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EFFECT OF ROASTING AND GRINDING ON THE PROPERTIESOF COCOA BEANS (THEOBROMA CACAO LINNAEUS) AND DERIVATIVES: CASE OF THE MIRANDA STATE PROCESSING PLANT, VENEZUELA.

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Summary

A study of the physicochemical and organoleptic variables of the cocoa bean and its derivatives was proposed in order to make modifications in the parameters of the processes involved, achieving a product without processing defects for processor A in Miranda state, Venezuela. The research applied the Venezuelan COVENIN standards (1315-79, 374:1995, 442:2016; 1480:1998) for the physicochemical study of cocoa beans (cut test and moisture), unroasted and roasted nibs (moisture and pH), and cocoa liquor (moisture, fineness and pH); and sensory analysis of flavor, odor, color and texture of cocoa beans and derivatives with a panel of tasters, both studies were applied to samples from two cocoa processors (processor A and processor B) in order to compare them. As relevant results, in the sensory analysis, an evident over-roasting was obtained in processor A when compared to processor B. In the physicochemical analysis, a cocoa liquor moisture content (final product) of 0.8935%, a pH of 5.64 and a fineness of 52.5 µm was obtained for processor A; and for processor B, 1.77% moisture content, a pH of 4.96 and a fineness of 79.5 µm. Once the properties were evaluated, changes in the operating parameters such as temperature and roasting time were suggested, depending on the genetics and humidity of the grain; in the case of milling, the results do not allow considering a change in the process parameters.

Key words: Cocoa, Roasting, Milling, Physicochemical variables, Organoleptic variables.

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Abstract

A study of the physicochemical and organoleptic variables of the cocoa bean and its derivatives was proposed in order to generate modifications in the parameters of the processes involved, and thus achieve a product without process defects for cocoa processor A in the state of Miranda, Venezuela. The Venezuelan COVENIN standards (1315-79, 374:1995, 442:2016; 1480:1998) were applied for the physicochemical study of the cocoa bean (cut and moisture test), unroasted and roasted nibs (moisture and pH), and cocoa liquor (moisture, fineness and pH); and sensory analysis of flavor, smell, color and texture of cocoa beans and derivatives was done with a trained panel; both studies were applied to samples from two cocoa processors (cocoa processor A and cocoa processor B) in order to compare them. As relevant results, an evident “over-roasted” was obtained in the sensory analysis in cocoa processor A when compared with cocoa processor B. In the physicochemical analysis, a humidity of cocoa liquor (final product) of 0.8935%, a pH of 5, 64 and a fineness of 52.5 µm was obtained for processor A; and for processor B 1.77% humidity, a pH of 4.96 and a fineness of 79.5 µm. Once the properties have been evaluated, changes were suggested in the operating parameters such as temperature and roasting time, according to the genetics and humidity of the grain. In the case of grinding, the results do not allow considering a change in the process parameters.

Keyword: Cocoa, Roasting, Grinding, Physicochemical variables, Organoleptic variables.

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INDEX

Introduction

Currently, the global demand for fine aroma cocoa has increased rapidly; countries such as France, Switzerland, Spain, Portugal, Japan, the United States and others have become the first consumers of fine cocoa, so they demand the best quality cocoa, investing in those countries that produce it (Quintero and Diaz, 2004).

The term “fine aroma” is a categorization of the International Cocoa Organization (ICCO, 2010), which describes a cocoa of exquisite aroma and flavor; Venezuela has the privilege of producing 95% of fine aroma cocoa (International Cocoa Organization, n.d.), due to the prodigious conditions of climate and soil composition, being an export product.

It is important to mention that the lineage (genetic line) for Theobroma Cacao, depends on its subspecies, and have been classified into three groups: Criollo, Forastero and Trinitario (hybrid between Criollo and Forastero) (Observatorio del Cacao, 2018). In Venezuela, cocoa has a great genetic diversity that attributes scents and flavors with unique fruity and aromatic notes, where according to Crespo (2016) from Zulia to Sucre, each town is a denomination of origin of Venezuelan cocoa. These characteristics make Venezuelan cocoa recognized worldwide as one of the “finest”.

It should be taken into account that the post-harvest processes of fermentation, drying, and industrial roasting and grinding processes, which are carried out for the production of cocoa liquor, attribute changes to the bean that must be rigorously evaluated (Suazo, 2012). Roasting and grinding are processes carried out by cocoa processing companies, and in Venezuela, these companies are in constant research to preserve the characteristics of a “fine” cocoa, in order to maintain international renown.

Cocoa derivatives, such as nibs or cocoa liquor, can lose their fine aroma characteristics if their post-harvest or industrial processing is not adequate, being the roasting stage the one that allows the development of cocoa aroma (Vera et al., 2021). In Venezuela, there is little published research on the changes in the initial characteristics of the cocoa bean due to the industrial process it undergoes to become cocoa liquor. In this sense, it has been proposed to evaluate the change produced by the roasting process on the physicochemical properties and on the fatty acid profile of cocoa beans (Álvarez et al. 2012). Knowing and specifying the composition of a food product is important as it allows controlling the quality, assessing the nutritional content, giving confidence to the consumer, so it is a requirement of labeling (Sanchez et al., 2016). Regarding the instruments for sensory evaluation to classify Venezuelan cocoa and its derivatives, Gómez et al. (2013) constructed a flavor and odor wheel to catalog, with a trained panel of tasters, the odors and flavors of Venezuelan cocoa. The temperature and duration of the roasting process can influence the final product, and can alter its flavor by excessive or insufficient roasting (Suazo, 2012; Di Giacobbe, 2011; Molina, 2018). Similarly, the grinding process, its speed and duration can influence the consistency and fineness of the cocoa liquor (Arriagada, 2013; Beckett, 2009; Industria Alimenticia, 2012); hence the importance of monitoring through physicochemical analysis and scientific observation of both stages.

Based on the above, the effects of the roasting and grinding process on cocoa beans at processing plant A in Miranda State, Venezuela, are analyzed. To achieve this objective, the physicochemical and organoleptic properties of cocoa beans, unroasted and roasted nibs, and cocoa liquor are evaluated in order to verify the control parameters in roasting and grinding. The physicochemical analysis is supported by official methods for the food industry, coming from the Venezuelan COVENIN standards (1315-79, 374:1995, 442:2016; 1480:1998). According to García (2014) and Chavarrias (2016), sensory evaluation is considered as the examination of the sensory attributes of a product achievable with the human senses, which includes evaluation of the appearance, flavor, aroma and texture of a food or raw material; this represents an important tool to determine the changes that can be perceived by the human senses in the cocoa bean originated by industrial processes and can be evaluated with instruments such as taste or odor wheels (Gómez, et al., 2013).

Methodology

By its nature the present research is a quantitative study (Monje, 2011), according to the scope it is a descriptive study (Namakforoosh, 2005), it is a field research (Sierra, 2012) and documentary (Martínez, 2017).

Variables and operationalization

The variables considered in the study are the physicochemical and organoleptic properties for cocoa beans and their derivatives, where the procedures described in the standards or works indicated below are used as a method of determination.

Physicochemical properties and lineage: a) Shear test (COVENIN 442:1995). b) Humidity (COVENIN 374:1995). c) pH (COVENIN 1315-79). d) Fineness (COVENIN 1640:1980 and COVENIN 1480:1998).

Organoleptic properties: a) Odor (Gómez et al., 2013). b) Color (COVENIN 442:2016, Hex Code (Source: Encycolorpedia)). c) Flavor (Gómez et al., 2013). d) Texture. Peruvian Technical Standard NTP-ISO 5492 2008.

Process variables: a) Roasting temperature and time. b) Grinding speed and time.

Population and sample

For this work, the sample was taken according to the product. For cocoa beans, the procedure described in the Venezuelan standard COVENIN 1339:1995 was used. In the case of unroasted and roasted nibs and cocoa liquor (natural), an approximate natural sample of 200 g - 300 g per batch was taken with the corresponding sampler for each equipment for each load in processing company A.

Technique and Instrument

The instruments and techniques used were: 1) Structured and non-participant (spectator) direct observation. 2) Flow diagram to learn about the production process of the cocoa processing plant in Miranda state. 3) Cause-effect diagram, a technique that allows defining how the variables of the products to be analyzed depend on process variables.

Research Design

The study included the following phases:

Bibliographic review: documentary research to gather information on the subject, using sources such as previous research in the Venezuelan cocoa field (scientific journals and graduate studies), regulations for the food sector (Venezuelan COVENIN standard, ISO technical standards and the quality requirements of the chocolate and cocoa industry by the European Cocoa Association, Caobisco & Federation of Cocoa Trade).

Visualization and recognition of the plant's processes: a tour of the plant of processing company A in Miranda state to observe the process stages and identify the variables and control parameters of the cocoa roasting and grinding processes. The cause-effect analysis of cocoa liquor production was applied to identify the variables that have the greatest impact on the physicochemical and organoleptic characteristics.

Training in the test equipment to be used and collection of samples for testing: The test equipment used for the determination of the physicochemical properties of cocoa beans and their derivatives are located in the Quality Control Management Systems Laboratory of Processor A. The equipment used are: 1) Guillotine for cocoa beans and their derivatives. The equipment is as follows: 1) Guillotine for cocoa beans. 2) Oven. 3) pH meter. 4) Micrometer screw and 75 µm sieve. 5) Samples of products (cocoa beans, roasted nibs and cocoa liquor) belonging to other cocoa processing companies were received through a mutual agreement between the companies.

Preparation of the organoleptic tests: as a standard for Venezuelan flavors in cocoa and its derivatives, the flavor and aroma wheel proposed by Gómez et al. (2013) was used to create a tasting card following the model of the spreadsheet proposed by Burgos et al. (2017). The Hex Code (Source: Encycolorpedia) was integrated to this form to code color, and the Peruvian Technical Standard NTP-ISO 5492 2008 to evaluate texture, which determine the "measurement" of organoleptic variables. With the resulting file, several tastings were carried out with the panel composed of the Quality Control Management System personnel of processing company A, made up of eight people. After carrying out the sensory evaluations with the formulated form, the sensory profile was made for each sample, in which the coincidences answered by the panelists according to the sample were taken, where certain panelists are better calibrated for certain types of notes (floral, vegetable, chemical, animal or microbiological), therefore the cards answered by these calibrated panelists are more outstanding than other cards answered by individuals who are not so sensitive to certain aromas or flavors.

Experimental determination of physicochemical characteristics and lineage: the characteristics obtained were determined according to the Venezuelan COVENIN standard and the measurement repetition for each of the variables according to ISO 17025. General requirements for the competence of testing and calibration laboratories. 1) Shear Test (COVENIN 1339:1995 and COVENIN 442:1995). 2) Humidity (COVENIN 374:1995). 3) pH (COVENIN 1315-79). 4) Fineness: 5g of cocoa liquor sample was used at 60 °C and 5g of kerosene was added to degrease the sample, dried at room temperature and then the remaining particles were measured with the micrometer screw.

Analysis for the determination of process variables, tabulation and analysis of results: the presentation of the data is in tables, the data collected for each physicochemical variable of the cocoa beans, unroasted nib, roasted and cocoa liquor, are classified according to their production zone (Guárico, Monagas, Mérida and Sucre) and whether they are products of processor A or processor B, in order to perform a descriptive analysis. The central tendency (mean) was calculated for the different measurements of physicochemical variables (Mellado, n.d.). The results are then compared for the different origins (cocoa beans), and between processor A and processor B (unroasted nib, roasted, and cocoa liquor). Finally, the process variables that need to be modified according to the results obtained are determined, with the final objective of achieving the desired organoleptic characteristics for each of the products treated by processor A in Miranda State.

Results and Discussion

The different cocoa bean production zones in the country considered in this study are: Guárico, Monagas, Mérida and Sucre. Table 1 below shows the results of the physicochemical characteristics for the samples of cocoa beans, unroasted nibs, roasted nibs and cocoa liquor. The cocoa beans from Guárico and Monagas were processed by company A, while the beans from Mérida and Sucre were processed by company B, both from the state of Miranda.

Table 1. Sample of cocoa beans and derivatives from different origins.

Sample Type	Cut-off test (Lineage)	Humidity (%)	pH (-)	Fineness
Name: Monagas170119. From: Monagas				
Cocoa beans	Creole: 0.45%. Trinitario: 72.66%. Outsider: 26.89%.	9,40%	-	-
Unroasted Nib	-	1,96%	5,29	-
Nib roasted	-	1,42%	5,31	-
Cocoa liquor	-	0,98%	5,72	99.89% 75μm sieve. Micrometer screw 56μm
Name: Guarico270219. Country of origin: Guárico.				
Cocoa beans	3.34% Creole 63.77% Trinitario 32.89% Outsider	8,79%	-	-
Unroasted Nib	-	1,29%	5,03	-
Nib roasted	-	0,37%	5,14	-
Cocoa liquor	-	0,76%	5,56	99.36% 75μm sieve. Micrometer screw 49μm
Name: Surdellago. Provenance: Merida.				
Cocoa beans	Creole: 100%. Trinitario: 0%. Outsider: 0%	8,40%	-	-
Nib roasted	-	2,09%	4,75	-
Cocoa liquor	-	1,40%	4,90	Micrometer screw 81μm
Name: RioCaribe. Origin: Sucre.				
Cocoa beans	Creole: 13.67%. Trinitario: 54.66%. Outsider: 31.67%.	7,80%	-	-
Nib roasted	-	1,44%	4,80	-
Cocoa liquor	-	1,72%	5,03	Micrometer screw 78μm

For cocoa beans, lineage and humidity are considered. In terms of lineage, the cocoa beans processed are mostly Trinitarios and Forasteros; while in relation to moisture, the beans from Guárico and Monagas have higher moisture than the beans from Mérida and Sucre, which infers that there are differences in post-harvest drying practices for these areas of the country. In this sense, for cocoa beans with humidities between 9 - 10%, the nib roasting process can be used at 120°C for 3 min; while for cocoa beans with humidities below 8%, it is suggested to follow the indications according to bean genetics (Molina, 2018).

In the case of unroasted nibs, samples were only obtained from the processing plant in Miranda state. There is a difference in pH, where the sample of unroasted nibs from Guárico has a higher acidity than the sample from Monagas. As for moisture, the sample from Monagas, which had more moisture in the grain, is the one with the highest moisture as unroasted nibs, compared to the sample from Guárico.

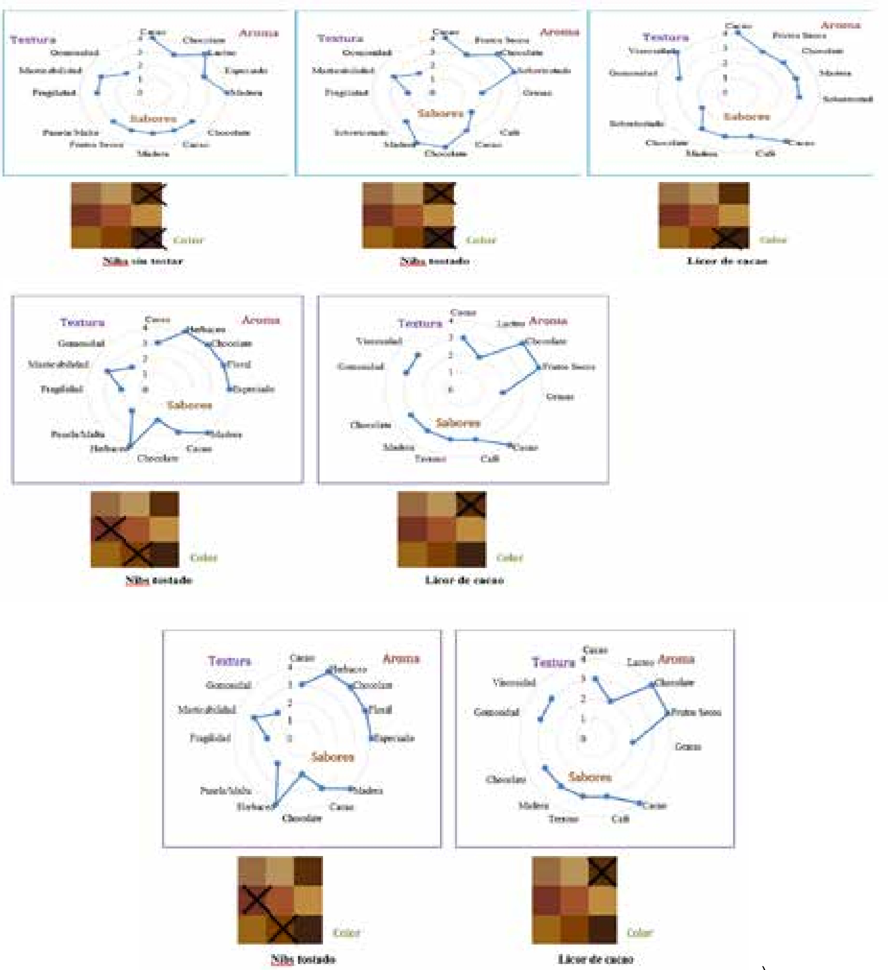
Analyzing the roasted nibs, the samples from the different zones were compared, and the difference between the pH of the different samples was observed, with the samples from company A having more alkalinity than those processed in company B. This may be due to the fact that the greater the roasting of the grain or nib, the greater the evaporation of volatile organic compounds that decrease its acidity. In relation to humidity, considering the working temperatures (processor A: 120°C, processor B: 105°C), and the differences in the roasting processes, it is inferred that humidity is lower in company A due to an excess of temperature in roasting. Molina (2018) indicates that the appropriate conditions for roasting mostly Criollo beans are 80°C for 5 min, for mostly Trinitario beans, 100°C for 4 min, and for Forasteros beans 110°C for 3 min, so processor A uses at least 10°C in excess temperature in its process.

For the cocoa liquor, the fineness, percentage of humidity and pH of processor A and processor B were compared. It is observed that the cocoa liquors from Monagas and Guárico have a lower fineness than those produced by processor B (Mérida, Sucre), which are less refined (lower fineness). The humidity of the cocoa liquor for processor A is lower in comparison with the humidity percentages determined for processor B, since they work the roasting at different temperatures and with different processes. The pH obtained for the samples from processor A is less acidic than those processed by processor B, this is attributed to the high roasting temperatures in processor A and differences in roasting that produce evaporation of volatile compounds that provide acidity.

Figure 1 below shows graphs to effectively visualize the results obtained in the sensory analysis of the samples from different origins (Monagas, Guárico, Mérida and Sucre). In these graphs, three of the four variables studied can be observed: flavor, aroma and texture, on a scale of 1 to 5, while the color analysis is presented in a separate scheme, within the same figures.

The sensory profile for the sample from the state of Monagas (Figure 1.a) indicates that the unroasted nibs have more intense aromas of cocoa, dairy and wood; while the flavor is balanced with chocolate, cocoa, wood, nuts and honeyed notes, similar to those reported by Vera et al. (2021); in terms of texture, it has a fragility and chewiness with medium intensity and a barely perceptible gumminess. The identified colors are two, with Hex codes: #7B3F00 and #3F2212. In the case of the sample of the most outstanding aromatic notes are cocoa, chocolate and the defect of over-roasting; for the flavor, a predominant profile is obtained for chocolate and wood flavors, and no notes of caramel or nuts are perceived; for the texture, an outstanding chewiness over brittleness and gumminess was obtained. The colors identified are two, with Hex codes: #7B3F00 and #3F2212. For the cocoa liquor, processed by company A, the flavors and aromas are flatter and changes are perceived drastic changes in aroma with respect to the unroasted Nib, spicy and chocolate aromas are observed to decrease. The color identified is one with Hex code: #3F2212.

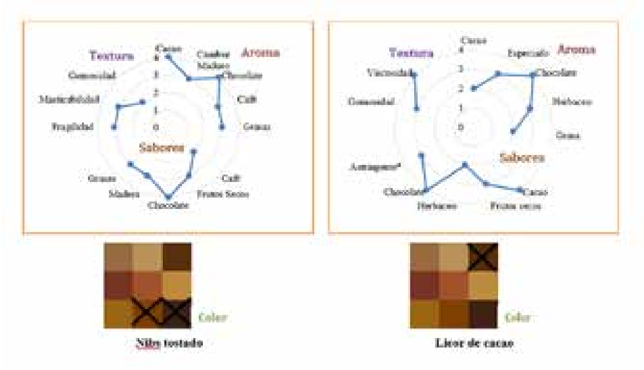
Figure 1. Sensory analysis for the sample from the state of:
a) Monagas. b) Guárico. c) Mérida. d) Sucre.



a)

b)

c)



d)

The sensory profile for the samples from the state of Guárico is shown in Figure 1.b. It is observed that within the organoleptic properties for the unroasted nibs, the chocolatey note stands out in its aroma, followed by notes of coffee, nuts and cocoa, finally a slight note of ripe cambur; as for the flavor, chocolate and coffee flavors predominate, then cocoa and nut flavors, and a slight fatty flavor; the texture has a medium fragility and chewiness, and a low gumminess; and the identified colors are 2, their Hex codes are: #7B3F00 and #3F2212. In roasted nibs, the aroma is highlighted by chocolate and spicy notes, followed, to a lesser extent, by lactic, woody and nutty notes; the aroma of ripe banana, present in unroasted nibs, is no longer perceived; the flavor has a strong presence of chocolate flavor, followed by the flavors of wood, cocoa and over-roasted, a defect in the roasting process, and finally a slight note of nuts; the texture obtained a medium fragility and chewiness, and a low gumminess; the predominant color of the sample is Hex code: #3F2212; in the sensory analysis for the cocoa liquor processed in company A, its aroma highlights the defect of over-roasting, followed by weaker notes such as chocolate, wood, lactic and cocoa; the flavor is dominated by an over-roasted note that shows how defective its roasting process was, followed by earthy, coffee, cocoa and finally caramel notes; its texture has a high viscosity and medium gumminess; the color identified for this liquor is Hex code: #3F2212.

The samples that come from Mérida (Sur del Lago) and are processed by company B, have in the organoleptic profile of the roasted nibs sample, an aroma that presents a balance of spicy, floral, chocolaty and herbaceous notes, followed by a cocoa note; in the flavors a strong herbaceous and woody flavor is perceived, followed by a cocoa note and finally there are notes of caramel and chocolate; its texture has a medium chewiness and low brittleness and gumminess; the predominant colors have the Hex codes: #A05000 and #954535. The cocoa liquor sample has an aroma with dominant notes of chocolate and nuts, with less intensity of cocoa and finally fats and dairy products. Its flavor is balanced with medium notes of chocolate, wood, earthy, coffee, with a highlighted cocoa flavor; its texture, viscosity and gumminess are medium; the identified color is Hex code: #7B3F00.

The sensory profile of the samples from the state of Sucre (Río Caribe) processed by company B, is shown in Figure 1.d. It can be seen that the aroma of the roasted nibs is dominated by notes of chocolate and cocoa, followed to a lesser degree by notes of ripe banana, coffee and fats; in flavor, a strong chocolate flavor was found, followed by flavors of nuts, fats and wood, and finally coffee flavor; its texture has a medium chewiness and brittleness with low gumminess. The colors identified for the sample are Hex codes: #A05000 and #3F2212. In the organoleptic analysis of the cocoa liquor sample, it is observed that its aroma is dominated by the chocolate note, followed by herbaceous and spicy notes, and finally by fat and cocoa odors; its flavor is accentuated by cocoa and chocolate notes, followed by a nutty and astringent note (descriptor not found in the spreadsheet, but identified by the panel), and a slight herbaceous flavor; the texture of the cocoa liquor is quite viscous, with a medium gumminess; only one color was identified for the sample of code Hex: #7B3F00.

Conclusions

According to the sensory tests and physicochemical evaluations, cocoa processor A is over-roasting the roasted nibs and, consequently, the cocoa liquor (final product). The differences in the degree of fineness of the samples analyzed do not allow any conclusions to be drawn regarding grinding. The variables and control parameters for roasting should be varied according to the genetics of the cocoa bean or according to the humidity of the cocoa bean received. When comparing the samples, the process carried out by processor A is more industrialized and has a good grinding process but poor preservation of flavors and aromas due to over-roasting; unlike processor B, which has greater control of the roasting process for the preservation of organoleptic properties but fails in the quality of the grinding process. For the productive zones of the country, certain similarities can be established in terms of flavor, texture and color; however, in terms of aroma, a wide range of notes were found that differentiate each zone evaluated in this study.

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