German Federal Institute for Risk Assessment

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BfR assesses study on tea bags and microplastic particles

No health impairments expected based on current knowledge

According to a study from 2019 (Hernandez et al.), tea bags release numerous microplastic particles. According to the study, just one cup of tea brewed with a plastic tea bag at a temperature of 95 °C would release around 11.6 billion microplastic particles – including 2.3 million particles with a diameter greater than 1 micrometer (µm) – and 3.1 billion nanoplastics (with a diameter below 0.1 µm). The German Federal Institute for Risk Assessment (BfR) already looked into the study in 2020 and conducted its own experiments. These showed that the figures reported by Hernandez and her team for microplastic particles with a diameter greater than 1 µm are probably two to three orders of magnitude too high and that the particles were not released from the plastic tea bags.

The main criticism of the study is the sample preparation. The tea bags were extracted with hot water, and the extracts were then examined for microplastic particles using scanning electron microscopy (SEM). However, the extracts were evaporated before the examination. Non-volatile substances that were previously dissolved in the extract precipitate as solids during this drying process and can be incorrectly identified and counted as microplastic particles. Thus, the majority of the particles found by Hernandez and her team are apparently not microplastics, but so-called oligomers, short-chain by-products from the manufacture of the plastics used. Accordingly, in the opinion of the BfR, the sample preparation methodology used in the study is completely unsuitable for testing for microplastics.

The substances extracted from the tea bags have been assessed for health risks and do not pose a health risk in the (very small) amounts reported. The BfR's own investigations also show that the vast majority of microplastic particles are not released from the tea bags themselves during the cooking process, but were already present on the surface of the tea bags and were partially washed off during cooking. This was demonstrated by comparative electron microscope images of the surface of the tea bags before and after cooking.

Based on current knowledge, it is unlikely that microplastic particles in food pose a health risk to humans. The BfR's own investigations conducted with various model particles on the oral intake of microparticles in mice or using cell culture experiments did not reveal any evidence of damage to intestinal tissue or other cells. However, due to insufficient data, it is not yet possible to provide a full assessment of the effects of microplastics on the intestinal barrier or the human body. However, there is no evidence of harmful effects of microplastic particles on human health.

Hernandez et al. investigated the release of microplastics from tea bags. The tea bags were cut open, the tea was removed and the pouches were rinsed with cold water. Three tea bags were then extracted in 10 ml of water heated to 95 °C for five minutes. An aliquot of the extracts was dried on a silicon wafer, and the residue was examined using scanning electron microscopy (SEM). Particles larger than 3 nanometres (diameter) were counted. The identity of the particles was not examined individually. Instead, the dried film was examined using Fourier transform infrared spectroscopy (FTIR) and X-ray photoelectron spectroscopy (XPS), and the spectra obtained were compared with those of polyamide (nylon 6.6) and polyethylene terephthalate (PET). The authors report that, based on calculations from a tea bag, an average of 2.3 million microplastic particles with a diameter greater than 1 µm and 14.7 billion microplastic particles with a diameter smaller than 1 µm were released. Of these, 3.1 billion particles had a diameter smaller than 100 nm.

Other researchers, including those from the BfR, already examined the study in 2020, identified its main weaknesses and conducted their own experiments (Busse et al. 2020). Therein, tea bags were also extracted with hot water. The extract was examined using micro-Raman spectroscopy. This technique examines the chemical identity of each individual particle (rather than a dried layer). Between 5,800 and 20,400 microplastic particles with a diameter greater than 1 µm were found per tea bag, i.e. two to three orders of magnitude less than reported by Hernandez et al. (2019) (2.3 million particles). The proportion of microplastic particles in all particles found was in the low single-digit percentage range.

The main criticism of the study by Hernandez et al. (2019) is the sample preparation. By drying the extracts on the silicon wafer before examination by SEM, it is to be expected that substances previously dissolved in the extract, which migrated from the tea bag into the hot water, precipitate or crystallise and are then also counted as microplastic particles – especially since the identification was not carried out individually for each particle but only for the dried layer. However, as these substances are soluble, they should not be counted as microplastics. According to the BfR and the authors of Busse et al. (2020), these substances dissolved in hot water are mainly polyamide or PET oligomers. This is also made plausible by hypothetical calculations and comparison with literature data. Various studies have shown that the release of polyamide oligomers from nylon into hot water is in the range of 50–1,000 µg/l. Based on the number of particles with a diameter of less than 1 µm reported by Hernandez et al. (2019) and their size distribution, a total mass of 24.7–1,898 µg/l is calculated, which is in the same order of magnitude as the typical release quantities.

Busse et al. (2020) also examined the tea bags before and after extraction in hot water using electron microscopy. They found particles adhering to the surface both before and after

extraction, with a slight trend towards fewer particles after extraction. No superficial changes to the material were observed. However, this would be expected if the microplastic particles found had actually been formed from the material itself. Overall, the results therefore indicate that the particles found in the extract were washed off the surface and not released from the material during the cooking process.

Hernandez et al. (2020) published a response to the criticism of Busse et al. (2020). However, in the opinion of the BfR, this does not address the main points of criticism and weaknesses of the original study.

In summary, the BfR believes that the numbers of microplastic particles reported by Hernandez et al. (2019) are inconsistent and clearly too high. Furthermore, other studies contradict the assumption that the particles are released from the plastic bags during the cooking process:

- The number of microplastic particles with a diameter greater than 1 µm is probably 2-3 orders of magnitude too high.
- The majority of the particles found by Hernandez et al. (2019) are not microplastics, but consist of oligomers of the plastics used, which can typically migrate into hot water in amounts of up to 1 mg/l. These oligomers have been subjected to a risk assessment by the BfR, among others, and do not pose a health risk in the reported amounts according to the current state of knowledge (https://www.bfr.bund.de/cm/349/polyamide-kitchen-utensils-keep-contact-with-hot-food-as-brief-as-possible.pdf).
- Investigations by the BfR and others show that microplastic particles are not released or generated from the tea bags themselves, but were already present on the surface of the tea bags and were partially washed off during the cooking process. The number of particles with a diameter greater than 1 µm found in the process ranged between 5,800 and 20,400.

Based on current knowledge, it is unlikely that microplastic particles in food pose a health risk to humans. The BfR's own investigations carried out with various model particles on the oral intake of microparticles in mice or using cell culture experiments did not reveal any evidence of damage to intestinal tissue or other cells. However, due to insufficient data, it is not yet possible to provide a full assessment of the effects of microplastics on the intestinal barrier or the human body. However, there is no evidence of harmful effects of microplastic particles on human health.

Microplastic particles larger than 1 mm are assumed to be completely excreted via the intestines. According to the European Food Safety Authority (EFSA), it is very likely that only particles smaller than 150 µm can pass through the intestinal barrier. However, only particles smaller than 1.5 µm can be distributed further via the bloodstream. Studies also show that only a very small proportion of microplastic particles ingested orally can cross the intestinal barrier.

Scientific publications on microplastics in tea bags:

Hernandez, Laura M. *et al.* Plastic Teabags Release Billions of Microparticles and Nanoparticles into Tea. Environ. Sci. Technol., 53, 21, 12300–12310 (2019).
https://pubs.acs.org/doi/10.1021/acs.est.9b02540

Busse, Kristin *et al.* Comment on “Plastic Teabags Release Billions of Microparticles and Nanoparticles into Tea”. Environ. Sci. Technol., 54, 21, 14134–14135 (2020). https://pubs.acs.org/doi/10.1021/acs.est.0c03182

Hernandez, Laura M. *et al.* Response to Comment on “Plastic Teabags Release Billions of Microparticles and Nanoparticles into Tea”. Environ. Sci. Technol., 54, 21, 14136–14137 (2020). https://pubs.acs.org/doi/10.1021/acs.est.0c06422

Further information on the BfR website on the topic of microplastics

Questions and answers about microplastics:
https://www.bfr.bund.de/en/service/frequently-asked-questions/topic/microplastics-facts-research-and-open-questions/

BfR podcast on microplastics (in German):
https://podcast.bfr.bund.de/3-mikroplastik-kleine-partikel-grosses-risiko-003

About the BfR

The German Federal Institute for Risk Assessment (BfR) is a scientifically independent institution within the portfolio of the German Federal Ministry of Agriculture, Food and Regional Identity (BMLEH). It protects people's health preventively in the fields of public health and veterinary public health. The BfR provides advice to the Federal Government as well as the Federal States ('Laender') on questions related to food, feed, chemical and product safety. The BfR conducts its own research on topics closely related to its assessment tasks.

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