



Microplastics along the food chain: contamination pathways, consumer perception, and implications for sustainable food systems in Romania

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Abstract. Sustainable food systems must reconcile rising global food demand with reducing environmental pressures across the entire food chain, and plastic-related pollution is increasingly recognized as one such pressure. Microplastics (MPs), particles smaller than 5 mm generated through the manufacture, use, and degradation of plastics, have been detected in agricultural soils, aquaculture systems, food-processing environments, packaging materials, and a wide range of food commodities, from seafood and table salt to honey, sugar, milk, and bottled water, as well as in human blood, placenta, and breast milk. This paper combines a review of the scientific literature on microplastic contamination pathways relevant to sustainable food systems with an empirical assessment of public awareness and behavioral readiness, based on a structured questionnaire administered in Romania in 2026 (n = 124). The review synthesizes evidence on primary and secondary sources of microplastics in food production, processing, and packaging, their occurrence in food commodities, human exposure routes, analytical challenges, and emerging mitigation strategies within a circular-economy framework. The survey shows that respondents readily associate food packaging with plastic content (124 of 124 respondents) and identify packaging as the leading perceived source of microplastics (95 of 124 respondents). However, awareness of specific food-related exposure pathways and of the analytical difficulties in confirming them remains limited. Willingness to adopt low-effort, food-shopping-related behaviors, such as using reusable bags and personal containers, is high, whereas support decreases for actions that require political or corporate engagement. The findings support the need for integrated communication and policy strategies that translate awareness into concrete, food-system-relevant sustainable behavior.

Keywords: plastic pollution, food packaging, consumer perception, human exposure, circular economy.

Introduction. Sustainable food systems are commonly defined as systems that deliver food and nutrition security for all without compromising the economic, social, and environmental bases required to guarantee food security and nutrition for future generations (HLPE, 2014). Meeting this objective is becoming more difficult as the world's population is projected to reach approximately 10.3 billion people by the end of the century, requiring an estimated increase in food production of at least 50% relative to current output (Frias et al., 2026). This growth trajectory places additional pressure on food producers and supply chains that already depend heavily on plastic materials for irrigation, aquaculture pens and cages, storage (big bags, bins, crates), and packaging (Frias et al., 2026).

Global plastic production has expanded from 464 million tons in 2020 to an estimated 884 million tons by 2050, with a cumulative amount exceeding 4,725 million tons of waste plastic generated between 2000 and 2050 (Dokl et al., 2024). Historically, of the plastic manufactured worldwide between 1950 and 2015, only about 9% was recycled, and 12% incinerated, while the remaining 79% accumulated in landfills or was released directly into the environment (Geyer et al., 2017; Geyer, 2020). Even with recent advances in recycling and waste management, only around one-fifth of global plastic waste is currently recycled

or incinerated, and the remainder continues to accumulate in terrestrial and marine ecosystems (Mondol et al., 2026). This accumulation is not merely an ecological concern but also carries a measurable economic cost, as reflected in willingness-to-pay estimates for reducing plastic litter in the European Arctic (Abate et al., 2020), and has prompted calls for a binding international agreement to curb marine plastic pollution at its source (Borrelle et al., 2017). As plastic items degrade through weathering, mechanical abrasion, and photolytic and biological processes, they fragment into microplastics (MPs), synthetic polymer particles smaller than 5 mm, and even smaller nanoplastics (Andrady, 2017; De-la-Torre, 2020).

Because agriculture, aquaculture, and the food-processing industry rely so extensively on plastic materials, the food system has become both a source and a recipient of microplastic contamination. Microplastics have been reported in agricultural soils amended with compost, digestate, or sewage sludge, in aquaculture gear such as nets, ropes, and cages, in food-processing equipment and packaging, and, ultimately, in a wide array of food commodities, including seafood, table salt, sugar, honey, bottled water, beer, and milk (De-la-Torre, 2020; Kwon et al., 2020; Mondol et al., 2026; Frias et al., 2026). Human biomonitoring studies have further confirmed microplastics in stool, blood, placenta, and breast milk, suggesting that dietary exposure may translate into systemic exposure (Schwabl et al., 2019; Leslie et al., 2022; Zhu et al., 2023; Ragusa et al., 2022).

Addressing this emerging contaminant requires not only technical and regulatory interventions but also an informed and engaged public, since consumer choices about packaging, single-use plastics, and food-shopping habits are integral to transitioning toward a more circular, less plastic-dependent food system. However, public understanding of microplastics is frequently incomplete. Several studies report that awareness of microplastics does not necessarily extend to an understanding of their sources, environmental fate, or specific relevance to food and health (Praveena, 2024; Deng et al., 2020; Fian et al., 2024; Fian et al., 2025). This gap between general awareness and food-specific understanding has been highlighted as a critical link to strengthen along the entire food chain, from ocean to table (Khorsandi et al., 2025). In Romania specifically, recent work has highlighted persistent knowledge gaps and the need to strengthen circular-economy responses to plastic and microplastic pollution (Mihai et al., 2024).

This paper has three objectives: (i) to synthesize, in the specific context of sustainable food systems, the scientific evidence on the pathways through which microplastics originate, migrate, and accumulate in food production, processing, and packaging, together with their occurrence in food commodities and their implications for human exposure; (ii) to assess, through an empirical survey, the awareness, knowledge, and behavioral readiness of a Romanian sample of respondents with regard to microplastics, with emphasis on food-packaging-related items; and (iii) to discuss the implications of these combined findings for policy, communication, and circular-economy strategies capable of supporting a more sustainable food system.

Material and Method

Literature synthesis. The review component of this study follows a narrative synthesis approach. Sources were selected from peer-reviewed journals covering microplastic sources and pathways in agriculture, aquaculture, and food processing; the occurrence of microplastics in food commodities; human exposure and toxicological evidence; analytical and detection challenges; and sustainability-oriented mitigation strategies, including bio-based packaging and circular-economy approaches. Priority was given to recent reviews and editorials (2019-2026) that explicitly address the food system as a unit of analysis, complemented by primary biomonitoring studies frequently cited within these reviews.

Survey design and sample. Primary data were collected through a survey using a structured questionnaire adapted, in part, from instruments used in previous public-perception studies on plastic and microplastic pollution (Praveena, 2024; Deng et al., 2020). This adaptation strategy follows a precedent already established in Romania, where

the Deng et al. (2020) instrument was previously adapted to study disposal behavior toward single-use masks (Petrescu et al., 2023) and, in modified form, to study how media coverage shapes public risk perception of microplastics (Pop et al., 2023). The questionnaire was distributed online in 2026 using snowball sampling. Participants were encouraged to circulate the questionnaire to people with different profiles to broaden the range of respondents, although this procedure cannot eliminate self-selection and network-related sampling bias. We collected 124 valid responses from Romanian residents.

All responses were collected anonymously. The online form did not record names, e-mail addresses, IP addresses, or other personally identifying information, and participants were informed of the anonymous, voluntary nature of the survey before starting. It comprised 21 items organized into five sections: (1) demographic characteristics (age, gender, education, residential environment, net monthly income); (2) baseline knowledge of plastic materials and their decomposition; (3) awareness of the concept of microplastics, sources of information, and level of concern; (4) knowledge of the sources and environmental fate of microplastics; and (5) current plastic-related behavior, willingness to adopt sustainable alternatives, and the attribution of responsibility for mitigation. Two batteries of items used a five-point Likert scale, one assessing the level of support for systemic and policy-level mitigation actions, and the other assessing willingness to adopt specific daily behaviors, several of which are directly relevant to food shopping and food packaging (e.g., use of reusable bags, personal containers, and avoidance of plastic packaging for fresh produce). Data were analyzed using descriptive statistics (frequencies and percentages), given the exploratory and descriptive character of the study, inferential statistical testing was not performed.

Respondents ranged in age from 18 to 67 years (mean 33.3 years), with the largest group aged 18-24 (57 respondents). The sample was predominantly female (87 respondents, 70.2%) relative to male (36) and non-binary (1) respondents. Most participants held tertiary education, a bachelor's (67) or a master's degree (27), while smaller numbers reported secondary (24), post-secondary non-tertiary (4), or lower secondary education (2); none reported doctoral-level education. Respondents were predominantly urban (108) rather than rural (16) residents. Regarding net monthly income, the largest single group (35 respondents) preferred not to disclose this information, while the remainder were distributed across all offered brackets, from under 1,000 RON to over 7,001 RON. Overall, the sample skews toward young, urban, and highly educated respondents, a profile considered when interpreting the results below.

Results and Discussion

Literature synthesis

Plastics as a structural component of contemporary food systems. Plastic materials are deeply embedded in modern agri-food value chains. In agriculture, plastics are used for mulching films, greenhouse covers, and irrigation infrastructure; in aquaculture, for nets, ropes, cages, and buoys; and across food processing and retail, for conveyor belts, storage containers, and packaging films, trays, and bottles (Frias et al., 2026). This dependence reflects the favorable properties of plastics: low cost, light weight, chemical resistance, and durability (Mondol et al., 2026). However, these same properties make plastics highly persistent once released into the environment, and the wear, weathering, and fragmentation of food-contact plastics constitute a continuous, low-level but pervasive source of microplastics throughout the food chain.

Pathways of microplastic contamination in food production, processing, and packaging. Microplastic contamination of food can be traced to primary sources, which act directly within the processing line, and secondary sources, which arise after processing during storage, transport, distribution, or retail, through packaging degradation and mechanical or thermal stress (Mondol et al., 2026). Table 1 summarizes the principal stages of the

food-processing chain where microplastics may be introduced, together with the associated polymer types.

Table 1

Principal stages of food processing associated with microplastic release (adapted from Mondol et al., 2026)

<i>Processing stage</i>	<i>Main release mechanism</i>	<i>Typical polymers</i>
Raw material handling	Abrasion from crates, bins, mesh bags; contact with contaminated soil/water	PE, PP, PA, PES
Washing and cleaning	Release from hoses, tanks, PVC pipes, gaskets; contaminated wash water	PVC, PP, PE
Cutting, peeling, grinding	Wear from cutting boards, coated blades, conveyor-belt friction	HDPE, LDPE, PP
Mixing and blending	Shedding from mixer paddles, coated shafts and linings	PP, PE, PA
Thermal processing	Heat-induced degradation of utensils, non-stick coatings, containers	PTFE, PP, PE
Filling, sealing, packaging	Migration from films, trays, bottles, caps and laminates	PET, PP, PS, PVC
Storage and transport	Film cracking, tray deformation, abrasion during stacking/transit	PS, PE, PP, PET.

A separate but related pathway concerns the reintroduction of microplastics into agricultural soils via the land application of composts, digestates, and sewage sludge. Recent field-scale studies reviewed by Frias et al. (2026) reported microplastic concentrations of up to about 3,300 particles per kilogram (wet weight) in lagoon material from anaerobic co-digestion of food waste and dairy manure, with a potential loading exceeding 20 million particles per hectare when such material is applied to land, indicating that waste-treatment pathways can act as vectors redistributing microplastics from the food-waste stream into agricultural soils. In parallel, high concentrations of microplastics, reaching a mean of approximately 112,400 items per kilogram of soil, have been documented in agricultural fields used for sweet potato cultivation in China, together with a co-occurrence of microplastics and trace metals such as cadmium (Frias et al., 2026; Shi et al., 2024), while surveys of commercial composts have shown that plastic content depends less on the proportion of food waste used as feedstock than on the efficiency of contaminant-removal steps applied during processing. Because these composting and digestion pathways are part of a broader agricultural-waste management chain (Rao et al., 2024), improving handling and treatment at the source has been proposed as a preventive lever to limit downstream microplastic loading in food-producing soils.

Occurrence of microplastics in food commodities relevant to sustainable diets. Microplastics have been documented in virtually every category of food associated with sustainable and healthy diets. Seafood is the most extensively studied matrix. Thus, bivalves such as mussels and oysters, which filter large volumes of water, have been reported to contain between roughly 0.2 and 10.5 particles per gram of soft tissue depending on species, location, and analytical method, and European consumers of shellfish have been estimated to ingest between about 1,800 and 11,000 microplastic particles per year through this food group alone (Van Cauwenberghe & Janssen, 2014; Li et al., 2015; Cho et al., 2019; Teng et al., 2019). Commercial sea salts from multiple countries contain microplastics ranging from non-detectable levels to several thousand particles per kilogram, most frequently fibers and fragments of polyethylene, polypropylene, and polyester (Yang et al., 2015; Karami et al., 2017). Beyond these particulate contaminants, marine environments also receive chemically distinct plastic-derived compounds, such as styrene oligomers released during the degradation of polystyrene marine debris, which have been proposed as complementary tracers of plastic pollution in marine-derived food matrices (Kwon et al., 2015). Microplastic-like particles have also been reported in honey, sugar, tap water, beer, canned food, and milk, indicating

that plastic contact throughout the supply chain, not only marine origin, is an important contributor to dietary exposure (Liebezeit & Liebezeit, 2013; Kosuth et al., 2018; De-la-Torre, 2020). Everyday food-contact materials themselves generate microplastics under normal use. For example, cutting boards have been shown to shed substantial quantities of polyethylene and polypropylene particles during routine food preparation (Yadav et al., 2023), and take-out packaging has been associated with elevated microplastic release when exposed to heat and oily foods (Bai et al., 2022). Cox et al., (2019) estimated that an average adult following a typical American diet might ingest approximately 39,000 to 52,000 microplastic particles per year through food and beverages, underscoring the cumulative, multi-source nature of dietary exposure.

Biomonitoring evidence indicates that this dietary and environmental exposure is not confined to the gastrointestinal tract. Microplastics have been detected in human stool samples (Schwabl et al., 2019), in human blood (Leslie et al., 2022), in human placenta (Zhu et al., 2023), and in breast milk (Ragusa et al., 2022), as well as in infant formula (Kadac-Czapska et al., 2024), pointing to systemic translocation and to early-life exposure windows that are of particular relevance for food-system sustainability and public-health policy.

Analytical challenges in detecting microplastics in food. A recurring theme across the reviewed literature is the lack of standardized protocols for isolating and identifying microplastics in food matrices, which complicates comparisons across studies and undermines the harmonized monitoring that a sustainable food system would require. Table 2 summarizes the main identification methods used and their principal trade-offs, adapted from a systematic review of analytical approaches (Kwon et al., 2020).

Table 2

Main analytical methods used to identify microplastics in food and their trade-offs
(adapted from Kwon et al., 2020)

<i>Method</i>	<i>Advantage</i>	<i>Limitation</i>
Visual inspection	Inexpensive, rapid	High risk of false-positive identification
Scanning electron microscopy	Not limited by particle size	Possible false-positive identification
Microscopy coupled with FT-IR	Chemical confirmation of polymer type	Limited to particles larger than about 20 µm
Microscopy coupled with Raman spectroscopy	Detects sub-micron particles; strong chemical specificity	Time-consuming and costly
Pyrolysis-GC/MS	Provides mass-based quantification; suits complex matrices	Destructive; no particle-size information.

The lack of harmonization is compounded by the fact that toxicological effects have mostly been observed for particles smaller than the 10-20 micrometer detection threshold of routine FT-IR and Raman methods, creating a gap between the exposure levels that can be reliably measured and those considered biologically relevant (Kwon et al., 2020). Adopting emerging standards, such as ISO 24187:2023 for the analysis of microplastics in the environment, has been proposed as a step toward harmonized, comparable data that could support food-safety regulation within a sustainable food-systems framework (Frias et al., 2026).

Mitigation strategies and the transition toward a circular, plastic-resilient food system. Reducing microplastic loading in the food system requires action at multiple points of the value chain. At the material level, bio-based and biodegradable polymers, such as polylactic acid, polyhydroxyalkanoates, and cellulose- or starch-based films, are being developed as substitutes for conventional food-contact plastics, although questions remain

regarding their mechanical performance, cost, and the possibility that some biodegradable materials themselves fragment into micro- and nanoparticles under real-world conditions (Mondol et al., 2026). At the process level, replacing polymer-based equipment with durable stainless-steel surfaces, improving in-line filtration of process water, and adopting closed-loop water-management systems can reduce microplastic release during processing (Mondol et al., 2026). This approach aligns with reviews of wastewater-treatment technologies showing that conventional and advanced treatment stages can remove a substantial share of microplastics before water re-enters the environment or the production cycle, even though complete removal remains technically difficult to achieve (Iyare et al., 2020). At the packaging level, mono-material and easily recyclable packaging formats, refill and bulk-dispensing systems, and deposit-return schemes for beverage containers align with a circular-economy approach that keeps plastic materials in use longer and reduces both macro- and microplastic leakage (Kumar et al., 2021; Nowicki et al., 2023).

In Romania, a national deposit-return system for non-reusable primary packaging (colloquially known by its brand name, Returo) was introduced through Government Decision no. 1,074/2021 and became operational in 2023. Several respondents spontaneously mentioned this policy instrument in the present survey as a measure of interest, suggesting a degree of public familiarity with circular-economy-oriented packaging policy, even though broader knowledge gaps regarding microplastics specifically persist at the national level (Mihai et al., 2024).

At the governance level, harmonized analytical standards, extended producer responsibility, and coordinated monitoring across the food, waste-water, and sludge-management sectors have been identified as priorities for aligning food-safety objectives with circular-economy goals (Frias et al., 2026; Koelmans et al., 2019). None of these interventions, however, can be fully effective without an informed and supportive public, which this paper focuses on.

Questionnaire insights

Baseline knowledge of plastic materials. All respondents (124 of 124) correctly identified food packaging as a plastic-containing product, the highest recognition rate among the ten product categories tested, ahead of toys (122), buckets (113), baby bottles (110), disposable straws (103), synthetic clothing (102), PVC pipes (100), fishing nets (89), polystyrene items (82), and rubber tires (47) (Figure 1). This near-universal recognition of food packaging as a plastic item is a favorable starting point for food-system-oriented communication, since it suggests that consumers already associate the product category most relevant to dietary exposure with plastic content.

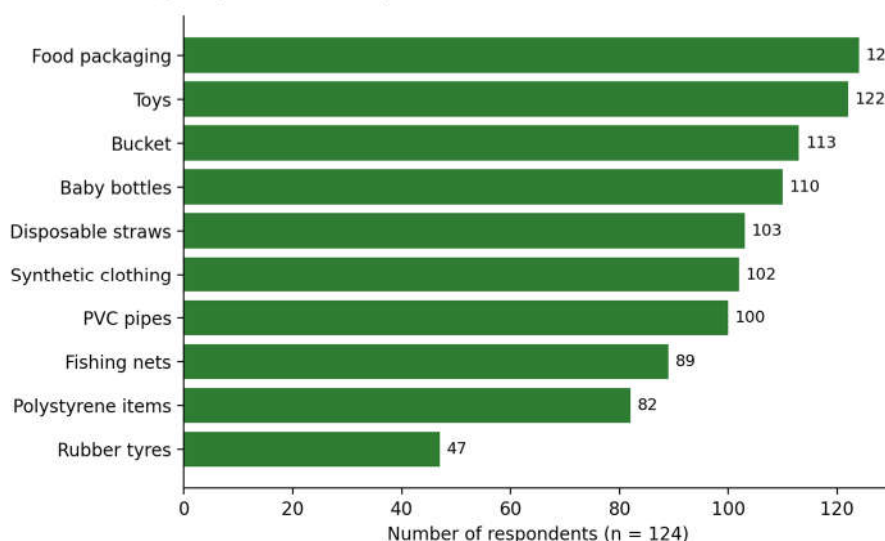


Figure 1. Products spontaneously identified by respondents as containing plastic (multiple answers allowed, n = 124).

When asked about the decomposition time of common plastics such as PET, only 56 respondents (45.2%) selected the correct answer (400-500 years), while 44 (35.5%) underestimated it as 50-100 years, 19 (15.3%) selected "I don't know", and 5 (4.0%) selected 10-20 years (Figure 2), indicating that even among a sample with strong recognition of plastic products, the persistence of plastic materials is commonly underestimated. Regarding the mechanism of plastic decomposition, however, 119 respondents (96.0%) correctly identified plastic fragments as microparticles that can pollute the environment, rather than degrading into harmless natural substances or dissolving completely in water, suggesting a solid understanding of the fragmentation process that generates microplastics.

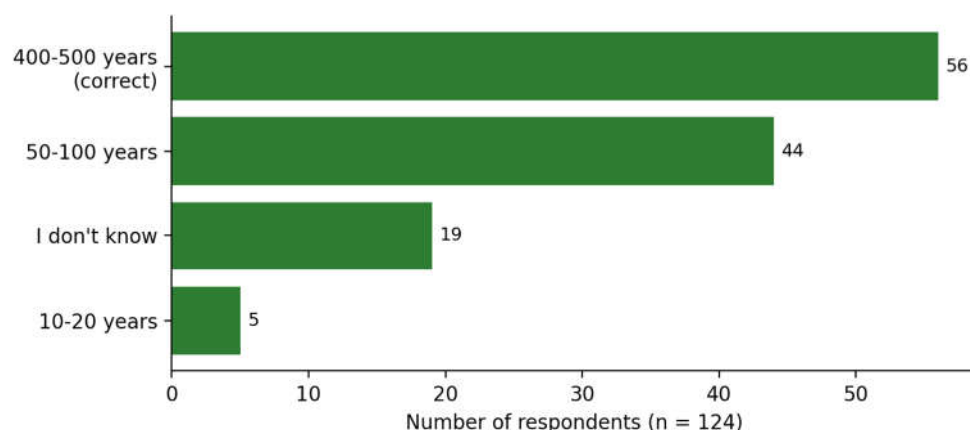


Figure 2. Respondents' knowledge of the approximate decomposition time of common plastics such as PET (n = 124).

Awareness and concern regarding microplastics. A large majority of respondents (112 of 124, 90.3%) reported having heard the term "microplastics" before taking part in the survey (Figure 3). Among this group, social media (71 respondents) was the leading source of information, followed by general websites (44), television/radio and school/university (41 each), books/magazines (18), government policies (16), and volunteering activities (14). Self-reported familiarity with the topic was moderate: 5 respondents described themselves as very familiar, 38 as familiar, 49 as partially familiar, and 20 as not very familiar, with no respondent selecting "not at all familiar".

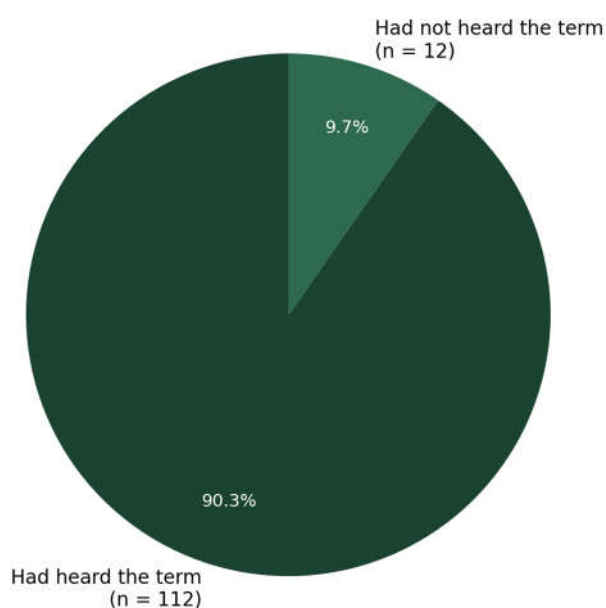


Figure 3. Prior awareness of the term "microplastics" among respondents (n = 124).

Concern regarding microplastics was high in both the group already familiar with the term and the smaller group encountering it for the first time during the survey (Figure 4). Among the 112 respondents already aware of the term, 37 (33.0%) reported being very concerned and 50 (44.6%) somewhat concerned, while only 3 (2.7%) reported no concern. Among the 12 respondents unfamiliar with the term, who were given a short definition before being asked about their concern level, 5 reported being very concerned and 2 somewhat concerned, with none reporting no concern. This pattern indicates that concern is not contingent on prior familiarity: once the concept is explained, concern levels converge, which is encouraging for food-system communication strategies that must reach audiences with varying baseline knowledge.

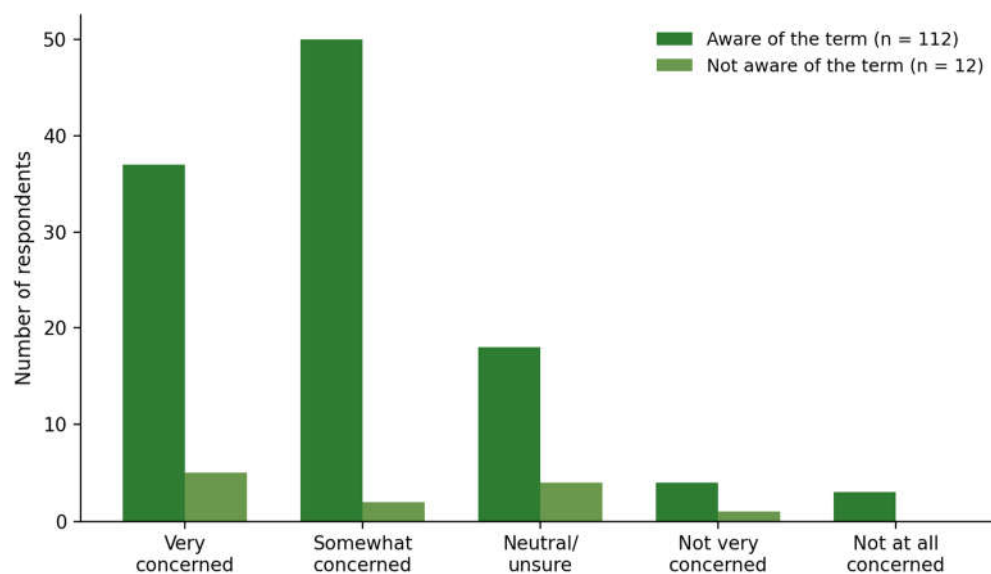


Figure 4. Self-reported level of concern regarding microplastics, compared between respondents already aware of the term (n = 112) and respondents encountering it for the first time during the survey (n = 12).

Knowledge of microplastic sources and environmental fate. When asked to identify the source they consider most responsible for generating microplastics, respondents overwhelmingly selected plastic packaging (95 of 124 respondents, 76.6%), far ahead of synthetic textiles (11), plastic pellets/resin (10), vehicle tires (5), personal care products (2), fishing nets (1), and other sources (2) (Figure 5). This result mirrors the earlier finding on product recognition and reinforces packaging, the product category most directly linked to food, as the dominant mental model that respondents hold regarding microplastic origins.

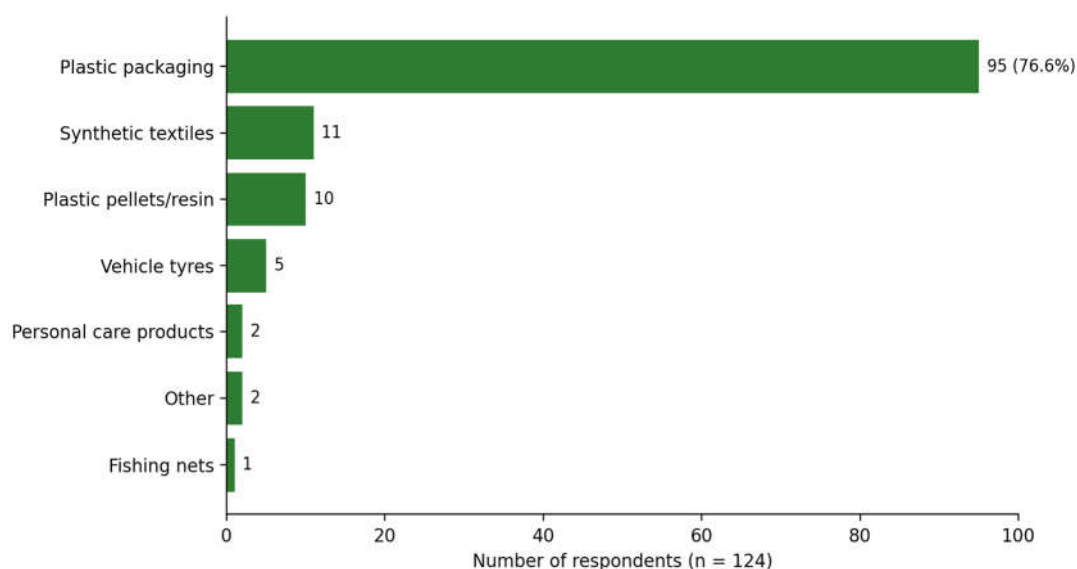


Figure 5. Source perceived by respondents as the main contributor to microplastic pollution (single choice, n = 124).

Regarding the environmental compartments where microplastics are believed to accumulate most, oceans were by far the most frequently selected option (98 of 124 respondents), followed by rivers and lakes (63), the human body (38), animals (25), plants (17), and soil (1), with 8 respondents indicating they were not sure (Figure 6). The comparatively low recognition of soil as an accumulation compartment (selected by only 1 respondent) is notable given that agricultural soils receiving compost, digestate, or sludge are increasingly documented as a substantial microplastic reservoir in the scientific literature (Frias et al., 2026), suggesting that public understanding of terrestrial, food-production-related pathways lags behind understanding of marine pathways, which have historically received greater media coverage.

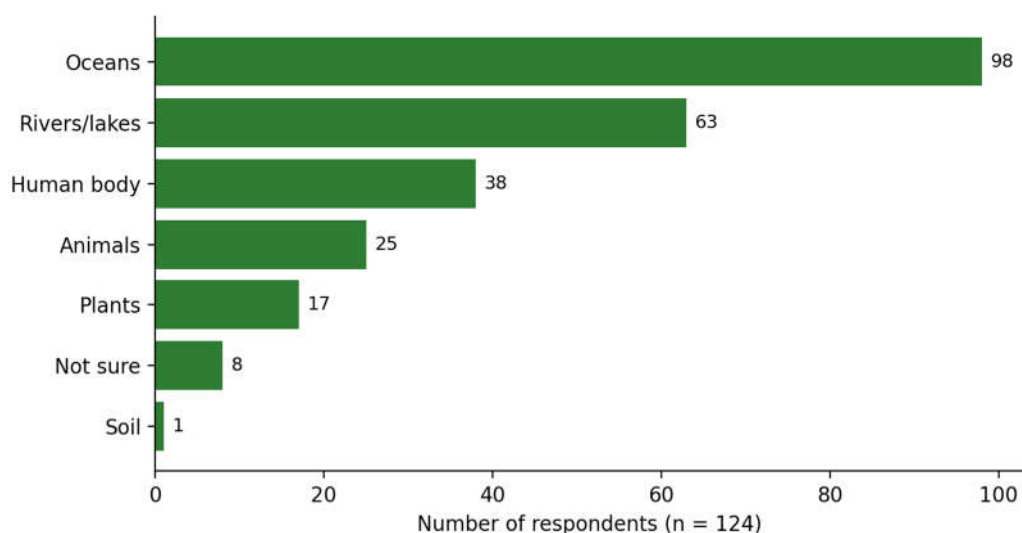


Figure 6. Environmental compartments perceived by respondents as the main accumulation sites for microplastics (multiple answers allowed, n = 124).

Reasons for continued plastic use in food-related consumption. Respondents were asked why they continue to prefer plastic products in daily life, a question directly relevant to food-shopping behavior, given that food packaging was the most recognized plastic-containing category. Convenience ("easy to use", 69 respondents) and low cost (66) were

the two most frequently cited reasons, followed by reusability (57), lack of alternatives (47), light weight (46), the higher cost of available alternatives (33), water resistance (24), ease of cleaning (23), and heat resistance (3) (Figure 7). A small number of respondents (6) volunteered that they do not actually prefer plastic but consider it unavoidable given its ubiquity. These results suggest that cost and convenience, rather than a lack of concern, are the principal barriers to reducing plastic use in food-related contexts, a finding with direct implications for the pricing and availability of sustainable packaging alternatives.

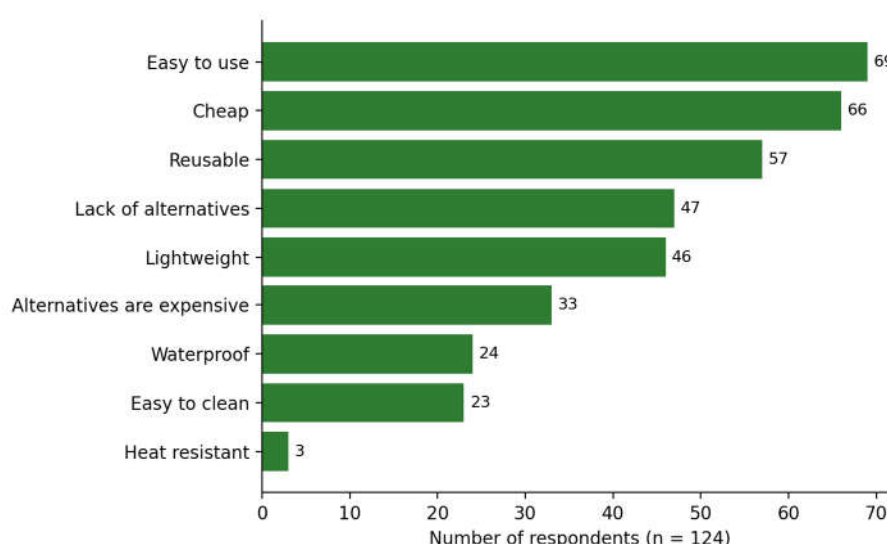


Figure 7. Reasons cited by respondents for preferring plastic products in everyday consumption (multiple answers allowed, n = 124).

Support for systemic and policy-level mitigation actions. Respondents strongly supported nearly all proposed systemic actions to reduce microplastic pollution (Figure 8), except the statement that no intervention is necessary, which 78.2% of respondents strongly opposed. The actions receiving the highest levels of strong support were improving current recycling and waste-disposal facilities (81.5%), increasing the availability of alternatives to plastic products (78.2%), investing in advanced waste-management systems (71.8%), and awareness-raising education (69.4%). Support for stricter environmental regulation on single-use plastics (66.9% strongly supportive) and for using social-media platforms for continuing education (61.3% strongly supportive) was likewise high. Comparatively lower, though still majority, support was recorded for introducing taxes and levies, particularly on single-use plastics, for which only 29.0% expressed strong support and 28.2% remained undecided, suggesting greater public reluctance toward fiscal instruments than toward regulatory or infrastructural measures.

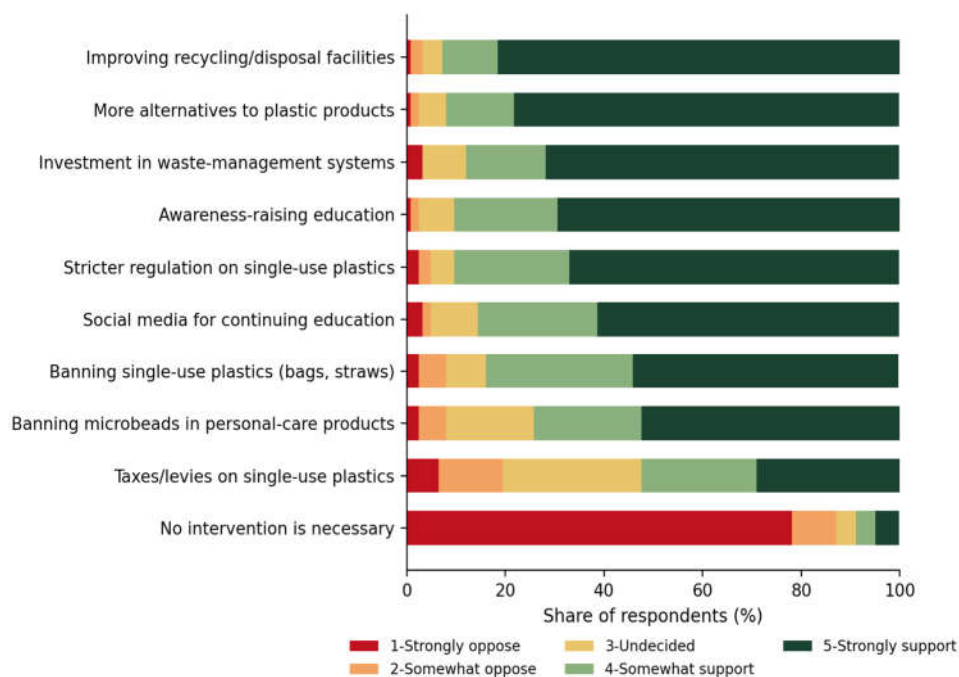


Figure 8. Level of support for proposed systemic actions to reduce microplastic pollution (percentage of respondents per response category, n = 124).

Willingness to adopt sustainable food-shopping and consumption behaviors. The final behavioral battery asked respondents how likely they would be to adopt specific daily actions to reduce plastic waste, several of which relate directly to sustainable food shopping and packaging choices (Figure 9). The most widely endorsed actions were using one's own shopping bag at a store or market (79.8% would certainly do so), using one's own cutlery instead of single-use items provided with takeaway food (69.4%), and using a reusable water bottle (68.5%). Support decreased progressively for actions requiring greater planning or a change in established retail habits, such as deliberately choosing unpackaged products at a shop or market (22.6% would certainly do so) or bringing one's own container for restaurant leftovers or takeaway food (21.0%). The least supported actions of all were contacting political representatives to request support for measures reducing plastic pollution (8.1% would certainly do so) and contacting specific companies or brands to request reduced plastic in products or packaging (7.3%), indicating a marked gap between respondents' willingness to modify personal, food-shopping-related behavior and their willingness to engage in advocacy directed at producers and policymakers.

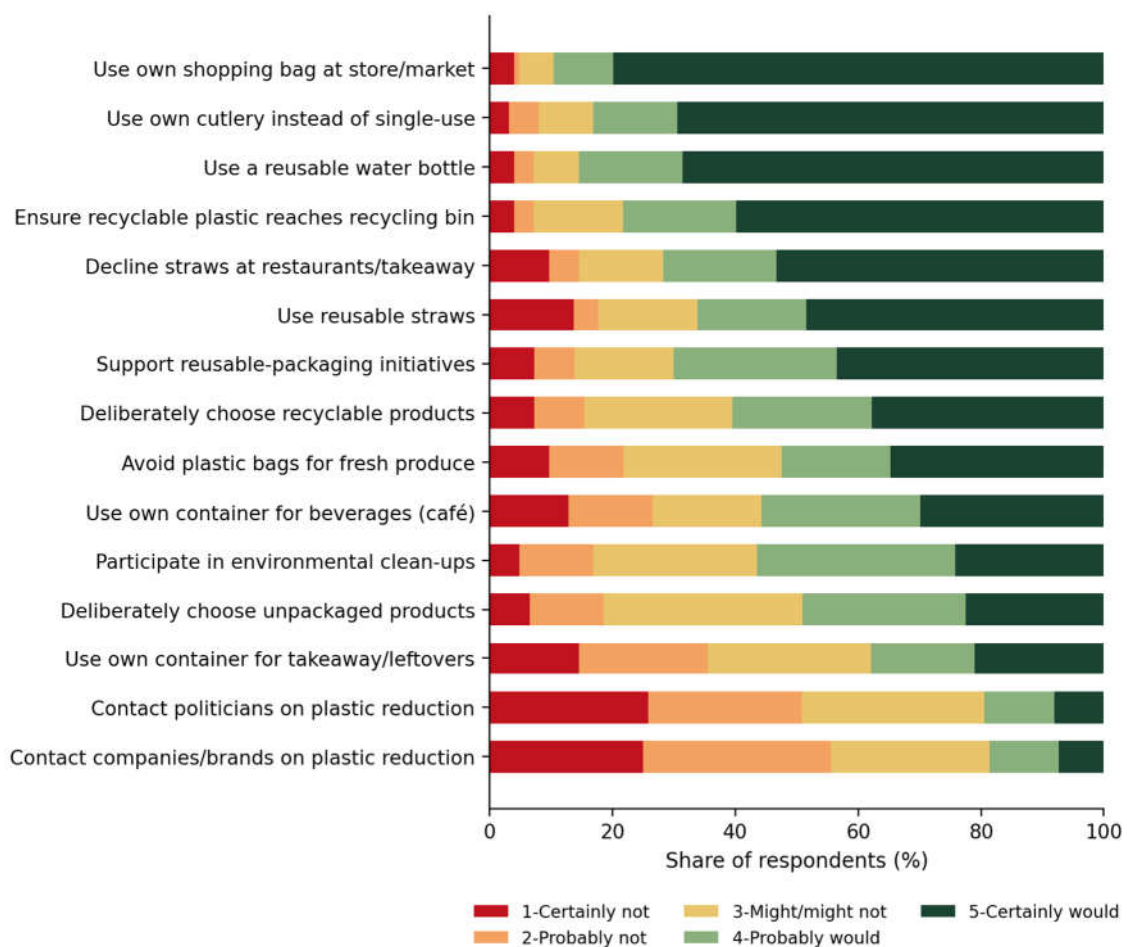


Figure 9. Willingness to adopt daily behaviors to reduce plastic waste, with emphasis on food-shopping-related actions (percentage of respondents per response category, n = 124).

Attribution of responsibility. When asked who bears the greatest responsibility for reducing plastic use and preventing further microplastic pollution, respondents most frequently selected consumers/buyers of plastic products (37 of 124, 29.8%), followed closely by national government/central administration (35, 28.2%) and the plastics industry, i.e., raw-material producers (32, 25.8%), with manufacturers of plastic products trailing at 8.1% (Figure 10). Only 6 respondents were unsure, and 4 attributed the greatest responsibility to local/municipal authorities. No respondent selected county-level authorities or the option indicating that no one should be held responsible. The near-even three-way split among consumers, government, and industry suggests that respondents perceive responsibility for the food system's plastic dependency as shared rather than located exclusively with any single actor.

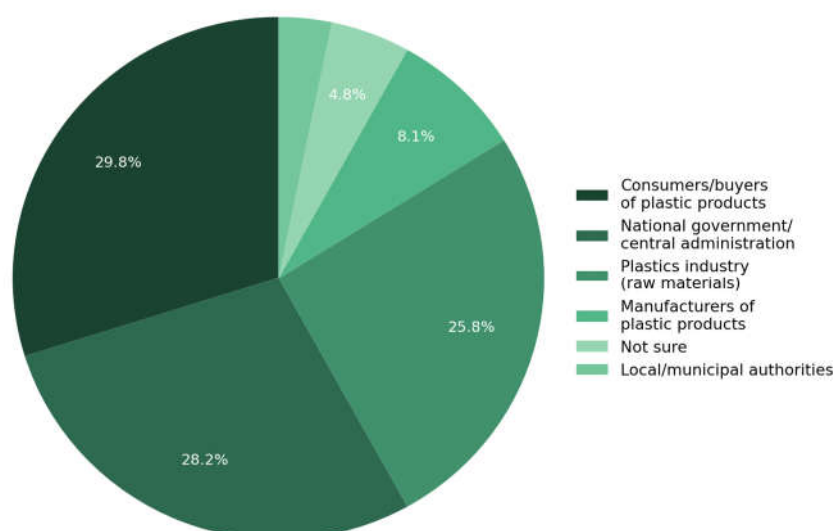


Figure 10. Actor perceived by respondents as bearing the greatest responsibility for reducing plastic use and microplastic pollution (n = 124).

Bridging awareness and sustainable food-system transformation. Taken together, the literature review and the survey findings point to a partial alignment between scientific evidence and public perception. Both converge on packaging as a central node of concern: the reviewed literature identifies packaging degradation, filling, and sealing operations as major primary and secondary sources of microplastics in the food chain (Mondol et al., 2026), and respondents independently identified food packaging as the plastic product they recognize most readily and as the leading perceived source of microplastic pollution. This convergence represents a valuable entry point for food-system communication and policy, since interventions targeting packaging, such as mono-material design, refill systems, and deposit-return schemes, are likely to resonate with an already receptive public.

At the same time, important gaps remain. The survey suggests limited public awareness of terrestrial, agricultural pathways, such as the land application of compost, digestate, and sludge, that the literature identifies as a substantial and likely underestimated route of microplastic input into food-producing soils (Frias et al., 2026). Oceans dominate the public's mental model of microplastic accumulation, while only a single respondent selected soil. Likewise, the marked gap between high willingness to adopt low-effort, individual food-shopping behaviors and low willingness to engage in advocacy toward companies or policymakers mirrors a pattern already reported in other national surveys, where support for systemic, government-led action is high in the abstract but individual engagement in political or corporate advocacy remains limited (Deng et al., 2020; Kramm et al., 2022; Masud et al., 2024; Hossain, 2024). This is consistent with the observation that cost and convenience, not indifference, are the main reported barriers to reducing plastic use, implying that policy measures making sustainable alternatives cheaper and more widely available (through, for example, extended producer responsibility schemes or the expansion of deposit-return systems such as Romania's Returo programme) may be more effective than relying on individual behavior change or awareness campaigns alone (Kumar et al., 2021; Nowicki et al., 2023).

The persistence of analytical challenges documented in the literature (Kwon et al., 2020) further compounds the communication gap: without harmonized, comparable data on microplastic levels in specific food commodities, it is difficult to translate public concern into commodity-specific dietary guidance or food-safety standards. Strengthening the link between analytical science, food-safety regulation, and public communication therefore appears to be a priority for advancing microplastic-related aspects of sustainable food systems, alongside continued investment in circular-economy infrastructure and sustainable packaging alternatives.

Comparison with previous public-perception studies. The demographic and attitudinal profile obtained here is broadly consistent with earlier public-perception research on plastics and microplastics, while also revealing patterns that appear specific to the food-system framing adopted in this study. Praveena (2024) and Deng et al. (2020) similarly report high general awareness of microplastics coupled with only moderate understanding of specific sources and health mechanisms, a pattern closely mirrored in the present sample, where 90.3% of respondents recognized the term but only 45.2% correctly estimated the decomposition time of a common plastic. The finding that social media was the leading source of information about microplastics (71 of 112 respondents) aligns with growing recognition of media as the principal interface through which the public encounters environmental risk information. Using a nationally oriented Romanian sample, Pop et al. (2023) found that media narratives measurably shape both awareness and risk perception of microplastics, while noting that scientific and media framings of microplastic risk do not always align. This raises the possibility that some of the concern reported by the present sample, 33.0% “very concerned” among those already aware of the term, is shaped as much by media salience as by a technical understanding of exposure pathways, a caveat that also applies to the strong association our respondents made between microplastics and marine, rather than terrestrial or food-production, environments.

The pronounced gap between willingness to adopt low-effort personal actions and reluctance to engage in advocacy toward companies or policymakers, most visible in this survey between using a reusable shopping bag (79.8% “certainly would”) and contacting political representatives (8.1%) or companies (7.3%), replicates a pattern documented across several national contexts. Kramm et al. (2022), working with a representative German sample, similarly found that risk perception of microplastics did not translate proportionally into support for the most demanding policy instruments, while Masud et al. (2024) and Hossain (2024) both report that attitudinal support for systemic plastic-reduction measures coexists with limited individual willingness to bear direct costs, such as taxes or levies, a pattern also visible in the present data, where support for taxing single-use plastics (29.0% strongly supportive) was the lowest among all systemic actions tested. A related precedent from Romania itself comes from Petrescu et al. (2023), who examined the determinants of proper disposal behavior for single-use masks during the COVID-19 pandemic using a questionnaire design adapted, as in the present study, from Deng et al. (2020); that study similarly found that behavioral intention was driven more by convenience and habit than by risk awareness alone, and that responsibility for waste outcomes was attributed jointly to individual users and public authorities, a distribution of responsibility echoed almost exactly by the three-way split (consumers, government, industry) obtained in the responsibility-attribution item of the present survey (Figure 10). These parallels suggest that the awareness-action gap identified here is not an artifact of the specific sample or questionnaire, but a recurring feature of how publics, in Romania and elsewhere, relate to diffuse, cumulative environmental risks such as plastic and microplastic pollution.

Reducing the plastic footprint of food systems should be understood as part of a broader sustainability transition in which environmental outcomes depend not only on individual consumer choices but also on the conditions that enable those choices. Evidence from Romania illustrates this more broadly across food-system transitions. Research on dietary change shows that shifts toward lower-impact protein sources can reduce environmental pressures, including agricultural land use (Balan & Trasca, 2025), while studies of meat alternatives indicate that adoption is constrained by costs, availability, cultural expectations, and consumer perceptions (Petrescu-Mag et al., 2025, 2026). Similar constraints emerge in the present study, where respondents identified cost, convenience, and limited alternatives as important reasons for continued plastic use. Although plastic reduction and dietary transitions concern different environmental challenges, they therefore point to a common policy implication: sustainable food-system change cannot rely primarily on consumers accepting additional costs or inconvenience. Policies that improve the affordability and availability of alternatives, while distributing responsibility across consumers, government, and industry, may provide more supportive conditions for behavioral change.

Finally, the broader scientific and regulatory context in which food-system microplastic research is developing is also shifting toward more ethical and sustainable methodologies. In a recent commentary, Jaeschke and Ramachandran (2025) note that new approach methodologies (NAMs), including organoids, microphysiological systems, and computational modeling, are increasingly popular precisely because they promise more human-relevant toxicological evidence while reducing reliance on animal experiments, although they caution that important technical and interpretive challenges remain before such methods can fully replace traditional testing. Complementing this perspective with a systematic, bibliometric view of the field, Petrescu-Mag et al. (2026) document a rapid expansion of NAMs-related research, *in vitro*, *in silico*, and in chemico testing, driven jointly by ethical concerns over animal use and by the pursuit of more sustainable evidence generation. Because much of the toxicological evidence underpinning current concern about microplastics, including the biomonitoring studies discussed above (Schwabl et al., 2019; Leslie et al., 2022; Zhu et al., 2023; Ragusa et al., 2022), still relies substantially on animal models and *in vitro* assays with uncertain translatability to real-world dietary exposure, this wider transition toward NAMs is directly relevant to closing the evidentiary gaps that, as discussed above, currently limit the translation of public concern into commodity-specific, food-safety-relevant guidance.

Limitations. This study has several limitations. The survey used online snowball sampling, which facilitated data collection but favors self-selection, may reproduce similar social profiles through closely connected networks, and does not provide a representative sample of the Romanian population. The sample is also skewed toward younger, urban, and more highly educated respondents. Results should therefore be interpreted with caution and should not be generalized beyond the sample studied. All behavioral measures were self-reported and may be subject to social-desirability bias, particularly for items concerning environmentally favorable behavior. The cross-sectional design does not allow causal inferences regarding the relationship between awareness, concern, and willingness to act. Finally, the literature synthesis, while covering recent and relevant sources, is narrative rather than systematic and does not claim to be exhaustive of the rapidly growing body of research on microplastics in food systems.

Conclusions. Microplastic contamination is embedded throughout contemporary food systems, from agricultural soils and aquaculture gear to processing equipment, packaging, and a broad range of food commodities, with growing biomonitoring evidence of systemic human exposure. Advancing sustainable food systems will require coordinated action on material substitution, process redesign, packaging circularity, and harmonized analytical standards. The survey indicates that public awareness of microplastics in Romania is moderate to high and closely tied, in the public mind, to food packaging, which is both encouraging and consistent with scientific evidence identifying packaging as a major contamination pathway. However, awareness of specific, food-relevant exposure routes, particularly agricultural and soil-related pathways, remains limited, and willingness to act decreases sharply once behaviors move beyond low-effort, individual food-shopping choices toward advocacy directed at companies or policymakers. Bridging this gap calls for communication strategies that extend public understanding beyond marine and packaging-centered narratives, and for policy instruments, such as extended producer responsibility and deposit-return systems, that reduce the cost and convenience barriers respondents themselves identify as the main obstacles to more sustainable, lower-plastic food consumption.

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