

Bromatological characterization of three types of semi-industrial chocolates

Pérez-Obrador, Christian A.¹; Córdova-Ávalos, Víctor^{1*}; Solana-Villanueva, N.¹; Zaldívar-Cruz, Juan M.¹; García-Alamilla P.²

¹ Colegio de Postgraduados Campus Tabasco. Periférico Carlos A. Molina S/N Km. 3, Periférico Carlos A Molina SN, Ranchería Río Seco y Montaña, 86500 Cárdenas, Tabasco, México.

² Universidad Juárez Autónoma de Tabasco. División Académica de Ciencias Agropecuarias. Carretera Villahermosa-Teapa, Teapa, Tabasco, México.

* Correspondence: vcordova@colpos.com.mx

ABSTRACT

Objective: To determine the physical and chemical characteristics of three types of semi-industrial chocolate.

Design/Methodology/Approach: Three types of semi-industrial chocolate made from dry fermented cocoa were analyzed in triplicate. Five nutrients were evaluated: total fat, protein, crude fiber, moisture, and carbohydrates. A completely randomized experimental design was applied. Significant differences between treatments were identified using Analysis of Variance (ANOVA) at a 95% confidence level, followed by Tukey's multiple mean comparison test.

Results: Milk chocolate contained 6.37% protein, 48% carbohydrates, 38.99% fat, 3.38% fiber, and 1.55% moisture. Semi-dark chocolate showed 6.83% protein, 36.06% carbohydrates, 50.25% fat, 3.27% fiber, and 1.91% moisture. Dark chocolate exhibited 7.74% protein, 35.51% carbohydrates, 48.42% fat, 3.95% fiber, and 2.29% moisture. Significant differences were observed in protein, fat, carbohydrates, and fiber, except for moisture.

Study Limitations/Implications: The study was limited to a single type of cocoa cultivated under conventional agricultural practices. Consequently, the findings are applicable primarily to producers combining traditional and modern techniques in cocoa cultivation.

Findings/Conclusions: The nutrient analysis of semi-industrial chocolates highlights their nutritional quality, supporting their marketing potential, labeling with origin traceability, and disclosure of nutritional content. Chocolates with higher protein, cocoa fat, and cocoa percentages were identified as nutritious options for consumers.

Keywords: chocolate, characterization, standards, cocoa paste.

Citation: Pérez-Obrador, C. A., Córdova-Ávalos, V., Solana-Villanueva, N., Zaldívar-Cruz, J. M., & García-Alamilla P. (2025). Bromatological characterization of three types of semi-industrial chocolates. *Agro Productividad*. <https://doi.org/10.32854/fnz7h270>

Academic Editor: Jorge Cadena Iñiguez

Associate Editor: Dra. Lucero del Mar Ruiz Posadas

Guest Editor: Daniel Alejandro Cadena Zamudio

Received: August 03, 2024.

Accepted: March 10, 2025.

Published on-line: April XX, 2025.

Agro Productividad, 18(3). March. 2025. pp: 211-216.

This work is licensed under a Creative Commons Attribution-Non-Commercial 4.0 International license.



INTRODUCTION

In Mexico, cacao (*Theobroma cacao* L.) is a millenary, ancestral, medicinal, and cultural food that has been intertwined with the traditions and customs of Indigenous peoples in the Americas, including Ecuador, Brazil, Venezuela, Colombia, Peru, and Mexico (Battcock *et al.*, 2022; Fins *et al.*, 2013). Since pre-Hispanic times, cacao has been used in human nutrition. Following the Spanish arrival in Mexico, cacao consumption expanded to Europe (Huamanchumo, 2017; Coe & Coe, 2013). The *per capita* consumption of chocolate



in Europe is 10 kg, while in Mexico it increased from 600 to 700 g between 2016 and 2023 (Camacho-Gómez, 2017), with milk chocolate being the consumers' favorite due to its flavor and aroma (Arvelo-Sánchez, 2017). Today, consumers seek high-quality chocolates with good nutritional content (Brambila, 2008). Chocolate with a higher cocoa content, at least 70%, is considered beneficial to human health (Córdova *et al.*, 2023). However, micro-enterprises producing chocolate face several limitations in their production processes, such as challenges accessing markets, lack of nutritional labeling for their products, and insufficient training in technological innovation for adding value. There is also a lack of financing, subsidies, and specialized advice for developing individual and collective brands. These factors highlight the need for bromatological analysis to comply with regulatory standards (Martínez-Salvador & Martínez-Salvador, 2020). Considering these challenges, the aim of this research is to analyze the nutritional content of the chocolates produced at the chocolate school/factory of the Colegio de Postgraduados Campus Tabasco, with the aim of transferring this innovation model to cacao producers in Tabasco.

MATERIALS AND METHODS

Location of the study area

The research was carried out in the chocolate school laboratory of the Tabasco Campus, College of Postgraduates, located in the Ranchería Río Seco second section of Huimanguillo, Tabasco (17° 58' 34" N, 93° 23' 11" W).

Preparation process of the three types of chocolates

The cocoa was purchased from a producer in the José María Morelos y Pavón Ejido, located in Cárdenas, Tabasco. Its quality was determined based on NMX-FF-118, 2014, using a cut test conducted at the chocolate school, classifying it as extra-fine cocoa, fermented and sun-dried, of the Patastillo variety (NMX-FF-118, 2014; Aguilar, 2016). The moisture content was 6%, measured with a DICKEY-John (GAC500 XT, United States) device.

The cocoa beans were selected by removing impurities, broken beans, insect-damaged beans, moldy beans, and beans without cotyledons (CXS 87-1981, 2022). The selected cocoa was roasted in a Micron 5 kg roaster. The grinding and shelling process was carried out using a CITLALI sheller (CACDES003, Mexico). The grinding was performed with a Pulvex 9 Hp mill (200, Mexico), resulting in cocoa paste, which was stored in a cooler at 5° C for use the following day. For the preparation of the chocolate types used in the bromatological characterization, a completely randomized design with three repetitions was applied. The first treatment consisted of milk chocolate with 30% cocoa paste; the second treatment was semi-dark chocolate with 50% cocoa paste; and the third treatment was dark chocolate with 70% cocoa paste. The treatments were prepared according to the proportions of fat, milk, sugar, cinnamon, and vanilla (Table 1).

Each sample was refined, tempered, molded, crystallized. The crystallized bars and tablets were disassembled for wrapping, bagging, sealing, labeling and coding for our analysis.

Table 1. Semi-industrial chocolate treatments.

Type of semi-industrial chocolate			
Ingredients	T1 With milk	T2 Semi-bitter	T3 Bitter
Cocoa paste	30%	50%	70%
Brown sugar	28%	30%	20%
Cocoa butter	20%	20%	10%
Whole milk powder	20%	-	-
Natural vanilla extract	2%	-	-

Methods and techniques of analysis

The techniques used to measure the five attributes were as follows: total fats were determined using the SOXHLET method (NMX-F-615-NORMEX-2004); protein content was measured using the assay method (NMX-F-608-NORMEX-2011); crude fiber was analyzed using the general test method (NMX-F-613-NORMEX-2017); moisture was determined through the desiccation method (NMX-F-030-1985); and carbohydrate content was calculated.

Statistical analysis: model

The analysis model for the completely randomized design was as follows:

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$$

Where: Y_{ij} represents the observation in the i -th experimental unit assigned to the j -th treatment. μ is the general or overall mean of all observations. τ_i is the effect of the i -th treatment. ε_{ij} is the random error or residual, representing the variation not explained by the treatments.

Hypothesis

H_0 : $T_1 = T_2 = \dots = T_9$, meaning there is no interaction between the effect of cocoa concentration on the nutrients in chocolate.

H_1 : $T_i \neq T_j$, meaning there is interaction, indicating that different cocoa concentrations result in varying nutrient levels. The analyzed nutrients included protein, carbohydrates, fats, fiber, and moisture. An Analysis of Variance (ANOVA) was conducted at a 95% confidence level, followed by Tukey's mean comparison test to identify significant differences in the nutritional content among the types of chocolate.

RESULTS AND DISCUSSION

Of the analyzed nutrients, milk chocolate (30% cocoa) contained 6.37% protein, 48% carbohydrates, 38.99% fat, 3.38% fiber, and 1.55% moisture. Semi-dark chocolate (50% cocoa) had 6.83% protein, 36.06% carbohydrates, 50.25% fat, 3.27% fiber, and 1.91% moisture. Dark chocolate (70% cocoa) showed 7.74% protein, 35.51% carbohydrates, 48.42% fat, 3.95% fiber, and 2.29% moisture. Significant differences were observed in

protein, fats, carbohydrates, and fiber, while no significant differences were found in moisture (see Table 2).

Protein: As observed in terms of protein, the null hypothesis was rejected, and H_1 was accepted, as the p-value (0.05) was similar to the α value. The results showed a gradual increase in protein content with higher cocoa concentrations, with dark chocolate (70% cocoa) having the highest protein content. Protein values ranged between 6% and 7%, aligning with the findings of Enríquez-Estrella and El Salous (2022), who reported a protein content of 9.26%, and Sánchez *et al.* (2016), who observed 8.75% protein in homemade dark chocolates from the Chontalpa region for pure 100% cocoa chocolates. It is worth noting that the analyzed chocolates were made using cocoa paste, whereas large multinational companies use cocoa with vegetable fat, as permitted by regulations.

Carbohydrates: Regarding carbohydrates, the p-value (0.002) was less than α (0.05), leading to the rejection of the null hypothesis (H_0) and acceptance of H_1 . The results indicate a gradual decrease in carbohydrate content as the cocoa percentage increases. This is attributed to the formulation, as milk chocolate (30% cocoa) contains a higher amount of cane sugar, resulting in a greater carbohydrate content compared to dark chocolate. Clará-Nolasco (2017) reported a carbohydrate content of 88% in a chocolate bar with a high sucrose formulation (78% sugar), which corroborates the findings observed in this study.

Total fats: For total fats, the p-value (0.00662) was less than α (0.05), leading to the acceptance of H_1 , indicating that different cocoa concentrations result in changes in fat content. It was observed that semi-dark chocolate (50% cocoa) contained slightly more fat on average compared to the other types, while milk chocolate (30% cocoa) had the lowest fat content. Fat content ranged between 40% and 50%, aligning with the findings of Quiróz-Martínez *et al.* (2023), who reported 39.68% fat in goat milk chocolate, and Sánchez *et al.* (2016), who found fat percentages ranging from 10-30% in milk chocolates, 30-40% in semi-dark chocolates, and similar values for dark chocolates at 40%. Cocoa fat, or cocoa butter, contains approximately 35% oleic acid, 35% stearic acid, and 25% palmitic acid, with the remaining 5% composed of various short-chain fatty acids (Valenzuela B., 2007). This composition provides cardiovascular health benefits, which are absent in chocolates that replace cocoa butter with other vegetable fats.

Fiber: In terms of crude fiber, differences were observed based on cocoa concentration, as the p-value (0.004) was less than α (0.05). This leads to the rejection of the null hypothesis (H_0) and acceptance of H_1 . Dark chocolate, with a fiber content of 3.95%, had the highest

Table 2. Difference in attributes according to cocoa concentration.

Treatment	Protein(%)	Carbohydrates(%)	Fat(%)	Fiber(%)	Moisture (%)
T1 With milk	6.36±0.60a	47.99±0.96a	38.99±0.42a	3.38±0.08a	1.55 ±0.74a
T2 Semi-bitter	6.83±0.715ab	36.06±4.68b	50.25±4.63a	3.27±0.25b	1.91 ±1.60a
T3 Bitter	7.74±0.09b	35.51±1.27b	48.42±1.92b	3.95±0.07b	2.29 ±0.65a
p-value	0.0536	0.00281	0.00662	0.00425	0.719

* Mean values ± standard deviation. Means with the same letter in the same column are not significantly different according to Tukey's test ($\alpha=0.05$).

value, aligning with Ropero (n.d.), who reported fiber contents of 0.8%, 3.9%, and 3.1% for milk chocolate, milk and almond chocolate, and milk chocolate with polyalcohols, respectively, as well as 9.1% for dark chocolate with almonds. These findings confirm that higher cocoa concentrations result in greater fiber content in the final product. Fiber is essential for maintaining a healthy digestive tract and serves as an ally in preventing metabolic diseases (Almeida-Alvarado *et al.*, 2014).

Moisture: Finally, with a p-value (0.7) greater than α (0.05), moisture levels across the three cocoa concentrations were statistically similar, ranging between 1.55% and 2.3%. These values are consistent with findings by Quiróz-Martínez *et al.* (2023), Enríquez-Estrella and Salous (2022), and Clará-Nolasco (2017), who reported moisture levels of 1.59%, 1.81%, and 2.74%, respectively.

CONCLUSIONS

It is concluded that dark chocolate, with a higher cocoa concentration, offers superior nutritional benefits in terms of protein and fiber. Conversely, chocolates with lower cocoa concentrations tend to have higher carbohydrate content due to increased added sugar. Overall, the results highlight the importance of considering cocoa concentration when evaluating the nutritional properties of chocolate, which are vital for consumer health and well-being. These benefits are particularly evident when opting for chocolates with a high cocoa concentration.

ACKNOWLEDGMENTS

Thanks to COLPOS for providing the facilities to conduct the sample analysis and to CONAHCYT for funding the project.

REFERENCES

- Aguilar, Héctor. (2016). Manual para la Evaluación de la Calidad del Grano de Cacao /Héctor Aguilar. 1a. ed. La Lima, Cortés: FHIA, 2016, 22p.il.
- Almeida-Alvarado, Sonia Lorena, Aguilar-López, Tania, & Hervert-Hernández, Deisy. (2014). La fibra y sus beneficios a la salud. *Anales Venezolanos de Nutrición*, 27(1), 73-76.
- Arvelo Sánchez, M. Á. (Ed.). (2017). Estado actual sobre la producción, el comercio y cultivo del cacao en América. IICA; Colegio de Postgraduados: Fundación COLPOS.
- Battcock, C., Casanova García, E. y De Giuseppe, M. (2022). Cacao. La planta que transita los tiempos. Editorial
- Brambila, P. J. J. 2008. En el umbral de una agricultura nueva. Primera reimpresión. Universidad Autónoma Chapingo. 315 p.
- Camacho-Gómez, M. (2017). Chocolate artesanal en México: cultura, consumo y marketing. Recuperado el 30 de julio de 2024 de http://www.web.facpya.uan.mx/vinculategica/vinculat%C3%A9gica_2/61%20CAMACHO.pdf
- Coe, S. D., & Coe, M. D. (2013). La verdadera historia del chocolate. Fondo de Cultura Económica. ISBN: 9786071657749. No de paginas
- Clará Nolasco, C. A. (2017). Formulación de una tablilla de cacao (*Theobroma cacao*) para la elaboración de una bebida caliente saborizada, su análisis sensorial y bromatológico. Recuperado el 27 de julio de 2024 de <http://www.redicces.org.sv/jspui/bitstream/10972/3707/1/0002689-ADTESCF.pdf>
- CXS 87-1981. (2022). NORMA PARA EL CHOCOLATE Y LOS PRODUCTOS DEL CHOCOLATE CODEX STAN 87-1981. Recuperado el 12 de julio de 2024 de https://www.fao.org/fao-who-codexalimentarius/sh-proxy/es/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252Fstandards%252FCXS%2B87-1981%252FCXS_087s.pdf

- Huamanchumo De La Cuba, O. (2017). Cacao. Producción, consumo y comercio. Del período prehispánico a la actualidad en América Latina. *Fronteras de la Historia*, 22(1), 237-242.
- Laura Elena Martínez-Salvador & Carolina, Martínez-Salvador. (2020). Innovación social en organizaciones cacaoteras en Tabasco, México. Aproximaciones desde la gobernanza territorial y la participación femenina en la agricultura. *Revista de alimentación Contemporánea y Desarrollo Regional*, 30(55), 1-14
- Quirós-Martínez, M. C., Chacón-Villalobos, A., Pineda-Castro, M. L., & Alfaro-Álvarez, I. (2023). Características fisicoquímicas y sensoriales de chocolates de leche caprina y bovina1. *Agronomía Mesoamericana*, 34(1). <https://www.redalyc.org/journal/437/43772368004/html>
- Ropero Lara, A. B. (s.f.). Cacao y chocolate. Recuperado el 12 de julio de 2024 de <https://badali.umh.es/assets/documentos/pdf/artic/cacao.pdf>
- Secretaría de Economía. (2014). NMX-FF-118-SCFI-2013. PRODUCTOS AGRICOLAS NO INDUSTRIALIZADOS-CACAO EN GRANO (Theobroma cacao L)-ESPECIFICACIONES Y METODOS DE PRUEBA. https://www.dof.gob.mx/nota_detalle.php?codigo=5345710&fecha=22/05/2014#gsc.tab=0
- Secretaría de Economía. (2014). NOM-186-SSA1/SCFI-2013. Cacao, chocolate y productos similares, y derivados del cacao. Especificaciones sanitarias. Denominación comercial. Métodos de prueba. https://www.dof.gob.mx/nota_detalle.php?codigo=5338717&fecha=28/03/2014#gsc.tab=0
- Sol Sánchez, Ángel, Naranjo González, José Alberto, Córdova Avalos, Víctor, Ávalos de la Cruz, Dora Angélica, & Zaldívar Cruz, Juan Manuel. (2016). Caracterización bromatológica de los productos derivados de cacao (*Theobroma cacao* L.) en la Chontalpa, Tabasco, México. *Revista mexicana de ciencias agrícolas*, 7(14), 2817-2830. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S200709342016001002817&lng=es&tlng=es.
- Valenzuela B, A. (2007). El Chocolate, un Placer Saludable. *Revista chilena de nutrición*, 34(3). <http://dx.doi.org/10.4067/S0717-75182007000300001>.

