4 treatments; reducing the violet and slate grains below 10 and 5%, respectively. The highest acceptance was established for the T2 treatment, defining it between very good and excellent. In conclusion, the pre-drying favors the quality of cocoa beans CCN-51.

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INTRODUCTION

In Ecuador, cocoa production is one of the most important agricultural items within its agricultural gross domestic product, contributing mostly, along with bananas and coffee, with 20% of this economic indicator (Monteros and Salvador, 2015). This importance is also reflected in the agricultural area for its cultivation, hence it is estimated that 37.43% of the area occupied by permanent crops at the national level corresponds to cocoa (Ecuadorian Institute of Statistics and Census [INEC], 2016); proportion that also defines it as the one with the largest planted area in the national territory. Due to its importance in generating employment, the agricultural activity related to cocoa is one of the most socioeconomic influences for the country, along with those of banana and corn (Monteros and Salvador, 2015). The fermentation of cocoa beans; a fundamental activity so that they acquire their characteristic aroma and flavor (Paredes, 2009), which in the end define their quality and their respective economic valuation. One cannot speak at all of standard methods for post-harvest treatment of cocoa beans; not even in the same fermentation as such, because it must be specific for regions, genotypes and situations that should be known, managed and improved by the producer to maintain or increase the quality of said grains (Enríquez, 1998). Due to the multiple factors that govern it, fermentation continues to be based on empirical criteria that do not allow to continuously maintain a certain quality, and therefore, there is an obligation for the process to be recurrently modified (De La Cruz, Vargas & Del Ángel, nd); adding new ideas, which allow the end to have a cocoa of good flavor, aroma and properly fermented. On the other hand evidences on pre-drying have also been published by Amores, Jiménez and Saltos (2007); who could verify a modification in the basic flavors (cocoa, bitterness, astringency and acidity) of CCN-51 cocoa beans when subjected to 8 hours of pre-drying, prior to fermentation. Also, Caiza (2015), could establish a greater presence of fermented grains in both the National type cacao and the CCN-51, by submitting the grains at a time of three hours of pre-drying with respect to the grains that did not have this treatment. Consequently, the performance of tasks such as pre-drying before submitting the beans to fermentation,

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can contribute significantly to the improvement of quality; since it favors a greater presence of oxygen, and therefore, better fermented grains. In correspondence with this criterion, this study was carried out, where it was proposed to evaluate the effect of several initial sugar contents determined through the Brix degrees and adjusted by pre-drying, on the physical and sensory characteristics of the cocoa beans.

MATERIALS AND METHODS

The experience was carried out in the facilities of the exporting company of grains and semifinished cocoa COFINA S.A., located in the canton Durán of the province of Guayas. The average climatic conditions of the area are 20.4 ° C and 30.0 ° C of minimum and maximum temperature, respectively; 82% relative humidity; and 3.2 hours of heliophany (FAO CLIMWAT 2.0 Database). Cobs from the CCN-51 cocoa clone from the same farm were used, from which the grains were extracted, which were immediately subjected to a pre-drying process, with the purpose of adjusting the ranges of Brix degrees (° Bx). Which are indicated in Table 1; that for this case, constituted the treatments evaluated. The amount of fresh grains that was considered for each treatment was 50 kg.

Table 1. Evaluated treatments

N°	Treatments	Pre-drying times (hours)
1	1 °Bx	15
2	1 - 5 °Bx	10
3	5 - 10 ° Bx	8
4	10 - 15 °Bx	5
5	More tan 15 °Bx	3

The pre-drying was done by exposing the fresh cocoa seeds to the environment in concrete slabs, from where continuous sampling was done to adjust the sugars. It should be noted that the procedure followed to determine Brix degrees was not a standard method described in the literature, since no information was found about it. For the readings, 20 grains were selected every hour, the same ones that were weighed and washed with distilled water, whose volume was equivalent to a quarter of the weight of the selected sample (20 grains). The readings were taken in the liquid waste. Once obtained the ranges of sugars defined by the Brix degrees, the samples were subjected to the normal process of fermentation in jute bags for 3 days, making piles of 10 of these sacks, half packed, and covered with a tarpaulin inside a shed. After this process, the samples were subjected to the respective natural drying until leaving it with approximately 7% humidity; subsequently, from these samples the physical and sensory characteristics were evaluated. The physical characteristics were evaluated through the proportion of fermented grains, violet grains and slate grains, all expressed in percentage form; for which the test of longitudinal cut of the grain is realized, using a guillotine and the visual scale that indicates in the Figure 1. And the sensory quality was determined through a scale of 0 to 5, as can be seen in Table 2.

Figure 1. Visual effects of the different degrees of fermentation.(1:medium fermented grains, 2: fermented grains, 3: salte grains, 4: violet beads) Source: http://cacaomovil.com/guia/8/contenido/ejercicio-1/

Table 2. Scale used in the sensory evaluation of acceptance

Value	Characteristic
0	Undesirable
1	Undesirable
2	Regular
3	Good
4	Very good
5	Excellent

Additionally, temperature evaluations were carried out during the three days of the fermentation process, using a digital pen-type thermometer. Likewise, the acidity of the samples was evaluated through the pH, both at the beginning of this process and at the end of it. The experiment was conducted under a completely randomized distribution, referring to the allocation of treatments. For the verification of significant differences between treatments, analysis of variance was used, after confirming normality and homocedasticity of the data. The averages were compared using the Tukey test, considering a maximum error probability of 5% for these two statistical tests. This analysis was made with the help of IBM SPSS 20.0 software.

RESULTS

The different concentrations of mucilage, as shown in Table 3, allowed obtaining the full range of values of the hedonic scale used for acceptance, reporting significant differences among the treatments evaluated ($p < 0.05$). From this result it could be established that leaving the cocoa beans in the pre-drying with a sugar content between 1 and 5 ° Brix (Treatment 2), made it possible to have a definite acceptance between very good and excellent. Regarding the proportion of fermented grains, according to what is indicated in table 3, it was established that achieving a pre-drying with 10 or less Bx of sugars makes it possible to obtain proportions that go beyond 90% of fermented grains; standing out in this case, with significant differences, the treatment from 1 to 5 ° Bx (T2). Consequently, in relation to the presence of violet grains and slate grains, these were present in less than 9% for the first case and less than 5% for the second, between treatments 1, 2, 3 and 4; presenting significant differences between them. Likewise, in these last two variables, the treatment in which the grains were allowed to contain between 1 to 5 ° Bx (T2), was able to obtain averages of less than 3% and 1%, for both violet and slate grains respectively.

Table 3. Results of the sensory and physical evaluation of the treatments

N°	Treatmens	Acceptance	Fermented grains (%)	Violet beads (%)	Slate grains (%)
1	1 °Bx	3,5 b	92,8 ab	6,0 b	1,0 bc
2	1 - 5 °Bx	4,5 a	96,8 a	2,6 b	0,6 c
3	5 - 10 ° Bx	2,9 b	90,6 ab	6,8 b	2,4 bc
4	10 - 15 °Bx	1,9 c	86,8 b	8,6 b	4,6 ab
5	More than 15 °Bx	0,9 d	73,0 c	20,4 a	6,6 a
Coefficient Var. (%)		14,2%	5,0%	19,3%*	20,6%**

* Coefficient of variation with data adjusted to $\sqrt{y}$.
** Coefficient of variation with data adjusted to $\sqrt{(y + 1)}$.
Equal letters do not differ significantly.

Among the parameters of the process, the hydrogen potential readings allowed to deduce an increase of this between the beginning of the fermentation stage and the end of the same in

each treatment, time that lasted 72 hours (see figure 2). Also of note is a slight difference in this process indicator, between the grains with less mucilage (1 ° Bx) and the grains with greater presence of this fluid (more than 15 ° Bx).

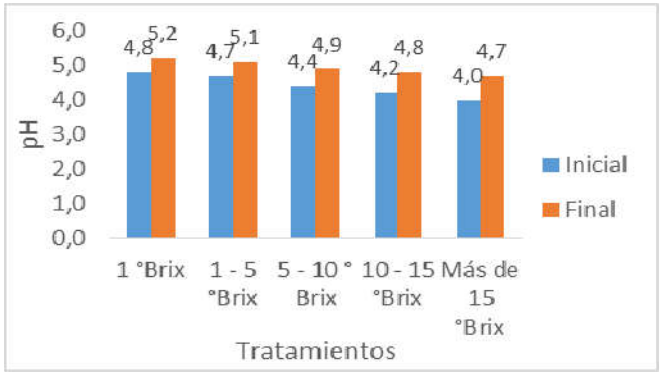
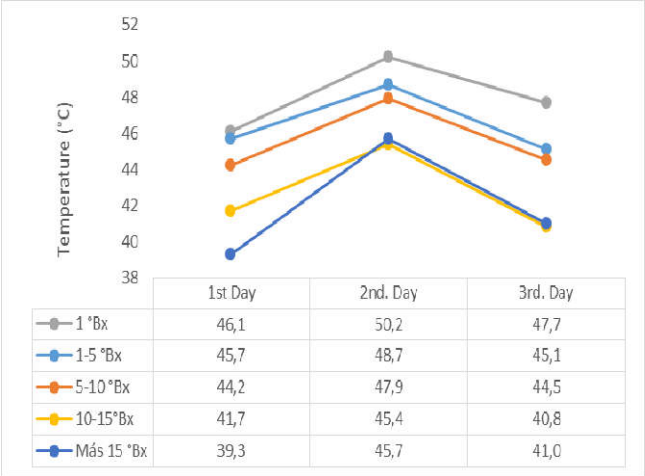


Figure 2. pH values at the beginning and end of the fermentation process

According to the temperature records measured during the fermentation process, it remained between 39 and 46 ° C in the first 24 hours within the five treatments evaluated (Figure 3), however, an increase of up to 5 ° could be evidenced C 48 hours after the start of the fermentation process, and then return to its starting temperature at 72 hours.



	1st Day	2nd. Day	3rd. Day
1 °Bx	46,1	50,2	47,7
1-5 °Bx	45,7	48,7	45,1
5-10 °Bx	44,2	47,9	44,5
10-15°Bx	41,7	45,4	40,8
Más 15 °Bx	39,3	45,7	41,0

Figure 3. Temperature values (° C) measured during the fermentation

DISCUSSION

Since cocoa CCN-51 is a clone with a high production of mucilage, according to the results it can be seen that the reduction of this pulp allowed a substantial improvement in the acceptance of the cocoa mass by the sensory panel, especially when this it is less than 5 ° Bx (table 3). This situation can be attributed to a greater presence of oxygen in the fermentation process as there is less pulp in the grains, which in some way favored the presence of microorganisms that act in the process of conversion of ethanol to acetic acid in the anaerobic stages and aerobic, and which occur successively in the fermentation phase (Batista, 2009); which in turn reduces the presence of astringent, bitter and acid flavors (Amores et al., 2007), mostly present when this process is deficient due to lack of aeration (Criollo et al., 2010). When observing the results in a joint way between the general acceptance and the quantity of fermented grains (Table 3), it can be deduced that the reduction of the pulp of the cocoa beans, up to 5 ° Bx, significantly favored the occurrence more or less correct of anaerobic and aerobic activity; in such a way that enough acetic acid could be produced to kill the cotyledons and favor the microbial activities, which decisively influenced the biochemical processes within the grains, and which in turn, define the magnitude of the color and flavor of the product final (Nielsen et al., 2008, cited by De La Cruz, Vargas & Del Ángel, s.f). In all treatments, an increase in temperature could be observed on the second day of the fermentation stage, with a range between 45 and 50 ° C (Figure 2), in accordance with the thermal condition necessary for an adequate fermentation process that must occur between 40 and 60 ° C (Enríquez, 1985). However, the highest averages occurred in treatments 1, 2 and 3 that contained mucilage concentrations of up to 10 ° Bx, which contributed to a greater presence of oxidative microorganisms that caused exothermic reactions of greater magnitude, and therefore, a higher temperature (Ortiz, Graziani and Rovedas, 2009). The relationship between the highest acceptance and the highest proportion of adequately fermented grains obtained in treatment 2 (Table 3), to some extent are related to a significant presence of oxygen and microorganisms that cause exothermic reactions, which allowed the necessary production of acetic acid and sufficient heat to eliminate the embryo of the almonds and facilitate the flowering of taste precursors (Enríquez, 1985; Schwan and Las Ronchas, 2010). However, contrary to what happened in this study, Romero and Zambrano (2012) indicate that a greater presence of sugars in cocoa pulps may favor better fermentation, something that cannot be supported by noting that the greater proportion of brown colored grains, which indicate a complete fermentation (Stevenson et al., 1993), occurred at lower Brix degrees. The greater proportion of violet grains and slate grains in the treatment 5 could be attributed to a bad fermentative process in the sense of a lack of oxygenation, a condition that makes the lactic and butyric fermentation that are the cause of poor quality occur with greater intensity of cocoa beans (Batista, 2009). However, the quantity of these grains in the treatments from 1 to 4, which were adjusted up to 15 ° Bx, made it possible to comply with the Ecuadorian Technical Norm INEN 0176; which establishes a maximum of 18% and 5% for slate and violet, grains, respectively, in clone CCN-51. Given the presence of citric acid and glucose in the pulp of cocoa beans in their initial stage of fermentation, it causes it to be present at low pH values (Batista, 2009, Hardy, 1961). However, in the process the alcoholic transformation generates that it tends to increase (Ohene, et al., 2011); as it happened in this study, that at the end of the three days of fermentation some increase in the pH of all the treatments could be established (Figure 2).

Conclusione

The reduction of the mucilage during pre-drying in cocoa CCN-51, adjusted up to 5 ° Bx, can favor a greater development of the profile in terms of the basic flavor of cocoa, and therefore, to obtain a greater sensory acceptance. With the pre-drying of cocoa beans CCN-51, an increase in the proportion of fermented grains can also be achieved; reducing at the same time, the presence of violet and slate grains that diminish their quality.

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