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FACULTY OF AGRICULTURE SCIENCES AND ALLIED INDUSTRIES

Unit I

For

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Course Instructor

Dr Atul Yadav

FASAI(Horticulture)

Rama University, Kanpur

LECTURE 10. PACKAGING TECHNOLOGY

The increasing demand for fresh and quality packaged food, consumer convenience and manufacturers concern for longer shelf life of the food products is driving the market for Global active and smart packaging technology for food Markets. Being perishable, fruits and vegetables require to be preserved until they are sold and used by consumers. This offers challenges in food preservation. The package must not only act as an inert barrier to the external environment but also resist respiration issues. Demands on package performance continue to increase as a result of market and social changes. Active packaging reduces the need for additional preservatives in perishable food stuffs. Thus the shelf-life is extended and the food stuffs maintain freshness longer and are mildly preserved. Research work in this area brings out newer methods and technologies for improving the active packaging. Some of the new developments:

Ethylene scavenger:

Ethylene (produced by all plants) is a plant growth hormone and has a detrimental impact even at low concentrations on the quality and shelf-life of many fruits and vegetables during storage and distribution. Ethylene induces fruit ripening and accelerates fruit softening and ageing. There are several methods used by the horticultural industry to minimize the impact of ethylene during storage and distribution. The two major methods are:

1. Low temperatures of storage: reduces the production of ethylene by lowering respiration and metabolic rates of the produce.
2. Controlled atmospheric storage with low oxygen and high level of carbon dioxide: suppresses respiration rates and renders the produce less sensitive to the effects of ethylene. There is a need to generate varying concentrations of carbon dioxide to suit specific food requirements. Since carbon dioxide is more permeable through plastic films than is oxygen, carbon dioxide will need to be actively produced in some applications to maintain the desired atmosphere in the package.

Packaging technologies with an aim to scavenge or absorb ethylene from the surrounding environment of packaged produce have also been developed. The most widely used ethylene-scavenging packaging technology is based on a sachet that contains either potassium permanganate or activated carbon with a metal catalyst. Several ethylene-removing plastic film-based products consisting of PE impregnated with finely dispersed minerals like clays, zeolites and carbon have been developed. Oxygen scavengers can be incorporated in the packaging system itself rather than being added as sachets or labels as seen above. The oxygen scavenger can be incorporated into crowns, cans and a variety of metal and plastic closures. A novel plastic- based ethylene-scavenging technology developed by Food Science Australia is based on irreversible and specific reaction between diene (Tetrazine) and ethylene. Tetrazine is colored while its product with ethylene is colorless. This feature can provide the indication of the residual ethylene scavenging activity. The disadvantage however is that Tetrazine is sensitive to moisture. Another alternative approach is to use of ethylene inhibitors such as 1- methylcylcopropene (1-MCP). 1-MCP binds to the ethylene receptors in plant tissue and, as a result prevents the hormonal action of ethylene. However, it requires a dedicated fumigation chamber. A chemical reagent, incorporated into the packaging film, traps the ethylene produced by ripening fruit or vegetables. The reaction is irreversible and only small quantities of the scavenger are required to remove ethylene at the concentrations at which it is produced.

Oxygen Scavenger:

The presence of oxygen in food packages accelerates the spoilage of many foods. Oxygen can cause off-flavour, colour change and nutrient loss, among other degradation. One of the most promising applications of oxygen scavenging systems in food packages is to control mould growth. Most moulds require oxygen to grow and in standard packages it is frequently mould growth which limits the shelf life. This also delays oxidation of and therefore rancidity development. Sachets containing oxygen absorbents, where the scavenging material is usually finely divided iron oxide.

Antimicrobial Packaging: Extends shelf-life and promotes safety by

reducing the rate of growth of specifc microorganisms by allowing direct contact of the package with the surface of solid foods. The packaging could be self-sterilizing or sanitizing to greatly reduce the potential for recontamination of processed products and simplify the treatment of materials to eliminate product contamination. Antimicrobial systems can be constructed by using antimicrobial packaging materials, antimicrobial inserts (such as sachets) to generate antimicrobial atmosphere conditions inside packages, or antimicrobial edible food ingredients in the formulation of food. Since antimicrobial packaging systems are designed to control the growth of micro- organisms in packaged foods, the systems essentially consist of packaging materials, the in-package atmosphere, target micro-organisms, and antimicrobial agents. These elements are related to one another and to the final system design features. Antimicrobial packaging technologies have been developed considerably. Technologies that release volatile or gaseous microbial control agents are preferred due to the typically limited contact of the produce with the package surfaces.

Controlled Release of Sulfur Dioxide: Sulfur dioxide (SO_2) is an effective gaseous microbial agent, in use for over 80 years. SO_2 is traditionally used as antioxidant and preservative in fruit and vegetable products, dried fruits, snack products and wine. The main advantage of SO_2 is the combination of antioxidative activity with its ability to inhibit polyphenol oxidase, which is catalysing browning of food products. Furthermore, sulphur dioxide acts as food preservative preventing microbial growth. However, SO_2 and sulphites strongly reduce vitamin B1 uptake. Reduced uptake of this vitamin can lead to several health problems such as chronic headache and disturbance of the memory. Food is the main source for the uptake of sulphur dioxide. A special risk group is the group of asthma patients, as sulphites promote attacks of asthma. High levels of sulfur dioxide can result in undesirable bleaching of the fruit, making them unacceptable for sale. Furthermore, in 1989, a residue tolerance level of 10 ppm for sulfur dioxide was introduced by the US. Environmental Protection Agency (EPA) because it can cause adverse effect on people suffering from asthma. Several approaches to developing a plastic- based packaging film for the controlled release of sulfur dioxide have beenused. Some methods that show potential are:

- Multi layer plastic film with external surface containing calcium sulfite that will release sulfur dioxide with inside layer of organic acid like citric acid. Moisture from produce gets absorbed by inner layer. This causes migration of hydrogen ion from acid compound to outer layer. Reaction of acid with calcium sulfite triggers liberation of sulfur dioxide.
- Sodium metabisulfite can be blended into the polymer having different water vapour transmission rates. A film based on this modified polymer can release sulfur dioxide in controlled manner depending upon its water transmission rate.
- A plastic film that has been incorporated by sodium chloride in the form of encapsulation can release chlorine dioxide, a general biocide in controlled rates.
- Laminating a sulfite-containing film to a film containing a food grade organic acid such as citric or succinic acid.

Three approaches are followed to finally replace SO_2 and sulphites in food:

a. Reduction of oxygen contact of the food products by modified atmosphere packaging or by edible coatings for fruits and vegetables

b. Use of plant metabolites as antioxidants and antimicrobial agents

c. Inhibition of polyphenol oxidase, which is responsible for enzymatic browning in fruit and vegetable products

Modified Atmosphere Packaging (MAP): A technique used for prolonging the shelf-life period of fresh or minimally processed foods. In this preservation technique, the air surrounding the food in the package is changed to another composition. This way the initial fresh state of the product may be prolonged. Shelf-life is prolonged with MAP since it slows the natural deterioration of the product. MAP is used with various types of products, where the mixture of gases in the package depends on the type of product, packaging materials and storage temperature. Meat and fish need very low gas permeability films so for non-respiring products (meat, fish, cheese etc.) high barrier films are used. Fruits and vegetables are respiring products where the interaction of the packaging material with the product is important. If the permeability (for O_2 and CO_2) of the packaging film is adapted to the products respiration, an equilibrium modified atmosphere will establish in the package and the shelf- life of the product will increase. Instead of preserving foods through the extremes of heat (sterilization) or cold (freezing), MAP utilizes "minimal processing" - preserving food with the absolute least amount of damage to quality, texture, taste and nutrition. MAP has been in existence for the last several decades. Several technologies have been developed with an aim to replace the existing headspace gas mixture with the ideal ratio of oxygen and carbon dioxide to preserve the produce until it is consumed by the user. Some of the most common MAP systems are:

- Micro perforation of PE packaging film
- Incorporation of inorganic particles along with micro perforated PE film

Humidity and condensation control

Water loss from fresh produce or minimally processed foods as a result of normal respiration, microbiological activity, or physical activity can occur as a result of evaporation from the product followed by permeation through the package material, when the package material does not provide an adequate water-vapor barrier. Condensation or "sweating" is a problem in many kinds of packaged foods, particularly fresh fruit and vegetables. When one part of the package becomes cooler than another, water vapor condenses as liquid droplets in the cooler areas. If the liquid water is kept away from the product, it harms package appearance and consumer appeal, both of which are important. When condensation moistens the product's surface, soluble nutrients leak into the water, encouraging rapid growth of mold spores and leading to loss of nutrients. The use of humidity-control technology reduces condensation inside packages of respiring and other high-water-content foods and eliminates water films on the food without further drying the food. Therefore, moisture-sensitive humidity of the tray is controlled by :

- The presence of sodium chloride;
- Overwrap material claimed to be capable of controlling the relative humidity within a package that consists of a duplex of two sheets: the external sheet is a water-vapor barrier and the inner sheet is a water-vapor-permeable (but not water-permeable) film;
- A sandwich package composed of two sheets of polyvinyl alcohol (PVA) film sealed along the edge. Between the two sheets is a layer of propylene glycol humidifying agent.
- The PVA film is very permeable to water-vapor but is a barrier to the propylene glycol;
- A sheet made of aluminum metallized film with nonwoven fabric on the reverse side, to absorb meat and fish exudations.
- Multilayer package containing a layer of PVOH or cellulosic fiber like paper sandwiched between PE films.

Although active packaging may provide many benefits to shelf life extension, there are several issues to consider before implementing such a packaging system. The regulatory status of the active packaging system, cost-to-benefit ratio, production capability, commercial viability, consumer acceptance, and sensory effects on the food. Generally, the shelf life has clearly been extended through implementation of active packaging. Combinations of systems along with new technologies to be further developed will continue to improve the quality and safety of food.