

Eco Friendly Packaging

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Introduction

Packaging is an **essential** component in the **complex distribution system**. The main aim of packaging is to safeguard the food material from microbial attack and other contaminants and prevent damage during the distribution. There is **huge demand for the packaging material**, which will be **causing huge environmental concerns** as they are **majorly plastics** which will **degrade very slowly**. In order to overcome this problem **“Biodegradable Packaging”** has emerged.

Definition of Bio-Packaging Materials

“Biobased food packaging materials are materials **derived from renewable sources**. These materials can be used for food applications”. The renewable sources are **from plants, marine life and animals**.

Degradable Plastic

Plastic designed to undergo significant change in its chemical structure under specific environmental conditions, resulting in loss of some properties that may be measured by standard methods appropriate to the plastic and application in a period of time that determines its classification.

Biodegradable Plastic

Degradable plastic in which the **degradation** must result from the action of **naturally occurring micro organisms**.

Compostable Plastic

Plastic that undergoes **biological degradation during composting** to yield carbon dioxide, water, inorganic compounds and biomass at a rate consistent with other known compostable materials and leaves with **no visually distinguishable or toxic residues**.

Polymers Directly Extracted From Biomass

These are the material, which find their **origin** from the **marine and agriculture, animals and plants**. They are having very good “**Gas barrier property**”. These materials are **hydrophilic**, by nature and are crystalline, because of which they cause problems to certain extent, mainly in the Packaging of moist food products.

Polysaccharides

The polysaccharides are **cellulose, starch, gums, and chitosan**. The more complex polysaccharides **produced by fungi and bacteria** such as xanthan, curdlan, pullan and hyaluronic acid are of greater interest in the future.

Starch and its derivatives

- Principle source is **Corn and Potatoes**.
- It is a very competitive material as compared to the other plastics.
- To increase the mechanical strength, plasticization, blending with other materials, chemical modification are used.

Cellulose and its derivatives

- Most commonly available polymer on the earth.
- It has regular structure and array of hydroxyl groups, which tends to form strongly hydrogen bonded crystalline microfibrils and fibres
- It is **most familiar in the form of paper or cardboard** in the packaging industries.
- Cellulose is a cheap raw material, but difficult to use because of its hydrophilic nature, insolubility and crystalline structure.

The Biobased Polymers and their Sources

Biobased polymers

- **Cellophane film**; it is very hydrophilic in nature and has good mechanical Properties.
- In order to improve the barrier properties of the packaging material the cellophane is coated with other plastic materials like Saran etc.

Nitrocellulose, wax or PVC or PVDC (Poly vinylidene chloride), Cellulose acetate (C.A), is the most commonly used Packaging material in food industry.

Uses of packaging material in foods

- Baked Goods.
- Processed Meat.
- Cheese and its products.
- Candies.

Chitin

- Chitin is chemically composed of repeating units of **1,4-linked deoxy-2-acetoamido-Dglucose**
- Chitosan is a polymers derived from chitin.
- It is the **second most abundant polysaccharide** material available **after cellulose**.

Chitosan

- Chitosan also readily forms films and, in general, produces materials with very high gas barrier properties.
- It is widely used for the production of edible coating.
- The cationic properties of chitosan offer good opportunities to take advantage of electron interactions with numerous compounds during processing and incorporating specific properties into the material.
- The advantages of this material include **antimicrobial property and their ability to absorb the heavy metals**.
- Laminates made of chitosan, cellulose, and polycaprolactone is used in Modified Atmospheric Packaging (MAP).

Proteins

- A protein is considered to be a random copolymer of amino acids and the side chains are highly suitable for chemical modification which is helpful to the material engineering, for getting required properties of the Packaging material.
- The proteins can be divided into two categories,
 - 1) **Plant origin** and 2) **Animal origin**.
- Plant origin: Gluten, Soya, Pea, Potato.
- Animal origin: Casein, Whey, Collagen, Keratin.

The Properties of Proteins used in Packaging material:

1. High gas barrier property.
2. Efficient and suitable application for packaging of foods.

Drawback: Sensitive to relative humidity.

Animal Origin

- **Casein**
- Casein is a **milk-derived protein**. It is easily processable due to **its random coil structure**.
- Upon processing with suitable plasticizers at temperatures of 80- 100°C, materials can be made with mechanical performance varying from stiff and brittle to flexible and tough performance.
- Casein films have an **opaque appearance**.
- Casein materials do not dissolve directly in water. The main drawback of casein is its **relatively high price**.
- Casein was used as a **thermoset plastic** for buttons in the 1940's and 50's.
- **Whey**
- Have relatively high nutritional value, are available in large amounts worldwide and have been extensively investigated as edible coatings and films.
- Whey proteins are readily processable and have some potential as exterior films, if, used with gelatin, suitable modification strategies can be developed to reduce moisture sensitivity.

Collagen

- Collagen is a **fibrous, structural protein in animal tissue**, particularly skin, bones and tendons.
- Collagen is a **flexible polymer**. However, because of its complex helical and fibrous structure, collagen is very insoluble and difficult to process.
- **Collagen is the basic raw material for the production of gelatine**

Keratin

- Keratin is by far the cheapest protein. It can be **extracted from waste streams such as hair, nails and feathers**.
- Due to its structure and a **high content of cysteine groups**, keratin is also the most difficult protein to process.
- After processing, a fully biodegradable, water insoluble- plastic is obtained.

The main **drawback** of all protein plastics, apart from keratin, is their **sensitivity to relative humidity**.

Plant origin

- ***Gluten***
- Gluten is the main storage protein in **wheat and corn**.
- They **do not dissolve in water**, but they do absorb water during immersion.
- Due to its abundance and low price, research on the use of gluten in edible films, adhesives, or for thermoplastic applications is currently being carried out.

- ***Soy protein***
- Commercially available as soy flour, soy concentrate and soy isolate, all differing in protein content.
- Consists of two major protein fractions: **7S (conglycinin, 35%) and 11S (glycinin, 52%) fraction**.
- The best results are obtained **with soy isolate (approx.90% protein)**.
- The **most successful applications of soy proteins are paper coatings**.

Potato

- Potato starch produces a more **translucent plastic**.
- The potato starch plastic display significantly greater water absorption than those made from other sources.

Zein

- Zein comprises a group of alcohol soluble proteins (prolamines) found in **corn endosperm**.
- Films may be formed by casting, drawing or extrusion techniques (Reiners et al., 1973).
- The films are brittle and need plasticizers to make them flexible.
- Zein-based films show a great potential for uses in **edible coatings and biobased packaging**.

Polymers Produced from Classical Chemical Synthesis from Bio - based Monomers

- Using classical chemical synthesis for the production of polymers gives a wide spectrum of possible “bio-polyesters”.
- To date, polylactic acid is the polymer with the highest potential for a commercial major scale production of renewable packaging materials.
- However, a wide range of other bio polyesters can be made.
- In theory, all the conventional packaging materials derived from mineral oil today can in the future be produced from renewable monomers gained by e.g. fermentation.

Polylactic acid (PLA)

- Lactic acid, the monomer of polylactic acid (PLA), may easily be produced by fermentation of carbohydrate feedstock.
- The carbohydrate feedstock may be agricultural products such as maize, wheat or alternatively may consist of waste products from agriculture or the food industry, such as molasses, whey, green juice, etc.
- PLA is polyester with a high potential for packaging applications.
- A 90/10% D/L PLA copolymer gives a material which can be polymerized in the melt, oriented above its T_g (Temperature gradient) and is easy processable showing very high potential of meeting the requirements of a food packaging.
- Furthermore, PLA may be plasticized with its monomer or, alternatively, oligomeric lactic acid and the presence of plasticizers lower the T_g.

Polymers Produced Directly by Natural Or Genetically Modified Organisms

- Polyhydroxyalkanoates (PHAS) are the polyester compounds that are accumulated by a major group of bacteria as carbon reserve (Energy source), of which the main polyester is Polyhydroxybutyrate (PHB).
- Two more PHAS were discovered namely 3- hydroxy butyrate (PHB) and 3- hydroxyl valerate (PHBV).
- As these both are known for their compositability and biodegradability they are generally used for packaging material production.
- The very important property of the PHAS, is their low water vapour permeability which is essential requirement in food packaging.
- The major application of medium chain length PHAS are biodegradable cheese coatings and biodegradable rubbers.

PHAS from bacteria

- The major packaging compounds of the bacteria are “Bacterial Cellulose”.
- Strains of *Acetobacter xylinum*, *Acetobacter pasteurianus* are capable of producing cellulose.
- The cellulose thus produced from bacteria is processed at ambient conditions.
- This technique is not that successful on the economic terms as its production cost is very high.

Bio Packaging of Foods

- Most commonly used food packages clearly fall into primary, secondary or tertiary packaging categories.
- A number of approaches are used to design packages for specific products.
- Such product-specific packaging includes applying of edible films and coatings, active packaging, modified atmosphere packaging (MAP), and using combinations of packaging materials.
- Of these packaging techniques specified above bio films or edible films are of importance.

Edible films

- Edible coatings and films comprise a unique category of packaging materials.
- Edible coatings are applied and formed directly on the food product either by addition of a liquid film-forming solution or molten compounds. They may be applied with a paintbrush, by spraying, dipping or fluidising.
- Edible coatings should not have impact on the sensory characteristics of the food.
- Edible films, on the other hand, are freestanding structures, formed and later applied to foods.
- Edible films and coatings may provide barriers towards moisture, oxygen (O₂), carbon dioxide (CO₂), aromas, lipids, etc., carry food ingredients (e.g. antimicrobial, antioxidants, and flavour components).

- They may be used to reduce the amount of primary synthetic packaging material used in a product or allow conversion from a multi-layer, multi-component packaging material to a single component material.
- Edible coatings may also help maintain food quality by preventing moisture and aroma uptake or loss, etc. after opening of the primary packaging.
- Bio-based packaging materials must also comply with food and packaging legislation, and interactions between the food and packaging material must not compromise food quality or safety.

Application of Biodegradable Packaging in Dairy Industry

The potential bio-based packaging materials which are tested for dairy products are as follows:

1. Cheese and Varieties: The packaging materials which can be used are starch laminates and nitrocellulose lacquered cellophanes as they have good moisture and gas barrier properties.
2. Yoghurt, Fermented foods: The packaging material can be Biodegradable plastics, PLA , as they have good mechanical, CO₂ and moisture barrier properties.
3. Butter and Fat rich products: The packaging material can be Laminate, Butter paper, PLA, PLA + PCL which possess good moisture and Light barrier properties.
4. Ice Cream: The packaging materials which can be used are Acetylated monoglycerides as they possess good moisture barrier properties.

Recent Technologies for Producing Biodegradable Plastics

- Bio – degradable plastics are being produced from plants by Fermentation, Recombinant DNA engineering etc.