

ADVERSE EFFECTS OF CHEMICALS USED IN FOOD PACKAGING MATERIALS ON HUMAN HEALTH

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Abstract

Food packaging materials may contaminate the food due to the migration of some undesirable chemicals from FPM to the food stuff and lead to significant health threats. Any interaction between FPM and food is considered to be highly undesirable. Commonly used FPMs metal, plastic ,paper and glass may release poisonous chemicals into the food . Extent of contamination of food by these FPMs depends on the constitution and nature of food as well as of packaging materials .The paper aims to discuss the harmful effects of the chemicals migrating into the food from FPM
Keywords : FPM , migrants, contamination

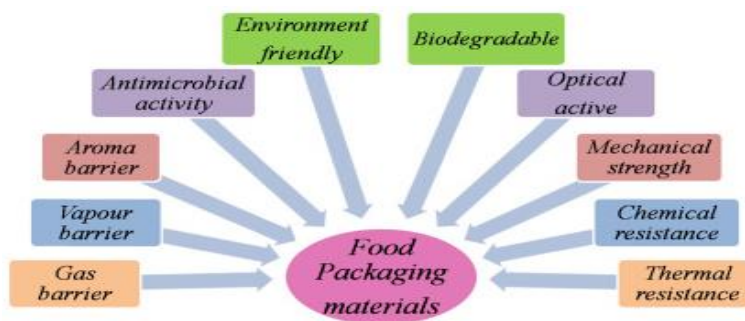
Introduction

Food is basically composed of moisture, proteins, fat ,carbohydrate or sugar, vitamins and minerals .The above mentioned constituents in food are the source of energy and make food essential for life. At the same time they also makes food accessible or vulnerable to microorganisms. Packaging of food has become a necessary element of the food producing procedure and to improve the quality of these polymeric food packaging materials various additives like coagulants, lubricants ,anti blocking agents and antioxidants are added. Packaging not only plays a significant role in maintaining the quality of the food by preventing it from bacterial contamination but is also essential for providing the quality food to the consumers . Packaging of food protects the food products from chemical ,physical and biological deteriorations and also makes it easier to transfer and keep for a longer time . Chemical protection prevents the food from changes caused by exposure to gases like oxygen or light (UV or IR).Similarly biological preservation provides a barrier to the growth of microbes(pathogens),insects rodents and other animals. Physical protection prevents the food from mechanical damages. Food packaging materials (FPM)are a barrier against the penetration of vapours of water, gases like oxygen ,carbon dioxide and volatile compounds(flavors and odours).FPMs are also known to possess good thermal, mechanical and optical properties .The complete life cycle of FPMs is given in fig as below



Presence of a number of chemical compounds in these food packaging materials (FPMs) can contaminate the food. Food and beverages can very aggressively interact with materials they come in contact with e.g oils can leach the plastic containers and beverages can break down the unprotected carton boards. FPMs have the possibility of releasing and transferring their harmful components into the food(1). Transfer of any type of contaminant from the packaging material into the food content is known as migration .For maintaining the safety of food these migrants should be monitored regularly .This migration depends on how hot the material becomes, on the length of time, the material with which the food is in contact with , the proportion of the food in contact with the material, and the food chemistry (e.g chemicals migrate more in acidic foods). This migration then can result to an exposure of the consumer with the migrating components and/or their reaction products and when these chemicals are ingested by the consumer they may lead to serious health threats. In fact none of the packaging

material is inert so there is always a possibility of migration of harmful chemicals into food from FPMs. The basic properties necessary for the packaging material are as given in Fig as below



Substances migrating from FPM

Substances migrating from FPMs can be subdivided into two categories

- 1.No-intentionally added substances (NIAS): these substances are not added intentionally during manufacturing process of FPM but are produced as a result of reactions and degradation processes
- 2.Intentionally added substances(IAS). These substances are added directly to improve the quality FPMs i.e. these may be the FPM like metals or the minor constituents used during the production process of the FPM such as , plastifiers ,plastic monomers and dyes etc.

Migration of harmful chemicals components into foods is major way of human exposure to FPMs and/or their harmful chemical contaminants .

type	Class of substance	Substance	FPM/Use
IAS	plastic monomers	Vinyl chloride	PVCs
		Acrylamide	polyacrylamides
		caprolactam,	polyamide
		6-aminohexanoic acid	polyamides
		p-hydroxybenzoic acid	polyesters
		2-hydroxy-6-naphthoic acid	polyesters
	Metals	Aluminium	Aluminium foils
		plastifiers,	coated paper/cardboard, plastic polymers, coated aluminium cans
	Dyes		Paper/cardboard
	Antioxidants		Plastic polymers
	plastifiers	Bisphenol A,phthalates	Plastic polymers
	Photo-initiators	2-isopropylthioxanthone	Paper/cardboard
	water/fat repellents	perfluorinated acids etc	Paper/cardboard
NIAS	Mineral oils	MOSH*/MOAH*	Recycled Paper

Table: 1 Substances migrating from FPM

(*MOSH -Mineral oil saturated hydrocarbons,* MOAH-Mineral oil Aromatic hydrocarbons)

Types of Food Packaging Materials

Food is packed in a variety of containers which are mainly made from four type of materials but are not limited to these(2)

1. plastic
 - 2.Metal
 - 3.Paper and Cardboard
 - 4.Glass
- The type of chemical that can migrate from these FPMs into the food depends upon the material used for packaging .Various FPMs are found to be a source of harmful heavy metals like arsenic, cadmium ,mercury ,lead, barium etc. These heavy metals are always present in trace amount in these FPMs and may disrupt our metabolic system by accumulating in our vital organs.

Migration in Plastic polymers based packaging material

Plastic bags were introduced in 1970 and since then these are being popularly used by Retailers and consumers. Shape of plastics can easily be moulded into a variety of products like bottles, jars, and plastic bags which are ideal for food packaging. Various types of plastics are being used as packaging materials for food throughout the world (3) which includes polyvinyl chloride, polyvinylidene chloride, polyolefin, polyester, polystyrene, polyamide, and ethylene vinyl alcohol. Although more than thirty types of plastics have been used as packaging materials (4) yet the most commonly used are polyesters and polyolefins.

Chemicals used during the manufacturing of plastic are found to be highly carcinogenic and have effects on nervous system and kidney. Major drawback of plastic FPMs is that they require some additives to assure certain properties required for their function e.g. to provide sufficient plasticity plastifiers, to protect from degradation by atmospheric oxygen antioxidants, to decrease UV-light dependent degradation light protectants, to generate the attractive appearance of the package colours, to apply written and graphic information printing inks. These additives are consistently present in FPM and can easily migrate into the food. A notable example is Acrylamide, a rodent carcinogen and neurotoxic agent in humans. Acrylamide is generally used for the production of polyacrylamide polymers, which may also be used in other FPMs (5). Vinylchloride and Styrene are the other examples of monomers that may migrate into food. Although the levels migrating into food items may be regulated and controlled under standard conditions, however their migration up to some degree is unavoidable practically.

It is found that rate and magnitude of leaching of chemicals from PET bottles depends on the storage temperature. When The PET bottles are stored at 37°C to 47°C there is a remarkable increase in the concentration of nitrate ion, sulphate ion, chemical oxygen demand, electrical conductivity and total dissolved salts (6). Increase in electrical conductivity and total dissolved salts may be due to the leaching of ions from plastic to the water.

One of the intentionally added substances during the production of plastics are plastifiers, the most notable one is Bisphenol A a so called 'endocrine disruptor' i.e, a synthetic chemical compound which affects the functions of endocrine system pivotal for development, reproduction and many other vital functions of the organisms. Risk arising from the exposure and migration of Bisphenol A from FPM into the food is widely studied by many toxicologists (7). Bisphenol A exposure in common person generally comes from consumption of food and beverages (8).

Another widely used plastifier is the group of Phthalates (9) which also affects endocrine functions and acts as liver tumor promoter.

Migration in Metal based packaging material

The most commonly used metals in packaging are aluminium and steel. When steel and aluminum are used for the packaging of food, it is required to make lacquering to prevent food interaction because these materials are not inert as glass (10). If anyhow this internal lacquering is cracked the underlying metal may get corroded by the aggressive reaction between the can and its contents, causing the lacquer to peel away from the can surface (11). Thin aluminium cans that are used to store refreshing beverages contain ortho-phenylphenol, a pesticide that is used to kill fungus and bacteria; it is known to be carcinogenic compound. Migrants from coating may also contain epoxy resin (used for internal coating) monomers like bisphenol-F, bisphenol-A and their diglycidyl ethers, oligomers and additives which may migrate from can lacquers into canned foods, these migrants are considered to be a potential risk to human health (12). If traces of epoxy resins leak into the digestive system of consumer they will suffer from deadly epoxy poisoning.

When aluminium foil is used in cooking it provides an easy way for metal to enter in human body. If the food baked with aluminium foil is consumed excessively it may cause a serious threat to human health. Increase in the temperature of cooking causes more leaching. At the same time leaching also depends on the pH value of food, spices and salts added to the food.

According to the National Institute of Nutrition toxic levels of aluminium are associated with the diseases like Alzheimer's, Parkinson's disease, various dementias and bone diseases.

Migration in Paper and Cardboard based Packaging material

These materials are derived from wood. Although paper and cardboard are natural FPMs, yet the production process of these materials may require use of a broad spectrum of chemical compounds. These include various preservatives for protecting the Food packaging materials from degradation by microbes, plastic polymer coatings to improve the normally weak barrier function of paper, colours, printing inks, some UV protectants, and chemicals needed in the pulp and paper production.

Paper and cardboard are mainly used for the packaging of fast food ,hot beverages, teabags ,bakery products and dry fruits etc .In addition to this these are also used in packaging of flour, sugar and pasta and in very frequently in the transport of fruits, vegetables and eggs. In comparison to the other packaging material like metal, plastics and glass paper and cardboard due to their porous structure may absorb oily and aqueous liquids from the food and keep the volatile compounds that are responsible for the bad odour(13).

Some of the chemical components like printing inks(e.g. photo initiators such as benzophenone) may transfer directly from the external surface of packaging to the food in contact. Another way of migration is via evaporation and then leach into the food via gaseous phase(14).

while using the recycled paper and cardboard during the production of FPMs one of the major problematic issue is that the recycled papers may get contaminated with a variety of harmful chemicals mostly obtained from printing inks. Likewise, mineral oils are frequently present in recycled paper/cardboard and, due to their lipophilicity and persistence, are easily found in the foods items (15).

Since paper and cardboard used as FPM are weak barriers these are coated with plastic polymers for strengthening therefore these FPMs have the same problems as the plastic polymers . Furthermore, polyfluorinated acids and related compounds are used for coating of paper to provide resistance to moisture and oil (16). The most noticeable products to consumers are the use of perfluorochemicals which are used as processing aid to make polytetrafluoroethylene (PTFE) commonly known by the name Teflon™ and frequently used in non-stick coatings of cookware; they are also used to coat the paper for making it resistant to oil and moisture. In 2005 there were reports that fluoropolymers that are used in the manufacturing of grease-resistant packaging of candy, microwave popcorn ,pizza and hundreds of other foods are absorbed by fatty foods and then broken down by the body into the carcinogen perfluorooctanoic acid (PFOA).

Migration in Glass packaging material

Glass is one of the most safe FPM as it is made from natural raw substances that are inert toxicologically. The major constituents, i.e. sodium/potassium silicates are non-toxic and are chemically inert. Even if the transfer of the silicates or any other cation takes place into the food it is marginal and harmless toxicologically as the cations that are usually present are non-toxic. Virtually no traces of problematic migrants originating from the glass are found in glass-bottled food products (17).

A few type of glass bottles used for storing liquids may contain lead which is also present in glass manufacturing silica at very low level .Lead is a potent known neurotoxin and is known to interfere with several functions of the body. Prolonged exposure to high concentrations of lead can cause vomiting, poisoning, and liver and kidney damage.

While it is true that no toxic chemicals virtually migrate from glass into food, but there have been problems with the closures used to seal glass jars, specially the gaskets inside the metal lids. These metal caps are known to be a source of harmful chemical contaminant phthalate which affects the endocrine system.

Plasticizers like epoxidised soybean oil (ESBO) have been found to migrate from glass container closures containing PVC gaskets . ESBO is a commonly used plasticizer and scavenger for HCL liberated from polyvinyl chloride (PVC) during heat treatment of manufacturing .PVC containing ESBO is used for gaskets in lids. ESBO can cause mild irritation in eye and skin and has a very low acute toxicity.

Thus it is obvious from the chemical composition of these food packaging materials that these can cause a threat impact on human health some of which can be summarised as given in the table 2 below

S.No.	Chemical group/name	Packaging use and migration	Health effects
1.	Bisphenol A (BPA) & alternatives: • Bisphenol S (BPS) • Bisphenol B (BPB) • Bisphenol F (BPF) • 4-cumyl-phenol (HPP)	Epoxy resin liners in cans and additives in polycarbonate plastic (rigid #7 plastics) — BPA found in a majority of sampled foods in the U.S. and when migrating from resins, shown to pose health hazards. BPA migrates from polycarbonate bottles into the water ,migration increases with	BPA is a well known human carcinogen (Prop 65), it causes endocrine disruption and is harmful to the reproductive system. Other harmful effects include liver damage; cardiac toxicity; obesity and pulmonary effects such as asthma,. Alternatives may be endocrine disrupters as well.

		rise in temperatures.	
2.	PHTHALATES: • Di(2-ethylhexyl) adipate (DEHP) • Diisononyl phthalate (DiNP) • Disobutylphthalate (DiBP)	Plasticizers —these are often added to plastic resins to create flexibility. Phthalates may migrate from recycled paper and cardboard packaging into dry food products such as rice, infant food ,breadcrumbs, and cereals. Packaging of school meals increased the presence of phthalate by more than 100%.	Endocrine disruption, cancer (Prop 65). DEHP is well known for its Cardiac toxicity
3.	Di (2-ethylhexyl) adipate (DEHA)	A non-phthalate plasticizer used in wrapping meat and cheese products	Potential carcinogen
4.	4-Nonylphenol	A breakdown product of tris (nonylphenol) phosphite (TNPP) .It is found to be present in rubber products and food wraps made of polyvinylchloride (PCV). Found in high levels in polystyrene and PVC food packaging	Endocrine disruption
5.	FLUORINATED SUBSTANCES: • Perfluorooctaine sulfate (PFOS) • Perfluorooctanoic Acid (PFOA) • Perfluoroalkyl acids (PFAAs)	Used in greaseproof paper wrappings and coating for the fiber-based food containers. May migrate from paper packaging to food.	PFOA: Cardiac disease and toxicity Endocrine disruption, potent carcinogens, liver damage, low birth weight.
6.	Styrene	Monomer that leaches out of polystyrene	Cancer (Prop 65)

Table :2 Some toxic chemicals used in FPM and their Harmful effect

Conclusion

Packaging of food plays an important role in maintaining food quality and preventing bacterial contamination. However, the presence of various Intentionally added or non intentionally added chemicals in food packaging materials(FPM) can contaminate food and result in to serious health consequences. FPMs have the potential to release and transfer of its components into the food .This transfer can lead the the consumer to get exposed to these harmful components .Among the frequently used FPMs plastic polymers, metals and paper/cardboard have been found to be an important source for unwanted chemicals in the food. These occur via migration of mostly intentionally added constituents or the FPM material itself (metals) into the food thus affecting its quality .Although most of the migrants are present at very low levels such as mg/kg(parts per million or ppm) , $\mu\text{g}/\text{kg}$ (parts per billion or ppb) or ng/kg(parts per trillion or ppt) which is considered as acceptable yet more research is needed to be done in this field .It is evident in most of the cases that glass due to its inert nature and non toxic constituents represents a safe and ideal FPM with respect to consumer health. Taking into consideration that the synthetic packaging materials are not only a serious threat to the consumers health but also these are not biodegradable hence more research is needed to discover new biodegradable polymeric packaging materials that should be safe for the consumer too.

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