18 Food Packaging

Introduction

This chapter is in the newly named *Aspects of Food Processing* section of the text. The chapters covering *food preservation* and *food additives* components of the food processing section are discussed in Chaps. 16 and 17, respectively.

Adequate packaging is an industry technique that may be used along with preservation and has the intent of slowing down or stopping spoilage that would otherwise exhibit loss of taste, textural quality, or nutritive value of food. C*rops* as well as *animal products* produce market-ready and adequately long shelf life food products if adequately packaged.

As presented in the chapter on food preservation, processed foods represent the change of raw material into food of another form. Food processing involves preservation and also packaging.

For added clarification, and a succinct explanation, the following is utilized.

> Food processing and preservation are two techniques that are used to maintain the quality and freshness of foods. In terms of how they are performed, food processing and preservation are different; food preservation is just part of the entire procedure of processing foods. Food processing mostly involves both *packaging* and preservation, while food preservation is concerned with the control and elimination of the agents of food spoilage… (http://www.wisegeek.com/what-is-the-difference-between-food-processing-and-preservation.htm)
>
> (italics added)

Packaging as part of food processing assists in preserving food against spoilage and contamination as well as extending the shelf life. It provides containment (holding the product), protection (quality, safety, freshness), information (graphics, labels), and utility of use or convenience (The Society of the Plastics Industry (SPI), Washington, DC). Yet, packaging offers much more than these benefits to the manufacturer and consumer. Packaging protects food, may modify atmosphere, thus extending shelf life, gets a message across, aids in marketing, provides added content security, and so forth. It may provide portion control, combating "portion distortion," convenience of use, and convenient transport. This assists the child as well as the adult consumer.

Packaging may simply involve having clean hands, a sanitary pair of foodservice tongs, and a piece of tissue in a bag served across a bakery counter or, it may involve adherence to a specific time and temperature heat application in a foodservice can that is transported along continents. There is great variance in the idea of packaging food to be discussed in this chapter.

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There exist various packaging materials, including films, and package oxygen levels that protect foods from air. Packaging may also maintain time-sensitive foods and use dating or doneness indicators. It may be used as a promotion tool on store sales shelves.

Packaging materials for food include metal, glass, paper, plastics, foil, wood crates, cotton, or burlap (jute). Food may be vacuum packaged, subject to controlled or modified atmospheric packaging, or be aseptically packaged. Manufacturers must adhere to FDA regulations regarding both the method and materials of packaging.

Routinely, we see that consumer-convenient packaging such as microwaveable packages, single-serve products, tubs, and zippered pouches tampers evidence, and package atmosphere has become increasingly important as a packaging selection (Sloan 1996). Packaging functionality is a demand of both consumers and food companies alike, who want packaging/materials that meet their needs. Packaging can certainly be very creative.

Types of Packaging Containers

Packaging containers are classified as primary, secondary, and tertiary. Specific packaging materials are discussed later. One packaging material though, namely, plastic wrap, may function as all three types. A ***primary*** container is the bottle, can, drink box, and so forth that contains food. It is a *direct* food contact surface and is, therefore, subject to approval by the Food and Drug Administration (FDA), which tests for the possible migration of packaging materials into food.

Several primary containers are held together in ***secondary*** containers, such as corrugated fiberboard boxes (commonly, yet not correctly, referred to as cardboard), and do *not* have *direct* food contact. In turn, several secondary containers are bundled into ***tertiary*** containers such as corrugated boxes or overwraps that prepare the food product for distribution or palletizing. This offers additional food protection during storage and distribution where errors, such as dropping and denting or crushing cartons, may occur. Tertiary containers prevent the brunt of the impact from falling on the individual food container.

See foodandbeveragepackaging.com.

Packaging Functions

The functions of packaging are numerous and include such purposes as protecting *raw* or *processed* foods against *spoilage* and *contamination* by an array of external hazards. Packaging serves as a barrier in controlling potentially damaging levels of light, oxygen, and water. It facilitates ease of use, offers adequate storage, conveys information, and provides evidence of possible product tampering.

Packaging achieves its functions/goals by assisting in the following manners:

- Preserving against spoilage of color, flavor, odor, texture, and other food qualities.
- Preventing contamination by biological, chemical, or physical hazards.
- Controlling absorption and losses of O_2 and water vapor.
- Facilitating ease of using product contents—such as packaging that incorporates the components of a meal together in meal "kits" (e.g., tacos).
- Offering adequate storage before use—such as stockable, resealable, pourable.
- Preventing/indicating tampering with contents by tamper-evident labels.
- Communicating information regarding ingredients, nutrition facts, manufacturer name and address, weight, bar code information, and so forth via package labeling.
- Marketing—standards of packaging, including worldwide acceptability of certain colors and picture symbols, vary and should be known by the processor. Packages themselves may promote sales. They may be rigid, flexible,

metallized, and so forth and may also carry such information as merchandising messages, health messages, recipes, and coupons.

Packaging Materials

Packaging materials for food may differ in commercial and retail operations. Either type of operation though may include some of the same materials for food packaging. Included as packaging materials may be paper, glass, plastic, metal, cloth, including burlap, paper, poly or mesh bags for 5# or 10# of fresh potatoes. As well, there exist packaging/shipping materials such as bottles, jugs, jars, or cans; plastic 4- and 6-pack rings for securing cans or bottles; boxes for items such as pizza, cakes, pies, cupcake inserts, confections, or take-out foods, disposable deli tissue, insulated "cold packs," tubes, pails, drums, paper or plastic wraps or bags, and shipping foam "peanuts," just to name a few items!

In choosing the appropriate packaging for their product, packers must consider many variables. For example, *canners* must make packaging choices based on cost, product compatibility, shelf life, flexibility of size, handling systems, production line filling and closing speeds, processing reaction, impermeability, dent and tamper resistance, and consumer convenience and preference (Sloan 1996).

Processors who use *films* for their product must select film material based on its "barrier" properties that prevent oxygen, water vapor, or light from negatively affecting the food. As an example, the use of packaging material that prevents light-induced reactions will control degradation of the chlorophyll pigment, bleaching or discoloration of vegetable and red meats, destruction of riboflavin in milk, and oxidation of vitamin C.

The most common food packaging materials include metals, glass, paper, and plastic. Some examples of these leading materials appear in the following text.

Metal

Metals such as steel and aluminum are used in cans and trays. A metal can forms a hermetic seal, which is a complete seal against gases and vapor entry or escape, and it offers protection to the contents. The trays may be reusable, or disposable recyclable trays, and either steam table or No. 10 can size. Metal is also used for bottle closures and wraps.

Steel

Steel has a noncorrosive coating of tin inside, thus the name "tin can," whereas *tin-free steel* (TFS) relies on the inclusion of chromium or aluminum in place of tin. Steel is manufactured into the traditional *three-piece* construction can, which includes a base, cylinder, and lid, and also a *two-piece* can, consisting of a base and cylinder in one piece without a seam and a lid. The latter are lightweight and stackable. The vast majority of the many billion cans used annually in the United States are made of steel.

In addition to steel cans and trays, tens of billions of beverage bottle crowns (closures with crimped edges) made of steel are used annually in the United States. The five primary types of steel vacuum closures include side seal caps, lug caps, press–twist caps, snap-on caps, and composite caps.

Aluminum

Aluminum is easily formed into cans with hermetic seals. It is also used in trays and for wraps such as aluminum foil, which provide an oxygen and light barrier. Aluminum is lighter in weight than steel and resists corrosion.

Glass

Glass is derived from metal oxides such as silicon dioxide (sand). Glass is used in forming bottles or jars (which subsequently receive hermetic seals) and thus protects against water vapor or oxygen loss. The thickness of glass must be sufficient to prevent breakage from internal pressure, external impact, or thermal stress. Glass that is *too* thick increases weight and thus freight costs and is subject to an increased likelihood of thermal stress or external impact breakage.

Technological advances in glass packaging have led to improvements in strength and weight, as well as color and shape. A resurgence of glass may be noted on supermarket shelves. The product is commercially sterile, yet the see-through glass tends to denote "fresh" to the consumer.

Glass coatings, similar to eyeglass coatings of silicons and waxes, may be applied to glass containers in order to minimize damage-causing nicks and scratches.

Paper

Paper is derived from the pulp of wood and may contain additives such as aluminum particle laminates, plastic coating, resins, or waxes. These additives provide burst strength (strength against bursting), wet strength (leak protection), and grease and tear resistance, as well as barrier properties that assure freshness, protect the packaged food against vapor loss and environmental contaminants, and increase shelf life.

Varying thicknesses of paper may be used to achieve thicker and more rigid packaging.

- *Paper* is thin (one layer) and flexible, typically used in bags and wrappers. Kraft (or "strong" in German) paper is the strongest paper. It may be bleached and used as butcher wrap or may remain unbleached and used in grocery bags.
- *Paperboard* is thicker (although still one layer) and more rigid. Ovenable paperboard is made for use in either conventional or microwave ovens by coating paperboard with PET polyester (see Plastic).
- Multilayers of paper form *fiberboard*, which is recognized as "*cardboard*."

When packaging serves as a *primary* container for food, it is a food contact surface and must be coated or treated accordingly. For example, *paper* bags or wraps for bakery products (thus a food contact surface) may be laminated to improve burst or wet strength, grease, and tear resistance or prevent loss of product moisture. *Paperboard* may be lined and formed to hold fluid milk. It may be formed into canisters with foil linings and resealable plastic overwraps, to provide convenience, protection, and extended shelf life. Another example is *corrugated paperboard* which may be waxed in order to package foods such as raw poultry.

Dual-ovenable trays are designed to be *microwaveable* and also able to be placed in a *conventional* oven. As with all new processing and packaging technology, the use of these trays is a new concept for many people and may require consumer education, including written instructions provided by the food manufacturers.

Recycled papers may contain small metal fragments that could be unacceptable in packaging used for microwave cooking. The sparks, generated as the microwaves are reflected by metal, may "arc" and start a fire in the microwave oven. Yet, paper may be purposely manufactured to designated specifications and deliberately contain areas with small particles of aluminum, which form a "*susceptor*."

Susceptors are desirable for browning and crisping microwaveable foods such as baked goods, french fries (often placed in individual compartments of a susceptor), and pizzas. They are also used in packages of microwaveable popcorn. Due to the fact that the metal reflects microwaves, which subsequently heat the surface of the food, the browning and crisping can occur.

Paper may be used in combination with metal, such as aluminum, to produce fiber-wound tubing. An example of fiber-wound tube containers used for refrigerated biscuits is shown in Fig. 18.1.

Paper and metallized films are increasingly chosen for food applications. The appearance, and its barrier properties to grease, and moisture are desirable for packaging specific foods. These materials may also contain plastic, which is discussed in the following chapter section.

Fig. 18.1 An example of fiber-wound tubes (*Source*: Sara Lee Corporation)

Plastic

Plastic has shrink, nonshrink, flexible, semirigid, and rigid applications and varies in its degree of thickness. In making plastics, pellets and blown bubbles may be seen in Figures18.2 and 18.3.

Important *properties* of the many types of plastics that make them good choices for packaging material include the following:

- Flexible and stretchable
- Lightweight
- Low-temperature formability
- Resistant to breakage, with high burst strength
- Strong heat sealability
- Versatile in its barrier properties to O_2, moisture, and light

Basic hydrocarbon building blocks such as ethane and methane, which are derived from natural gas and petroleum, form organic chemical compounds called *monomers*. These are then chemically linked to form plastic molecular chains, or *polymers*. Their manufacture represents a small percentage of total US energy consumed. Plastic has multiple *functions* as a packaging material, including use in bottles and jars, closures, coatings, films, pouches, tubs, and trays (The Society of the Plastics Industry (SPI), Washington, DC). It may also be used *in combination* with other packaging materials such as metal (for lining cans), paper, and so forth.

Fig. 18.2 Polyethylene pellets (*Courtesy*: Rodeo Plastic Bag and Film, Inc., Mesquite, TX)

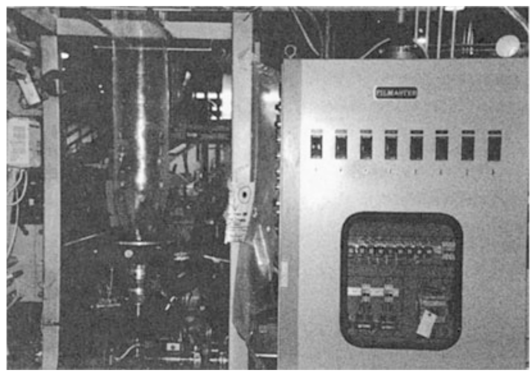

Fig. 18.3 Blown film bubble coming off the die (*Courtesy*: Rodeo Plastic Bag and Film, Inc., Mesquite, TX)

Choices of Plastics for Packaging. The food industry must provide packaging with barrier protection (against moisture, light, air, grease, and so forth) and must be familiar with what level of barrier performance is warranted for the foods they are packaging. *Insufficient* packaging, attributable in part to a high cost of materials, is not satisfactory, and *too much* performance (excesses in packaging contribution), with excessive barrier protection, is unnecessary.

Among the thousand types of plastics that are created, less than two dozen are polymers utilized in food packaging (see Table 18.1). Some of the more commonly used plastics for food products are briefly discussed in the following.

Table 18.1 Example of the repeating units of common packaging polymers

Polymer	Repeating unit
Polyester (PET)	
Polyethylene (PE)	
Polypropylene (PP)	
Polystyrene (PS)	

Source: The Society of the Plastics Industry

Polyethylene (PE): Polyethylene is the most common and the least expensive plastic, comprising the largest percentage of total plastic packaging. It is a water vapor (moisture) barrier and prevents dehydration and freezer burn. Polyethylene pellets are used in producing plastic, such as plastic bags, "zipper" seals, and plastic storage containers. Use of this PE may be recommended for less plasticizer migration into food.

Polyethylene with ethyl vinyl acetate (EVA): Polyethylene with ethyl vinyl acetate creates "freezer wrap," which offers moisture-loss protection without getting brittle in low temperatures. Polyethylene terephthalate (PET) has been used widely, including as a tube which dispenses food. Some advantages of PET is that it withstands high-temperature foods and is lighter in weight than the glass that it replaces. Polyethylene naphthalate (PEN) received FDA approval in 1996 for use in food packaging. It provides a barrier against gas, moisture, and ultraviolet light. As bottled beverages, including waters, teas, and juices, continue to appear in the marketplace, the use of plastic bottle containers made of PET and PEN may be increasing.

Polypropylene (PP): Polypropylene has a higher melting point and greater tensile strength than polyethylene. It is often used as the inside layer of food packages that are subject to higher temperatures of sterilization (e.g., retort pouches or tubs).

Polystyrene (PS): Polystyrene is a versatile, inexpensive packaging material and represents less than 10 % of total plastic packaging. When foamed, its generic name is expandable polystyrene (EPS). This styrofoam has applications in disposable packaging and drinking cups. It offers thermal insulation and protective packaging. EPS is used in "clam shell" fast-food packaging, egg cartons, bowls, cups, and meat trays and is the "peanuts" in packages. Substantially less energy is required to form polystyrene cups than paperboard cups.

Polyvinyl chloride (PVC or vinyl): Polyvinyl chloride comprises less than 10 % of total plastic packaging. It blocks out air and moisture, preventing freezer burn, and offers low permeability to gases, liquid, flavors, and odors. PVC prevents the transfer of odor and keeps food fresh by controlling dehydration and is capable of withstanding high temperatures without melting. PVC has good puncture resistance and "cling" properties. It is used to prevent splattering in microwave food preparation.

Polyvinylidene chloride (*PVDC*, Saran®): Polyvinylidene chloride is a thermoplastic resin used for household wraps and has excellent barrier properties. *Cryovac* is a Saran film used in vacuum-sealing (*Kryos* = cold, *Vacus* = empty in Latin).

Polyvinylidene chloride (PVDC) and ethylene vinyl alcohol (EVOH) are also utilized as barrier plastics. They have properties related to oxygen and water vapor permeability.

Purpose of Packaging: Food and Agriculture Organization (FAO) of the United Nations.

The basic purpose of packaging is to protect meat and meat products from undesirable impacts on quality including microbiological and physio-chemical alterations. Packaging **protects** foodstuffs during processing, storage and distribution from:

- **Contamination by dirt** (by *contact with surfaces and hands*)
- **Contamination by micro-organisms** (*bacteria, moulds, yeasts*)
- **Contamination by parasites** (*mainly insects*)
- **Contamination by toxic substances** (*chemicals*)

- **Influences affecting colour, smell and taste** (*off-odour, light, oxygen*)
- **Loss or uptake of moisture** (*evaporation* or *water absorption*)

Adequate packaging can prevent the above listed secondary contamination of meat and meat products. But the further growth of microorganisms, which are already present in meat and meat products, cannot be interrupted through packaging only. To halt or reduce microbial growth, packaging has to be **combined** with other treatments, such as **refrigeration**, which will slow down or stop the further growth of microorganisms, or with **heating/sterilization**, which will reduce or completely eliminate contaminating microorganisms.—FAO

(Other foods too)

Many manufacturers specify proprietary molded and shaped bottles to hold their specific food contents. The appropriate plastic may be chosen to satisfy this highly specialized demand.

Manufacturers may also use *food-based* materials to produce thermal plastic resins. They are made from natural sugars found in corn and other plants. For example, wheat starch and corn sugar are being developed for packaging purposes as biodegradable materials that will compost down fully in around 30–60 days (Higgins 2000).

Metal, glass, paper, and plastic, the most common food packaging materials, have been discussed briefly. At this point, let us move on to view some other packaging materials.

Other Packaging Materials

Cotton or **burlap** (jute) may be used for grains, flour, legumes, and some vegetables, primarily in transport.

Edible films are subject to FDA approval because they become part of the food. Natural edible films extend shelf life, although for shorter time than synthetic nonedible packaging materials. Edible films are a unique type of packaging material.

These films are "... defined as a thin layer of edible material formed on a food as a coating or placed (pre-formed) on or between food components. Its purpose is to inhibit migration of moisture, oxygen, carbon dioxide, aromas, and lipids, etc.; carry food ingredients (e.g. antioxidants, antimicrobials, flavor); and/or improve mechanical integrity or handling characteristics of the food" (Krochta & DuMulder-Johnston 1997).

Antimicrobials may be included in films or containers. Antimicrobial activity may be due to the addition of specific substances, radiation, or gas flushing. Irradiation sterilization of packaging materials may be forthcoming with FDA approval.

Examples of edible films include those used as the sugar shell on individual chocolate-covered candies (M&Ms®), *casings*, such as in sausage, and *edible waxes*, such as those applied to fruits and vegetables. Serving in the role of edible films, the casings "contain," and the waxes function to improve or maintain appearance, prevent mold, and contain moisture while still allowing respiration. As well, food may be coated with a thin layer of polysaccharides such as cellulose, pectin, starch and vegetable gums, or proteins, such as casein and gelatin. Cut, dried, fruit pieces are often sprayed with an edible film prior to their inclusion into items such as breakfast cereal (see "Active Packaging Technologies" section).

Bindings may be applied to a food's surface to be an adhesive for seasoning. Other coatings may significantly improve appearance (and reduce microbial contamination) by replacing egg washes and acting as a glaze.

Foil is a packaging material that may be used in snack bags (chips) or as a laminate in aseptic packaging (see Aseptic Packaging). It is used as a wrapping for dry, refrigerator, or freezer storage. It provides a moisture-proof and vapor-proof barrier.

Laminates are multilayers of foil, paper, or plastics that may be utilized selectively according to the specific food packaging need.

In combination, the various laminates may provide more strength and barrier protection than the individual laminate material. Laminates provide barriers useful in controlling O_2, water vapor, and light transmission, and they provide good burst strength. The laminates may resist pinholes and flex cracking. Retort pouches are examples of laminates used in packaging and contain polyester film, aluminum foil, and polypropylene.

Resins are used for sealing food packages. They must withstand the stress of processing and offer seal integrity that prevents product contamination.

Wood may be used in the manufacture of crates that contain fresh fruits and vegetables.

Bag in a box is now offered in five-gallon bags with snap-on caps over a 1″ polyethylene spout. There is a high barrier film, with heat resistance up to 190 °F.

Regardless of the materials that are selected for use, *source reduction*, *reuse*, and *recycling* should be important considerations of packaging manufacturers. The food industry challenge is to provide the appropriate materials to accomplish packaging functions at reasonable cost.

Controlling Packaging Atmosphere

Reduced *temperature* remains as the primary means of food protection. However, controlling the *other* known elements in the package environment, such as O_2 (controlled or modified atmosphere in packaging), CO_2, water vapor, and ethylene concentration, may also reduce spoilage and contamination (e.g., enzymatic, biological), thus extending shelf life. The material that follows in this chapter will address controlling the internal package environment and modification of gases.

The following are the significant manners of controlling packaging atmosphere. (ROP is defined as any packaging procedure that results in a reduced oxygen level in a sealed package.) The term is often used because it is an inclusive term and can include other packaging options such as (1) *cook-chill*, (2) *controlled atmosphere packaging (CAP)*, (3) *Modified Atmosphere Packaging (MAP)*, (4) *sous vide*, *and* (5) *vacuum packaging*.

A definition and examples of reduced oxygen packaging follow.

What is ROP?

ANFP Association of Nutrition & Foodservice Professionals

(http://www.anfponline.org/CE/food_protection/2010_11.shtml)

According to AFNP

> Packaging using an ROP method can be used to describe any packaging process in which a sealed product has an environment that is reduced in oxygen. ROP is an all-inclusive term used to describe methods such as Controlled Oxygen Packaging (CAP), Modified Atmosphere Packaging (MAP), Cook-Chill, Vacuum Packing (VP), and Sous Vide. Each form of ROP has its unique methods and outcomes, but all have one thing in common: the final product will be in a sealed package in which there is little or no oxygen present. . .
>
> The method of Sous Vide is a specific process of ROP utilized for food that requires refrigeration/freezing after packaging—usually potentially hazardous foods (PHF). The process of Sous Vide does reduce the initial bacterial load of a product to lower levels, but not low enough to make the food shelf stable. The process generally has several steps: preparation of the raw materials (which may include partial grilling or a similar step); packaging the product by use of vacuum sealing; cooking/pasteurizing the product to the desired cooking temperature while in the package; rapid cooling/freezing; reheating to 165 °F for hot holding or any temperature for immediate service. This method is said to retain the color, texture, moisture, and flavor of the final product.—AFNP

See the following for ***Definitions:***

http://www.cfsan.fda.gov/~dms/fcannex6.html

FDA (B) Definitions.

The term ROP is defined as any packaging procedure that results in a reduced oxygen level in a sealed package. The term is often used because it is an inclusive term and can include other packaging options such as:

1. *Cook-chill* is a process that uses a plastic bag filled with hot cooked food from which air has been expelled and which is closed with a plastic or metal crimp.
2. *Controlled atmosphere packaging (CAP)* is an active system which continuously maintains the desired atmosphere within a package throughout the shelf life of a product by the use of agents to bind or scavenge oxygen or a sachet containing compounds to emit a gas. Controlled atmosphere packaging (CAP) is defined as packaging of a product in a modified atmosphere followed by maintaining subsequent control of that atmosphere.
3. *Modified Atmosphere Packaging (MAP)* is a process that employs a gas flushing and sealing process or reduction of oxygen through respiration of vegetables or microbial action. Modified Atmosphere Packaging (MAP) is defined as packaging of product in an atmosphere which has had a one-time modification of gaseous composition so that it is different from that of air, which normally contains 78.08 % nitrogen, 20.96 % oxygen, and 0.03 % carbon dioxide.
4. *Sous vide* is a specialized process of ROP for partially cooked ingredients alone or combined with raw foods that require refrigeration or frozen storage until the package is thoroughly heated immediately before service. The sous-vide process is a pasteurization step that reduces bacterial load but is not sufficient to make the food shelf stable. The process involves the following steps:
   (a) Preparation of the raw materials (this step may include partial cooking of some or all ingredients).
   (b) Packaging of the product, application of vacuum, and sealing of the package.
   (c) Pasteurization of the product for a specified and monitored time/temperature.
   (d) Rapid and monitored cooling of the product at or below 3 °C (38 °F) or frozen.
   (e) Reheating of the packages to a specified temperature before opening and service.
5. *Vacuum packaging* reduces the amount of air from a package and hermetically seals the package so that a near-perfect vacuum remains inside. A common variation of the process is vacuum skin packaging (VSP). A highly flexible plastic barrier is used by this technology that allows the package to mold itself to the contours of the food being packaged.

   The creation of a packaging environment with little or no oxygen has beneficial applications for the food industry. However, microbiological concerns arise simultaneously. As will be discussed, proper controls need to be in place for reduced oxygen packages.

FDA: Benefits of ROP

ROP can create a significantly anaerobic environment that prevents the growth of aerobic spoilage organisms, which generally are Gram-negative bacteria such as Pseudomonads or aerobic yeast and molds. These organisms are responsible for off-odors, slime, and texture changes, which are signs of spoilage.

ROP can be used to prevent degradation or oxidative processes in food products. Reducing the oxygen in and around a food retards the amount of oxidative rancidity in fats and oils. ROP also prevents color deterioration in raw meats caused by oxygen. An additional effect of sealing food in ROP is the reduction of product shrinkage by preventing water loss.

These benefits of ROP allow an extended shelf life for foods in the distribution chain, providing additional time to reach new geographic markets or longer display at retail. Providing an extended shelf life for ready-to-eat convenience foods and advertising foods as

"Fresh-Never Frozen" are examples of economical and quality advantages.

Providing oxygen control in packaging is needed by fruits and vegetables. They continue to breathe and require oxygen after harvesting and processing; thus, the package must contain oxygen. Yet it needs to be controlled, as *too high* a level causes oxidation and spoilage and *too low* a level leads to anaerobic spoilage. In extending shelf life of fruit, oxygen levels should approximate 5 % and carbon dioxide at 1–3 % (with refrigeration maintained at temperature-specific levels). Packaging environments must match the respiration rate as closely as possible.

The function of CO_2 addition in packaging is to inhibit growth of many bacteria and molds. The O_2 maintains respiration and color and inhibits growth of anaerobic microorganisms. Nitrogen (N_2) is used to flush the package and rid it of air (O_2 specifically). Nitrogen also prevents a collapse of the loose-fitting packaging material.

Cook-Chill

Cook-chill is defined as a packaging procedure that also results in reduced oxygen levels. By the FDA definition, it "is a process that uses a plastic bag filled with hot cooked food from which air has been expelled and which is closed with a plastic or metal crimp." Such a system is one that may be frequently employed in hospital foodservice operations as an alternative to a more conventional foodservice operation.

Modified Atmosphere Packaging

Modified Atmosphere Packaging (MAP) modifies the internal package atmosphere of food. It replaces the air in the package with nitrogen or carbon dioxide, and the shelf life of the product can increase by as much as 200 %. Gas flushing and sealing reduces oxygen coming through respiration of vegetables. MAP is a *one-time modification* of gases so that it is different from air, which normally contains 78.08 % nitrogen, 20.96 % oxygen, and 0.03 % carbon dioxide.

MAP is *primarily* applied to fresh or minimally processed foods that are still undergoing respiration, and it is used for the packaging of a variety of foods. Such foods include baked goods, coffees and teas, dairy products, dry and dehydrated foods, lunch kits, and processed meats (to keep the meat pigment looking desirable). It is also used for nuts, snack food applications, and pasta packaging. This type of packaging with high CO_2 levels inhibits many aerobic bacteria, molds, and yeasts.

MAP is one of the most widely used packaging technologies, as it functions to enhance appearance, minimize destructive waste, extend shelf life, and reduce the need for artificial preservatives. Its use thus expands a product's ability to reach new markets. Nitrogen is used in bread products, while carbon dioxide is best suited to high-fat products.

Following the packaging of foods, a machine vacuums out *all* of the package air and then, through the same package perforations, *evenly inserts* the new, desired gas combination. Since MAP contains the food under a gaseous environment that differs from air (some other percentage), it controls normal product respiration (consuming O_2 and generating CO_2, water vapor, and perhaps ethylene) and growth of aerobic microorganisms. For example, the change in CO_2 level shows an inhibitory effect on aerobic microorganisms. This effect is dependent upon conditions such as the level of CO_2 (a high level in proportion to air is more effective), moisture, pH, and temperature.

The initial mix of packaging atmosphere changes over time as a result of factors such as product respiration, the aerobic and anaerobic bacterial load, respiration of bacteria, permeation of gases through the packaging materials/seals, temperature, light, and time (Labuza 1996).

The addition of *nitrogen* gas, which is odorless, tasteless, colorless, nontoxic, and nonflammable, is introduced into the food package *after* all atmosphere has been removed from the pouch and vacuum chamber, and just *prior* to hermetic sealing of the package. It increases the package's internal pressure. This modification, by a predetermined dose of liquid nitrogen (LIN), offers protection from spoilage, oxidation, dehydration, weight loss, and freezer burn and extends shelf life, as nitrogen consumes oxygen.

Unlike vacuum packaging, the high barrier film (used to keep air out and to prevent the modified atmosphere from escaping) used for MAP remains loose-fitting. This avoids the crushing effects of skintight vacuum packaging. When used in combination with aseptic packaging, which reduces the microbial load, MAP becomes a more effective technology. Most new and minimally processed foods use MAP in combination with aseptic technology and reduced temperature.

Controlled Atmosphere Storage and Packaging

Both controlled atmosphere (CA) in *storage* environments and ***controlled atmosphere packaging*** (CAP) are utilized in order to permit controlled oxygen and carbon dioxide exchange, thus preserving foods. As well, CAP is a prime alternative to pesticides and preservatives. When storage temperatures and conditions of distribution vary in fresh and processed foods, CAP and MAP assist in standardizing these variables and maintaining product quality.

The FDA defines CAP as "an active system which *continuously* maintains the desired atmosphere within a package throughout the shelf-life of a product by the use of agents to bind or scavenge oxygen or a sachet containing compounds to emit a gas." Controlled atmosphere packaging (CAP) is defined as a packaging of a product in a modified atmosphere followed by maintaining subsequent control of that atmosphere.

However, at any given time, and under variable environments, there is no continual "control" that the food technologist would describe as "ideal." The question then becomes: how much control *is* there in the package environment? Is it then more likely that the atmosphere is *modified*? This form of packaging also utilizes a high barrier film (or pouch), which may be EVOH high barrier polymers, or polyamide, a form of nylon.

Many packaged food products undergo respiration and microbial growth, requiring oxygen, while producing CO_2 and water. The carbohydrate molecule, in the presence of oxygen, $C_6H_{12}O_6 + O_2$, for example, yields $CO_2 + H_2O$ + heat. Therefore, CA or CAP containers offer control by reducing the available O_2, elevating CO_2, and controlling water vapor and ethylene concentration. The worldwide distribution and marketing of produce depends on CAP for high-quality food. A benefit is that less senescence and maintenance of nutritional value is observed.

C. botulinum is an anaerobic bacterium that grows in the absence of available oxygen. Therefore, it may grow in anaerobic packaging environments. To retard its growth in CAP food products, foods must have short-storage times and be held at cold temperatures. Control of water activity (A_w) and salt is also necessary to prevent growth as sodium competes with the bacteria for water absorption.

Food production has shown a rising use, thus the demand for various industrial gases such as CO_2 and N_2. Perhaps this increase in demand may be attributed to more convenient foods and packagings that provide a longer shelf life, CAP, and MAP.

Certainly, if the packaging material is a *poor* barrier, then the nitrogen or carbon dioxide will be replaced with the surrounding oxygen due to diffusion. Considering the opposite effect, if the packaging offers a *good* barrier, then the gases will remain in the package for a longer period of time, protecting the product.

Sous Vide

Sous vide ("under vacuum") packaging involves mild, partial precooking of food prior to vacuum packaging. Once again, according to the FDA definition in the 1999 Guidelines for ROP, "Sous Vide is a specialized process of ROP for partially cooked ingredients alone or combined with raw foods that require refrigeration or frozen storage until the package is thoroughly heated immediately before service. The sous

Fig. 18.4 An example of small vacuum-packaging machinery. Countertop (C200 Courtesy of *Multivac, Inc.*)

Fig. 18.5 An example of very large floor standing vacuum-packaging machinery (C800 Courtesy of *Multivac, Inc.*)

vide process is a pasteurization step that reduces bacterial load but is not sufficient to make the food shelf-stable." Since *some* of the ingredients may be partially cooked, and other ingredients may be raw, the product requires refrigeration or freezing, and then heating through prior to service.

The product package will have its levels of oxygen *reduced* and CO_2 *raised* in the packaging environment in order to reduce the microbial (aerobic pathogens) load and extend the shelf life. Sous-vide products are pasteurized, yet are *not* sterile, and may contain heat-resistant microorganisms and spores. Therefore, strict temperature regulation in production, as well as in the distribution process, is necessary to assure product safety. Food products must be kept cold to prevent the growth of bacteria.

According to FDA guidelines, guidelines related to the sous-vide process include the following: some cooking, packaging, pasteurization, proper cooling and reheating.

Vacuum Packaging

Vacuum packaging modifies the atmosphere surrounding the food by removing oxygen, and it extends shelf life. Further explained by the FDA, in its guidelines for reduced oxygen packaging (ROP), "Vacuum packaging reduces the amount of air from a package and hermetically seals the package so that a near-perfect vacuum remains inside. . . A highly flexible plastic barrier is used by this technology that allows the package to mold itself to the contours of the food being packaged."

With the removal of oxygen, vacuum packaging controls rancidity that occurs with the oxidation of fatty acids. Vacuum-packaging machines are available for small-, medium-, or large-scale production capacity (Figs. 18.4 and 18.5) and may be used to successfully package a variety of food sizes and forms such as small cheese blocks, large primal cuts of meat, or liquids.

In order to get an idea of the sizes:

Countertop Model C200 or smaller—countertop use

Floor Model C800 machine dimensions: width 1,650 mm, depth 1,050 mm, height 1,070 mm, weight approx. 720 kg

The procedure used for vacuum packaging is to place the food in a flexible film and barrier pouch and put it inside a vacuum-packaging chamber, where oxygen is removed. This creates a skintight package wall and protects against the entry or escape of gases such as air and CO_2 or water vapor. It assures inhibition of microbial growth that would alter microbial and organoleptic properties such as appearance and odor. Water weight loss and freezer burn are also inhibited with this packaging method. The transparent, vacuum-packaging film allows product visibility from all angles.

Controls Needed for Vacuum Packaging. The FDA recommends that local regulatory agencies prohibit vacuum packaging in retail stores unless the following six controls are all in effect:

- Foods must be limited to those that do not support growth of *Cl. botulinum* (as it is an anaerobe).
- Temperatures of 45 °F (7 °C) and below are maintained at all times. Anaerobic pathogens increase their growth rate exponentially with an increase in temperature.
- Consumer packages are prominently labeled with storage–temperature requirements and shelf life.
- Shelf life must neither exceed 10 days nor extend that labeled by the initial processor.
- Detailed, written in-store procedures must be developed, observed, and carefully monitored. These should be HACCP based and include records subject to review by regulatory authorities.
- Operators must certify that individuals responsible are qualified in the equipment, procedures, and concepts of safe vacuum packaging.

Good manufacturing practice to prevent contamination with pathogens is still needed.

FDA: Safety Concerns

The use of ROP with some foods can markedly increase safety concerns. Unless potentially hazardous foods are protected inherently, simply placing them in ROP without regard to microbial growth will increase the risk of foodborne illnesses. ROP processors and regulators must assume that during distribution of foods or while they are held by retailers or consumers, refrigerated temperatures may not be consistently maintained. In fact, a serious concern is that the increased use of vacuum packaging at retail supermarket deli-type operations may be followed by temperature abuse in the establishment or by the consumer. Consequently, at least one barrier or multiple hurdles resulting in a barrier need to be incorporated into the production process for products packaged using ROP. The incorporation of several subinhibitory barriers, none of which could individually inhibit microbial growth but which in combination provide a full barrier to growth, is necessary to ensure food safety.

(1) *Refrigerated Holding Requirements for Foods in ROP*

Safe use of ROP technology demands that adequate refrigeration be maintained during the entire shelf life of potentially hazardous foods to ensure product safety.

Active Packaging Technologies

Active packaging began as "*smart*" *packaging* in the 1980s and was referred to as "*interactive*" *packaging* almost from the start. All three terms describe the same thing, which is packaging that could "sense" changes in the internal environment and respond by adapting as necessary. Included in a food package are small packets in order to control elements such as ethanol, oxygen, or microbes (Brody 2000).

By means of its inherent design, packaging typically serves in a *passive* role by protecting food products from the external environment. It provides a physical barrier to external spoilage, contamination, and physical abuse in storage and distribution. Today, packaging more *actively* contributes to the product's development, controls product maturation and ripening, helps in achieving the proper color development in meats, and extends shelf life. Thus, it is considered to play an *active* (not passive) role in protecting foods. Yet, despite the many attributes and benefits of smart/interactive/active packaging, it generally does not actually "sense" the environment conditions and change accordingly.

Examples of ***active packaging*** technologies are listed in the following text.

Active packaging for *fresh and minimally processed* foods provides the following:

- Edible moisture or oxygen barrier (to control loss of moisture and enzymatic oxidative browning in fresh-cut fruits and vegetables and to provide controlled permeability rates matched to the respiration rate of the fruit)
- Edible antimicrobial (biocidal) polymer films and coatings (which may release controlled amounts of chlorine dioxide into the food, depending on temperature and humidity, or destroy *E. coli* 0157:H7 in meats and prevent mold growth in fruits)
- Films that are scavengers of off-odors
- Oxygen scavengers for low-oxygen packaging

Active packaging for *processed* foods provides the following:

- Edible moisture barrier
- O_2, CO_2, and odor scavenger

Other active packaging technologies include the following:

- Microwave doneness integrators (indicators)
- Microwave susceptor films to allow browning and crispness (french fries, baked products, popcorn)
- Steam release films
- Time–temperature indicators (TTI) which are unable to reverse their color when the product has been subject to time–temperature abuse

Specifically, the predictability of the behavior of a living, breathable fruit or vegetable, or even meat, is quite different from a nonfood item that is packaged. There are numerous interactions between the food, any internal gas in the package atmosphere, and the material used for packaging. Sachets or films may release their intended effect at a controlled rate.

The FDA gave the "go ahead" for a type of active packaging that releases chlorine dioxide gas to kill harmful bacteria and spoilage organisms (Higgins 2001a).

Aseptic Packaging

In order to destroy any *C. botulinum* spores and extend the shelf life of low-acid foods, ***aseptic packaging*** may be utilized. Independent sterilization of both the *foods* and *packaging material*, with assembly under *sterile environmental* conditions, is the rule for aseptic packaging.

In an aseptic system of packaging, the packaging material consists of *layers* of polyethylene, paperboard, and foil (Fig. 18.6). It is sterilized by heat (superheated steam or dry hot air) or a combination of heat and hydrogen peroxide and then roll-fed through the packer to create the typical brick/block shape (Fig. 18.7).

The container is filled with a sterile (no pathogens or spores) or commercially sterile (no pathogens, although *some* spores) liquid food product and sealed in a closed, sterile chamber. Once packed, the product requires no refrigeration. Liquids such as creamers, milk, or juices may be packed in this manner. Triple or multiple packs of flavored milk and juice, with attached straws, are available on grocery shelves. The market leaders of aseptic packages have introduced easy-open, easy-pour features into their cartons. The plastic devices are injection molded and adhere to the package tops.

The sterility of packaging material has formerly relied on *chemical* technologies of sterilization (principally heat with hydrogen peroxide). *Nonchemical* techniques have been explored in order to avoid chemical sterilant residues. Ionizing and nonionizing radiation have been tested for use in aseptic packaging.

Flexible Packaging

Flexible packaging is available for packaging use in the foodservice industry and is finding more applications at the *retail* level, including packaging for bagged cereal candies, poultry, red meat, and sliced deli meat. Nonrigid packaging

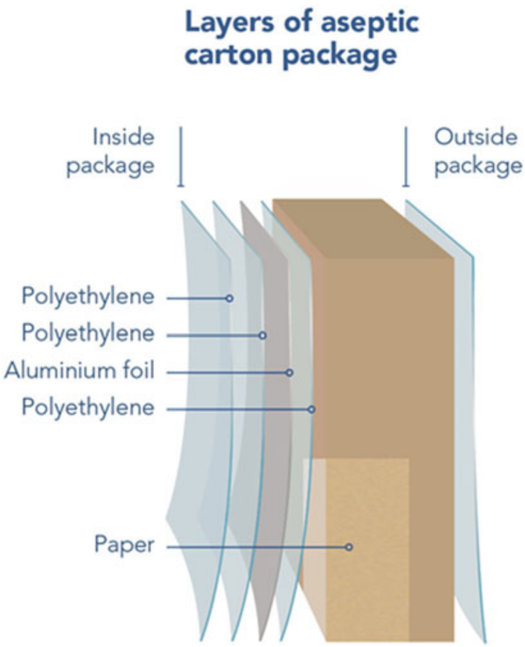

Fig. 18.6 Tetra Brik® aseptic packaging material layers (*Source*: Tetra Pak Inc.)

containers such as stand-up pouches or tubes and zippered bags are examples of flexible packaging used for peanuts, peanut butter, or produce such as fresh-cut lettuce and peeled baby carrots. The same packaging might also need to be *resealable* to meet consumer demands and may require zipper handles or spouts with *easy-open* screw-off tops.

"Flexible packaging uses less material. It keeps products fresh by providing flavor and aroma barriers, which keep outside odors out and flavors in. It is used for fresh fruits and vegetables and matches respiration rate as closely as possible. Overall, the Flexible Packaging Industry encourages innovation and excellence in part by giving packaging achievement awards based on factors including Packaging Excellence, Technical Innovation, Sustainability and Environmental Achievement, and Printing Achievement."

Manufacturers are offering more food products in flexible packaging and find that cost savings and environmental concerns are some of the driving forces behind the switch to flexible packaging.

Fig. 18.7 Different Tetra Brik® aseptic package sizes (*Source*: Tetra Pak Inc.)

Freezer Packaging Protection

Freezing foods is a means of preservation, although foods may spoil due to desiccation or cavity ice if they are not adequately protected. Therefore, a moisture-barrier film, such as a freezer wrap, is needed in packaging material. Tear strength and wet strength are also needed in packaging material for freezer storage.

Freezer Burn

Pronounced desiccation occurs as water diffuses from the product to the atmosphere. This results in ***freezer burn*** with its resultant change in appearance, flavor, texture, and weight.

Cavity Ice

Cavity ice is the ice formation within the food package due to water condensation. Therefore, it is important to use moisture-proof and vapor-proof packaging.

Tamper-Evident Banding and Sleeve Labeling

Tamper-evident banding and sleeve labeling may assist manufacturers and consumers by providing protection and offering the security that the package contents are unviolated. Today, tamper-evident neckbands and shrink-film sleeves are made in a number of colors and may be custom printed. Technology for full-body shrink-labels over glass and plastic bottles is more apparent, as it has become more affordable and attractive. Pull-tabs and perforations provide ease of use.

While the majority of rigid packaging includes tamper-evident attributes, not all food is packaged in this manner. Considering security issues, especially susceptible may be bakery and dairy products (Higgins 2001b).

Manufacturing Concerns in Packaging

Selection of Packaging Materials

Environmental conditions in package transport and government regulations may dictate the materials a company uses in shipping food containers domestically or overseas. Many components of the food industry demand that packaging material is biodegradable, recyclable, strong, and waste-to-energy efficient. The food processor must choose materials that effectively preserve shelf life and are environmentally friendly and affordable. The packaging material needs to meet all criteria of shipment, labeling, marketing, and other purposes of packaging.

A list of food and beverage packaging associations appear in the 2012 Food & Beverage Packaging Buyer's Guide. Food&Beverage Packaging. 2012;(12):82–83. foodandbeveragepackaging.com. see Associations and References at the end of this chapter.

Migration from Packaging Materials

The packaging industry recognizes that the migration of substances from the packaging into the food *could* be harmful to the consumer or have an adverse effect on the acceptability of the food. Therefore, compliance with limits set on migration of packaging materials and control of additives at the point of manufacture is ensured.

Plastics have a greater likelihood of imparting their "plastic taste" and odor to a food than paper. They may contain many additives, including antioxidants, antistatics, plasticizers (to improve the flexibility of some "cling" films), and stabilizers to improve the functional properties of the plastics. Although there has been no report of danger to human health from plasticizer additives, the plastics industry has reformulated some grades of films that contain plasticizers and continues to offer polyethylene plastic wraps with low levels of plasticizers

The FDA has responded to the stories about the dangers of chemicals leaching from plastics into microwaved food. Any plastic used as a "food contact surface" needs FDA approval that it is safe for its intended use (usefulness and harmlessness) prior to being approved for use. According to the FDA, "It's true that substances used to make plastics can leach into food. But as part of the approval process the FDA considers the amount of a substance expected to migrate into food and the toxicological concerns about the particular chemical." While the FDA finds that levels of migrating material are well within the established margin of safety, the issue will continually be revaluated in light of new materials or new data.

Diethylhexyl adipate (DEHA) is commonly used in polyvinyl chloride (PVC) food wrap as a plasticizer. PVC does not use the plasticizer with phthalates. A close analysis of DEHA indicated *no* toxic affect in animal studies. It is approved as a food contact surface.

Migration from packaging materials is more likely to occur at high temperatures with fatty foods; therefore, *industry* packaging of microwave foods is designed to be safe for microwave use at high temperatures. *Consumers* who use packaging films for cooking or reheating in the microwave should be aware that "microwave safe" criteria may not be established for packaging films that can have direct contact with food during reheating in a microwave. Therefore, using *glass* containers may be preferable choices for microwave reheating.

In addition to plastics, the printing *ink* on the package must be controlled, as it too imparts undesirable flavor to packaged food, and may stain the surface of material it contacts while hot (i.e., microwave oven).

The use of recycled plastics and paper reduces control over contaminants that may be in the second-hand materials. Further research on the use of recycled materials must be conducted and brought forth, before it is recommended that recycled materials be used in food contact applications (due to the possible migration of contaminants).

There is another concern regarding dioxins in plastic food wrap. According to the FDA, a concern for *dioxins* in plastic is not warranted. "The FDA has seen no evidence that plastic containers or films contain dioxins and knows of no reason why the would" (FDA—Machuga).

Packaging Lines at Processing Plants and Foodservice Operations

Packaging lines at processing plants may operate efficiently when correctly managed, or be down and hold up production. As well, *product shelf life and safety*; *consumer and environmental concerns*, including ease of use and recycling; as well as *economics* of packaging are important food packaging ideas. Future packaging ideas continue to be explored and utilized.

Although labels are discussed in another chapter of this text, they will be mentioned here, in packaging. Paper and perhaps full sleeve, heat shrink PVC labels may be applied to food containers. They offer graphics, assistance as a marketing tool, provide tamper evidence and information, and more. The latest in development and marketing of packaging technologies is available online and at various trade shows.

Packaging with Radio-Frequency Identification Tags

Radio-frequency identification (RFID) tags may be contained in packaging. RFID is more than an inventory or packaging/labeling technology as it assists manufactures and users track packaged food throughout the supply chain. Although it may be required (mandated) of vendors delivering to suppliers, such as major food clubs, trials are still ongoing at this point. Currently, improvement is desired in readability rates, tag costs and availability, tag application, accurate customer recording, and other aspects of this newer technology (Food Engineering).

The RFID Journal is also available to packers.

> Selecting the Right RFID Tag becomes important. For example, does the packaging company need high-frequency or ultrahigh-frequency tags, passive or active technology? There is a rapid evolution of RFID technology.
>
> "RFID tags contain a microchip and antenna, and come in a wide variety of sizes and form factors. Some are as small as a grain of rice and encased in glass, while others are enclosed in plastic and the size of a key fob or credit card. Still others, known as smart labels, are embedded in paper. Some are disposable, while others can be reused. Costs vary widely, too, depending on the form factor, the amount of data the tag can store and the volume of tags purchased.
>
> With the increasing use of RFID technology and the adoption of standards for some categories of tags by the International Organization for Standardization (ISO) and EPCglobal, tag prices have been falling. Electronic Product Code (EPC) passive UHF tags, widely used in supply-chain applications, cost about 7 cents each. Active (battery-powered) tags, commonly deployed for tracking assets over longer distances, generally cost upwards of $50."
>
> (RFID Journal—How to Select the Right RFID Tag)

Packaging as a Communication and Marketing Tool

Packages contain and protect food during storage, shipment, and sale and serve other functions, as discussed, such as to provide convenience and utility of use. They also *communicate* important consumer information on their labels. For example, information regarding ingredients, nutrition facts, manufacturers' name and address, contents weight, bar coding, and so forth appear on package labels. The food processor must be aware of worldwide differences in acceptability of packaging format, including use of colors and picture symbols, before a product is marketed in another culture.

Packaging serves as a *marketing tool*. The package and label design are significant in attracting potential customers, and many labels may carry recipes, coupons, mail-in offers, or announcements of special upcoming events. It may be that a change in packaging greatly increases sales. Yet changes must not confuse consumers who have built product loyalty by familiarity over the years. For example, milk cartons may not be readily accepted if changed, yet a difference in packaging material, such as cereal without a cardboard box, might be well accepted and profitable.

It is reported that consumers use more of a product at a time when it comes in a *larger* package. This may be attributed to (1) the buy-more, use-more phenomenon, as consumers perceive food products as less expensive when purchased in larger quantity (although this is not always true), (2) less concern with running out, and (3) desire to finish the food product as the large size occupies excessive shelf space (Tufts University Diet & Nutrition Letter 1997). At the other end of the spectrum, *single* servings of products are also popular in the marketplace.

Environmental Considerations and Packaging

Sustainable package development shows environmental consideration and responsibility; *reduce*, *reuse*, *and recycle* must be kept in mind from initial packaging development to discards of those packages. Responsibility dictates that packaging materials should be environmentally friendly.

Safety Considerations and Packaging

Keeping the food supply a safe one is an important consideration of food packaging. Packaging is part of food processing, and it assists in preserving food against spoilage and contamination as well as extending the shelf life. Adequate packaging is an industry technique that may be used along with preservation and has the intent of slowing down or stopping spoilage that would otherwise exhibit loss of taste, textural quality, or nutritive value of food. C*rops* and *animal products* produce market-ready and adequately long shelf life food products if adequately packaged.

Of interest to some readers might be irradiation and packaging, addressed by the FDA as follows:

> **Effects of Irradiation**
>
> Irradiation can cause changes to a packaging material that might affect its integrity and functionality as a barrier to chemical or microbial contamination. Radiation does not generally affect all properties of a polymer or adjuvant to the same degree. Two concepts are important here. **First**, most food packaging materials are composed of polymers that may be susceptible to chemical changes induced by ionizing radiation that are the result of two competing reactions, cross-linking (polymerization) and chain scission (degradation). Radiation-induced cross-linking of polymers dominates under vacuum or an inert atmosphere. Chain scission dominates during irradiation of polymers in the presence of oxygen or air. Both reactions are random, generally proportional to dose, and depend on dose rate and the oxygen content of the atmosphere in which the polymer is irradiated. The idea of cross-linking predominating under vacuum or in an inert atmosphere is important because it served as the basis for granting recent exemption requests under 21 *CFR* 170.39 for packaging materials irradiated in contact with food either in a verifiably oxygen-free environment or while frozen and contained under vacuum.
>
> **Second**, in the presence of an oxygen atmosphere, radiation-induced degradation of both the base polymer and adjuvants, such as antioxidants or stabilizers, is likely to occur and result in the formation of radiolytic products. The radiolytic products formed upon irradiation may be present at significant levels such that they could migrate into food and affect the odor, taste, or safety of the irradiated food. For example, it is well known that certain adjuvants are prone to degradation during polymer processing. During irradiation they would be expected to degrade preferentially over the

polymer and result in the formation of radiolytic products in the polymer that could potentially migrate into food. Therefore, the migration of both base polymers and adjuvants, as well as migration of their radiolytic products, must be evaluated in the premarket safety assessment of new packaging materials prior to their use, especially at high dose levels and in the presence of oxygen.—FDA

Packaging serves as a safety barrier in controlling potentially damaging levels of light, oxygen, and water. It facilitates ease of use, offers adequate storage, conveys information, and provides evidence of possible safety issues of unsafe product tampering.

Food Traceability

Beginning in 2005, FDA required certain food facilities to maintain records identifying the sources, recipients, and transporters of food products. The purpose of these records is to allow FDA to trace an article of food through each stage of the food supply chain—from a retail shelf back to a farm—if FDA has a reasonable belief that a food product is adulterated and presents a serious health threat. Traceability is the ability to follow the movement of a food product through the stages of production, processing, and distribution. Traceability includes both traceback and trace forward. Traceback is the ability to trace a food product from the retail shelf back to the farm.

Conversely, trace forward is the ability to trace a food product from the farm forward to the retail shelf. Traceability is often needed to identify the sources of food contamination and the recipients of contaminated food in product recalls and seizures. this study refers to such a situation as a 'food emergency.' (Department Of Health And Human Services office of Inspector General 2009) Traceability In The Food Supply Chain

Packaged Food and Irradiation

CFR 179 specifies that the irradiation of both food and packaging materials in contact with food is subject to premarket approval before introduction of the food into interstate commerce (Reports REGULATORY REPORT | December 2007/January 2008 Food Safety magazine in an article entitled *Irradiation of Food Packaging Materials*).

"The U.S. Food and Drug Administration (FDA) allows the use of irradiation as a means for improving food safety and extending the shelf life of certain foods. Although not yet widely used, irradiation can kill the bacteria responsible for foodborne illness and food spoilage, as well as insects and parasites that may be present on food. Additionally, in certain fruits and vegetables irradiation can inhibit sprouting and delay ripening. For example, irradiated strawberries stay unspoiled up to 3 weeks, versus 3–5 days for untreated berries. Foods are typically packaged in final form prior to being irradiated, thus reducing the likelihood that new pathogens will be introduced after the irradiation step. This means that the packaging materials are being exposed to the same irradiation source as the food itself. In an effort to ensure the safety of the food, one must be certain that an otherwise safe packaging material is not being altered in a fashion that causes a chemical in the packaging to be added indirectly to the food.

Over the years many food packaging materials have been approved for irradiation. Likewise, new food packaging products, such as oxygen barrier materials, have also been introduced. The safety assessment of such complex materials has presented new challenges to FDA and the food industry. This article describes FDA regulations pertaining to packaging materials that are in contact with food during irradiation, the effects of irradiation on new food packaging materials, and the premarket safety assessments of these materials.. . .

Improved microbiological safety of food may be attained by using irradiation in the production of several types of raw or minimally processed foods such as poultry, meat and meat products, fish, seafood, fruits, and vegetables. In fact, following the recent outbreaks of foodborne pathogens in fresh produce, there has been increased interest in using irradiation for improving the safety of fresh produce. However, food manufacturers must ensure that both the irradiated food and packaging materials used during the irradiation process are authorized for the proposed use.

Most significantly, 21 *CFR* 179 specifies that the irradiation of both food and packaging materials in contact with food is subject to premarket approval before introduction of the food into interstate commerce. It further specifies that the current good manufacturing practice for irradiated foods includes three things. First, manufacturers must comply with the general requirements of the current good manufacturing practice for manufacturing, packaging or holding human food, found in 21 *CFR* 110. Second, manufacturers must ensure that the radiation dose used is the minimum dose required to achieve the intended technical effect and does not exceed the level specified in the regulations. Third, the packaging materials used during the irradiation treatment must comply with the requirements found in 21 *CFR* 179.45, the specifications for an effective food contact notification, or a threshold of regulation (TOR) exemption. Foods currently permitted to be irradiated are listed in 21 CFR 179.26(b) [Table 1]. Finally, the irradiated food must be properly labeled.

Although many packaging materials and their components are available for non-irradiation uses, their utilization during the irradiation of prepackaged food is considered a new use and they must pass a premarket safety evaluation before they can be legally used in direct contact with food during irradiation. . . .

Irradiating New Materials

FDA's safety assessment relies on evaluating probable consumer exposure to a food contact substance, including all constituents or impurities as a result of the proposed use and on the available toxicological information. It is important to understand that the safety assessment focuses on those substances that would be expected to become components of food as a result of the proposed use of the food contact substance. The safety information required in a new submission to the Center for Food Safety and Applied Nutrition's Office of Food Additive Safety generally includes chemical, toxicological and environmental components. The chemistry data, include the identity and amounts of migrants, as well as other data to allow the calculation of dietary exposures for the migrants under the intended conditions of use. FDA's toxicological assessment is based on a tiered approach and, therefore, the recommended toxicological data depend on the exposure estimates for the radiolytic products and other migrants from the proposed use. FDA recommends that all data and information be generated in accordance with the available guidance documents. The identities, residue and migration levels, and consumer exposures to the radiolytic products that are generated in the packaging materials may be of concern depending on the regulatory status of the substances, as well as the presence or absence of oxygen. . .

Currently the packaging materials that comply with the provisions of 21 *CFR* 179.45, the specifications of an effective food FCN [food contact notification] or a TOR [threshold of regulation] exemption may be used in direct contact with food during irradiation. Materials that do not fall under one of these umbrellas require a premarket safety assessment before being used in foods. In instances where food packages contain oxygen, such as in modified atmosphere packaging to maintain the quality of fresh produce, the safety assessments can be quite complex. . . FDA encourages individuals to discuss proposed studies with FDA prior to the submitting a petition or notification to ensure that the studies will address FDA's safety concerns, and provide adequate data. . . .

Conclusion
Improved microbiological safety of food may be attained by using irradiation in the production of several types of raw or minimally processed foods such as poultry, meat and meat products, fish, seafood, fruits, and vegetables. In fact, following the recent outbreaks of foodborne pathogens in fresh produce, there has been increased interest in using irradiation for improving the safety of fresh produce. However, food manufacturers must ensure that both the irradiated food and packaging materials used during the irradiation process are authorized for the proposed use."

http://www.foodsafetymagazine.com/magazine-archive1/December-2007january-2008/irradiation-of-food-packaging- materials

Government Concerns in Packaging

Government concerns must be addressed as they arise, and prevention must be practiced as necessary to avoid errors that lead to illness.

FDA Packaging & Food Contact Substances (FCS)

http://www.fda.gov/Food/IngredientsPackagingLabeling/PackagingFCS/default.htm

FDA Irradiated Food & Packaging

http://www.fda.gov/Food/IngredientsPackagingLabeling/IrradiatedFoodPackaging/default.htm

FDA is responsible for regulating the use of irradiation in the treatment of food and food packaging. This authority derives from the 1958 Food Additives Amendment to the Federal Food, Drug, and Cosmetic Act (FD&C Act) where ***Congress explicitly defined a source of radiation as a food additive*** (Section 201(s) of the FD&C Act). FDA

FDA Environmental Decisions

http://www.fda.gov/Food/IngredientsPackagingLabeling/EnvironmentalDecisions/default.htm

The National Environmental Policy Act of 1969 (NEPA) requires all agencies of the Federal Government to take, to the fullest extent possible, environmental considerations into account in the planning and making of their major and final agency decisions. In a manner that is consistent with the FDA's authority under the Federal Food, Drug, and Cosmetic Act, the Public Health Service Act, and with its NEPA-implementing regulations in 21 CFR 25, the agency assesses, as an integral part of its decisionmaking process, the environmental impacts of its actions and ensures that the interested and affected public is informed of environmental analyses. Such actions include approval of a food additive, color additive, or (Generally Recognized as Safe) GRAS affirmation petitions, the granting of a request for exemption from regulation as a food additive under 21 CFR 170.39, or allowing a notification submitted under 21 USC 348(h) to become effective. FDA

"Packaging or equipment that contacts food may be subject to FDA regulation if their chemical components are deemed by FDA to be "indirect food additives," also known as "Food Contact Substances." (FCS) The determination of how a particular food contact substance is regulated by FDA depends on its chemical composition." http://www.registrarcorp.com/fda-food/contact-substances/index.jsp?lang=en

Packaging of the Future

http://www.futureofpackaging.com/ represents Packaging Technology Integrated Solutions (PTIS).

"The Future of Packaging: 2013–2023 is an invitation-only event and is limited to industry leaders from across the packaging value chain. We keep the number of sponsors to a small group to enable an environment rich with dialogue, content and value. Proprietary research and insights, strategies, and tools for driving growth will be shared exclusively with sponsors and will not be made available at any other time.

> The Power of Packaging is unleashed at The Future of Packaging: 2013–2023. If you are responsible for ensuring that packaging drives bottom-line impact and growth for your business, request your invitation today to gain a long-term strategic, yet practical understanding of packaging that will pay dividends today and for years to come. You'll come away with:
>
> - An understanding of why Holistic Packaging Design is central to packaging in the future
> - Cutting-edge, proprietary research on packaging innovation, global consumer trends, mass customization, emerging markets, and the role of mobile and social technology
> - A global view of scenarios affecting packaging over the next decade
> - A 10-year strategic packaging roadmap—PTIS

In its year-end e-mail message, consulting company Packaging Technology Integrated Solutions (PTIS) believe the Top 9 trends for packaging in 2013 will be:

10. **Clean machine design** helps drive OEM growth and meet new regulations.
9. **Digital printing** continues to make advances and becomes a reality.
8. **Sustainable packaging and waste to value** propositions get more clarity and harmonization.
7. **Interactive and intelligent packaging** becomes more real and gets commercialized.
6. **Flexible packaging** growing in new markets and categories globally.
5. **Companies ramp up new processes** to look at risk and anticipatory issues.
4. **Digital media and package design:** Social media and zero moment of truth will offer big opportunities for packaging going forward.
3. **Packaging enabled innovation and growth:** More companies targeting a percentage of their growth driven by packaging.
2. **Consumer insight for packaging:** Companies recognize the importance of consumer insights for packaging and how it can vary, and expect more data from suppliers."

PTIS asks readers to submit ideas for the **number-one** trend in packaging for 2013!

See more at http://www.packworld.com/trends-and-issues/oee-amp-lean-manufacturing/top-9-packaging-trends-2013

Conclusion

Primary, secondary, and tertiary packaging protects raw and processed food against spoilage and contamination while offering convenience and product information to the consumer. A variety of packaging materials, such as metal, glass, paper, and plastics or combinations of these, are used for packaging if they meet with FDA requirements. A number of professional trade shows are dedicated to packaging technologies.

Packaging films and atmospheres may be selected according to a food product's storage and distribution needs. They may eliminate damaging levels of oxygen, light, and temperature and prevent water vapor loss while at the same time protecting the food from spoilage and contamination. Compliance with limits set on migration of packaging materials and control of additives in the materials must be ensured. A variety of packaging technologies, including vacuum packaging, flushing the package with gas, or *active* packaging, may be used to contribute to effective packaging of food.

Packaging protects food; may modify atmosphere, thus extending shelf life; gets a message across; aids in marketing; provides added content security; and so forth. It may provide portion control, combating "portion distortion," convenience of use, and convenient transport. This assists the child as well as the adult consumer.

Tamper-evident banding is a protection against external hazards and may be viewed as essential by the manufacturer and consumer. The package label may communicate important information to the consumer serving as a marketing tool. Packaging today provides protection for food products that was unavailable in the past.

Reduce, reuse, and recycle are important to the environment. More advances in such considerations as safe, effective, convenient, and creative packaging are on the horizon.

Packaging may simply involve having clean hands, a sanitary pair of foodservice tongs, and a piece of tissue in a bag served across a bakery counter. It may involve adherence to a specific time and temperature heat application in a foodservice can that is transported along continents. There is great variance in the idea of packaging food as discussed in this chapter.

(some articles are old, yet are retained as they are classic in their content)

Notes

CULINARY ALERT!

Glossary

Active packaging Packaging that makes an active, not passive, contribution to product development or shelf life by such techniques as providing an oxygen barrier, or odor and oxygen scavenger.

Aseptic packaging Independent sterilization of foods and packaging with assembly under sterile conditions.

Cavity ice Ice formation with the frozen food package due to water condensation and freezing.

Controlled atmosphere packaging (CAP) Controls O_2, CO_2, water vapor, and ethylene concentration.

Flexible packaging Nonrigid packaging such as stand-up pouches, tubes, or zippered bags.

Freezer burn Desiccation of frozen food product as the water diffuses from the frozen food to the atmosphere.

Modified Atmosphere Packaging (MAP) Or gas flush packaging—modification of O_2, CO_2, water vapor, and ethylene concentration by flushing with nitrogen gas.

Polyethylene Most common, least expensive plastic film used in packaging material.

Polystyrene Plastic type that is typically foamed to create expandable polystyrene or styrofoam.

Polyvinyl chloride (PVC or vinyl) Plastic packaging film.

Polyvinylidene chloride (PVDC or Saran®) Plastic packaging film.

Primary container A direct food contact surface as in bottle, can, or drink box that contains food or beverage.

Secondary container Does not have food contact but holds several primary containers in materials such as corrugated fiberboard, boxes, or wraps.

Sous vide Mild, partial precooking to reduce the microbial load, followed by vacuum packaging to extend the shelf life.

Tamper-evident banding Sleeves or neckbands providing protection and offering security by indicating evidence of tampering with the product.

Tertiary container Holds several secondary containers in corrugated fiberboard boxes, overwraps, and so forth.

Vacuum packaging Removes all atmosphere from the pouch and creates a skintight package wall.

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21 CFR 179.45 Table 2 Packaging materials listed for use during irradiation of prepackaged foods

21 CFR 179.26 (b) Table 1 Foods permitted to be irradiated (as of Oct. 2007)

Association of Nutrition and Foodservice Professionals (ANFP)

Food and Agriculture Organization of the United Nations (FAO)

Global Supplier Quality Assurance (GSQA)

Sonoco Products Company. Hartsville, South Carolina (Sonoco was named the top global packaging company for sustainability and corporate responsibility in the 2011 and 2012 the Dow Jones Sustainability World Index)

Associations and Organizations

A list of food and beverage packaging associations appears in the 2012 Food & Beverage Packaging Buyer's Guide. Food & Beverage Packaging. 2012; (12):82–83. foodandbeveragepackaging.com