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REVIEW ARTICLE

Convenience Foods and Its Packaging Effects on Human Health: A Review

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Abstract

In the 21st century increasing world population, rising food prices and other socioeconomic impacts are expected to generate a great threat to agriculture and food security worldwide. Food is one of the basic needs of the human being. It is required for the normal functioning of the body parts and for a healthy growth. Consumer interest in ready-to-eat (RTE) snack and ready-to-serve (RTS) food is growing due to their convenience, value, attractive appearance, taste and texture. Most of the foods packed in plastic material. But longer use of plastic coated material is slow poison for human health. So the aim of this review to highlights the migration of chemicals from plastic material to food and its side effects on human health.

Keywords: Convenience foods, Packaging, Plastics, Chemical migration.

1. Introduction

Food is one of the basic needs of the human being. It is required for the normal functioning of the body parts and for a healthy growth. The processed, semi processed and ready to eat food are called convenience foods. Technological development of food processing equipment, process and packaging material, have got revolution in the development of convenience food sector as for the necessity of taste, nutritional requirements of consumers. Food processors like MTR foods, ITC foods, Priya foods, ADF foods and many others are developing newer and newer products to meet the demand of Indian palate. Consumer interest in ready-to-eat (RTE) snack foods is growing due to their convenience, value, attractive appearance, taste and texture. Today more number of women are working than before and hence looking for products convenient to cook fast.

The ready-to-eat (RTE) market in India, currently estimated at Rs. 128 crore (2006) is expected to expand to reach Rs. 2,900 crore by 2015, according to an analysis done by Tata Strategic Management Group (TSMG). In its analysis, TSMG said that the factors contributing to the growth would be changes like cold chain development, disintermediation, streamlining of taxation, economies of scale on the supply side, coupled with increasing disposable incomes, diminishing culinary skills and the need for convenience on the demand side (Vijaybhaskar and Sundaram, 2012).

2. Fast Food and Its Effect

Fast food refers to food that can be served ready to eat. The terms fast food and junk food are often used interchangeably. Most of the junk foods are fast foods as they are prepared and served fast, but not all fast foods are junk foods, especially when they are prepared with nutritious contents. The definitions of various food items are described in Table 1.

Consumption pattern of snacks have a role to play in the development of not only obesity but chronic diseases also like diabetes, hypertension and cardiac diseases and thus snacking needs to be considered in obesity treatment, prevention and general dietary recommendations (Dhruv *et al*., 2011).

India has rich heritage of foods and recipes. Popular north Indian fast foods include aloo tikki, bhel puri, chaat, pakora, chole bhature, pav bhaji, dhokla, samosa and pani puri. Calorie and fat content in Indian fast food depends on the cooking method. Most of Indian fast foods are prepared by deep frying in fats especially trans-fat and saturated fats. Foods which are baked, roasted or cooked in tandoor have lower fat content.

Hydrogenated oil used in Indian cooking is rich in trans-fats and have been replaced in many restaurants by refined vegetable oil. Consumption of diet high in sugar, saturated fat, salt and calorie content in childhood can lead to early development of obesity and cardiovascular diseases.

3. Plastic Packaging of Food

India packaged food industry has expanded at an unparalleled growth rate over the last few years. The market for packaged food in India was valued at USD 15 billion in FY'2013. Growing at a compound annual growth rate (CAGR) of about 15 to 20 per cent annually, the Indian packaged food industry is likely to touch $30 billion by 2015 (ASSOCHAM). Plastic packaging plays a significant role in the shelf life and

Table 1: Definitions Related to Fast Foods

Type of Food	Definition	Examples
Fast food	Foods sold in a restaurant or store which are rapidly prepared and quickly served in a packaged form for take away.	Burgers, pizzas, fries, hamburgers, patties, nuggets. Indian foods like pakora, samosa, namkeen etc.
Junk food	Energy dense foods with high sugar/ fat/ salt content and low nutrient value in terms of etc. protein, fiber, vitamin and mineral content.	Chips, chocolate, icecream, soft drinks, burgers, pizzas
Instant foods	Foods that undergo special processing that are ready to be served once dissolved or dispersed in a liquid with low cooking time.	Noodles, corn flakes, soup powder.
Street foods	Ready to eat foods and beverages prepared and sold by hawkers or vendors in streets or other public places.	Chaat, gol guppa, samosa, tikki, noodles, chowmein, burgers etc

Source: Kaushik *et al.* (2011).

ease of storage and cooking for many foods. Plastic packaging, containers and cling films often have instructions on how to use them safely to keep the chemical migration to a minimum. However some people have expressed health concerns regarding chemicals migrating from the plastic packaging or cling film into food in contact with it.

The portion size in pre-packaged, ready-to-eat and restaurant foods is increasing in the US and elsewhere, building on the consumers' desire for 'value for money'. In recent years the number of restaurants offering 'supersize' options on their menu has rapidly risen, and other food items, especially snack foods, have increased package weight (French, 2001).

The information below outlines different types of plastics and their uses around food, and packaging, and how to reduce the risk of chemicals from plastic migrating into food. More than 30 types of plastics have been used as packaging materials including polyethylene, polypropylene, polycarbonates and polyvinyl chlorides1. Polyethylene and polypropylene are the most common.

3.1 Polyethylene

Polyethylene plastic comes in high or low density. High-density polyethylene is stiff and strong and used for milk bottles, water and juice bottles, cereal box liners, margarine tubs, grocery, rubbish and retail bags but is not heat stable (i.e. it melts at a relatively low temperature). Low-density polyethylene is relatively transparent and used to make films of various sorts (including domestic/household cling film), and bread bags, freezer bags, flexible lids and squeezable food bottles.

3.2 Polyethylene Terephthalate (PET or PETE)

PET or PETE is polyester. It is commonly used in soft drink bottles, jars and tubs, thermoformed trays and bags and snack wrappers because it is strong, heat resistant and resistant to gases and acidic foods. It can be transparent or opaque.

3.3 Polypropylene

Polypropylene is more heat resistant, harder, denser and more transparent than polyethylene so is used for heat-resistant microwavable packaging and sauce or salad dressing bottles.

3.4 Polycarbonate

Polycarbonate is clear, heat resistant and durable and often used as a replacement for glass in items such as refillable water bottles and sterilisable baby bottles. It is also sometimes used in epoxy-based lacquers on the inside of food and drink cans to prevent the contents reacting with the metal of the can.

3.5 Polyvinyl chloride (PVC)

PVC is heavy, stiff and transparent and often used with added plasticisers such as phthalates or adipates. Common uses of PVC with plasticisers include commercial-grade cling films for over-wrap of trays in supermarkets and filled rolls at delicatessens.

4. Migration of Chemicals from Food

From plastic bottles and some cans lined with polycarbonate – tiny amounts of **bisphenol A** are formed when polycarbonate bottles are washed with harsh detergents or bleach (eg, sodium hypochlorite). Some food or drink cans may be lined with a lacquer to stop the food interacting with the tin. This may also release tiny amounts of bisphenol A. At high levels of exposure, bisphenol A **(BPA)** is potentially hazardous because it mimics the female hormone estrogen. From commercial cling films made from PVC **–** **DEHA:** diethylhexyl adipate is a food-compatible phthalate plasticiser and tiny amounts may migrate into fatty food (such as meat or cheese), especially with heating. **DEHP** (diethylhexyl phthalate) is another plasticiser that has been of concern because it can migrate, and for that reason it is not used in food-related products in USA. It has been used as jar or bottle seals and lid inserts of bottles, spreads and juices and may be in printing ink for labels.

4.1 Bisphenol A

Bisphenol A is used primarily to make plastics, and products using bisphenol A-based plastics have been in commercial use since 1957 (Zheng *et al.*, 2007).

Polycarbonate plastic, which is clear and nearly shatter-proof, is used to make a variety of common products including baby and water bottles, sports equipment, medical and dental devices, dental fillings sealants, CDs and DVDs, household electronics, eyeglass lenses, foundry castings, and the lining of water pipes. BPA is also used in the synthesis of poly-salons and polyether ketones, as an antioxidant in some plasticizers, and as a polymerization inhibitor in PVC. Epoxy resins containing bisphenol-A are used as coatings on the inside of almost all food and beverage cans. However, due to BPA health concerns, in Japan epoxy coating was mostly replaced by PET film. Bisphenol A is also a precursor to the flame retardant tetrabromo-bisphenol A, and formerly was used as a fungicide.

4.1.1 Human Exposure Sources

The major human exposure route to BPA is diet, including ingestion of contaminated food and water. Bisphenol A is leached from the lining of food and beverage cans where it is used as an ingredient in the plastic used to protect the food from direct contact with the can. It is especially likely to leach from plastics when they are cleaned with harsh detergents or when they contain acidic or high-temperature liquids. BPA is used to form epoxy resin coating of water pipes; in older buildings, such resin coatings are used to avoid replacement of deteriorating pipes. There is limited evidence on inhalation exposure but the body of research on dermal absorption continues to grow. There are many uses of BPA for which related potential exposures have not been fully assessed including digital media, electrical and electronic equipment, automobiles, sports' safety equipment, electrical laminates for printed circuit boards, composites, paints, and adhesives.

In November 2009, the Consumer Reports magazine published an analysis of BPA content in some canned foods and beverages, where in specific cases the content of a single can of food could exceed the FDA "Cumulative Exposure Daily Intake" limit.

Consumer groups recommend that people wishing to lower their exposure to bisphenol A avoid canned food and polycarbonate plastic containers (which shares resin identification code 7 with many other plastics) unless the packaging indicates the plastic is bisphenol A-free. To avoid the possibility of BPA leaching into food or drink, the National Toxicology Panel recommends avoiding microwaving food in plastic containers, putting plastics in the dishwasher, or using harsh detergents.

4.1.2 Health Effects

The largest exposure humans have to BPA is by mouth from such sources as food packaging, the epoxy lining of metal food and beverage cans and plastic bottles.

- **Obesity:** Bisphenol A may increase the risk for obesity. Endocrine disruptors, like bisphenol A (a monomer of polycarbonate plastic), can distress neural circuits that regulate feeding behaviour, which has been proposed to increase the risk of obesity (John and Mike, 2012).

- **Neurological Effects:** BPA altered long-term potentiating the hippocampus and even nanomolar (10^{-9} mol) dosage could induce significant effects on memory processes (Nadal, 2013).

- **Disruption of the Dopaminergic System:** A 2008 review concluded that BPA mimics estrogenic activity and affects various dopaminergic processes to enhance mesolimbic dopamine activity resulting in hyperactivity, attention deficits, and a heightened sensitivity to drugs of abuse, (Wolstenholme *et al*., 2012).

- **Thyroid Function:** BPA is a thyroid-disrupting chemical, (Tanida *et al*., 2009) that may especially affect pregnant women, neonates and small children (Zoeller, 2007).

- **Cancer Research:** Bisphenol A may increase breast cancer risk (Recchia *et al.,* 2004).

- **Neuroblastoma:** BPA promotes the growth, invasiveness and metastasis of cells from a laboratory neuroblastomacancer cell line (LaPensee *et al.*, 2010; Zhu *et al*., 2009; Zhu *et al*., 2010).

- **Brain Tumors:** A Chinese human study linked BPA to noncancerous brain tumors. Those with higher urine BPA levels were about 1.6 times more likely to have meningioma compared to those with lower concentrations (Zheng *et al.,* 2007).

- **Reproductive System and Sexual Behaviour:** A 2009 study had shown exposure to BPA in the workplace was associated with self-reported adult male sexual dysfunction (Prins *et al.*, 2008).

4.2 Diethylhexyl Adipate or DEHA

Diethylhexyl adipate or DEHA is a plasticizer. DEHA is an ester of 2-ethylhexanol and adipic acid. Its chemical formula is $C_{22}H_{42}O_4$. DEHA is used as a plasticizer which is used primarily in food-contact wrapping. Occupational exposure to DEHA during manufacture is minimized through the use of good industrial hygiene practices which include personal protective equipment such as gloves and dust mask as appropriate. The World Health Organization has established an international drinking water guideline for di (2-ethylhexyl) adipate of 80 μg/L. The United States Environmental Protection Agency (1998) has set a maximum contaminant level (MCL) for di (2-ethylhexyl) adipate in drinking water of 0.4 mg/L.

DEHA can migrate from cling film wrappings to food. In general, higher levels of DEHA are found in food with high fat content (Harrison, 1988). Decreasing the storage temperature to 5°C inhibits the migration by 22%, and decreasing the temperature to -18°C inhibits the migration by up to 75%. Conversely, increasing the temperature to 50°C enhances the migration up to 400%. Microwave cooking of foods can also enhance migration. The extent to which high temperature enhances migration of DEHA into foods is dependent on the area in contact and the fat content of the food.

Estimates of total DEHA consumption are low with the MAFF reporting an estimated total consumption of 8.2 mg/person/day (117 μg/kg/day for a 70 kg person). Studies in humans indicate that this value may be an upper limit with a median exposure of 2.7 mg/person/day determined from a limited sampling (Loftus *et al*., 1994).

4.2.1 Effects on Human Health

- **Acute Toxicity**

  The effects of acute exposure to DEHA are summarized in the SIDS Profile. Oral treatment of rats with DEHA has not resulted in mortality or clinical signs of toxicity except at dose levels greater than the current 2000 mg/kg limit dose level (Smyth *et al*., 1951; Anonymous, 1976a). Data for acute inhalation exposure are limited, but available information shows no mortality to rats exposed to air saturated with DEHA for 8 hours (Smyth *et al*., 1951). Dermal exposure does not result in lethality or clinical signs of toxicity even at dose levels in excess of the current limit dose level of 2 000 mg/kg (Smyth *et al*., 1951). Dermal irritation following prolonged exposure (24 hours) was slight, but a shorter exposure period did not result in any signs of irritation (Smyth *et al*., 1951).

- **Repeated Dose Toxicity**

  DEHA has been evaluated for systemic toxicity in 14, 21, and 90 day oral feeding studies of rats and mice. Although none of the studies were conducted according to current testing guidelines, the information available suggests that repeated exposure of animals to DEHA (up to 90 days) resulted in reduced body weight gain for rats at dose levels of 6300 ppm in feed and higher, and for mice 3100 ppm in feed and higher (Anonymous, 1976b; Anonymous, 1980).

- **Mutagenicity**

  Geno-toxicity studies *in vitro* have been negative for mutations, unscheduled DNA synthesis, and DNA interaction. In addition, there was no evidence of mammalian cell mutation in mouse lymphoma assays conducted with and without metabolic activation. No chromatic exchange was observed in an SCE assay using Chinese hamster ovary cells with or without activation (Galloway *et al*., 1987), and there was no induction of unscheduled DNA synthesis in primary rat hepatocytes incubated with DEHA.

  In vivo studies for genotoxicity have also been negative for micronucleus and dominant-lethal assays. Two independent mouse micronucleus assays were conducted without evidence of interaction with DNA even at a dose level of 5 000 mg/kg (Shelby *et al*., 1993). In a dominant-lethal study using mice, DEHA did not demonstrate decreases in litter size that might suggest adverse effects on spermatogenesis (Singh *et al*., 1975).

4.3 Diethylhexyl Phthalate (DEHP)

DEHP is an organic compound with the formula C_6H_4 $(C_8H_{17}COO)_2$. DEHP is the most common of the class of phthalates which are used as plasticizers, accounting for an almost 54% market share in 2010 (Anonymous, 2011). It is the diester of phthalic acid and the branched-chain 2-ethylhexanol. This colourless viscous liquid is soluble in oil, but not in water. DEHP is a chemical. Plastic drink bottles, particularly water bottles, are generally made of polyethylene terephthalate (PET). Two of the chemicals used in making this kind of plastic, di-ethylexyl adipate (DEHA) and di-ethylhexyl phthalate (DEHP) have been rumoured to cause cancer but neither are classed as being carcinogenic (cancer causing) (Anonymous, 2012).

DEHP has been used as a plasticiser in medical devices such as intravenous tubing and bags, catheters, nasogastric tubes, dialysis bags and tubing, and blood bags and transfusion tubing, and air tubes. For this reason, concern has been expressed about leachates transported into the patient, especially for those requiring extensive infusions, e.g. new born in intensive care nursery settings, hemophiliacs, and kidney dialysis patients. According to the European Commission Scientific Committee on Health and Environmental Risks (SCHER), exposure to DEHP may exceed the tolerable daily intake in some specific population groups, namely people exposed through medical procedures such as kidney dialysis. The American Academy of Paediatrics has advocated not to use medical devices that can leach DEHP into patients and, instead, to resort to DEHP-free alternatives. In July 2002, the U.S. FDA issued a Public Health Notification on DEHP, stating in part, "We recommend considering such alternatives when these high-risk procedures are to be performed on male neonates, pregnant women who are carrying male fetuses, and peripubertal males" noting that the alternatives were to look for non-DEHP exposure solutions; they mention a database of alternatives (FDA, 2002).

4.3.1 Effect of Living Organisms

- **Obesity**

  A study on CDC data, published in *Environmental Health Perspectives* (EHP), "revealed that American men with abdominal obesity or insulin resistance (a precursor to diabetes) were more likely to have high levels of [DEHP and DBP] metabolites in their urine than men without those problems (Emily Main, 2007).

- **Cardio Toxicity**

  A clinically relevant dose and duration of exposure to DEHP has been shown to have a significant impact on the behavior of cardiac cells in culture. This includes an uncoupling effect that leads to irregular rhythms in vitro. This is observed in conjunction with a significant decrease in the amount of gap junctional connexin proteins in cardiomyocytes treated with DEHP (Gillum *et al.*, 2009).

5. Environmental Exposure

DEHP has a low vapor pressure, but the temperatures for processing PVC articles are often high, leading to release of elevated levels, raising concerns about health risks. It can be absorbed from food and water. Higher levels have been found in milk and cheese. It can also leach into a liquid that comes in contact with the plastic; it extracts faster into nonpolar solvents (e.g. oils and fats in foods packed in PVC). Food and Drug Administration (FDA) therefore permits use of DEHP-containing packaging only for foods that primarily contain water. The US EPA limits for DEHP in drinking water is 6 ppb. DEHP levels in some European samples of milk were found at 2000 times higher than the EPA Safe Drinking Water limits (12,000 ppb). Levels of DEHP in some European cheeses and creams were even higher, up to 200,000 ppb (Sharman *et al.*, 1994). The U.S. agency OSHA's limit for occupational exposure is 5 mg/m^3 of air.

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