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Research Article

Sensory and Physical Evaluation of Cocoas (*Theobroma cacao L.*) From Different Countries for its Use in a Gourmet Chocolate

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Abstract

The genetic origin and the climate surrounding the plantation help cacao fruits developing their sensory quality and those of the final chocolate flavor. The postharvest procedure is also influential in the sensory quality of the cocoa derivatives. The physical properties and sensory profile of cacao beans after the postharvest have to be evaluated to guaranty the chocolate sensory quality. The evaluation has be done using formats to compile the information described in the national and international norms and literature. The objectives were to design formats and protocols to evaluate and compare physically and sensorial the cocoa beans from different world regions to select the best cacao with citric notes. From physical characteristics data, was selected the cocoa with the best quality. Once selected, it was applied to the roasting protocol to obtain cacao liquor. On the cacao liquor, using descriptive analysis of the taste descriptor profile was determined the sensory profile. The data have shown that the formats designed facilitate compilation and calculation of data obtained from the cocoa. Barinas cacao has shown the best flavor characteristics for its use in the elaboration of gourmet chocolate with citrus notes.

Keywords: Cocoa Sensorial Notes; Cutting Test; Chocolate; Citrus Notes

Introduction

The genetic origin and the climate surrounding the plantation help cacao fruits developing their sensory quality and those of the final chocolate flavor. The postharvest procedure is also influential in the sensory quality of the cocoa derivatives, making them fine flavored. Venezuelan cocoa is recognized as 100% fine-flavored [1-5]. Just curious what referring system are you using? The Venezuelan cocoas have quite diverse flavor notes as a function of the cultivation region. Cocoa beans grown in Uganda, Tanzania, Dominican Republic, Ecuador, and Venezuela have similar sensorial characters in terms of flavors and aromas (fruit, citrus, wood, earthy, and almond). Later in your methods, I see you mentioned USA, here simply mention all the countries that you worked in. It should be

of interest identify, which of the cocoas have the fine flavors composition with specific notes, such as; citrus or floral to elaborate a chocolate gourmet. Therefore, it is necessary to evaluate them in their physical and sensory characteristic using formats to compile the information described in the national and international norms and literature to select the best cacao [6-8]. The cacao's physical and sensory properties have to be evaluated as a guarantee of chocolate sensory quality. The goals of the study were to design formats for the identification and calculation of physical properties of the cacao bean and the identification of the aromatic notes of the cocoa liquor. Also to applied these formats to compile the physical identification, the cutting test parameters, and sensory analysis on the different regional cocoas, to select the cocoa with the best sensory quality to be used on the recipe for the elaboration of gourmet bars with floral and citrus notes.

Materials and Methods

Materials

Cocoa (*Theobroma cacao*) beans from Uganda, Tanzania, Dominican Republic, Ecuador (Super Tree and CCN51) and Venezuela (Choroní, Aragua state and Barinas, Barinas state).

Methods

Moisture content

Moisture content was determined by using the AgraTronix (coffee tester), according to the equipment manual.

Beans grading

- Design of the format for data compilation from the physical test compilation
- Physical identification

It was done the physical analysis of the cocoa beans, from the five countries. Weight of beans (n ≥ 30), weight of 100 grains, and number of grains in 100 grams of cocoa beans were calculated. External defects as; twin, flat, shrunk, and germinated beans, were accounted. The percent of impurities (pieces of shell or grain), and the foreign material (brand, leaves, stone, and other materials different from the cocoa) were also evaluated [6]. All results were registered in table 1.

Cocoa identification					
Date					
Sample origin					
Sample identification					
Weight sampling sample					
Weight analysis sample					
Fermented and sundried cocoa beans analysis					
The average weight of grain (n≥30)	Replica 1	Replica 2	Replica 3	Means	
Moisture content					Cocoa paste preparation Protocol for sensorial analysis.
Weight of 100 beans					
Number of beans in 100 gram					
Descriptive analysis of external defects					
	Replica 1	Replica 2	Replica 3	Means	
% Multiples/twin					
% Flat					
% Shrunken					
% Germinated					
% worm-infested					
Atypical Material					
	Replica 1	Replica 2	Replica 3		
% Impurities					
% Foreign material					
Internal defect. Cutting Test					
	Replica 1	Replica 2	Replica 3	Means	
% Moldy					
% Slaty					
%Violet					
% Partially violet					
% Light breaking					
% Worm infested					
% Fermentation					
Beans sensorial					
Foreign odor					
Color					
Odor					

Table 1: Format for identification of the cocoa and description of the evaluated parameters.

Cutting test

Fifty grains from the sample were cut by half lengthwise so that the maximum surface area of the husked grain was examined naked eye in daylight. Each grain with more than one defect was classified exclusively in a defective category [6].

To visualize inside of the grain, determine the degree of fermentation of the batch, and identify the bean's internal defects as mold infection, insect infestation, slaty beans, violet and partially violet beans, light breaking beans, the cutting test was done. Once performed the cutting test, the percent of fermented beans was calculated. All results were was registered in a table as described in table 1.

The selected and cleaned cocoa beans were roasted at 110°C for 15 minutes. The roasted beans were hand dehulled to obtain the cocoa nibs. The nibs were milled to produce the cocoa paste with a granulometry of 75µ. The cocoa paste was stored at 40°C in a hermetically sealed container until to be analyzed.

Sensorial analysis

The sensory analysis was done by a descriptive analysis of taste descriptor profile as follows the method described by Hernández Alarcón.in 2005 using the modified format for taste descriptor profile from the descriptive analysis as described in table 2.

The cocoa beans from Uganda, Tanzania, and the Dominican Republic were evaluated in New York City, USA for two semi-trained panelists in an environment lit and conditioned to develop the objective. Cocoa beans samples from Ecuador (CCN51 and Super-Tree) were equally settled and analyzed in the sensory evaluation area of the Finca Saquifrancia in Puyo, Ecuador, and the cocoa from Venezuela (Choroní and Barinas) was evaluated at the chocolate company Cakawa laboratory, both by semi-trained panelists.

Protocol for the preparation of cocoa paste for sensory analysis

A minimum of 1 kg of fermented and dried cocoa beans is recommended to roast and prepare the paste sample for the sensory analysis. The nibs sample weight must be between 200 and 700 grams to achieve a representative profile.

Descriptive Analysis/ Taste Descriptor Profile

Name: _____Date_____

Product Name _____

Procedure:

In front of you is a sample of cocoa paste at 37-40°C. Observe the sample and evaluate the color and brightness of the cocoa paste, writing your observation below:

Color_____

Brightness_____

Touch and rub it between the fingers and check if the paste is dry or creamy. Smell the pasta and write down what is perceived.

Texture and odor perceived_____

Clean the palate with water at room temperature or unsalted soda cracker. To taste the cacao paste, place a third of the sugar in the spoon according to the amount of liquor to tasting. Example 70/30 or 60/40; cocoa paste: sugar. Taste the pasta/sugar, savoring flavors perceived making the procedure twice. Mark with an X (from 1 to 10) in the box, the term that best describes your tasting in the sample.

Taste descriptor	1	2	3	4	5	6	7	8	9	10
Caramel										
Floral										
Fruity										
Bitter										
Astringent										
Woody										
Citric.										
Chocolate										
Sea										
Tobacco										

Comments_____

Thanks

Table 2: Format for sensorial evaluation of cocoa by descriptive test (modified from Hernández Alarcón, [8]).

The cocoa beans were roasted at 110°C for 15 minutes. The beans were removed and quickly cooled once roasting time has been completed. Once the beans are roasted and cooled, were dehulled (removing the shell). The cacao beans were fragmented and unshelled to obtain the nibs. The nibs were crushed by a grinding process, transforming them into the liquid paste called cocoa liquor or paste [9].

Results and Discussion

Fine flavored beans are used by makers of high-quality fine chocolates. The cacao bean's color and flavor are quite necessary for these chocolate makers and users. Usually, these manufacturers establish and maintain direct contact with the farmers, to extent they plan directly from a farm or plantation. This practice is upon approval of a pre-shipment sample, retaining the right of refusal on delivery (with a replacement clause) [6].

The postharvest protocols include several steps; among them are fermentation, and drying [10,11] both of them are unitary operations that influence the cocoa bean's flavor quality. It means, that during the postharvest process is needed to apply good manufacturing practices (GMP) to guarantee the final product quality. Even if the beans are coming from genetic fine flavored cocoa plants, the absence, or deficient fermentation, for example, could change the final flavor of the chocolate. Therefore, the postharvest parameters to be analyzed are the degree of fermentation, drying, acidity, off-flavors, percentage of internal mould, insect infestation, and percentage of impurities.

Cocoa physical quality analysis

Moisture content, typification of the physical properties, and the cut-test are necessary analyses for grading and standardization of the cacao quality. Grading of the physical properties, looking for external and internal faults using the cut-test are parts of the control and quality assurance of the cocoa beans. These faults contribute to the fermentation degree calculation.

Moisture content and typing of the physical properties

The beans average size, the average percentage of beans showing faults, the degree of fermentation, and the organoleptic characteristics of the cocoa are necessary parameters to define to its final quality. Table 3 shown data from the cut-test of cocoas from the seven regions.

Cocoa identification from different countries							
Sample origin	**Uganda**	**Tanzania**	**Dominican Republic.**	**Ecuador**		**Venezuela**	
				Super tree	**CCN51**	**Barinas**	**Choroní**
Date	17/09/2020	17/09/2020	17/09/2020	16/09/2020	16/09/2020	7/10/2020	7/10/2020
Sample identification	Distrito de Bundibugyo	Valle Kilombero	Provincia de Duarte	Puyo, Ecuador	Puyo, Ecuador	Estado Barinas, Venezuela	Estado Aragua, Venezuela
Weight sampling sample (grams)	352	330	322	415	595	421	303
Weight analysis sample (grams)	300	300	100	300	300	300	300
Fermented and sundried cocoa beans analysis							
Weight of a grain (grams) (n≥30)	1.2	1.1	1.07	1.0	1.98	140	1.01
Moisture content (%)	5.30	6.70	5.70	7.4	7.3	7	8
Weight of 100 beans (grams)	117	110	107	135	198	155	101
Bean count in 100 grams	85	90	93	74	50	65	99
Descriptive analysis of external defects							
% Multiples/or cluster	0	0	0	0	6	0	0
% Flat	0	0	6	14	4	0	0
% Shrunken	0	0	0	10	11	0	0
% Germinated	0	0	0	0	0	0	0
% worm infested	0	0	0	0	0	0	0

Atypical Material							
% Impurities	0	0	0	0	0	0	0
% Foreign material	75	0	0	1	0	0	0
Internal defect-Cut-Test							
% Moldy	0	0	0	5	4	0	0
% Slaty	13	12	10	15	12	2	15
%Violet	5	7	5	21	17	12	2
% Partially violet	10	19	4	10	16	14	33
% Worm infested	0	0	0	0	0	0	0
% Fermentation	73	62	75	26	32	72	49
Beans sensorial							
Foreign odor	Non detected	Non detected	Non detected	Non detected	Non detected	Non detected	Non detected
Color	Dark brow/ Dark caramel	Dark brow	Light brown	Dark cafe	Dark cafe	Brown reddish	Light Brow
Odor	Red fruit chocolate	Fruit/Chocolate	Nut/Chocolate	Floral	Woody	Acid. floral and caramel	Sweet/ chocolate
Taste	Blueberries	Citrus/orange	Nuts/Almond	Fruit/floral	Woody/fruit	Raisin	
Cocoa paste preparation protocol for sensorial analysis: 110°C during 15 minutes							

Table 3: Average of the quality parameters of cocoa beans from the seven different regions (n ≥ 3).

As described by several national and international grading standards, the optimal moisture content must vary from 7 - 8% [6,7]. However, as was reported by ICCO in 2014, to ensure the quality of the bean, the moisture content shall be less than or equal to 7.5%.

Moisture results shown in table 3 varied in the range of 8% (high) to 5.3% (low). A low moisture content (less than 7%) produces broken beans, with the consequent loss of bean fragments, which are considered as impurities, increasing the broken beans. Both parameters are considered faulty beans. In contrast, a high moisture content higher than 7.5% in the bulk of the beans increase the moldy contamination and consequent toxins production. Besides, a high percent (higher than 3%) of moldy beans produce off-flavor in the final product. The cocoa from Barinas, Venezuela, and the two from Ecuador shown the optimal moisture content.

The average size of one bean is usually derived from the number of beans used to make up a given weight or the average weight in grams of 100 beans. This is referred to as the beans count. The method does not directly measure the size of the bean but relies on the natural fact that larger beans weigh more than small ones. Larger beans are preferred as the nib to shell ratio is higher. As is shown in table 3, the average weight of 100 cacao beans varies from 107 grams; show by the Dominican Republic cacaos to 198 grams presented by the Ecuadorian, CCN51. According to COVENIN 2016 to be classified as fine flavored, the mean weight of 100 cacao beans must be higher than 115 grams. Then the Barinas from Venezuelan (155 grams), the two from Ecuador (135 and 198 grams respectively), and those from Uganda (117) meet this requirement.

All cocoa beans from the different regions have a bean count of less than 100. It categorizes them as grade 1, according to certain norms national e international [6,7,12].

External faults such as flat and shrunken beans come from harvested immature pods. The flat cocoa bean has cotyledons too thin

to be cut to give a full length of the cotyledon surface. The cotyledons with low development produce a flat or shrunken bean after they are dried. Two beans or a cluster fused that cannot be separated by hand come from poor turning practice during the fermentation or dried procedure. Only the beans from the Dominican Republic and those from Ecuador shown these external faults.

Externally mouldy contamination, insect-damaged (visible beans to the naked eye,) and germinated beans were not found in any of the samples assayed.

Cut-test

The cut-test determines the internal faulty in the cocoa beans. There are two main categories of faulty beans; beans that show a certain amount of fermentation and beans that have been eaten by insects and/or contaminated by mould [6,7].

The degree of fermentation is shown by the color of the cotyledons. Cocoa beans fermented are those, where the color of the cotyledons have naked eye grooves, be fully brown (light or dark) and with chocolate notes. In the fermentation of most cocoa bean types, the cotyledons start a grey, slaty color. Then they turn purple, and finally becomes dark brown (breaking dark), if they are from trinarios o forasteros types, or light brown (light breaking) if they come from a Criollo type.

In the cut-test, it is required the number of purple or violet beans to be noted and the count of internal defective beans to calculate the fermentation degree. It was found in all of the samples assayed, referred to as internal defective beans; such as mouldy contaminated and insect-damaged beans (visible to the naked eye and observed by stereoscopy), and germinated beans. All defects are deducted from 100 to obtain the percentage of fermentation. Uganda with 73% of fermentation, Tanzania with 62%, the Dominican Republic per 75%, Ecuador showing 26 and 32% (Supertree and CCN51 respectively), and Venezuela with 72 and 49 (Barinas and Choroní, respectively) According to the Venezuelan norm [7], the cocoa from the Dominican Republic is fine flavored cocoa, with 75% fermentation. However, as previously postulated, the post-harvest unitary operations also have deep influence on the cocoa beans' flavor quality, and they also may define them as flavored fine cocoa.

Cocoa sensorial analysis

The grain quality is a factor important in the evolution of world commerce for cacao. Quality in cacao is mainly associated with its fine or flavor properties. The world cocoa market distinguishes between two broad categories of cocoa: "fine or flavor" cocoa beans and "bulk" or "ordinary" cocoa beans [13]. Therefore, cacao sensory quality is a factor that needs to be emphasized in the type of grain supplied and on the price-fixing.

Table 2 and figure 1 shown the descriptive sensorial notes of the cacaos from the seven regions of the world. As can be seen the cacaos from Barinas, Venezuela, even though, they are not commercially recognized are the most flavored cocoa with a high note of caramel, fruit, woody, and citric. The Barinas cacao with the bigger size of its beans (65 beans count in 100g), also dominates the physical cocoa quality parameters analyzed in this study. They show 7% moisture content, 72% fermentation with acid, floral and caramel odor, and raisin taste. Barines cacaos show the properties to be considered for the elaboration of gourmet chocolate with fruity and citric notes.

Taste Descriptor Scale 0 to 10	Caramel	Floral	Fruity	Bitter	Astringent	Woody	Citric	Chocolate	Sea	Tobacco
Uganda	7	0	5	0	1	8	0	8	0	0
Tanzania	0	0	7	0	6	0	6	0	0	0
Dominica Republic	0	0	7	0	6	0	6	4	0	0
Ecuador/Super Tree	4	8	4	2	0	0	0	0	0	0
Ecuador/CNN 51	0	8	0	3	4	7	2	0	0	0
Venezuela/Barinas	10	7	9	3	1	2	7	0	0	4
Venezuela/Choroni	2	3	7	0	0	7	7	0	0	4

Table 4: Descriptive sensorial notes of the cocoa from the seven regions (n ≥ 3).

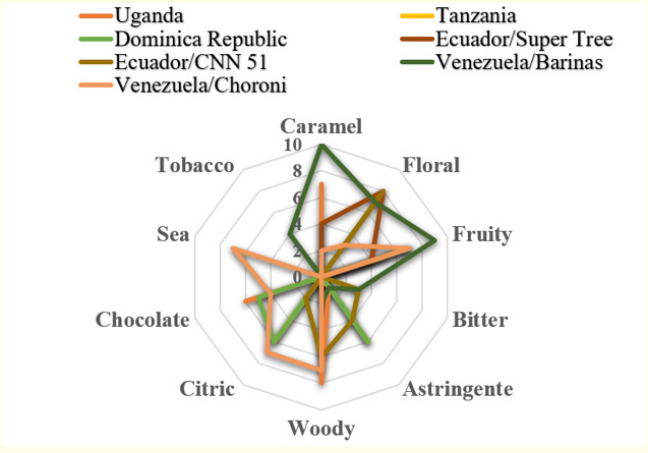

Figure 1: Graphical representation of the descriptive sensorial notes of the cocoa from the seven regions (n ≥ 3).

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Conclusion and Recommendations

Cacao physical and sensory quality analysis are the best methods to elucidate the best cocoa as raw material. The two tools used in this study (Table 1 and 2), facilitate the analysis of the data and calculation of the best indices, which are generated from the analysis of cocoa and are applicable for its use in the fine-flavored gourmet chocolate elaboration. The Barinas cacao showed the best properties to be used for fruity and citric flavored gourmet chocolate. It is recommended, to elaborate on the gourmet chocolate and perform a descriptive sensory profile on it.

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