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Package To Food Product- Migration of Toxic Substances

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Food is more convenient when it is packaged. It increases the assurance of food safety against microbes and other biological and chemical alterations, allowing packaged goods to have a longer shelf life. Packaging is now a necessary component of the food manufacturing process as a result. In India, the packaging category with the quickest rate of growth was flexible plastic packaging. Over the past few decades, there has been a notable surge in the advancement of food packaging to fulfil the enormous demand of the food sector. Presently, over thirty distinct types of plastic are employed as packaging materials. Additionally, a variety of additives, including lubricants, stabilizers, antioxidants, and anti-static and anti-blocking agents, has been developed to enhance the performance of these polymeric packaging materials during processing, fabrication, or use. The majority of concerns typically center on food additives, including those that are purposefully added to food as well as those that enter the food through packaging. Since the early 1980s, plasticizer migration from materials in contact with food into food has been a major source of concern for communities over packaging materials. This was explained by the shown carcinogenic impact in rats and the possible estrogenic effect in humans found in toxicological investigations of a number of widely used plasticizers. Due to the migration of contaminants from the packaging material into the food, such an occurrence suggested that the packaging itself could be a source of hazard.

Migration The word "migration" typically refers to a diffusion process that can be significantly impacted by how food ingredients interact with the packaging. The characteristics of the packaging material could be significantly impacted by this interaction. Food ingredients—especially fat that seep into polymers like PE or PP, on the other hand, can significantly boost the plastic's mobility and accelerate the food's migration within the container.

Significance of Migration

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Migration of substances from packaging to food poses health risks and affects food quality. To address this, the EU and FDA are implementing global regulations, listing safe substances and restricting toxic ones.

Paper and Paper Boards

Increased use of recycled paper and paper board in food packaging raises concerns about the safety of post-consumer contaminants, notably Benzophenone and heavy metals, which can migrate into food. Accelerated studies show Benzophenone absorption is higher in fatty foods, urging the need for low storage temperatures and barrier layers. Mitigating migration risks is crucial for ensuring food safety with recycled paper packaging.

Metal

Metal food packaging encompasses various types such as cans, closures, and trays, where metals like steel and aluminum are coated with protective materials to prevent food-metal interaction. These coatings often contain Bisphenol A diglycidyl ether (BADGE), which raises concerns due to its potential endocrine-disrupting effects. Studies indicate significant migration of BADGE, particularly under high processing temperatures. Additionally, gasket materials in vacuum closures can lead to plasticizer migration into fatty foods during sterilization. Although tinplate unavoidably contains trace amounts of lead due to ore composition, regulations limit lead content to ensure food safety standards.

Glass and Wood

Glass is recognized as the most inert packaging material for foods, with numerous studies worldwide confirming its safety regarding heavy metal migration, including lead, cadmium, chromium, and mercury, all of which were found to be below established thresholds. Clean lab methods reveal that lead concentrations in water from glass bottles remain well below regulatory limits for drinking water. Similarly, wood, being an organic material, is deemed safe for food packaging, with no serious health risks identified when foods are packed in wooden containers.

No.	Packaging Material	Food	Migrated Substance
1.	Wooden Packaging	Apples	I-propanol
2.	Cans coated with Lacquer	Tomato, Fruits	Epichlorohydrin, BADGE
3.	Al - laminated Cartons	Skimmed milk & Stirred Yoghurt	Aluminium

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4.	Aseptic Packaging	Milk	Hydrogen Peroxide
5.	Al - Foil paper laminates	Butter, Margarine	Phthalate esters (DBP, BBP, DEHP)
6.	Ceramic containers	Dairy Products	Lead, Cadmium
7.	Al – Can	Milk	Aluminium
8.	Recycled Paper & Board	-	4,4-bis(diethylaminobenzophenone)

Migration from Polymeric

Materials Plastic packaging includes trays and lids, films, pouches, bottles, and so on. Plastic reinforces metals for lining closures, glass to reduce container breakage, and paper for moisture resistance. Multilayer polymeric packaging is made by combining two or more plastic films through co-extrusion, blending, lamination, and coatings to achieve desired features such as gas and moisture barrier properties, UV and visible light transmission, flexibility, stretchability, heat sealability, low glass transition, and other mechanical properties indicative of strength or performance characteristics.

Hazardous Migrating Components in Plastic Packages (Additives)

Additives enhance the performance of polymers during processing and fabrication. Plasticizers, antioxidants, light stabilizers, lubricants, antistatic agents, slip compounds, thermal stabilizers and printing ink are the most commonly used additives in different types of polymeric packaging materials. Unreacted monomers and oligomers may also migrate from plastics to foods. Table below shows some monomer/oligomers and substances that may migrate from plastics to foods. The restriction has also been applied to the Specific Migration Limits for some metals and primary aromatic amines migrating from plastic packages into food.

No.	Packaging Material	Food	Migrating Substance
	Polystyrene	Milk, Yoghurt, Water, Instant foods, Beverages	Styrene
	PVC Films	Cheese	Bis(2-ethylhexyl) adipate (DEHA)

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	LDPE/HDPE	Food simulating liquids	Irganox 1010 (phenolic antioxidant)
	Microwave packaging		cPET (PET monomer)
	PP Cups	Cheese sauce	2-decanone
	PS + ABS + Waxed paperboard	Dairy products	Mineral Hydrocarbons
	LDPE	Milk	Naphthlene
	ABS	Dairy products	Mineral Hydrocarbons
	PC	Water	Bisphenol -A
	Polymers	Milk	Dioctylphthalate

Plasticizers

As a process aid, plasticizers are a class of chemicals that increase the stretch, workability, and flexibility of polymeric films while lowering melt flow. Plasticizers improve impact resistance in the finished plastic film and decrease shear during mixing stages in the polymer production process. Phthalic esters, such as di-2-ethylhexyl phthalate (DEHP), which make up around 80% of the plasticizer volume utilized in PVC formulations, are among the significant plasticizers. Due to their low molecular weight, plasticizers can pass from wrapped food into packing materials and end up as unintentional food additives. Di-(ethylhexyl) adipate, or DEHA, is a PVC plasticizer that can seep into fatty meals from packaging. Several workers have observed that plasticizers from plastics can migrate into meals. As a result of these studies, the packaging industry has replaced PVC with regenerated cellulose not associated with plasticizers.

Phthalates

Esters of phthalic acid, phthalates, or phthalate esters, are mostly utilized as plasticizers. Phthalates are known to disrupt the synthesis of male reproductive hormones in animals, and it's likely that they will do the same in people. Their effects on testosterone levels, sperm counts, and sperm quality are well-known from research conducted on animals. Additionally, testicular cancer and abnormalities of the male reproductive system might result from

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developmental exposure to phthalates. The most vulnerable are young children and developing fetuses. In one study, phthalate migration from baby bottles was examined under hot-fill settings of two hours at 70°C. The results showed that migration levels for DEHP were relatively lower (25 to 50 µg/kg), whereas those for diisobutyl phthalate (DiBP) and dibutyl phthalate (DBP) varied from 50 to 150 µg/kg. In a study involving olive oil, phthalates shown a high-transfer rate of 350% when utilized as gasket material for closures. This suggests transfer from behind the seal or rim as well as from the gasket. After 10 days of storage at 40°C, the migration of phthalates from a variety of food-packaging materials to food simulants was ascertained. Compared to PE film, more plasticizers were discovered to be emitted from PE bread bags. The packaging materials of Tetra Pack exhibit low levels of migration for DEHA and phthalates. Yogurt PS packaging exhibited relatively low migration. Different plasticizers are advised to adhere to different Specific Migration Limits, such as 1.5 mg/kg for DEHP, 0.3 mg/kg for DBP, and 30 mg/kg for BBP.

Bisphenol A

It is a part of the bisphenols group of chemical compounds with two hydroxyphenyl functionalities. It is a colorless solid that is soluble in organic solvents, but poorly soluble in water. In the European Union, the Total Dietary Intake is set at 0.05mg/kg body weight/day and a Specific Migration Limit of 0.6mg/kg food has been regulated. Since the beginning of the 90's, BPA has been the subject of increased scientific investigation regarding its estrogenicity. Scientists have found BPA to interact with estrogen receptors, both in the nucleus as well as on the cell membrane, to be an androgen receptor antagonist and to reduce the synthesis of some steroids at the molecular level. In vitro studies have found low-dose effects of BPA on adipose, reproductive and mammary tissue, the immune and nervous system, the liver and in pancreatic and pituitary models. In in vivo models, exposure levels below 50 mg/kg body weight/day have been observed to cause changes in brain physiology, brain structure, behaviour, sex differences in the brain, puberty in females, the mammary gland, uterus and vagina, ovary oocytes and female fertility as well as metabolism and the immune system. Further, effects such as carcinogenesis, male reproduction and adipogenesis have been also recently added to the list. Studies have found that foetuses and young children exposed to BPA are at risk for secondary sexual developmental changes, brain and behaviour changes and immune disorders. Infants fed with liquid formula are among the most exposed, and those fed

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formula from polycarbonate bottles can consume up to 13 µg/kg body weight/day. Yet, consensus regarding the health risks of BPA has not been established in the scientific community and discussion on the risk evaluation of BPA has been ongoing since the 1990s. Some of the scientists proposes that the current Total Dietary Intake for BPA is adequately justified and that the available evidence indicates that BPA exposure represents no noteworthy risk to the health of the human population, including new-borns and babies.

Contaminants

Apart from additives and monomer residues present in the packaging materials, other sources of food contamination have been reported as well. Decomposition products from additives or monomers will also migrate into the food under proper conditions. The presence of the residues of these chemicals may lead to contamination. Diphenylthiurea is used in the manufacturing of PVC film, benzene, dioxins processing agents (hydrogen peroxide) and other volatiles for some of the most representative residues.

Factors affecting Migration of toxic substances in to food

Several factors govern the migration of packaging materials residue in to the foods. This includes: Properties and composition of packaging materials, Properties/state and composition of food materials, surface contact area, head space, period of contact, temperature, light, irradiation, agitation, in-package processing and storage etc. The migration of additives or contaminants from food packaging to food may be separated into three different, but inter-related, stages: diffusion within the polymer, solvation at the polymer-food interface, and dispersion into bulk food

Conclusion

Food packaging is necessary for a number of reasons, thus the scientific community, governing bodies, and the general public should be informed seriously about the health and safety risks associated with migration from packaging materials. Surveillance should be conducted to ensure that certain monomers and additives from PS and PVC are properly monitored. The additives employed in the production of polymers deserve more consideration. Other areas, like the processing line and domestic cookware, need to be assessed because they could be a source of contamination. Migration is significantly impacted by modern processing and packaging methods including microwave heating and high-pressure processing inside packages, among others. Migration is likely to occur in packaged milk and milk products also,

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and most of the urban market of foods is served with packaged food. So, the utmost care should be taken in selection of packaging materials for food and there is a need to perform research work in this field in India as per Indian atmosphere and conditions.