

Session 4.9 – Packaging Technology

Introduction

- Packaging is an essential part of processing and distributing foods.
- Packaging must protect against a variety of assaults including microorganisms, insects and rodents. Environmental factors such as oxygen and water vapor will spoil foods if they are allowed to enter packages freely.

Shelf Life

- The Institute of Food Technologists (IFT) in the United States has defined shelf life as —the period between the manufacture and the retail purchase of a food product, during which time the product is in a state of satisfactory quality in terms of nutritional value, taste, texture and appearance.
- The Institute of Food Science and Technology (IFST) in the United Kingdom has defined shelf life as —the period of time during which the food product will remain safe; be certain to retain desired sensory, chemical, physical, microbiological and functional characteristics; and comply with any label declaration of nutritional data when stored under the recommended conditions|| .

Factors affecting shelf life

- Product characteristics: Product characteristics including formulation and processing parameters i.e. intrinsic factors
 - Water activity (a_w)
 - PH/total acidity
 - Natural micro flora and surviving microbiological counts in final product
 - Availability of oxygen
 - Reduction potential (Eh)
 - Natural biochemistry/chemistry of the product
 - Added preservatives (e.g. salt, spices, antioxidants)
 - Product formulation

Environmental factors

- Environment to which the product is exposed during distribution and storage i.e. extrinsic factors. Extrinsic factors are a result of the environment that the product encounters during life and include the following
- Temperature: Temperature is a key factor in determining the rates of deteriorative reactions, and in certain situations the packaging material can affect the temperature of the food. For packages that are stored in refrigerated display cabinets, most of the cooling takes place by conduction and convection. Simultaneously, there is a heat input by radiation from the fluorescent lamps used for lighting. Under these conditions, aluminum foil offers real advantages because of its high reflectivity and high conductivity.

- Relative humidity: The RH of the ambient environment is important and can influence the water activity (a_w) of the food unless the package provides an excellent barrier to water vapor. Many flexible plastic packaging materials provide good moisture barriers, but none is completely impermeable.
- Gas atmosphere: The presence and concentration of gases in the environment surrounding the food have a considerable influence on the growth of microorganisms, and the atmosphere inside the package is often modified. The simplest way of modifying the atmosphere is vacuum packaging, that is, removal of air (and thus O_2) from a package prior to sealing; it can have a beneficial effect by preventing the growth of aerobic microorganisms. Flushing the inside of the package with a gas such as CO_2 or N_2 before sealing is the basis of modified atmosphere packaging (MAP). For example, increased concentrations of gases such as CO_2 are used to retard microbial growth and thus extend the shelf life of foods. MAP is increasing in importance, especially with the packaging of fresh fruits and vegetables, fresh foods, and bakery products.

- Atmospheric O₂ generally has a detrimental effect on the nutritive quality of foods, and it is therefore desirable to maintain many types of foods at a low O₂ tension, or at least prevent a continuous supply of O₂ into the package. Lipid oxidation results in the formation of hydroperoxides, peroxides, and epoxides, which will, in turn, oxidize or otherwise react with carotenoids, tocopherols, and ascorbic acid to cause loss of vitamin activity

- With the exception of respiring fruits and vegetables and some fresh foods, changes in the gas atmosphere of packaged foods depend largely on the nature of the package. Adequately sealed metal and glass containers effectively prevent the interchange of gases between the food and the atmosphere. With flexible packaging, however, the diffusion of gases depends not only on the effectiveness of the closure but also on the permeability of the packaging material, which depends primarily on the physicochemical structure of the barrier.

- Light: Many deteriorative changes in the nutritional quality of foods are initiated or accelerated by light. Light is, essentially, an electromagnetic vibration in the wavelength range between 4000 and 7000 Å, the wavelength of ultraviolet (UV) light ranges between 2000 and 4000 Å. The catalytic effects of light are most pronounced in the lower wavelengths of the visible spectrum and in the UV spectrum. The intensity of light and the length of exposure are significant factors in the production of discoloration and flavor defects in packaged foods.

- Enzymic reactions: The major factors useful in controlling enzyme activity are temperature, aw, pH, chemicals that can inhibit enzyme action, alteration of substrates, alteration of products, and preprocessing control. Three of these factors are particularly relevant in a packaging context. The first is temperature i.e. the ability of a package to maintain a low product temperature and thus retard enzyme action will often increase product shelf life. The second important factor is aw, because the rate of enzyme activity is dependent on the amount of water available, low levels of water can severely restrict enzymic activities and even alter the pattern of activity. Finally, alteration of substrate (in particular, the ingress of O₂ into a package) is important in many O₂ dependent reactions that are catalyzed by enzymes, for example, enzymic browning due to oxidation of phenols in fruits and vegetables.

Functions of food packaging

- Packaging is an industrial and marketing technique for containing, protecting, identifying and facilitating the sale and distribution of agricultural, industrial and consumer products.
- The packaging institute international defines packaging as a enclosure of products, items or packages in a wrapped pouch, bag, box, cup, tray, can, tube, bottle or other container form to perform one or more of the following functions as containment, protection and /or preservation, communications and utility or performance. If the device or container performs one or more of these functions it is considered as a package.

Containment

- The containment function involves the ability of the packaging to maintain its integrity during the handling involved in filling, sealing, processing (in some cases, such as retorted, irradiated, and high-pressure-processed foods), transportation, marketing, and dispensing of the food.

Protection

- The need for protection depends on the food product but generally includes **prevention of biological contamination** (from microorganisms, insects, rodents), **oxidation** (of lipids, flavors, colors, vitamins, etc.), **moisture change** (which affects microbial growth, oxidation rates, and food texture), aroma loss or gain, and **physical damage** (abrasion, fracture. and/or crushing). Protection can also include providing **tamper evident features on the package**. In providing protection, packaging maintains food safety and quality achieved by refrigeration, freezing, drying, heat processing, and other preservation of foods.

Communication

- The information that a package provides involves meeting both legal requirements and marketing objectives.
- Food labels are required to provide information on the food processor, ingredients (including possible allergens in simple language), net content, nutrient contents, and country of origin. Package graphics are intended to communicate product quality and, thus, sell the product. Bar codes allow rapid check-out and tracking of inventory. Other package codes allow determination of food production location and date. Various open dating systems inform the consumer about the shelf life of the food product. Plastic containers incorporate a recycling code for identification of the plastic material.

Preservation

- Product protection is the most important function of packaging. Protection means the establishment of a barrier between the contained product and the environment .

Convenience

- Providing convenience (sometimes referred to as utility of use or functionality) to consumers has become a more important function of packaging. Range of sizes, easy handling, easy opening and dispensing, resealability, and food preparation in the package are examples of packaging providing convenience to the consumer.

Unitization

- Unitization reduces the number of handlings required in physical distribution and, thus, reduces the potential for damage. Because losses in physical distribution are significantly reduced with unitization, significant reductions in distribution costs are affected.

Brand communication

- Packaging provides brand communication to the consumers by the use of typography, symbols, illustrations, advertising and colour, thereby creating visual impact.

Promotion

- Packaging helps to promote the food as it informs to consumers about many offers i.e. free extra product, new product, money off etc.

Economy

- The package is also an important part of the manufacturing process and must be efficiently filled, closed, and processed at high speeds in order to reduce costs. It must be made of materials which are rugged enough to provide protection during distribution but be of low enough cost for use with foods. Packaging costs, which include the materials as well as the packaging machinery, are a significant part of the cost of manufacturing foods, and in many cases, these costs can be greater than the cost of the raw ingredients used to make the food. Therefore, packaging materials must be economical, given the value of the food product.

Features of Packaging Material

- Be nontoxic
- Protect against contamination from microorganisms
- Act as a barrier to moisture loss or gain and oxygen ingress
- Protect against ingress of odors or environmental toxicants
- Filter out harmful UV light
- Provide resistance to physical damage
- Be transparent , be tamper – resistant or tamper – evident
- Be easy to open
- Have dispensing and resealing features
- Be disposed of easily,
- Meet size, shape and weight requirements

- Have appearance, printability features
- Be low cost
- Be compatible with food
- Have special features such as utilizing groups of product together.

Packaging systems

- Aseptic packaging
- Modified Atmosphere Packaging
- Active packaging

Aseptic packaging

- Aseptic packaging is a method in which food is sterilized or commercially sterilized outside of the can, usually in a continuous process, and then aseptically placed in previously sterilized containers which are subsequently sealed in an aseptic environment.
- Aseptically processed foods can be packaged in the same types of containers used for retorted foods.
- However, another advantage of aseptically processed foods is that they can be packaged in containers that do not have to survive the conditions of a retort. These include LDPE/Pb/LDPE/AL/LDPE laminate cartons and multilayer plastic flexible packaging that has cost and convenience advantages.

- Another advantage of aseptically processed foods is that they can be filled into drums, railroad tank cars, tank trucks and silos that have been previously sterilized with steam.
- The disadvantage of these packages is that they are not as easily recycled as metal and glass containers.
- The sterilization agents available for aseptic packaging include heat, chemical treatment with hydrogen peroxide and high energy irradiation (UV light or ionizing (gamma) irradiation). A combination of hydrogen peroxide and mild heat is most commonly used with plastic and paperboard-based laminate packaging.

- The most commercially successful form of aseptic packaging utilizes paper and plastic materials which are sterilized, formed, filled and sealed in continuous operation.
- The disinfectant property of hydrogen peroxide (H_2O_2) is combined with heated air or ultra violet light to make lower temperatures effective in sterilizing these less heat resistant packaging materials.
- Aseptic packaging is also used with the metal cans as well as large plastic and metal drums or large flexible pouches

Modified Atmosphere Packaging

- Modified atmosphere packaging (MAP) is a procedure which involves replacing air inside a package with a predetermined mixture of gases prior to sealing it.
- Once the package is sealed, no further control is exercised over the composition of the in-package atmosphere.
- However, this composition may change during storage as a result of respiration of the contents and/or solution of some of the gas in the product

- The gases involved in modified atmosphere packaging, as applied commercially are carbon dioxide, nitrogen and oxygen.
- Carbon dioxide reacts with water in the product to form carbonic acid which lowers the pH of the food. It also inhibits the growth of certain microorganisms, mainly moulds and some aerobic bacteria.
- Lactic acid bacteria are resistant to the gas and may replace aerobic spoilage bacteria in modified atmosphere packaged meat

- Most yeasts are also resistant to carbon dioxide. Anaerobic bacteria, including food poisoning organisms, are little affected by carbon dioxide. Consequently, there is a potential health hazard in MAP products from these microorganisms.
- Nitrogen has no direct effect on microorganisms or foods, other than to replace oxygen, which can inhibit the oxidation of fats.
- As its solubility in water is low, it is used as a bulking material to prevent the collapse of MAP packages when the carbon dioxide dissolves in the food.
- This is also useful in packages of sliced or ground food materials, such as cheese, which may consolidate under vacuum.
- Oxygen is included in MAP packages of red meat to maintain the red colour, which is due to the oxidation of the myoglobin pigments. It is also included in MAP packages of white fish, to reduce the risk of botulism

- Argon, helium, xenon and neon, have also been used in MAP of some foods. MAP packages are either thermoformed trays with heat-sealed lids or pouches.
- With the exception of packages for fresh produce, these trays and pouches need to be made of materials with low permeability to gases (CO₂, N₂, and O₂).
- Laminates are used, made of various combinations of polyester (PET), polyvinylidene chloride (PVdC), polyethylene (PE) and polyamide.

Active packaging

- Active packaging refers to the incorporation of certain additives into packaging film or within packaging containers with the aim of maintaining and extending product shelf life.
- Packaging may be termed active when it performs some desired role in food preservation other than providing an inert barrier to external conditions
- Active packaging includes additives or 'freshness enhancers' that are capable of scavenging oxygen, adsorbing carbon dioxide, moisture, ethylene and/or flavor/odor taints, releasing ethanol, sorbates, antioxidants and/or other preservatives and/or maintaining temperature control.

Paper/Paperboard

- The principal differences between paper, paperboard and fiberboard are thickness and use.
- Paper are thin, flexible and used for bags and wraps, paperboard is thicker, more rigid and used to construct single layer cartons, fiberboard is made by combining layers of strong papers and is used to construct secondary shipping cartons.
- Paper from wood pulp is bleached and coated or impregnated with waxes, resins, lacquers, plastics and laminations of aluminum to improve its strength, especially in high humidity environments such as are often found around foods.
- Acid treatment of paper pulp modifies the cellulose and gives rise to water and oil resistant parchments of considerable wet strength. These papers are called greaseproof or glassine papers and are characterized by long wood pulp fibers which imparts increased physical strength.

Examples of paper and paperboard based packaging

- Paper bags, wrapping, packaging papers and infusible tissues, e.g. tea and coffee bags,
- Sachets, pouches, overwrapping paper, sugar and flour bags, carrier bags
- Multiwall paper sacks
- Folding cartons and rigid boxes
- Corrugated and solid fiberboard boxes (shipping cases)
- Paper based tubes, tubs and composite containers
- Fire drums
- Liquid packaging
- Moulded pulp containers
- Labels
- Sealing tapes
- Cushioning materials
- Cap liners (sealing wads) and diaphragms (membranes).



PETE

polyethylene terephthalate

soft drink bottles, mineral water, fruit juice container, cooking oil



HDPE

high-density polyethylene

milk jugs, cleaning agents, laundry detergents, bleaching agents, shampoo bottles, washing and shower soaps



PVC

polyvinyl chloride

trays for sweets, fruit, plastic packing (bubble foil) and food foils to wrap the foodstuff



LDPE

low-density polyethylene

crushed bottles, shopping bags, highly-resistant sacks and most of the wrappings



PP

polypropylene

furniture, consumers, luggage, toys as well as bumpers, lining and external borders of the cars



PS

polystyrene

toys, hard packing, refrigerator trays, cosmetic bags, costume jewellery, CD cases, vending cups



OTHER

other plastics, including acrylic, polycarbonate, polyactic fibers, nylon, fiberglass