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Chemical and Biological Hazards of Plastic Utensils Used for Cooking and Other Uses: A Review Article

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Abstract. Packaging accounted for over 40% of the 380 million metric tons of plastic produced worldwide in 2015. A range of polymers, additives, and other substances, like coatings and adhesives, are used to make plastic packaging. Packaging may include unintentionally added components like contaminants, oligomers, or degradation products, as well as residues from production processes like solvents. A comprehensive understanding of all the compounds involved is necessary to characterize the risks associated with chemicals that may be released during package manufacturing, use, disposal, and/or recycling. The Chemicals Associated with Plastic Packaging database comprises the chemicals utilized in manufacture and/or found in final packaging items.

Highlights:

1. Plastic packaging made up over 40% of global plastic production in 2015.
2. It contains both intentionally and unintentionally added chemicals.
3. Risk assessment requires full knowledge of all associated compounds.

Keywords: Chemical, Biological Hazards, Plastic Utensils, Cooking

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Introduction

Plastic packaging is becoming more and more popular [1], [2], [3]. outlined by the desire to decrease food waste and the rise in demand brought on by market expansion and population growth [4], [5], [6], [7]. However, concerns about the harm being done to the environment are also becoming more prevalent [8] and to human health [9]. Littering and the buildup of nonbiodegradable plastics in the environment are among these issues [10], [11], [12] generation of secondary microplastics and nanoplastics [13], [14], [15], [16], [17] and the discharge of dangerous substances

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during production and operation [18], [19], [20] [21] In addition to after landfilling [22], [23], [24] incineration [25] or inappropriate disposal that pollutes the environment [26], [27], [28], [29], [30]. Packaging accounted for over 40% of the 380 million metric tons of plastics produced worldwide in 2015 [31]. About 60% of all plastic packaging is used for food and drink, with the remaining portion going to nonfood applications like shipping, cosmetics, consumer goods, apparel, and healthcare. Efforts are currently being made to significantly enhance plastic recycling rates to lessen the effects on the environment [32], [33], [34].

Numerous chemicals, especially packaging plastics, are extremely dangerous when used to create plastics [35], thereby raising serious concerns about occupational health [36], [37], [38]. Furthermore, chemicals included in plastic packaging may find their way into goods like food or cosmetics, or the environment during future usage, disposal, and recycling [39]. Because of this, plastic packaging is probably going to significantly increase the amount of chemicals that people and the environment are exposed to [40], [41], [42]. Additionally, recycling may cause dangerous compounds to build up in secondary materials, which would lower their market value and limit their use in downstream processes [43], [44], [45], [46]. Consequently, a thorough evaluation of the chemicals linked to plastic packaging might be required [47], [48], [49], [50].

Numerous methods have already been put out for evaluating and rating dangerous compounds found in plastics [51], [52]. The high quantities of monomers and a few additions have been the subject of these investigations up to this point. However, the identities and concentrations of all substances involved should be known to fully inform design, production, and policy decisions supporting safe substitutes for dangerous chemicals in plastic packaging. This includes materials that are purposefully added, like the monomers that are used to create the polymer, other chemicals that are used specifically during manufacturing (like solvents or processing aids), and additives that are added to the polymer to give it a desired property or function. It also includes materials that are unintentionally added, like impurities, reaction by-products, and breakdown products [53], [54], [55].

PVC, polyethylene, polypropylene, polyethylene terephthalate, and polystyrene are the five polymers most frequently encountered in plastic packaging [56]. Other polymers, including acrylics, polylactic acid, polycarbonate, polyamides, polyurethanes,

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and even more specialized polymer types, are also used for specific packaging purposes [57], [58]. A recent study found that over 10% of post-consumer plastic packaging waste that is gathered for recycling may consist of less prevalent polymers [59], [60].

Fillers, plasticizers, colorants, stabilizers, lubricants, foaming agents, flame retardants, and antistatic agents are the key groups of plastic additives. According to total tons, they are presented in decreasing order. Stabilizers can be further classified into many classes with more specialized uses, such as biostabilizers (biocides), heat stabilizers, UV stabilizers, antioxidants, and antiozonants [61]. Numerous additional kinds of additives are also utilized in smaller quantities [62], [63], [64]. Laminated structures and multimaterial multilayers are commonly utilized for packaging in addition to single-material items. Adhesives are frequently utilized in these systems to keep the structure together, which adds another level of chemical diversity [65].

In the 1940s and 1950s, the industrial manufacture of plastic materials began to take off. The amount of plastic produced annually worldwide has doubled over the past 15 years, with an estimated 299 million tons produced in 2013 [66], [67]. 21 percent of the world's plastic demand is made up of thermoplastic polypropylene, with low- and linear low-density polyethylene coming in at 18 percent, polyvinyl chloride at 17 percent, and high-density polyethylene at 15 percent. Other highly sought-after plastic types include thermosetting plastic, polyurethane, expandable (8%), polyethylene terephthalate (7%, excluding PET fiber), and polystyrene [68].

Plastic polymers are utilized to make consumer goods as well as synthetic fibers, foams, coatings, adhesives, and sealants, all of which have several applications [69]. Low-density plastics save fuel and save pollutants when they are used in automobiles and aircraft instead of metals or ceramics; Plastic protective clothing and safety equipment (such as helmets, air bags, and fireproof materials) prevent injuries; Plastic items for medical purposes contribute to enhanced health (such as blood bags, tubings, throwaway syringes, and prosthesis); Plastic packaging saves resources by preventing food and products from being wasted or contaminated; Because plastic packaging is lighter than traditional materials, it uses less fuel and emits fewer emissions while being transported.

Nevertheless, a heterogeneous waste stream results from such varied usage. The main reason for the high amounts of plastic trash generated is the short lifespan of many

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plastic objects, with an estimated 40% of them having a service life of less than one month. This massive waste causes major management and environmental issues [70].

Method

This review article was developed based on an extensive examination of existing scientific literature related to the chemical and biological hazards of plastic utensils used in cooking and food packaging. Relevant peer-reviewed articles, books, and institutional reports were identified through searches in academic databases such as PubMed, ScienceDirect, and Google Scholar. The search included terms such as "plastic utensils," "chemical migration," "food contamination," "plastic additives," and "health risks."

Inclusion criteria were studies that specifically discussed chemical composition, migration risks, biological contamination pathways, and the health implications of plastic use in food-related applications. Preference was given to studies published in the last 15 years, although foundational works were also included when relevant.

The collected information was analyzed thematically and categorized into key discussion areas including food contamination, chemical leaching, transportation risks, interaction with cleaning agents, and food additives. This approach allows for a comprehensive synthesis of current knowledge and identification of gaps requiring further investigation.

Results and Discussion

1. Food Contamination

Natural toxins, environmental contaminants, agrochemical residues, food process toxicants, and purposefully added substances are the four main categories into which chemical pollutants found in food can be divided [71], [72]. As a result, there is an inherent and external danger of contamination in the food manufacturing chain [73], [74].

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2. Transportation

Both diesel and gasoline-powered vehicles can contaminate food while in transit by releasing too much carbon monoxide through their exhaust systems. When it comes to reducing the distances involved in moving food, developing nations' logistics management and transportation infrastructures are less effective [75]. This makes it more likely that undesirable materials may land on the food. The pollutants may land directly on the food or the container. Oxygen, carbon dioxide, and water vapor are the gases that are most frequently examined for permeation on packaging materials. Consequently, other unidentified substances could penetrate the packaging's barriers [76].

3. Cleaning Agents

In the food business, cleaning products are essential to food safety. Chemical sanitizers that are preferred for deep cleaning in the food business include sodium hypochlorite, hydrogen peroxide, and peracetic acid [77]. The majority of cleaning products and disinfectants contain dangerous substances that are caustic and have a strong odor. Despite their importance in thoroughly cleaning surfaces and the environment, they can readily find their way into food through improper handling and dangerous procedures, leaving lingering toxicity.

Approval and regulation are required for heavy industrial chemicals. A material safety data sheet must also be given to the chemical handlers. To reduce the risk of food contamination by cleaning agents, international organizations, including the US Food and Drug Administration and the Codex Alimentarius, have established standards. Although optional, these guidelines are important, particularly for businesses looking to engage in global trade. When improperly diluted, certain substances can have negative health consequences on people, such as chronic dermatitis, when they come into contact with the skin or are used for an extended period [78]. When added straight to food, this could be toxic [79].

4. Food Additives

Research in the food sector has advanced quickly, and new methods have been developed to combat food perishability and minimize food loss from microbial deterioration. However, due to their potential to create food-related disorders, these

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technologies must be introduced and handled carefully [80]. Among the improvements implemented in the food sector to reduce waste and increase the shelf life of foods are food additives [81]. According to estimates, the average person may ingest between 3.6 and 4.5 kg of food additives annually [82]. Substances of natural or synthetic origin added to food to fulfill a technological or sensory purpose are food additives. According to the Codex Alimentarius, the definition is further broadened to include any material that is typically employed as a food additive to give nutritional value but is not often ingested as food. Despite the scientific uncertainty surrounding certain pollutants, the World Health Organization and other international organizations advocate for the inclusion of food additives in risk and safety initiatives due to their extensive impact [83].

Conclusion

Further research is necessary to determine the amount of this type of pollution, particularly that caused by microplastics, as it is believed to be far more widespread than previously thought in terms of both larger volumes and smaller particles. While there have been reports of suffocation leading to death and other negative consequences from ingesting or becoming entangled in plastic particles, plastics' capacity to absorb POPs may also result in other issues.

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