Consortium for Educational Communication

Module

on

Food Packaging

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TEXT

1. INTRODUCTION

Food packaging is part of packaging technology that enables food to stay healthy and nutritious over a period of time. Packaging is the combination of food science, processing, and preservation. In modern society, the functions of food packaging are to protect the food from external damage and contamination, contain the product to allow for transport, and provide information about the package contents to consumers. In order to select the packaging system that best fits the food to be packaged a detailed analysis of the product's characteristics needs to be performed. The nature of the product (fresh, dried, frozen, processed), its physical form and mechanical properties (size, weight, material consistency, fluid, powder), and compositional characteristics such as pH, fat content are all important to determine the most appropriate packaging system. Knowledge of the perishability of the food is also fundamental because shelf stable products do not require specific precautions for storage, while perishable foods (fruits, vegetables, meat products, dairy products) need specific temperature requirements. Understanding the product quality requirements helps to determine the necessary barrier properties (gas, water vapor, light) that are required for effective protection. After taking into account all the product characteristics, the choice of the packaging material is also essential. The material should be suitable for consumer use but also convenient for transportation, since food packaging exists because of its basic functions – protection, containment, information, and utility of use.

2. Benefits and Value of Food Packaging

Food packaging can delay and protect food from physical, chemical, and, biological deterioration. It extends shelf-life and, maintain and assures the quality and safety of products. Packaging provides protection to the food product against factors that can negatively affect food like exposure to gases, moisture, light, protection against microorganisms, insects, rodents, and other animal pests, mechanical damage, shock, and vibrations during transport and distribution. However, the basic functions of packaging are more specifically stated as follows:

1. *Containment*: containing the product in its physical form and nature.
2. *Protection*: prevention of mechanical damage due to the hazards of distribution

3. *Preservation*: prevention or inhibition of chemical changes, biochemical changes and microbiological spoilage
4. *Information about the product*: information about legal requirements, product ingredients, etc
5. *Convenience*: for the pack handlers and user(s) throughout the packaging chain
6. *Presentation*: material type, shape, size, colour, etc.
7. *Brand communication*: pack *persona* by the use of typography, symbols, illustrations, advertising and colour, thereby creating visual impact
8. *Promotion* (*Selling*): *free* extra product, *new* product, etc.
9. *Economy*: efficiency in distribution, production and storage
10. *Environmental responsibility*: in manufacture, use, reuse, or recycling and final disposal.

3. Packaging systems

Packaging systems can be categorized into three main groups: primary packaging, secondary packaging, distribution or tertiary packaging.

3.1 Primary packaging

The first-level package that directly contacts the product is referred to as the "primary package." The examples include, a beverage can or a jar, a paper envelope for a tea bag is primary packages. Their main function is to contain and preserve the product. Primary packages must be non-toxic, compatible with food.

3.2 Secondary packaging

The secondary package contains two or more primary packages and protects the primary packages from damage during shipment and storage. Secondary packages are also used to prevent contaminants from soiling the primary packages; they also unitize groups of primary packages. The examples include shrink wrap and a plastic ring connector that bundles two or more cans together to enhance ease of handling.

3.3 Tertiary package

The tertiary package is the shipping container, which typically contains a number of the primary or secondary packages. It is also referred to as the "distribution package." A corrugated box is one of the most common forms of tertiary package. Its main function is to protect the product during distribution and to provide for efficient handling.

4. Materials for food packaging

4.1 Plastics

Plastics are a group of polymers that can be formed into a wide variety of shapes using controlled heat and pressure at relatively low temperatures, compared to metals and glass. Each plastic has its own unique properties, based on its chemical composition. The performance and interaction with a variety of foods are different for each material. Thus, the plastic material for the packaging of a specific food is selected to function well within the parameters of the application.

4.1.1. Types of plastics and general properties

a) Polyethylene (PE)

Polyethylene or polymerized from ethylene, is the plastic most commonly used for food packaging. PE generally has flexibility, good moisture control, oil and chemical resistance, and good impact strength. PE is usually the most economical choice. However, PE is of two types, high-density polyethylene (HDPE) and low-density polyethylene (LDPE). Low-density polyethylene is softer and more flexible, and has lower tensile strength than HDPE. Since it has relatively weak intermolecular forces, LDPE has a low melting temperature, 105–115 ˚C, so it is a useful material for heat sealing. LDPE also has good impact and tear strength. Common applications for LDPE include stretch wraps, shrink wraps, and many types of bags and pouches. Like LDPE, HDPE has good oil and grease resistance. It has better barrier properties than LDPE, since permeation occurs almost exclusively through amorphous areas of a polymer, and HDPE has less amorphous area and higher crystallinity than LDPE. The improved stiffness of HDPE makes it more suitable for rigid or semi-rigid packaging applications, such as bottles, tubs, and trays.

b) Polypropylene (PP)

Polypropylene which is polymerized from propylene gas has good chemical and grease resistance. Barrier properties of PP are similar to those of HDPE; it is a good water vapor barrier but a poor gas barrier. PP has a lower density and a higher glass transition temperature (the temperature above which a plastic becomes soft and flexible) and higher melting temperature than PE. PP is suitable for use with products that require moderately high temperatures such as hot filling or reheating (but not cooking) in a microwave oven. One of the main uses of PP in food packaging is in closures (caps).

c) Polystyrene (PS)

Polystyrene is a linear addition polymer of styrene resulting in a benzene ring attached to every other carbon in the main polymer chain. It is is brittle, clear, and has high surface gloss. The use of PS in food packaging is aesthetically appreciated, but the material cannot generally be used when extended shelf life is required because of its poor water vapor and gas barrier properties. The brittleness of PS limits its use where good impact resistance is required. In order to reduce the tendency to fracture, oriented polystyrene (OPS) is commonly used. Typical applications include produce and meat trays, lids for drink cups, and inexpensive party glasses. High-impact PS (HIPS) is a PS co-polymer with polybutadiene (synthetic rubber). Adding the synthetic rubber improves the impact resistance significantly. HIPS is commonly used for disposable cutlery, tubs, and other thermoformed containers.

d) Polyester (PET)

Polyethylene terephthalate (PET) is commonly produced by the reaction of ethylene glycol and terephthalic acid. The properties of PET are attractive as a food packaging material; it has very high mechanical strength, good chemical resistance, light weight, excellent clarity, and reasonably high barrier properties. PET is also stable over a wide range of temperatures (−60 ˚C to 220 ˚C). Thus, under some circumstances PET can be used for “boil-in-the-bag” products, since it has resistance to higher temperatures than many other plastics.

e) Polyvinyl chloride (PVC)

Polyvinyl chloride is produced from vinyl chloride monomers. PVC has high toughness and strength, good dimensional stability, good clarity, excellent oil barrier properties, and good heat sealability. One of the most widespread uses of PVC is in various blister packages (medical tablets, toothbrushes). The high plasticizer content and the presence of residual vinyl chloride monomer have been a concern for use of PVC as a food packaging material. The levels of vinyl chloride monomer (VCM) in PVC food packaging are currently extremely low.

f) Polyvinylidene chloride (PVDC)

Polyvinylidene chloride has one more chlorine atom per monomer unit than PVC. PVDC is also a very heat-sensitive material. PVDC can be modified with various co-monomers, typically in amounts between 6% and 28%. Properties of PVDC depend on the type as well as the amount of the co-monomer. The most noticeable benefit of this plastic is its excellent barrier properties against water vapor, odors/flavors, and gases. Thus, PVDC plastic is commonly used in food and pharmaceuticals as a barrier packaging material.

g) Polyamides (PA or nylon)

Nylons, or polyamides (PA), are a whole family of synthetic polymers. It is formed by the condensation polymerization of a di-amine and a di-basic acid or by polymerization of certain amino acids. Various chemical structures can be produced but the amide (−CONH−) functional group is always present in the main structure and is largely responsible for the mechanical strength and barrier properties. Based on their polymerization method, two categories of PA can be identified. One family is made by polymerizing a mixture of di-amines and di-acids (Nylon 6, 6). The other family of PAs is formed from only one type of monomer, an amino acid, and is identified by the number of carbons in that amino acid (Nylon 6). Polyamides in general provide excellent optical clarity, oil and chemical resistance, and mechanical strength over a wide range of temperatures. In packaging applications, the use of PA is often found in the form of film for high temperature sterilization or hot-filling applications. PA also acts as flavor and gas barriers, but have poor water vapor barrier properties.

h) Polycarbonate (PC)

Polycarbonate is made from carbonic acid and bisphenol A. The material is a very tough and rigid plastic with excellent clarity. However, it has a relatively high permeability to both water vapor and gases. Thus, it must be coated if good barrier properties are required. Its main packaging uses are large refillable water bottles and refillable milk jugs.

4.1.2. Processing of plastics

a) Extrusion

Most plastic forming processes begin with melting the plastic in an extruder. In the extruder, thermoplastics are mixed and softened, which enables shaping into some desired form when they reach an optimum temperature and pressure.

b) Thermoforming

In thermoforming, a plastic sheet heated to its optimum temperature (near its melting temperature) is placed over a mold, and pressure is applied to stretch it into a designed shape.

c) Molding

Injection molding

In an injection molding operation, the molten plastic (from the extruder) is injected into a mold with the desired shape, cooled, and ejected from the mold. Injection molding is widely used for making threaded closures (caps), tubs, and jars, and for making the initial shapes (preforms) used for injection blow-molded bottles.

Blow molding

In the blow molding process, an initial shape (called a parison) is surrounded by a mold with the desired shape, and air is blown into the parison to force it to expand against the wall of the mold. The mold is then opened and the solidified product is ejected.

4.2. Paper and paper-based materials

Paper and paperboard are the most commonly used packaging materials around the world. More than 95% of paper is made from wood, and the remaining sources are mainly agricultural by-products, such as straw (of wheat, rye, barley, and rice), sugar cane bagasse, cotton, flax, bamboo, corn husks, and so on. Making pulp is the initial stage in making paper or paperboard, and the quality of the paper is closely related to the quality of the pulp. Pulping can be done using mechanical, chemical, or a combination process. Mechanical pulping produces papers that are characterized by relatively high bulk and low strength as well as relatively low cost. Their use in packaging is very limited. Chemical pulping produces stronger and higher quality paper, and is also more expensive. Combination processes are intermediate in cost and properties. The pulp produced may be unbleached or bleached to various degrees.

4.2.1. Types of paper and their applications

Different varieties of papers are used in packaging applications. The major types of papers used for food packaging are as follows.

a) Kraft paper

Kraft paper is the most used packaging paper and has excellent strength. It is made using the chemical pulping process, and is usually produced from soft wood. Unbleached kraft is the strongest and most economical type of paper.

b) Bleached paper

Bleached paper is produced using bleached pulps that are relatively white, bright, and soft. Its whiteness enhances print quality and aesthetic appeal. It is generally weaker than unbleached paper. This type of paper is used uncoated for fancy bags, envelopes, and labels.

c) Greaseproof and glassine

Greaseproof is a dense, opaque, non-porous paper made from highly refined bleached kraft pulp. The prolonged beating during processing results in short fibers. Glassine derives its name from its glassy smooth surface. After the initial paper making process, it is further processed in the presence of steam. It does not have complete oil barrier but is still fairly resistant to oil. These papers are often used for packaging butter and other fatty foods.

d) Waxed paper

Waxed paper is produced by adding paraffin wax to one or both sides of the paper during drying. Many base papers are suitable for waxing, including greaseproof and glassine. The major types are dry waxed, wet waxed, and wax laminated. Dry-waxed paper is produced using a heated roller to allow the wax to soak into the paper. Wet-waxed paper is produced when the wax is cooled quickly after it is applied, so that the wax remains on the surface of the paper. Wax-laminated paper is bonded with a continuous film of wax which acts as an adhesive, so that it can provide both moisture barrier and a heat-sealable layer.

e) Vegetable parchment

Vegetable parchment is produced by adding concentrated sulfuric acid to the surface of the paper to swell and partially dissolve the cellulose fibers. It produces a grease resistant paper which maintains its strength well when it is wet. Vegetable parchment is odorless, tasteless, resists boiling temperature, and has a fiber-free surface. Labels and inserts on products with high oil or grease content are frequently made from parchment.

4.2.2. Paperboards and their applications

Various types of paperboard are manufactured but paperboard for food packaging generally includes white board, liner board, food board, carton board, chip board, and corrugated board.

a) White board

White board is made with a bleached pulp liner on one or both sides to improve appearance and printability, and the remaining part is filled with low-grade mechanical pulp. White board is suitable for contact with food and is often coated with polyethylene or wax for heat sealability. It is used for ice cream, chocolate, and frozen food cartons.

b) Liner board

Liner board is usually made from softwood kraft paper and is used for the solid faces of corrugated board. Liner board may have multiple plies. Increasingly, linerboards containing recycled fiber are being used in packaging.

c) Food board

Food board is used to produce cartons that are suitable for direct food contact. It is normally made using 100% pure pulp. Food board is a sanitary, coated, and water resistant paperboard. It should be designed to protect against migration of outside contaminants (such as ink or oil) into packaged food. Food board can be used for all types of foods, particularly frozen and baked foods.

d) Carton board (boxboard)

Carton board is used to make folding cartons and other types of boxes. Most often, this is a multilayer material made of more than one type of pulp, and often incorporating recycled fibers. To improve its appearance, it may be clay coated on one or both surfaces.

e) Chipboard

Chipboard is the lowest quality and lowest cost paperboard, made from 100% recycled fiber, and is not used in direct contact with foods. Outer cartons for tea and breakfast cereals are some examples. It is also commonly lined with whiteboard to produce a multi-ply board such as carton board.

f) Corrugated board

Corrugated board has an outer and inner lining of kraft paper with a central corrugating (fluted) material. Corrugated boards resist impact, abrasion, and compression forces so they are commonly used in shipping containers.

4.3. Metals

4.3.1. Types of metal and general properties

For food packaging, four types of metal are commonly used: steel, aluminum, tin, and chromium. Steel and aluminum are commonly used in production of food cans, and are the primary materials for metal packaging. Food cans are most often made of steel, and beverage cans are usually produced from aluminum. Steel tends to oxidize when it is exposed to moisture and oxygen, producing rust. Therefore, tin and chromium are used as protective layers for steel. Tinplate is a composite of tin and steel made by electrolytic coating of bare steel with a thin layer of tin to minimize corrosion. If chromium is used to provide corrosion protection instead of tin, the resulting material is called electrolytic chromium-coated steel (ECCS) or tin-free steel (TFS). ECCS is less resistant to corrosion than tinplate but has better heat resistance and is less expensive.

4.3.2. Two types of cans

There are two basic styles of cans: three-piece and twopiece. As the name indicates, a three-piece can is made from three pieces (a body blank and two ends), and a two-piece can is made from two pieces (one body and one end).

4.3.3. Metal foil and containers

Aluminum foil is the most commonly produced metal foil. It is manufactured by passing aluminum sheet between a series of rollers under pressure. Foil is widely used for wraps (9 μm), bottle caps (50 μm), and trays for ready-to-eat meals (50–100 μm). Aluminum foil has excellent barrier properties against gases and water vapor. Thus, it is also used as the barrier material in laminated films for packages, such as those in retort pouches. Collapsible aluminum tubes can be used for the packaging of viscous products such as mustard, mayonnaise, and ketchup.

4.3.4. Coating

One of the major problems associated with metal packaging is corrosion. The inside of a can is normally coated to prevent interaction between the can and its contents. The outside of a can is generally also coated to provide protection from the environment. Coatings used in cans need to provide an inert barrier (must not impart flavor to the product), must usually resist physical deformation during fabrication and be flexible. The coating must adhere well to the metal and be non-toxic (for food packaging). The commonly used coating materials for food packaging include the following.

a) **Epoxy-phenolic compounds**: these are used for all types of steel and cans. They are resistant to acids and have good heat resistance and flexibility. They are especially suitable for acidic products. Examples include beer, soft drinks, meat, fish, fruits, vegetables

b) **Vinyl compounds:** vinyl compounds have good adhesion and flexibility, and are resistant to acid and alkaline products. However, they are not suitable for high-temperature processes such as retorting of food. They are used for carbonated beverages and as clear exterior coatings.

c) **Phenolic lacquers:** phenolic compounds are inexpensive and resistant to acid and sulfide compounds. They are used for acid fruits, fish, meats, soups, and vegetables.

d) **Polybutadiene lacquers:** polybutadiene compounds have good adhesion, chemical resistance, and high heat resistance. They are used for beer and soft drinks, soups, and vegetables (if zinc oxide is added to the coating).

e) **Acrylic lacquers:** acrylic lacquers are expensive coating materials. They take heat processing well and provide an excellent white coat. They are used both internally and externally for fruits and vegetables.

f) **Epoxy amine lacquers:** epoxy amine lacquers are also expensive. They have excellent adhesion, heat and abrasion resistance, and flexibility, and no off-flavor. They are used for beer and soft drinks, dairy products, and fish.

4.4. Glass

Glass is defined as "an amorphous inorganic product of fusion that has been cooled to a rigid condition without crystallizing". For food packaging, bottles or jars are the types of glass packaging most often used, bottles being the primary use. Glass has many properties which make it a popular choice as a packaging material:

· Glass is able to withstand heat treatments such as pasteurization and sterilization.

· It does not react with food.

· It is rigid and protects the food from crushing and bruising.

· It is impervious to moisture, gases, odours and microorganisms.

· It is re-usable, re-sealable and recyclable.

4.4.1. Forming of glass

Glass is made primarily of silica, derived from sand or sandstone. For most glass, silica is combined with other raw materials in various proportions. The glass making process begins with weighing out and mixing of the raw materials and introduction of the raw material to the glass melting furnace, which is maintained at approximately 1500 ˚C. Cullet, broken or recycled glass, is also an important ingredient in glass production. In the melting furnace, the solid materials are converted to liquid, homogenized, and refined (getting the bubbles out). At the end of the furnace, a lump of molten glass, called a “gob,” is transferred to the glass forming process. For food packaging, glass can be formed using the blow and-blow process, or wide-mouth-press-and-blow process. In the blow-and blow process, compressed air blows the gob into the blank mold of the forming machine and creates the shape of the parison. Then, the completed parison is transferred into the blow mold where air blows the parison to form a final shape. In the wide-mouth-press-and-blow process, a metal plunger is used to form the gob into the parison shape, instead of using air blowing.