Modern Food Packaging Technologies: Regulatory Aspects and Global Trends

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Week – 08
Lecture – 36

Welcome to the NPTEL online certification course on modern food packaging technologies, regulatory aspects and global trends. In the last lecture we have seen the controlled atmospheric packaging. Now the present lecture we will be discussing with the modified atmospheric packaging. And the topics for discussion in this lecture are introduction, working of map that is the modified atmospheric packaging, types of map, gases used for map, influence of gases on microbes, criteria for selecting packaging materials, packaging materials used in map, advantages and disadvantages of map. The packaging of a perishable product in an atmosphere which has been modified so that its composition is other than that of air. It is used to extend the shelf life of fresh foods such as meat, fish and cut fruit as well as of various bakery products, snack foods and other dried fruits.

In this method of packaging air in the package is replaced with the gas composition that will retard microbial growth and slow down chemical deterioration of the food. Laptop can be defined as the enclosure of food in a package in which the atmosphere inside of package is modified or altered to provide an optimum atmosphere for increasing shelf life and maintaining the food quality. It is alteration of the gaseous environment produced as a result of respiration that is the passive mass or by addition and removal of gases from food packages that is active map to manipulate the levels of oxygen and carbon dioxide. Active modification involves displacing the air with a controlled desired mixture of gases, a procedure generally referred to as gas flushing.

Passive modification occurs as a consequence of foods respiration and or metabolism of organisms associated with the food. The package structure normally incorporates polymeric film and so the permeation of gases through the film which varies depending on the nature of the film and storage temperature also influences the composition of the atmosphere that develops. In cap the gas composition inside the food storage room is continually monitored and adjusted to maintain the optimum concentration within quite close tolerances. In contrast the less common modified atmosphere storage typically involves some initial modification of the atmospheric composition in an airtight storage room which changes further with time as a result of respiratory activity of the fresh fruit and growth of microorganisms. The three main gases used in MAP are oxygen, carbon dioxide and nitrogen.

The choice of gas is totally dependent upon the food product being packed. Used singly or in combination these gases are commonly used to balance extension of self life with optimal organoleptic properties of the food. Depleted oxygen and or enriched carbon dioxide levels can reduce respiration, delay ripening, decrease ethylene production, retard textural softening, slow down compositional changes associated with ripening thereby resulting in extension of shelf life. Typically 3 to 8 percent carbon dioxide and 2 to 5 percent oxygen are recommended for fruits and vegetables in MAP storage. The modified atmosphere packaging works by sealing food inside a package that contains a carefully controlled gas mixture which significantly slows down both the growth of microorganisms as well as the rate of oxidation.

By using this controlled atmosphere the underlying processes that contribute to food spoilage are slowed down resulting in longer shelf life for the food product and generally more stable level of quality over that product self life. The typical mixture of gases used for this purpose is some blend of nitrogen, pure oxygen and carbon dioxide and is driven largely by specific nature of the food product being protected. In the adjacent figure you can see that it is a type of food modified atmospheric packaging where the controlled atmosphere with the carbon dioxide, nitrogen and oxygen are created in that in the first step the air is removed and in the second step mixture of selected ratio a particular ratio of carbon dioxide, nitrogen and oxygen is flushed and then in third stage it is sealed in a conventional package. Sometimes the absorb vent pad is also used to scrub the some of the gases. Multi component foods such as frozen package diners for instance are more challenging to address due to variety of ingredients and food types that are contained in the package.

Beyond the specifics of the atmospheric gas makeup the other elements that need to be addressed in the design of map concerned the packaging material itself. These considerations include the permeability of the film or the package, the rate at which the vapor is transmitted and the method of sealing. It can be noted that there is a distinction between modified atmospheric packaging and controlled atmospheric packaging. In the former that is map once the food product has been sealed into the package with the gas mixture there is no longer any opportunity to alter the gas mixture percentage levels which will inevitably change over time due to the respiration activity of the packaged food. Whereas, in the latter that is the cap case the food is stored in an atmosphere of gas over which control does exist.

Permitting changes to be made to the gas proportion in that storage environment should conditions shift. This is the working or the packaging of map storage where the ethylene oxygen and carbon dioxide has not monitored it is first once it is whatever in the first

time whatever composition or ratio they have been filled and that is the packed that is all and the water vapor also does not have any control, but scrubbers can be used to control the humidity etc. The types of map there are two general types of map are called active modified atmosphere packaging and passive modified atmosphere packaging. In the first case passive there is no control where as in the case of map it can be controlled by using ethylene carbon dioxide and water absorbent or scrubbers. In active modified atmosphere packaging removes the gases in the package and replaces them with the new protective gas or protective gas mix.

There are three methods of AMAP, gas flushing scavenger or desiccant packs on package valves. Now the gas flushing, gas flushing is the most common active modified packaging method it involves actively pumping gas into the package to displace ambient air. The most frequently used gas is nitrogen which acts as a harmless chemically inert filler gas. It invades oxidation and microbial growth and maintains the integrity of the package. Because of the prevalence of nitrogen as a protective gas some sources refer to gas flushing or nitrogen flushing or use the terms gas flushing or MAP packaging or low oxygen packaging as if they are synonyms.

However, this is an over simplification depending on the perishable product and its properties other gases may be used. Again these include carbon dioxide, oxygen, certain noble gases or custom protective gas mixtures besides gas flushing is not the only MAP packaging method. The scavenger or desiccant packs, oxygen scavengers or desiccant packs often come treatment of MAP packaging. Oxygen scavengers also called oxygen absorber are such as filled with iron powder designed to draw oxygen from the atmosphere. Desiccant packs are filled with substances such as silica gel or activated carbon.

They intend to absorb moisture to prevent products from degradation and in with microbial growth. Oxygen scavengers and desiccant packs each serve a separate purpose and cannot be used interchangeably. It is debatable whether oxygen scavengers and desiccant packs are actually a type of active modified atmospheric packaging. On the one hand they do affect the atmosphere surrounding the food product. On the other hand the gases and moisture the scavenger or desiccant pack absorb do not leave the package.

They merely get concentrated in a small area within the package itself. The scavenger or desiccant packs examples of this are carbon dioxide scavenger, calcium hydroxide, carbon dioxide emitters, ascorbic acids, moisture absorber, silica gel, activated carbon and zeolite cellulose and derivatives. Whereas, the ethylene scavengers are potassium permanganate and activated carbon. On package valves, on package valves are another active modified atmospheric packaging method. These are small one way valve allow for

the controlled release of gases from inside of the packaging to the outside.

However, ambient air and moisture cannot enter the package from the outside. On package valves modify the atmosphere in the package to increase the product shelf life. They can also inhibit flavor and aroma loss as well as prevent the package from bursting. If the perishable products is known to release a lot of gas, this is the case for example, with coffee beans that tend to build up carbon dioxide. However, on package valves are also applied on packages of other products such as fresh vegetables and fruits which require respiration.

Now, the passive modified atmospheric packaging that is PMAP. PMAP implies breathable or permeable films which develop the desired atmosphere over time. There are two methods of PMAP, one is barrier films, another is vacuum skin packaging. Barrier films, barrier films are the passive way of achieving modified atmosphere packaging. Breathable films have their permeability fine tuned to work in conjunction with the respiration rate of the product.

Their purpose is to change the ambient air in package into an optimized atmosphere over time. Simultaneously, the barrier films invade oxygen and moisture from entering the package from the outside. In the context of barrier films, a new technology is emerging that is smart packaging films. Such as color changing films that are spiked with PS sensitive indicators can detect problems in the package and aid in monitoring freshness. Smart barrier films are part of a larger subset of technology called smart packaging or intelligent packaging which involve various change sensitive devices to monitor product quality.

Now, the vacuum skin packaging, in modified atmosphere packaging the composition of the gaseous atmosphere around a product is changed while in vacuum skin packaging the atmosphere is removed all together. Hence vacuum skin packaging is not a type of PMA packaging, but it is somewhat similar. Vacuum skin packaging is an ongoing trend in the market. Since it adds a visually appealing glossy appearance to food, it is particularly well suited to pack premium meat, fish and sea foods. The difference between passive and active map, in the no atmospheric packaging the product is simply kept in the environment that is oxygen water and temperature and quality decay occurs here.

Whereas, in the passive modified atmosphere packaging some permeation of gases takes place and whereas, in the map the scavengers and antimicrobial substances and this moisture absorbers are used. And if we see the graphical representation in the passive modification, the carbon dioxide increases gradually and the oxygen level decreases gradually because of the respiration of fruits and vegetables and the microorganisms

metabolic activity. Whereas, in the active modification there is sharp increase in carbon dioxide and sharp decrease in oxygen level because of the scrubbers used. Now, the gases used in the modified atmospheric packaging. There are three main gases used in map that is the oxygen, carbon dioxide and nitrogen.

The choice of gas depends entirely on the food to be packaged. These gases are used alone or in combination and are usually used in balance, the safety, shelf life and the best sensory properties. Rare or inert gases such as argon are used commercially in products such as coffee and snacks, but there is limited literature on their use and benefits. Several uses of carbon monoxide and sulphur dioxide have also been reported. The carbon dioxide, carbon dioxide is a colorless gas with a slightly pungent odor at very high concentrations.

Carbon dioxide is easily soluble in water that is 1.57 grams per kg at 100 kilo Pascal pressure and 20 degree Celsius temperature to form carbonic acid which increases the acidity of the solution and lowers the pH value. This gas is also soluble lipids and other organic compounds. The solubility of carbon dioxide increases with decreasing temperature. For this reason, the antibacterial activity of carbon dioxide is significantly higher at temperatures below 10 degree Celsius than at 15 degree Celsius or higher.

This has important implications for the food map discussed later. Due to the reduced air space, the high solubility of carbon dioxide will cause the packaging to deteriorate. In some map applications, compressed packaging is preferred such as cheese in retail packaging. Now the oxygen, the oxygen is highly reactive, odorless and colorless gas that promotes combustion. Its solubility in water is low that is 0.04 gram per kg at 100 kilo Pascal pressure and 20 degree Celsius temperature. Oxygen can cause many types of food spoilage reactions including fat oxidation, blackening reaction and pigment oxidation. The most common perishable bacteria and fungi require oxygen to grow. In order to extend the shelf life of food, the atmosphere of the package must therefore, contain low concentration of residual oxygen. Foods with low oxygen concentrations can cause quality and safety issues such as poor discoloration of red meat pigments, aging of fruits and vegetables and growth of food borne bacteria which should be considered when selecting gaseous formulations for prepackaged foods.

The nitrogen, the nitrogen is a relatively inert gas, odorless, tasteless or colorless, has a lower density than air, is non flammable and has low solubility in water that is 0.018 grams per kg at 100 kilo Pascal pressure and 20 degree Celsius temperature and other food ingredients. Nitrogen does not support the growth of aerobic microorganisms. So, it inhibits the growth of aerobic spoilage, but cannot prevent the growth of anaerobic bacteria. The nitrogen in the gas mixture compensates for the decrease in the volume

caused by the dissolution of the carbon dioxide.

Carbon monoxide, carbon monoxide is a colorless and odorless gas that is highly reactive and flammable. Its water solubility is poor, but it is relatively soluble in some organic solvents. The carbon monoxide was investigated and approved in the meat map used to prevent browning of packaged lettuce in the United States. Commercial use is restricted due to its toxicity and the formation of potentially explosive mixture with air. Noble gases, noble gases are a class of non reactive element including helium, argon, xenon and neon.

These gases are now used in many foods such as potato snacks. Although it is scientifically difficult to understand how the use of inert gases provides savings over nitrogen, they are still in use indicating that there may be a benefits that have not yet been announced. Effect of oxygen, aerobes require oxygen to grow and include the ubiquitous Pseudomonas gram negative spoilage bacteria. This group also includes some pathogenic bacteria such as Vibrio parahemolyticus. Microaerophiles grow at low concentration of oxygen therefore, the hypoxic environment is selective for some major pathogens such as Listeria, monocytogenes.

Even under conditions of low oxygen levels, higher carbon dioxide levels may be required to achieve optimal growth. Facultative anaerobes usually grow based under low oxygen, but they can grow without it. These include several important genre of the enterobacteriaceae including pathogens such as Escheria coli, Salmonella and Shigella, Staphylococcus aureus and Listeria monocytogenes. Aeromonas hydrophila is an emerging pathogen especially related to fish and fish products many strains are psychrophilic and some can grow at a temperature at 3 to 5 degree Celsius. The influence of gases on the microbes, this table represents the oxygen requirements of some microorganisms on the relevance of the modified atmospheric packaging.

The aerobic groups requires atmospheric oxygen for growth and this includes the micrococcus species, molds for example, Botrytis cinerea, Pseudomonas species and the pathogenic groups are Bacillus aureus, Yersinia enterocolitica, Vibrio parahemoliticus, Campylobacter jejuni. The microaerophils requires low concentration of oxygen for the growth for example, Lactobacillus species, Bacillus species and enterobacteriaceae and pathogens like Listeria monocytogenes, Aeromonas hydrophila, Escheria coli. Whereas the facultative anaerobes grow in presence or absence of oxygen for example, Brochothrix thermosphacta, Shewanella putrefaciens yeast and pathogens are Salmonella, Staphylococcus species and Vibrio species. Whereas the anaerobes they grow in complete absence of oxygen or in another words they are emitted by oxygen like Clostridium sporogenes and Clostridium tyrobutyricum and the pathogens are

Clostridium perfringens and Clostridium botulinum. The effect of carbon dioxide, the carbon dioxide will increase the lag period and generation time of microorganisms and this effect is expected to increase at lower temperature.

Antibacterial mechanisms include lowering carbon dioxide pH inhibiting succinate oxidase when carbon dioxide concentration is higher than 10 percent inhibiting certain decarboxylase and cell membrane changes. Carbon dioxide exposure is highly dependent on temperature therefore, in order to protect the health of consumers the integrity of temperature control must be maintained throughout the supply chain. Carbon dioxide stimulate Clostridium botulinum. These are the effect of carbon dioxide atmosphere on the growth. These are the list of microorganisms given here then most of them are either facultative or anaerobic and they grow well in the carbon dioxide.

So, they are either uninhibited or unaffected. Now the effect of nitrogen, nitrogen is a relatively inert gas it is used to replace the air in map especially oxygen. By removing oxygen the growth of aerobic organisms is inhibited or eliminated. Put pressure on the packaging to avoid tearing the packaging of foods with high moisture and fat content. For example, due to the solubility of carbon dioxide in water and fat these products tend to absorb carbon dioxide from the packaging environment. Now the criteria for selecting packaging materials, the food content approval, gas and vapor barrier properties, optical properties, anti-fogging properties, mechanical properties and heat sealing properties.

Now the packaging materials used in the map, the first is ethylene vinyl chloride, ethylene vinyl alcohol. It is used as a gas barrier in modified atmosphere packaging applications. This material has good processing properties. So, it is suitable for processing into plastic films and structures. The another is polyethylene or PE is characterized by poor gas barrier, but it is hydrophobicity makes it very good water vapor barrier.

Therefore map applications that require high gas barrier properties polyethylene cannot be used alone as a packaging material. The polyamide or nylon generally high tensile strength, good puncture resistance and abrasion resistance and good air tightness. Polyethylene terephthalate or PET has a good barrier to gas and water vapor, high strength, good transparency and high temperature resistance. Flexible PET films are used for barrier pouches and top webs as cover material for trays. Polypropylene or PP has good barrier properties of water vapor, but poor barrier properties of gases.

Foamed PP is used to provide structural properties in laminates for MAP thermoformed base trays where it is combined with ethylene vinyl alcohol barrier and the PE as heat sealing layer. The polystyrene, pure polystyrene is a stiff brittle material and has limited

use in modified atmosphere packaging applications. Polyvinyl chloride that is PVC it is a common structural material in map transform based trays where it is laminated to PE to provide the required heat sealing properties. Polyvinylidene chloride or PBDC it possesses excellent gas water vapor and odor barrier properties with good resistance of oil, grease and oil solvent organic solvents. Promopolymers and copolymers of PBDC are some of the best commercial available barriers for food packaging of applications.

The advantages of map the fresh appearance potential shelf life increase by 50 to 400 percent, product can be distributed to a long distance, high quality products and user friendly. The disadvantages are also associated with the map that is the added cost, temperature control is necessary during storage and the special equipment is required. These are the gas mixture composition for product stored under MAP like this table represents the temperature and the various composition of the oxygen, carbon dioxide and nitrogen. For different products like meat products, fish, plant products, baked products, pasta and ready to eat meals that is all for today. Thank you very much.