Waste Management in Food Packaging Industry

G. Mahesh Kumar, A. Irshad, B.V. Raghunath and G. Rajarajan

Abstract The increasing amount of food packaging waste is perceived as a problem in urgent need of solution in all industrialized countries. According to the environment protection act, waste is any substance which constitutes scrap material, an effluent, unwanted surplus substance, article which requires disposing of as being broken, worn out, contaminated or otherwise spoiled. Waste leads to the production of significant greenhouse gas, methane which is over 20 times more potent than carbon dioxide. Source reduction, reuse and recycle are the most powerful and effective thing we can do to manage waste. Plastic Waste Management has assumed great significance in view of the urbanization activities. Plastic waste generated by the polymer manufacturers at the production, extrusion, quality control and laboratory testing etc., stages, as well as, by the consumers require urgent disposal and recycling to avoid health hazards. Various strategies are being devised to mitigate the impact of plastic waste in India.

Keywords Food packaging industry · Waste management · Plastic recycling · Glass recycling · Aluminum recycling

1 Introduction

Food packaging material is expected to provide optimum protective properties so that the product it encloses remains in satisfactory condition for its anticipated shelf-life. The packaging technique, in conjunction with the choice of a packaging material endowed with appropriate gas and water barrier properties, aims to prevent

G. Mahesh Kumar (✉)
Department of Animal Genetics and Breeding, Veterinary College and Research Institute, Namakkal 637 002, India
e-mail: maheshvet1989@gmail.com

A. Irshad · B.V. Raghunath · G. Rajarajan
Department of Licestock Products Technology, Veterinary College and Research Institute, Namakkal 637 002, India

M. Prashanthi and R. Sundaram (eds.), *Integrated Waste Management in India*, Environmental Science and Engineering, DOI 10.1007/978-3-319-27228-3_24

destruction of food by microbial and insect attack. According to Paine and Paine (1992) food packaging is complex, dynamic, scientific, artistic and controversial segment of business. One of the major targets of society is to satisfy its population demand for goods of every kind. The increased consumer demand for high quality, long-shelf-life, ready-to-eat foods has initiated the development of mildly preserved products that keep their natural and fresh appearance as long as possible (Baldwin et al. 1995; Guilbert et al. 1996). However, this would be impossible without suitable packaging.

The materials and designs employed for each packaging operation depend on the product itself reflecting the role that it was designed to perform. Packaging is used for meeting the following requirements (Waite 1995; Krochta et al. 1997),

- Protection of product from mechanical damage, contamination and deterioration
- Promotion and advertisement of the product
- Information disclosure to the consumer regarding the content, composition and instructions for safe use
- Improvement of distribution and reduction of storage and transportation costs
- Convenience
- Safety function and prevention of inappropriate use.

Packaging, despite the convenience it provides to the consumer, is subject to many debates concerning environmental issues. It has been considered a constant source of environmental waste due to its volume, since it occupies close to two-thirds of trash can volume. Furthermore, the constant increase in the use of plastics makes their disposal a major environmental issue. Packaging represents approximately 30 % weight of municipal solid waste (MSW), but appears much more significant because it occupies close to 65 % of waste volume due to its bulkiness (Krochta et al. 1997).

2 Waste

According to the environment protection act waste is any substance which constitutes scrap material, an effluent, unwanted surplus substance, article which requires disposing of as being broken, worn out, contaminated or otherwise spoiled. The main approaches to waste management are,

- Recycling
- Combustion for energy recovery
- Combustion for volume reduction
- Landfill
- Save money
- Help the environment

3 Purpose of Food Waste Management

3.1 Save Money

Waste reduction allows you to save money on commodities, labor, energy and disposal costs. Consider that if 4–10 % of the food you purchase will become pre-consumer waste before ever reaching a guest, it becomes clear that waste reduction should be one of the first and easiest ways to control costs (and hedge food cost inflation).

3.2 Help the Environment

Waste leads to significant carbon emissions. In the case of food waste, farm inputs, transportation and storage each require petroleum inputs. And landfill disposal often leads to production of methane gas, a greenhouse gas which is over 20 times more potent than carbon dioxide. By reducing foodservice waste, can make a real environmental difference.

3.3 Community Engagement

Engage staff, guests and community members by showing that waste reduction is achievable and makes a positive difference for all.

4 Waste Management Hierarchy in Food Service

Most foodservice operators are familiar with the phrase “Reduce, Reuse, Recycle” which has been used for many years to describe waste control options other than straight disposal, what many people do not realize is that this phrase represents a hierarchy of activities, starting with the most beneficial and moving to the least attractive (Fig. 1).

Reduce: Source reduction is the most powerful and effective thing that could manage waste. By designing systems and policies to prevent, minimize, or avoid waste in the first place, human have an opportunity to save food and labor dollars while making the largest positive impact on the environment. When preventing waste, money is not spending on raw materials that would otherwise go in the garbage. At the same time, money will be saved on labor costs associated with handling or processing these materials. It is also avoided, hauling and landfill fees

Fig. 1 The waste management hierarchy in food service

(and carbon emissions) associated with recycling, composting or disposing of the waste.

Reuse: Reuse is next best option after source reduction. With reuse, it could find a secondary way to obtain value from an item that would otherwise be wasted. In food service, the most common reuse opportunities involve: (1) redeploying overproduced food elsewhere on the menu and (2) donating to a food recovery program that will provide it to those in need. In certain jurisdictions, food can also be donated to feed animals provided it is handled and treated correctly.

Recycle/Compost: It is the final good option prior to disposal. By recycling or composting, can divert the waste from the landfill or elsewhere in the solid waste stream and ensure ongoing value when the item is converted into some-thing useful, such as a soil amendment with composting. Some of the common wastes in food packaging industry were discussed in this chapter.

4.1 Plastic Use in Packaging Application

Plastic is the major source used in packaging of foods. The thermoplastic materials used for packaging purpose are qualified based on the code as 1–7 (Fig. 2) and the various applications of the different quality of the plastic materials are given in Table 1.

Fig. 2 Codes of thermoplastic

Table 1 Thermoplastics and their used in food packaging

S. no.	Thermoplastic materials	Packaging application
1	Polyethylene terephthalate (PET)	Drinking bottles Microwavable packaging Soft-drink bottles Food jar for butter Jelly and Plastic films
2	Polypropylene (PP)	Drinking bottles Bottles for milk and juice
3	Poly vinyl acetate (PVA)	Common food packaging
4	Poly vinyl chloride (PVC)	Plastic bags Frozen foods stretch films Container lid
5	Polystyrene (PS)	Food container Bottle caps Medicine bottles Straws
6	Low density polyethylene	Disposal cups Glasses Plates Spoon
7	High density polyethylene	Custom packaging

4.1.1 Methods of Plastic Recycling

Steps involved in the recycling process are (Pappa et al. 2001)

- *selection*: The recyclers/reprocessors have to select the waste/scrap which are suitable for recycling/reprocessing
- *segregation*: The plastics waste shall be segregated as per the codes 1-7 mentioned in the BIS guidelines and
- *processing*: After selection and segregation of the pre-consumer waste (factory waste) shall be directly recycled. The post-consumer waste (used plastic waste) shall be washed, shredded, agglomerated and extruded.

Mechanical Recycling

Mechanical recycling is the material reprocessing of waste plastics by physical means into plastics products. The sorted plastics are cleaned and processed directly into end products or into flakes or pellets of consistent quality acceptable to manufactures. The steps taken to recycle post-consumer plastics may vary from operation to operation, but typically involve inspection for removal of contaminants or further sorting, grinding, washing and drying and conversion into either flakes or pellets. Pellets are made by melting down the dry plastic flakes and then extruding it into thin strands that are chopped into small, uniform pieces. The molten plastic is forced through a fine screen (filter) to remove any contaminants that may have eluded the washing cycle. The strands are cooled, chopped into pellets and stored for sale and shipment. Different plastics may also under different reforming conditions such as different processing temperatures, the use of vacuum stripping, or other procedures that could influence contaminant levels. During the grinding or melting phases, the reprocessed material may be blended with virgin polymer or compounded with additives. Mechanical recycling is the preferred recovery route for homogeneous and relatively clean plastics waste streams, provided end markets exist for the resultant recyclate. This technique is also well suited for developing countries since it is less cost-intensive compared to the others (Dodbiba et al. 2005).

Feedstock or Chemical Recycling

Chemical recycling or feedstock recycling means a polymeric product broken down into its individual components (monomers for plastics or hydrocarbon feedstock synthesis gas) and these components is then fed back as raw material to reproduce the original product or others. Feedstock recycling include chemical depolymerisation (glycolysis, methanolysis, hydrolysis, ammonolysis etc.), gasification and partial oxidation, thermal degradation (thermal cracking, pyrolisis, steam cracking, etc.), catalytic cracking and reforming, and hydrogenation. Besides conventional treatments (pyrolisis, gasification), new technological approaches for the degradation of plastics, such as conversion under supercritical conditions and co processing with coal are being tested (Santos et al. 2005). This technique of recycling is however not suitable for developing countries. This is because it requires a lot of expertise, capital intensive and is quite cumbersome. Even in the developed countries, it is still under development and is being practiced by only a few companies. A number of companies have successfully developed and demonstrated technologies many of which can process mixed plastics streams. There has been some renewed interest in other areas of feedstock recycling, such as the depolymerisation of PET or treatment of PVC to make chemicals which can then be used in the production of new plastics.

Environmentally Sound Manner

Recycling of plastics should be carried in such a manner to enhance the efficiency of the process and conserve the energy. Plastic recycling technologies have been historically divided into four general types-primary, secondary, tertiary and quaternary. Primary recycling involves processing of a waste/scrap into a product with characteristics similar to those of original product. Secondary recycling involves processing of waste/scrap plastics into materials that have characteristics different from those of original plastics product. Tertiary recycling involves the production of basic chemicals and fuels from plastics waste/scrap as part of the municipal waste stream or as a segregated waste. Quaternary recycling retrieves the energy content of waste/scrap plastics by burning/incineration.

Plastics Waste Disposal Through Plasma Pyrolysis Technology (PPT)

Plastic waste disposal through plasma pyrolysis is a state of the art, technology, which integrates the thermo-chemical properties of plasma with the pyrolysis process (Kaminsky 1995). In plasma pyrolysis, firstly the plastics waste is fed into the primary chamber at 850 °C through a feeder. The waste material dissociates into carbon monoxide, hydrogen, methane, higher hydrocarbons etc. Induced draft fan drains the pyrolysis gases as well as plastics waste into the secondary chamber, where these gases are combusted in the presence of excess air. The inflammable gases are ignited with high voltage spark. The secondary chamber temperature is maintained at around 1050 °C. The hydrocarbon, carbon monoxide and hydrogen are combusted into safe carbon dioxide and water. The process conditions are maintained so that it eliminates the possibility of formation of toxic dioxins and furans molecules (in case of chlorinated waste). The conversion of organic waste into nontoxic gases (CO_2, H_2O) is more than 99 %.

Some Alternative Method of Waste Disposal

Landfill defined as the disposal, compression and embankment fill of the waste at the appropriate site (Read 1999). (Anaerobic degradation) Landfill is the easy, adjustable with lower cost than other rest of disposal methods. Important factor is that selection of the correct disposal site. In anaerobic degradation or digestion, microorganisms slowly break down solid waste primarily organic based materials such as wood and paper (in the absence of oxygen) into primarily carbon dioxide, methane and ammonia. Anaerobic degradation is mostly used to treat bio solids (sewage sludge) and organic waste contaminants. More research is necessary to realize the full potential of anaerobic degradation in the management of solid waste.

Incineration is the process of combustion to convert the waste material into CO_2 and water. Reduction of waste volume through incineration achieved 80–90 %. *Pyrolysis* is best method for high molecular waste substances. It is the thermal degradation of macromolecule. Pyrolysis products consist 34 % ethylene, 9 % propane, 39 % oil (mainly aromatic compound) Pyrolysis are mainly used for plastics. *Composting* refers to self-heating, aerobic process of organic waste and other industrial organic compound in order to convert them to a mature and plant compatible substrate. The final product of composting is rich in organic matter. Generally it takes 3 months in optimal degradation condition and 1–2 years in normal condition.

4.1.2 Energy Recovery

Plastics are almost all derived from oil and plastic wastes is a waste with a high calorific value. Energy recovered from plastic waste can make a major contribution to energy production. Plastics can be co-incinerated with other wastes or used as alternative fuel (e.g. coal) in several industry processes (cement kilns). The energy content of plastic waste can be recovered in other thermal and chemical processes such as pyrolysis. As plastic waste is continuously being recycled, they lose their physical and chemical properties at their end of life cycle. Continuous recycling could lead to substandard and low quality products. Hence it would no longer be economically profitable to recycle further. Incineration with energy recovery would be the economically preferred option at this stage.

Conversion of Plastics Waste into Liquid Fuel

A research-cum-demonstration plant was set up at Nagpur, Maharashtra for conversion of waste plastics into liquid fuel. The process adopted is based on random de-polymerization of waste plastics into liquid fuel in presence of a catalyst. The entire process is undertaken in closed reactor vessel followed by condensation, if required. Waste plastics while heating up to 2700–3000 °C convert into liquid vapor state, which is collected in condensation chamber in the form of liquid fuel while the tarry liquid waste is topped-down from the heating reactor vessel. The organic gas is generated which is vented due to lack of storage facility. However, the gas can be used in dual fuel diesel-generator set for generation of electricity.

4.2 Glass Recycling

Glass has an extremely long history in food packaging; the 1st glass objects for holding food are believed to have appeared around 3000 BC (Waite 1995). However, during the last hundred years, mechanized glass blowing techniques have revolutionized the production of glass containers, allowing bottles to be produced quickly and cheaper (Vogas 1995; Pearson 1996). The production of glass containers involves heating a mixture of silica (the glass former), sodium carbonate (the melting agent), and limestone/calcium carbonate and alumina (stabilizers) to high temperatures until the materials melt into a thick liquid mass that is then poured into molds. Recycled broken glass (cullet) is also used in glass manufacture and may account for as much as 60 % of all raw materials. The process is illustrated in Fig. 3 and Table 2 give the recycling rates.

The recycling process of glass depends entirely on the type of glass that will be produced (Stotzel 1997). Main advantage is energy saving. Glass cullet requires

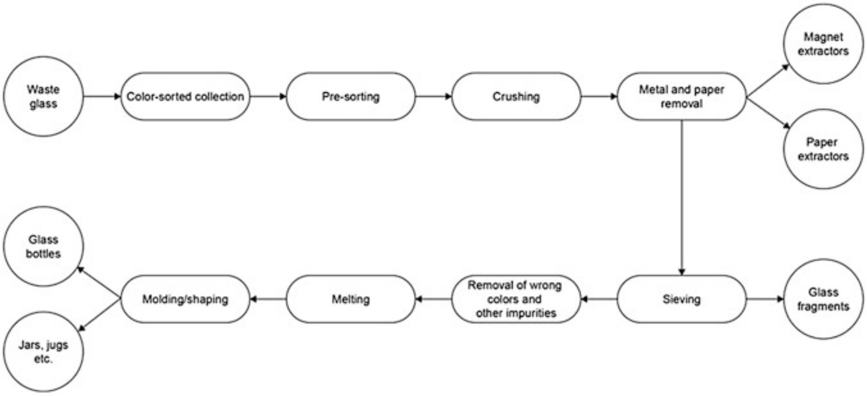


Fig. 3 Glass recycling process (*source* Arvanitoyannis and Bosnea 2001)

Table 2 Glass recycling rates around the world (%)

Country	1991	1993	1994	1995	1996	1997
Germany	55	71	75	82	85	89
France		46	48	50	50	
Italy		52	54		53	
UK	21	29	28	27	26	26
Spain		29	31		35	
Holland		73	77	80	81	
Belgium		55	67	67		
Austria		68	76			
Denmark		64	67			
Sweden		54	56		72	
Portugal		29	32			
Greece		27	29	29		
Norway			72		75	
Finland			50			
Ireland		29	31			
Switzerland		78	84		89	
Australia					89	
USA	25				33	
Japan					60	

Source Arvanitoyannis and Bosnea (2001)

less temperature for melting than raw material. Saved energy = 0.25 × % of recycled glass cullet used. There are some basic rules to be followed during glass recycling, so glass should be free from metal tops, ceramics and stones and be sorted according to colour. There should be a thorough removal of foreign materials; otherwise the produced glass might be defective. The quantity of ceramics left on the cullet should not be more than 25 g per tonne, while the metal particles should be less than 5 g per tonne. Therefore, the basic container glass recycling process steps are (Fig. 3):

- Initial rinsing, cap and lid removal
- Color separation
- Volume reduction by breaking or crushing
- Packaging and shipping
- Final treatment.

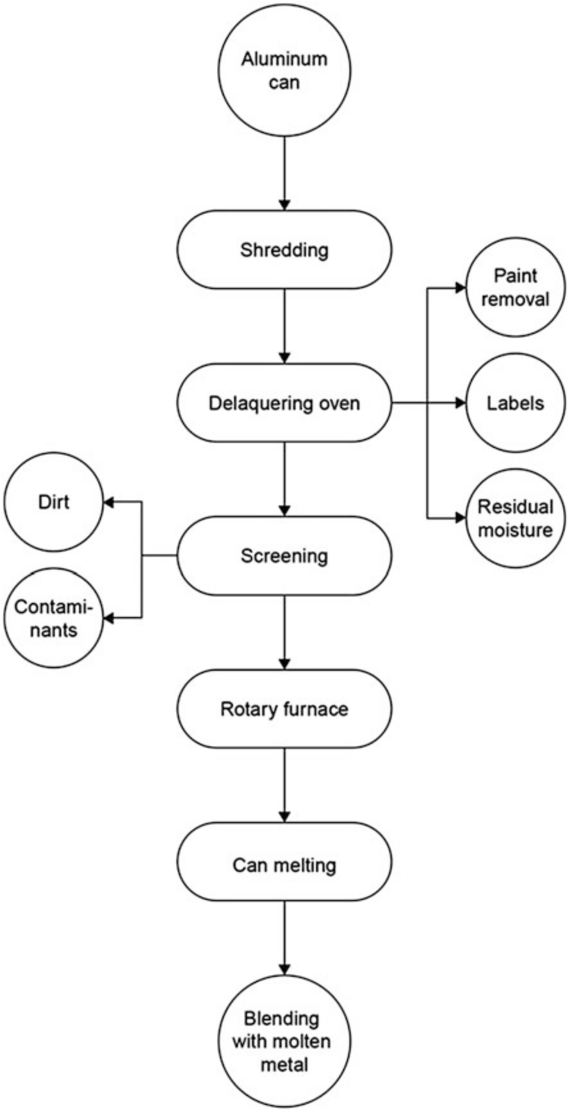
4.3 Aluminum Recycling

In contrast to many other materials, in the recycling of metal there are no quality losses. Compared to primary metal extraction, a 95 % savings in energy can be achieved with recycling. The economic value of aluminum has always been the main reason for bringing the material into the loop of metal extraction, processing, use and recovery. Aluminum has been recycled since the days it was first commercially produced and today recycled aluminum accounts for one-third of global aluminum consumption worldwide (Fig. 4).

4.4 Paper/Carton Recycling

In spite of synthetic packaging materials and electronic media, internationally paper and board consumption is increasing steadily. While in 1950, about 50 million tonnes of paper were produced worldwide, in 2010, approximately 400 million tonnes were produced. To make this increase in paper production possible and for saving resources at the same time, paper recycling has been intensified steadily in the last decades and has now reached a high technical level. Most of the products made of paper only have a life span of a few days (e.g. newspapers) or a few weeks (e.g. packaging). The increase of recovered paper use in industrialized countries is determined by problems of disposal. Thus, recovered paper is today the most important raw material for the production of paper, paperboard and corrugated board (Fig. 5).

Fig. 4 Flow diagram for metal recycling (*source* Onusseit 2006)



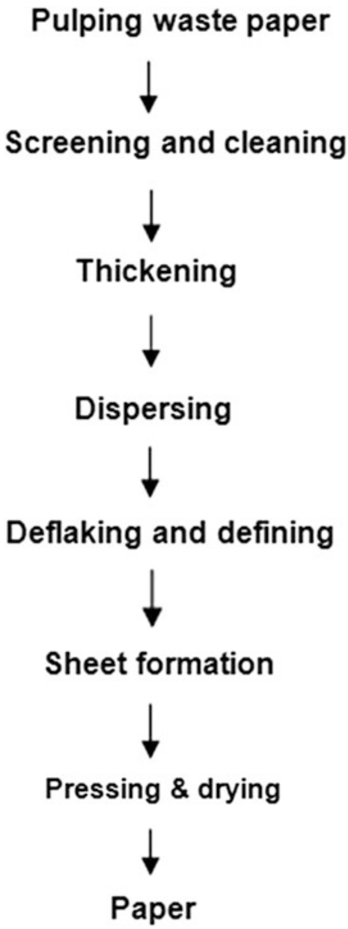


Fig. 5 Process of waste paper recycling

5 Conclusion

Packaging, despite the convenience it provides to the consumer, is subject to many debates concerning environmental issues. It has been considered a constant source of environmental waste due to its volume, since it occupies close to two-thirds of trash can volume. Plastic waste management has assumed great significance in view of the urbanization activities. Plastic waste generated by the polymer manufacturers at the production, extrusion, quality control and laboratory testing etc. it is urgent that disposal and recycling should be done to avoid health hazards. Various strategies are being devised to mitigate the impact of plastic waste in India.

References

Arvanitoyannis IS, Bosnea LA (2001) Recycling glass used for food packaging. In: 1st Balkan conference proceedings of glass recycling. University of Thessaly, Volos, pp 572–580
Baldwin EA, Nisperos-Carriedo MO, Baker RA (1995) Use of edible coatings to preserve quality of lightly (and slightly) processed products. Crit Rev Food Sci Nutr 35:509–524
Dodbiba G, Sadaki J, Okaya K, Shibayama A, Fujita T (2005) The use of air tabling and triboelectric separation for separating a mixture of three plastics. Miner Eng 18:1350–1360
Guilbert S, Gontard N, Gorris GM (1996) Prolongation of the shelf life of perishable food products using biodegradable films and coatings. Lebensm Wiss Technol 29:10–17
Kaminsky W (1995) Pyrolysis with respect to recycling of polymer. Angew Makromol Chem 232 (4137):151–165
Krochta JM, De Mulder-Johnston C (1997) Edible and biodegradable polymer films: challenges and opportunities. Food Technol 51(2):61–74
Onusseit H (2006) The influence of adhesives on recycling. Resour Conser Recycl 46:168–181
Paine FA, Paine HY (1992) A handbook of food packaging. Blackie Academic Professional, London, pp 1–52
Pappa G, Boukouvalas C, Giannaris C (2001) The selective dissolution /precipitation technique for polymer recycling: a pilot unit application. Resour Conser Recycl 34:33–44
Pearson W (1996) Plastics. The McGraw Hill recycling handbook. McGraw Hill, New York
Read AD (1999) Making waste work: making UK national solid waste strategy work at the local scale. Resour Conser Recycl 26:259–285
Santos ASF, Teixeira BAN, Agnelli JAM, Manrich S (2005) Characterization of effluents through a typical plastic recycling process: an evaluation of cleaning performance and environmental pollution. Resour Conser Recycl 45:159–171
Stotzel E (1997) Cullet for flat glass. Glass Technol 38(6):185–188
Vogas P (1995) Organization, management, marketing and communication in a complete system of reuse and recycling of materials. Int Org Biopolitics pp 38–81
Waite R (1995) Household waste recycling. Earthsian Publications Limited, London