Modern Food Packaging Technologies: Regulatory Aspects and Global Trends

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Welcome to the NPTEL online certification course on Modern Fortification. We will be covering about packaging technologies, regulatory aspects and global trends. Dear friends, in the last lecture we have seen the septic packaging and now we shall be discussing with active and intelligent packaging. And we are will be we will be covering in this introduction definitions, active packaging system and intelligent packaging systems. For a long time packaging also had an active role in processing and preservation of quality of foods. Variations in the way food products are produced, circulated, stored and sold reflecting the continuing increase in consumer demand for improved safety, quality and safe life for packaged foods are assigning greater demands on the performance of food packaging.

Consumers want to be assured that the packaging is fulfilling its function of protecting the quality, freshness and safety of foods. Thus, advances in food packaging are both anticipated and expected. Society is becoming increasingly complex and innovative packaging is outcome of consumers demand for packaging that is more advanced and creative than what is currently offered. Active packaging and intelligent packaging are the result of innovating thinking of packaging.

Active packaging can be defined as packaging in which supplementary constituents have been deliberately added either in or on the packaging material of the package headspace to improve the performance of package system. In simple terms active packaging is an extension of the protection purpose of a package and is commonly used to protect against oxygen or moisture. It permits packages to interact with food and environment thus play a dynamic role in food preservation. Development in active packaging have led to advances in many areas like delayed oxidation and controlled respiration rate, microbial growth and moisture migration. Other active packaging technologies include carbon dioxide absorber or emitters, odor absorbers, ethylene removers and aromas emitters.

On the other hand intelligent packaging can be defined as packaging that has an external or internal indicator to provide information about characteristics of the history of the package and or the quality of the food packed. Intelligent packaging is an extension of the communication purpose of conventional packaging and provides information to the

consumer based on its ability to sense, detect or record external or internal changes in the products environment. For example, time temperature indicators, ripeness indicators, biosensors and radio frequency identification. A variety of terms can be found in the literature to describe the growing and important areas of active and intelligent packaging including active, interactive, smart, clever and intelligent packaging. Often the terms are used without being defined or if they are defined the definitions are either so broad that they include many packages which are not active or intelligent or so narrow that they exclude important examples.

The meanings of words gain their legitimacy from shared use. So, in the final analysis there is no correct meaning. However, unless there is a general consensus around the meaning of these terms there will continue to be confusion. Before giving a definition it is worth recapping some basic facts. Foods are packed using a variety of materials and the primary function of such materials is to contain and protect the food.

In many cases there is a head space or wired inside the package and the composition of that head space can have an important influence on the shelf life of the food. In addition the packaging material or a component of it such as a seal or closure may interact with the package or permit the transfer of certain compounds into or out of the package. In addition to the food the package might also contain a sachet or pad which might absorb or emit a specific gas in the case of a sachet or water in the case of a pad. These facts should be kept in mind when the definitions of active and intelligent packaging are considered. Active packaging, the active packaging is defined as packaging in which subsidiary constituents have been deliberately included either in or on the packaging material or the package head space to enhance the performance of the package system.

The two keywords are deliberately and enhance. Shift in this definition is that performance of the package system includes maintaining and often improving the sensory, safety and quality aspects of the food. In light of the aforementioned definition it is possible to list processes which are not active packaging although some authors have described them as such. Modified atmospheric packaging as normally practiced which we have covered in the lecture 36 is passive not active packaging per say unless there is some way in which the package or a sachet added to the package actively affects the internal gas atmosphere other than via normal permeation through plastic films. The reason for confusion over whether or not a map is active packaging is that the creation of the modified atmosphere can be either passive, the atmosphere changes over time as a result of biochemical activity by the food or its microorganisms are active, air is removed from the pack or a gas mixture is admitted immediately prior to sealing, but active map is not necessarily active packaging.

However, if the package contained gas scavenging or emitting sachet then it could be classified as active packaging. The interaction between tin and food constituents inside a can is corrosion not active packaging. The aforementioned definition also excludes the scalping of automatic flavors by for example, the plastic layer in contact with fruit juices on the inside of laminate paper board curtains. Selected examples of active packaging systems are given in the following table. This table represents the active packaging systems like oxygen absorber which are using oxygen absorbers carbon dioxide absorbers, ethylene absorbers and like so on and the uses of those had been listed in this table and the mechanism is also listed in this table.

Now, the intelligent packaging. Intelligent is defined as having or showing understanding clever, quick of mind the primary meaning intended when the word is applied to packaging is showing understanding although clever is preferred for non technical audiences. Intelligent packaging is defined as packaging that contains an internal or external indicator to provide information about the history of the package and or the quality of the food. The key word in this definition is indicator and includes all the indicators whether for gases, ripeness, temperature or tempering including radio frequency identification or RFID sensors, but not RFID tags or labels because the latter do not indicate the history of the package or the quality of the food, but merely its location. RFID tags are an example of smart labels and are in essence data carriers from now onwards only RFID tags that incorporate centers sensors should be classed as intelligent packaging.

The definitions of active and intelligent packaging. Active packaging the packaging in which subsidiaries constituents have been deliberately included in or on either the packaging material or the package head space to enhance the performance of the package system. Whereas, the intelligent packaging is defined like packaging that contains an external or external indicator to provide information about aspects of the history of the package and or the quality of the food. The active packaging system there are several ways in which active packaging systems can be classified. Typically the classification is based on what the system actually does.

For example, absorbs oxygen rather than it impacts on the food that prevents oxidation. A similar classification will be adopted here in addition active packaging systems will be divided into two categories. Those in which the active compounds are filled into such as or pads which are then placed inside packages and those in which the active compounds are incorporated deliberately are incorporated directly into or on the packaging materials. Sachets or pads sachets and pads can be a highly efficient form of active packaging, but they suffer from two major drawbacks. They cannot be used in liquid foods and in packages made from or containing a flexible film, the film may cling to the sachet and

isolate it from areas where it is needed to perform its function.

To overcome the later problem the sachet can be glued to the inner valve of the package or the active ingredients incorporated into a label which can be a fixed to the inside valve of the package. Like this is the plastic film covering food and this is the food product contained in that and the flow of intended liquid takes place in this way and this is the plastic tray and this is the actually the absorbing pad which absorbs the factor which deteriorates the food. Oxygen absorbers, oxygen absorbers also referred to as oxygen scavengers and abbreviated as OS use either powdered iron or ascorbic acid the former being more common. Powdered iron is used to provide a large reaction surface area the overall reaction proceeds as follows. The 4 Fe plus 3 O 2 plus 6 H 2 O is equal to 4 Fe O 3 that is ferric hydroxide.

The prevent the oxygen absorbers prevent corrosive gases and moisture from the packaging and the food storage generally uses this is tea, coffee, beef, nuts, dairy products, sweets, pet snacks, baked tea and the pharma storage are multibeta means proteins, pre filled syringes, eye drops, tablets and capsules, diagnostics and nutraceuticals. By using iron powder it is possible to reduce the oxygen concentration in the head space to less than 0.1 percent which is much lower than the typical 0.3 to 3 percent residual oxygen levels achievable by vacuum or gas flushing. Absorbers can be characterized by two main properties that is absorption capacity and absorption rate constant.

Several interrelated factors influence the choice of the type and size of absorbent required. These include nature of the food that is size, shape and weight. Water activity of the food, amount of the dissolved oxygen in the food, desired shelf life of the food, initial oxygen level in the package head space and oxygen permeability of the packaging material. Like to prevent deterioration during transportation and storage which causes by moisture absorption it can be used. For control of fungus and bacteria growth for the long term storage of food and pharmaceutical components that is US FDA approved.

And for extension of the shelf life of the packaging that is the storage transportation for oil and nutraceuticals products stored, metal components etc. One disadvantage of iron based scavenger is that they normally cannot pass the metal detectors often installed on packaging lines. Nonmetallic oxygen scavenger include those that use organic reducing agents such as ascorbic acid, ascorbate salts or catechol. They also include enzymic oxygen scavenger system using either glucose oxidase or ethanol oxidase which can be incorporated into sachets adhesive levels or immobilized onto package surfaces. However, their use is not widespread.

The carbon dioxide absorbers are emitters. The sachets that absorb only carbon dioxide are rare. Carbon dioxide scavengers can be composed either of a physical absorbent like zeolite or an active carbon powder or a chemical absorbent such as calcium hydroxide and magnesium hydroxide. Typically packaged in a small pouches of paper coated with perforated polypropylene. And the reaction goes like this that carbon dioxide when reacts with calcium hydroxide that produces calcium carbonate and water.

The carbon dioxide gas retorts spoilage bacteria extends products. Here the carbon dioxide absorber has been used this blue in the meat tray and then it is wrapped with a film. Sachets that contain calcium hydroxide in addition to iron powder absorb carbon dioxide as well as oxygen and find a niche application inside packages of roasted or ground coffee. Fresh roasted coffee releases considerable amount of carbon dioxide formed by the mallard reaction during roasting. And unless it is removed it can cause swelling or even bursting of the package.

Carbon dioxide fresh pads from carbon dioxide technologies Iowa have been adopted for meat poultry and seafood processes. The system contains citric acid and sodium bicarbonate as moisture actuated carbon dioxide generating materials in the pad. Infrared between layers of absorbent material and bound to fibers of the material. The ethylene absorbers the plant hormone ethylene is produced during the ripening of fruit and vegetables and can have both positive and negative effects on fresh produce. Positive effects include catalyzing the ripening process while negative effects include increasing the respiration rate which leads to softening of fruit tissue and accelerated senescence, degrading chlorophyll and promoting a number of post harvest disorders.

Here in the tomato tray the ethylene scavenger sachet is used which retorts the ripening of the tomatoes during the transportation. Many ethylene absorbing substances have been described in the patent literature, but those that have been commercialized are based on potassium permanganate which oxidizes ethylene in a series of reaction to acetaldehyde and then acetic acid which in turn can be further oxidized to carbon dioxide and water with a overall reaction which is represented here. Ethylene and potassium permanganate is decomposed to manganese oxide and KOH and carbon dioxide. Because KMnO 4 or potassium permanganate is toxic it cannot be integrated into food contact packaging. Instead about 4 to 6 percent of KMnO 4 is added to an inert substrate with a large surface area such as pearlite, alumina, silica gel, vermicolite, activated carbon or celite and placed inside a sachet which can be safely added to packages.

The moisture absorbers if the package has a low permeability to water vapor water accumulation inside the package is more pronounced. The excess water development inside a food package usually occurs due to the respiration of fresh produce, temperature

fluctuations in high equilibrium relative humidity food packages or the drip of tissue fluid from cut meats poultry and produce. In the adjacent figure the action of active agent has been shown which absorbs the either oxygen or that inflow of oxygen takes place in the food packet. An effective way of controlling excess water accumulation in a food package that has a high barrier to water vapor is to use a moisture or water vapor scavenger like silica gel, molecular sieves, natural clays, calcium oxide, calcium chloride and modified starch or other moisture absorbing substances. Silica gel is the most widely used desiccant because it is non-toxic and non-corrosive.

The advantages of active packaging are as follows increasing the shelf life of the product, prevent oxidation phenomena during storage, prevent color loss and other ripening of fruits and vegetable in package, prevent growth of aerobic microorganisms and slow down the metabolism of food. Now, the disadvantages of active packaging includes the increase the cost of production of food, most of the active packaging systems except self heating and self cooling system cannot be applied in liquid food, possible migration of issues of complex packaging materials into the product, lack of recyclability of disposable and possible mistrust confusion of technology. Now, the intelligent packaging system intelligent packaging is defined as packaging that contains an external or internal indicator to provide information about aspects of the history of package and or quality of the food. Intelligent packaging system can be classified into three categories. First one is indicate product quality for example, quality indicators, temperature and time temperature indicators and gas concentration indicators.

The second provide more convenience for example, during preparation and cooking of food. Third one to provide protection against theft, counterfeiting and tempering. The quality or freshness indicator. In this application of intelligent packaging quality or freshness indicators are used to indicate if the quality of product has become unacceptable during storage. Transport and retailing and in consumers homes, intelligent indicators typically undergo a color change that remains permanent and is easy to read and interpret by consumers.

The indicator responds to the volatile gases emitted by many fruits as they ripen that is not ethylene, but probably the complex mixture of volatiles which include alcohols, esters, aldehyde, ketones and lactones that contribute to the aroma. The label can be attached to a four piece pet clam shell pungent with a temper evident seal that has the added advantage of protecting the fruit from the damage then often occurs as consumers handle produce prior to making their selections. The time temperature indicators or TTI's. TTI's are devices which integrate the exposure of temperature over time by accumulating the effect of such exposures and exhibiting a change in color or other physiological characteristics. Although the majority of these devices were developed

specifically for frozen foods that is now widespread interest in TTI's for most categories of food especially those where the rate of quality deterioration is highly temperature sensitive.

The different types of TTI's are available like diffusion based, enzyme based, polymer based, microbial based and they used for the in the meat, fruits, milk, blood capsules, vaccines and they are at the same time eco friendly, composite nano materials, flexibility,versality and minimaturation and at the same time they are low cost. TTI's can be divided into two categories partial history indicators which do not respond unless some predominant threshold temperature is exceeded and full history indicators which respond continuously to all temperatures within the limit of the functional temperature range of the TTI. Thus giving an integrated time temperature measure related to the entire life of the product to be monitored. Partial history indicators are intended to identify abusive temperature conditions and thus there is no direct correlation between food quality change and the response of this class of indicators. TTI's are based on irreversible physical, chemical, enzymatic or microbiological changes and their response is usually expressed in a visually quantifiable identifier in the form of mechanical deformation, color development or color movement.

The visible response reflects the cumulative time temperature history of the package on which they are placed. The time temperature indicator must satisfy some requirements to be effective as monitoring devices such as they must be easily activated and sensitive, they must provide a high degree of accuracy and precision, they should have tamper evident characteristics, response should be irreversible, reproducible and correlated with food quality changes. The physical and chemical characteristics of TTI's should be determined and the response should be easily readable and should not be confusing. The gas concentration indicators for many map applications which can include both gas flushing and vacuum, it is helpful to know the gas concentration inside the package head space and whether or not it is changing over time. Any changes could be as a result of enzymatic activity in the food such as respiration of fruits and vegetables, deliberate absorption or generation of gases by added absorbers or generators as discussed earlier or loss of package integrity due to faulty seals or pin holes.

The two gases of most interest are oxygen and to a lesser extent carbon dioxide. The types of gas indicators available commercially are based on either colorimetric change or luminescence. The Ageless Eye and wonder sensor oxygen indicators are colorimetric redox dye based indicators and comprise the redox dye methylene blue and a strong reducing agent such as glucose in alkaline medium. In the absence of a significant level of oxygen that is less than or equal to 0.1 percent, most of the dye lies in its reduced colorless state that is leucomethylene blue rather than in its oxidized more colored form.

In contrast in the presence of a significant level of oxygen typically more than or equal to 0.5 percent, most of the dye lies in its oxidized or highly colored form. The reductant and its oxidized form are glucose and gluconic acid respectively. A non-redox sensitive dye that is acid red 52 is usually added to provide a background pink color to the indicator. This is in the oxygen free environment the color will be like this and when it is oxygen rich environment or when there is pinholes then it will turn to the blue which indicates that the package has been damaged.

The radio frequency identification or RFID is the use of radio frequencies to read information at a distant distance with few problems from obstructions or disorientation on a small device known as a tag or transponder that can be attached to an object commonly pilot or corrugated box so that the object can be identified and tracked. Till date most of most RFIDs have been used to increase convenience and efficiency in supply chain management and traceability being normally applied to secondary or tertiary packaging. To qualify as intelligent packaging they must contain an indicator that provides information about aspects of history of package for example, its temperature or the quality of the food and such intelligent RFID tags are now being commercialized. Till date most RFIDs have been used to increase convenience and efficiency in supply chain management and traceability being normally applied to secondary and tertiary packaging. When attached to an RFID chip reader can collect data from label that includes both the aggregate temperature history of the product and in the more sophisticated versions that qualify as intelligent packaging the remaining shelf life left.

This is provided for intelligent inventory management and create an opportunity to dramatically reduce the amount of expired products by first selling those products that the reader shows have the least shelf life left. The level of oxygen that indicates that like in the January if it is more and when in February it is less that gives then indication that this product should be sold first or as soon as possible. The functions of RFID food monitoring and traceability, improved supply chain efficiency, greater speed and efficiency, improved shelf life availability, enhanced forecasting, analyzing warehouse data and measurement of temperature, relativity, pH and volatile compounds. Now the biosensors, biosensors are compact devices that enable detection recording and transmission of information about biological reactions and offer the potential for real time pathogen detection. These devices consist of a bioreceptor that is specific for an analyte and a transducer that converts biological signals into a measurable electrical response.

The bioreceptor is an organic or biological material such as enzyme, antigen, microbe, hormone or nucleic acid. The transducer can assume many forms such as

electrochemical, optical or acoustic depending upon the parameters being measured. Now the thermochromic inks, the temperature sensitive thermochromic inks can be printed onto labels or containers which are to be heated or cooled prior to consumption to indicate the ideal drinking temperature for the product. Depending on their composition the inks will change color at specific temperatures and if appropriate color are chosen hidden messages such as drink now or too hot become visible. Thermochromic technology for beverages first became popular with wine labeling and has been adopted mainly for special occasions and promotions.

Now the advantages of active packaging, provision of information about the integrity of the package condition of food, detection of calamities during transport, reduce food loss and enhance bio security, enhance food quality and convenience, warning about possible problems and increase shelf life. There are certain disadvantages associated with that active packaging or equipment and supports are very high cost, possible mistrust confusion in the technology and lack of recyclability. That is all for today. Thank you very much.