



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Bureau
International des
Poids et
Mesures



Metrology for Sustainable Competitiveness in Cocoa: Advancing Industrial Innovation and Inclusive Economic Growth

INM implemented proficiency testing schemes, reference materials, and guidance documents for Colombian testing laboratories

*Instituto Nacional de Metrología de Colombia (INM)
Colombia (CO)*



The Challenge

Cocoa production in Colombia has been vital in recent years due to its reputation for high-quality fine and aromatic cocoa,¹ its strategic role as a legal alternative to illicit crops, generating rural employment in conflict zones (thousands of farming families have abandoned illicit crops in favor of a legal, profitable, and sustainable option), and the promotion of environmental sustainability (through the promotion of forest management arrangements).² Furthermore, it is the second most important crop in the country after coffee.³

Cocoa beans (see **Figure 1**) are produced by approximately 65 000 families in a sector that has been growing in recent years.⁴ Exports of cocoa and cocoa products reached over USD 265 million in 2024, an increase of more than 100 % from the previous year.⁵ Of these, cocoa bean exports reached USD 65.2 million in 2024, with approximately 25 % destined for the European Union.⁶ However, evidence shows that various factors—including soil-forming processes, the use of phosphate-based fertilizers, and mining activities in certain regions—contribute to relatively high cadmium levels in Colombian cocoa compared to other countries.⁷ Given that soil conditions, agricultural practices, and other variables differ across regions, some markets, such as the European Union (Directive EU No. 488 of 2014),⁸ and international bodies,

¹ Cristancho-Pinilla, Edwin; López, Laura; Mojica, Andrea; Pedraza, Erika y Valqui, Alexis. 2021. Proyecto ColombiaMide. Informe ejecutivo: Estudio sobre las necesidades y brechas de calidad en la cadena productiva de cacao y sus derivados y plan de acción. Santander y su zona de influencia. Bogotá. Colombia.

² EU REDD Facility. 2021. Diagnóstico de la cadena de valor del cacao, y mapeo de los indicadores y sistemas de información existentes: Resultado del diagnóstico participativo en Colombia (Documento de trabajo). EU REDD Facility.

³ Cristancho-Pinilla, Edwin; López, Laura; Mojica, Andrea; Pedraza, Erika y Valqui, Alexis. 2021. Proyecto ColombiaMide. Informe ejecutivo: Estudio sobre las necesidades y brechas de calidad en la cadena productiva de cacao y sus derivados y plan de acción. Santander y su zona de influencia. Bogotá. Colombia.

⁴ EU REDD Facility. 2021. Diagnóstico de la cadena de valor del cacao, y mapeo de los indicadores y sistemas de información existentes: Resultado del diagnóstico participativo en Colombia (Documento de trabajo). EU REDD Facility.

⁵ ANALDEX. 2025. Cacao y sus derivados duplicaron sus exportaciones y llegaron a los US\$265 millones en 2024, ¿podrá seguir este ritmo en 2025. Retrieved April 17, 2026 from <https://analdex.org/2025/04/09/cacao-y-sus-derivados-duplicaron-sus-exportaciones-y-llegaron-a-los-us265millones-en-2024-podra-seguir-este-ritmo-en-2025/>

⁶ FEDECACAO. 2025. Exportaciones e importaciones. Retrieved April 17, 2026 from <https://www.fepcacao.com.co/exportaciones-e-importaciones>

⁷ Cristancho-Pinilla, Edwin; López, Laura; Mojica, Andrea; Pedraza, Erika y Valqui, Alexis. 2021. Proyecto ColombiaMide. Informe ejecutivo: Estudio sobre las necesidades y brechas de calidad en la cadena productiva de cacao y sus derivados y plan de acción. Santander y su zona de influencia. Bogotá. Colombia.

⁸ Commission Regulation (EU). 2014. Official Journal of the European Union. Retrieved April 17, 2026 from <https://eur-lex.europa.eu/eli/reg/2014/488/oj/eng>



Figure 1. Cocoa beans are produced on a farm in San Vicente de Chucurí, Santander.

such as the Codex Alimentarius Commission, have established maximum permissible limits for cadmium in cocoa and chocolate products.⁹ As a result, exported cocoa must comply with these limits, prompting the Colombian government to implement strategies to reduce cadmium levels in cocoa production; among these, a key priority has been the development of measurement methods for cadmium and other heavy metals in cocoa beans, particularly because the country previously lacked accredited testing laboratories capable of performing such analyses.

Cocoa production involves small, medium, and large-scale producers, as well as industrial farms. The marketing sector includes various actors, such as associations, traders, producer groups, cooperatives, second-tier producer networks, commission agents, and industry (large companies).¹⁰ In cocoa processing and chocolate manufacturing, large companies and smaller

⁹ Cristancho-Pinilla, Edwin; López, Laura; Mojica, Andrea; Pedraza, Erika y Valqui, Alexis. 2021. Proyecto ColombiaMide. Informe ejecutivo: Estudio sobre las necesidades y brechas de calidad en la cadena productiva de cacao y sus derivados y plan de acción. Santander y su zona de influencia. Bogotá. Colombia.

¹⁰ EU REDD Facility. 2021. Diagnóstico de la cadena de valor del cacao, y mapeo de los indicadores y sistemas de información existentes: Resultado del diagnóstico participativo en Colombia (Documento de trabajo). EU REDD Facility.

processors play prominent roles.¹¹ In the marketing of processed products and market access, the domestic industry and other private importers and exporters are involved.¹²

The Solution

Given this challenge, the National Metrology Institute (INM) implemented several metrology-based initiatives, supported by international cooperation programs, to strengthen the country's capacity to ensure that cadmium measurements in dried cocoa beans are appropriate, comparable and equivalent to those performed in other economies. In 2019, the INM conducted a study¹³ to identify quality needs and gaps in the cocoa value chain, highlighting the importance of developing Certified Reference Materials (CRMs), organizing Proficiency Testing (PT) schemes,¹⁴ and promoting overall metrological assurance within the Colombian Metrology Network.

As a result, the INM developed a measurement method for cadmium in cocoa, produced a cadmium calibration solution, and created an innovative CRM for cadmium in cocoa powder—addressing a gap not covered by other countries, which typically only had CRMs for finished chocolate products.¹⁵ As the first step, INM developed a reference method for measuring cadmium in cocoa, which involved designing an experimental protocol and conducting rigorous validation to demonstrate accuracy, repeatability, and metrological traceability to the International System of Units (SI). The INM then produced certified reference materials (CRMs) (see **Figure 2a**) used as method-validation controls by food safety and cocoa product

¹¹ Cristancho-Pinilla, Edwin; López, Laura; Mojica, Andrea; Pedraza, Erika y Valqui, Alexis. 2021. Proyecto ColombiaMide. Informe ejecutivo: Estudio sobre las necesidades y brechas de calidad en la cadena productiva de cacao y sus derivados y plan de acción. Santander y su zona de influencia. Bogotá. Colombia.

¹² Cristancho-Pinilla, Edwin; López, Laura; Mojica, Andrea; Pedraza, Erika y Valqui, Alexis. 2021. Proyecto ColombiaMide. Informe ejecutivo: Estudio sobre las necesidades y brechas de calidad en la cadena productiva de cacao y sus derivados y plan de acción. Santander y su zona de influencia. Bogotá. Colombia.

¹³ Cristancho-Pinilla, Edwin; López, Laura; Mojica, Andrea; Pedraza, Erika y Valqui, Alexis. 2021. Proyecto ColombiaMide. Informe ejecutivo: Estudio sobre las necesidades y brechas de calidad en la cadena productiva de cacao y sus derivados y plan de acción. Santander y su zona de influencia. Bogotá. Colombia.

¹⁴ España, C., Gómez, G., Holguín, K., Abella, J., & Ahumada, D. A. 2020. Proficiency testing schemes for cadmium in cocoa powder analysis for Colombian laboratories. In 17th IMEKO TC10 and EUROLAB Virtual Conference: Global Trends in Testing, Diagnostics & Inspection for 2030 (pp. 141–146). IMEKO.

¹⁵ España, C., Gómez, G., Holguín, K., Abella, J., & Ahumada, D. A. 2020. Proficiency testing schemes for cadmium in cocoa powder analysis for Colombian laboratories. In 17th IMEKO TC10 and EUROLAB Virtual Conference: Global Trends in Testing, Diagnostics & Inspection for 2030 (pp. 141–146). IMEKO.



Figure 2. CRMs of cadmium in cocoa powder: (a) high and low concentrations; (b) Proficiency Test (PT) item: cadmium content in cocoa powder.

manufacturing testing laboratories. INM then conducted PT schemes based on various cadmium levels in cocoa, using value-assigned PT reference materials (**Figure 2b**).

The INM also developed several technical guidance documents^{16,17,18} to equip producers and laboratories with the resources needed to deliver reliable and internationally accepted results. This included a metrological traceability guide for cadmium measurements in the cocoa materials along the production chain. This was discussed through the Colombian Metrology Network (RCM) with the participation of 15 laboratories, including private, industry, and academic labs.¹⁹ A guide to selecting private calibration services for chemical testing laboratories was also developed.²⁰ An additional guide provided detailed content for producers and technical staff in manufacturing on selecting suppliers and the appropriate use of measurement data. It aims to help producers understand the importance of measurements in decision-making within their production processes.²¹

¹⁶ Instituto Nacional de Metrología (INM). 2021. Guía de trazabilidad metrológica: mediciones de cadmio en la cadena de cacao. INM/GTM I/01, versión 1. Bogotá, Colombia.

¹⁷ Instituto Nacional de Metrología de Colombia. (2021). Guía para la selección de servicios de calibración en laboratorios de ensayo químicos. Bogotá, Colombia.

¹⁸ Instituto Nacional de Metrología de Colombia. (2021). Guía para productores: Importancia, selección de proveedores y uso de las mediciones. Bogotá, Colombia

¹⁹ Instituto Nacional de Metrología (INM). 2021. Guía de trazabilidad metrológica: mediciones de cadmio en la cadena de cacao. INM/GTM I/01, versión 1. Bogotá, Colombia.

²⁰ Instituto Nacional de Metrología de Colombia. (2021). Guía para la selección de servicios de calibración en laboratorios de ensayo químicos. Bogotá, Colombia.

²¹ Instituto Nacional de Metrología de Colombia. (2021). Guía para productores: Importancia, selección de proveedores y uso de las mediciones. Bogotá, Colombia

The INM also organized two Proficiency Testing schemes in 2019 and 2021, involving 10 and 12 laboratories, respectively, to assess cadmium (and lead) measurements across different regions of the country. As part of the measurement service, the INM PT coordinators are prepared to provide technical recommendations to improve the metrological traceability of participants' measurements, enabling laboratories to assess where they fall short and incorporate improvements into their measurement processes. As a result, only one laboratory had unsatisfactory results, and, following its participation in PT, the INM PT coordinators identified and addressed the cause of the unsatisfactory results.

A Quantifiable Impact

The metrological capacity-building efforts led by the National Metrology Institute (INM) enabled Colombia to implement reliable methods for measuring cadmium in cocoa powder. First, it should be noted that the development of the cadmium CRM in cocoa marked a significant innovation in the industry, as no other country had produced such a CRM. At the time, cadmium CRMs were available in aqueous matrices and in cocoa derivatives (e.g., cadmium and acrylamide in cocoa and baking chocolate). However, these have different physicochemical properties from cocoa beans. A CRM for measuring cadmium in cocoa beans was of particular interest to the country.²²

The availability of a CRM for cadmium to be used as a calibration standard reduced the acquisition costs of this CRM, since the price at which the INM sold this CRM (approximately €48) was lower than that of other CRMs produced by metrology institutes from Europe and the United States.

Acknowledgments. This work has been made possible by the following cooperation projects “*Contribución a la medición del cadmio para la producción de cacao en Colombia*” carried out by Instituto Nacional de Metrología (INM) of Colombia and Swisscontact, and “*Calidad para la competitividad - Reduciendo las brechas de calidad en Micro, Pequeñas y Medianas Empresas MIPYME - ColombiaMide*”, a project implemented as part of the complementary support agreement between the European Union and the Ministry of Commerce, Industry, and Tourism of Colombia, carried out by the German National Metrology Institute (Physikalisch-Technische Bundesanstalt, PTB) with the support of the INM and with ICONTEC as the project beneficiaries. Photographs were provided by Luisa J. Bernal.

POC: Erika Bibiana Pedraza Guevara, ebpedraza@inm.gov.co

²² España, C., Gómez, G., Holguín, K., Abella, J., & Ahumada, D. A. 2020. Proficiency testing schemes for cadmium in cocoa powder analysis for Colombian laboratories. In 17th IMEKO TC10 and EUROLAB Virtual Conference: Global Trends in Testing, Diagnostics & Inspection for 2030 (pp. 141–146). IMEKO