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Use of non-conventional woods in cocoa fermenters and their influence on the organoleptic quality of the cocoa paste

Empleo de maderas no convencionales en fermentadores de cacao y su influencia sobre la calidad organoléptica en la pasta de cacao

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Abstract

The research was carried out at the Quevedo State Technical University, Faculty of Livestock Sciences, located in the Experimental Farm "La María". The influence of cocoa fermenters made from woods (Guayacán Blanco, Laurel, Pine) on the physicochemical quality of Trinitario and Nacional variety cocoa beans was evaluated; sensory and bromatological analysis of the cocoa paste. A completely randomized design (DCA) with factorial arrangement (3x2) was applied, it was determined by the cut test the minimum 60% of well fermented almonds, violet beans 21%, slate beans exceeded 12%, as for the specific flavor profile it was determined that the T1 (C. Nacional-C. Laurel) Cacao odor, T6 (C. Trinitario-Pino) Floral profile, T2 (C. Trinitario-Guayacán Blanco) Sweet and presents the best attributes; as for the basic bitterness flavor profile, T3 (C. Nacional-Pino) has a high average; T6 and T5 (Nacional-Guayacán Blanco) obtain an average in acidity and astringency; in acquired flavors Green and Mold, T6 and T3 present high averages in the cocoa paste. Regarding the physical-chemical analysis, T6 shows moisture (2.44%), T5 (3.37%) in ash, (51.11%) in fat, T4 (Trinitario-Laurel),

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T6 with a pH of (5.82) and T5 shows an acidity of (1.34%) in the cocoa paste. The maximum temperature reached in the fermentation of the Nacional cocoa (44.52°C) in pinewood crates, while the minimum temperature was for the Trinitario cocoa (35.66°C) in the fermenter made of Guayacán Blanco wood.

Key words: bitterness, attributes, astringency, cut test

Resumen

La investigación se llevó a cabo en la Universidad Técnica Estatal de Quevedo, Facultad de Ciencias Pecuarias, situada en la Finca Experimental "La María". Se valoró la influencia de fermentadores de cacao elaborados de maderas (Guayacán Blanco, Laurel, Pino) sobre la calidad físico-químicas de las almendras de cacao variedad Trinitario y Nacional; análisis sensorial y bromatológica a la pasta de cacao. Se aplicó un diseño completamente al azar (DCA) con arreglo factorial (3x2), se determinó mediante la prueba de corte el 60% mínimo de almendras bien fermentadas, granos violetas 21%, granos pizarrosos supero el 12%, en cuanto al perfil de sabores específicos logró determinarse que el T1 (C. Nacional-C. Laurel) olor a Cacao, T6 (C. Trinitario-Pino) perfil Floral, T2 (C. Trinitario-Guayacán Blanco) Dulce y presenta los mejores atributos; en cuanto al perfil de sabores básicos amargor el T3 (C. Nacional-Pino) tiene promedio alto; el T6 y T5 (Nacional-Guayacán Blanco) obtiene una media en acidez y astringencia; en sabores adquiridos Verde y Moho el T6 y T3 presentan promedios altos en la pasta de cacao. Referente a los análisis físicos químicos, el T6 presenta humedad (2,44%), el T5 (3,37%) en ceniza, (51,11%) en grasa el T4 (Trinitario- Laurel), el T6 con un pH de (5,82) y T5 presenta una acidez de (1,34%) en la pasta de cacao. La temperatura máxima alcanzada en la fermentación del cacao Nacional (44,52°C) en cajones de madera Pino, mientras que la temperatura mínima fue en el cacao Trinitario (35,66°C) en el fermentador elaborado de madera Guayacán Blanco.

Palabras clave: amargor, atributos, astringencia, prueba de corte

Introduction

Ecuador is one of the main exporters of cocoa in Latin America and the first producer of high quality "fine" grade cocoa beans in the world. (Samaniego et al., 2020).

For some time now, this product has represented 80% of production worldwide. Ecuador accounts for 60% of fine and aroma cocoa production, which is envied by other cocoa producing countries. This is due to the presence of cocoa called "National" originating from the Amazonian Forastero. (Ordoñez et al., 2019).

The post-harvest conditioning process of the cocoa bean, particularly fermentation, does not only influence aroma and flavor formation, but also contributes to the formation of bioactive compounds with health benefits (Domínguez-Pérez et al., 2020).

In the fermentation stage, innumerable volatile compounds and flavor precursors are developed, these are produced by microbial processes, involving several biochemical reactions, on carbohydrates, proteins and polyphenols, directly affecting the sensory characteristics of the grain. (Marseglia et al., 2020).

Due to microbial action, the cocoa pulp is degraded into different final metabolites, which diffuse into the beans and promote embryo death, transforming the seeds into beans suitable for subsequent drying and roasting for chocolate production. (Carolina et al., 2021).

The flavors and chemical substances produced during the fermentation process make this step one of the most important in the production of chocolate (Menezes et al., 2016).

The process begins with the manual extraction of cocoa beans from the cob; then, the beans are placed in piles, boxes (wooden or plastic) or trays and finally covered with banana leaves and left to ferment for 5-7 days (Dulce et al., 2021). Although it is generally based on the experience gained over generations, the cocoa genotype, origin, production method, ear maturity, storage and frequency of turning the beans. (Moreira et al., 2018).

Incorporate non-conventional woods in the manufacture of cocoa fermenting boxes and evaluate their influence on the physical, chemical and sensory attributes of the cocoa bean, based on the structure of the components that each wood possesses.

Therefore, the purpose of this research is to evaluate the effect of fermentation of (Theobroma cacao L.) Nacional and Trinitario varieties in non-conventional wood boxes on the physical and sensory quality, physical-chemical variables will be evaluated before, during and after fermentation, as well as the sensory profile of the cocoa paste.

Methodology

The cocoa samples were harvested in the Fayta area, in the parish of San Carlos belonging to the canton of Quevedo in the province of Los Ríos, "La Represa" farm, whose geographical location is 1°03'18'' South latitude and 79°25'24'' West longitude at an altitude of 90msnm, property of the State Technical University of Quevedo.

A total of 36 kilograms of cocoa was used, 18 kg for each variety (Nacional and Trinitario) using 2 kg for each experiment.

Boxes were built with three types of wood: white Guayacán, pine and laurel. The size of each box was 0.15 x 0.15 x 0.40 meters, each box had a total of 12 boxes to facilitate turning.

A completely randomized design (CRD) with a factorial arrangement (3 x 2) was used, with three types of non-conventional woods (Laurel, Pine, white Guayacan) as factor A for micro fermentation and two varieties of Nacional and Trinitario cocoa as factor B, with 6 treatments and 3 replications for a total of 18 experimental units. Tukey's multiple range test ($p \leq 0.05$) was used to compare the means of the treatments.

Healthy cocoa cobs of the Nacional and Trinitario varieties were selected. Once the cobs were harvested, two cuts were made in the middle of the cob and two cuts in the upper and lower part of the cob, thus facilitating the extraction of the cocoa beans.

After obtaining the beans or cocoa beans, 18 kg of cocoa beans were weighed for each variety, then each variety was divided into 2 kg samples.

With the three wooden boxes (white Guayacán, pine and laurel), duly identified, the 2 kg samples were placed, occupying 6 of the 12 available compartments per box, and covered with banana leaves. After the first 48 hours had elapsed, the first turning was carried out, and then the turning was repeated every 24 hours until reaching 144 hours (6 days). (Dulce et al., 2021).

The drying method was carried out in a natural way, that is, it was exposed to the sun in a slow way; the first days it was dried in the sun for 2 or 3 hours the grains were removed, from the third day the drying hours were increased from 5 to 6 hours removing every hour for 5 days, to know if the drying was finished, samples of the almonds were taken to determine the percentage of moisture in the grain. (Instituto Ecuatoriano de Normalizacion INEN, 2013). In the drying process it is important to reduce up to 7% for its correct storage. (Chang, 2018).

All the samples from each micro fermenter were transferred to a clay pot where the almonds were roasted at a temperature of (120-135°C) for 25 minutes.

After roasting the cocoa beans, the shelling process was carried out manually, removing the husk that covers the beans.

The process was repeated several times to reduce the particle size of the cocoa beans also called Nibs, i.e. the more the grinding process was repeated, the more the cocoa began to release its fat content which was transformed into cocoa paste or cocoa paste.

To assess the percentage of fermentation of the beans, the cutting test was performed, for which 100 cocoa beans were randomly collected, weighed and cut longitudinally; and according to the internal physical characteristics, the fermentation percentage of the bean was determined according to INEN 176:2006. (Instituto Ecuatoriano de Normalización, 2006).

To determine the hydrogen potential, the following was done:

Pour 10 grams of sample in 90ml of distilled water in a beaker. The sample was mixed with the distilled water, the potentiometer was placed on the sample and proceeded to take the reading (Association of Analytical Communities, 2020).

It was taken 10 grams of sample, introducing it in a volumetric flask of 250ml, 50ml of distilled water was added, shaking vigorously. The titration was carried out with sodium hydroxide and phenolphthalein as indicator. (Instituto Ecuatoriano de Normalización, 2006).

The crucibles were placed in the oven for 30 min, in order to eliminate existing humidity in the crucibles, then 1 g of sample was weighed to the nearest 0.1 mg, and it was taken to the muffle at 600°C for three hours. After that time, it was left to cool in the desiccator for half an hour, weighed accurately and made the respective calculations. (Instituto Ecuatoriano de Normalización, 2013).

The samples were placed in an oven at 110°C for 2 hours, then they were left to rest in the desiccator for 20 to 30 minutes, 1 gram of sample was weighed and placed in the Goldfish fat extractor, applying the methodology indicated in INEN Standard 174 (Instituto Ecuatoriano de Normalización., 2013).

The sensory evaluation was carried out by trained tasters establishing the main characteristics of cocoa, among which specific flavor profiles were determined: fruity, floral, nutty, sweet; specific flavor profiles: bitterness, acidity, astringency, acquired flavors: green, mold, others.... (Vera et al., 2014).

Results

Table I shows the chemical analysis of cocoa paste, finding significant difference ($p \leq 0.05$) between the mean moisture for all types of cocoa and the different woods, the humidity is higher in Trinitario when fermented with pine wood; this difference may be due to the type of cocoa and the conditions of the wood, these studies are referenced by the standard NTE-INEN - 0623 (Instituto Ecuatoriano de Normalización INEN, 1988)on the quality of cocoa paste and mentioned by Sanchez in studies of cocoa powder who found that the humidity is higher in these types of products. (Sánchez et al., 2017).

Table I. *Chemical characteristics of cocoa mass.*

Level	Humidity	Ash	Grease	pH	Acidity
Cocoa Variety/ Wood Type					
T1 National/Laurel	2,07 c	2,97 b	49,31 a	5,62 b	1,17 b
T2 Trinitario/Guayacan Blanco	2,20 b	2,98 b	50,00 a	5,68 a	1,21 b
T3 National/Pine	2,26 b	3,18 a	49,27 a	5.75 ab	1,21 b
T4 Trinitario/Laurel	2,32 b	3,33 a	51,11 a	5,79 a	1,27 a
T5 National/Guayacan Blanco	2,39 a	3,37 a	50,43 b	5,80 a	1,34 a
T6 Trinitario/Pino	2,44 a	3,31 a	50,45 b	5,82 a	1,32 a
Average	2,28	3,19	50,09	5,75	1,25
V. Maximum	2,44	3,37	51,11	5,82	1,34
V. Minimum	2,07	2,97	49,27	5,62	1,17
C.V (%)	4,32	3,83	1,05	0,99	3,77

Means with a common letter are not significantly different according to Tukey (p>0.05).

V. Maximum= Maximum value.

V. Minimum= Minimum value

C.V.= Coefficient of Variation

Table I shows the chemical analysis of the cocoa paste, finding no significant difference ($p \leq 0.05$) between the mean ash for all types of cocoa and the different woods, but statistical differences are observed in the interactions of the ash being higher when the national cocoa is fermented with the white guaiac wood, these studies are referenced by Vargas when conducting studies of the roasting process of cocoa beans who found that the ash is superior in these types of process (Alegría-Vargas, 2015).

The chemical analysis of cocoa paste found significant difference ($p \leq 0.05$) between the mean fat for all types of cocoa and interactions, the fat is manifested superior with CCN 51 and CCN 51 interactions fermented with laurel wood , these studies are referenced by Vera Jaime when conducting studies of physical-chemical and sensory attributes of almonds of fifteen clones of national cocoa (Theobroma cacao L.) in Ecuador finding % fat lower than those reported in this study. (Alegría-Vargas, 2015).

Table I shows a significant difference ($p \leq 0.05$) between the mean pH for all types of wood and interactions, the pH is higher when fermented with pine wood and the interactions of CCN 51 fermented with pine wood, these studies are referenced by Vera Jaime when conducting studies of physical-chemical and sensory attributes of almonds of fifteen clones of national cocoa (Theobroma cacao L.) in Ecuador, finding the pH values similar to those reported in this study (Alegría-Vargas, 2015).

According to Ruíz, in the studies carried out in the Influence of the harvest time on the quality of the national type cocoa paste he obtained values similar to 5.05 and 5.86 and points out that as the days of fermentation advance the pH tends to decrease and stabilize at a value close to five, conversely the acidity increases as the fermentation process progresses (Ruíz et al., 2014).

There is no significant difference ($p \leq 0.05$) between the mean acidity for all types of cocoa and wood; there are only differences in the interactions, the acidity is manifested higher in the interactions of National fermented cocoa with Guayacan Blanco wood, these studies are referenced by Aguila when conducting studies of determination of cadmium and lead in cocoa beans, fresh, dried and cocoa paste (Theobroma cacao) finding the acidity values similar to those reported in this study (Del Aguila-Melendez, 2017).

According to Armijos 2002, studies on the characteristics of acidity as a chemical parameter of quality in samples of fine and ordinary cocoa (Theobroma cacao L.) of national production during fermentation, who in his similar work found titratable acidity between 1.2 and 1.6 %.6 %; he emphasizes that in order to obtain optimum acidity in the kernel, good fermentation management is very important, since during this process the acetic and lactic acids produced in the pulp are diffused towards the cotyledon, increasing the acidity of the internal fraction of the kernel. (Armijos, 2002).

Table II and graph 1 show the effect of the micro fermenter on the cocoa beans, finding a significant difference ($p \leq 0.05$) between the mean of the fermenter temperature for all types of cocoa, hours of fermentation and the respective interactions, the National cocoa variety is superior in the time factor at 24 hours and the interactions with the Guayacán Blanco wood National cocoa, These studies are referenced by Erazo when conducting studies of "design of a pilot fermenter and solar dryer for two varieties of cocoa (Theobroma cacao l), in the canton of El Empalme, Guayas province" which fluctuates between 23o and 48o C, finding similar values in this study. (Guachamín & Flores, 2007).

Table 2. *Effect of wood on the temperature of almonds in the micro-fermenter.*

Level	Media	Error Est.	L Lower	L Superior
Cocoa Variety				
Trinitario	38,44 b	0,695	37,0013	39,88
National	40,90 a	0,695	39,4613	42,34
Fermentation hours				
	35,68 c	1,219	33,14	38,23
	38.82 bc	1,219	36,27	41,36
	39.65 bc	1,219	37,11	42,19
	41.50 ab	1,219	38,96	44,04
	42,70 a	1,219	40,16	45,24
Wood type				
White guaiac	38,80 a	0,8517	37,038	40,56
Laurel	39,88 a	0,8517	38,118	41,64
Pine	40,33 a	0,8517	38,568	42,09
Cocoa variety/wood type				
T1 National/ Laurel	**40,38 b**	1,2	37,88	42,87
T2 CCN-51/Guayacán Blanco	**35,66 a**	1,2	33,16	38,15
T3 National/Pine	**40,38 b**	1,2	37,88	42,87
T4 CCN-51/Laurel	**39,38 b**	1,2	36,88	41,87
T5 National/Guayacan Blanco	**41,94 b**	1,2	39,44	44,43
T6 CCN-51/Pine	**40,28 b**	1,2	37,78	42,77
Average	39,67			
V. Maximum	41,94			
V. Minimum	35,66			
C.V (%)	4,72			

Means with a common letter are not significantly different according to Tukey (p>0.05).

V. Maximum= Maximum value.

V. Minimum= Minimum value

C.V.= Coefficient of Variation

Organoleptic analysis of cocoa paste.

Table II shows the organoleptic analysis of cocoa paste finding no significant difference (p≤0.05) between the mean cocoa for all types of cocoa and wood, the cocoa variable is manifested superior in the interactions of National fermented cocoa with Laurel wood, these studies are referenced by Alvarez when conducting evaluation studies of the sensory properties of cocoa paste (Theobroma cacao L.) obtained in artisanal and industrial form finding the values of cocoa similar to those reported in this study (R. Álvarez et al., 2018).

For the attribute of floral profile, no significant difference was found (p≤0.05) between the mean for all types of cocoa and wood, the cocoa variable is superior in the interactions of Trinitario fermented cocoa with pine wood, these studies are referenced by Sanchez when conducting studies of organoleptic characterization of cocoa (Theobroma cacao L.), for the selection of trees with flavor profiles of commercial interest finding floral values similar to those reported in this study. (Sánchez-Campuzano, 2007).

In reference to the Nut and Sweet attribute there is no significant difference (p≤0.05) between the means, for all types of cocoa and wood, the cocoa variable is manifested superior in the interactions of Trinitario fermented cocoa with Pine and Guayacan Blanco wood, these studies are referenced by Moreno when conducting evaluation studies of the physical and sensory characteristics of cocoa paste associated with planting models finding the values of nut similar to those reported in this study. (Moreno-Martínez et al., 2019)Saavedra, in his research on the collection and study of morphological and organoleptic characteristics in fresh fruit and liquor of cocoa trees (Theobroma cacao L.) with attributes of possessing fine and aroma characteristics", found sweetness values similar to those reported in this study. (Saavedra et al., 2017).

According to Amores, they argue that insufficient fermentation or lack of fermentation negatively influences the sensory quality of cocoa, therefore harvest times and fermentation percentages favor the appearance of specific aromas in most liquors. (Amores et al., 2006).

Regarding the sensory profile of specific flavors, no significant difference is found in the attributes of bitterness, acidity and astringency, the cocoa variable is superior in the interactions of National fermented cocoa with Laurel and Pine wood, These studies are referenced by Camacho when studying the influence of the percentage of clone CCN-51 on the physicochemical and organoleptic characteristics of cocoa paste from Pucacaca and Hujingoyacu", finding bitterness values similar to those reported in this study. (Camacho, 2014).

Regarding the sensory profile of flavors acquired for both the green and moldy variables, there is no significant difference (p≤0.05), coinciding with what was expressed by Bajaña in the study of the evaluation of the quality of Trinidadian cocoa almonds of national descent in the area of Vinces and Ramos, which states that the moldy flavor is due to the moisture of the almond during storage. (Bajaña, 2015; Ramos, 2004).

Table3. *Sensory attributes of cocoa paste.*

	Specific Flavor Profile					Basic flavor profile			Acquired flavors		
	Cocoa	**Floral**	**Fruit tree**	**Walnut**	**Sweet**	**Bitterness**	**Acidity**	**Astringency**	**Green**	**Mold**	**Others**
T1(Nac/L)	6,20 A	5,20 A	4,00 A	2,20 A	2,60 A	5,60 A	1,60 A	3,20 A	0,20 A	0,20 A	0
T2(Trini-Gb)	6,00 A	4,60 A	3,20 A	2,00 A	5,40 A	4,00 A	2,20 A	2,80 A	0,20 A	0,00 A	0
T3(Nac/P)	4,00 A	2,00 A	2,20 A	2,20 A	2,80 A	5,60 A	3,20 A	4,40 A	0,40 A	0,60 A	0
T4(Trini/L)	3,80 A	5,40 A	2,40 A	1,60 A	2,60 A	4,80 A	2,80 A	3,60 A	0,40 A	0,40 A	0
T5(Nac/Gb)	4,80 A	4,40 A	1,00 A	2,40 A	2,00 A	4,20 A	2,80 A	4,60 A	0,20 A	0,20 A	0
T6(Trini/P)	5,60 A	5,60 A	1,60 A	2,60 A	2,20 A	5,00 A	3,80 A	4,20 A	1,40 A	0,00 A	0
Media	5,06	4,53	2,40	2,16	2,93	4,86	2,73	3,80	0,46	0,23	0
CV (%)	13,89	2,86	32,81	11,98	30,95	11,29	21,9	14,02	77,97	73,29	0

Means with a common letter are not significantly different according to Tukey (p>0.05).

Nac/L= National Cocoa, laurel fermenter.

Trini-Gb = Trinitario cocoa, white Guayacan fermenter.

Nac/P= National Cocoa, Pine fermenter

Trini-L = Trinitario Cocoa, Laurel fermenter

Nac/Gb= National Cocoa, white Guayacan fermenter

Trini-P = Trinitario Cocoa, Pine fermenter

C.V.= Coefficient of Variation.

Cutting test on almonds

The analysis of the cutting test that was performed on the almonds once fermented, taking 100 almonds at random for each treatment, making a longitudinal cut to classify them according to the almond corresponding to the type of fermentation and the type of defect present, based on the technical standard for the fermentation of cocoa INEN 176:2006, managing to identify the maximum and minimum percentage of well-fermented almonds, medium fermented, violet, slaty. Broadly speaking, it can be deduced that the three types of wood (Pine, White Guayacan, Laurel) are suitable for the good fermentation of the almonds, within the violet beans it was observed that they did comply with the maximum of 21 almonds as established by the standard, however, However, it was found that the slate beans exceeded the range established by the standard, which is a maximum of 12, this problem is located in greater proportion in the Guayacán Blanco and Pino woods in the two varieties of cocoa, with the National cocoa in Laurel being the only one that remains within the established parameters.

According to (Ortiz et al., 2009)in their study, they detail that the physical quality indexes of dry kernels are related to the degree of maturity of the almonds, i.e., cobs that are not completely mature give rise to insufficiently fermented, violet and slaty kernels. According to (C. Álvarez et al., 2010)in his research, he observed a good degree of fermentation according to the quality cut test, obtaining more than 80 % of fermented and dry kernels at different intervals in the removal of the dough (every 24 hours during the five days of fermentation).

Conclusions

Through the fermentation of the almonds, the maximum temperature (44.52°C) was obtained in the third micro fermenter with the National cocoa variety in Pine and Laurel wood, while the minimum temperature was (35.66°C) with the first micro fermenter in the CCN-51 variety with White Guayacan wood.

In the aspect of the sensory analysis of the cocoa paste in the profile of specific cocoa flavors, T1 (Nacional-Laurel), Floral T6 (CCN-51-Pino), Sweet T2 (CCN-51 GB) obtained better attributes, in the basic flavor profile, T1 and T3 (Nacional-Pino) presented high average bitterness, T6 has an average acidity in the cocoa paste, T5 (Nacional-Guayacán Blanco) obtained an average in astringency and acquired flavors Green and Mold, T6 and T3 presented high averages in the cocoa paste.

Within the bromatological analysis the cocoa paste presented a higher percentage of moisture in CCN-51-Pine, while in ash has a high average in National cocoa with Guayacán Blanco wood, in fat presents a high percentage in cocoa CCN-51 in Laurel; the pH of the cocoa paste is high with CCN-51 in Pine, the cocoa paste presents a high percentage in acidity in the National variety with Guayacán Blanco wood.

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