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SUSTAINABLE FOOD PACKAGING: AN INTEGRATIVE FRAMEWORK

Email

rajeshd423@gmail.com

[1]Akash Bundheliya and [2]Rajesh Deshmukh*

[1]Quality Executive, AMR dairy (Amreli District Cooperative Milk Union Ltd.), Amreli, Gujarat, India

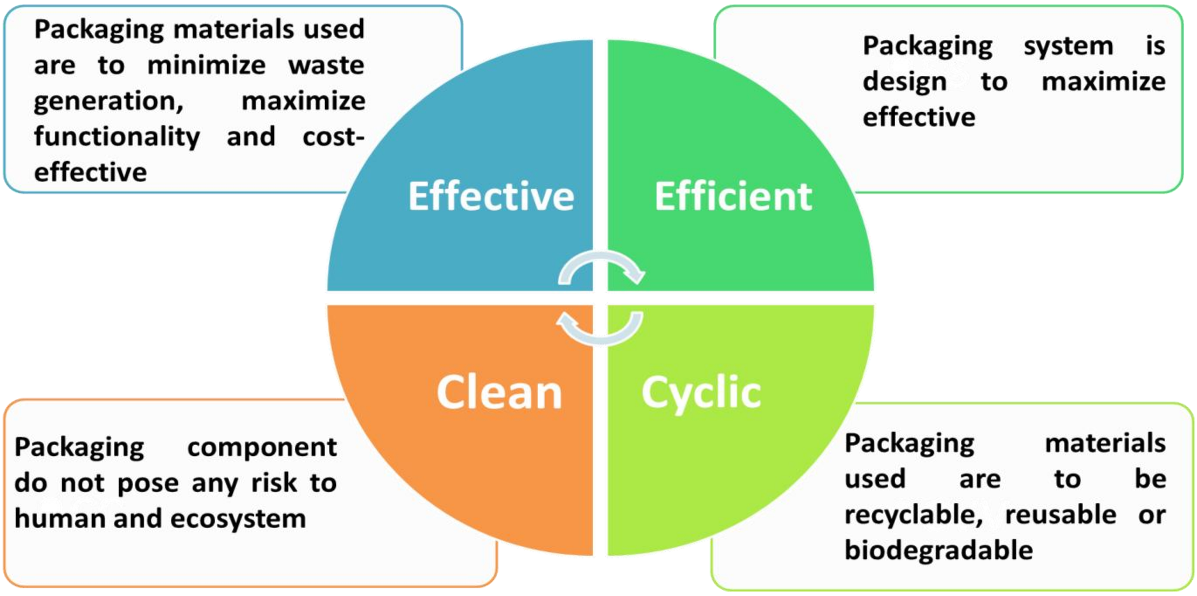
[2]Dairy Chemistry Division, ICAR-National Dairy Research Institute, Karnal, Haryana, India

Innovative sustainable packaging is intended to address waste and loss reduction by preserving food quality. It also helps keep food safe by preventing food-borne diseases and chemical contamination. It should deal with the long-term, important problem of plastic trash piling up in the environment. Packaging is one of the most important parts of keeping food fresh. It does this mainly by controlling the exchange of gases and vapours with the outside air. This helps keep food fresh during storage, prevents food-borne diseases and chemical contamination, and extends the shelf life of food.

When food and its packaging are thrown away together, it makes the environment go terrible. Between 2015 and 2016, the amount of plastic made went up by 4.2%, to 335 million tonnes. After a single and very short use as food packaging, 40% of the plastic ends up in a landfill, which is equivalent to 9 million tonnes of plastic packaging waste that will end up in soils. Another 32% leak out of collecting and sorting systems and end up in the soil and ocean as well (Jambeck et al., 2015). This marine and soil litter first breaks down into micro-sized particles and then into nano-sized particles. Since these particles are so small, they can easily get into living things like fish and move up the food chain, all the way to humans, where they have very bad long-term effects. If production and use keep going in the same way and nothing is done, there may be more plastic in the ocean than fish by 2050.

Sustainable Packaging

Sustainable packaging means making packaging film out of materials that can be recycled. It also means using life cycle assessments and life cycle inventories to make sure that the packaging has as little of an impact on the environment as possible. Packaging that meets the criteria set out by the Sustainable Packaging Coalition is considered sustainable.



- Throughout its whole lifespan, beneficial, risk-free, and healthy for consumers, communities, and the environment;
- Complying with market requirements in terms of both performance and price;
- Renewable energy sources used in the sourcing, manufacturing, transporting, and recycling of the product;
- Maximising the use of materials derived from sources that are either renewable or recycled;
- Manufactured with the use of clean production methods and industry-standard processes;
- Produced with materials that are risk-free in any and all possible scenarios regarding their end of life;
- Physically constructed to make the most efficient use of resources and energy;
- Effectively collected and put to use in closed-loop cycles, whether biological or industrial in nature.

Eco-friendly Food Packaging

1. Glass packaging

In the United States in 2010, 9.36 million tonnes of glass packaging waste was produced, and 33.4% of the used material was recycled, making glass the most recycled packaging material in terms of weight recovered (EPA, 2010). A 10% cullet addition to recycled glass reduces energy use by 2.5%. Glass bottles are technically recyclable indefinitely, however only around 75% are recycled since the remaining 25% are lost or broken in the process. Glass is heavier than other packing materials, therefore transporting it uses 5–6% of the total energy consumed, making it appear more expensive than transporting other materials.

2. Metal packaging

The good news is that cans made from recycled materials use as little as 4-8% of the energy necessary to create the equivalent cans from bauxite ore. Metal containers are a fantastic choice for recycling because they are inexpensive and infinitely recyclable. When compared to natural aluminium production, recycled aluminium can save 70-90% of the energy. Aluminum can be easily separated from other metals during the recycling process. Iron and other ferrous metals can be separated using a magnetic separator or flotation since they are lightweight and not magnetic. Internal coatings, ink, and any other organic pollutants are eliminated throughout the recycling process.

3. Paper Packaging

Paper is a superior material since it can be recycled and decomposed without much effort. Paper is reused and recycled at a rate of 80% and 20%, respectively. Over the past decade, there has been a rise in the percentage of recycled paper and paperboard. There were 37.7 million tonnes of paper and paperboard packaging waste in 2010. Of this, 71.3% was recycled (EPA, 2010). Due to the potential presence of contaminants introduced during the recycling process, recycled paper is unsuitable for use in most food contact packaging applications. Paper that has been recycled is never used for serving or packaging food. Physical and mechanical properties can be optimised by blending virgin and recovered fibres in varying quantities.

4. Plastic packaging

Gas from natural gas processing, as well as feedstock derived from refining crude oil, is used in the production of plastic. We all know that the extraction of oil and natural gas can have serious consequences for the surrounding ecosystem, An EPA research from 2014 found that recycling rates for plastic were only 9.5%, with 15% being burned for energy and the remaining 75.5% being dumped in landfills. PET recycling rates in India are the highest in the world. Of all PET bottles in India, 42% are recycled, 38% are sent to landfills, and 20% are incinerated.

Biodegradable and Compostable Food Packaging

Natural biopolymers developed from renewable sources that are biodegradable seem to be a promising alternative to traditional plastics in light of growing concerns about waste disposal issues and the environmental effects of plastics based on petroleum. Additionally, there has been a significant rise in oil prices recently. These facts have raised interest in biodegradable polymers made without petroleum. Biodegradation occurs as a result of the action of enzymes and/or biochemical deterioration linked to living organisms, and biodegradability depends instead on the chemical structure of the polymer and the environmental circumstances rather than the sources of the raw materials used to produce the polymer. Chemical structure, such as the chemical linkage, pending groups, etc., is related to susceptibility to degradation and environmental circumstance is related to living organisms.

It might be difficult to use biodegradable packaging materials if you want to preserve their mechanical and barrier qualities during the product's shelf life and, ideally, have them decompose swiftly after use. In filling and sealing machinery, the materials should ideally perform similarly to conventional packaging while costing the same. According to their place of origin and technique of synthesis, bio-based biodegradable polymers can be divided into three major types (van Tuil et al., 2000).

1. Directly removing or extracting polymers from biomaterials (for example, starch, cellulose, casein, etc.).
2. Monomers made from biomaterials are converted into polymers using the standard chemical synthesis process (for example, polylactide polymerized from lactic acid monomers).
3. Polymers made by microorganisms directly (for example, polyhydroxyalkanoates).

Biodegradable Polymers from Agricultural Crops

This category includes, for instance, starch-based polymers. Starch is a cheap, readily available, and eco-friendly material. When it comes to bioplastics, corn starch is by far the most popular option. Starch films are hydrophilic and have low mechanical strength if left unaltered. Forget about using them in any sort of packaging; they don't cut it. Biodegradable plasticizers such as glycerol and other low molecular weight polyhydroxy compounds, polyethers, etc., can reduce the brittleness of starch-based bioplastics (van Tuil *et al.*, 2000).

Plants produce a variety of polysaccharide resources, the most common of which being cellulose. Cellulose is a linear polymer composed of very long macromolecular chains made up of glucose monomers. Cellulose has many undesirable properties, such being extremely crystalline, brittle, infusible, and insoluble in all organic solvents (Chandra et al., 2007). Chemically modifying cellulose to make it soluble, followed by regeneration of the cellulose after it has been formed into film, yields cellophane films.

Biodegradable Polymers Synthesized From Bio-Derived Monomers

- **Polylactic acid (PLA)**

PLA is a biodegradable polymer used in food packaging. PLA is created chemically by starting with simple sugars derived from biomass and fermenting to lactic acid. The most popular method for producing PLA is ring opening polymerization by condensation of lactide with metal catalyst tin octoate at high temperatures but less than 200^{o}C. PLA is currently industrially processed using the same technology as traditional petroleum-based thermoplastics. It is marketed for single-use packaging applications such as bottles, cold drink cups, thermoformed trays and lidded containers, blister packages, overwraps, and flexible films. PLA biodegradability improved by grafting with chitosan. Polylactic acids offer good moisture and oxygen barrier qualities and are currently used in bakery and confectionery wrappers, paperboard coatings for cartons, and water bottles.

Biodegradable Polymers Produced Directly By Microorganisms

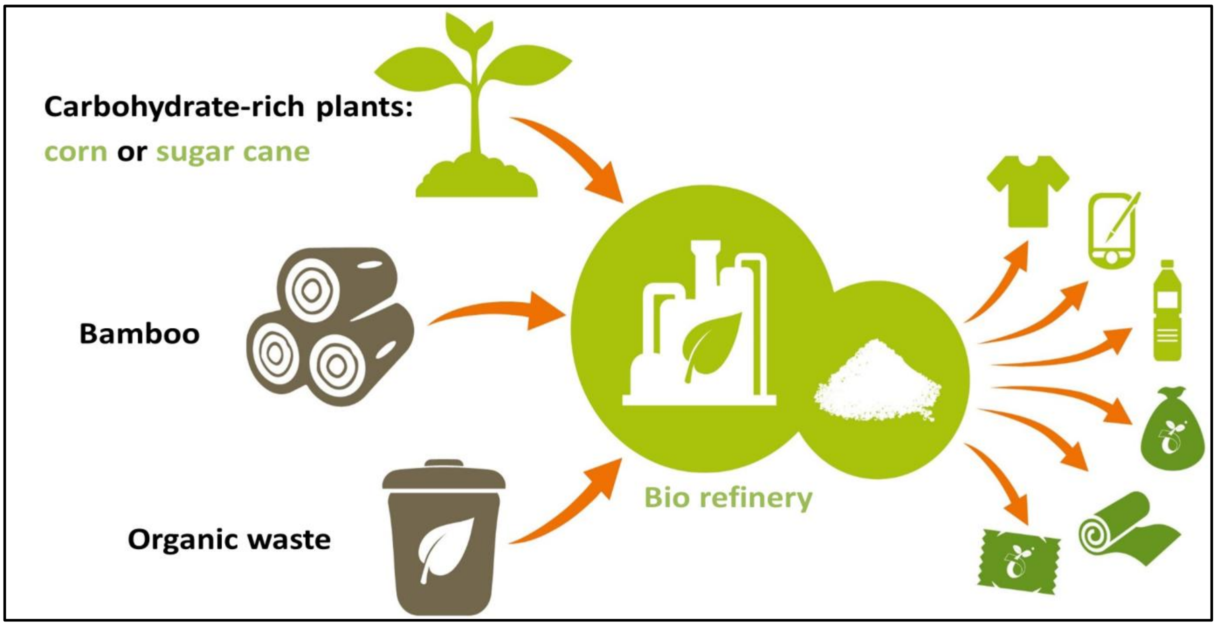
- **Polyhydroxybutyrate**

Bacteria make natural polyesters called poly (β-hydroxy-alkanoate) s (PHAs) from sugars or lipids. In response to nutritional constraints, bacteria produce and store PHA polymers as intracellular food and energy. Bacteria can store up to 60–80% of their weight in PHA to avoid hunger in the absence of key macro-elements like phosphorus, nitrogen, trace elements, or oxygen. Bacteria, fungi, and algae in different conditions break down PHAs. Poly(hydroxybutyrate) (PHB), the simplest and most common PHA, has excellent crystallinity and good gas barrier performance, making it popular for food packaging. It's possible that combining PHB with other polymers will make its qualities better.

Synthetic Biodegradable Polymers

Synthetic biodegradable polymers derived from petrochemical feedstock's with hydrolytic microbial attack-prone groups. Polycaprolactone (PCL) is a semi-crystalline aliphatic polyester with a low melting point (60°C). It degrades fully in marine, sewage, sludge, soil, and compost habitats. Another synthetic biodegradable polymer that is entirely soluble in water is polyvinyl alcohol (PVOH). Since 1970, researchers have been investigating the use of starch and PVOH as biodegradable packaging material. It is currently utilised to make starch-based loose fillers as a replacement for expanded PS. Polyesters, polyamides, polyurethanes and polyuria's, poly(amide-enamine) s, and polyanhydrides are examples of synthetic biodegradable polymers (Nair & Laurencin, 2007).

Recent Developments in Biodegradable Packaging



1. Maize Plastic: Using an industrial resin called PLA and corn kernels, a number of businesses have produced a biodegradable plastic.

2. Bamboo: Bamboo is one of the plants that grows the quickest on the planet, making it a great substitute for paper and plastic. Australian company Centaur Packaging makes plates, bowls, and cutlery from bamboo.

3. Plant fibres: Biodegradable packing materials are frequently made using cellulose derived from plant stuff.

4. Wood fibres: Paper is made from wood pulp, which is recycled into different paper goods. However, Innovia Films, founded in the UK, uses wood pulp to produce a cellulose-based film that resembles plastic.

5. Mushroom: To package their wares, marketers are utilising mushrooms. To replace polystyrene/styrofoam packaging, mycelium, the portion of mushrooms and other fungus that consists of thread-like roots, is blended with seed husks. (GoG, 2017 Agro and Food Processing).

Conclusion

Plastic packaging is not sustainable because it is difficult to recycle and detrimental to the environment. It is best to choose recyclable packaging materials that are kind to the environment, such as glass, metal, and paper, to conserve resources and have the fewest negative effects on the environment. The issue of packaging waste can be lessened by using recently created biodegradable packaging made from dairy or agricultural waste.

References:

Agro and Food Processing Government of Gujarat (2017). Retrieved from http://www.indextb.com/documents/Biodegradable-packaging-for-food-products.pdf

Environmental Protection Agency (EPA) (2010). Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2009. Retrived from www.epa.gov/epawaste/nonhaz/ municipal/pubs/msw_2010_rev_factsheet.pdf

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771.

Nair, L. S., & Laurencin, C. T. (2007). Biodegradable polymers as biomaterials. *Progress in Polymer Science*, 32(9), 762-798.

Tuil, R. V., Schennink, G., Beukelaer, H. D., Heemst, J. V., & Jaeger, R. (2000). Converting biobased polymers into food packagings. In *The Food Biopack Conference, Copenhagen (Denmark),* 27-29 Aug 2000. KVL.