Biodegradable Plastics: Emerging Environmental Risks to Food Safety and Security

Cecilia Bertacini, and Gary Hardiman

Queen's University Belfast, UK

ABSTRACT:
Plastic pollution is a critical challenge of the 21st century, with growing implications for food safety, food security, and human health. Each year, large volumes of plastic waste enter rivers, lakes, and oceans, breaking down into micro- and nanoplastics. These tiny particles are highly persistent and mobile, allowing them to accumulate in aquatic food chains, including species consumed by humans. Early developmental stages of aquatic organisms are particularly vulnerable. Research links microplastic exposure to reduced survival, impaired hatching, abnormal development, and disrupted organ formation in fish and other species. These effects not only threaten ecosystem stability but also raise concerns for seafood quality, safety, and supply, as stressed populations may impact fisheries and aquaculture yields. While biodegradable plastics are often promoted as safer alternatives, their biological impacts remain poorly understood. Importantly, "biodegradable" does not mean harmless, especially during sensitive developmental stages. Understanding these risks is essential for effective regulation and consumer protection. The zebrafish (*Danio rerio*) has become a powerful research model for assessing these impacts. Its transparent embryos and genetic similarities to humans enable detailed studies of survival, morphology, behaviour, and molecular changes during microplastic exposure. This study investigated the impacts of biodegradable polymers, Polylactic Acid (PLA, bio-based) and Polycaprolactone (PCL, fossil-based), as well as the non-biodegradable polymer Polystyrene (PS) on embryonic development and behavioural outcomes in zebrafish. Insights from this study provide clarity on how plastic particles interact with living systems and can be used to inform risk assessments for seafood safety and human health. By bridging environmental science and food safety, this research highlights the urgent need for mitigation strategies that not only reduce plastic pollution but also address its potential developmental, ecological, and food safety impacts, ensuring the resilience and safety of aquatic food systems for future generations.

KEYWORDS:
Biodegradable plastics, microplastics, zebrafish, embryonic development, Food security