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Malaysia's First National Survey of Neonicotinoids in Farmed Shrimp: A Risk Assessment for Food Safety and Trade

Norazlina Omar[1,2], Nurul Izzah Ahmad[3], Noorfatimah Yahaya[4], and Musfirah Zulkurnain[1]*

[1]*School of Industrial Technology, Universiti Sains Malaysia, 11800 Gelugor, Penang, Malaysia*
[2]*Food Safety and Quality Division, Ministry of Health, Menara Prisma, Precint 3, 62575 Putrajaya, Malaysia*
[3]*National Institute of Health, Ministry of Health, 40170 Shah Alam, Selangor, Malaysia*
[4]*Advanced Medical and Dental Institute, Universiti Sains Malaysia, 13200 Bertam, Kepala Batas, Penang, Malaysia*

ABSTRACT

Neonicotinoid insecticides, widely used in agriculture, may infiltrate aquaculture systems, raising food safety and trade concerns. This study presents the first nationwide surveillance of eight neonicotinoids in Pacific white shrimp (*Litopenaeus vannamei*) from Malaysian farms. A total of 174 samples from 13 states were analysed using an optimised QuEChERS (quick, easy, cheap, effective, rugged and safe) extraction coupled with liquid chromatography-tandem mass spectrometry (LC-MS/MS). Residues were detected in 22% of samples, mainly flupyradifurone (6.3%), thiamethoxam (5.2%), and imidacloprid (4.0%), all below the limit of quantification (LOQ). Detection was higher in East Malaysia (25.0%) than Peninsular Malaysia (19.8%), with 60.5% of positives occurring during the dry season (Southwest monsoon). Seasonal influence was evident, as most detections of clothianidin (100%), thiacloprid (100%), thiamethoxam (78%), sulfoxaflor (60%), and imidacloprid (57%) were recorded during this period, likely due to runoff and reduced dilution. Dietary exposure estimates indicated a maximum intake of 1.48×10^{-6} mg/kg bw/day (<0.01% of Acceptable Daily Intakes, ADIs), demonstrating negligible risk even under worst-case assumptions. These findings suggest minimal consumer health risks but highlight low-level contamination from agricultural sources. Regular seasonal monitoring is recommended to safeguard food safety, the environment, and compliance with international trade standards.

Keywords: Neonicotinoids, Malaysia, pesticide residues, risk assessment, shrimp

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E-mail addresses:
norazlina_omar@moh.gov.my (Norazlina Omar)
nizzah.a@moh.gov.my (Nurul Izzah Ahmad)
noorfatimah@usm.my (Noorfatimah Yahaya)
*musfirah.z@usm.my (Musfirah Zulkurnain)
* Corresponding author

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INTRODUCTION

Shrimp aquaculture is an important sector in Malaysia, with Pacific white shrimp (*Litopenaeus vannamei*) contributing ~50,000 tonnes annually and MYR 1.3 billion in exports (Department of Fisheries Malaysia, 2020). Processed shrimp are exported to markets including China, Taiwan, and Singapore, while raw shrimp serve as a local protein source. Data on neonicotinoid contamination remain limited, hindering dietary exposure assessment (Waras et al., 2024). These systemic insecticides are widely used in Asia (Food and Agriculture Organisation, 2024), and up to 80% may enter ecosystems via runoff or leaching, contaminating aquaculture (El-Nahhal & El-Nahhal, 2021). In Malaysia, maximum residue limits (MRLs) are enforced for plant-based foods, but animal products rely on a default limit of 0.01 mg/kg under the Food Act 1983 and Food Regulations 1985 (https://hq.moh.gov.my/fsq). Although the tropical climate and intensive agriculture increase contamination risks, surveillance data remain scarce, limiting effective food safety management.

PROBLEM STATEMENT

Malaysia's shrimp aquaculture sector lacks data on neonicotinoid contamination in *L.vannamei*, a major species for consumption and exports. With only a default residue limit and risks from intensive pesticide use and monsoon runoff, this study provides the first nationwide surveillance of eight neonicotinoids in farmed shrimp and assesses dietary exposure in Malaysian consumers.

RESEARCH QUESTIONS

This study examined; (i) the occurrence and concentrations of neonicotinoid residues in farmed *L.vannamei* across Malaysia's aquaculture regions, (ii) the influence of Southwest and Northeast monsoons on residue detection, (iii) the potential dietary exposure risk to Malaysian adults.

MATERIALS AND METHODS

A total of 174 Pacific white shrimp *(Litopenaeus vannamei)* samples were collected from farms across 13 Malaysian states during 2023 – 2024, covering both Northeast (October to March, rainy season) and Southwest (April to September, dry season) monsoon. Samples were analysed by LC-MS/MS after extraction with a modified QuEChERS method using certified standards (Omar et al., 2025). For health risk assessment, chronic dietary exposure was estimated using shrimp consumption and body weight data from Ahmad et al. (2016). Concentrations below the LOQ were replaced with half-LOQ values (World Health Organization, 2009), based on LOQs from Omar et al. (2025). Estimated Daily

Intakes (EDIs, mg/kg bw/day) were compared with the Codex Acceptable Daily Intake (ADI) (Codex Alimentarius Commission, 2025).

RESULTS AND DISCUSSION

Residues were detected in 38 of 174 shrimp samples (22.0%), mainly flupyradifurone (11/174, 6.3%), thiamethoxam (9/174, 5.2%), and imidacloprid (7/174, 4.0%), with all concentrations below the limit of quantification (LOQ). Flupyradifurone (11/38) was the most frequently detected, consistent with its widespread agricultural use (Food and Agriculture Organisation, 2024). Detection was higher in East Malaysia (17/68, 25.0%) than in Peninsular Malaysia (21/106, 19.8%), with most positives (23/38, 60.5%) during the Southwest monsoon. Several compounds, including clothianidin, thiacloprid, thiamethoxam, sulfoxaflor, and imidacloprid, were predominantly found in the dry season, reflecting monsoon-driven runoff and hydrological influence (El-Nahhal & El-Nahhal, 2021).

Dietary exposure assessment showed that Estimated Daily Intakes (EDIs) for all neonicotinoids were far below their Acceptable Daily Intake (ADI). Values ranged between 7.10×10^{-7} (thiacloprid) and 1.48×10^{-6} (sulfoxaflor) mg/kg bw/day, all <0.01% of ADI (Table 1). Clothianidin (36%) and thiacloprid (26%) contributed the most due to stricter ADIs, yet cumulative exposure remained well under 100%. These results confirm negligible dietary risk while underscoring the need to prioritise compounds with higher toxicological relevance in monitoring (Waras et al., 2024).

Table 1
Estimated Daily Intake (EDI) and chronic dietary exposure risk (%ADI) of neonicotinoid residues in Pacific white shrimp (worst-case scenario)

Compound	EDI (mg/kg bw/day)	%ADI	Contribution (%)
Thiamethoxam	7.74×10^{-7}	9.67×10^{-4}	3%
Flonicamid	1.23×10^{-6}	1.75×10^{-3}	6%
Clothianidin	9.68×10^{-7}	9.68×10^{-3}	36%
Imidacloprid	1.10×10^{-6}	1.83×10^{-3}	7%
Acetamiprid	1.10×10^{-6}	1.57×10^{-3}	6%
Flupyradifurone	1.03×10^{-6}	1.29×10^{-3}	5%
Thiacloprid	7.10×10^{-7}	7.10×10^{-3}	26%
Sulfoxaflor	1.48×10^{-6}	2.97×10^{-3}	11%

CONCLUSION

Detection of neonicotinoids in *L. vannamei* indicates agricultural runoff, with regional and seasonal patterns reflecting environmental influence. Although overall dietary exposure was negligible, higher %ADI contributions from clothianidin and thiacloprid highlight

the need for stricter monitoring and updated regulations to safeguard aquaculture food safety in Malaysia.

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