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Are Plastic Packaging in Food Sure for Living Consumers?

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Introduction

Plastic packages have been the preferred means of transporting foods to consumers. However technological development in the food industry have expanded their functions, and they now serve a variety of purposes. These include preserve food quality, providing information to consumers, and protecting packaged products from external contamination [1].

Plastic packaging stands out first and foremost for being hygienic, convenient, and attractive. The disadvantage of plastic packaging is the potential for food contamination due to chemicals migrating from the package due to their low molecular weight, diffuse to the surface in contact with the food and dissolve in it can contribute to such contamination [2].

Contaminants that can affect food by migrating to it from packaging materials [3,4]:

- Vinyl chloride monomer
- Styrene
- Acrylonitrile
- Phthalate esters
- Organotin compounds
- Polyfluorinated compounds
- Bisphenol.

Consequences for food range from strange taste contamination with toxic compounds. For this reason, the formulation of plastic materials must be selected in such a way that migration is minimal and that the substances that migrate do not pose toxicological risk to consumers [3,5].

The migration of material from plastic packaging is related to all the low-molecular-weight components added to, or remaining as residues in the plastic, which can transfer to food. These include [6]:

- Polymerisation residues: Monomers, catalysts, solvents, plasticisers, phthalic esters, adipics.
- Stabilisers: Organic compounds of tin, lead, vegetable oils among others.

The two variables that must be established in studies relating to the migration of packaging materials under experimental conditions are time and temperature, according to the process or type of storage to which the food will be subjected [7].

Compounds used in food packaging

Phthalates esters (PAEs): They are commonly used as plasticisers in the manufacture of polyvinyl chloride (PVC) packaging to improve flexibility and softness of the packaging, part of the composition of materials such as tubes typically used in milking process; and lid gaskets and globes used in food preparation. They can migrate into food from these objects, as they are not part of the polymer matrix [8,9].

Drinking water stored in polyethylene terephthalate (PET) bottles has become popular due to its convenience and low cost, growing by 6.44% per year between 2017 and 2024. Three types of PAEs have been detected in bottled drinking water: dibutyl phthalate (DBP), diethyl phthalate (DEHP), and di (2- ethylhexyl phthalate) (DEHP). The concentration of these compounds in bottled water was up to 20 times higher than in water contained in glass bottles [8,10].

The leaching of PAEs from PET bottles is affected by storage conditions, mainly temperature and duration.

Phthalates are classified as endocrine disrupting compounds (EDC) and have been associated with adverse health effects, particularly in relation to exposure at an early age.

High - fat foods may contain elevated molecular weight phthalates, which are mostly lipophilic as is the case with DEHP. Poultry, dairy, and fat products are commonly contaminated with high concentrations of DEHP compared with other foods [11,12].

Generally, phthalate concentrations decline after cooking, except in vegetables, where no change is observed. DEHP is present in all raw foods, although the percentage decreases by 65% after cooking [11,12].

A study conducted in Italy showed that lunches in primary schools and nursery schools had the highest concentrations of DEHP and DBP. These lunches were packaged in aluminium trays covered with polyethylene and kept warm in an electric oven, which might have caused migration of the compounds from the packaging [13].

Polyfluorinated compounds (PFCs): Polyfluorinated compounds are also used in food packaging and kitchen utensils. For example, the compound polytetrafluoroethylene (PTFE) is used in the surfaces of kitchen utensils and in paper used as wrapping material for some foods. Other compounds involved in this type of packaging are polyfluorinated ester (PFE), perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA).

These compounds can migrate from utensils or food packages into the food itself, where they can be ingested depending on the type of material, contact time, temperature, and polyfluorinated agent chain length [14].

The highest concentrations of PFE (27.3 μg/kg) have been measured in various food products, such as fried food, sandwiches, pizzas, meat, fish, pastries and pasta. Many of these are commonly packaged in greaseproof paper [14,15]. Contamination of baby food is also thought to likely result from the migration of PFC compounds from the packaging or containers used in its production, distribution or storage [16].

Furthermore, PFCs have been detected in fish, milk and dairy products, drinking water, vegetables, and grains. In addition, the pronounced biomagnification of these substances via the aquatic food chain results in highly contaminated fish [15,17].

Bisphenol A (BPA): The primary source of human exposure to BPA is through food, due to the use of plastic packages made from polycarbonates and epoxy resins, such as those used throughout the food production line in beverage containers [18].

Both *in vivo* and *in vitro* studies have identified BPA as an estrogen inhibitor capable of binding to the membrane estrogen receptor (MER). Recent studies have shown that BPA produces same potency and efficacy as estradiol. These studies have also indicated that BPA interacts with other receptors and pathways including androgen and thyroid hormone signalling pathways [20].

Recommendations and regulation

PAEs: The level of risk to human health due to PAE exposure occurs through multiple routes. Therefore, recommended conditions, such as storage in places that do not exceed 24°C, away from sunlight and for a short period of time, should be followed by distributors and consumers of bottled waters [10,11].

In terms of regulation, in the U.S., phthalates have approved by the Food and Drug Administration (FDA) as "Plasticisers for food packaging and food contact substances using during processing and storage", while the European Commission and Chinese Authorities have restricted the use of materials made with plasticisers that come into contact with food since 2008 - 2009 [9].

PFCs: The European Food Safety Authority (EFSA) recommends limiting the use of PFCs in food contact materials and food additives such as flavourings, food processing aids etc. This includes the use of ammonium perfluorooctanoate (APFO) for articles intended for repeated use, and for those that are subjected to high temperatures [21].

The negative health and environmental consequences of PFAs have led to changes in legislation. For example, Denmark banned the use packaging containing PFAs in 2020. Additionally, 11 U.S. states established regulatory standards prohibiting the use of PFAs in food packaging in 2022 [22].

BPA: In response to recent regulations restricting the use of BPA in materials that come into contact with food, food packaging companies are exploring substitutes with the aim of phasing out BPA from their products. BPA analogues, such as bisphenol S (BPS) and bisphenol F (BPF), which are part of the basic structure of bisphenol, are being widely used in the manufacture of consumer products since the ban of the use of BPA in several countries [19]. However, several studies have revealed that BPS and BPF produced hormonal effects similar to those generated by BPA, including metabolic, reproductive, and carcinogenic effects [19].

The daily intake of BPA in adults is around 1.5 µg/kg, with tolerable daily intake (TDI) estimated at 4 µg/kg body weight day [21].

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