ILSI-INDIA Monograph

Role Of Packaging In Ensuring Food Safety And Security

International Life Sciences Institute-India
India and South Asian Region

About ILSI-India

ILSI-India is a branch of International Life Sciences Institute (ILSI) with headquarters in Washington DC. It works on issue relating to food safety nutrition, toxicology, risk assessment, biotechnology and environment . It works very closely with industry, R&D organizations and government departments, Ministry of Health, Department of Biotechnology, Ministry of Science and Technology, Ministry of Agriculture and Ministry of Food Processing Industries.

ILSI-India carries out its mission through sponsoring workshops, conferences, seminars training programs and research. It also brings out publications and organizes educational programs. ILSI-India activities cover India and South Asian Region.

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- toxicology and risk science
- nutrition, health and well-being
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Preface

Food safety and security are promoted by innovative technologies in food processing and, what is equally important, is food packaging. In the whole chain from agricultural production, food processing, transportation and storage, quality and safety of food products are ensured by efficient packaging.

Food packaging is designed to protect the food product from contamination from micro-organisms, pests, chemicals etc. while maintaining the form, shape, texture and flavor of food. The choice of packaging is a strategic decision for the food industry. It is necessary to look at the properties of the packaging material, its suitability for the type of food to be packaged, consumer exposure and possible food-package interaction. These factors also determine the safety and shelf life of the product.

A number of packaging materials are used by food and beverage industry. The most common are paper and paperboard, glass, metals and plastics. Innovation is ceaseless and new packaging materials are developed to suit the needs of consumers and industry. They also need to be recyclable to avoid waste and pollution.

The most versatile and common packaging material currently being used is plastics. It includes a vast range of polymer based packaging materials. The most common are: PE, HDPE, PET,PVC, PS and PC.The choice of material depends on the application which can be bottles, containers, films or coatings.

Regulations have been laid down in different countries to regulate the use of packaging materials including plastics. Safety assessment of packaging materials is carried out. Data generated from systematic scientific studies form the backbone of regulations to ensure that they are safe for use in food packaging and they do not cause any health hazard to the consumer or lead to change in sensory property or composition of foods. The Food Safety and Standards Authority of India (Ministry of Health and Family Welfare), GOI regulates the use of packaging materials in India.

ILSI-India organized its second Conference on “Role of Packaging in Ensuring Food Safety and Security” in February 2017 to discuss: use of packaging materials for ensuring food safety as also ensuring food security, innovations in consumer packaging for different categories of food products and beverages, safety of packaging materials, national and international regulations on packaging, waste management and recycling and strategy for adoption of safe packaging for promoting food safety and food security and environment protection. This Monograph is based on the presentations made by – national and international experts and recommendations made during the deliberations as also additional scientific literatures referred by the authors. I am grateful to Mr. Ashish Bahuguna, Chairperson, FSSAI and Mr. Pawan Agarwal, CEO, FSSAI for gracing the Conference and sharing their views.

It is hoped that the Monograph will be useful in focusing attention on the indispensible role of packaging materials in promoting food safety and security, clear misconceptions surrounding their usage and motivate further research into packaging materials.

17th October 2017

D. H. Pai Panandiker
Chairman, ILSI-India

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A Conference on **"Role of Packaging in Ensuring Food Security and Safety"** was organized by ILSI-India on 27-28 February, 2017 in New Delhi. A number of national and international experts presented their views. ILSI-India appreciates their contribution as also the suggestions from experts who participated.

The Conference was addressed by: **Mr. Pawan Agarwal**, (*CEO, Food Safety & Standards Authority of India, New Delhi*); **Dr. Tanweer Alam**, (*Joint Director & Branch Head, Indian Institute of Packaging, New Delhi*); **Mr. Ashish Bahuguna**, (*Chairperson, Food Safety And Standard Authority Of India, (Ministry of Health & Family Welfare) GOI, New Delhi*); **Dr. Himanish Das,** (*General Manager- Innovation & Technology, MTR Foods Pvt Ltd., Bangalore*); **Prof. Alok Dhawan**, (*Director, Indian Institute for Toxicology Research, Lucknow*); **Mr. Jaideep Gokhale**, (*Communications Director, South Asia Markets & Regional Director for Marketing Communications, South Asia, East Asia & Oceania, Tetra Pak India Pvt. Ltd., Gurugram*); **Dr. V G Habbu**, (*Senior Vice President, Polyester Sector – Sustainability Assurance, Reliance Industries Ltd., Mumbai*); **Mr. Rajat Kedia**, (*Director - Exports, Manjushree Technopack Ltd., Bengaluru*); ***Mr. N M Kejriwal***, *(President, ILSI-India, New Delhi);* **Mr Kevin C. Kenny**, (*Chief Operating Officer, Decernis, Washington DC*); **Dr Ajit Kumar**, (*Vice Chancellor, National Institute of Food Technology, Entrepreneurship and Management, Haryana*); **Mr. Bimal Kumar Lakhotia**, (*AVP- Packaging Development & Commercialization, Hindustan Coca-Cola Beverages Pvt. Ltd., Gurgaon*); **Mr. V. Lakshmikumaran**, (*Managing Partner, Lakshmikumaran & Sridharan, New Delhi*); **Mr. Pravin Mallick**, (*Environment Director, Tetra Pak India Pvt. Ltd., Gurugram*); **Dr. Rajeshwar S Matche**, (*Sr. Principal Scientist & Head, Department of Food Packaging Technology, CFTRI, Mysore*);**Mr. Deepak Manchanda**, (*Guest Faculty, Indian Institute of Packaging, New Delhi*); **Dr. T S R Murali**, (*CRDO, Mother Dairy Fruit & Vegetable Pvt. Ltd., New Delhi*);**Dr.Shanmugam Nadanasabapathi**, (*Associate Director & Scientist G, Dept. of Food Engineering and Packaging Technology, Defence Food Research Laboratory, Mysore*); **Mr. D H Pai Panandiker**, (*Chairman, ILSI-India, New Delhi);* **Dr. V Prakash**, (*Distinguished Scientist, CSIR, Former Director, CFTRI, Mysore*); **Mr. Muthusubramanian Ramaiah**, (*Director – Sustainable Packaging, Hindustan Unilever Ltd., Bangalore*);**Mr. Amit Ray**, (*Executive Director, Packaging Division, Uflex Ltd., Noida*); **Dr. N C Saha**, (*Director, Indian Institute of Packaging, Mumbai*); **Mr. Sukhdev Saini**, (*Head – Packaging AMEA, General Mills India Pvt. Ltd., Mumbai*); **Mr. Vinay Saran**, (*Head Marketing Sub-Committee/Member Executive Committee, AIGMF and Sr. Vice President, HNG Inds. Ltd., Kolkata*); **Dr. S K Saxena**, (*Director, Export Inspection Council, GOI, New Delhi*); **Prof. P. K. Seth** (*NASI Senior Scientist Platinum Jubilee Fellow, Lucknow*); **Dr. V P Sharma**, (*Senior Principal Scientist - Developmental Toxicology, Indian Institute of Toxicology Research, Lucknow*); **Dr. Inder Jit Singh**, (*Additional Secretary, Department of Commerce, Ministry of Commerce and Industry, Government of India, New Delhi*); and **Mr. Saumya Tyagi**, (*Marketing Director, South Asia Markets, Tetra Pak India Pvt. Ltd., Gurgaon*).

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The Monograph includes essence of the presentations and discussions at the conference.

Abbreviations

S. No.	Abbreviations	Expanded Form
1.	As	Arsenic
2.	BIS	Bureau of Indian Standards
3.	BPA	Bisphenol A
4.	Cd	Cadmium
5.	Cr	Chromium
6.	DEHP	Di Ethyl Hexyl Phthalate
7.	EDCs	Endocrine Disrupting Chemicals
8.	EOE	Easy open ends
9.	EPR	Extended Producers Responsibility
10.	ESL	Extended Shelf Life
11.	EU	European Union
12.	FCMs	Food Contact Materials
13.	FSC	Forest Stewardship Council
14.	FSSAI	Food Safety and Standards Authority of India
15.	Hg	Mercury
16.	ISO	International Standards Organization
17.	JHOSPA	Japan Hygienic Olefin and Styrene Plastics Association
18.	LCA	Life Cycle Assessment
19.	MRP	Maximum Retail Price
20.	MSW	Municipal Solid Waste
21.	NGO	Non-Government Organisation
22.	NGT	National Green Tribunal
23.	NNPB	Narrow Neck Press and Blow
24.	OECD	The Organization for Economic Co-Operation and Development
25.	OML	Overall Migration Limit
26.	Pb	Lead
27.	PDP	Principal Display Panel
28.	PET	Polyethylene terephthalate
29.	PHA	Poly Hydroxyalkylanoates
30.	PLA	Poly Lactic Acid
31.	PTT	PolyTrimethylene Terephthalate
32.	PWM	Plastics Waste Management
33.	QM	Quantity Measurement
34.	Sb	Antimony
35.	SML	Specific Migration Limit
36.	SWM	Solid Waste Management
37.	USA	United States of America
38.	USD	United States Dollar
39.	USFDA	United States Food and Drug Administration

Introduction

Packaging is essential and critical for promoting food safety, extended shelf life and thereby enhancing food security. Foods whether fresh or processed are susceptible to spoilage. A package not only protects food but prevents tampering and meets special physical, chemical, physico-chemical, and biological safety needs of the product that is contained in the package. Adhering to the prescribed regulatory requirements for packaged foods is important. With globalization of food distribution networks ensuring safety of packaged foods assumes paramount significance. It is necessary to pay attention to packaging and packaging materials. Hence, the choice of packaging material and packaging technology are critical.

The two primary objectives of packaging are to:

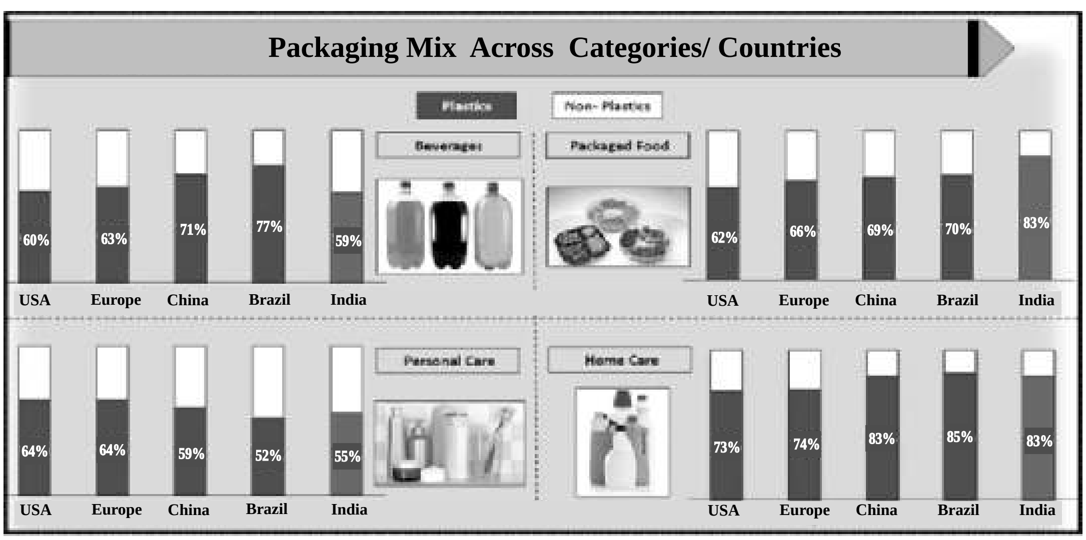
1) *Protect the contents from microbiological, chemical, physical, and atmospheric contamination and preserve the food and thereby protect consumer's health and*
2) *To inform the consumers about the contents of the products, nutrition facts, allergy alerts, date of manufacture and best before and MRP through label and help them in making informed choice.*

There have been many technological breakthroughs in recent years in food packaging. New packaging materials have been developed to ensure that they are:

- *Beneficial throughout the life cycle.*
- *Designed to meet market criteria for performance and cost.*
- *Manufactured using clean production technologies and best practices.*
- *Made from materials suitable in all possible end-of-life scenarios.*
- *Physically designed to optimize material and energy uses.*
- *Can be effectively recovered mechanically, biologically or as energy.*
- *Compliant to the packaging material disposal regulations prescribed from time to time all over the world.*

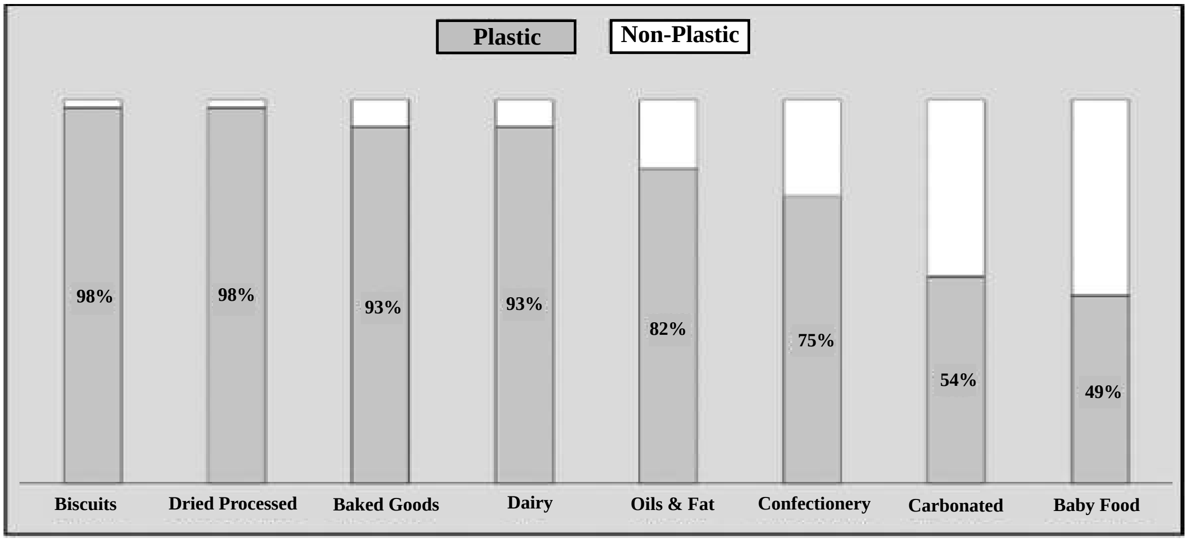
A variety of packaging materials are being used by food and beverage industry ranging from glass and metal to paper and plastics. Over the years there has been a shift in their usage and currently plastics have the largest share. The usage of different types of packaging materials in the country is well illustrated in the following figure.

Figure 1 a: Use of Food Packaging Materials Across Countries and Categories



Source: Presentation by Dr Vijay Habbu

Figure 1 b: Use of Food Packaging Materials in India



Source: Presentation by Dr Vijay Habbu

Irrespective of the myriad benefits of packaging a food product, it is important that attention is also paid to safety of packaging materials, carbon foot prints and impact on environment, waste management, as also recycling of packaging materials. With technological advancements it is possible to address these concerns. **Science based regulations / guidelines** are laid down to ensure compliance and protect public health and environment.

The changing lifestyle of consumers and greater demand for processed foods and beverages combined with availability of raw materials for processing, offer tremendous opportunity for development of food processing industries in the country. Food industry is coming up with innovative products which are healthier, minimise cooking time and have better shelf life. It is imperative that packaging industry supplements food industry's efforts by providing to them affordable and attractively designed packaging materials.

Higher incomes, changing lifestyles, demographic profiles, growing access to internet and increased use of smartphone apps have encouraged on-line purchases and provided flexibility in purchase time frames. The customer has no opportunity to touch, smell, see or feel the packaged product. Further, with the surge in online offers and e-commerce, today's busy consumer is bombarded with a whole range of competitive products round the clock, and throughout the year with just a few seconds to make an informed choice. Packaging will be the discerning factor to catch the customer's attention and ultimately the success of the product will be determined by packaging system. In such online purchases packaging serves as a silent salesman and assists in making decisions on buying a product. Smart packaging will also be an enabler for speedy clearance of purchases at exit points at supermarkets. Thus, innovative superior packaging is the need of the hour. Today's consumer is also willing to pay a higher price if the packaging is personalised and environmentally safe.

India is experiencing a youth bulge. Nearly two-thirds of Indians are under 35 and half are under 25. By 2020, India will be the youngest country in the world, with a median age of 29 years, compared with a median age of 37 years in China (India's Youth Challenge, the Editorial Board, and New York Times April 17, 2014). It will be quite challenging for the food industry to provide convenient, healthy and nutritious and safe processed food products to the large segment of young adults who are always on the go, work long hours and desire to accomplish speedy professional growth.

Packaging has evolved from an end-of-the-line activity to an end-of-the-line solution. It is an applied science with a judicious combination of art, science and technology to meet the needs of the markets.

Section -1
Need of Food Packaging

Well packaged foods and beverages not only help in ensuring food safety but they also extend the reach of supply chain with increased shelf life, and increased availability of foods for masses. R&D in packaging materials has provided various options for packaging foods and beverages and has helped in growth of food industry and trade by enhancing and extending food security.

Food Packaging specifically imparts following benefits:

1.1: Food Safety

Packaging can retard product deterioration, retain the beneficial effects of processing, extend shelf-life, and maintain or increase the quality and safety of food and beverages. In doing so, packaging provides protection from three major classes of external influences: chemical, biological and physical.

Chemical protection minimizes compositional changes triggered by environmental influences such as exposure to gases (typically oxygen), moisture (gain or loss), or light (visible, infrared, or ultraviolet). Many different packaging materials can provide a chemical barrier.

Biological protection provides a barrier to microorganisms (pathogens and spoiling agents), insects, rodents and other animals, thereby preventing disease and spoilage.

Physical protection shields food from mechanical damage and includes cushioning against the shock and vibration encountered during distribution.

1.2: Food Security

Providing food security to the world's growing population is of critical importance. About one third of all food produced for human consumption is lost or wasted, which is approximately USD 750 Billion and 3.3 G Tons of CO_2 equivalent annually. This is combined effect of losses due to poor practices in harvesting, storage, packing, transport, infrastructure or market / price mechanisms, as well as institutional and legal frameworks. Food losses represent a waste of resources used in production such as land, water, energy and inputs, and increase in the green gas emissions. Around 30% of available agricultural land is used to produce food that goes uneaten, which is equivalent to the size of China (FAO 2013).

Any assessment of food packaging’s impact on the environment must consider the positive benefits of reduced food waste throughout the supply chain. Packaging reduces waste by extending the shelf-life of foods, thereby prolonging their usability. It has been found that the per capita waste generated in Mexico City contained less packaging, more food waste, and one-third more total waste than generated in comparable U.S. cities (March K and Bugusu B (2007)).

1.3: Product Information

A package is the face of a product and often is the only product exposure consumers experience prior to purchase. In addition to branding, the labeling of food products is a mandatory legal and regulatory requirement for product identification, nutritional facts/values, ingredient declaration, net weight/content, name and address of manufacturer, batch details etc. Additionally, the package can convey important information about the product such as cooking instructions for preparation when needed, pricing, alerts and warnings.

1.4: Traceability

Traceability is the ability to follow the movement of a food through specified stage(s) of production, processing and distribution. It has three objectives: to improve supply management, to facilitate trace-back for food safety and quality purposes, and to differentiate and market foods with subtle or undetectable quality attributes. Food manufacturing companies incorporate unique codes, which allow them to track their products throughout the distribution process.

1.5: Convenience

Convenience features such as ease of access, handling, and disposal; product visibility; re-sealability and microwavability greatly influence package innovation. As a consequence, packaging minimizes the effort necessary to prepare and serve foods. Advances in food packaging have facilitated the development of modern retail formats that offer consumers the convenience of one-stop shopping.

1.6: Growing Needs of Rural Markets

A Harvard Business School Review, titled "Unlocking the Wealth of Rural Markets" indicates that rural markets are growing faster than ever in some of the largest emerging economies. Now here is this phenomenon more evident than in India. From 2009 to 2012, spending by India's 800+ million rural residents reached $69 billion, some 25% more than their urban counterparts spent over the same period. And projected growth rates are simply astounding: According to this Review, recent Nielsen estimates consumption in rural areas is growing at 1.5 times the rate in urban areas, and today's $12 billion consumer goods market in rural India is expected to hit $100 billion by 2025.What's more, rural Indians are trading up. Commodities are giving way to branded products, and more-expensive goods are replacing entry-level versions (Harvard Business School Review, June 2014 Issue).

It is here that the small packs are expected to become more popular. Mass communication through popular television channels and smart mobile phones has enabled the rural consumer to be updated and virtually visualise available packaged food products. Demand for smaller single serve/one-time use packs will increase. This will need to be supported by efficient supply chain practices (stacking, storage, distribution and tracking).

1.7: Tamper Evidence

Digital marketing, rural market, shelf stable packaging options, products innovations, analytics impacting products reputation are important factors which will influence production of processed foods and beverages. Packaging sector will need to evolve as per these trends by providing appropriate packaging materials and innovations in materials and systems needed by the processed food industries.

Food needs to be protected from physical, chemical, biological changes/spoilage to retain the beneficial effects of processing, extend shelf-life, and maintain or increase the quality and safety of food products. Modern consumers, whether in the cities/towns/rural areas within the country as well as globally, desire well protected, safe, nutritious, organoleptically acceptable food. Packaging is the means to fulfill all these needs as well as for convenience, tamper evidence and provide information about the product. Food packaging is here to stay.

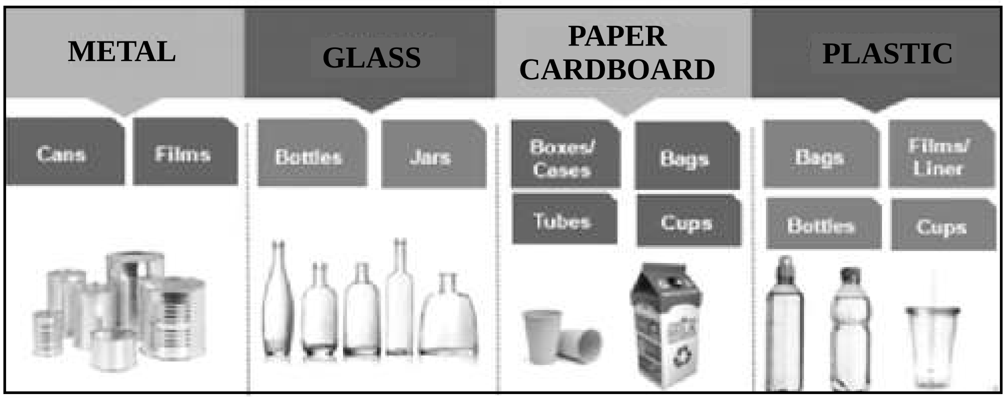
ABOVE ALL PACKAGING WILL NEED TO SUPPORT THE INITIATIVES TO REDUCE FOOD WASTAGE

Section 2

Packaging Materials and their Innovations for Food Packaging Applications

A wide range of packaging materials are available today. Initially glass and metals were being used for packaging food products. Today glass, paper, metals, aseptic packages, composites, and plastics are being used. Many new packaging solutions are in the offing including edible packaging material, biodegradable cellulose based packaging material.

Figure 2: Multiple Types of Food Packaging Material



Source: Presentation by Mr. Saumya Tyagi

2.1: Metal Packaging

Metal is a versatile packaging material. It offers a combination of excellent physical protection and barrier properties, form ability and decorative potential, recyclability and consumer acceptance. The two most predominantly used metal packaging materials are aluminium and steel.

New technology of using less metal and yet delivering the same safety and barrier has been developed.

INNOVATIONS

Recent innovations in the design and manufacture of metal packaging for food products include: large opening stay-on-tab ends for drink cans, widgets to provide a foam head to beer and chilled coffee, self-heating and self-chilling drink cans, full aperture food can ends which are easier to open, square section processed food cans for more efficient shelf storage, peel-able membrane ends for processed food cans, two-piece drawn and wall iron as well as two-piece drawn and redrawn cans made from steel with plastic extrusion coatings for safety during food contact.

Metal cans manufacturers have developed attractive shapes and attractive labels with graphic designs in printed Principal Display Panels for a product pack system. Kettle shaped, fluted surface, hour glass shaped for healthcare products, even microwaveable cans have been developed. The can bottle with closure in the beverage sector is a unique development by the metal can industry. Developments in printing have been applied to enable textured feel and unique modernized appearance.

2.2: Glass Packaging

Glass has an extremely long history in food packaging; the first glass objects for holding food are believed to have appeared around 3000 BC (Sacharow and Griffin 1980). The two main types of glass container used in food packaging are bottles, which have narrow necks, and jars and pots, which have wide openings.

The glass package has a modern profile with distinct advantages, including:

- *Quality perception, Transparency, Surface texture, Color, Decorative possibilities, Impermeability, Chemical integrity, Design potential, Heat processable, Microwaveable, Tamper evident, Ease of opening, UV protection, Strength, Hygiene Aesthetic appeal, Product visibility and associated appetite appeal, Resealability, highly recyclable resulting in environmental benefits. Returnable glass bottles may be reused multiple times.*
- *Option to use a wide range of decorative formats such as unique colors, frosting newer labeling format.*
- *Retention of product identities, as glass is an inert material with regard to its application to packaged food.*

INNOVATIONS

Some of the world's most prestigious products are packaged in glass.

One of the important innovations has been development of Ultra-Light Weight NNPB (Narrow Neck Press and Blow) Glass Bottles. NNPB allows the glass containers to be about 25% lighter and thinner, retaining the original strength and at the same time significantly reducing production costs and making the glass container cheaper.

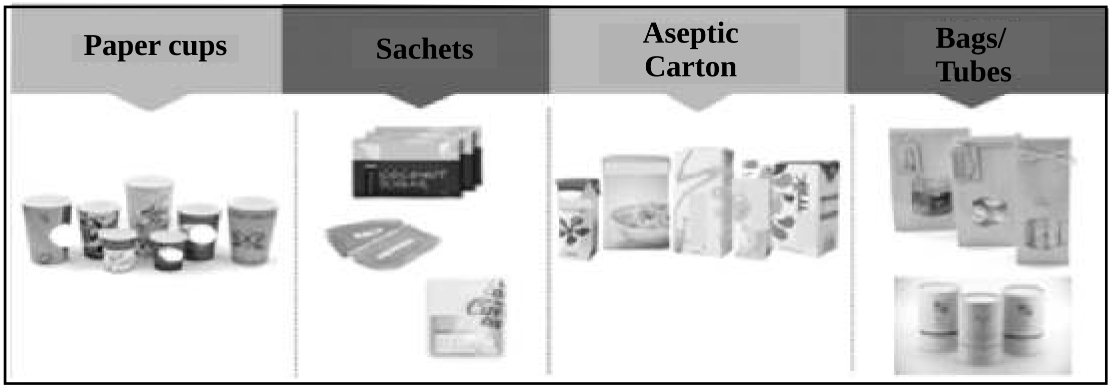
An innovation which also doubles up as an anti-counterfeit solution is the debossed bottle with unique debossed design features inside the body of the bottle which are difficult to replicate. The design is heat-pressed into the surface of the bottle, creating a depressed (or indented) image.The molds for such features are very expensive hence require large scales operations to be cost effective. Another unique innovation is the spiral path on the inside of the neck of the bottle which enables higher foaming of the product on exit from the container. Another evolution is in the ring -pull feature in the closure for ease and speedy opening of the glass container.

2.3: Paper, Paperboard and Paper Based Packaging

A wide range of paper, paperboard and paper based packaging is used in packaging today. Recyclability, flexibility, printability and mechanical resistance are the major attributes of paper based packaging.

Paper and paperboards are used for packaging a wide range of products: from thin tissues to thick boards. The different types of paper and paper based packaging include : paper bags, wrapping, packaging papers and infusible tissues, e.g. tea and coffee bags, sachets, pouches, over wrapping paper, sugar and flour bags, carrier bags, multiwall paper sacks, folding cartons and rigid boxes, corrugated and solid fiberboard boxes (shipping cases), paper based tubes, tubs and composite containers, fiber drums, liquid packaging, molded pulp containers, labels, sealing tapes, cushioning materials, cap liners (sealing wads) and diaphragms (membranes).

Figure 3: Types of Paper based Packaging



Source: Presentation by Mr. Saumya Tyagi

INNOVATIONS

Paper based packaging innovations include: Bio based Box and Plantable Packaging. Speciality coatings on the surface of paper helps in making the paper water-proof, when used in box making it increases stack stability and wet strength of the paper and subsequently of the box. Paperboard with Hexagonal corrugations, a relatively new development, is applicable for use in making heavy duty pallets as replacements for wooden pallets with associated advantages.

2.4: Plastics in Food Packaging

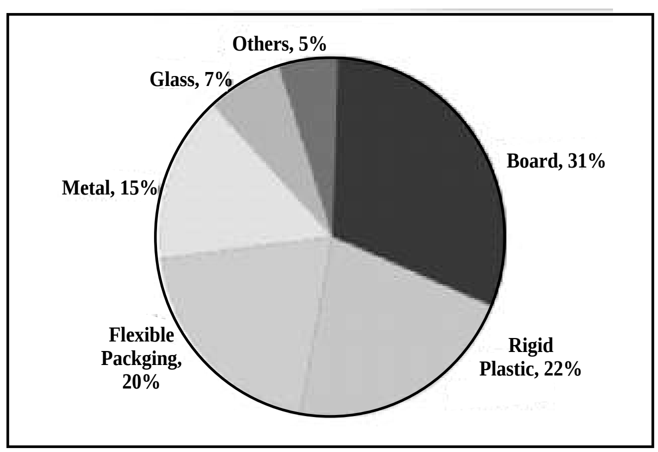
Plastics are materials made up of wide range of synthetic or semi-synthetic organic compounds that can be molded into solid objects of diverse shapes. Plastics materials are widely used for food and beverages packaging. The major advantage is their bio-inertness, resistance to corrosion and stability under acidic or alkaline condition.

Plastic also have:

- *Adaptability- can be easily molded in any shapes.*
- *Versatility- offers endless packaging option i.e. pouches, bottles, blisters, flow wraps, containers, films, trays, shells, drums.*
- *Provide protection to the product over the desired shelf life cycle of the product.*
- *They are cost effective in meeting market needs.*
- *They are lightweight.*
- *They provide choices in respect of transparency, color, heat sealing, heat resistance and barrier properties as needed.*
- *Plastics are commonly and frequently recycled.*

Plastics have properties of strength and toughness. The selection of plastic material used for packaging of food products and beverages depends on method of processing and product characteristics, specific requirements for packing, distribution and storage, product usage and consumer's needs. An illustration of different types of plastic packaging materials used for packaging and their share is given in the figure –4.

Figure 4: Share of Different Plastic Packaging Materials by Use



Source: Presentation by Dr V G Habbu

orts, Analysis by Tata Strategic

Plastics are used as containers, container components and flexible packaging. In usage, by weight, they are the second most widely used type of packaging and first in terms of value.

INNOVATIONS

R&D has led to introduction of many innovations in packaging materials and ancillaries. Some major innovations are:

- ***In-mold Labeling:*** This label application during plastic manufacturing reduces weight.
- ***Intelligent Packaging:*** Absorbs oxygen, odors and CO_2 retaining freshness and nutrition.
- ***Compostable Bio-based Plastics:*** Undergo decomposition under composting conditions in industrial facilities. They are made from biomass/avocado seeds, they degrade naturally. Some commercial examples include: Poly Lactic Acid (PLA), Poly Hydroxyalkylanoates (PHA), PolyTrimethylene Terephthalate (Bio PTT). These account for 40% energy savings in production vis-à-vis their petrochemical counterparts.
- ***Eco-friendly "Plant Bottle":*** This is a new packaging that looks and feels the same as traditional petroleum based plastic bottles; the main difference is that it is a more environment friendly, renewable plant-based manufacturing process. Natural sugars found in plants are used the ingredients for making PET [a form of polyester] plastic bottles.

2.5: Aseptic Packaging

Aseptic packaging is very well accepted in food service applications worldwide as a safe and high-quality packaging option. Aseptic processing sterilizes food products by destroying the harmful bacteria and pathogenic micro-organisms through a tightly controlled thermal process and combines the sterile product with the sterile packaging material in a sterile environment. The end result is a shelf-stable product requiring no refrigeration. Paper based packaging including aseptic packaging is gaining popularity due to their easy storage, handling and transportation. They also help to curb counterfeiting and sale of fake products. Paper-based aseptic cartons have the added significant benefit of maximum protection for an extended period without the need for refrigeration or preservatives. Further they protect the contents and:

- *They promote food safety (meets / exceeds local and international regulations).*
- *They promote environmental safety (no leaching of packaging into the environment; fully recyclable; FSC paperboard; packaging that has amongst the lowest environmental footprint).*
- *They are logistics/storage/transport friendly: one-way packaging, lightweight, easily stackable, durable etc.*
- *They are consumer / user-friendly: tamper-evident, safe to handle by children, safe to handle by waste pickers, easy to store, easy to consume.*
- *They are Information-carrier for consumers: have design capabilities, enable use of printing technologies, have wide surface area for providing information.*

Generally to achieve all required properties, aseptic packages incorporate more than one material in the structure that is assembled by lamination or co-extrusion process. The use of plastics in the innermost layer of aseptic packaging significantly increases the non-refrigerated shelf life and availability of many perishable products.

INNOVATIONS

Ergonomically stable pack design is seen in the aseptic package called the carton bottle. This combines the easy handling with one hand and pouring of a bottle with the environmental advantages of a carton. Carton bottles are used for fluid products such as ambient milk, enriched and flavored milk, toddler milk and dairy alternatives such as soy, almond and oat milk. This is a user-friendly pack for children and senior citizens overcoming their difficulty in handling rectangular aseptic cartons using both hands to avoid spillage during dispensation into a glass. This is ideal for value added products. The carton bottle package structure combines the body of a liquid carton with the top of a plastic bottle.

2.6: Ancillary Packaging Materials

Ancillary packaging materials include caps and closures, labels, leaflets, adhesives, adhesive tapes, straps, pins, printing inks etc. In the case of adhesives and printing inks these are prepared in accordance to recipe proportion of various constituent ingredients. It is important to check these materials for migration of undesired components into the product.

It is critical to assess the suitability of all packaging materials for their safety and performance on the packaging machinery and during transportation and storage.

A plethora of packaging materials are available today. In the case of food packaging, a judicious scientific selection of packaging material is essential to meet the needs of the markets and the consuming populations. Initially glass and metals were being used for packaging food products. Today glass, paper, metals, aseptic packages, composite packaging materials, and plastics are being used. Innovations in packaging materials, container designs, convenience features enable unique product presentations with desired shelf life. Many new packaging solutions are in the offing including edible packaging material and biodegradable cellulose based packaging material.

Section 3

Safety Assessment of Packaging Materials

3.1: Need for Safety Assessment

Various packaging materials are used to pack different foods. They offer foods excellent protection against various hazards. However, the packaging materials themselves can affect food safety. This can happen because of various reasons such as migration of residual chemicals, insufficient barrier properties, packaging failure and loss of seal integrity.

In order to give packaging materials the desired functional properties for protection of foods - from factors such as against oxygen, impart moisture barrier properties and ensure their machinability on manufacturing lines - different additives, coatings and other chemicals are used during manufacturing.

Movement of chemical constituents from packaging material is possible. This movement is called Migration. Factors like diffusion coefficient, molecular weight of migrants is equally important. These substances may bring in change in organoleptic quality or safety of food. Factors responsible could also be concentration of the additives, type of plastic material, type of food product, type of ingredients, period of contact, temperature, thickness of the material, volume of solvents and type of exposure.

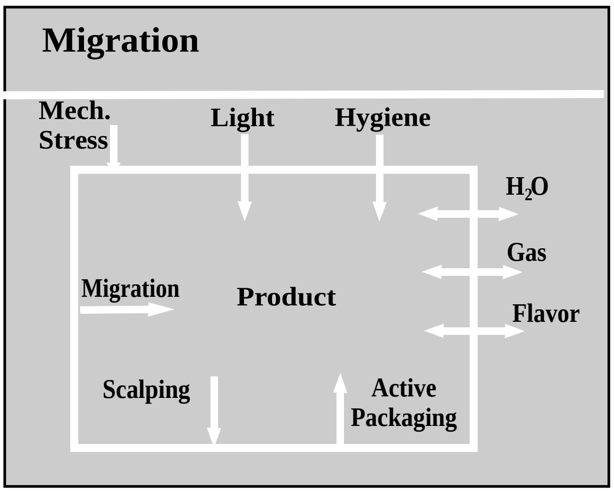
Following is the brief information on the various packing materials and various chemicals used in their manufacturing which can cause risk to their use if proper care is not taken:

- **Plastic polymers** of various compositions can fulfil many of these functions in a more or less acceptable way. A major drawback of plastic food packaging materials is that they require additives to acquire certain properties required for their function. These include plasticisers, antioxidants, light protectants, colors to generate the intended appearance of the package, printing inks to apply written and graphic information. Furthermore, the nature of the polymerization process makes it unavoidable that these materials contain residues of mono- and oligomers of the starting material(s) as well as additives required for the polymerization and maturation process.
- **Paper and cardboard** is another important group of packaging materials used for foods. These materials mainly originate from wood, which is treated in various ways. The manufacturing process of these materials may require the use of a broad spectrum of chemicals. These include preservatives to protect from microorganisms, plastic polymer coatings to improve the normally weak barrier function of paper, printing inks and colors, UV protectants, and chemicals used for the pulp and paper production itself. Because of porous nature of these packaging materials, aqueous or oily liquids (from the food) may have access to the body of the material eventually extracting those chemicals. The use of recycled paper and cardboard for the production of packaging materials is another problematic issue because of chemicals already present in the recycled materials.
- **Metal** is the third large group of food packaging materials. In this case iron-based can bodies are in use and they usually have to be coated inside with polymers to avoid direct contact with the food. Corrosion by high-salt or acidic food items is a major issue, coating with polymers avoids direct contact between food and metals. Aluminium cans have to be coated with

polymers as well, since aluminium also is a corrosion-prone metal and gets unstable when it comes into contact with many foods.

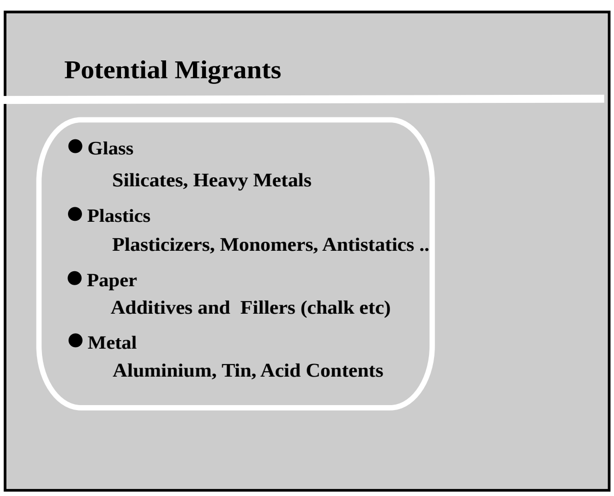
- **Glass** is another widely used well known food packing material which is made from natural materials. Contrary to all other food packing materials glass does not require any plastic layer to protect the food. Also barring few heavy metals, no constituents from glass are known to migrate into the food.

Figure 5 a: Factors Responsible for Migration



Source: Presentation by Mr. Rajeshwar S Matche

Figure 5 b: Potential Migrants



Source: Presentation by Mr. Rajeshwar S Matche

The foregoing discussion underlines that it is absolutely necessary to carry out safety evaluation of packaging materials and ensure their safe use

This will ensure the following:

- *Streamline proper and safe use*
- *Safeguard human health.*
- *Avoid unacceptable change in the composition the food.*
- *Inhibit deterioration in the organoleptic characteristics thereof.*
- *Prevent migration (leaching) of unacceptable level of contents from packaging into the product.*

3.2: Safety Assessment of Packaging Materials and Ancillary Materials

It will be important to understand how safety assessment of food packaging materials is carried out in systematic and scientific manner which will help in selection of proper packaging materials for packaging food and beverages including water.

Standards of different countries provide the regulatory requirements for protection of consumer against inadmissible chemical contamination from food contact materials. **Although "all" the packaging materials may have issues of migration of different chemicals, the focus is on plastics because of their increasing applications in food packaging.**

Further, it is also important that ancillary materials be selected with care based on material of the container and the packaged contents. Some of the considerations are the intended usage conditions, dimensional stability, heat resistance, environmental stress, product characteristics, compatibility etc. For example: same printing ink system may be safe for use on food packaging or unsuitable for food packaging depending on -– type of the packaging material it is printed on, the printing conditions, the food that is packed with the printed packaging and the manufacturing conditions during the packaging manufacturing and filling.

Human exposure to packaging materials and/or their components occurs from migration into foods. Protection against migration of ingredients/components of packaging material/ ancillary material into food product is one of the most important aspects of ensuring safety of food product that is packaged. Therefore, risk assessment of packaging materials themselves in a scientific manner is important for food safety.

Various countries and regions have framed their own guidelines/regulations. In India, Bureau of Indian Standards (BIS) has developed standards for primary packaging materials.

The migration studies are carried out by use of "Simulants". Simulants are solvents used for migration studies which are closer in nature of food and pH of food. These tests are known as Global Migration Tests.

Figure 6: Simulants used for Migration Studies as per BIS India

No	Food Category	Food Simulant
A	Non acid (pH > 5.0)	Water
B	Acidic (pH <= 5.0)	3% Acetic acid
C1	Alcoholic beverages < 10%	10% Ethanol
C2	Alcoholic beverages > 10%	50 % Ethanol
D	Oils and fats, aqueous and non-aqueous with free oil or fat including water in oil emulsions	n-Heptane

BIS has also specified actual examples about which foods to be classified and studied with what stimulant. For example: foods like skimmed milk or honey could be having A as simulant, Beer as C1, whisky C2 or vegetable oils D. Foods like butter could have simulant A and D.

Similarly all other country regulations have their own list of simulants for the scientific studies of migration. In order to get very clear logical idea about food migrants, even time and temperature for these studies are specified.

The objective of food packaging safety assessment is to protect the consumer by controlling the contamination of food by chemicals transferred from the packaging materials. Following migration limits are commonly considered:

- ***OML for all leachates (migrants) from the plastic as the first quality measure; and***
- ***SML for each leachate, based on its hazardous properties.***

Overall migration limit (OML) is a sum total of all leachates and is assessed for a particular plastic under the intended use conditions. The specific migration limit (SML) on the other hand, are set based on a risk assessment, taking into account the estimated dietary exposure and toxicological properties of individual leachates. Compliance with OML and SMLs is mandatory for regulatory approval. In India FSSAI prescribes the BIS standards for packaging materials in food contact.

BIS standards have specific migration limits enlisted in individual standards; however there is a scope to conduct systematic studies to confirm these conclusions.

Analytical methods have been developed to check the migration levels. These limits can be brought into effect either by controlling migration from packaging into food or by setting a limit for the concentration of the substance in the plastic, compositional limits, commonly known as quantity measurement (QM).

OML is minimum requirement or hygiene factor for any packaging material. However the regulations also specify that the material in contact with food should not cause health hazard, should not change the composition or sensory characteristics of the food.

3.3: Case Study on Polyethylene Terephthalate (PET) Safety

An analysis of global regulations demonstrates that PET is universally permitted for specified food contact applications.

Of late concerns are raised about migration of contaminants from PET plastic packaging under high temperatures and management of packaging waste. However, it must be noted that a number of studies have been conducted by national and international agencies to address issues raised regarding safety of PET and today PET packaging has continued to enjoy the confidence of regulators and consumers across the world.

Some of key facts regarding PET packaging are are given as follows:

- *PET does not contain Heavy metals (like As, Cd, Cr, Hg, Pb); Phthalates (e.g. DEHP) and Bisphenol-A.*
- I*n India PET for food packaging application is well regulated and PET packaging manufacturer and user industry needs to comply with various FSSAI-BIS standards such as IS: 12252-1987 (2016), IS 12229-1987 (2005), IS 9845-1998 (2010) and IS 9833-1998 (2016) related to plastic materials and articles intended to come into contact with food.*
- *PET does not contain any hazardous chemicals and is not carcinogenic.*
- *PET is very well established as safe packaging material for foods and pharmaceuticals by national and international regulatory bodies.*

3.3.1: Misconceptions and Facts about PET Packaging Materials

It is important that awareness be created about correct status of PET so that the consumers, industry, government, NGOs and other stakeholders are well informed about the safety and benefits of PET packaging material. The major misconceptions and facts are given below:

PET contains Heavy Metals

- **FACT:** The fact is PET does not need Arsenic (As), Cadmium (Cd), Chromium (Cr), Mercury (Hg), Lead (Pb) or any other heavy metals except Antimony (Sb) at any stage of its manufacture. In fact, the presence of these heavy metals is counter-productive as it produces haze in product. Hence, they are not used in the PET manufacturing process.

PET leaches Antimony

- **FACT:** Antimony is used as a catalyst in the PET manufacturing process. It is used in trace amounts and is fixed in the PET matrix. As for migration at high temperature, modelling studies even at temperatures as high as150°C, have established that leaching of antimony is well within permissible limits.

PET contains DEHP and other Phthalates

- **FACT:** These chemicals are not needed nor generated in PET manufacturing, hence these are not present in PET. Other than similarity in their names, phthalates and polyethylene terephthalate do not have anything in common.

Unsafe Colorants are used in PET

- **FACT:** Colours in PET bottles are used in accordance with BIS standard IS 9833 which contains positive list of colorants that can be used as colorants in plastics for contact with foodstuffs, pharmaceuticals, drinking waters etc.

PET contains Bisphenol-A (BPA)

- **FACT:** PET chemistry does not involve BPA. BPA is a constituent of Polycarbonate, which is different plastic than PET. PET is always BPA-free.

PET contains Endocrine Disruptors and Oestrogenic Chemicals

- **FACT:** Endocrine Disrupting chemicals (EDCs) are neither used nor generated in the PET manufacture. PET is not listed in US-EPA's EDCs screening programme.

PET is not Recyclable

- **FACT:** In India all PET bottles/containers are commonly recycled into products such as garments, upholstery, strappings or furnishings. Internationally, wherever commercially viable, used-PET bottles are also recycled back into bottles/ containers meant for food packaging applications.

3.4: Regulation Overview

Globally many different regulatory bodies have developed frameworks. e.g. in USA, the USFDA has developed framework regarding Food Contact Materials (FCMs). In the EU, regulations for packaging material are developed in consultation with European Food Safety Authority.

In India regulatory framework for food packaging is developed by Food Safety and Standards Authority of India (FSSAI) under Ministry of Health and Family Welfare. However many standards used by packaging industry come from Bureau of Indian Standards (BIS) which is a voluntary standard making body under Ministry of Consumer Affairs. FSSAI has adopted key BIS standards for packaging materials making them mandatory. Thus it can be stated that collectively BIS and FSSAI have developed packaging framework which governs use of food packaging in India.

3.4.1: Indian Regulations

Food Safety and Standards Authority of India (FSSAI)

Currently FSSAI governs the use of food packaging through "Food Safety Standards (Packaging and Labelling) regulations 2011." This covers general requirements and few IS standards for plastics and polymers. It also covers few specific products such as Milk and Milk products, Edible oil/ fat, Fruits and vegetables, Canned meat and Packaged drinking water.

FSSAI is now drafting an exclusive regulation called Food Safety Standards (Packaging) Regulations 2017 which takes good care of food safety vs packaging. It has given lot of clarity with regards to safe use of food packaging. It lays down that packaging materials have to be of food grade quality. The draft rules prohibit use of certain materials such as rusty metal containers, copper or brass which are not properly tinned. It prohibits reuse of tin container. The draft lays down overall migration limits of 60mg/kg with no visible migration for plastic packaging materials . Detailed information on product category and the packaging materials which can be used is also given.

Bureau of Indian Standards has various standards. These are included in *Appendix - 1*.

3.4.2: International Regulations

Select regulations which are referenced widely are:

- **USA**

  21 CFR 174: General Indirect Food Additives

  21 CFR 175: Adhesives and Components of Coatings

  21 CFR 176: Paper and Paperboard Components

  21 CFR 177: Indirect Food Additives: Polymers

- **European Union**
  - Regulation (EU) 1934/2004 on materials and articles intended to come into contact with food
  - Regulation (EU) 10/2011 Plastics Regulation (as amended)
- **Japan**
  - Food Sanitation Law, 1947
  - 30 Basic Polymers Covered by JHOSPA

When compared with global regulations, Indian regulations *stand at par* with global regulations and are evolving further. For example in recent revision of BIS standard IS 12252: Polyalkylene terephthalates (PET and PBT), their copolymers and list of constituents in raw materials and end products for their safe use in contact with foodstuffs and pharmaceuticals (first revision) OML of 60mg/L or 10mg/dm^2 and SMLs for 9 substances have been set bringing standard at par with global standards.

List of Countires Permitting PET is given in ***Appendix - 2***

All the packaging materials used for food packaging are regulated in each country by different regulations. These regulations are based on the data generated from systematic scientific studies to ensure that they are safe for use in Food packaging and they do not cause any health hazard to the consumer or lead to change in sensory property or composition of Foods.

Section 4

Waste Management and Recycling

4.1: Waste Management

India faces major environmental challenges associated with waste generation and inadequate waste collection, transport, treatment and disposal. Current systems in India cannot cope with the volumes of waste generated by an increasing urban population, and this has impact on the environment and public health. Solid waste management (SWM) is a major problem for many urban local bodies in India, where urbanization, industrialization and economic growth have resulted in increased municipal solid waste (MSW) generation per person.

The advances in the field of packaging have played a key role in ensuring food safety and security across globe. Right packaging ensures that food is supplied to consumers in a safe manner. However, it is crucial that packaging materials are managed in an environmental friendly way. Over the years developments which benefitted human society are also responsible for some of the challenges that society is facing. Food packaging has also contributed to generating waste.

With the increased importance / relevance of packaging, there is a need for adopting sustainable waste disposal mechanisms. The regulatory authorities across the globe are facing and dealing with the challenging task of handling, segregation and disposal of packaging material post consumption in a safe and environmentally sustainable manner.

4.1.1: Indian Regulations

Waste Management rules in India include: Environment (Protection) Act 1986, E-waste (Management) Rules, Bio-Medical Waste Management Rules, Construction and Demolition Waste Management Rules, Hazardous and other Wastes (Management and Trans boundary Movement) Rules, Plastic Waste Management Rules and Solid Waste Management Rules.

Of these, the Solid Waste Management Rules 2016 are the comprehensive rules that cover all packaging waste such as tin, glass, plastics packaging, etc.

The Plastic Waste Management Rules 2016 mandates "Extended Producer's Responsibility" (EPR) for producers and prescribes to phase out non-recyclable multi-layered plastic in two years' time. The Solid Waste Management Rules 2016 have mandated the source segregation of waste in order to channelize the waste to wealth by recovery, reuse and recycle. Waste generators must segregate waste into three streams- Biodegradables, Dry (Plastic, Paper, Metal, Wood, etc.) and Domestic Hazardous waste (diapers, napkins, mosquito repellents, cleaning agents etc.) before handing it over to the collector.

The solid Waste Management Rules 2016 also proposes that a Central Monitoring Committee under the chairmanship of Secretary, Ministry of Environment Forest and Climate Change be constituted to monitor the overall implementation of the rules. The Committee comprising of various stakeholders from the Central Government and State Governments will meet once a year to monitor the implementation of these rules.

While rules and regulations are made, right strategies to implement them are a prerequisite for effective waste management. Private and public partnership complemented with consumer education is most desirable way forward; right approaches will generate heightened social and environmental consciousness, right regulations on pollutants and right way of management of municipal solid waste (MSW) which are keys to achieve effective waste management.

4.1.2: Extended Producer Responsibility (EPR) as an Environmental Policy Approach

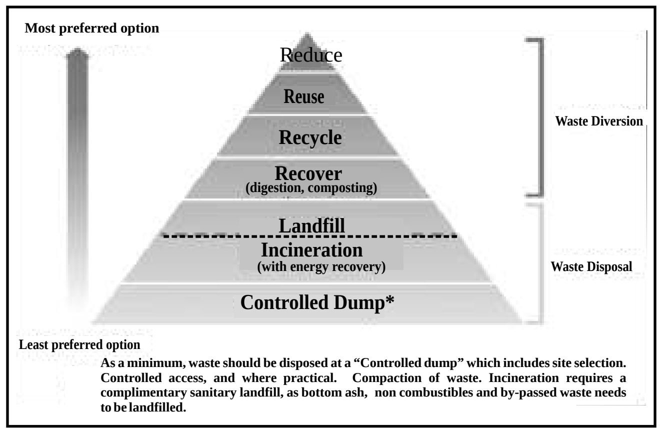
EPR as an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle and has been practiced in many countries, particularly OECD countries, for more than two decades now. **The Plastic Waste Management Rules 2016** and the **Solid Waste Management Rules 2016** in India have mandated EPR for packaging waste in India. However, its implementation in present form has its own set of challenges and opportunities. This is because despite legislations, waste is not segregated at source. There is consumer apathy to waste segregation and there is no support system for collection of segregated waste. Municipalities and formal service providers can thus neither provide collection service to all house-holds, nor guarantee an effective recycling and an environmentally sound treatment or disposal of wastes. Recycling largely relies on informal waste pickers, who are unorganised and extremely scattered. Some of the pre-requisites that need to be considered for adopting EPR policies in India are as follows:

1. *Municipalities separately collect recyclables from households.*
2. *EPR policies apply to all consumer packaging types without exception.*
3. *The costs assigned to producers are directly proportional to what they can influence and control.*
4. *It is based on solutions tested with pilot programs.*

4.1.3: Waste Management Strategies

The waste management sector follows a generally accepted hierarchy. The hierarchy responds to financial, environmental, social and management considerations. The hierarchy also encourages minimization of Green House Gas emissions. This is typically depicted in the diagram below.

Figure 7: Waste Management Hierarchy



Source: World Bank, What A Waste: A Global Review of Solid Waste Management

1. **Waste Reduction:** Waste or source reduction initiatives (including prevention, minimization, and reuse) seek to reduce the quantity of waste at generation points by redesigning products or changing patterns of production and consumption.

2. **Recycling and Materials Recovery:** The key advantages of recycling and recovery are reduced quantities of disposed waste and the return of materials to the economy. In many developing countries, informal waste pickers at collection points and disposal sites recover a significant portion of discards.

3. **Aerobic Composting and Anaerobic Digestion:** Composting with windrows or enclosed vessels is intended to be an aerobic (with oxygen) operation that avoids the formation of methane associated with anaerobic conditions (without oxygen). When using an anaerobic digestion process, organic waste is treated in an enclosed vessel.

4. **Incineration:** Incineration of waste (with energy recovery) can reduce the volume of disposed waste by up to 90%. These high-volume reductions are seen only in waste streams with very high amounts of packaging materials, paper, cardboard, plastics and horticultural waste. Recovering the energy value embedded in waste prior to final disposal is considered preferable to direct land filling — assuming pollution control requirements and costs are adequately addressed.

5. **Landfill:** The waste or residue from other processes should be sent to a disposal site. Landfills are a common final disposal site for waste and should be engineered and operated to protect the environment and public health

In India, returnable, refillable and reusable in glass packing existed in practice for Government Milk Supply Schemes in cities like Mumbai and same is also used for soft drinks. However such practices are now getting discontinued with advancement of use of plastic containers.

Globally, returnable, refillable and reusable plastic products are currently in use in some countries e.g. in Sweden, PET drinks bottles are returnable. Plastic pallets, plastic trays and plastic boxes (totes) used in distribution are returnable and reusable. Further development of this concept will reduce the amount of plastic in the waste stream.

Efforts are needed to prevent the accumulation of thin gauge plastics in the sea. Researchers have demonstrated that these plastics are transferred in the marine food web. They may account for the majority of marine micro litter accumulating in the food chain.

Other regulatory bodies across globe are working towards overall reduction of waste generation. There is an opportunity to learn from such approaches and adopt right strategies.

4.2: Life Cycle Analysis

Packaging has to create value for the consumers and business. At the same time it should be sustainable, eco-friendly, affordable and should preserve the product safely for the declared period of time. The end to end evaluation of impact to planet is very critical and hence lifecycle approach has to be adopted.

4.2.1: Life-cycle Assessment (LCA)

It is also known as life-cycle analysis, eco-balance, and cradle-to-grave analysis. LCA is a technique to assess environmental impacts associated with all the stages of a product's life from raw material through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. Designers use this process to help critique their products. LCAs can help avoid a narrow outlook on environmental concerns by:

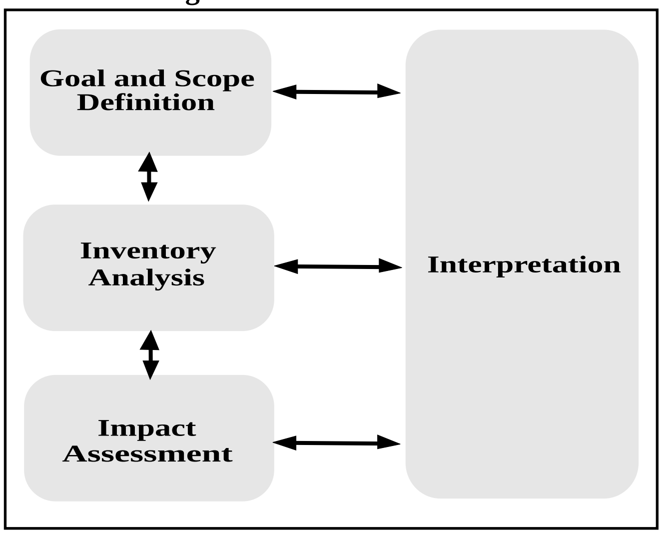
- *Compiling an inventory of relevant energy and material inputs and environmental releases.*
- *Evaluating the potential impacts associated with identified inputs and releases.*
- *Interpreting the results to help make a more informed decision.*

The goal of LCA is to compare the full range of environmental effects assignable to products and services by quantifying all inputs and outputs of material flows and assessing how these material flows affect the environment. This information is used to improve processes, support policy and provide a sound basis for informed decisions.

4.2.2: ISO 14040 and LCA

The procedures of life cycle assessment (LCA) are part of the ISO 140000 environmental management standards: in ISO 14040:2006 and 14044:2006. (ISO 14044 replaced earlier versions of ISO 14041 to ISO 14043.). This standard provides systematic study of LCA and suggests following four main phases.

Figure 8: Phases in ISO 14040



Source: Introduction to Life Cycle Assessment and International Standard ISO, LCA Module A1. 14040. 2015, Liv Haselbach, Quinn Langfitt

I. Goal and Scope

An LCA starts with an explicit statement of the goal and scope of the study, which sets out the context of the study and explains how and to whom the results are to be communicated.

Goal will include: intended use, reasons for study, and audience.

Scope will include: product systems, functions of system, system boundaries, procedures, impact categories, assessment methods, data requirement, assumptions, limitations and quality requirements.

II. Life Cycle Inventory (LCI)

LCI involves collection of input and output collected. This will include inputs of water, energy, and raw materials, and releases to air, land, and water.

III. Impact Assessment

This is conversion of inventory data into environmental impact potentials. This phase of LCA is aimed at evaluating the significance of potential environmental impacts based on the LCI flow results. Classical life cycle impact assessment (LCIA) consists of the following mandatory elements:

- *Selection of impact categories, category indicators, and characterization models*
- *Classification into stage, where the inventory parameters are sorted and assigned to specific impact categories; and*
- *Impact measurement, where the categorized LCI flows is characterized, using one of many possible LCIA methodologies, into common equivalence units that are then summed to provide an overall impact category total.*

IV. Interpretation

This is continually ongoing during assessment to help guide other phases. Discussion of inventory analysis and impact assessment results in LCA study. This can be modeled as conclusions and recommendations to the decision maker. This should be consistent with and based on goal and scope of the study.

4.2.3: LCA and Plastics Recycling

Plastics are ubiquitous materials in all advanced societies. Because of their advantageous characteristics they have contributed decisively to improving the standard of living of the societies. Use of plastics as food packaging materials certainly offer distinct advantages like low weight, offering protection to the products against oxygen, water vapor, insects and increasing the shelf life.

However, they are perceived to have objectionable impact on the environment.

In such a situation, tools such as LCA and economic analysis can be effectively used to assist in that decision. The existing literature on LCA of plastic waste management is vast and the results reported are generally consistent, showing that recycling generates the lowest global warming potential and total energy use environmental impacts. On the other hand, the economic literature addressing only the MSW plastic fraction is scarce. Furthermore, several methodologies were used to perform the economic analyses, some limited only to financial costs; only a few studies included externalities (external costs).

Future Scope: Hence, while the LCA methodology seems to be well established in plastic waste management systems, efforts have still to be made to implement an economic assessment methodology, as well as the corresponding standard methods. In spite of that, the present work allows the conclusion that existing assessment tools may effectively assist in establishing a plastic waste prevention and management hierarchy, as mandated by the Waste Framework Directive.

4.3: Recycling

Recycling means the processing of used materials or waste into new product. Effective legislation sets the foundation for recycling. However, recycling has to be a shared responsibility among all stake holders i.e. consumers, government and the private sector. Collective aim should be that eventually all materials get recovered/recycled.

Recycling diverts materials from the waste stream to material recovery. Unlike reuse, which involves using a returned product in its original form, recycling involves reprocessing material into new products. A typical recycling program entails collection, sorting and processing, manufacturing, and sale of recycled materials and products. Almost all packaging materials (glass, metal, thermoplastic, paper, and paperboard) are technically recyclable, but economics favors easily identified materials such as glass, metal, high-density polyethylene, and polyethylene terephthalate. The various benefits of recycling are as follows:

- ***Recycling helps to conserve natural resources*** *such as oil, metal and water. For example plastic bottles can be recycled into new plastic bottles and polyester fibers for use in fleece jumpers and car mats.*
- ***Recycling saves energy.*** *Recycling aluminium saves 95% of the energy required to produce aluminium from raw materials. Recycling just one plastic bottle will save enough energy to power a 60 watt light bulb for 3 hours!*
- ***Recycling protects the environment.*** *Recycling helps to conserve energy, so less greenhouse gases are emitted. Recycling reduces our dependence on landfill. With less materials going to landfill, less harmful emissions like methane gas are released into the earth's atmosphere.*
- ***Recycling can save money.*** *By putting more recyclable materials into recycling bin both time and money is saved.*

A closed-loop recycling for packaging plastics is also supported by public pressure. The manufacturers and users of packaging need to take responsibility for their packaging materials and environmental concerns. There are three types of plastics recycling operations:

1) *Primary recycling (e.g., industrial scrap).*
2) *Secondary recycling (e.g., physical reprocessing, such as grinding, melting, reforming).*
3) *Tertiary recycling (or regeneration of purified starting materials, such as by methanolysis or glycolysis).*

Recycling also has its impact on the quality of recycled material across range of materials such as recycled paper (shortening of fibers), glass (reused as opaque or colored bottles), metal (recycled aluminium cannot used for foil manufacturing), and plastic (change in physical properties). Hence the recycled materials are analysed for the composition of raw materials, food contact ingredients and migration test to ensure its safety and quality for reuse.

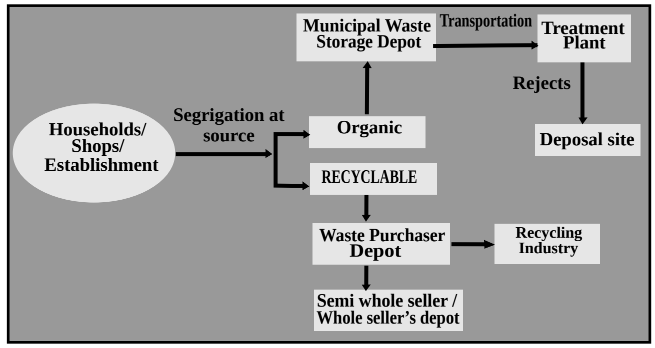
Plastics are materials made of a wide range of synthetic or semi-synthetic organics that can be moulded into solid objects of diverse shapes. Value chain for PET recycling already exists and country has enough capacity for recycling of PET. Recycled Polyester Fibre (r-PSF), Recycled Yarn, T-shirt, blankets etc. can be made using plastic waste.

4.3.1 Recycling of Plastics

It is a prime area for innovation and sustainability. In India, there are 3500 organized and 4000 unorganized plastic recycling units. Most plastics (PET, PE, PVC, PP, and PS) are recycled via mechanical route. Recycling of plastics ~3.6 MnTPA, provides employment to ~ 1.6 million people (0.6 million directly, 1 million indirectly).

Inertness of the polymer is the basic parameter which determines the possibility for closed-loop recycling of packaging plastics. The inertness of common packaging polymers decreases in the following sequence: Poly (ethylene naphthalate) (PEN), poly (ethylene terephthalate) (PET), rigid poly (vinyl chloride) (PVC) > polystyrene (PS) > high density polyethylene (HDPE), polypropylene (PP) > low density polyethylene (LDPE).

Figure 9: Recycling Steps in India



Source: Presentation by Dr. S N Sabapathi

Cooperation and active participation of all stakeholders is required to bring a change in the approach towards waste management, recycling and environment protection. While the government can make rules, industry, consumers and NGOs have to be equal partners with shared responsibilities.

Some of the industries have initiated laudable measures towards waste collection, management and recycling. These can be emulated by others. One of the large manufacturers of aseptic packaging cartons has taken the following steps:

- *Created awareness in scrap dealers, waste pickers, institutional and commercial waste dealers about non degradable and bio-degradable wastes as also differences in packaging materials such as paper and cartons through workshops and street plays.*
- *Set-up collection centres with the Indian Army and organized daily collections of Milk cartons given to army jawans from these collection centres.*
- *Established a network of small waste dealers and large waste dealers for collections of aseptic cartons.*
- *Sensitised consumers about the responsible behaviour. For example, aseptic carton recycling*

program has been launched in schools as a part of engaging consumers. The program is running successfully. It is called "Cartons Le Aao, Classroom Banao" (Bring cartons and Build classrooms). Such cartons are used for making furniture for the classrooms.

- *In Mumbai "Dabbawalas" (caterers) have been involved in collection of used cartons to bring them to the company.*

NGOs can also help in waste segregation and recycling. An NGO has been conducting schemes in association with various organizations including industry and newspapers for segregation of wet and dry waste at consumers' level. This scheme is called "Doh Bin" (Two Bins).This scheme is helpful in promoting recycling and making sure that the garbage sent for landfill is already separated making it easier to process the garbage.

4.3.2: Polyethylene Terephthalate (PET) Recycling

PET is 100% recyclable. In most countries PET bottles are approved for continual reuse. Regulations in 70+ countries also permit or require PET recycling and post-consumer polyethylene terephthalate (PET) products. The list of recycling rate is given in ***Appendix - 3***. Only few countries, other than India, do not permit recycled PET in food contact or pharmaceutical applications.

Post-consumer polyethylene terephthalate (PET) applications include:, Sleep Products, Automotive Products, Clothing Products, Fabrics and Fibers, Plastic Straps, Construction Products, Mattresses, Medical and Pharmaceutical Products, Plastic Blends and Composites.

PET is most recycled plastic globally. It is 100% recyclable. Globally PET recycling is doubling every 2-3 years. Capacity in some countries (US, China) is growing faster than collection rates. Deposit/Return systems is 2.5 times more than collection.

Extended producer responsibility (EPR) is required in 46 countries. It is designed to promote the integration of environmental costs associated with goods throughout their life cycles into the market price of the products.EPR uses financial incentives to encourage manufacturers to design environmentally friendly products by holding producers responsible for the costs of managing their products at end of life.

4.3.3: Recycling of Aseptic Packaging (Beverage Cartons)

Aseptic cartons have a unique environmental attribute – they are the only commonly found liquid food packaging system made primarily from a natural, renewable resource - wood. In general cartons are composed of the following 3 materials:

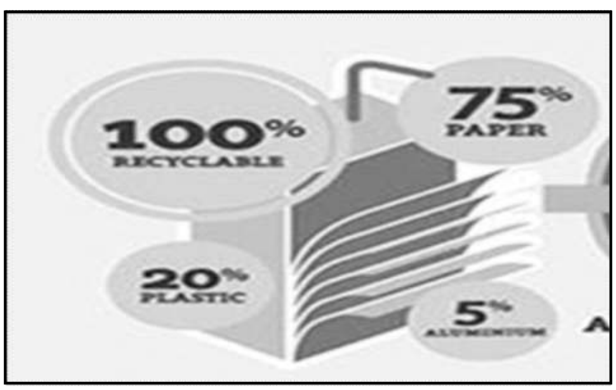
- **Paperboard:** The main ingredient in the aseptic packages is paperboard which constitutes roughly 75% by weight of the carton. It uses just enough paperboard to make the package stable, without adding unnecessary weight
- **Polyethylene:** Thin layers of polyethylene - a commonly used plastic- are added to seal in the liquid and protect the product from external moisture
- **Aluminum:** Packages designed to store food without refrigeration also contain a thin layer of aluminum foil. This protects the product from oxygen, flavors and light

The different layers of the aseptic carton – paper board, polyethylene and aluminum – can all be recycled using relatively simple techniques and turned into new products. Recycling means that less waste is sent to landfill and reduces demand for resources.

Hydra-pulping is a process in which used aseptic cartons can be easily re-pulped (no chemical and no high temperature is required) i.e. the paperboard is separated from the carton's plastic and aluminum layers. Pulp is recovered, enabling the high-quality paper fiber to be used for new paper (board) products. While the recycled paperboard is not used for manufacturing new aseptic cartons, it finds great uses in other applications- e.g. kraft paper, board and products like egg trays, paper bags etc.

The plastic and aluminum recovered after re-pulping can be processed to produce products such as roof tiles, extrusion based granules etc. The market for roofing sheets has grown significantly as they benefit consumers immensely because of its strength and ability to insulate against heat. The plastic and aluminum can also be extruded to form granules that are useful for injection molding/ roto-molding based applications. as roof tiles, extrusion based granules etc. The market for roofing sheets has grown significantly as they benefit consumers immensely because of its strength and ability to insulate against heat. The plastic and aluminum can also be extruded to form granules that are useful for injection molding/ roto- molding based applications.

Figure 10: Recycling of Aseptic Packaging



Source: Presentation by Mr. Pravin Mallick & Mr. Jaideep Gokhale

4.4: Sustainability of Plastic Packaging

Sustainable plastic is defined as the packaging material which will meet the needs or requirements today without damaging or making any harmful effect to the next generation of tomorrow. Hence most countries and communities are largely concerned with using sustainable packaging.

Following characteristics of plastics make them cost efficient and environment friendly:

- *They are lightweight, which lowers transportation costs and fuel emissions.*
- *They are strong, so product damage and loss can easily be avoided.*
- *They are easy to recycle, meaning new products can be created over and over.*

Plastics have a very good environmental profile. Only 4% of the world's oil production is used for plastics and much less energy is used to produce it compared to other materials. When plastics have completed their use phase they can either be recycled or if this is not economic or environmentally beneficial the calorific value of the plastic can be recovered through energy from waste, incineration to provide a much source of home-grown power.

And yet plastics have a bad reputation when it comes to sustainability. The main cause of this situation is that these are not bio degradable. There is no proper waste disposal system and the concept of Reduce, Reuse, Recycleis not properly followed in developing countries. This may be result of inabilities of Municipalities to segregate the waste at source, also apathy and lack of awareness of consumers towards proper waste disposal.

In India the Environment Ministry is working towards addressing certain health and environmental concerns.

Packaging and Food industry R & D teams also have role to play. This could be by means trying to reduce the use by development of minimum packaging by giving maximum shelf life or by innovative packaging solutions.

Following actions can be initiated towards proper disposal, reuse, recycling of packaging which will help to make plastic packaging sustainable:

- Industry should clearly mention on packaging label as to how to dispose of packaging materials depending on whether they are biodegradable, non-degradable and recyclable as is the practice in countries like Japan. This will not only promote safe packaging but will also address waste management issue.
- Developed countries like US and Europe permit recycling of bottle for use by food industry. However, lack of infrastructure has prevented adoption of this environment friendly and cost effective strategy in India. Recycling of bottles should be allowed.
- A model system of collection and segregation of packaging waste should be built on the basis of type of packaging. Matching reuse/recycle technology/infrastructure should be developed / adopted.
- A program should be undertaken for educating citizen / students about different packaging materials, their responsible use and disposal as also misuse by consumer of empty containers (oil in drinking water bottles).
- Self-help groups like "Stree Mukti Sanghatana" (NGO working for women empowerment) are doing notable work for this cause. They are conducting programmes like Parisar Vikas (Surroundings development) since 1998. Under this programme "Waste Pickers" who are generally women from lower income group are trained about waste segregation. These groups then create awareness cooperative housing societies and help them to segregate the waste so that it could be reused and recycled.

Such initiatives give very positive picture, hope and confidence that plastics can be used as sustainable and useful means for packaging of foods by collaborated efforts by Government, Industry, NGOs and Consumers.

Managing waste is very critical in the interest of environment protection and public health in modern life. This is true in countries like India as well as in the global scenario. Therefore the regulations are becoming stricter for the systematic waste management. The success is certain because of growing Government/ Public participations for such programs. Concepts of "Reduce, Resuse, Recycle" are fast catching up. This has enabled to reduce effects of waste reduction in general and for plastic packaging materials in particular. All these efforts will ensure the sustainability of plastics as packaging materials.

Section 5
Conclusions and Recommendations

It is imperative that due attention is given to ensure that materials used for packaging processed foods and beverages should be safe and free from contaminants to:

- Safeguard the consumer's health.
- Ensure food and nutrition security.
- Optimize usage by keeping appropriate combination of packaging and its contents.
- Minimize packaging waste by reduce, reuse &recycle.
- Protect environment.

Actions should be initiated in the following specific areas:

5.1: Packaging Systems

- Packaging system should be selected to ensure safety and quality of its contents.
- While developing new packaging, approaches to reduce packaging materials, selection of environmentally friendly packaging materials (such as compostable, recyclable) should be considered.
- Labelling instructions for consumers indicating method of disposal can be helpful.
- Strategies such as incentive on returning waste, Private Public Partnerships should be considered.
- All of the above steps will collectively help in reducing carbon foot print on environment. While doing so, manufacturers must maintain integrity of packaging and ensure that safe food is delivered from farm to fork.

5.2: Standards/Guidelines Development

- **Science Based Standards**
  - In India various standards have been already laid down by different Ministries/ Departments on specific aspects relating to packaging. Food Safety and Standards Authority India (FSSAI) has adopted Bureau of Indian Standards (BIS) standards regarding packaging materials.
  - BIS standards have established safety of packaging in terms of contaminants (Overall Migration and Specific Migration) and should be revised based on safety considerations and global developments.
  - Scope of current standards related to packaging materials can be extended to ancillary packaging material and packaging materials used by food service institutions such as catering, canteens, restaurants and QSRs (quick service restaurants).
  - While deciding on contaminants, it is important to ensure availability of validated analytical methods and should be considered during the stage of formulation of these standards.
- **Good Regulatory Practices**
  Many countries are following "GOOD REGULATORY PRACTICES". This ensures that the once regulations are drafted they are analysed from the point of view of implementation and benefits. India should also follow "GOOD REGULATORY PRACTICES".

- **Recycling**
  Developed countries like US and Europe permit use of bottles made from recycled plastics by food industry. However, lack of infrastructure has prevented adoption of this environment friendly and cost effective strategy in India. This could be achieved by changing regulations for reuse as well as development of model systems for collection and reuse.

- **Packaging Materials Indications**
  PET and other packaging should be mandatorily stamped with the "Food-Safe" symbol as approved by FSSAI.

- **Scientific Panel on Safety of Packaging Material**
  A scientific panel should be formed to deal with safety issues related with food contact packaging material.

5.3: R&D in Packaging Materials

- Ways of increasing R&D expenditure in India towards better processes and new packaging materials need to be found.

- Central Government and State Governments should instruct research institutes and manufacturers to carry out R&D to find solutions to non-recyclable packaging materials.

- Research is required towards minimising the use of packaging material while maintaining food safety intact.

5.4: Capacity Building

- There is a need to give attention to capacity building for implementation of state of art Quality Management System.

- Innovative and smart centres should be developed with private-public partnerships for capacity building.

5.5: Waste Management / Recycling

- This is one area which has great scope for improvement. Participation by local Government bodies as well as public (who are end users) will be very effective in dealing with waste management / recycling.

- A model system of collection and segregation of packaging waste should be built on the basis of type of packaging. A matching reuse /recycle technology /infrastructure should be developed / adopted. All stakeholders including Government, Industry (Producer and User industry), NGOs, Households, Educational and Research Institutes should be involved in this endeavour.

- A programm should be undertaken for educating citizens/students about different packaging materials, their responsible use and disposal as well as potential misuse by consumer of empty containers (e.g. storing of oil in drinking water bottles).

- Use of plastic waste materials must be promoted. E.g. it can be used in building roads or fabricating building materials.

5.6: Use of LCA Studies

- Use of scientific tools like LCA studies need to be promoted as this will help in building awareness on actual environmental impact of any packaging material by “Cradle to Grave” or even “Cradle to Cradle” approach as also for making responsible choices of packaging materials.

- Guidelines should be laid down for conducting LCA studies.

- LCA studies should include eco-footprint too, so that the usage of land and the vegetation to produce the food packaging materials is accounted for.

- The density of the packaging material should also be included in the LCA studies so that the quantity of various packaging materials needed to package the same amount of contents is accounted for.

5.7: Sustainability of Plastics as Food Packaging Materials

Implementation of strategy of "Reduce, Reuse, Recycle" for plastic packaging material by Government with public participation and creating awareness of the distinct advantages of the strategy is very important. This will improve the utilisation of plastics which have numerous advantages for food packaging.

5.8: Meeting the Needs of the Youth and Evolving Lifestyles of Consumers

Innovative superior packaging is required to meet the requirements of the consumers in the country especially the youth-both in urban and rural areas-for meeting their requirements of innovative food product which are healthier, minimise cooking time and have better shelf life yet enable purchases through internet and e-commerce.

5.9: ILSI-India

As an independent science based organization ILSI-India should periodically discuss issues related to food packaging to review food safety standards in the light of developments in science and technology.

Appendix 1

BIS Standards for Food Packaging Materials

- IS 8639 (1977): Code for evaluation of the effect of packaging and storage on the sensory qualities of foods and beverages
- IS 9843 (1991): Code of practice for use of adhesives for packaging
- IS 10106 Part 1 Section 1(1990): Packaging code: Part 1 Product packaging,Section 1 Foodstuffs and perishables
- IS 15495 (2004): Printing Ink for food packaging - Code of practice

NON-PLASTICS:

- IS 21 specification for Wrought Aluminium and Aluminium Alloy for utensils*
- IS 1107 (1986): Glass bottles crown finish for Aerated water
- IS 1392 (1999): Glass bottles for Milk
- IS 1662 (1974): Glass bottles for Liquor
- IS 1994 (1987): Metal Crown Closures Specification
- IS 2091 (1983): Glass Bottles for Beer Mulitrip
- IS 2771 (1990): CFB Boxes 1 General Requirement
- IS 3728 (1985): Wooden boxes for packaging of apples
- IS 7162 (1973): Waxed cartons for packaging of ice cream
- IS 8113 (1976): Primary cartons for packaging butter
- IS 8971 (1978): Paper aluminium foil laminates for general packaging
- IS 9313 (2009): Corrugated fibreboard boxes for the export packaging of glass jars and bottles filled with processed foods
- IS 10402 (1982): Pin-needle hardboard boxes for packaging of apples
- IS 11844 (1987): Corrugated fibreboard boxes for transport packaging of apples
- IS 12212 (1987): Corrugated fibreboard boxes for transport packaging of butter packed in primary cartons
- IS 13228 (2006): CFB Boxes for Packing & Transportation
- IS 14407 (1996): Aluminium Cans for Beverages
- IS 14636 (1998): Flexible Packaging Materials for Packaging of Edible Oils, Ghee and Vanaspati
- IS 15410 (2003): Containers for Packaging of Natural Mineral Water and Packaged Drinking Water

GENERAL PLASTICS:

- IS 9833 (2016): List of colorants for use in plastic in contact with foodstuffs and pharmaceuticals (second revision)
- IS 9845 (1998): Determination of Overall Migration of constituents of Plastics Materials and Articles intended to come in contact with Foodstuffs – Method of Analysis
- IS 10171 (2010): Guide on suitability of plastics for food packaging
- IS 14534 (2016): Guidelines for recycling of plastics

PET:

- IS 12229 (2013): Positive list of constituents of polyalkylene terephthalates (PET and PBT) for their safe use in contact with foodstuffs, pharmaceutical and drinking water
- IS 12252 (2016): Polyalkylene terephthalates (PET and PBT), their copolymers and list of constituents in raw materials and end products for their safe use in contact with foodstuffs and pharmaceuticals (first revision)*
- IS 12887 (1989): Polyethylene Terephthalate (PET) Bottles for Packaging of Edible Oils
- IS 14537 (1998): Polyethylene Terephthalate (PET) Bottles for Packaging of Alcoholic Liquors
- IS 14764 (2000): Polyethylene Terephthalate (PET) Containers for Packaging of Vanaspati

PLASTICS OTHER THAN PET:

- IS 2058 (1984): Low Density Polyethylene Films
- IS 9907 (1981): High Density Poly-ethylene (HDPE) Crates for 500-ml Glass Milk Bottles
- IS10142 (1999): Polystyrene (crystal and high impact) for its safe use in contact with foodstuffs, pharmaceuticals and drinking water*
- IS 10146 (1982): Polyethylene for its safe use in contact with foodstuffs, pharmaceuticals and drinking water*
- IS 10151 (1982): Polyvinylchloride (PVC) and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water*
- IS 10840 (1994): Blow Moulded HDPE Containers for Packing of Vanaspati
- IS 10910 (1984): Polypropylene and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water*
- IS 11434 (1985): Ionomers resins for its safe use in contact with foodstuffs, pharmaceuticals and drinking water*
- IS11704 (1986): Ethylene/ acrylic acid (EAA) copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water*
- IS 11805 (2007): Polyethylene Pouches for Packaging Liquid Milk
- IS 12229 (2013): Positive list of constituents of polyalkylene terephthalates (PET and PBT) for their safe use in contact with foodstuffs, pharmaceutical and drinking waterIS12247 (1988): Nylon 6 polymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water*
- IS13601 (1993): Ethylene Vinyl Acetate (EVA) copolymers for their safe use in contact with foodstuffs, pharmaceuticals and drinking water*
- IS13576 (1992): Ethylene Metha Acrylic Acid (EMAA) copolymers and terpolymers for their safe use in contact with foodstuffs, pharmaceuticals and drinking water*
- IS 14129 (1994): Flexible Packaging Materials for the Packing of Vanaspati in 10 kg and 15 kg Packs
- IS 14500 (1998): Linear Low Density Polyethylene (LLDPE) Films
- IS 14995 (2001): Stretch Cling Films
- IS 15473 (2004): Blow Moulded HDPE Containers for Packaging of Edible Oils
- IS 15532 (2005): Plastics Crates for Fruits and Vegetables

Appendix 2

Countries Permitting PET:
(Positive List or Incorporation by Reference)

COUNTRY	INCORPORATES
Albania	
Algeria	
Argentina	Mercosur
Armenia	Eurasian Economic Union
Aruba (Netherlands)	European Union
Australia	European Union/United States
Austria	European Union
Azores (Portugal)	European Union
Bahrain	GCC/GSO
Belarus	Eurasian Economic Union
Belgium	European Union
Bermuda	European Union/United States
Bolivia	Mercosur
Bosnia-Herzegovina	
Brazil	Mercosur
British Virgin Islands (UK)	European Union
Bulgaria	European Union
Canada	
China	
Colombia	
Croatia	European Union
Cyprus	European Union
Czech Republic	European Union
Denmark	European Union
Dominican Republic	
Ecuador	
Egypt	
Estonia	European Union
Fiji	
Finland	European Union
France	European Union
French Guiana (France)	European Union
French Polynesia (France)	European Union
Germany	European Union
Greece	European Union
Grenada	European Union
Guadeloupe (France)	
Guam	United States
Guatemala	
Guyana	European Union/United States
Hong Kong	
Hungary	European Union
Iceland	
India	
Indonesia	
Iran	
Ireland	European Union
Israel	
Italy	European Union
Japan	
Korea	
Kuwait	GCC/GSO

COUNTRY	INCORPORATES
Kuwait	GCC/GSO
Kazakhstan	Eurasian Economic Union
Korea	
Kyrgyzstan	Eurasian Economic Union
Latvia	European Union
Lithuania	European Union
Luxembourg	European Union
Madeira (Portugal)	European Union
Malaysia	
Malta	European Union
Marshall Islands	United States
Martinique (France)	European Union
Mayotte (France)	European Union
Mexico	United States
Netherlands	European Union
New Caledonia (France)	European Union
New Zealand	European Union/United States
Norway	
Oman	GCC/GSO
Palestine	
Paraguay	Mercosur
Peru	
Philippines	Japan/United States
Poland	European Union
Portugal	European Union
Puerto Rico	United States
Qatar	GCC/GSO
Réunion (France)	European Union
Romania	European Union
Russia	Eurasian Economic Union
Russia	
Saint Lucia	United States
Saint Martin (France)	European Union
Saudi Arabia	GCC/GSO
Seychelles	
Slovakia	European Union
Slovenia	European Union
South Africa	European Union/ United States
Spain	European Union
Sri Lanka	
Sweden	European Union
Switzerland	
Taiwan	
Thailand	
Turkey	
United Arab Emirates	GCC/GSO
United Kingdom	European Union
United States	
Uruguay	Mercosur
US Virgin Islands	United States
Venezuela	Mercosur
Yemen	GCC/GSO

Source: Presentation by Kevin C. Kenny

Appendix 3

Recycling PET: Country Legislation & Recycling Rates

COUNTRY	PET BOTTLE RECYCLING RATE
Argentina	30%
Aruba (Netherlands)	59%
Australia (deposit)	30%
Austria (deposit)	70%
Azores (Portugal)	
Bahrain	10%
Belgium	81%
Beliz	
Bolivia	
Brazil	52%
British Virgin Islands (UK)	59%
Bulgaria	59%
Canada (deposit)	70%
China	90%
Colombia	
Costa Rica	
Croatia (deposit)	59%
Cyprus	56%
Czech Republic	70%
Denmark (deposit)	59%
Dominican Republic	
Ecuador (deposit)	112%
Egypt	20%
Estonia (deposit)	59%
Faroe Islands (deposit)	
Fiji (deposit)	
Finland (deposit)	59%
France	67%
French Guiana (France)	
French Polynesia (France)	
Germany (Deposit)	94%
Greece	59%
Guadeloupe (France)	
Hong Kong	30%
Hungary	50%
Iceland	42%
India	80%
Ireland	71%
Israel (deposit)	61%
Italy	58%
Japan	72%
Korea	49%
Kuwait	10%
Latvia	59%
Lithuania (deposit)	59%
Luxembourg	59%
Madeira (Portugal)	
Malaysia	13%
Malt	38%
Martinique (France)	
Mayotte (France)	
Mexico (Voluntary)	35%
Netherlands (deposit)	71%
New Caledonia (France)	
Norway (deposit)	83%
Oman	10%
Paraguay	
Poland	59%
Portugal	59%
Qatar	10%
Réunion (France)	
Romania	59%
Saint Martin (France)	
Saudi Arabia	10%
Singapore	60%
Slovenia	69%
South Africa (Voluntary)	45%
Spain	71%
Sweden (Deposit)	85%
Switzerland	81%
Taiwan	73%
Thailand	29%
United Arab Emirates	10%
United Kingdom	61%
United States (some deposit)	30%

Source: Presentation by Kevin C. Kenny

Appendix 4

4.1 Ranking of Various Films with Respect to Specified Properties

Polymer	Water vapour transmission rate	Gas permeability	Optics	Machine performance	Sealing
LDPE	3	4	4	4	1
Cast PP	3	4	2	4	2
OPP	2	2	2	2	2
OPP coated	1	1	1	2	1
PET	2	2	1	1	4
PVC (Plasticised)	3	2	2	4	2

1 = Excellent, 2 = Very Good, 3 = Good, 4 = Poor

4.2 General Gas and Moisture Barrier Properties of Flexible Films

Film (25 ì m thickness)	Water vapour transmission rate (WVTR)	Oxygen transmission rate
LDPE	10–20	6500–8500
HDPE	7–10	1600–2000
OPP	5–7	2000–2500
Cast PP	10–12	3500–4500
EVOH	1000	0.5
PVdC	0.5–1.0	2–4
PA	300–400	50–75
PS	70–150	4500–6000
PET	15–20	100–150
Aluminium	0	0

Units: WVTR in g m- 2/24 h at tropical conditions of 90% RH at 38°C and gas permeability in cm3 m- 2/24 hrs.

4.3 Examples of Suitability of Various Films for Packing the Food Products

Product	LDPE	OPP	OPP (metallised)	OPP (coated)	Laminate (no Al)	Laminate (+ Al)	Package type
Fresh bread	***	***	0	0	0	0	HFF
Long life bread	0	0	*	*(MAP)	**(MAP)	**(MAP)	HFF
Snacks/crisps (chips)	0	*	***	***	**	***	VFF
Biscuits	0	0	**	***	**	***	HFF
Nuts	0	0	**(MAP)	*(MAP)	**(MAP)	***(MAP)	VFF
Cooked meat	0	0	*	**	**(MAP)	***(MAP)	Pouch
Frozen food	**	*	*	0	***	***	Various

0 = Not suitable, * = short life, ** =medium life, *** = long life, MAP = modified atmosphere pack.

Source: Table 1,2,3 Richard Coles, Derek Mcdowell, Mark J. Kirwan, Food Packaging Technology, Blackwell Publishing, CRC Press

Appendix 5

Plastic ID Codes

Plastic ID code	Name	Color	Density (g/ml)	Application	Recycled product
1	PET- Polyethylene Terphthalate	Green	1.35	Fizzy drinks bottles, frozen meal packages, water bottle, bear bottle, mouthwash bottle	Fiberfill in coats, Carpet, Camera film, Lumber
2	HDPE- High-Density Polyethelene	Red	1.00-0.93	Milk, washing-up liquid bottles, detergent bottles, oil bottles, toys plastic bags	Trash cans, Floor tile, Flower pots, Garden furniture
3	PVC- Polyvinyl Chloride	—	1.40	Food trays, cling film, bottles for squash, minera; water, shampoo, vegetable oil bottles, blister packaging	Floor mats, Flexable hoses, Playground equipments
4	LDPE Low-Density Polyethylene	White Bread	0.93-0.86	Carrie Bags, bin liners, bread bags clothing, carpet, furniture, garment bags, shrink-wrap	Floor tile, Furniture, Garbage Can Liner
5	PP- Polypropylene	Purple	0.90	Microwaveable meal trays.	Videoocassette cases Lawn mower wheels, battery cable, Landscape boarders
6	PS- Polystyrens	Translu- cent white	1.05	Yoghurt pots, foam meat or fish trays, hamburger boxes, egg cartons, vending cups, plastic cutlery, protective packaging for electronic goods and toys	Flower pots, Trash cans, Thermoters, Ruler
7	Others	—	—	The plastics that don't fall into any of above categories, such as Melamine.	—

Source: 1. Plastic Packaging, Ruben J. Hernandez/ Susan E.M.Selke/ John D. Culter Hanser Gardner Publications, Inc., Cincinnati
2. ASTM D7611 for SPI codes
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