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MRC MICROPLASTIC RESEARCH AT CEN

Microplastic on asparagus and strawberries- A comparison of different packaging materials, farming methods and processing stages

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Introduction

Why performing this study?

Microplastic contamination of different foods and the possible uptake by consumption are still underrepresented in the present research. As strawberries and especially asparagus are important seasonal crops in German agriculture and highly popular, and furthermore are mostly cultivated using plastic films, they present a highly interesting research subject in the context of microplastic contamination.

What is the objective of this study?

The major objective is to identify the extent and chemical composition of microplastic (Mp) contamination in order to evaluate the potential intake of Mp by human consumption.

Material & Methods

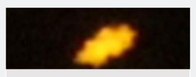
Collection of samples in supermarkets and directly from producers (strawberries n= 16, asparagus n= 20)

Sampling 50 g of material per sample and washing it in 500ml filtered (1.6 µm) ultrapure water via a shaker for 10 minutes

Filtration of the wash water (5-13 µm) and subsequent filter transfer to a glass petri dish for drying

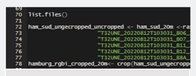
Second wash in filtered (1.6 µm) ethanol with subsequent filtration and filter transfer to a glass petri dish

Filter staining with NileRed (1mg/ml in $CHCl_3$)



Visual identification via fluorescence microscopy

Chemical analysis via µRaman spectroscopy of (n= 76) randomly selected Mp particles



Statistical analysis with R and SPSS

Results & Discussion

Asparagus microplastic contamination and distribution

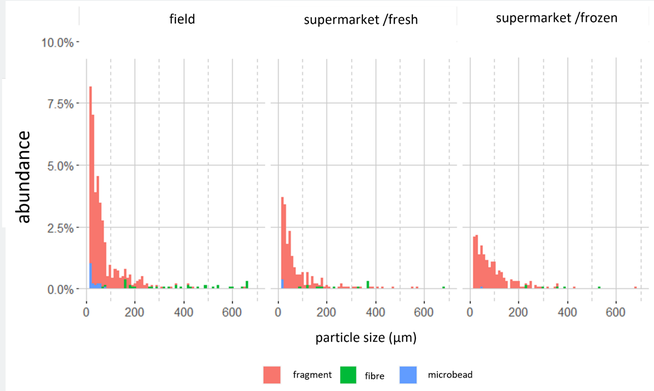


Fig. 1 : Size distribution for fibers, fragments and microbeads on asparagus.

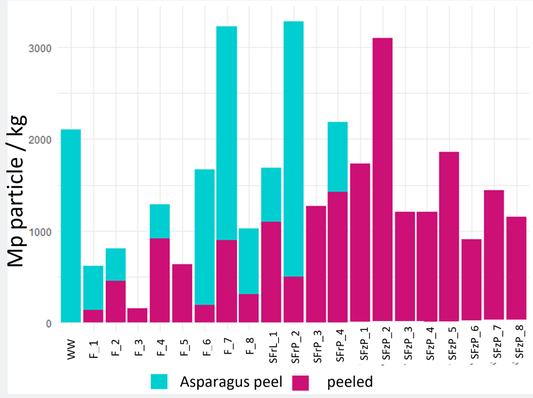


Fig. 2: Microplastic abundance per kg asparagus, separated according to peeled and unpeeled (F= field, S= supermarket, Fr= fresh, Fz= frozen, L= loose, P= packaged).

The Mp abundance in asparagus samples ranges from 157 particles/kg to 3,284 particles/kg (fresh weight). Comparing different processing methods in three groups: products directly from the producer "field" (1,176 ± 937 particles/kg), fresh supermarket products (2,106 ± 870) and frozen supermarket products (1.567 ± 691 particles/kg). No significant difference was found between the groups. However, as can be seen in figure 2, the asparagus peel has a high share of Mp particles. The processed asparagus samples, especially the frozen products, are washed several times during processing and are mechanically peeled. When comparing the results of the fresh samples from the field (461 ± 322 particles/kg), excluding the peel contamination, with the frozen ones (1.567 ± 691 particles/kg), the difference between the groups is significant ($p < 0.05$). The size distribution shows that the fragments of the frozen group are significantly larger than those of the two fresh groups, in addition to the increased occurrence of microbeads and fibers in the field group (fig. 1).

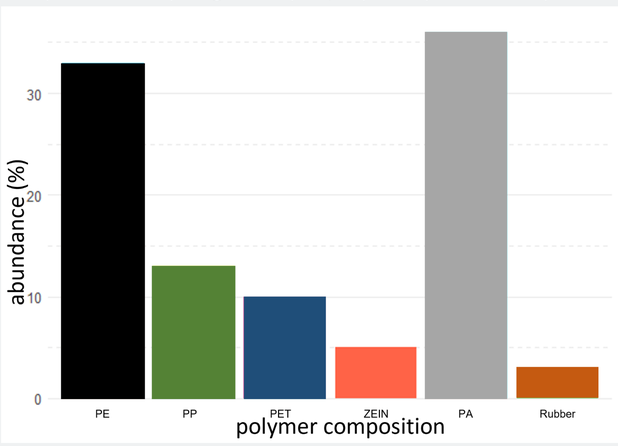


Fig. 3: Asparagus polymer composition including both fibers and fragments

The analysis of the chemical composition of 39 particles by µRaman spectroscopy showed that most of the particles were PE (28,8%) and PA (32,5%), while all fibers analyzed were PET (fig.3) .

Agricultural soils are highly contaminated with Mp and therefore represent a source of contamination for crops grown in the soil. The findings on asparagus are in line with the results of Oliveri Conti et al. 2020, which found a higher Mp contamination of products grown in the soil compared to above ground cultivation. The field samples show very low contamination levels after peeling and the initial washing, so the high MP contamination of the frozen products can be attributed to processing and packaging.

The diversity of the MP particles is greater in the fresh samples, so it can be assumed that a large part of the fibers and microbeads are washed off during processing. PA and PE as the most common polymers are in line with previous research on Mp in agricultural soils with the highest proportion of PE, followed by PP and PA (Yang et al. 2021). These polymers have a low density with an associated good mobility. The polymer foils used for asparagus cultivation are made of PE. The amount of MP that could be absorbed by asparagus is not discussed further, as this is too speculative due to the possible use of the peel. However, it is assumed that asparagus can absorb Mp due to the high amount of adhering microbeads, which could be absorbed by the plants from the soil (Li et al. 2020).

Strawberry microplastic contamination and distribution

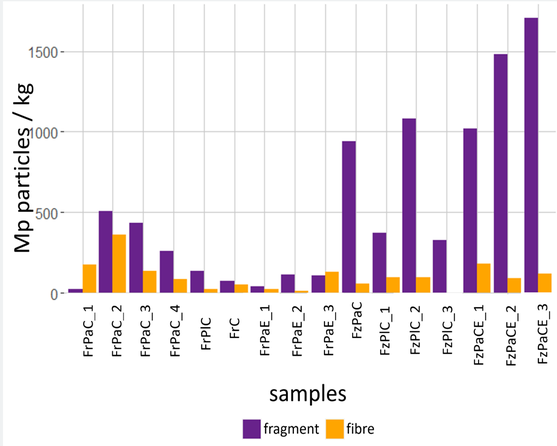


Fig. 4: Microplastic abundance per kg of strawberries (Fr= fresh, Pa=paper, C=conventional, E= ecological, Pl= plastic, Fz= frozen)

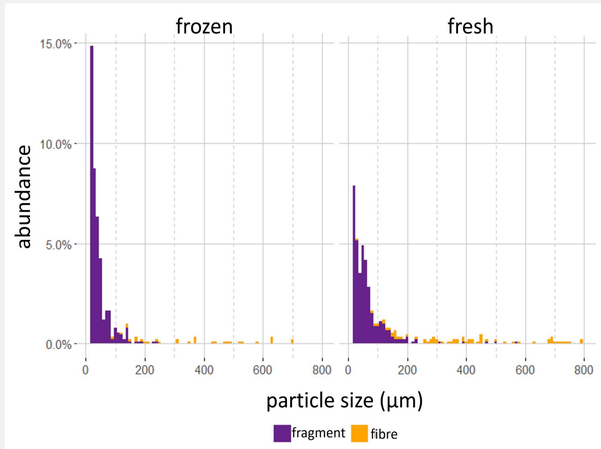


Fig. 5: Size distribution for fibers and fragments on strawberries.

The Mp concentrations in strawberries range from 88 particles/kg (64 fragments and 23 fibers) to 1,824 particles/kg (1,704 fragments and 120 fibers) (fig. 4). The average level of contamination however varies widely between frozen and fresh products, with 226 ± 151 (fresh) and 1,081 ± 502 (frozen) particles/kg. This difference is highly significant ($p=0.002$). Likewise, the difference in particle size, with larger particles found in the fresh products (fig. 5), is highly significant ($p < 0.001$). This study did not find significant differences in the contamination of both conventional and organic farming, neither paper and plastic packaging. Nonetheless, the average contamination of conventional farmed strawberries is higher (497 ± 250 particles/kg) than the contamination of organic farmed strawberries (142 ± 71 particles/kg).

The result of the µRaman spectroscopy shows that a major part of the material consist of PE (fig. 5). All analyzed polymer fibers are PET. A comparison of the spectral data of the packaging and Mp particles found showed no adequate match.

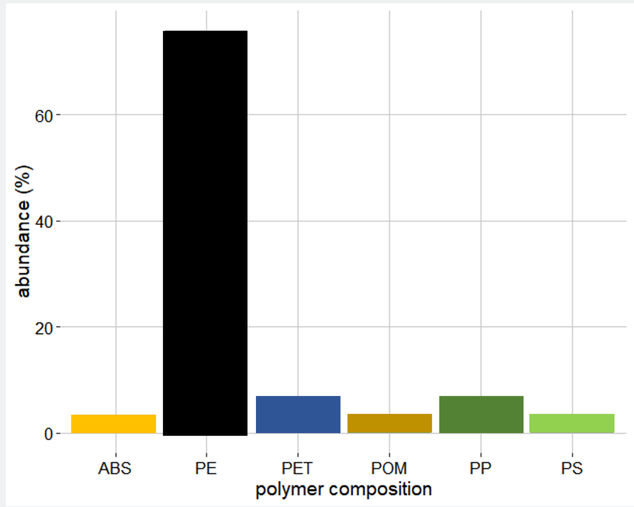


Fig. 5: Strawberry fragment polymer composition (excluding fibers)

Considering the results of the second washing in filtered ethanol as an indicator for human consumption, the average Mp particle intake per kg is 75 and 105 for fresh and frozen strawberries, respectively. By simply washing the strawberries the intake from surface contamination, assuming the second wash removes all Mp particles, can therefore be reduced to 1/5 of the starting contamination for fresh and 1/10 for frozen strawberries.

With the highly significant difference between frozen and fresh strawberries we assume that like the contamination of the asparagus, much of the Mp is a result of processing. To pinpoint the exact amount of contamination step by step is almost impossible since several factors from plastic material, worker contamination or airborne Mp particles interact (Ziino et al. 2021). The fiber contamination most certainly originates from synthetic clothing as they are made of PET. Those can be brought in by either atmospheric deposition or by workers harvesting the strawberries. Other studies describe the possible influence of plastic packaging material, however, the impact of the packaging material on Mp concentration couldn't be verified in this study, a smaller filter pore size combined with more polymer analyses might be able to produce matching values.

Conclusion

Every sample contained, although varying in quantity, a certain amount of Mp. Unsurprisingly, the major polymer types found are PE and PA, as they are the mostly used polymer types in Europe (Plastics Europe 2021). The most notable influence factor for both asparagus and strawberries contamination level is the processing. Other factors such as the soil Mp contamination and use of agricultural polymer foils are a probable source of Mp contamination in the end product, especially for asparagus. As the soil contamination effects the asparagus in a broader manner, the average contamination across the asparagus samples is higher than the contamination of the strawberries. With the initial knowledge of strawberry and asparagus Mp contamination and methods of data collection, more precise researches can ensue, focusing more specifically on different processing stages, contamination vectors and influence of packaging material.

References

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