MICROPLASTICS IN THE FOOD CHAIN: RISK CHARACTERIZATION FOR HUMAN HEALTH AND PREVALENCE

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ABSTRACT

The presence of microplastics in the marine and terrestrial environment has gained a lot of attention over the past decade. Especially the continuously increasing litter contamination has led to an increased concern about plastics and more specifically, microplastics in the marine environment. However, it remains unclear to what extent microplastics in the whole food basket affect human health.

Research on microplastics in seafood already led to several publications. Only recently, the presence of microplastics in a few other food items, such as salt, honey, beer and drinking water, has gained some attention. On the other hand, the analytical methods and the associated quality assessments to quantify microplastics in different food products are still evolving and not readily comparable. Therefore, total exposure of the consumer to microplastics via food is still unknown.

The main contamination routes of microplastics in food are either environmental, i.e. through contamination by the surrounding water or air, or through food processing and packaging. The relative importance of both contamination routes of food remains unclear. Also, the risks associated with microplastic exposure, being related to either chemical, biological or physical hazards, still needs to be investigated. Toxicity tests already revealed different effects on marine animals. Still, little is known on human health effects.

The current state of the worldwide research does not yet allow a sound risk characterization of microplastic exposure through food, as essential information on the daily intake of humans as well as the associated toxicity are still lacking. It is a work in progress, in which ILVO wants to play a key role, both at national and international levels.

INTRODUCTION

Plastic production increased worldwide from 1.5 million ton in 1950 to 230 million ton in 2009 (Hammer et al., 2012). Since plastics are strong, durable and buoyant, they are persistent in the environment and may be transported over long distances (Derraik, 2002). One major aspect of plastic pollution is the occurrence of microplastics. Microplastics are defined as particles <5 mm (Van Der Meulen et al., 2015). They may originate from primary as well as from secondary sources. Primary sources include particles which are produced either for direct use, such as industrial abrasives, exfoliants and cosmetics, or as precursors (resin pellets) for the production of consumer products. Secondary sources are the formation of microplastics due to the degradation of larger plastic material (Piha Henna et al., 2011).

Because of their small size, microplastics are potentially bioavailable to a wide range of organisms. They can be ingested by low trophic feeders and can be transferred through the food web to higher trophic levels (Setälä et al., 2014). As accumulation of microplastics in the marine environment became of high concern, several scientific publications focused on the presence of microplastics in seafood (e.g. Devriese et al., 2015; De Witte et al., 2014; Van Cauwenberghe et al., 2015; Van Cauwenberghe & Janssen, 2014; Vandermeersch et al., 2015). However, awareness is growing that other food matrices may also be highly contaminated. Recent years, research has extended to other food matrices such as sea salt, beer, honey, sugar, drinking water, …

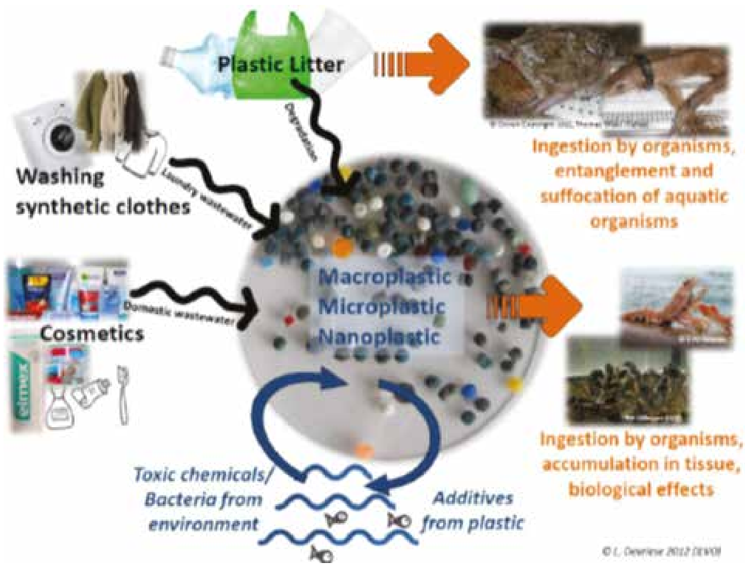

Figure 1. Sources and effects of plastic exposure (© L. Devriese – ILVO, 2012)

ANALYTICAL METHODOLOGY

The analytical methodology for microplastic determination in food has strongly evolved over the last decade. However, many different methods exist, and although the analytical methods are slowly converting towards each other and standardization of quality assurance is increasing, this process is still ongoing. Therefore, the methodology should be carefully checked when interpreting public data on microplastic contamination.

The research on microplastics in food generally consists of an appropriate sampling, followed by a digestion of the matrix, filtering the digested sample, and counting and determining the microplastics. Diversification between microplastics can be made based on color, shape or size and based on polymer type (**Figure 2**). An appropriate digestion agent is capable of efficiently digesting the food matrix without degrading plastics. Acid digestion was frequently performed in previous research, but high concentrations of nitric, hydrofluoric, perchloric and sulphuric acid may damage or destroy certain polymers, particularly at high temperatures. Therefore, alkaline and enzymatic digestions are becoming the preferred methods (Dehaut et al., 2017; Lusher et al., 2017).

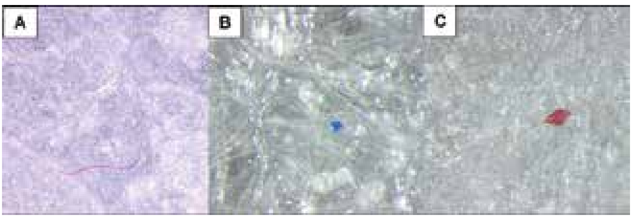

Figure 2. Example of different microplastic shapes in salt: (A) fibre, (B) granule and (C) sheet (Devriese et al., 2017a)

Microplastic analysis is subject to background contamination. Contact with plastic materials, use of non-filtered solvents or water, use of non-rinsed glassware or exposure to laboratory air may lead to highly overestimated concentrations of microplastic contamination. The use of appropriate measures against background contamination and the analysis of multiple procedure blanks are minimum requirements for high quality microplastic assessments in different food products. Also, the use of validated methods for microplastics determination is gaining importance. At the moment, this is hampered by the lack of appropriate reference material and the lack of proficiency testing schemes, although progress in this field is expected in the near future.

MICROPLASTIC EXPOSURE ROUTES

Food products may be contaminated by microplastics either through environmental contamination or through food processing and packaging materials.

The occurrence of microplastics in marine waters, lakes or river waters all can lead to microplastic contamination of seafood. However, fish filets are normally not affected by this contamination route, as the potentially ingested microplastics are too big to pass the intestinal wall towards the blood or muscles. On the other hand, seafood from which the gut is not removed before consumption, such as mussels and shrimps, may be of higher risk to human health, once contaminated with microplastics (Devriese et al., 2015; De Witte et al., 2014; Van Cauwenberghe et al., 2015; Van Cauwenberghe & Janssen, 2014; Vandermeersch et al., 2015). In a recent study, the presence of microplastics in sea salt revealed higher microplastic contamination when the salt was harvested at the water surface (Devriese et al., 2017a).

Atmospheric fallout may also be a significant source of microplastic contamination (Dris et al., 2016). Fibres originate from clothes, households, degradation of macroplastics, landfills and waste incineration. Liebezeit & Liebezeit (2013) suggested that the transport of particles by bees into the hive is a major contamination route for microplastics in honey. Also in beer, airborne particles are seen as a main source of microplastics (Liebezeit & Liebezeit, 2014).

Also the food processing and packaging contamination route may be an important source of microplastics. In many cases, food comes in contact with plastic food contact materials during transport, processing, storage or serving. During processing, food products may be rinsed with water containing microplastics, or they can be exposed to indoor air within an industrial environment. All those steps may affect the microplastic concentrations in food. Whereas most of these steps will increase microplastic contamination, the inverse may also happen. For instance, rinsing sea salt with brine seems to reduce the microplastic contamination of industrial salts (Devriese et al., 2017a). The use of plastic packaging material, on the other hand, was suggested to slightly increase the microplastic concentration in salt (Devriese et al., 2017a).

RISKS ASSOCIATED WITH MICROPLASTIC EXPOSURE

Up till now, it remains unclear to which extent microplastic exposure through food is a health risk for the consumer. Risks associated with microplastic exposure involve chemical, biological and physical hazards.

Many chemical compounds have been identified when extracting microplastics with organic solvents followed by GC-MS analysis (Gauquie et al., 2015). Numerous plastic additives incorporated during manufacturing as well as accumulated environmental pollutants can be detected. This may potentially lead to an additional contaminant exposure route (Teuten et al., 2009), although this seems to be highly dependent on the bioavailability of the contaminants. Bioavailability depends of the chemical compound as well as of the polymer type. Devriese et al. (2017b) showed that the relative uptake of polychlorinated biphenyls in Norwegian lobster is much higher when these contaminants where attached to polyethylene compared to polystyrene microplastics. Due to the strong binding capabilities of microplastics, the presence of such microplastic particles may even reduce toxicity (Koelmans et al., 2013). It is questionable if exposure to chemicals sorbed onto microplastics is really relevant compared to other exposure routes. For example, Koelmans et al. (2013) stated that water and food are more important for chemical contaminant exposure of aquatic organisms than microplastics. A similar argumentation sounds plausible for human exposure risks.

Also, the biological impact of microplastic contamination needs to be further investigated. The bacterial flora on microplastics found in marine waters is clearly distinct from the surrounding marine environment (De Tender et al., 2015). Microorganisms, including pathogens, may rapidly colonize microplastics (Zettler et al., 2013). Still, it remains unclear to which extent this can influence human health (EFSA, 2016).

The physical effects of microplastic ingestion are related to the translocation potential of such small particles. The epithelium of the gut wall represents an important barrier to microplastics. However, translocation from the gut into the lymphatic system is possible, and may cause systemic exposure (EFSA, 2016). Moreover, such translocation routes may be even more profound for the smaller fraction of plastics, i.e. the nanoplastics, causing a much bigger problem to animal and human health. For a number of marine invertebrates, a physical impact of microplastics has been reported, related to an influence on growth, reproduction, stress and hormonal functioning (Horton et al., 2017). Still, the toxicity of microplastics to human consumers has not yet been studied in detail. As such, it remains unclear to which extent microplastics are a real threat to human health. This poses a major challenge for future research at ILVO and collaborating institutes.

CONCLUSIONS

Microplastics can contaminate food via the environment, but also via food processing and packaging materials. The total extent of human exposure to microplastics is however, still unclear. Although the analysis of microplastics in food has evolved over the last decade, further standardization and validation of the methods is needed.
Microplastic contamination not only poses a risk in physical terms, but also in chemical and biological terms. Therefore many challenges remain for the risk evaluation, including the assessment of potential health effects posed by the exposure to microplastics (and also to possible substances released from or absorbed on microplastics).

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