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MICROPLASTICS IN ANIMAL FEED: FROM FEED CONTAMINATION TO HEALTH AND PRODUCTION CONSEQUENCES

MIKROPLASTIKA U HRANI ZA ŽIVOTINJE: OD KONTAMINACIJE HRANE DO UTJECAJA NA PROIZVODNE POKAZATELJE ŽIVOTINJA

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SUMMARY

This review tries to comprehend the problem of microplastic accumulation in the environment with the focus on microplastic contamination of animal feed, their impact on animal health and productivity. Overproduction of plastic, and low recycling percentage, means lot of plastic ends up in the environment, polluting soil, water sources and air. Also, increasing use of plastic in the agriculture production and misuse of those materials increases the amount of plastic in soil intended for crop production or grazing. There are a number of ways that microplastic particles could end up in animal feed: absorption by plants and ending up in edible plant tissues, grazing on contaminated pastures, contamination during harvest and preservation of crops, pelleting feed, feeding pre-consumer supermarket food waste, using sea salt or fishmeal in rations, not separating plastic made strings and foils from conserved feed. Plastic particles consumed by animals either through feed or water or inhaled from air have potential to end up in animals' digestive system. Contaminated animal feed means that there is a risk of microplastic particles translocating from digestive tract to blood and consequently to other organs. Knowing that microplastic can be imbued by toxic substances and heavy metals means that their accumulation in animal tissues possess risk not only to the farm animals, but also to humans consuming their products. Due to the fact that present publications regarding microplastic contamination of feed are scarce, research regarding this issue should substantially increase.

Keywords: microplastics, feed contamination, farm animals, food safety

INTRODUCTION

Plastics have become indispensable in modern society due to their versatility, durability, and low production costs. However, these same characteristics contribute to their persistence in the environment, where improper disposal and inadequate recycling lead to the accumulation of plastic waste on a global scale (Geyer et al., 2017). Over time, larger plastic debris fragments into microplastic particles, defined as those smaller than 5 mm, and even into nanoplastic. These particles have now been identified across virtually all ecosystems, including terrestrial soils, freshwater, marine environments, and the

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atmosphere (Rai, et al., 2023). While research has primarily focused on aquatic organisms and human health, less attention has been given to terrestrial food systems, particularly the contamination of animal feed and its implications for farm animals and, ultimately, food safety.

Microplastics can enter feed through multiple pathways, including plant uptake from contaminated soils, grazing on polluted pastures, crop handling and preservation processes, or the use of additives such as fishmeal and sea salt. Feed processing, storage in plastic materials, and inclusion of pre-consumer supermarket waste further increase the risk of exposure. Once ingested or inhaled, these particles may accumulate in the digestive tract or cross into the bloodstream (Lee et al., 2023), potentially carrying toxic substances and heavy metals that can compromise animal health, productivity, and the safety of animal-derived food products. Despite these concerns, studies addressing microplastic contamination in animal feed remain scarce, leaving a significant gap in knowledge that must be urgently addressed. This review therefore seeks to summarize current evidence on pathways of feed contamination, impacts on animal health, and the broader implications for food safety.

MICROPLASTIC SOURCES

Microplastic particles are defined as those from size of 5 mm to 1 μm, and even smaller particles are called nanoplastic. Microplastic originates from numerous sources, contributing to global environmental contamination. From the source point of view microplastic particles can be categorized as primary or secondary (Gong and Xie, 2020). Primary microplastic is the one intentionally produced, such as those used in cosmetics, as an industrial abrasive or synthetic fibers in textiles. Secondary microplastic is the one that forms from the breakdown of larger plastic items. This happens through mechanical wear, chemical processes, and UV exposure of plastic materials (Baho et al., 2021). These particles infiltrate ecosystems through improper waste disposal, plastic degradation, and industrial discharge (Rai, et al., 2023). Additionally, the use of plastic-based agricultural materials such as mulch films and irrigation systems contributes to environmental contamination (Briassoulis et al., 2013). Over the last 70 years, plastic production has substantially increased. The world production was just two million tons of plastic products in 1950 (Ritchie et al., 2023). In 2023 world production of plastics reached 413.8 million metric tons (PlasticsEurope, 2024). The versatility of this group of materials accounts for the continued growth in production year after year. Geyer et al. (2017) estimated that 8.3 billion metric tons of virgin plastics have been produced up to the year 2017. Adding up annual production, and small recycling of used plastic this number comes close to 10.5 billion today. Only 9% of plastic waste is recycled, 15% is collected for recycling, but 40% of this is disposed of as residues. A further 19% is incinerated, 50% is landfilled, and 22% escapes proper waste management and end up in landfills, is incinerated in open pits, or pollutes the terrestrial and aquatic environment (OECD, 2022).

PATHWAY FOR MICROPLASTIC EXPOSURE IN FARM ANIMALS

Farm animals, including cattle, poultry, and pigs, are exposed to microplastic through the environment, feed, and water. Unlike aquatic species that absorb microplastic directly from contaminated water, humans and farm animals primarily ingest it through contaminated feed and drinking water (Al Mamun et al., 2023). But one should not forget about airborne microplastic particles that can be inhaled and, in that way, increase exposure levels, which could be even higher in confined farming environments (van der Veen et al., 2022).

FEED AS A PATHWAY FOR MICROPLASTIC EXPOSURE IN FARM ANIMALS

Farm animals can be fed a variety of sources, including fresh pasture for grazing, preserved crops like silages, cereals, protein sources, oil seeds, feed sources that have been mechanically processed, byproducts of industry and pre-consumer food store waste and mineral additives from different sources including sea salt. Young animals such as calves are often fed whole milk or milk replacers to support their growth.

Microplastics, either directly released or formed through plastic degradation, accumulate extensively in terrestrial environments, particularly in soils. Studies have shown that in North America and Europe, the number of microplastic particles entering agricultural soils through sludge application and other pathways, far exceeds the quantity determined in surface water environments (Horton et al., 2017). Chinese researchers compared soil of differently economically developed regions, including regions of intensive agricultural activity. They find that accumulation in soil has been attributed with prolonged use of plastic films in agriculture and the application of sludge to increase soil fertility (Zhang and Liu, 2018). In the industrial zones, very high concentrations of microplastic particles have also been detected (Liu et al., 2018).

Research shows that different plant species have ability to absorb microplastic particles from soil through their roots. Plants such as wheat (*Triticum aestivum*) and lettuce (*Lactuca sativa*) can absorb microplastic particles (Li et al., 2020). Research indicates that submicrometer- and micrometer-sized particles of polystyrene and polymethylmethacrylate can penetrate plant roots through the crack-entry pathway at lateral root emergence sites. Once inside the root system, these plastic particles are transported upwards to the shoots, primarily driven by the transpiration pull (Li et al., 2020). This mechanism shows potential risk for accumulation of microplastic in edible tissues of crops grown on contaminated soil. The edible parts of plants contaminated with microplastic, used as a feed, contaminate rations of farm animals.

Microplastic potentially present in the soil of grazing meadows may be consumed by grazers who are known to consume soil along with the vegetation. Grazing animals and wildlife may inadvertently consume plastic mulch or improperly disposed plastic waste. Dermal uptake is not expected unless there is damage to the skin and contact with plastic (van der Veen et al., 2022).

Crop contamination during harvesting and preservation can occur through direct contact with plastics, especially when materials like plastic covers are used for silage preparation and storage (Briassoulis, 2023). As plastic covers degrade under sunlight and environmental conditions, they break down into microplastics that can contaminate the crops (Wang et al., 2020). Additionally, wear and tear on plastic parts in harvesting machinery, such as plastic gears or belts, can lead to microplastic particles being shed into the environment, potentially contaminating the harvested crops and forage (Walkinshaw et al., 2022). The use of plastic materials for crop storage, such as plastic wraps or bags, can also contribute to microplastic contamination if the plastic deteriorates over time (Briassoulis, 2023).

Microplastics were detected in cow feed pellets, identifying a mixture of polyethylene and polypropylene, though only polyaniline was quantified, while polypropylene was below the detection limit (van der Veen et al., 2022). In contrast, no quantifiable plastic was found in the hay samples, indicating a difference in contamination levels between pellet and roughage feed. Microplastic contamination could potentially increase during the pelleting process due to the friction and heat involved, which can cause wear and tear on plastic components in machinery, releasing microplastic particles. Additionally, the use of plastic bags for storing can contribute to contamination (Mortula et al., 2021), as plastic may degrade over time, shedding microplastics into the pellets. This dual source of microplastic contamination in both the production and storage stages can affect the quality of the final product and pose potential risks to animals consuming the pellets.

Pre-consumer supermarket food waste, such as bread, pastries, and sweets that are no longer suitable for human consumption due to expired dates, is also used in farm animal nutrition. These feed products are typically sourced locally (van der Veen et al., 2022). Food contamination by microplastics can occur from plastic packaging as tiny particles may leach into food, especially when exposed to heat, sunlight, or prolonged storage. This contamination is linked to the breakdown of plastic materials and the migration of microplastics into the food they contain. Studies suggest that packaged foods, particularly those in plastic containers or wraps, can be significant sources of microplastic ingestion (Lin et al., 2022).

Salt is commonly used as an additive in farm animal meals to provide essential minerals. However, sea salt can be a source of microplastics due to the high contamination of seawater with microplastic particles originating from land-based sources. These particles enter the ocean through rivers, wastewater, and runoff, eventually accumulating in sea salt during the evaporation process. Study of Lin et al. (2022) has shown that samples of sea salt from Italy and Croatia (Renzi and Blašković, 2018) are among the most contaminated in Europe.

Fishmeal, used in animal feed for pigs and poultry, can be a source of microplastic (MP) contamination (Walkinshaw et al., 2022). Since fishmeal is derived from marine fish, which often ingest microplastics present in polluted waters, these plastics can accumulate in the fish's tissues and subsequently transfer into the fishmeal during processing. As a result, microplastic may enter the feed supply, potentially exposing livestock to microplastic contamination through their diet (Thiele et al., 2021). This might be especially true for the fishmeal coming from seas or oceans highly contaminated with plastic and microplastic.

In some countries, livestock farmers are required to remove all plastic packaging from feed bales before offering it to animals. This regulation was introduced after it was observed that animals were being fed with feed that still had plastic fully or partially attached, often with the intention of keeping the feed clean. Despite these regulations, plastic wrapping is still not always removed for various reasons, such as keeping the roughage moist or preventing air exposure. In some cases, holes are made in the plastic packaging to allow animals to access the feed, which can lead nonselective eaters, like cows, to ingest plastic through this route (van der Veen et al., 2022).

In intensive milk production units' calves are usually reared on milk replacers or less often on cows' milk, which can be contaminated with microplastics (van der Veen et al., 2022). Milk replacers may be contaminated with microplastics due to the use of plastic packaging, like plastic bags, during storage and transportation, as well as potential plastic particles introduced during production (Zhao et al., 2025). Cows' milk could also be contaminated with microplastics, as research has shown that these particles can be excreted by the milk gland, due to the microplastics consumed with contaminated feed or water (Urli et al., 2023).

WATER AS A PATHWAY FOR MICROPLASTIC EXPOSURE IN FARM ANIMALS

When talking about possible ways of exposure one must not forget water since it is consumed by the animals on the everyday level. Microplastic can be present in water sources, either ground water or what is more likely in the surface waters. Besides that, microplastic can also leach into drinking water from pipes, tanks, and water containers. A number of pollution sources: sewage sludge, wastewater treatment plant effluents, atmospheric deposition, runoff from urban areas, industry and agricultural production may bring plastic and microplastic into rivers and lakes (Wagner et al., 2014). Microplastic in soil has the ability to penetrate deeper layers and enter groundwater. According to Sangkham et al. (2023), microplastic particles can traverse long distances before building up in aquifers. Also, due to their resistance to degradation, this could result in exposure and contamination over a lengthy period of time (Colmenarejo et al., 2024). In groundwater concentration of microplastic particles can range from 0 to 6,832 particles per liter, according to Lee et al. (2024). The highest concentrations were found in shallow wells close to industrial sites and lowest in the properly maintained groundwater systems despite agricultural production nearby. Land use, the distance from pollution sources, and sampling techniques are some of the variables that affect variations in microplastic concentration and composition (Coffin et al., 2021). Samples of ground water underneath agricultural areas are characterized by lesser variability in plastic polymers due to a more specialized use of plastic in the agricultural activities (Lee et al., 2024).

Due to the groundwater contamination animals can be exposed to microplastic, but additional microplastic can come from water pipes or vessels in which the water is stored or offered to animals. Due to their versatility plastic water vessels are often used to provide water to animals. Even inside, but especially if kept outside these vessels are susceptible to deterioration from heat, humidity, and sunshine, which allows microplastic to leak into the water (Yousif and Haddad, 2013). Also, deposition from the air may cause microplastic particles to settle in water even if other materials are used for vessels (Allen et al., 2019). Poorly maintained water troughs are also prone to bacterial contamination from dust and manure. In combination with that, microplastic particles can increase bacterial contamination since they present a potential point for colonization (Hossain et al., 2019). Increased bacterial contamination can lead to digestive tract inflammation after consummation. On the other hand, bacterial colonization, may affect the physical and chemical characteristics of the plastics (Hossain et al., 2019), potentially increasing toxicity.

AIR AS A PATHWAY FOR MICROPLASTIC EXPOSURE IN FARM ANIMALS

Animals are exposed to the microplastic particles in the air. Particles are inhaled either through the nose or mouth and are deposited in the airways. They can penetrate in lower respiratory tract if their size is smaller, the smallest can go all the way to alveoli (Gou et al., 2024). Smaller plastic particles can enter the lung capillaries by absorption, but larger particles are usually coughed up and may end up in the digestive tract. Although it is known that the main source of microplastic in the air is degradation of textiles and tire abrasion (Wright et al., 2021), agricultural activities can also contribute to this. Dust, animal feed, manure, aged equipment, and agricultural plastics are common sources of airborne microplastic in livestock facilities (Sheriff et al., 2023). These particles can build up in livestock housing due to inadequate ventilation (Khan et al., 2024). When air quality is poor, domestic animals are more likely to be exposed to airborne microplastic particles (Prata and Dias-Pereira, 2023). Microbial development can be facilitated by the high humidity and air temperature present during summer months in animal facilities. Microplastic particles in the air have the ability to transmit bacteria, and if they are pathogen they can facilitate health problems, especially in intensive animal production (Urli et al., 2023).

TRANSLOCATION OF MICROPLASTICS FROM THE GUT TO THE BLOODSTREAM

Although, skin contact can be a possible entry way for microplastic, most prominent are ingestion and inhalation (Lackner and Branka, 2024). In the case of inhalation, microplastic pose a risk to lung tissue, since particles are deposited in the respiratory tract and depending on their size, may be absorbed. Larger particles that become trapped in mucus on the walls of the airways are usually coughed up and then swallowed, passing from the lungs to the gastrointestinal tract (Sun and Wang, 2023). This mechanism is another route by which microplastic particles can enter the digestive tract. This mechanism adds another pathway through which microplastic particles can enter the digestive tract.

Upon ingestion, microplastic travels through the digestive tract and can potentially do damage. But, what is more significant, particles that cross intestinal barrier into the blood could pose a more severe risk for animal health and production. The efficiency of this translocation depends on various factors, including the size, surface properties, and chemical composition of the microplastic as well as the environment in the gastrointestinal tract (Donkers et al., 2022). The intestinal barrier with the epithelial cells as a first layer, regulates the absorption of nutrients and protects against harmful substances. Although it does not allow very large particles to cross, it is not impermeable, and depending on conditions within the gastrointestinal tract, it can be damaged. Damaged wall of intestines is more permeable to absorption (Wu et al., 2025).

To translocate into the bloodstream, microplastic must pass through the intestinal epithelium, either by fitting between the cells, known as a paracellular transport, or being absorbed by enterocytes or specialized cells such as M cell of the Payers patches. Very small plastic particles especially those of nano-size to several micrometers in diameter, are more likely to be absorbed due to their ability to move more easily across biological membranes (Choi et al., 2024). Research has shown that not only the size, but also the surface characteristics of microplastic play a critical role in their ability to cross the intestinal barrier (Chen et al., 2023). Microplastic particles up to 10 μm in size can be absorbed within 12 hours of exposure at *in vitro* conditions (Sofield, et al., 2024). Hydrophobic microplastic may accumulate at the surface of the gut lining, while hydrophilic particles might even past cellular membranes through water channels or specialized transporters (Schwarzfischer and Rogler, 2022). Eichinger et al. (2024) state that M cells in Peyer's patches are the primary site for microplastic penetration through the gut, facilitating transcytosis from the intestinal lumen into underlying tissues.

Presence of microplastic has been shown to change gut microbiota composition. These changes in microbial diversity can disrupt gut homeostasis, impacting mucus secretion and weakening the intestinal epithelial barrier (Jin et al., 2019). As a consequence, gut dysbiosis may contribute to inflammation, affecting overall gut health and increase in permeability of intestinal barrier (Schwarzfischer and Rogler, 2022). Also, chronic diseases of the gastrointestinal tract, such as inflammatory bowel disease or Crohn's disease in humans may increase the likelihood of microplastic crossing the intestinal barrier, as the epithelial layer becomes more permeable during inflammation (Wu et al., 2025). Studies have shown that inflammation of the gut can disrupt tight junctions between cells, making it easier for particles to pass through (Sofield, et al., 2024). Microplastic particles larger than 150 μm, are generally not absorbed into the bloodstream but can contribute to local inflammation in the intestines. Their potential impact depends largely on how long they remain in the digestive tract, as slower intestinal movement can lead to more damage (Lackner and Branka, 2024).

A type of diet can also influence conditions of the gastrointestinal tract and have impact on microplastic translocation. For example, high-fat diets may influence the uptake of certain types of microplastic, as lipids in the diet can affect the permeability of the intestinal lining (Sofield, et al., 2024).

In the stomach, microplastic might not be significantly affected by gastric acid, as they are corrosion-resistant and largely unchanged by the acid environment (Lackner and Branka, 2024). On the other hand, Khan et al. (2024) shows that the crop, a storage organ in chickens, contains larger plastic particles while the gizzard contains both larger and smaller particles, and feces only contain smaller microplastic particles. This indicates that larger particles are broken down into smaller particles during digestion (Khan et al., 2024).

Li et al. (2023a) determined *in vitro* that gastric fluids can alter the surface properties of the microplastic, increasing desorption of toxic substances from microplastic carriers under simulated gastrointestinal conditions. Although desorption from microplastics was substantially higher in the intestinal environment than in the gastric environment, the specific gastrointestinal environment can increase the bioaccessibility of pollutants (Li et al., 2023a).

Ruminants, which possess a rumen specialized anaerobic microflora may experience different processes of microplastic degradation and absorption compared to monogastric animals. There is limited research regarding the rumen microflora abilities for microplastic degradation (Liao and Yang, 2022). Although, potential of fungi to degrade microplastic have been recognize (Ibrahim et al., 2024), it still has to be researched whether those fungi that live in the rumen have potential for that.

ORGAN ACCUMULATION OF MICROPLASTICS AND ASSOCIATED RISKS

As explained, microplastic particles can potentially change intestinal environment by interfering with gut microbiota, but main concern regarding its negative influence starts when they cross the gut barrier and enter blood or lymph (Vethaak and Leslie, 2016). If they enter lacteal, a lymph vessel starting in the intestinal villi, they are drained by the mesenteric lymph vessels and accumulate in lymph nodes. Lymph nodes are the mayor filtering sites of lymphatic system, where immune cells such as macrophages and dendritic cells may phagocytize microplastic particles. In that way microplastic could potentially accumulate in lymphoid tissues. Smaller microplastic particles, especially those smaller than 50 nm, are more likely to accumulate in the lymphatic system since they are more prone to evade gut barrier (Kannan and Vimalkumar, 2021). Microplastic particles that are not picked up by immune cells end up in bloodstream after major lymph vessel joins blood circulatory system.

Some of the microplastic particles can enter the portal bloodstream directly from the intestines. Nutrients, but also toxins and microplastic particles are carried through the portal vein toward liver for filtration. In this way, the liver is the major defensive organ which filters foreign particles that penetrate gut barrier. In the liver microplastic particles can be phagocytosed by the Kupffer cells. The Kupffer cells are liver's macrophages, and they have a role in clearing foreign substances (Jenner et al., 2022). The capacity for phagocytosis is limited, but what is more important foreign and toxic substances taken by the liver cells can cause inflammation and oxidative stress, within those cells, potentially having negative effect on the liver health. Liver cells produce bile, and in that way microplastic could be released from the liver cells into the bile, potentially re-entering the digestive tract again. Although research regarding this is scarce, potential for this recirculation is plausible.

Additionally, if microplastic particles evade liver filtration they enter systemic circulation, which allows them to travel to other organs, including the heart, lungs, kidneys, brain, intestines, uterus, and ovaries (Garcia et al., 2023). In humans, microplastic has been detected in blood, indicating their capacity to circulate throughout the body (Lee et al., 2023). Research on animals has shown that polystyrene microplastics can accumulate in organs, confirming the ability of microplastic particles to cross biological barriers ending up in organs (Deng et al., 2017). These findings underscore the potential for microplastic to reach and impact multiple organ systems, raising concerns about their long-term health effects.

HEALTH ISSUES IN FARM ANIMALS

Most research on microplastics has been focused on marine life, laboratory animals, and humans, leaving a significant knowledge gap about their health impact on farm animals (Li et al., 2023b). Lifespan of farm animals is much shorter compared to humans so chronic exposure to microplastic and toxic substances associated with it might not be as clearly evident as in humans. However, similarities in physiological processes suggest that microplastic can adversely affect farm animals also.

Microplastics can potentially be contaminated with either living microorganisms like bacteria, viruses, and algae or abiotic substances (Cverenkárová et al., 2021). Microorganisms often form biofilms on the surface of microplastic particles, and in that way not only enhance their persistence in the environment but also increasing risks to farm animals (Cverenkárová et al., 2021). The composition of plastic materials and surface characteristics can promote microbial adhesion and proliferation. Reason for this might be found in the ability of microplastic to absorb pollutants such as inorganic nutrients and organic substances, which creates a suitable substrate for microbial growth (Bakir et al., 2014). In that way microplastic particles can facilitate the transport of pathogenic microorganisms, increasing the potential risk for animals that ingest or inhale them.

In addition to biological contaminants, microplastic can be imbued with additives that enhance or modulate the properties of plastic materials. These can be colorants, flame retardants, antioxidants, water/oil-proofing compounds (Venetti et al., 2025). Also, many environmental pollutants can be absorbed on the surface of the microplastic particles. This can include organic pollutants, perfluorinated compounds, heavy metals or pharmaceuticals (Liu et al., 2021). The adsorption capacity of microplastic particles for these contaminants depends on their surface structure and specific surface area (Costigan et al., 2022). For example, polypropylene and polyethylene show higher adsorption capacities for polycyclic aromatic hydrocarbons and polychlorinated biphenyls compared to polyethylene terephthalate and polyvinyl chloride (Oberbeckmann et al., 2014). The dual ability of microplastic to transport both abiotic and biological contaminants increase not only the environmental risks associated with their presence but also a risk for farm animals' health.

Ingested microplastic particles have potential to disrupt gut microbiota and, in that way, disrupt digestion and absorption of nutrients. This can lead to lower weight gain or less productivity of milk and eggs, but also to increased susceptibility to infections (Prata et al., 2021). Additionally, microplastic can cause oxidative stress and inflammatory responses in detoxification organs, such as the liver and kidneys, which can potentially impair their metabolic function (Pulvirenti et al., 2022). In severe cases, exposure to MPs has been associated with tissue necrosis, fibrosis, and even carcinogenesis (Huang et al., 2024). Chronic exposure to microplastics can also lead to immune suppression, making animals more vulnerable to diseases and infections (Vanetti et al., 2025). Additionally, emerging research suggests that nanoplastic may impact the central nervous system, raising concerns about neurological effects (Naz et al., 2024). In the reproductive system, microplastic and nanoplastic have been linked to hormonal imbalances and reduced fertility, affecting egg and sperm quality and impair early embryonic development (Zurub et al., 2024).

The impact of microplastic on different farm animal species might be different. In ruminants such as cattle, sheep, and goats, ingestion of larger plastic items, like bags, ropes, or bottle caps, can accumulate in the rumen, causing ruminal impaction (Khan et al., 2024). As mentioned previously, microorganisms in rumen have small, potential to degrade microplastic, if any. But microplastic can act as a carrier for bioaccumulative and toxic chemicals, including polycyclic aromatic hydrocarbons, organochlorine pesticides, and dioxins, which might interrupt normal rumen microbiome and rumen processes (Khan et al., 2024).

In poultry, the ingestion of plastics has been observed to cause harm to the digestive system. Prolonged retention of plastics in the digestive system can negatively impact health by reducing food consumption and gizzard volume (Khan et al., 2024). Ingestion of plastics in both aquatic and terrestrial birds has led to gastrointestinal blockages, internal injury, inflammation, and a false sense of satiation (Khan et al., 2024). Although these results raise significant concerns, further research is essential to fully understand the health risks associated with microplastic exposure (Naz et al., 2024).

IMPACT OF MICROPLASTICS ON FARM ANIMAL PRODUCTIVITY AND FOOD SAFETY

As previously stated, microplastic can disrupt gut microbiota and potentially cause inflammation of the gut, leading to oxidative stress and immune suppression. These effects can have negative influence on the growth and productivity of farm animals. They can reduce feed efficiency, slow weight gain, decrease milk or egg production and increase susceptibility to disease. Chronic exposure to microplastic has also been linked to hormonal imbalances that may affect reproductive performance, one of the key aspects of livestock production. Also, accumulation of toxic chemicals and heavy metals bound to microplastic particles can not only influence level of production but also quality of meat, milk, and egg quality (Urli et al., 2023).

The presence of microplastic in edible animal products raises concerns about food safety, if they are consumed by humans (Borriello et al., 2023). Studies have shown that microplastic is present in animal products like meat, dairy products, fish, honey (Zeng et al., 2025) and eggs (Liu et al., 2022). The presence of microplastic in the gizzard of poultry poses risks to human health, as gizzards are consumed as food (Khan et al., 2024). Although, so far there are no regulations regarding microplastic in animal products if imposed, strict regulations might also lead to economic losses. Accumulation of microplastic in the animal feed and the environment will increase risk for accumulation in animal tissues, and as a consequence the risk of human exposure through dietary intake will also increase. This underscores the need for more comprehensive research and effective policy measures to address the presence of microplastics in terrestrial ecosystems and agricultural systems (Borriello et al., 2023).

CONCLUSION

As stated in this paper, microplastic will not disappear from the environment any time soon. The production of plastic is increasing, and the recycling is on a low level compared to the overall plastic waste disposal. Accordingly, the amount of microplastic particles in the air, water and soil will increase. As a consequence, this will increase the amount of microplastic particles reaching animal digestive tract, cross the intestinal barrier and reach different organs. Although many papers show evidence of microplastic in different organs, through this moment, we cannot be sure about real biological influence of microplastic on overall health of farm animals. Therefore, more research is needed. This brings potential problems of bioethics and animal welfare in focus. Direct contamination of animal feed with microplastics will probably be approved for laboratory animal experiments but less likely for farm animal experiments. Nevertheless, much more research regarding the extent of contamination of farm animal feed is urgently needed. If microplastic is proven to have detrimental effect on human health, much will have to change in regulation of animal production regarding the ways to minimize presence of microplastic in animal products. Considering the persistence of microplastic in the overall environment, this will not be an easy task.

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SAŽETAK

Ovaj pregledni rad nastoji sagledati problem nakupljanja mikroplastike u okolišu koncentrirajući se na kontaminaciju stočne hrane mikroplastikom i njezine utjecaje na zdravlje i proizvodnost. Prekomjerna proizvodnja plastike i nizak postotak recikliranja rezultira nakupljanjem plastike u okolišu, zagađujući tlo, izvore vode i zrak. Sve veća uporaba plastike u poljoprivrednoj proizvodnji i nepravilna upotreba tih materijala povećava količinu plastike u tlu, namijenjenu proizvodnji krmiva ili ispaši. Brojni su putovi kojima čestice mikroplastike mogu dospjeti u hranu za životinje: apsorpcijom putem korijena biljke, ispašom na kontaminiranim pašnjacima, kontaminacijom tijekom žetve i čuvanja usjeva, obradom hrane poput peletiranja, hranjenjem hranom pred istekom roka valjanosti, korištenjem morske soli ili ribljega brašna u obrocima te neadekvatnim zbrinjavanja plastičnih vezica i folija koje su služile za pakiranje ili konzerviranje hrane. Čestice plastike koje životinje konzumiraju hranom ili vodom ili ih udišu iz zraka ulaze u probavni sustav životinja. Povećana je opasnost od prijenosa čestica mikroplastike iz probavnoga sustava u krv te u druge organe. S obzirom na to da da mikroplastika može na svojoj površini nositi mikroorganizme, otrove i teške metale, njezino nakupljanje u životinjskim tkivima predstavlja opasnost ne samo za domaće životinje, već i za ljude koji konzumiraju proizvode životinjskoga podrijetla. Zbog činjenice da trenutačno nema mnogo publikacija o kontaminaciji hrane za životinje mikroplastikom, a uočen je potencijalno ozbiljan izazov, trebalo bi znatno više pozornosti posvetiti tim istraživanjima.

Ključne riječi: mikroplastika, kontaminacija hrane za životinje, domaće životinje, sigurnost hrane