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Effect of Food Packaging on Human Health – A Review

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ABSTRACT

Food and drug packing substances are essential to human beings. Poisonous elements are accidentally covered in packaging materials in various phases of manufacturing. Adulterants, colorants, and heavy metal interference are frequent sources of contamination in food packaging materials. Harmful heavy metals have adverse effects on living organisms. Chemicals alloy is t to food products and is shielded with glaze to stop the moving of the metal parts and metal-food link. Global warming potential is lower in metal packaging materials because of the magnetic properties that assist in the simple partition between them. This article reviews the effects of heavy metals in Food packaging on human beings and how we can control them.

INTRODUCTION

Metal packing materials provide excellent properties and are therefore being sold in a wide range of food packing items. $ 974 billion was the global demand estimate by 2018 in Asian countries (1). Metal Packaging comprises 15% that are being utilized across the globe (2). Metal-based packaging materials like aluminum, and tin, are sold in inflexible and stiff packing and are utilized for eatables packings. 364.4 billion cans were the global production in 2014. The beverage industry leads with 75% in 2014 of which alcoholic drinks comprise 45% and the rest is from non-alcoholic beverages. (3). Different shapes and sizes of cans are available but 90% of the market represents the standard cans. (4) The rising demand for aerated soft drinks has been increasing globally which impacts the metal cans market positively. (5) The packaging industry has both positive and negative effects on health and the environment. The food packing industry has both strengths and weaknesses that affect the well-being of human beings and the environment. Alloy packing gives a wonderful shield to heat, illumination, gasoline, humidity, recyclability, simple alteration into different forms, capacity for resisting extreme temperature flexible designing, shipping to far places, and distinctive properties. However, all assistance comes at a greater price. Global warming is the most obstructive impact of metal packaging which is due to greenhouse gases discharge of noxious chemicals from box to food, and a decrease in resources es. (6)

The present article reviews heavy metals' effect on humans' food packing materials. The review also elaborates on techniques for evaluating toxicity, including molecular biology and its adverse effects on humans.

EFFECTS OF PACKAGING ON THE ENVIRONMENTAL HEALTH

The greatest origin of environmental contamination is the heavy poisonous alloys. The poisonous nature of

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these metals leads to several dangerous health effects on the biological health systems and human life. (4) Lead is the main metal in paints, batteries, and inks and most countries ban it due to serious health effects. The main reason metals are used for food packing is to save and conserve the food items' flavor. Soil is a contaminant for food contamination. Poisonous metals can enter the soil and can go into the food chain and cause infection to the raw sources of food. (5) Pesticides sprayed on the foods can cause contamination and cause different diseases like immunocompetent, and hormonal disruption. (6)

RECENT ADVANCES OR TRENDS IN FOOD PACKING:

The 2020s have well become known for the decennary packing revolution in the food and beverage industry. Driven by a switch in demand in diverse areas—including sustainability, customer convenience, and an expanding preference for lucidity, it has been growing tremendously, everywhere.

- **PAPER PACKING**

There are growing feasible replacements for plastic packing materials like paper and cardboard which are made of reusable and reprocessed materials. Paper replacements can get the same strength and resistance through impregnable techniques. There is a growing trend in the food packaging sector for removing plastic straws for juices and replacing them with wood products. (7)

- **REDUCING PACKAGING VOLUME**

The easy way to make a change in improving sustainability in food packing is to separate unwanted elements which will give a huge impact. (7)

It's not abnormal to see foods packed with huge quantities of plastic—for example in the case of separately packed fruits. This is a consequence of wrong packing design which is wasted and even more costly. Recognizing and eliminating packaging components that are not fresh is the initial step. (7)

- **REFILLABLE PACKING**

The exclusive way of constructing packing from substances like plastic more sustainable is by asking consumers to recycle them and giving them ways to do so. (8) The idea of recyclable food packing is successful because consumer food companies are accumulating packing substances for daily use materials, cleaning them, and sanitizing them for future ahead of deliveries. This type of packing is believed to be "environmentally neutral" after being used 3 times. The notion is increasingly becoming popular in the dispense sphere, Netherlands is the largest producer using recycled fruits and vegetables. (7)

- **RECYCLED PLASTIC PACKING**

Integrating reusable plastic items for food packing is another considerable way to minimize the complete impact of plastic packing on the environment and exhibit justifiable authorization to consumers. Though it is a big provocation to produce packing foods that are recycled from plastic because of safety issues, there is more creative and transformative research is upcoming in this area to minimize the number of new plastics that can be used in food packing. (7)

TYPES OF METHODS USED FOR PACKING

- Creamery packing methods

Air, light, and moisture reduce the shelf life of milk and milk products by increasing the activity of microorganisms. Thus, to avoid this ultra-heat-treated baggage, tin cans, and metal canisters are used for packaging. The essence of milk is mainly packed in metal canisters. These canisters are formed by multi-layered bags which are closed by aluminum foil. This aluminum foil acts as a separating layer. Milk that is ultra-heat treated is packed in these canisters which can be kept for a long period and the packing also attracts the consumers. This milk is having a shelf life of 6 months to 1 year. (8)

The milk products contain fat. Thus, the fat gets oxidized by light and oxygen. Hence the cream, butter, etc. are packed in a protective layer which prevents its oxidation. Thus, the butter, and cheese are packed in plastic or aluminum foils. These can be stored for 6 months to years. (9)

The other fermented milk products like dahi, yogurt, etc. high effect polystyrene (HIPS) and polypropylene containers are used for a shorter period of shelf life (8) for tight closing of the packet's aluminum foils, plastic and paper boards, and even foils with coating are used.

Fresh cheese, spreads, etc. are packed using printed foils to extend the shelf life without losing their freshness.

India is famous for cultured milk sweets like khoa, roseola, gulab Jamun, somalia, paneer, chana, etc. which are mainly exported to other countries. Hence the extended shelf life is necessary. Therefore, laminated tin

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containers are used. They withstand more volume to 1.5l. To maximize the exports of the sweets with maintaining the aroma and freshness they use layered coated materials of polyvinylidene chloride/aluminum foil/polypropylene. For example, burfi which are used for 2 to 3 months are packed with tin cans at room temperature. Hot gulab jamuns are packed in tin cans which can be used for 6 months at room temperature (10).

Benzoates are used as preservatives for paneer. The tin cans used for packing help in maintaining a good shelf life of up to 6 months. Many eastern Indian sweets are used for 45 days like Sandesh and chenopods. The packing material used is nylon which is a copolymer. They also used cast polypropylene (CPP)]. These are used for 30 days and are stored in the refrigerator (11) These are also stored in three-layer plastic bags with 12lm polyethylene terephthalate or else they are also packed with 9 ml aluminum foil.

Different plastic reusable boxes or packets are used for ice cream. At some shops, tin cans are used to make easy scoops. (11) These help to maintain the aroma and extended shelf life.

Milk powders are packed with metal boxes covered with tin lids These can be easily opened. This helps to maintain freshness and to avoid moisture and air contamination. Nitrogen gas is flushed to maintain low oxygen levels thus avoiding other reactions and preventing lipid per- oxidation (12).

- **Soft drinks**

These are high-carbonated drinks containing more amount of sugar and carbonic acid gas and few other taste-giving elements. These drinks are packed in tin cans as these have withstood high pressure of carbon dioxide. These cans should be corrosion-free; hence they use three layers of tin materials. These layers help to endure the internal carbon dioxide pressure and they are prepared in such a way that the edges of the three layers help to prevent the migration of metals for short periods. (13) These types of packaging materials are first used for beers in 1950. The lids are tight and they are known as 'stab on the tab' (14). These aluminum cans are lightweight and help to stop the bad odors of wine like sulfur. The wine fermentation is preserved with temperature and also used as cooling cans. (15)

Fruits and vegetables

Fruits and vegetables are stored in such a way that their nutrients, sweetness, and freshness should be maintained for a prolonged period. For this, they give more heat treatment to fruits and vegetables called canning. These canned fruits and vegetables are safely stored in a metallic packing which helps to maintain their safety coatings at good storage time. The canning is decided on a particular type of fruit and vegetable. The vegetables and fruits contain nitrates, sulfates, and many other elements. These elements may react with the metals migrating from the packaging such as tin and plastic boxes, and paper boards. The preservatives used dioxide in fruit juices react with iron present in the metal and corrode it. The other preservative used for raspberries and red fruits reacts with the metal pack and results in corrosion. The preservative that is mainly used is antanthocyaninsulfur containing garlic, onion, asparagus, and a few vegetables containing nitrates. These react with metals and form metallic sulfides and nitrites. These appear as black spots on fruits and vegetables. The sulfate gases are released from the cans. Thus, to prevent this zinc-based and type II laminated are used to prevent black staining or spots. The pineapple juices packed in tin cans without laminates have shown a reaction. Hence consumption of these should be restricted and used only for a specific period. (16)

Fish, meat, poultry, and seafood

Foods are canned for lengthy storage. These canned foods are ready-to-eat foods. Nowadays it has become a trend to eat such foods from the market. Ready-to-eat seafood like crab, shrimp curry, and prawns are canned in laminated tin-free steel (TFS). These foods are made with an extended shelf life of 24 months. The canning process is done at a temperature of 28 ± 2 ºC. (17) Examples of such canned food are mainly mackerel in brine and oil which is a fish product, and prawns in brine. Tuna is a Euthynnu saffron fish that is canned food and ready to eat. This is canned in a different way than an open canned process. In this system, the food is opened to sanitary (OTS) cans which are glazed sulfur persistent, for this ECCS containers are used with clear PET laminating. These products have a shelf life of 5 months or more and can be used at room temperature. (18)

The other example is fish curry named rohu or Laborite. This product is canned in a TFS which is polyester

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coated. The fish and curry ratio are 60:40. Stored in usable form maintains its texture and taste and other important elements. This can also be stored and used for 6 months at room temperature. (19)

The other food product is mackerel fish and Scomberomorus guttatus or Seer fish curry. This is also packed in a plastic pouch which can be adjustable. This pouch has three-layer and is made up of polyester, aluminum, and polypropylene. 12l polyester and 15l aluminum foil and 75l polypropylene are used for storage for 24 or 12 months. (20) The other type of packing is four layered retort bags which consist of polyester 12l and aluminum foils 12l and also cast 75l polypropylene and also 15l biaxially oriented nylon which is used to prevent air and moisture contamination. And then thermal treatment is done for these bags so that they can be reused. Food that is stored in such products is aerogun josh, a traditional meat curry of Kashmir. (21)

The other ready-to-eat product is black clam (Villoritacyprinoides). This is stored in three layered retort bags which consist of 12.5l polyester, 12.5l aluminum foil, and 80l cast polypropylene. In these bags, the food is stored for one year related to the surrounding temperature (22). This food has shown metal contains when tested and even they stored at normal temperature. (23)

- Bakery and confectionary products

These are packed in an attractive way and specialized to prevent reaction with air, and moisture. For traditional sweets, aluminum foil which is of 0.009 mm thickness is used. The other different type of packing is a heat-treated coating which has aluminum foil and LDPE. This type is most commonly used. The attractive packing contains metal boxes and nitrogen gas which help to maintain a good quality product. The food stored in such type of packing are chocolates, bakery products like biscuits, cookies, and fried items. For chocolates, metallic thin films are used to cover just to avoid moisture. For sweets, aluminum foils are coated which are edible and also help to maintain goodness and taste. These aluminum foils used are having different thicknesses. (24)

Coffee and tea

Coffee and tea powders are mainly packed in tin plate cans. The roasted and ground coffee powder in tin can packing helps to maintain the rich aroma of coffee with no loss of its texture and taste. The carbon dioxide gas is passed at the time of storage. Thus the metal or plastic packing also helps to withstand the pressure. These packings have aluminum as the middle layer with a thickness of 12 ml. aluminum packing is mainly used for packing in bulk. This has a shelf life of 1 year to 18 months. The metal packing contains aluminum foil which is layered between PET and LDPE I, e PET-Al foil-LDPE. Paper board boxes are used with aluminum foil lining for longer storage packing with tight lids called Snap-On lids. This type of packing allows to maintain good odor, texture, and taste of coffee, and tea. This also helps in exports. (25)

Studies showing the metal in food packing:

Sl. No	Metals present	Type of packaging material	References
1.	Cadmium	Leak-proof bags, plastic bags	Imtiaz al.2015(26)
2.	Arsenic found	paper wrapping and paper board	Park et al. 2010(27)
3.	Mercury	Paper as food packing	Bernhoft RA et al. 2012(28)
4.	Mercury	paper plastic food packing containers	Peng X, et al 2020(29)
5.	Toxic metals	multilayer plastic food packing	Nerín C et al. 2007(30)
6.	Heavy metals – cadmium, mercury, vanadium, arsenic in	adulterants and coloring agents used in food packing	Dong Z et. 2014(31)
7.	Heavy metals	Papers and paper boards in food packing	Sood S et al. 2019 (32)

Concentrations of metals in food packing:

Pb(lead) conc. In packing:

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In paper packing, Pb Conc. was between 1.39-12.9mgkg^{-1}. In this paper, packing showed a high concentration of lead as a result of coloring processes to obtain color.(33) On the paper board lead, conc was between 1.45-11.1mgkg^{-1}. Corrugated board packaging between 1.69-12.77mgkg^{-1}and had high lead concentration. Some cardboard packaging materials with colors of red, yellow, and white were showing high lead conc.(33)
Studies showed that the amount of lead in food at paper packing showed 9.42mg.kg^{-1}, 6.39 mg.kg^{-1} in paper board packing and in grooved paper packing it was 7.95mg.kg^{-1}

Mercury conc.in packing:
1.82 mg.kg^{-1} was the mercury concentration in paper packaging and 0.01 to 0.99 mg.kg-1 in paper board packaging and 3.8 mg.kg^{-1} in grooved paper packaging. Excessive amount in grooved paper packaging is because of the application of mercury compounds to raise the surface stress of the paper. Studies showed that the highest amount of Hg in food is mainly due to the use of paper, a paper board using and corrugated paper packing showed the highest content of Hg in food.(33)

Cadmium conc in packing:
Yellow and red are the shades that are regularly used among the dark shades with the concentration of cadmium as.0.3 to 0.18 mg.kg-1,0.02 to 0.09 in paper board packaging, and 0.07 to 0.16 mg.kg-1 in grooved packaging. (15). 68 mg.kg-1 in food because of the utility of paper, paper board packaging
This quantity is beyond the limits value set by the European commission. This value was close to all packing materials used for food packing.(33)

Zinc conc in packing:
Paper is very rarely packed using zinc oxide. or sulfate of zinc components that are rarely needed to raise the opacity which is used in manufacturing paper packing. The white color is to add to apply metallic colors. 3.06 to 10.11 mg.kg^{-1} is the concentration of zinc utilized in paper packaging and 1.36 to 7.33 mg.kg-1 for paper board packing and 13.98 to 61.30 mg.kg-1. For grooved paper packaging.(33)
The content of Zn in paper packing is 67.15 mg.kg^{-1}, in paper board packing is 307.10 mg.kg^{-1}, and in corrugated paper packing showed 82.62 mg.kg^{-1}. These values exceeded the limit according to the European commission.(33)

Aluminum conc in packing;
Aluminum in packing appears from aluminum sulfate, aluminum chloride hydroxide, aluminum formate, aluminum nitrate, and sodium aluminum components used as precipitators, and stabilizers. The concentration of aluminium in paper 34.8 to 11,470 mg.kg^{-1} and paper board 1.392 to 5,642 mg.kg^{-1} and corrugated board packaging 1.268 to 3,909 mg.kg^{-1}.
The content of aluminium in food in paper packing 1.15 to 1,022 mg.kg^{-1}, in paper board 1.73 to 1,218 mg.kg^{-1} and for corrugated paper board packaging 813.7 to 1,046 mg.kg^{-1}. Studies show this was high in comparison to the europian commission. Thus applying the color in the water dissolves and forms an acidic environment and this makes the aluminum foil corrosive.
But these colors have pigments mainly turquoise, yellow, and white toxic metal sources and red which is the main color from light to dark on the color scale. Thus these colors have optical characteristics with different scores of light. They are mainly paper and paper board in which toxic metals are present such as green for Ni, white for Zn and Pb, and red and blue for Cu metals.[33]

Adverse changes induced by heavy metals in humans:

The toxicity in packed food is because of the leaching of metals from metal packing. In metal packing the protocol followed is acetic acid3%, ethanol10%, ethanol50%, n-heptane. Nut coating of acetic acid is of no use which is shown in a meta-reference. (34)
The interaction between metal and food occurs at the contact surface. The chemical reaction mainly depends on the chemical composition of the packing of the food canned process used for food treatment,
coating of the package, the temperature at which the material is used for the making of the containers, Gases released for the food to maintain its freshness, and moisture used in packets for the maintaining moistness of the food.
Hence based on all these factors the reactions take place between the food and the containers.
Thus these reactions lead to corrosion, perforation, loss of coating, and quality of food degradation which causes

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loss of food color and also causes a hollow type of food with no texture, loss of taste, and smell.
The food contains some gases used for preservatives to help increase the rate of reaction between the package and the food.

Bisphenol A (BPA) is used in Tin cans production. It is also called 2,2-(4,40-dihydroxy diphenyl) propane and helps in making tin cans. It acts as a plasticizer and helps to inhibit the polymerization of PVC (polyvinyl chloride). Studies have shown that this chemical is leached from the containers to the food and causes disrupting of the endocrine membrane in the reproductive system. This later causes miscarriages and failure to conceive. This chemical also induces carcinogenic activity.

The studies have shown that leaching of BPA in thermally treated tuna fish when compared with nonthermal treatment cans with the coating of witorganismalol, epoxy phenolic.

Organosolresin-coated cans contain 646.5 mg/kg of BPA. Thus this makes it unsafe for consumption. (34)
The leaching of the BPA from cans into coffee has shown a connection with the caffeine content of the coffee. Thus when caffeine levels are measured they showed differently.0.05, 0.1, and 1.0mg/Ml caffeine content, but in canned coffee the caffeine content changed to higher content(35)
The liquid chromatography-mass spectrometry method showed that BPA in solid food is different from that BPA in liquid portions. (36)

The food items which are commonly used but canned are mainly fruits, vegetables, soups, fish, and meat. A study done on the Belgian market showed that BPA contamination in canned food was40.3 ng/g. (37).
Another study done on canned food at Japan market reported bisphenol A and chlorohydrins of diglyceryl ether (BADGE) and bisphenol F diglyceryl ether which is called (BFDGE) was found in vegetables and coffee items. These were used as epoxy resins and fillers in the production of packaging materials. The limit of the migration was 600 LG/kg. this is shown in given by European Union. But these BADGE and BFDGE form toxic compounds with the other preservatives present in the food and these questions were unanswered. (38) thus, these products are not safe for consumption.

A study conducted in New Zealand documented the assessment of exposure to BPA. This showed that iatrogenicity of 7% but the effect of this is still under research. (39) but the effect of coating materials like bisphenol and BFDGE (derivative of bisphenol) and NOGE that is novellas glycidyl ethers is banned in European Union. (33)

Many studies showed that aluminum in food items mainly bakery items like pastries and ready-to-eat meals are present on aluminum trays for a longer period. Many studies on animals have shown that the link between aluminum and Alzheimer's disease.

Thus the FAO/WHO has decided the safe limit of aluminum reduced to 7 to 1 mg/kg body.
According to Joshi et al. aluminum content in the food increase with a decrease in the pH of the food. and as the food temperature increases the leaching of the aluminum from the can increases. this is for consumption (40)

The side effects caused by more consumption of tin are l irritations in GIT like, diarrhea, l cramps in the stomach, etc. The normal content of tin in food is 250 mg/kg to its highest and in liquids 150 mg/kg to its highest. These standards were as per Agriculture Organization (FAO). Thus, the tin level for canned food is measured like fruits, pineapples, pineapple, lychees, etc. The tin content for a papaya which is canned showed 269.8 and for canned apricots is 153.4 mg/L. The acidic juices will corrode the tin and this makes it increase in food content (41).
The other toxic metal is chromium, which is made at tin plate treatment and causes mutagenic and carcinogenic changes. Lead which is present in canned food used during manufacturing at the time of joining with heating of metal is more effects on the kids and bones. (42)

Furthermore, research is required to study about tin and its effects on the human body.

Effect on human life:

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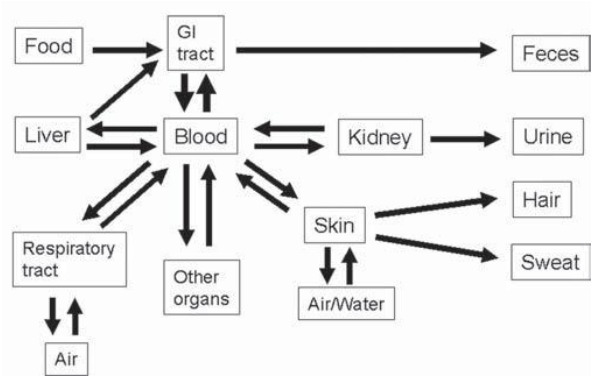

Figure 1. ABSORPTION AND DISTRIBUTION OF CHEMICALS IN THE HUMAN BODY.

Systems toxicology and risk assessment

Risk assessment needs are context-dependent and can vary from simply classifying a substance as hazardous (e.g., whether it is genotoxic) to prioritizing by nature and extent hazard severity for further investigation to quantitative risk estimation to determine the urgency and nature of any risk management action. While current approaches have served society well, there is a growing concern, some factual and some hypothetical, that the assumptions used in the current risk assessment may there be significant weaknesses. These include the shape of the dose-response relationship in human-relevant exposure, whether biological thresholds exist and what parameters, and the extent of population variability in toxicological responses. study and the influence of factors such as life stage on response. Despite a considerable amount of research, in the way of animal study, these issues have not been addressed. This shortcoming is due to the intrinsic limitation of all empirical observations by the study's power of

systemic toxicology can give collective information on quantitative mechanistic models and address such issues. It also helps to give a good understanding of the effects of toxicity and helps to understand the effects of reactive chemical agents. Thus, the complete description of systemic toxicology is not sufficient in the previous studies. since the new inventions in technology have made different packing and allow for much more research. (43). Hence understanding this complexity of systems toxicology is very difficult and the drawback is that the risk assessors are not that much trained in mathematics to give the exact calculations about the toxic elements and their leaching in food from the containers. Thus, reducing this, it can be done by adapting the model of adverse outcomes. That is MOA/AOP which helps to cover all the necessary events of chemical reactions in toxicology. But it needs a modular approach and it should be started from a systems-based model and with the dose-response connection and their collective information. Thus, this is also known as the deterministic biological model. Through this, the complete necessary things can be assessed and help future generations to understand the perspective and it also experimentally has the advantage of easy verification.

Many non-animal testing methods such as the high flux toxicology program help to assess the hazards of chemicals and their risk of management. Thus systemic toxicology is the perfect key to assessing the risk assessment but it's a time-consuming effort. This future helps to provide steps for the development and in vitro approaches for the systems of toxicology. (43)

Conclusion

We cannot prohibit the usage of metal packages since they are so closely related to our day-to-day life activities. The current generation is giving importance more to hygiene concerns knowingly or unknowingly we are creating problems that are particularly affecting health. The metal packets are reusable and environment friendly not just like plastics. Because of this advantage country cannot ban metal packaging. Furthermore, additional research is required to study the effects of metals on the body. The permissible concentration of each metal should be studied and that should be adapted in the manufacturing of the metal packages. Thus this review throws light on the effects of metals on human health and their toxicity to the environment.

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