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An Overview on Application of Paper and Plastics as Food Packaging Materials

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Abstract

The role of paper and plastics as food packaging materials is reviewed in brief. The inherent properties of these food packaging materials that should be considered by food processors are also discussed. The current efforts need of consumers in ensuring food's quality with prolonged shelf life during storage. This review reflects on the emerging trends in technology that deals with innovations on modified atmosphere packaging, active packaging, intelligent packaging and the use of antimicrobial nonmaterial agents to extend the shelf life of foods under storage and distribution conditions. These packaging materials in the food industries and their impacts on the environment and the public health at large will continue to receive attention in future.

Keywords: Packaging materials, Paper, Plastics, Antimicrobial

1. Introduction

The most necessary materials to preserve, protect, retail, market and distribute foods are food packaging materials. These play a significant role in how these products reach the consumers in a safe and wholesome form without any compromising quality. The relationship between the food and packaging material continuously interact and contribute to change that can occur over time in these products. So, it is urgent to consider that several factors to choose the right packaging material for a particular food product. The packaging material may either be rigid or flexible. Rigid containers include glass, plastic bottles, jars, cans, pottery, wood boxes, drums, tins, plastic pots and tubes. They give physical protection to the food inside that. Flexible packaging is a major group of materials that includes bags, envelopes, pouches, sachets, and wraps made of easily yielding materials such as film, foil, or paper sheeting [1] which, when filled and sealed, acquires workable shape. Polymeric packaging materials are used to surround a package completely, securing its contents from gases, vapors, moisture, and biological effects [2] of the outside environment. The taste, color, and nutritional content of the packaged good may be altering, if water vapor and atmospheric gases is allowed to permeate in or out of package. The effects of gas and vapors on food are complex and comprise a major branch of food science [3, 4]. In earlier, men used a variety of locally available natural containers to store and eat foods. Now, significant developments in food packaging have provided the means to lower the growth of microbes as well as protect foods from external microbial contamination. Packaging materials are developed to prevent the deterioration of foods by microbes resulting from exposure to air, moisture, or pH changes associated with the food or its surrounding atmosphere. Food industries have to decide which packaging material will be more appropriate for their food product taking note of the quality, safety, advantages and disadvantages of their choice.

2. Historical background

The earliest forms of packaging materials were leaves, hollowed-out tree limbs, grounds, skins, reed baskets and earthenware vessels as containers. As civilization developed, more complex containers were developed to meet specific needs. Paper (from stems of papyrus) is used as flexible packaging. It was reported that sheets of treated mulberry bark were used as a flexible packaging material by the Chinese to wrap foods and then the papermaking technique was refined and transported [5]. The use of metal containers as packaging materials started from ancient boxes and cups, made from silver and gold, which were too valuable for common use. Plastic is the latest in comparison with other packaging materials. Insulation and cushioning materials as well as foam boxes, cups and meat trays for the food industry became popular. Vinyl chloride provided the opportunity for the further development of rubber chemistry. For packaging, molded deodorant squeeze bottles, heat shrinkable films were developed from blending styrene with synthetic rubber. There were new manufacturing processes developed using various methods such as forming, molding, casting, and extrusion to churn out plastic products in vast quantities [6]. The polyethylene terephthalate (PETE) container became available during the last two decades with its use for beverages. Foods and other hot-fill products such as jams could also be packaged in PETE. Aluminium trays were replaced by plastic, microwavable trays. Metallocene catalysed polyolefins was introduced to reduce food waste. Polylactic acid from corn entered the packaging market of bio based plastic [7].

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Table 1: Different types of paper and paperboard used in food packaging.

Name of paper/paperboard	**Characteristics**	**Applications**
Kraft paper	produced by a sulfate treatment process, available in natural brown, unbleached, heavy duty, and bleached white, strongest of all commonly used paper	used to package flour, sugar, and dried fruits and vegetables
Sulfite paper	lighter and weaker than kraft paper, glazed it to improve its appearance and to increase its wet strength and oil resistance	used in laminates with plastic or foil, make small bags or wrappers for packaging biscuits and confectionary
Greaseproof paper	made through beating of cellulose fibers undergo a longer than normal hydration period, resistant to oils but not wet agents	used to wrap snack foods, cookies, candy bars, and other oily foods, a use that is being replaced by plastic films.
Glassine	very dense sheet with a highly smooth and glossy finish	used as a liner for biscuits, cooking fats, fast foods, and baked goods
Parchment paper	sulfurated cellulose to make it smoother and impervious to water and oil, not provide a good barrier to air and moisture, not heat sealable	used to package fats such as butter and lard
White board	several thin layers of bleached chemical pulp, coated with wax or laminated with polyethylene for heat seal ability	used as the inner layer of a carton
Solid board	multiple layers of bleached sulfate board, possess strength and durability	used to create liquid cartons (known as milk board) and package fruit juices and soft drinks
Chipboard	recycled paper and often contains blemishes and impurities,	used to make the outer layers of cartons for foods such as tea and cereals
Fiberboard	solid type provides good protection against impact and compression, corrugated type resistance to impact abrasion and crushing damage	used to package dry products like coffee and milk powder, shipping bulk food and case packing of retail food products

Fig. 1: Examples of paper food packages, polyethylene added to increase stiffness and strength.

Table 2: Commonly used polymeric materials, their typical properties and applications in food packaging.

Polymer name	Abbreviation	Recycling symbol	Properties	Applications
Polyethylene terephthalate	PET		Low permeability to gases and vapours, good resistant to heat, mineral oils, solvents and acids	Bottles for carbonated drinks, containers, trays and blister packs
High-density polyethylene	HDPE		Stiff, strong, tough, resistant to chemical and moisture and easy to process	Bottles for milk, juice and water, margarine tubs and cereal box liners
Polyvinyl chloride	PVC		Stiff, medium strong and transparent, resistant to chemicals, grease and oil, good flow characteristics and stable electrical properties	Bottles, packaging films and blister packs
Low-density polyethylene	LDPE		Flexible, strong, tough, easy to seal, resistant to moisture	Film applications like bread and frozen food bags, flexible lids and squeezable food bottles
Polypropylene	PP		Harder, denser, transparent and resistant to heat and chemicals	Yogurt containers and margarine tubs and microwavable packaging
Polystyrene	PS		Clear, hard and brittle, opaque, rigid, lightweight material with impact protection and thermal insulation	Egg cartons/trays, containers, lids, cups, plates, bottles and food trays

Fig. 2: Examples of plastic packaging materials

3. Commonly available food packaging materials

The most commonly used food packaging materials are glass, wood, metal, plastics, paper and other flexible packages as coatings and adhesives. Each of these packages offers unique advantages and disadvantages that have to be critically considered in making the right choice by the food processor.

Paper and paperboards

Paper and paperboard are sheet materials made from cellulose fibers derived from wood. The fibers are then pulped, bleached and treated with chemicals and strengthening agents to produce the paper product. These are commonly used in corrugated boxes, milk cartons, folding cartons, bags, sacks and wrapping paper. Paper and paperboards provides mechanical strength, they are biodegradable and have good printability. To improve their poor barrier properties, paper can coated with waxes or polymeric materials. Paper can be laminated with plastic or aluminum to improve various properties. For example, paper can be laminated with polyethylene to make it heat sealable and to improve gas and moisture barrier properties. Laminated paper is used to package dried products such as soups, herbs, and spices. Paperboards on the other hand are thicker than paper with a higher weight per unit area and often made in multiple layers. They are commonly used to make containers for shipping, such as boxes, cartons, and trays. They are seldom used for direct food contact. Apart from their poor barrier properties to oxygen, carbondioxide and water vapour other drawbacks include their being opaque, porous and not heat sealable. Different types of paper [8, 9] and paperboard [10, 9] used in food packaging can be categorized as presented in Table 1 and Fig. 1.

Plastics

The use of plastics in packaging has increased worldwide owing to their functionality, lightweight, low cost and ease of processability than conventional materials (glass, ceramics, metals, papers and boards). The packaging industry uses plastics more than 90% for flexible packaging than rigid packaging. There are more than thirty different plastics in packaging; the most common are polyolefins, polyvinyls and polyesters. The commonly used polymeric materials, their typical properties and applications in food packaging are summarized [11] in Table 2 and Fig. 2.

4. Polymer nanotechnology in packaging

The worldwide sales of nanotechnology products to the food packaging sector have risen steadily [12, 13]. There are new innovations to encourage packaging which involves the combination of food-packaging materials with antimicrobial substances such as the incorporation of antibacterial nanoparticles into polymer films to control microbial surface contamination of foods. It was observed that an intensive contact between the food product and packaging material is required to migrating and non-migrating antimicrobial materials and therefore potential food applications include vacuum or skin-packaged products, e.g. vacuum-packaged meat, fish, poultry or cheese. Nanocomposites exhibit increased barrier properties, mechanical strength, and heat resistance compared to their neat polymers and conventional composites [14, 15]. Nanoclays, kaolinite, carbon nanotubes and graphene nanosheets are used as fillers to show potentials improve the ability of plastic packaging against migration of gases and flavour compounds [16, 17, 18]. Cellulose, polylactic acid (PLA) has received attention as sustainable, biocompatible, biodegradable materials with good mechanical and optical properties. Lactic acid, the monomer of PLA, may easily be produced by fermentation of carbohydrate feedstock such as corn. Thus, PLA offers more disposal options and its manufacture is less environmentally hazards than traditional petroleum-based plastics [18, 19]. There are also possibilities to combine antimicrobial compounds with different types of carriers (plastic and rubber articles, paper-based materials, textile fibrils and food-packaging materials). A successful polymer nanotechnology in food packaging will have to take into consideration the complete life cycle of the packaging material [16]. The life cycle assessment consider the overall impact on the environment from all the stages of raw materials sourcing to the production process, transportation and delivery until it reaches end users and finally being disposed [20]. Therefore, new packaging materials are being developed to facilitate the goal of true sustainability.

5. Future trend and conclusion

The production and the use of plastics in the world have been enormously increased, worsening the problem of the waste disposal. The growing interest in environmental impact of discarded plastics has directed research on the development of plastics that degrade more rapidly in the environment. Biopolymers should be used in those applications where biodegradability and the derivation of natural resources give added value. There are health concerns regarding residual monomer and components in plastics and paper, including stabilizers, plasticizers, and condensation components such as bisphenol A. In order to ensure public safety, national and international regulatory bodies such as Food and Drug Administration (FDA), European Food Safety Authority (EFSA) carefully reviews and regulates substances used to make plastics and other packaging materials. Any substance that can reasonably be expected to migrate into food is classified as an indirect food additive. The choice of a particular plastic or a flexible package will be linked to develop in engineering and consumer studies. There will continuously be new packaging materials that will reflect developments in the technology of food processing, life style changes and environmental issues. Research and progress in these areas not only will benefit the current applications but would also lead to new markets as well in future development of packaging materials.

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