Traceability for Safe Seafood - Relevance of Residue and Contaminant Analysis

The following article is a part of FIFP webinars conducted on 29th March 2025 on the topic Traceability for Safe Seafood - Relevance of Residue and Contaminant Analysis

Note from the Chief Editor:

Traceability for safe seafood - relevance of residue and contaminant analysis comprised the main theme of FIFP webinar conducted on 29th March 2025. Residue analysis is an essential component of food safety, ensuring that food products are free from harmful chemicals and contaminants. Sri Roopak Subramanian's presentation was insightful and beneficial for the seafood export industry. He elaborated steps involved in residue traceability and the role of Government agencies in residue analysis. He explained the importance of Pre-Harvest Testing (PHT) and Pre-Export Testing (PET) and requirements for setting up reliable testing laboratory. While classifying the types of residues, he also provided list of banned substances. He highlighted the emerging challenges in residue analysis such as PFAS (Per- and polyfluoroalkyl substances), which are becoming a significant concern in food safety.

Introduction

Residue traceability involves tracking a contaminated food product back through the supply chain to its origin. This includes identifying the farm where the product was sourced and determining which chemicals (such as pesticides or veterinary drugs) may have caused the residue. This traceability process is vital for accountability and ensuring that any food residue is linked to its source, helping to pinpoint the cause of contamination and ensuring corrective measures. The primary goal of residue analysis is to confirm that food is free from harmful substances and to ensure the traceability of food products to their sources, ensuring safety throughout the supply chain.

Definitions

Residues are substances that remain in food after the application of chemicals like veterinary drugs or pesticides. Codex Alimentarius defines residues as specified substances present in food or feed due to chemical use. Contaminants are substances unintentionally present in food, often due to production, processing, or environmental contamination.

Historical background

The background for residue analysis traces back to the 1998 EU ban on Indian seafood, which led India to align with EU Council Directive 96/23/EC. This was a crucial step for resuming seafood exports to the EU by ensuring compliance with safety standards for pesticide and veterinary drug residues. While Directive 96/23/EC has been repealed, current regulations, such as Regulation (EU) 2017/625, govern the trade today. Similarly, the United States follows FDA and EPA regulations to manage pesticide and chemical residues in food, and Japan regulates food safety through its Food Sanitation Act. Other major countries that have residue analysis requirements include Russia, South Korea, South Africa, and Vietnam. Most of these countries derive their Maximum Residue Limits (MRLs) from Codex MRL standards.

Role of Government agencies in residue analysis

Key government bodies involved in residue analysis in India include MPEDA (Marine Products Export Development Authority) and the Export Inspection Council (EIC). MPEDA plays a central role by managing testing and ensuring that the Indian seafood industry complies with international standards. Samples are taken from aquaculture farms by Residue Monitoring Officers (RMO), forwarded to MPEDA's QC laboratories, and analysed for various parameters like antibiotic residues, pesticides, and heavy metals. These results are communicated to the EIC, which forwards them to relevant international bodies, such as the EU. Regular audits by the EU ensure that Indian seafood meets these residue standards. MPEDA operates several laboratories across India and performs the National Residue Control Program (NRCP) to ensure compliance with these standards.

Pre-Harvest Testing (PHT)

Pre-Harvest Testing (PHT) is mandatory for all aquaculture farms aimed at exporting to the EU. The PHT process begins when farmers submit requests for testing through the e-PHT portal. After verification, a sampler is assigned to collect the samples, which are then tested for residues, including antibiotics, using methods like ELISA and LC-MS/MS for confirmation. These results are essential for ensuring the safety of products before they reach the market.

Pre-Export Testing (PET)

Pre-Export Testing (PET) is a consignment-based testing method for antibiotic residues. This testing is initiated by exporters or processors, with samples collected by EIC-approved samplers. The analysis results are then

used to issue health certificates for international shipments. PET is crucial for ensuring that finished products meet the residue requirements of importing countries, including the EU, Japan, South Korea, South Africa, Saudi Arabia, and Russia. For exports to other countries, including the USA, the samples are analysed in EIC-approved laboratories.

Classification of types of residues

Residue analysis also involves the classification of different types of residues. Antibiotic residues are categorized into banned/unauthorized substances and permitted/authorized substances. Banned substances include compounds like Chloramphenicol, Nitrofurans, and dyes, which are banned due to their mutagenic or carcinogenic properties. Authorized substances, like Tetracyclines and Sulphonamides, have Maximum Residue Limits (MRLs) based on the dietary intake that is considered safe.

Contaminants in food

Contaminants in food, such as pesticides and heavy metals, are also a focus of residue analysis. Pesticides are chemicals used to control pests but can be toxic if not properly managed. They are categorized into organochlorine pesticides (OCPs), organophosphorus pesticides (OPPs), and pyrethroids. Heavy metals like cadmium, lead, mercury, and arsenic are also closely monitored due to their potential toxic effects at trace levels.

Requirements for setting up reliable testing laboratory

Setting up a reliable testing laboratory requires significant investment in infrastructure and equipment. A laboratory should have approximately 3000 sq. ft. of space with temperature-controlled rooms for equipment and air filtration systems. Key equipment includes LC-MS/MS for antibiotic analysis, GC-MS/MS for pesticide analysis, ICP-MS for heavy metals, and HPLC-UV for histamine and aflatoxin detection. Minor equipment needs include homogenizers, analytical balances, vortex mixers, and nitrogen evaporators. Additionally, laboratories must have dedicated, skilled technical personnel and adhere to proper safety and operational standards.

The establishment of a testing laboratory also requires the availability of essential consumables like specific-grade chemicals and solvents, deep freezers for sample storage, and protective gear for laboratory staff. Laboratories should be equipped with fume hoods, air circulation systems, and certified reference materials traceable to ISO 17034:2016 to ensure accuracy and safety. The estimated cost for setting up a chemical testing laboratory with essential equipment and consumables is approximately ₹5.93 crores.

To identify a reliable testing facility in India, one can check whether the laboratory is accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL). NABL accreditation ensures that the facility complies with the ISO/IEC 17025:2017 standard, which outlines the general requirements for testing and calibration laboratories. NABL's website provides a laboratory search tool to verify the accreditation status and scope of various laboratories in India, ensuring that they can perform the necessary tests.

Challenges in residue analysis

Emerging challenges in residue analysis include PFAS (Per- and polyfluoroalkyl substances), which are becoming a significant concern in food safety. PFAS compounds, such as PFOS, PFOA, and PFHxS, have stringent Maximum Residue Limits (MRLs) set by regulatory bodies for both crustaceans and fish. For instance, PFOS has an MRL of 3 ppb in crustaceans and 2 ppb in fish, while PFOA has a limit of 0.7 ppb in crustaceans and 0.2 ppb in fish. PFNA has limits of 1 ppb in crustaceans and 0.5 ppb in fish, while PFHxS is restricted to 1.5 ppb in crustaceans and 0.2 ppb in fish. These limits aim to mitigate the health risks associated with PFAS exposure.

Conclusion

Residue analysis is an essential component of food safety, ensuring that food products are free from harmful chemicals and contaminants. Effective residue testing supports traceability, helping to identify the source of any contamination and ensuring compliance with international food safety standards. Reliable testing facilities, adequate infrastructure, skilled personnel, and adherence to global standards are key to maintaining food safety and meeting international trade requirements.

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Mr. Roopak Subramanian currently serving as a Technical Officer (QC) at MPEDA QC Laboratory, Kochi has15 years of expertise in chemical testing of marine and aquaculture products including antibiotic residues, pesticides, and heavy metals. Over the years, he has held key roles such as Technical Manager and Deputy Quality Manager at MPEDA labs in Kochi and Bhimavaram. He is also an NABL assessor in chemical testing for marine and aquaculture products. Before joining MPEDA in 2009, he had gained extensive industry experience. He worked as Online QC Supervisor at HT Foods Pvt Ltd, Kochi, specializing in breaded shrimp lines. He handled QC

operations for Sri Lankan tuna shipments at Phillips Foods India Pvt Ltd, Tuticorin. His earlier roles included working with IQF and cooking lines at Choice Canning Co., Kochi, and as a Technologist at Baby Marine Products, Malpe, focusing on block frozen seafoods. He began his career as a trainee at Amizons Pvt Ltd, Edakochi. He also had short stints at Relish Seafoods, Kanyakumari, Gulf Seafoods LLC, Dubai, and Sandy Bay Seafood, Vishakapatnam further enhancing his expertise in the seafood industry.