DOI 10.15520/sslej.v5i05.2672 http://sslej.in/index.php/sslej Research Article

ISSN: 2456-2408 Social Science learning Education Journal

Fermenter Type and Fermentation Time Effects in the Physicochemical and Organoleptic Characteristics of Cocoa (*Theobroma Cacao L.)*

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Summary

Objectives and purpose of the work: *The study aimed to evaluate the types of fermenters and the different fermentation times used by creole cocoa producers in the Amazonas region, Peru.*

Materials and methods: *For work purposes, three types of fermenters were studied: plastic bucket, wooden box and jute bag, with a storage capacity of 90 kg of cocoa and fermentation times of 4; 6 and 8 days; in addition, an unfermented control was evaluated.The method used was that of a bi-factorial experiment with three repetitions in a completely randomized block design. Data were processed by analysis of variance with the Tukey test at 5% probability.The physicochemical and organoleptic variables were analyzed. The study was conducted in 2018.*

Results: *The tests showed that the fermentation time, unlike the type of fermenter, had an influence on the physicochemical characteristics analyzed.The increase in the percentage of fermented grains and the decrease in violet grains occurred in ascending form from the beginning to the end of the process.The chemical quality improved with the reduction in pH due to the fermentation process, which had an impact on the organoleptic characteristics of creole cocoa.*

Conclusions: *The best quality characteristics were obtained after 8 days of fermentation with the type of wooden box fermenter.*

Keywords*: - Cocoa, fermentation, fermenters, slime creole.*

Introduction

Cocoa (Theobroma cacao L.), is a species native to the humid tropical forests of South America. Its grains constitute the basic input for the chocolate, cosmetic, pharmaceutical and other derivatives industry (ICCO, 2002). The fermentation and drying of cocoa is an important stage in the processing, since the biochemical changes that give rise to the aroma and flavor precursors occur (Contreras et al., 2002). The ripe cocoa fruit contains about 30 to 40 cocoa beans, coated by the mucilage, rich in carbohydrates, (Schwan et al., 1995). According to Cheesman (1944) all cocoa Varieties are classified into three groups: Creole, Outsider and Trinitarian. Cros et al., (1994) argue that cocoa quality includes physical and organoleptic characteristics.The physical quality is based on the external presentation of the grain (Moreira, 1994). The qualification given by buyers and manufacturers of chocolate to cocoa beans depends on the appearance, degree of fermentation, moisture, foreign materials, mold and insects (Pastorelly, 1992).The percentage of fermentation is determined by the "cutting test" which consists in analyzing the internal coloring of the grain, (Pinto,

Álvarez, 2001). A dominant point in the qualification of cocoa is based on organoleptic characteristics (taste and aroma) (Armijos, 2002).

The organoleptic qualities that cocoa beans must gather to develop a good chocolate depend on the aroma and that they are free of secondary flavors especially smoke, mold, excessive acidity, the smell of smoked ham that is caused by an over fermentation (Navarrete, 1992).For the manufacturer, sensory evaluation is the only reliable test to determine if you can use certain cocoa for your products. (Jiménez, 2003).

The importance of the compounds involved in the formation of cocoa aroma and therefore the development of chocolate flavor precursors is reflected in volatile compounds such as pyrazines and aldehydes that represent a basic flavor; the esters that originate a fruity taste. Also the degree of astringency of chocolate is determined by polyphenolic compounds and bitterness by purines (caffeine and theobromine); the complex polypeptides-phenols and pyrazines, are involved in the sweet and nutty taste (Decotton, 1995). The characteristic aroma of chocolate is formed while the rapid destruction of anthocyanins occurs. (Braudeau, 1970). The roasting of cocoa is carried out with the purpose of facilitating the elimination of the husk. Pinto and Álvarez (2001) argue that the control of time and temperature is important in the roasting process.The genetic variability in cocoa has a great influence on the flavor, color, size, butter content and especially aroma (Moreno et al., 1989). A cocoa of a certain genetic origin has very characteristic organoleptic properties, so two types of grains can be identified: common cocoa, from Amazonian trees, located under the name of outsider, and fine cocoa that comes from Creole and Trinitarian trees (Calderón, 2002). Foreign cocoas are less bitter and less astringent than Trinitarian, the genetics of the Creole cocoa group tends to produce a low cocoa flavor but favors a high level of nutty notes (Liendo, 2003). Certain characteristics of cocoa beans are affected by the environment during the development of the ear or fruit, the deficiency of water and nutrients in the soil reduces the size of the fruits and grains (Moreira, 1994). Fermentation is the balanced action of temperature, alcohols, pH, humidity and acids. The temperature rise plays a very important role in the fermentation, it is partly responsible for the death of the embryo of the grains and initiation of the enzymatic reactions in the tissues of the cotyledons (Braudeau, 1970). The fresh pulp has a pH of 3,4 to 4,6; at the same stage the pH of the cotyledons is 6,6. Because the testa is permeable to acetic acid, it passes into the cotyledon and on the third day kills the embryo and lowers the pH to 4,8 (Hernández, 1991).

In the Amazonas region it is customary to carry out the fermentation process between 4 and 8 days, depending on the climatic conditions. According to Rodríguez (2006), the anaerobic phase begins as soon as the cocoa beans are deposited inside the fermenters; it lasts 48 hours in which the grain mucilage is degraded by yeasts, transforming the sugars into alcohol, without the presence of air, therefore, during this stage the grain must remain covered with jute sacks or banana leaves. The aerobic phase is the continuation of the anaerobic one where a series of biochemical reactions caused by bacteria occur, which produce physical and chemical changes within the grain, such as: temperature increase, death of the germ or embryo, swelling and fissure of the grain and the changes of internal and external coloration that generate the development of the precursors of the aroma of cocoa.The removal consists in promoting the changes that cause the death of the grain, with this activity the ventilation is increased and the development of the bacteria is favored, which are responsible for the fermentation and therefore, the uniformity of the latter in the whole mass (Rohan, 1964).

The fermentation takes place in dry wood drawers designed with draining holes in the base as a strainer, to allow the juice to drain and give good aeration, it must not have strong odors, or paint. The most appropriate wood is the "screw" (Cedrelinga catenaeformis) for its resistance, abundance and relatively low cost (Enriquez, 1985).

The objective of the study was to determine the effect of the type of fermenter and the fermentation time on the physicochemical and organoleptic characteristics of the cocoa (Theobroma cacao L.) creole type in the district of Cajaruro, Amazonas region, Peru, in order to establish the appropriate parameters that improve the quality and price of cocoa.

Materials and methods

The field work was carried out in the district of Cajaruro, province of Utcubamba, Amazonas region, Peru.The province is located geographically at 440 m.a.s.l., between the coordinates 5° 23' 25" and 6° 10' 13" South Altitude and, 77° 51' 7 " and 78° 42 '12" West Longitude. For the investigation, a total of 810 kg of cocoa beans (Theobroma cacao L.) creole in drool were used, with three types of fermenters (plastic bucket, wooden drawer and jute bag) with a capacity of 90 kg of cocoa and times of fermentation of 4; 6 and 8 days and an unfermented control with the same capacity and volume of the treatments in question, the removal was the same for all fermenters.The method used was that of a bi-factorial experiment with three repetitions in a completely randomized block design with three repetitions.The data were processed using the Statgraphics Centurion statistical software and the analysis of variance. For the comparison of treatment means, the Tukey test was used at a 5% probability. For each fermentation time (4; 6 and 8 days), the cutting test was performed to determine the physical characteristics (percentage of well fermented, partially fermented, violet, slate and defective grains) continuing with the drying, both in solar canopy as in dried wood parihuela.To the most representative samples of the physical analysis, a physicochemical and organoleptic analysis were applied to determine the humidity, pH, acidity, ashes and fat, as well as: the basic flavors (acidity, bitterness, astringency), the specific flavors (cocoa, floral, fruit and nut) and, the acquired flavors (mold, earth, raw / green).

Results

Figure 1 shows the evolution of the temperature in the fermentation process.

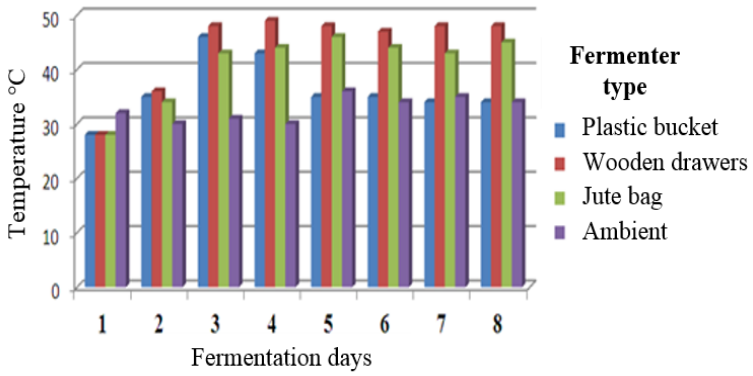

Figure 1. Average temperature values during fermentation

Source: Own elaboration

Figure 2 shows the fermentation levels at 4; 6 and 8 days of the process.

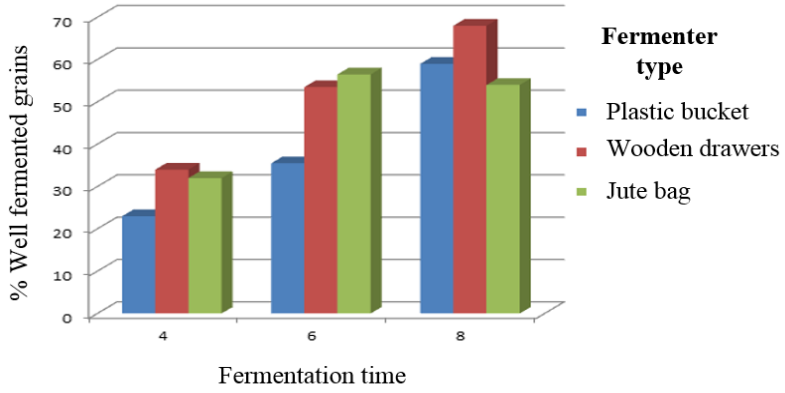

Figure 2. Average values of the percentage of well fermented cocoa beans
Source: Own elaboration

Figure 3 shows that on day 8 of fermentation there is the lowest percentage of partially fermented grains for the three types of fermenters (plastic bucket, wooden drawer and jute bag), differentiating the wooden crate as the best treatment with lower percentage of this.

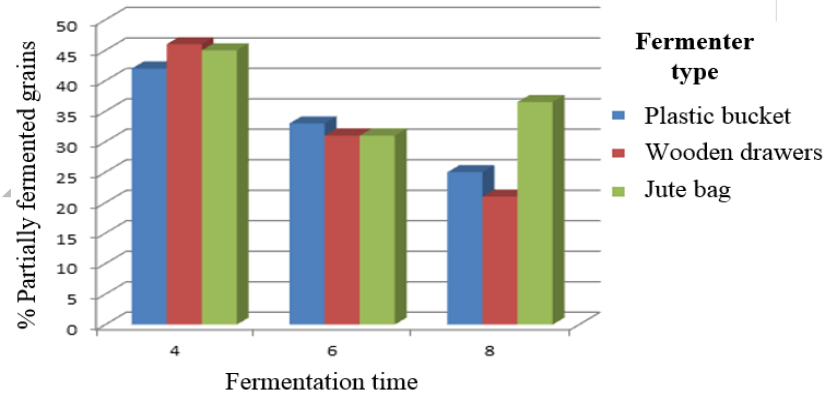

Figure 3. Average values of the percentage of partially fermented cocoa beans
Source: Own elaboration

Figure 4 clearly shows that as the days of fermentation passed, the percentage of violet grains in the three types of fermenters (plastic bucket, wooden box and jute bag) decreased, differentiating on day 8, the drawer of wood and jute bag as the best treatments with lower percentages of violet grains.

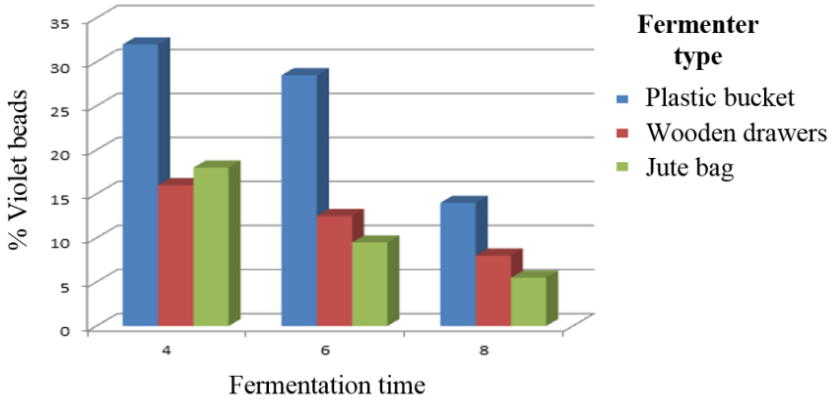

Figure 4. Average values of the physical characteristic of violet grains

Source: Own elaboration

Figure 5 shows that fermentation type and time has no influence on the percentage of defective grains.

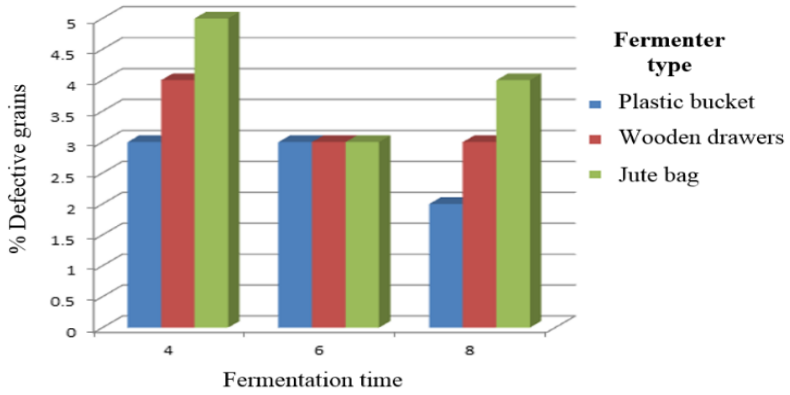

Figure 5. Average values of the defective grain characteristic

Source: Own elaboration

Figure 6 shows that variation of the humidity in wooden box is within the parameters.

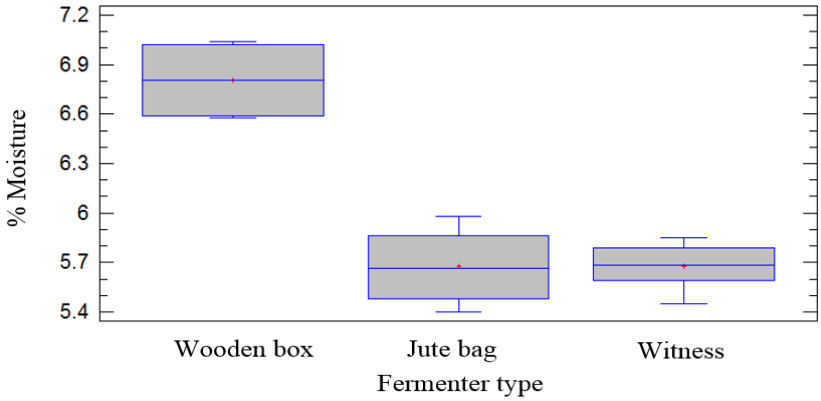

Figure 6. Variation of % humidity with respect to the type of fermenter

Source: Own elaboration

Figure 7 shows that drying in solar canopy favors the quality of cocoa.

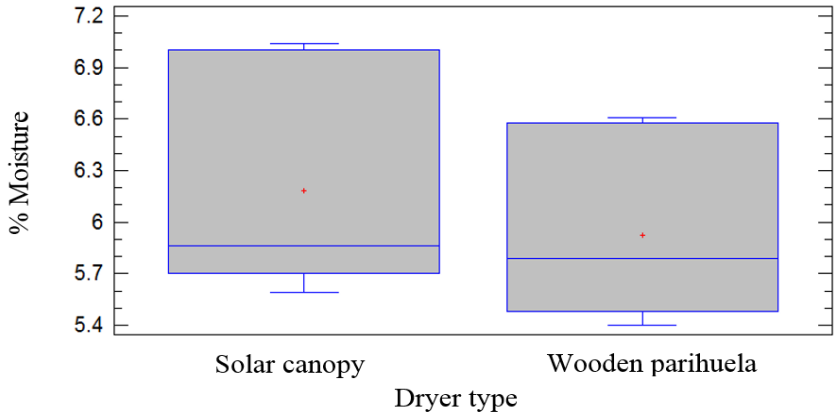

Figure 7. Humidity percentage variation

Source: Own elaboration

Figure 8 shows the variation of the pH according to the type of fermenter.

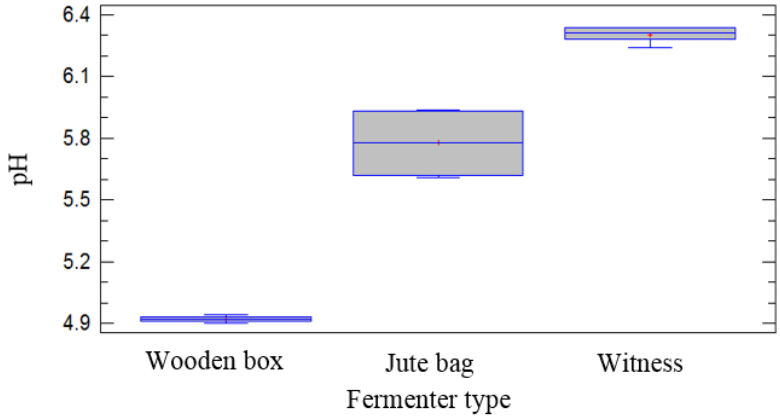

Figure 8. Variation of pH with respect to the type of fermenter

Source: Own elaboration

Figure 9 shows variations according to type of dryer used.

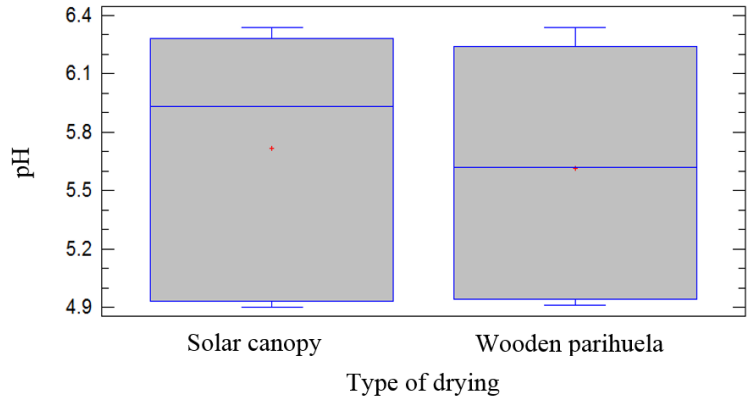

Figure 9. Variation of pH with respect to the type of drying.

Source: Own elaboration

Figure 10 shows that on day 8 of fermentation there is a more optimal pH, compared to control.

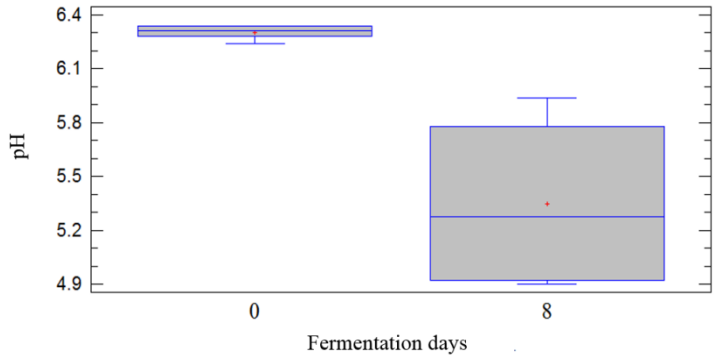

Figure 10. Variation of pH with respect to the day of fermentation

Source: Own elaboraion

Figure 11 shows that in jute and control bags there is a lower percentage of acidity, compared to wooden box for the same fermentation process.

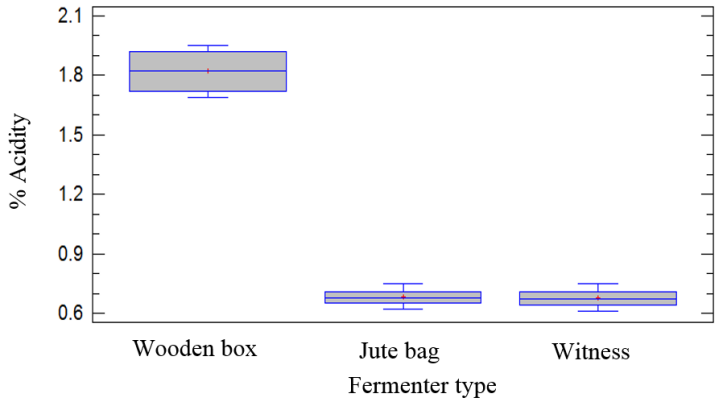

Figure 11. Variation in the percentage of acidity with respect to the type of fermenter
Source: Own elaboration

Figure 12 shows that there is a lower percentage of acidity in solar canopy drying.

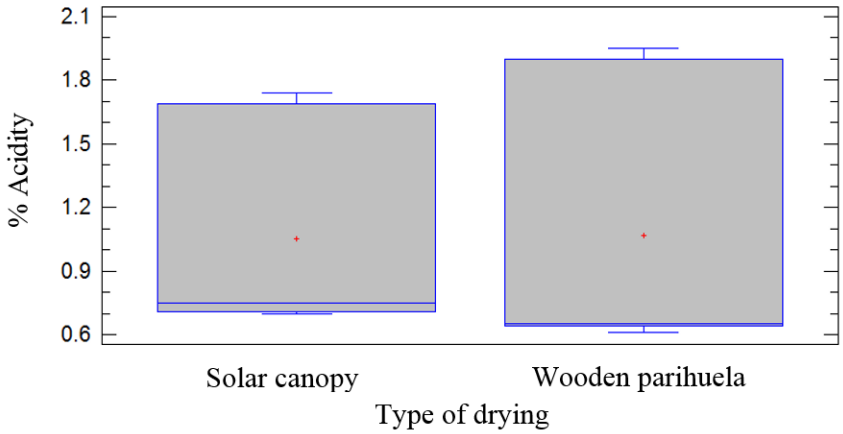

Figure 12. Variation of the acidity percentage with respect to the type of drying
Source: Own elaboration

Figure 13 shows the variation of acidity in relation to the days of fermentation.

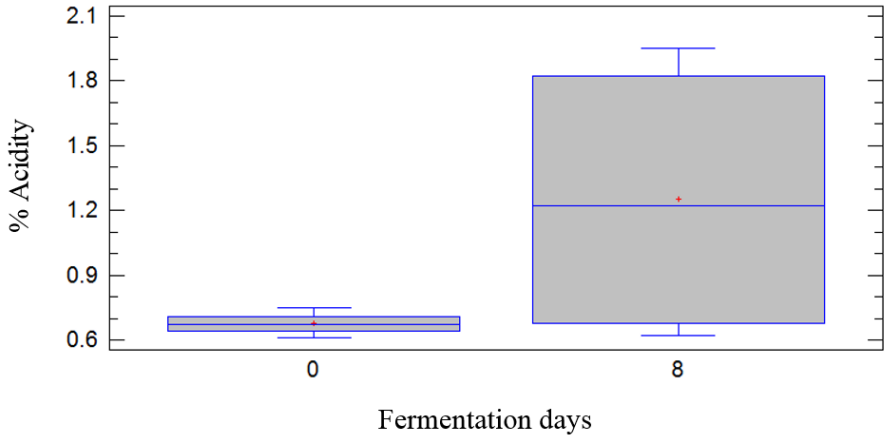

Figure 13. Variation in % of acidity with respect to fermentation days

Source: Own elaboration

Figure 14 shows the sensory analysis score.

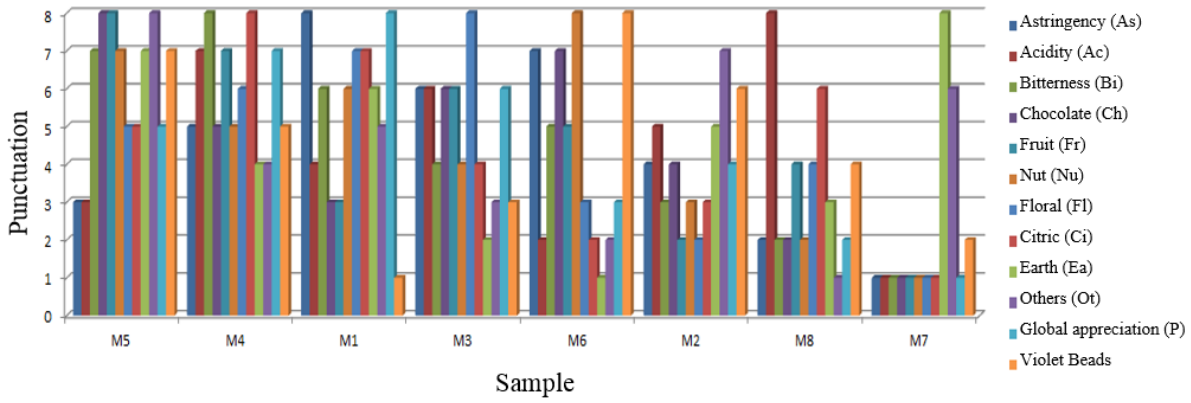

Figure 14. Scoring of the sensory analysis, with respect to the samples analyzed

Source: Own elaboration

Discussion

In Figure 1, the temperature behavior is observed during the 8 days of fermentation of the slime cocoa beans (Theobroma cacao L.), where it is shown that the initial temperature was 28° C., in the three types of fermenters, reaching a maximum temperature of 48° C., in the wooden drawer and jute bag indicating a better fermentation process. Braudeau (1970), pointed out that the increase in temperature occurs with the beginning of fermentation by microbial activity, causing an increase in temperature to reach a maximum (40º C - 45º C) and then descends as a result of the inactivation of acetic bacteria, causing the death of the embryo and the start of enzymatic reactions in cotyledon tissues, giving rise to chocolate flavor and aroma precursors.

Figure 2 shows that on day 8 of fermentation the highest percentages of well-fermented grains have been obtained in the wooden box with 68% and lower percentages of this in jute bag (54%) and plastic bucket (59%), this is possibly due to the fact that the rise in the temperature of the dough during the fermentation process was very slow, a criterion that coincides with Rohan (1960), who considers that the fermentation is faster as the temperature advances, while at lower temperatures a low percentage of well-fermented grains is obtained, the same author states that working with several types of fermenters, a lower fermentation rate with the sack type has been found, contrary to the results of fermentation in piles or in drawers, which was attributed to the fact that the bag does not meet the proper conditions for aeration and drainage. Rivera et al. (2012), with respect to fermenters, they mention that the wooden box reached the highest percentage of fermented grains with 73,3%, while the other fermenters remained with a percentage lower than 70%. In the present investigation, a higher percentage of fermented grains and a lower percentage of violet grains were observed in the wooden box-type fermenter. Like the fermentation time, the type of fermenter did not influence the content of slate and defective grains. According to the Tukey means test, in figure 3 we found significant differences (P <0,05) between the values of partially fermented grains, as well as between fermenters and fermentation days. According to Rohan (1964), the physical indices of quality of dried cocoa beans are related to the degree of ripeness of the fruits, observing that ears that are not completely ripe give rise to partially fermented, violet and slate grains, since they lack of enough sugar for proper fermentation. The violet grains had an inverse behavior to the fermented grains, that is to say that as the fermentation time increased the percentage of violet grains decreased, since as you can see the lower content of these grains was found in the last days of the fermentation, reducing around 80% on day 8, noting in Figure 4, a lower percentage of this in the wooden box (8%) and in the jute bag (5,5%), then there is a better

fermentation process with respect to the plastic bucket (14%). According to Contreras et al., (2002), this decrease revealed adequate handling during fermentation, a process in which chemical reactions change the color of the grains from violet to brown.

Figure 5 shows that the slate and defective grains remained around 5%, and their percentage was not influenced by the type and time of fermentation. According to Rohan (1964), it is likely that this percentage is the result of fruits that did not have an adequate degree of maturity -other- damaged or diseased ears of black beans at the time of harvest, a criterion that coincides with the Ecuadorian Technical Standard 0176 (INEN, 2006), this standard allows between 4 and 12% of slate and defective grains. For certain classifications, according to it, it is necessary to take into account the use that will be given to cocoa, mainly, if it is for the production of chocolates, since some chocolate industries associate it with unpleasant flavors.

With respect to the moisture content (figure 6), the values are in a range of variability between 5,48 to 6,90%, where the homogeneous group with the best characteristics is fermented in a wooden box with a higher humidity.Value that is close to the parameters required by Colombian Technical Standard 1252 (ICONTEC, 2003), this standard allows 7% of maximum moisture content, requirements that cocoa beans for industrialization for human consumption and export type cocoa must meet.

The variation of the humidity percentages with respect to the type of dryer (figure 7), show ranges of variability between 5,5 and 7%. Here the type of solar canopy drying shows a higher level of humidity.

Figure 8 shows on day 8 the variations in pH between the two fermenters and the control sample, these results are due to the changes that occur during fermentation by the action of microorganisms (yeasts, bacteria), to the elevation of temperature of the mass in fermentation and the penetration of acetic acid towards the cotyledon.

The control sample recorded a pH of 6,31; the wooden box a pH of 4,92 and the jute bag pH 5,93. These results are related to what was stated by Meyer et al., (1989) who found that low pH values (≤ 4,5) in the cotyledons decrease the aromatic potential in cocoa, while values around 5,0 - 5,5 lead to an increase in potential, so that removals every 24 hours favor the increase in pH. However, it is noteworthy in this research work that the two removal frequencies led to the pH of the mass being around 5,0.

Regarding the variation of the pH with respect to the type of dryer (figure 9), it is noted that drying in wooden parihuela would slightly influence a better quality of cocoa. The value obtained from the pH of fermented cocoa in a wooden box on day 8 (figure 10), is in a range of 4,9 on average, this result indicates a good fermentation process. In this regard, Afoakwa et al., (2008) believe that fermented cocoa with a pH between 5,5-5,8 is considered poorly fermented, while a cocoa with a pH between 4,7-5,2 is considered to have been properly fermented.The acidity values show statistically significant differences in the wooden box, jute bag and control of dried cocoa beans (figure 11), presenting a lower acidity in the samples fermented in jute bag and the unfermented sample with a percentage of acidity of 0,72% and 0,63% this is because the sample, did not reach a good fermentation, there is deficiency in the drying of the grains and an accumulation of the water content in the cotyledons.

The reduction in acidity values, mainly of volatile and free acids in fermented and sun-dried grains, coincides with the greater decrease in moisture content during drying (Nogales et al., 2006). The highest percentage of acidity (figure 12), was found in the wooden drawer fermenter where drying in solar canopy reached 1,72% and drying in wooden parihuela achieved 1,93%, in that sense a better fermentation process validated with sensory analysis. The percentage of acidity with respect to fermentation times was favorable on the eight day compared to the control (figure 13). As mentioned by the different specialists consulted, volatile acidity is related mainly to the content of acetic acid originated in fermentation, in addition to oleic and stearic acids that produce pleasant aromas; when

volatile acidity is associated with the aromatic fraction, it is likely that there will be a change from the typical basic flavors (acidity, astringency, bitterness, among others) to the specific ones (floral, fruity, walnut, among others) characteristic of creole cocoa.

Conclusions

In general, it can be affirmed that according to the results obtained, the types of fermenters and the times used strongly influence the quality of creole cocoa.This is because the physicochemical changes occur from the beginning of the fermentation process. However, the time unlike the type of fermenter has a greater influence on the changes in mention and in this way as the fermentation days increased the percentages of well-fermented grains and those of violet grains decreased.

Fermentation levels greater than 65% of fermented grains and pH values close to 5 in the cotyledons at the end of the fermentation process could be considered as a criterion of good benefit of creole cocoa.

The physical and sensory evaluations showed that the best results were obtained with the type of wooden box fermenter eight days after the fermentation process and drying in a solar canopy.The results showed 69,33% of fermented grains with little influence of unfermented grains (4,33%); moderate acidity and astringency and fruity, floral, nutty and slightly lactic flavors.

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