PorciTrace™: First Rapid Ultrasensitive Fluorescence-Amplified ELISA Platform for Detecting Porcine meat adulteration in Global Meat Supply Chains

Introduction and Problem statement

Food fraud continues to escalate as a major global threat to food security, public health, and international trade integrity, with annual economic losses estimated between USD 40–110 billion worldwide (1,2). Meat and processed meat products are among the most vulnerable categories due to high economic value, inter-species price differentials, and increasingly complex transnational supply chains (3). Undeclared porcine contamination, whether through deliberate substitution or inadvertent cross-contamination during slaughter, mincing, processing, or logistics—poses disproportionate regulatory and trade consequences in certification-driven markets. The global certified and traceability-based food economy now exceeds USD 2 trillion annually, and importing jurisdictions increasingly require laboratory-verified species authentication rather than reliance on documentation alone (4). The Gulf Cooperation Council (GCC) region represents one of the fastest-growing protein import ecosystems, with annual food imports exceeding USD 60 billion and inspection systems processing millions of tons of meat annually through high-throughput port facilities (5). Even trace contamination events can trigger shipment rejection, supplier suspension, and cascading financial losses, underscoring the urgent need for rapid, ultrasensitive, and field-deployable detection technologies.

India, with a population exceeding 1.4 billion and a food processing sector valued above USD 400 billion, is a major exporter of buffalo meat and processed poultry products to West Asia, Southeast Asia, and Africa (6). Meat exports reached approximately USD 4 billion in 2024–2025 despite increasing regulatory scrutiny (7). However, decentralized molecular testing capacity remains uneven across states, particularly in rural abattoirs and SME-operated processing units, which constitute nearly 80% of the sector. Export rejection rates in high-scrutiny markets have been reported at 10–15% in certain segments, contributing to annual losses estimated at USD 150–250 million across the value chain (8). These structural gaps highlight the need for accessible, high-sensitivity screening tools that function outside centralized laboratory settings.

Critical Diagnostic Gap and Unmet need

Current gold-standard detection paradigms including polymerase chain reaction (PCR), liquid chromatography–tandem mass spectrometry (LC-MS/MS), and sequencing-based methods, etc. achieve limits of detection below 0.01% under controlled conditions but require capital investments exceeding USD 100,000 per instrument, extended assay durations (4–8 hours or longer), cold-chain reagent logistics, and specialized personnel (9). In decentralized inspection environments such as port-of-entry laboratories, mobile inspection units, and slaughterhouses, these constraints limit throughput and inflate compliance costs. Conventional ELISA-based immunoassays provide a more accessible alternative; however, many commercially available kits exhibit detection thresholds between 0.1–1% contamination and reduced sensitivity in thermally processed matrices due to protein denaturation and epitope degradation (10). The global rapid food safety testing market, valued at approximately USD 19.7 billion in 2025 and projected to reach USD 31.2 billion by 2030 (CAGR ~9–10%), reflects rising demand for point-of-care (POC) solutions, yet only a minority of platforms maintain high sensitivity in complex processed matrices (11). A critical diagnostic

Head Office & Manufacturing Unit:
36, Therpet Road
D. Kota - 635107

R & D unit:
F7, COXBIT, TNAU
Coimbatore – 641003

+91 89 39 75 07 52
info@mittilifetek.com

gap therefore persists at the intersection of ultrasensitivity, rapid turnaround, affordability, and decentralized deployment.

Our Innovative Solution: The PorciTrace™ Translational Immunodiagnostic Platform

To address this gap, Mitti Lifetek PharmaDx Pvt. Ltd. in close cooperation with Xact Diagnotek Private Limited, operating within the Center for Excellence in Biotechnology (COXBIT) at Tamil Nadu Agricultural University (TNAU), has developed PorciTrace™, an ultrasensitive fluorescence-amplified ELISA platform anchored in our proprietary Rapid Amplified Reporter-ELISA (RAR-ELISA) technology (Indian Patent Application #202341052841). This system deploys multiplexed antibodies targeting conserved porcine myofibrillar epitopes, coupled with near-infrared fluorophore signal amplification to achieve nanogram-to-picogram limits of detection (approximately 0.0001–0.001% w/w). The entire process is simple 4- step addition procedure that does not require any specialized technical skills. Validation across more than 50 raw and processed matrices, including autoclaved products, demonstrated 100% analytical specificity with no cross-reactivity against non-target species. The assay delivers quantitative results within 90 minutes using a streamlined four-step workflow, while reagent optimization reduces per-test cost to approximately USD 3–5, representing a 60–70% reduction relative to many commercial kits.

The resulting platform is designed for operation under ambient temperatures up to 40°C, enabling deployment in high-volume slaughterhouses, customs checkpoints, and decentralized inspection units. By functioning as a first-line triage tool, the system is projected to reduce reliance on centralized PCR confirmation by up to 60%, decrease compliance costs by 40–50%, and enable screening throughput exceeding 100 samples per hour in high-volume settings.

Economic Impact and Commercialization Potential

The socio-economic implications are significant. In India, where meat exports are predominantly oriented toward high-compliance markets, rapid on-site screening could reduce rejection incidents by an estimated 25–40%, strengthen SME competitiveness, and improve supply-chain traceability under FSSAI's regulatory modernization initiatives. In the GCC region, where annual food imports exceed USD 60 billion and halal-certified trade is tightly regulated, real-time POC verification could mitigate estimated annual rejection losses of USD 200–300 million across import channels (5,8). The broader food authenticity testing market, valued at approximately USD 9–10 billion in 2025 with sustained growth driven by Codex harmonization and consumer transparency demands (12), provides a scalable commercialization pathway.

Collectively, PorciTrace™ represents a first-in-class Indian-developed fluorescence-amplified ELISA-to-strip translational platform for trace-level porcine detection. By closing critical diagnostic gaps in decentralized inspection ecosystems, the technology aligns with global regulatory modernization trends, strengthens export competitiveness, and advances science-driven transparency in international food supply chains.

References

1. FAO. Global Food Fraud and Adulteration Review, 2024–2025.
2. OECD. Illicit Trade in Food Products Report, 2024.

Head Office & Manufacturing Unit:
36, Therpet Road
D. Kota - 635107

R & D unit:
F7, COXBIT, TNAU
Coimbatore – 641003

+91 89 39 75 07 52
info@mittilifetek.com

3. Europol & Interpol. Operation Opson Reports (latest edition).
4. State of the Global Islamic Economy Report, 2024.
5. Alpen Capital. GCC Food Industry Report, 2025.
6. Ministry of Food Processing Industries (MoFPI), India, 2024–25 data.
7. APEDA Export Statistics, 2024–2025.
8. Trade & Customs Rejection Analyses, GCC Import Reports 2024–2025.
9. Codex Alimentarius Commission. Guidelines on Food Authenticity and Traceability.
10. Sentandreu & Sentandreu, Food Chemistry Reviews on ELISA in Meat Speciation.
11. Global Rapid Food Safety Testing Market Forecast Report, 2025–2030.
12. Global Food Authenticity Testing Market Analysis, 2025.

Head Office & Manufacturing Unit:
36, Therpet Road
D. Kota - 635107

R & D unit:
F7, COXBIT, TNAU
Coimbatore – 641003

+91 89 39 75 07 52
info@mittilifetek.com