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The Multiplier Effect: NMISA's Mycotoxin Reference Material Programme

NMISA led an RMO-focused pilot programme to develop mycotoxin reference materials and food safety testing laboratory capabilities, which now underpins food testing and safety across many African nations

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The Challenge

According to the African Union, Africa faces serious food safety and trade challenges that directly affect public health, economic development, and food security. Both acute and chronic dietary exposure to mycotoxins in staple foods like maize and groundnuts has been linked to deaths, severe illness, elevated liver cancer rates, and childhood stunting across the continent.^{1,2} The trade impact is equally significant: in 2017-2019, nearly half (48 %) of all European Union Rapid Alert System for Food and Feed (EU RASFF)³ notifications against African food exports involved mycotoxin contamination in nuts and cereals, making mycotoxins the continent's foremost barrier to international market access (**Figure 1A**). Compounding these challenges was a critical measurement infrastructure gap that limited the effectiveness of broader food safety initiatives, resulting in unreliable surveillance data, weak compliance with international standards, and constrained laboratory accreditation.

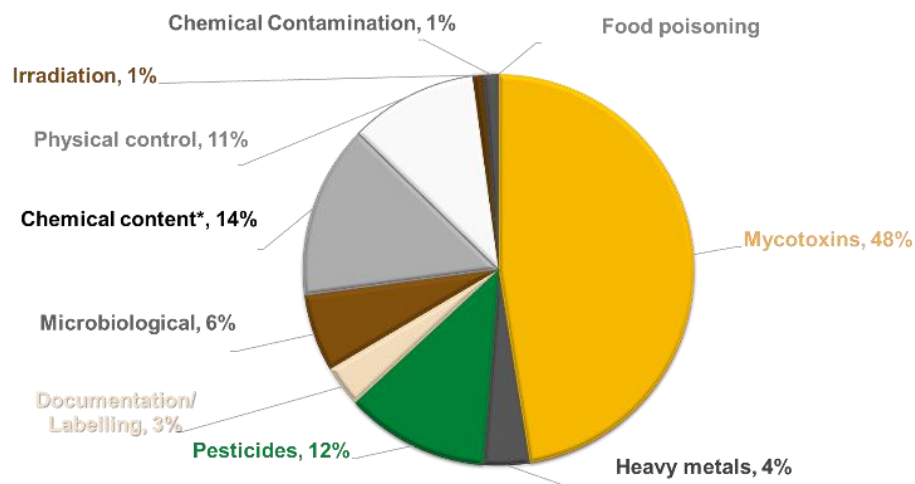
African food testing laboratories lacked access to affordable, regionally-relevant certified reference materials (CRMs) for mycotoxin analysis, undermining the measurement foundation needed to support policy makers, regulatory authorities, and trade officials. International mycotoxin proficiency testing (PT) studies have shown that when laboratories rely solely on in-house calibration standards, measurement variability can exceed 40 %. This applies to laboratories whether or not they are ISO/IEC 17025-accredited. A significant reduction in measurement variability (to approximately 16 %) was observed when testing laboratories used a common SI-traceable calibrator.⁴ This stark difference demonstrates the impact of key metrological interventions related to calibration materials on improving measurement comparability and strengthening the evidence base required for sound decision-making.

¹ Food Safety Strategy for Africa 2022-2036. AU Department of Agriculture, Rural Development, Blue Economy and Sustainable Environment. Addis Ababa: African Union – DARBE, 2022.

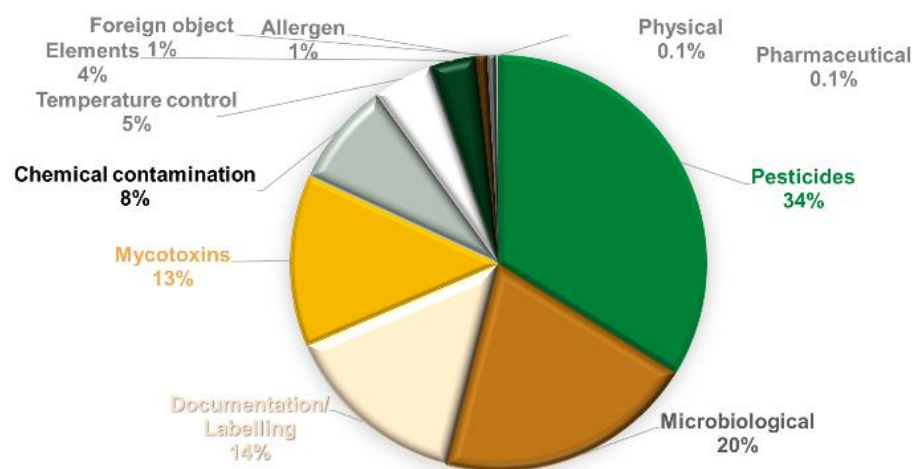
² Ayalew, A. "Partnership for Aflatoxin Control in Africa (PACA). Integrated Approach to Mycotoxin Control and the PACA Experience," in Africa Food Safety Workshop, Pretoria, South Africa, 2018.

³ European Commission, EU RASFF portal. <https://webgate.ec.europa.eu/rasff-window/portal/>

⁴ Josephs RD, Krska, R., "International interlaboratory study for the determination of the Fusarium mycotoxins zearalenone and deoxynivalenol in agricultural commodities," Food Additives & Contaminants, vol. Volume 18, no. 5, pp. 417-430, 2001.



A. 2017-2019



B. 2021-2024

*Chemical content is related to chemicals added to or inherent to a specific commodity.

**Chemical contamination is a chemical that should not be present in a specific commodity; this excludes pesticides and mycotoxins that have been grouped separately due to the number of associated alerts.

Figure 1. European Union Rapid Alert System for Food and Feed (EU RASFF) notifications, alerts, and/or rejections received by Africa during A. 2017-2019, and B. 2021-2024. The reduction in mycotoxin alerts is clearly received after multi-stakeholder global CBKT interventions.

The Solution

In 2015, NMISA established the African Food and Feed Reference Material Programme (AFFRMP), piloting indigenous mycotoxins as prioritized CRMs needed to support food and feed testing laboratories in South Africa and across the continent. Through participation in the International Bureau for Weights and Measures (BIPM) Mycotoxin Metrology Capacity Building and Knowledge Transfer (CBKT) Programme (2016-2019),⁵ NMISA developed new analytical measurement capability (i.e., quantitative ¹H-NMR) and subsequently developed metrologically traceable mycotoxin calibration solution CRMs for aflatoxin B1, B2, G1, and G2, zearalenone, deoxynivalenol, ochratoxin-A, and patulin (**Figure 2**). The new capability was underpinned by Calibration and Measurement Capabilities (CMCs) declared under the International Committee for Weights and Measures Mutual Recognition Arrangement (CIPM MRA). Using these calibrators, NMISA developed complementary matrix CRMs for multiple mycotoxins in white maize, peanut slurry, and peanut butter matrices.

For the first time, African food testing laboratories had access to regionally relevant, accessible, and affordable reference materials made on the continent. This sustainable, African-owned measurement infrastructure also supports innovation in industry and infrastructure, establishes long-term regional capacity, and reduces reliance on costly imports.



⁵ BIPM Capacity Building and Knowledge Transfer Programme, “Metrology for Safe Food and Feed - Mycotoxins,” BIPM, 2016. <https://www.bipm.org/en/committees/cb/cbkt/wg/cbkt-mm-bipm>

Figure 1. Clockwise: NMISA Mycotoxin calibration solution CRMs for aflatoxins B1, B2, G1, G2 (top left). NMISA Ochratoxin-A CRM solution (top right), and matrix CRMs for multiple mycotoxins in white maize (bottom left), and aflatoxins in peanut butter (bottom right).

These NMISA-produced CRMs became the metrological foundation for collaborative capacity building activities across Africa, delivered jointly with multiple stakeholders through:

- BIPM Capacity Building and Knowledge Transfer Mycotoxin Metrology Programme, expanding into metrology for safe food and feed (pesticides and veterinary drug residues), enabling comparisons and CMCs for new mycotoxin and pesticide CRMs⁶
- Intra-Africa Metrology System (AFRIMETS) Food Safety Capacity Building initiatives for hands-on training and PT schemes,⁷ supported by Physikalisch-Technische Bundesanstalt (PTB) Germany, alongside initiatives for fellow NMIs; Egypt's National Institute of Standards (NIS), Kenya Bureau of Standards (KEBS), and the Tunisian designated chemical metrology institute: Institut National de Recherche et d'Analyse Physico-chimique (INRAP);
- The Joint United Nations Food and Agricultural Organisation (FAO) and International Atomic Energy Agency (IAEA) Centre of Nuclear techniques in Food and Agriculture and IAEA Africa Region Technical Cooperation projects (RAF 5067, 5078, 5084, and 5091) under the Africa Food Safety Network (AFoSaN) supporting PT schemes, spanning 30 mandated food monitoring and inspection laboratories across the continent^{8,9}
- Association of Official Analytical Collaboration (AOAC) Africa Laboratory Performance Benchmarking Programme (LPBP), which used NMISA matrix CRMs as the metrologically-traceable reference materials for benchmarking laboratory performance against Standard Method Performance Requirements (SMPRs)¹⁰
- Pan African Quality Infrastructure (PAQI) Cassava Project, supported by PTB Germany, preparing reference materials for proficiency testing of mycotoxins and other food hazards in cassava flour¹¹

⁶ BIPM, BIPM CBKT Metrology for Safe Food and Feed - Pesticides and Veterinary Drug Residues, 2026.

<https://www.bipm.org/en/committees/cb/cbkt/wg/cbkt-pv-bipm>

⁷ NMISA, NMISA Proficiency Testing Schemes, 2026. <https://www.nmisa.org/products-and-services/proficiency-testing-schemes/Pages/default.aspx>

⁸ Joint IAEA-FAO, [Online]. Available: <https://www.iaea.org/newscenter/news/iaea-fao-workshop-strengthens-food-safety-network-across-africa>

⁹ IAEA AFRA Technical Cooperation, IAEA Regional Projects RAF5091, 2024. <https://www.iaea.org/projects/tc/raf5091>

¹⁰ AOAC International - Africa Section, "AOAC Africa - Laboratory Performance Benchmarking Programme White Paper," 2021. https://aoacsafrica.org/wp-content/uploads/2023/03/AOAC-Africa-White-Paper_LPBP.pdf.

¹¹ The Role of Quality Infrastructure in the Cassava Value Chain, https://www.qi-africa.ptb.de/fileadmin/Ressourcen_Downloads_Dokumente/Final_The_role_of_quality_infrastructure_in_the_cassava_value_chain_Vrs_02.pdf

These activities encompassed workshops, proficiency testing (PT) schemes, hands-on training, and visiting scientist exchanges for mandated food monitoring and inspection laboratories, with the shared objective of expanding the number of ISO/IEC 17025 accredited food safety testing services on the continent, reinforced through the use of metrologically traceable calibrators.

A Quantifiable Impact

The intervention was grounded in nearly a decade of systematic stakeholder engagement and data collection. Surveys of South African testing laboratories in 2008-2009 first identified the absence of affordable, matrix-matched mycotoxin CRMs as a critical analytical limitation. Following the 2014-2015 launch of AFFRMP, structured stakeholder consultations with regional testing laboratories prioritized mycotoxins as the highest-priority CRMs for both calibration and food matrix measurements. In 2017, this evidence base was extended through the IAEA AFRA Technical Cooperation network (the Africa Food Safety Network), which confirmed identical priorities across participating Member States. The 2023 AFRIMETS Pan African Food Safety Testing Capacity Survey, supported by PTB Germany, provides the most recent evidence of progress and remaining gaps.¹²

Data quality across all NMISA-produced CRMs and PT reference values is ensured through metrological traceability to the SI, ISO/IEC 17025, 17043, and ISO 17034 accreditation as RM producer, and demonstration of equivalence through participation in CCQM Key Comparisons (e.g., CCQM-K138 aflatoxins in figs, CCQM-K168 trans-Zearalenone in maize, and the CCQM K154 series for the BIPM CBKT calibration solution CRM series).

Over the past decade, the collaborative reference material and PT activities, built around NMISA's CRMs and complemented by partner contributions (Joint FAO-IAEA, AFRIMETS, BIPM CBKT, National Metrology Institute of Japan (NMIJ), National Institute of Metrology (NIM) China, Asia Pacific Metrology Programme (APMP), AOAC-Africa, and PTB Germany), have delivered measurable improvements in food safety testing capabilities across Africa. This has included demonstrable PT performance improvement for mycotoxin analysis among participating laboratories over successive PT rounds since 2018, with PT schemes covering aflatoxins in peanut slurry (2018), peanut butter, and mycotoxins in cereals (2019). **Table 1** highlights the 20-40 % improvement in food testing laboratories achieving satisfactory PT scheme performance scores over a 7-year time period.¹³ Continuous independent monitoring through PT participation is valuable for identifying potential bias and new measurement challenges where matrix RMs are not available (e.g., cassava).

¹² AFRIMETS, "Pan African Food Safety Testing Capacity Survey 2023," 2023.

<http://www.afrimets.org/Lists/Events/Attachments/100/PTB FOOD SAFETY TESTING CAPACITY SURVEY REPORT FINAL Rev II Oct 2023.pdf>

¹³ NMISA, "Africa Food Safety Workshop 2022 Proceedings," in

<https://www.nmisa.org/SiteAssets/AFSW%202022%20Post%20Event%20Report%20-%20Attendees.pdf>, 2022.



Figure 3. Top row: NMISA hands-on training for AFRIMETS mycotoxin analysis (Tanzania, Malawi, Lesotho, Ethiopia), and bottom row: in-house RM production (IAEA RAF 5084 Fellowship training for Benin, Botswana, Morocco, and Nigeria).

A further benefit is the cost savings and rapid response capability for the South African food industry. For example, immediate access to NMISA patulin and aflatoxin CRM calibrators and peanut slurry and peanut butter matrix CRMs alleviated the South African Perishable Product Export Control Board (PPECB) and the wider private testing community during COVID-era testing pressures for patulin in apple and grape juice, and more recently, aflatoxin-related peanut butter product recalls. This expanded analytical scope has also qualified NMISA to offer ISO 17034 RMs and ISO/IEC 17043 accredited PT schemes that now cover priority contaminants (mycotoxins, heavy metals, pesticides) in white maize, groundnuts, almonds, macadamias, cassava, wheat, fruits, and cocoa. It is also important to acknowledge the BIPM CBKT mycotoxin metrology programme, which has enabled multiple AFRIMETS NMIs (NMISA, NIS, KEBS, INRAP) to produce mycotoxin calibration solution CRMs for the first time, with CMCs progressively published under the CIPM MRA.

Table 1. Progressive improvement in Aflatoxin B1 Proficiency Test performance by selected Africa Food Safety Network laboratories for mycotoxin testing in groundnuts and cereals, 2018 – 2025.

Year	PT Study (Nuts)	No. of labs ^a	%z-score < 2	PT Study (Feed/Cereals)	No. of labs	%z-score < 2
2018	Ground nuts	33	61			
2019	Ground nuts	12	67	Maize	54	63
2019	Ground nuts	12	100	----		---
2020	Ground nuts	10	90	Cassava	22	73
2021	Ground nuts (low level)	21	81	Feed (general)	14	100
2021	Ground nuts (high level)	20	80	----		---
2022	----		---	Maize	18	100
2023	Ground nuts	20	80	----		---
2024	Ground nuts	25	48*	Feed (general)	20	100
2025	Almonds	4	100	Wheat	16	94
2025	----		---	Cassava	22	40**

^aNumber of laboratories that were used in the PT scoring

*A different set of less experienced testing laboratories within the network participated in this round

** Cassava CRM for method validation was not available, additional less experienced laboratories participating in this round

Because of these multifaceted, highly coordinated activities, a significant reduction in EU-RASFF notifications of African exports for mycotoxin contamination (from 48 % to 13 %) was observed during 2021-2024 (**Figure 1B**). This significant achievement was only made possible through the collective efforts of a global community of food safety stakeholders CBKT interventions, with NMISA's metrologically traceable CRMs contributing to the measurement foundation that enabled testing laboratories to demonstrate compliance reliably. The fundamental shift, from dependency on expensive, non-matrix-matched imported reference materials to indigenous, regionally tailored measurement capacity, represents a sustainable transformation of the analytical foundation underpinning food safety in Africa.

The collaborative mycotoxin metrology initiatives led by NMISA and fellow African NMIs (NIS, KEBS, and INRAP), complemented by PTB, BIPM-CBKT, IAEA, Joint FAO-IAEA, and AOAC partners, have collectively informed continental policy by providing the technical foundation that enables African countries to implement indigenous food safety standards and engage meaningfully within the African Continental Free Trade Area (AfCFTA).

The current "Pan African Project for Upgrading of Quality Infrastructure in Africa", supported by PTB Germany,¹⁴ also builds directly on this approach, supporting at least 10 additional food testing laboratories to expand their ISO/IEC 17025 accredited testing services through CRMs, PT, and targeted training. Within the Pan African Quality Infrastructure (PAQI) framework, encompassing the Intra-Africa Metrology System (AFRIMETS), African Organisation for Standardisation (ARSO), African Accreditation Cooperation (AFRAC), and African Electrotechnical Standardization Commission (AFSEC), these activities continue with new reference materials and PT schemes for emerging Africa CODEX standards, most recently including chemical hazards in the indigenous cassava-based foodstuffs.¹⁵ This programme serves as an exemplar of regional and global cooperation and partnership to achieve the UN SDGs.

The case demonstrates that sustained, coordinated investment in regional metrology –rather than isolated national efforts – generates institutional capacity that transcends borders, supports evidence-based policy, and positions African institutions as active collaborative contributors to global food safety governance, rather than passive recipients of external standards.

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¹⁴ Physikalisch-Technische Bundesanstalt, "The Pan-African Project "Upgrading Quality Infrastructure in Africa"," 2024. <https://www.qi-africa.ptb.de/our-efforts-in-africa-1>

¹⁵ Physikalisch-Technische Bundesanstalt, "Pan-African Quality Infrastructure (PAQI) - Celebrating 10 Years of Success," 2023. https://www.qi-africa.ptb.de/fileadmin/Ressourcen_Downloads_Dokumente/PAQI_Commemorative_publication_10Y_WEB.pdf