

POLICY BRIEF

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Modernizing Pesticide Residue Monitoring in Philippine Mangoes: Integrating Nanosensor Technology for Safer, Competitive and Export-Ready Agriculture

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Key Policy Recommendations

- **Adopt nanosensor-based rapid pesticide residue detection as an official pre-screening tool** in mango-producing regions to decentralize and accelerate Maximum Residue Level (MRL) compliance.
- **Establish a National Pesticide Residue Monitoring Program** that integrates nanosensor testing with existing BPI-PPSSD laboratory systems, enabling routine field-level monitoring and farmer training.
- **Implement incentive and support mechanisms** (grants, subsidies, tax incentives) for cooperatives, exporters, and LGUs to adopt nanosensor technology and improve food-safety compliance.
- **Strengthen public-private partnerships (PPP)** to expand research, validation, and deployment of nanosensors across post-harvest, consolidation, and export stages of the mango value chain.
- **Engage export partners (Japan, South Korea, China)** to recognize nanosensor-based on-site screening as a valid step in pre-export verification, reducing delays and rejection risk.

Brief Summary of the Project

This research project focuses on developing a smart metal oxide nanosensor capable of rapidly detecting pesticide residues, specifically cypermethrin, on post-harvest mangoes. Using a physical vapor deposition technique, the project team synthesized highly sensitive nanomaterials measuring 50–100 nanometers and integrated them into an electronic sensing platform. These nanosensors were tested on mangoes treated with varying pesticide concentrations, producing clear and measurable changes in voltage readings that corresponded to residue levels.

The results demonstrate the nanosensor's potential as a fast, low-cost, and field-deployable pre-screening tool that complements existing laboratory-based MRL testing. By enabling real-time detection at farms, consolidation points, and packing houses, the project offers a practical solution to improve food safety compliance and reduce post-harvest losses in the Philippine mango value chain.

Why these Recommendations Matter

The Philippine mango industry faces mounting pressure to comply with MRL standards set by major export markets, including Japan, South Korea, and China. In 2020, the Philippine fruit and vegetable sector produced approximately Php 402.634 billion worth of crops, yet 10–40% of this produce was lost before reaching consumers, largely during the production and post-harvest stages. A Department of Agriculture (DA) Mango Value Chain Workshop revealed that stakeholders across key production regions—including Guimaras, Palawan, Romblon, North Luzon, CALABARZON, and Mindanao—consistently struggle to meet pesticide residue standards. High pesticide residues have been documented at the farm, trader, and consolidator levels, threatening market access and the competitiveness of Philippine mangoes. Non-compliance with MRLs carries serious consequences, including rejected shipments, financial losses, erosion of market trust, oversupply that depresses farmgate prices, and diminished bargaining power for



smallholder farmers. These challenges underscore the urgent need for a reliable, accessible, and rapid pesticide monitoring system.

Current MRL testing capacity in the Philippines is insufficient to meet demand. Only nine accredited laboratories operating under the Bureau of Plant Industry-Plant Product Safety Services Division (BPI-PPSSD) exist, with turnaround times ranging from 3 to 20 days. Many laboratories are geographically distant from production sites, creating logistical challenges for the shipment of highly perishable mangoes. Moreover, testing costs are prohibitive for smallholder farmers and cooperatives.

Furthermore, widespread pesticide misuse persists due to a lack of on-site monitoring, limited access to training, and insufficient real-time diagnostic tools. Farmers often apply chemicals incorrectly or use products on unintended pests or crops, while traders and consolidators frequently receive batches flagged for high residues.

Nanosensor technology provides a practical, scalable, and science-based solution to these challenges. AniTech's metal oxide nanosensors are highly sensitive due to their nanostructured surfaces and can detect minute concentrations of pesticides and other volatile compounds. The sensors consume low energy and deliver rapid, real-time readings, making them ideal for

portable, field-level deployment. In controlled tests with mangoes treated with varying concentrations of cypermethrin, the sensor recorded voltage changes from 2.95 V (no pesticide) to 2.91 V (0.5 mL pesticide) and 2.83 V (0.8 mL pesticide), clearly demonstrating its ability to differentiate residue levels. This capability enables farmers and exporters to pre-screen produce before submitting samples to accredited laboratories, reducing both risk and reliance on costly lab testing.

The mango industry, which contributed Php 35.52 billion to the Philippine agricultural economy in 2020, faces compounding challenges. Between 2010 and 2020, mango production experienced a negative average annual growth rate of -0.93%, with post-harvest losses reaching 26–30% in the absence of technological interventions. The Ilocos Region, the top mango-producing area, accounts for 29% of total national mango output. However, farmers and exporters continue to struggle with unstable prices, disease outbreaks, and high production costs. Strict quality assurance processes, particularly governing pesticide residue levels, further complicate market access, making it difficult for producers to compete internationally. These figures highlight the need for improved post-harvest monitoring and food safety interventions to protect both farmers' incomes and the country's export potential.

Integrating nanosensors into the mango value chain directly supports the strategic objectives outlined in the Philippine Mango Industry Roadmap 2021–2025 and the Vegetable Industry Roadmap 2021–2025. These roadmaps emphasize food safety compliance, post-harvest

loss reduction, modernization of handling systems, enhanced quality assurance, and improved export competitiveness. Nanosensor technology provides real-time quality control, data-driven post-harvest management, improved traceability, and greater adherence to MRL standards. By adopting this innovation, the Philippines can position itself as a regional leader in agricultural technology and strengthen its competitive edge in global mango markets.

The economic impact of implementing nanosensors is significant. Rapid, on-site detection can prevent shipment rejections, reduce losses at consolidation and export stages, shorten lead times, increase farmer income through better compliance, and build confidence among international buyers. For an industry valued at Php 35.52 billion, even minor improvements in compliance and post-harvest monitoring can translate into substantial economic gains. Furthermore, by decreasing post-harvest losses of 10–40% and providing reliable residue data, nanosensors contribute to more efficient supply chains, reducing oversupply and stabilizing market prices for producers and traders alike.

In conclusion, the Philippine mango industry urgently needs a decentralized, accessible, and cost-effective pesticide residue monitoring system. Nanosensor technology represents a breakthrough solution, enabling rapid, real-time detection of residues at farms, consolidation centers, and packing facilities. By identifying contaminated batches early, the technology reduces dependency on slow and costly laboratory testing while enhancing compliance with global standards.

Policymakers should prioritize integrating nanosensor-based monitoring into national food safety programs, support farmers and cooperatives in adopting the technology, and foster public-private partnerships to further develop and deploy nanosensors. By doing so, the Philippines can modernize post-harvest systems, reduce losses, boost global competitiveness, and build a more resilient and sustainable agricultural sector.

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