

RESEARCH ON THE QUANTIFICATION AND CHARACTERIZATION OF MICROPLASTICS FROM MILK AND DAIRY PRODUCTS - IMPACT ON HEALTH AND ENVIRONMENT

PhD. Student Andreea Laura Banica

PhD. Advisor Prof. Cristiana Radulescu

Abstract

Given the accumulation of microplastics in the environment and their transport in the food chain through direct contamination of (natural and processed) food products, which has become a global threat to both the environment and human health, **this doctoral thesis represents a benchmark for scientific research in Romania, but also abroad**, through precise, unequivocal data regarding the significant risk to the environment and humans associated with exposure to microplastics. The interdisciplinary character of the research started from identifying the relevant societal context for a clean environment and implicitly safe food for a healthy life (without emerging contaminants) and understanding the various factors applicable to the field of environmental engineering by applying computational methods, as well as relevant experimental techniques, but also data analysis approaches.

The choice of the theme was made based on an in-depth study of the specialized literature, taking into account the fact that, at the time of starting the scientific incursion, the data were limited, the few studies being based on assumptions and presumptive hypotheses without a practical/experimental foundation and without the stability of clear correlations on a statistical basis. On the other hand, another criterion, which was the basis for choosing the theme, was related to innovation, which in the clean environment-safe food system mainly must *(i)* contribute to reducing the plastic footprint, *(ii)* ensure the safety and sustainability of food products, *(iii)* improve the concept of safe food, and *(iv)* contribute to indeclining global objectives.

The topic proposed in the doctoral thesis entitled **Research on the quantification and characterization of microplastics present in milk and dairy products – Impact on health and the environment** has an interdisciplinary character, falling within the fundamental field of Engineering Sciences, the field of Environmental Engineering, within the Doctoral School of the Faculty of Chemical Engineering and Biotechnology.

The doctoral thesis presents a **high degree of novelty**, also through the protocol developed in this thesis for isolating microplastics from dairy products, which has been patented at national and international levels.

Given the ubiquity of microplastics in the environment and the health risk associated with exposure to them, the stated aim of the doctoral thesis was to separate, quantify, and morphologically and chemically analyze, but also to highlight the health and environmental risk associated with the presence of a cumulation of contaminants, such as microplastics, polycyclic aromatic hydrocarbons, and heavy metals, taking into account the most recent and representative research in this field. Primary sorption processes that increase exposure to emerging contaminants linked to microplastics include key mechanisms such as electrostatic interactions, hydrophobic interactions, hydrogen bonding, and steric effects.

The research undertaken in the development of the doctoral thesis entitled **Search on the quantification and characterization of microplastics present in milk and dairy products – Impact on health and the environment** aimed at the following objectives:

- O1.** establishing sample selection criteria using a survey;
- O2.** selection, preparation, and processing of samples, taking into account the complex organic matrix of the samples, as well as their susceptibility to pathogens;
- O3.** isolation of microplastics from milk and fermented products with different fat content;
- O4.** complex morphological investigations on isolated microparticles through high-performance analytical techniques, such as optical microscopy, scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS), and micro-Fourier transform infrared spectroscopy (micro-FTIR);
- O5.** identification and chemical characterization of microplastics by micro-Fourier transform infrared spectroscopy (micro-FTIR);
- O6.** investigation of potential emerging contaminants, such as polycyclic aromatic hydrocarbons (by high-performance liquid chromatography with fluorescence detection, HPLC-FLD) and heavy metals (by inductively coupled plasma mass spectrometry, ICP-MS) in milk samples, to sketch a possible hypothesis regarding the property of microplastics to act as vectors for these contaminants;
- O7.** estimating the risk associated with exposure to emerging contaminants, in terms of the environment and human health (children and adults);
- O8.** studie of microplastics dimensions through complex morphological investigations, but also analytical ones regarding chemical composition, correlated and statistically interpreted, with the estimation of the risk to the environment and human health associated with exposure to emerging contaminants, an assumed objective of the doctoral thesis. Secondary factors, taking into account historical soil pollution, animal feeding methods, geographical conditions, relief, habitat, etc., and statistical analyses, contribute to the stability of fundamental correct hypotheses and interpretations to achieve the objectives assumed within this scientific research;
- O9.** possibilities for implementing the patented method of isolating microplastics in industry by evaluating the effectiveness of the HACCP system in controlling microplastics and other contaminants in finished products, with reference to Romania.

Novelty items:

- 1.** development and patenting of the method for isolating microplastics from dairy products, RO 137927 B1/2025 (OSIM) and WO2025/071426 A1 (WIPO/PCT).
- 2.** quantification and morphological, elemental, and chemical study of isolated microplastics through high-performance analytical techniques such as optical microscopy, scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDS), and micro-Fourier transform infrared spectroscopy (micro-FTIR);
- 3.** quantitative determination of potentially carcinogenic contaminants, such as polycyclic aromatic hydrocarbons and heavy metals, by high-performance liquid chromatography with fluorescence detection (HPLC-FLD) and by inductively coupled plasma mass spectrometry (ICP-MS);
- 4.** estimating the environmental and human health risk associated with exposure to microplastics and other emerging carcinogenic contaminants (heavy metals and polycyclic aromatic hydrocarbons);
- 5.** alternative regarding the implementation of the patented microplastic isolation method, in terms of the effectiveness of the HACCP system, in the separation/control of microplastics in dairy products, which is based on the identification of critical points in

the technological process of manufacturing dairy products and on continuous monitoring of potential contamination;

6. evaluating the effectiveness of the HACCP system in controlling microplastics and other contaminants in dairy products.

The dissemination of scientific research presented in the doctoral thesis was the subject of five articles in prestigious ISI journals, two patents, and participation in invention salons and international conferences in the field, where over 20 awards and medals were obtained.