JMBFS
Journal of Microbiology, Biotechnology and Food Sciences
International peer-reviewed scientific online journal

Published by
Faculty of
Biotechnology and
Food Sciences

SAFETY ISSUES OF MICROPLASTICS RELEASED FROM FOOD CONTACT MATERIALS

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https://doi.org/10.55251/jmbfs.10317

ARTICLE INFO

Received 15. 3. 2023
Revised 21. 6. 2023
Accepted 26. 6. 2023
Published 1. 10. 2023

Regular article

OPEN ACCESS

ABSTRACT

Microplastics released from food contact materials have raised concerns regarding their safety implications for human health. In this way, several studies have shown that microplastics can migrate from food contact materials into beverages and food, leading to human exposure through ingestion. The small size and persistent nature of microplastics make them capable of accumulating in various organs and tissues, potentially causing adverse health effects. Furthermore, the toxicological properties are amplified by their ability to adsorb and transport hazardous chemicals, including additives, endocrine disruptors, and toxic metals. Their health impacts include inflammation, oxidative stress, genotoxicity, and disruption of the endocrine system. Carcinogenic effects, reproductive disorders, and developmental abnormalities have also been reported. Moreover, microplastics can act as vectors for microbial pathogens, posing additional health risks. Further research and testing methods are required to understand the sources, distribution, and toxicity of microplastic particles, to improve customers safety issue. Additionally, concerted efforts from stakeholders, including manufacturers, regulators, and consumers are needed, including activities that support the development and adoption of alternative non-toxic, biodegradable, and sustainable packaging materials.

Keywords: Food contact material, Microplastics, Human, Toxicity

INTRODUCTION

Food contact materials and finished articles are generally presented by food packaging, food storage material (incl. containers, bottles, cups), food processing equipment, kitchen, and tableware. In the European Union the regulation EU 10/2011 includes a list of authorized substances for the manufacture of plastic materials and articles in contact with food and, for some of the chemicals, their permitted maximum concentration (specific migration limit) (**EC, 2011**). Synthetic organic polymers known as plastics are formed through the polymerization process of monomers derived from hydrocarbon sources (**Rios et al., 2007**). Plastics are known for their cost-effectiveness, lightweight nature, versatility, and durability, are extensively used worldwide in various industries (**Wang et al., 2016**). Among the sectors, packaging materials alone contribute to approximately 39.6% of the total plastic demand (**PlasticsEurope, 2020**). Plastic-based packaging materials for food and beverages have gained significant importance in the food industry due to their ability to store perishable goods, control temperature and atmosphere, and their ease of production and processing (**Bott et al., 2014**). The advantages of plastic packaging extend beyond prolonging the shelf life of fresh produce. They also provide protection against chemical and microbial contamination, as well as mechanical damage during transportation (**Rydz et al., 2018**). A wide range of plastic food packaging and container types, including trays, foils, bags, sealings, bottles, caps, cups, and containers, are manufactured to accommodate various food products and beverages (**Geueke et al., 2018**). These packaging materials primarily consist of thermoplastic resins such as polyvinyl chloride (PVC), polyethylene terephthalate (PET), polypropylene (PP), low-density polyethylene (LDPE), high-density polyethylene (HDPE), and polystyrene (PS), each suited for specific packaging purposes (**Geueke et al., 2018**; **Hahladakis and Iacovidou, 2018**). However, the extensive usage of plastics also comes with adverse consequences. Improper waste management practices have led to the accumulation of over 250,000 tons of plastic fragments in our oceans (**Eriksen et al., 2014**). Plastics present in the environment undergo gradual degradation processes, including photolysis, thermo-oxidation, and biodegradation, resulting in the formation of smaller fragmented pieces known as secondary microplastics, measuring less than 5 mm (**Andrady, 2017**). These microplastics are widespread in both the environment and consumer products, leading to inevitable human exposure. The impact of microplastics on human health and their implications for food safety require further investigation. Therefore, the objective of this study is to provide evidence of the presence of microplastics in food and elucidate their significance concerning food safety and potential risks to human health.

MICROPLASTICS

The generation of microplastics is influenced by various environmental factors, including sunlight, temperature, physical stress, and water (**Frias et al., 2019**). Microplastic particles can vary in size, ranging from 0.1 to 5000 µm (**Petersen, 2016**). Based on their origin, micro-sized plastic particles can be categorized into primary and secondary. Primary microplastics are intentionally manufactured small-sized particles with microscopic dimensions (e.g. cosmetics, such as exfoliants or toothpaste) (**Shim et al., 2018**). On the other hand, particles that result from the abrasion, degradation, and fragmentation processes of plastic materials are referred to as secondary microplastics (**Browne et al. 2009**; **Peixoto et al., 2019**). Plastic particles that are even smaller than microplastics, ranging from 1 to 100 nm, are referred to as nanoplastics (**Mattsson et al., 2018**). To provide a comprehensive definition of microplastics, several characteristics have been selected (**Wichels et al. 2017**; **Leslie, 2017**; **Verschoor, 2015**): Solid particles, Synthetic materials with a high polymer content, Size smaller than 5 mm, Resistance to degradation, Insolubility in water. Microplastics have been detected in a wide range of beverages and foodstuffs: Water – mineral and tap (**Mason et al., 2018**; **Kosuth et al., 2018**; **Liebezeit and Liebezeit, 2014**), Beer (**Kosuth et al., 2018**; **Liebezeit and Liebezeit, 2014**), Milk (**Kutralam-Muniasamy et al., 2020**), Salt (**Renzi and Blaškovic´, 2018**; **Iñiguez et al., 2018**; **Karami et al., 2017**), Sugar (**Liebezeit and Liebezeit, 2013**), Fish and Canned fish (**Akhbarizadeh et al., 2018**; **Karami et al., 2018**; **Neves et al., 2015**), Crustaceans and Seafood (**Devriese et al., 2015**; **Van Cauwenberghe and Janssen, 2014**), Honey (**Liebezeit and Liebezeit, 2015**; **Liebezeit and Liebezeit, 2013**). The presence of synthetic or anthropogenic microplastic particles contaminants in beverages and food is a growing concern due to the potential for contamination (**Oßmann et al., 2018**). These micro-sized particles can be directly ingested by humans, making their presence in beverages and food particularly significant (**Oßmann et al., 2018**). Furthermore, these microplastics can contaminate drinking water sources – the major pathway for microplastic ingestion (**Marsden et al., 2019**). **Cox et al. (2019)** estimated that the average human consumption of microplastics through commonly consumed foods and air ranges from 203 to 332 particles per person per day.

Food contact materials on plastic base

In the modern current era, plastic cups, bottles, wraps, containers, infant feeders are commonly used for the storage, transport, and preservation of beverages and food, including those with plastic linings such as glass bottles and aluminium cans

(**Fadare et al., 2020**). Beside of many advantages in the usage of these plastic packaging products, they may release microplastics and nanoplastics into the beverages and foods, which are then consumed by individuals (**Fadare et al., 2020**; **Bouwmeester et al., 2015**). These plastic particles can possess various hazardous physical and chemical properties, contributing to potential risks (**Belluz and Viswanathan, 2018**).

Bottles

Plastic bottles to store beverages and drinking water has shown a significant and continuous increase in usage across the beverage industry. **Mason et al. (2018)**, in their study (tested 259 bottles from 11 different brands and various locations in 9 countries) examined the release of microplastics into bottled water. They found that approximately 93% of tested water bottles were contaminated with microplastics. Furthermore, the concentration of microplastics in these bottles was found to be twice as high as the concentration of microplastics in tap water (**Mason et al., 2018**). Aging and the degradation of plastic bottles significantly contribute to the release of microplastics into the water (**Oßmann et al., 2018**). Even the mechanical stresses experienced during the opening and closing of bottle caps can release millions of microplastic particles into the water (**Winkler et al., 2019**). Additionally, beverage cartons, caps, and glass bottles, which are coated with polyethylene foils, also serve as sources of microplastics (**Schymanski et al., 2018**). **Zuccarello et al. (2019)** estimated daily consumption of microplastics in adults through drinking bottled water to approximately 1,531,524 microplastics (to kilogram of the body weight per a day), while children consume over 3,350,208 microplastics (to kilogram of the body weight per a day). Infant diet preparation and storage often involve the use of plastic infant feeding bottles, primarily made of polypropylene (PP). These bottles are commonly used for preparing instant nutrition by shaking them with hot water (70 - 100 °C) (**FAO/WHO, 2007**). The shaking process at high temperatures accelerates the degradation process, leading to the release of polypropylene microplastics into prepared nutrition. **Li et al. (2020)** revealed approximately 16,200,000 polypropylene microplastics released per liter of prepared formula milk. Other plastic products used for nutrition preparation and storage, such as lunch boxes and kettles, also release similar amounts of microplastics.

Cups

Disposable paper cups are commonly used for beverages serving (**Deshwal et al., 2019**). These cups, especially when used for hot drinks, have an interior lining of hydrophobic plastic films, primarily made of polyethylene such as high-density polyethylene (HDPE) (**Arumugam et al., 2018**; **Constant, 2016**). For testing the safety issue of such a product, **Ranjan et al. (2021)** examined the release of microplastics from paper cups into hot water. Outputs of the study demonstrated the reaction of such a paper cup when they come into the contact with hot liquids. The plastic films begin to deteriorate and release microplastic particles.

Food containers

The widespread use of plastic containers for food packaging and delivery, as well as disposable plastic cups for drinking, has been steadily increasing. This has unintentionally led to the consumption of secondary microplastics by humans. Considering that plastic containers come into direct contact with food, the issue of food safety associated with plastic packaging cannot be ignored (**Fadare et al., 2020**). **Du et al. (2020)** pointed to the presence of microplastics in plastic take-out containers due to deposition of microplastics from the manufacturing process of food, as well as the flaking of plastic particles from the inner surfaces of containers due to slight mechanical force, loose structure, and rough surfaces. These microplastics, released from newly manufactured plastic products used for water consumption, food delivery, and food packaging pose a significant risk to human intake (**Fadare et al., 2020**). According to **Du et al., (2020)** the estimated human consumption of microplastics through take-out food is approximately 2977 microplastics per person per year. Individuals consuming plastic-packaged food (plastic containers) 4-7 times a week may be exposed to ingesting around 12-203 microplastics per week.

Trays

Kedzierski et al. (2020) determinate the contamination of meat with microplastics through the extruded polystyrene (XPS) with plastic film – the material used commonly for packaging purpose for such a product. They found the presence of microplastics on the surface of the meat samples.

Tea bags

The plastic tea bags commonly replace traditional paper teabags. Tea bags are frequently brewed with water (above 95 ˚C). Thus, bags degrade and release approximately 11.6 billion microplastics and 3.1 billion nanoplastics into prepared cup of tea (**Hernandez et al. 2019**; **Bach et al., 2013**). To assess the potential toxicity of these micro and nanoplastics, they provided test on common water flea (*Daphnia magna*). The results revealed abnormalities in the development and swimming behavior due to their uptake. Although direct extrapolation to human ingestion is not possible, this assay provides valuable information on potential chronic oral intoxication in humans (**Hernandez et al., 2019**).

Degradation of plastic-base materials

The prolonged exposure of plastic materials to various environmental factors: light, heat, moisture, and microbial action, results in their fragmentation. The degradation rate depends on the type of plastic and specific environmental factors (**Chamas et al., 2020**; **Law et al., 2014**). Plastic materials conversion to plastic flakes or microplastics is caused by the action of several environmental factors as are: thermal, photo, mechanical, and biological degradation (**Svedin, 2020**). Thermal degradation occurs when increased temperatures affect the chemical and physical structure of the polymer. Photodegradation occurs when plastic bonds, break due to exposure to sunlight radiation. This process is more efficient in the presence of oxygen and UV light. Biological degradation, where microorganisms play a significant role, occurring under aerobic or anaerobic conditions (enzymatic degradation). Additionally, repetitive use, external abrasive forces, physical stress contribute to mechanical degradation of plastics (**Fotopoulou and Karapanagioti, 2017**; **Gewert et al., 2015**). **Klein et al. (2018)** emphasized, that the degradation process does not stop at the microplastic stage, it continues to nano-sized particles creation referred to as nanoplastics. Various factors contribute to the flaking and release of microplastics from plastic packaging materials into food. While multiple factors can influence the degradation of plastic, the primary contributors to the abrasion and flaking of packaging materials are aging - lead to the deterioration of plastic packaging materials, making them more prone to flaking and fragmentation. Temperature - elevated temperatures may causing that plastics become more brittle and susceptible to breaking into smaller particles. External mechanical forces - friction, rubbing, or impacts, exerted on plastic packaging materials during transportation, handling, or storage can contribute to their abrasion and the subsequent release of microplastics. It is clear, that mentioned key factors plays a significant role in the contamination of food with microplastics originating from plastic packaging materials.

Temperature

Research conducted by **Hernandez et al. (2019)** revealed that the temperature of water may impact the release of microplastics from plastic tea bags into prepared tea. The high temperature of water can cause the materials of the tea bag to become fragile, leading to an increased release of particles. This finding aligns with studies conducted on paper cups with inner plastic layer, which also demonstrated the influence of liquid temperatures on the release of microplastics from interior layers (**Ranjan et al., 2021**; **Li et al., 2020**). Similar findings have been observed by **Li et al. (2020)** in their study focused to how high-temperature water (100 °C) plays a role on plastics degradation during the sterilization process of infant feeding bottles. They revealed the release of microplastics due to the deterioration of the multilayer interior structure of the polypropylene bottles. Recently, **Du et al. (2020)** provided several tests with food containers used in take-out food delivery. They tested the containers using hot water and shaking to simulate the delivery process. Surprisingly, they found that this treatment did not significantly affect the abundance of microplastics.

The age

In relation to the age of packaging materials, the presence and release of microplastic particles can vary significantly. Two studies investigating microplastics in bottled water have reported that reusable bottles tend to have higher levels of microplastics compared to single-use bottles, and the age of these reusable bottles also plays a role in microplastic release (**Oßmann et al., 2018**; **Schymanski et al., 2018**). Furthermore, **Schymanski et al. (2018)** found that single-use plastic bottles contained approximately 14 particles per liter, beverage cartons had around 11, while reusable bottles had a much higher count of about 118 particles per liter. This indicated that the water from reusable bottles had approximately 8 times more microplastics than water from single-use bottles and roughly 10 times more than water from beverage cartons. Similarly, **Oßmann et al. (2018)** investigated both new and older reusable bottles. They observed approximately 2689 ± 4371 microplastics/l in new reusable bottled water, which was like the amount found in single-use bottles. However, in older reusable bottled water, the count significantly increased to approximately 8339 ± 7043 microplastics/l, around 3 times higher than in new reusable bottles. This demonstrates the significant influence of bottle age on the release of microplastics into water.

Mechanical stress

Microplastics particles can be released from plastic packaging materials and containers during routine tasks like cutting, tearing, scissoring, or opening plastic caps. Studies focused to determine the impact of mechanical stress on the bottle surfaces (PET bottlenecks and HDPE caps) to release microplastics (including repeated bottle openings and closings) revealed, that after 100 cycles of opening and closing, significant signs of mechanical stress, such as deep grooves and abrasions, were observed on the cap material. Microplastics were found in the cap-bottleneck area, and the reuse of PET bottles, along with repeated cap-bottleneck friction, resulted in the release of millions of microplastics on the inner cap surface and up to 148 ± 253 microplastics per liter in the water. Additionally, empty bottles were subjected to crushing or squeezing to investigate the release of microplastics from the inner surface during handling and reuse. No stress cracks were detected on the inner surface of the bottle, indicating that the PET bottles tested were resistant to mechanical stress and did not release microplastics into the bottled water during handling or use. However, squeezing a filled water bottle did influence the release of microplastics due to the mechanical stress on the bottle body. How the filling process of mineral water bottles, involving high pressure and hydrodynamic pressure, scraping forces and shear stress on the bottle body, leads to the release of microplastics was described by **Makhdoumi et al. (2021)**. Moreover, the presence of chemical species (ions and biosolids) in water also influences the fragmentation and agglomeration of microplastics and nanoparticles (**Enfrin et al., 2020**). The friction between food or tableware and the inner surface of the container during the act of eating has been investigated by **Du et al. (2020)**. The slight mechanical force induced during food consumption resulted in flaking and contamination of microplastics in the food.

Alternatives to plastic food contact materials

The primary purpose of food packaging is to ensure protection, containment, convenience, and effective communication with consumers. It is crucial that packaging materials prioritize non-toxicity to safeguard consumers' health. In this way, alternatives for plastic food contact materials have gained significant attention due to the proven toxicity of plastic packaging materials to both consumers' health and the environment (**Marti, 2018**). To fulfil mentioned goals, extensive research has been conducted on alternative materials. Bioplastics have also been studied extensively, exploring various fabrication techniques and modifications, including the incorporation of nanocomposites to enhance their functionality (**Fotie et al., 2020**). By-products derived from processed vegetables, fruits, and fermented grains have been modified and utilized for food packaging applications. While natural bioplastics have characteristics such as water solubility, moisture sensitivity, and water vapor permeability, what may cause several restrictions on use, these limitations can be overcome through the modification of raw materials using nanocomposite fabrication processes. Additionally, nanomaterials usage improves antimicrobial properties of the packaging films (**Dilucia et al., 2020**). By utilizing natural and modified materials, incorporating nanotechnology, and addressing the limitations through innovative approaches, it is possible to create safe and sustainable packaging options for the food industry.

THE IMPACT OF PLASTICS TO HUMAN HEALTH

The health effects of direct consumption of microplastics and nanoplastics by humans are still not fully understood. However, sub-lethal effects such as inflammatory, immune, and metabolic disorders have been observed in other organisms like mice, fish, algae, zooplankton, and indicating a potential human health risk (**Hernandez et al., 2019**). Numerous studies on animal consumption of microplastics have reported immunotoxicity and disruptive impacts on inflammatory imbalances, dysbiosis, and disruption of epithelial permeability (**Hirt and Body-Malapel, 2020**). Rats have been studied to understand the mechanism of translocation and fate of microplastics after ingestion or inhalation (**Xu et al., 2002**; **Yacobi et al., 2008**). **Prata et al. (2020)** presents the risk how such particles can translocate to organs such as kidneys, liver, spleen, and through circulation, leading to vascular occlusions, pulmonary hypertension, blood cell cytotoxicity, inflammation, and increased coagulability. Furthermore, researchers have confirmed microplastic particles presence in human bloodstreams and cells, where they enter via endothelial cells or macrophages of blood vessels (**Donaldson et al., 2000**; **Revel et al., 2018**; **Yoo et al., 2011**). Various types of microplastics have been found in the human gastrointestinal tract, but their transport and effects are still unclear (**Katyal et al., 2020**; **Quenqua, 2018**). Individual intake habits directly influence the abundance of particles in feces, where polypropylene is the most common component among the detected monomers (**Zhang et al., 2021**). **Ragusa et al. (2021)** in their study under Raman spectroscopy analysis discovered microplastic traces in human placentas. **Braun et al. (2021)** found microplastics larger than 50 μm in placentas and the first feces of newborns. Moreover, the accumulation of polystyrene particles with reduced clearance may lead to prolonged half-life and potential renal dysfunction (**Monti et al., 2015**). Micro-sized and nano-sized polystyrene and polyethylene particles can reach bone cells through blood circulation. In response to these particles, primary human peripheral blood mononuclear cells release osteolytic cytokines and activate osteoclasts, leading to impaired bone metabolism and subsequent bone loss (**Prata et al., 2020**; **Ormsby et al., 2016**). Human exposure to microplastics through the ingestion (considered as the major route of human exposure to microplastics) of contaminated food is inevitable and poses risks to food security and human health (**Galloway, 2015**). Chronic exposure to low concentrations of microplastics may pose potential threats to human health.

Physical and chemical characteristics determine the toxicity

Fadare et al. (2020) concluded, that plastic particles of smaller size can lead to more pronounced toxic effects. Furthermore, irregularly shaped particles, compared to uniformly shaped particles, are retained for longer periods in the body. **Lithner et al. (2011)** described on *in vitro* study the cytotoxic effects of microplastics released from commonly used plastic polymers, such as polyethylene and polystyrene, on cerebral and epithelial human cells (**Schirinzi et al., 2017**). The study examined the oxidative stress and cell viability of T98G and HeLa cells exposed to mentioned polymers. The results showed that polyethylene induced significant generation of reactive oxygen species (oxidative stress descriptor) in T98G cells, while both T98G and HeLa cell cultures exhibited higher reactive oxygen species generation due to polystyrene. The production of reactive oxygen species is known to have detrimental effects on human health (**Valavanidis et al., 2013**), particularly in the growth and proliferation of cancer cells. Similarly, certain plastics like polyvinylchloride, styrene polymers, polyurethanes, and epoxy resins, have been identified as major concerns due to their environmental and health effects. Their monomers are classified as mutagenic and carcinogenic. The severity of damage increased with higher concentrations and roughness of microfragments. Additionally, the consumption of micro-sized or nano-sized polypropylene particles, may impact cytokine production from immune cells and lead to health issues (**Hwang et al., 2019**).

Additives

Plastic food contact materials, in addition to microplastics, release bioactive chemicals - endocrine disruptors such as phthalate and bisphenol A into beverages and food. These chemicals can disrupt hormonal balance in the human body by interfering with thyroid gland hormones and inhibiting the effects of testosterone even at low concentrations (**Belluz and Viswanathan, 2018**; **Cole et al., 2011**), they are associated with carcinogenesis and can impact human reproduction and growth as well (**Rist et al., 2018**; **Barbat et al., 2013**). Plastic food packaging may contain stabilizers, which can have carcinogenic impacts on humans or cause mild health effects such as vomiting and abdominal cramps (**Cherif Lahimer et al., 2017**). Furthermore, toxic metals like cadmium, lead, and antimony presented as additives in plastic food packaging and storage containers (**Campanale et al., 2020**; **Hahladakis et al., 2018**) may play a role in severe health hazards, including cytotoxicity, congenital disabilities, estrogen interactions, various damages to the respiratory, hematological, cardiovascular, gastrointestinal, renal, and other systems. Additionally, neurological disorders (**Chen et al., 2019**; **Ranft et al., 2009**), pulmonary hypertension (**Zargorski et al., 2003**), anemia, and carcinogenic effects on lungs, liver, kidneys (**Deng et al., 2017**), and breast have been associated with these metals (**Hansen et al., 2013**).

Associated microbiological tasks

The unique physical characteristics of plastic materials create an ideal environment for the growth and colonization of diverse microbial communities (**Zettler et al., 2013**). These microbial biofilms that develop on the surface of plastics can serve as reservoirs for various pathogens (**Keswani et al., 2016**). Moreover, microplastics can act as vectors, facilitating the transport and dissemination of microorganisms. Recent investigations have revealed the presence of potentially harmful microbes colonizing microplastics in the environment. **Kirstein et al. (2016)** collected microplastics from the Baltic and North seas using Neuston nets and subsequently isolated bacterial colonies from these microplastics. Their findings confirmed the presence of the pathogenic bacterium *Vibrio parahaemolyticus* in different types of polymers (**Kirstein et al., 2016**). Other studies have also reported the colonization of microplastics by pathogenic communities (e.g., **Virsek et al., 2017**). Furthermore, laboratory research conducted by **Harrison et al. (2014)** demonstrated that bacteria can readily colonize low-density polyethylene within a short period of time in a 14-day microcosm experiment. Evidence of multi-contamination risk raising from environmental contamination by microplastics colonised by detrimental microorganisms is opening a few security issues in context of wild animals and those used for human diet.

The presence of residual antibiotics in conjunction with microplastics may result in heightened ecological risks for aquatic organisms (**Xu et al., 2013**). If antibiotics are capable of being absorbed by microplastics, depending on their physicochemical properties such as specific surface area, degree of crystallinity, and pore size distribution, their combined pollution could lead to increased toxic effects on aquatic life. Studies have provided evidence that persistent organic pollutants (POPs) can transfer from microplastics to *Artemia nauplii* and subsequently to zebrafish through a trophic food web (**Batel et al., 2016**). Therefore, it is crucial to comprehend the potential interactions between different types of antibiotics and microplastics to accurately assess their environmental risks.

CONCLUSION

The safety issues associated with microplastics released from food contact materials have raised significant concerns regarding their potential impact on human health. This review paper has provided an extensive overview of the various aspects related to microplastics released from food packaging and their potential risks to human well-being.

First and foremost, it has been established that plastic packaging materials commonly used in the food industry, such as bottles, containers, cups, and tea bags, are significant sources of microplastics. They can be released into beverages and food, leading to human exposure. Even seemingly innocent components like plastic caps, sealing films, and interior plastic coatings of paper cups and beverage cartons contribute to the release of microplastics. The size, quality, and quantity of microplastics released into food are important factors to consider. While the quality of microplastics found in food may not be identical to the original packaging material due to potential environmental or external contamination, the release of particles of varying sizes and their potential fragmentation under mechanical stress raises concerns about their potential health effects. The presence of additives and other bioactive chemicals in plastic packaging materials exacerbates the safety concerns. Chemicals like phthalates and bisphenol A, known as endocrine disruptors, can disrupt hormonal balance even in low concentrations. These chemicals have been associated with hazardous effects such as carcinogenesis, reproductive disorders, and growth abnormalities. Moreover, the release of toxic metals, including lead, cadmium, and antimony, as additives in plastic food packaging, poses severe health hazards and can lead to various disorders and diseases. The impacts of microplastics on human health have been the subject of limited but concerning research. Although more studies are needed to understand their direct effects on the human body, alarming findings from animal studies indicate potential health hazards associated with their consumption. The generation of reactive oxygen species, cytotoxicity, and inflammation are among the observed consequences of microplastic exposure, suggesting potential links to various health conditions, including cardiovascular, respiratory, and neurological disorders, as well as cancer.

Furthermore, the age of packaging materials, temperature, and recycling practices influence the release of microplastics. Older, recycled, or reusable plastic packaging materials are more likely to release higher amounts of micro, or nano-plastic particles. High temperatures can further accelerate the release of microplastics into food, and the microplastic release capacity of specific plastic-based food containers warrants further investigation. Considering the findings of this study, and on behalf of Food and Agriculture Organization (FAO) global food security request (**FAO, 2002**), urgent action is needed to address the safety issues associated with microplastics in food contact materials. Stricter regulations, improved testing methods, and standardized risk assessments are necessary to ensure the protection of human health. Alternatives to traditional plastic polymers, such as natural-based bioplastics derived from polysaccharides, lipids, and proteins, offer promising solutions as they are environmentally friendly and pose lower risks to human health.

The safety concerns surrounding microplastics released from food contact materials highlight the need for comprehensive research, awareness, and measures to mitigate potential health risks. By addressing these issues, we can strive for safer food packaging practices and protect the well-being of individuals consuming food and beverages packaged in plastic materials.

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