Modern Food Packaging Technologies: Regulatory Aspects and Global Trends

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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 active and intelligent packaging. Now, onwards we shall be taking the packaging of food products and the first product we will be taking the meat and poultry products. And in this we will be covering the introduction, importance of meat packaging, packaging of fresh meat, packaging of fresh meat materials and techniques, tray with over wrap, shrink packaging, vacuum packaging, skin packaging and modified atmospheric packaging especially for the meats. The meat industry is an important sector of food industry in the world and comes in the first five ranked agricultural commodities like rice, milk, wheat etcetera. However, in India this industry is not so developed due to religious taboos and economic conditions.

The India is the largest producer of animals in the world. In the adjacent picture we can see that India produces about 63 million tons of meat standing fifth in rank of the world meat production. Out of this the 62 percent is bovine meat production followed by poultry which is around 11 percent followed by pig that is 10 percent and then goats 10 percent and the least is the sheep. Both animal husbandry and meat industry have a great socio economic and cultural importance in the country.

Though India possesses 48 percent of the world's animal population comprising about 209 million cattle, 92 million buffalo, 121 million goats, 56 million sheep and 16 million pigs and 407 million poultry it shares less than 1 percent of the total meat production. In the picture also it is depicted that out of total meat produced the poultry contribute about more than just slightly more than the 50 percent followed by the buffaloes which is 18.43 percent followed by goats that is 13.72, then sheep that is 8.94 percent, then pig 4.

82 percent and then cattle that is 3.59 percent. Though 70 percent of Indian population is considered non vegetarian the per capita meat consumption is hardly 2.5 kilogram per annum due to several reasons. India produces 4.

7 million tons of meat valued of rupees 15,500 crores annually which is only 2.13 percent of the 221.15 million tons of meat produced in the world. The meat and meat processing industry in India is growing steadily with the increasing urbanization, quality

consciousness and change in food habits and hence there is a market for scientifically produced meat products. There is also a growing demand for processed, packaged, convenience and ready to eat or ready to serve meat products that require minimal preparation.

The meat and meat products can generally be classified as fresh meat, frozen meat, cured meat, thermo processed meat and dehydrated meat products. The packaging requirements could vary across these product groups. The adjacent picture shows that worldwide annual production of meat in million tons of carcass which is growing increasingly from 1961 which is amounts about 71 million tons to 364 million tons in 2023. The food packaging is an integral part of food processing and a vital link between the processor and the eventual consumer for the safe delivery of the product through the various stages of processing, storage, transport, distribution and marketing. All over the world the consumers are showing greater awareness towards food packaging as it provides awareness to the quality, quantity and the hygienic standards.

A very important aspect of meat preservation is the suitable packaging of the product. The main purpose of packaging is to protect meat or meat product from microbial contamination, effect of light, oxygen or any physical damage or chemical changes. The selection of the packaging material has to be done very carefully to protect the different physicochemical properties like nature of pigments, sensory attributes and microflora. The purpose is to retard or prevent the main deteriorative changes and make the products available to the consumers in the most attractive form. However, initial quality of the meat has to be very good because packaging can only maintain the existing quality of the meat or delay the onset of spoilage by controlling the factors that contribute to it.

The product therefore, is only protected for a limited period determined by the system that is used. Thus, meat and meat products need a specialized package profile depending upon the type of processing, conditions of storage and distribution. The packaging of fresh meat, the fresh meat is highly perishable and a biologically active item. The quality of fresh meat is affected by the growth of microorganisms, enzyme activity and by oxidation. The microbiological activity continues even after refrigeration and packaging though at a reduced rate.

The factors that make fresh meat unsalable are changes in color, odor, taste and texture. The pigments present in fresh meat are proteins like hemoglobin and myoglobin. Hemoglobin does the function of transfer of oxygen from the blood and myoglobin acts as a storage mechanism of oxygen in cells. The myoglobin has a purple red color which is the characteristic color of fresh meat when it is first cut. In presence of oxygen there is transformation of oxymyoglobin which imparts a bright red color to the meat.

In the absence of oxygen oxymyoglobin gets reconverted to myoglobin. This is the pictorial diagram which tells that this is the deoxymyoglobin or the myoglobin in presence of oxygen it turns to the oxymyoglobin which is having bright red color when it is further oxidized then it turns to metamyoglobin which has the brown color and when it is reduced from the myoglobin also or the deoxymyoglobin also directly due to oxidation it may turn to the metamyoglobin which is of brown color and this is continuous process that is depend upon the availability of the oxygen. And this is the another representation that the oxymyoglobin is of bright red color it is turned to metamyoglobin this process is slow whereas, from metamyoglobin it is converted to myoglobin this process is faster and again with the presence or absence of oxygen it turns to and this process continues depending upon the concentration and availability of the oxygen. The major factors which affects the red meat color is storage temperature, oxygen partial pressure and meat pH. The storage temperature if it is high that favors the greater oxygen scavenging by residual respiratory enzymes plus other oxygen consuming processes such as fat oxidation.

It also enhances dissociation of oxygen from oxymyoglobin thereby increasing the tendency of auto oxidation of the myoglobin whereas, the low storage temperature that promotes increased penetration of oxygen into the surface and also enhances oxygen solubility in tissue fluids. Both aforementioned effects increase depth of oxymyoglobin at the surface whereas, the oxygen partial pressure if it is high it favors the formation of oxymyoglobin and if it is low then at that favors the formation of metamyoglobin. However, the pH also affects the red meat color if pH is high then it accelerates respiratory activity of meat tissues resulting in thin layer of oxymyoglobin with underlying myoglobin more apparent. Muscle fiber swell thereby reducing oxygen diffusion and thereby formation of oxymyoglobin. If the pH is low that causes denaturation of the globin moiety and subsequent dissociation of oxygen from the heme.

It promotes oxidation of myoglobin and undesirable brown color is formed due to metamyoglobin when meat gets exposed to air for a few days. Yet another form of discoloration on the surface of the meat which is dark reddish brown color is due to loss of moisture. This dehydration of meat on the surface results in the concentration of the pigments. Further concentration of pigments occurs when the interior moisture containing dissolved pigments migrate to the surface and evaporates. Another factor which accelerates desiccation and oxidation of meat is ultraviolet light.

Undesirable flavors, odors and texture can occur due to the action of enzymes, molds, bacteria and oxygen if they are not properly controlled. During the storage of fresh meat the flavor or odor may get affected due to the pickup of foreign odors or as a result of

oxidative density. Hence the principle role of meat packaging is to prevent the moisture loss, to offer the product to the consumer in most desirable color that is red blue, to prevent further biological contamination of the meat, to arrest pickup of foreign flavor and odor by the meat and to control oxygen transfer. To prevent dehydration a relative humidity of 85 to 95 percent is required. During storage this can be achieved by the use of packaging material which has a good water vapor barrier.

The material should also prevent absorption of odors and flavors from external sources. The control of oxygen penetration requires a compromise between the development of ideal color and preservation of oxidative density of fats. Therefore it is recommended to use a plastic film with moderate oxygen barrier properties. In order to retain the desired red color of the meat a packaging material with a good oxygen permeability of 5000 milliliters of oxygen per meter square of area per 24 hours at 10 atmospheric pressure and at 24 degree Celsius temperature with 100 percent relative humidity inside and 52 percent relative humidity outside the pack is required. Temperature has a very strong influence on the spoilage of meat due to bacteria or molds.

Proper storage conditions and selection of good packaging film can help accomplish these objectives. Fresh meat should be stored at 0 degree Celsius and 85 to 90 percent relative humidity. Now, the packaging of fresh meat materials and techniques. Tray with over wrap. Retail cuts of fresh meat are generally placed in rigid trays of expanded polystyrene or clear plastic trays over wrapped with transparent plastic films.

The advantage of using these trays are that they are non absorbent and aesthetically appealing. Usually blotters are kept at the base of the tray to absorb the meat juice. The over wrapping film should have excellent optical properties. Cellophane coated with nitrocellulose on one side has been in use for wrapping fresh meat for a long time. The uncoated side is kept in contact with the meat.

The moisture saturation on the inner side of the film increases its oxygen permeability while nitrocellulose coating on the outer side prevents excessive moisture loss to the atmosphere. Another grade of cellophane with polyethylene coating on one side is used to pack irregular shaped meat cuts. LDPE may also be used for fresh meat packaging. At gauges lower than 0.001 inch, it is sufficiently permeable to oxygen and provides a suitable moisture vapor barrier.

One problem however, has been the condensation of moisture on the inner surface of the polyethylene. In order to avoid this LDPE film with minute holes is used. Meat thus wrapped can be kept for approximately 10 days at a temperature of 0 degree Celsius before it becomes microbiologically unacceptable. However, it would be uncellable in

less than half this time because although still edible it changes color from red to an unattractive brown. If during storage there are fluctuations in temperature up to 5 degree Celsius which are quite likely commercially the actual shelf life would be only 2 days.

The storage life of meat is dependent on the initial level of bacterial contamination and the temperature during the storage. Generally therefore, prepack fresh meat are refrigerated as near as possible to minus 1 degree Celsius which is the lowest temperature at which meat can be stored without freezing it. Now, the shrink packaging. The plastic shrink films are used for wrapping large and uneven cuts of fresh meat. It is a technique in which heat shrinkable polymer film is shrunk around the meat product by application of heat to achieve a skin tight and compact pack.

The packaging film should have structural strength. It should be a good water vapor barrier and be capable of withstanding storage temperature of about minus 45 degree Celsius. The advantage of plastic shrink film include neat appearance, ease in handling and a contour fit. Hot tunnels are used to effect the tight wrap. Heat shrinkable polyvinyl chloride, polypropylene, irradiated polyethylene, polyvinylidene chloride and rubber hydrochlorides are used to shrink wrap fresh meat.

Now, the vacuum packaging. This technique is used for packaging of primal and sub primal cuts of meat. In vacuum packaging, the product is filled in a bag or pouch, air is withdrawn either by nozzle vacuum or by chamber vacuuming and the bag or pouch is heat sealed thus storing the product in an air free environment. The plastic film used for vacuum packaging must be of high resistance to gases and water vapor with perfect seals and good mechanical strength. Since vacuum packaging provides a barrier to the product from oxygen and moisture, it is suitable for a period of 3 weeks. This is the pictorial diagram for vacuum packaging of the beef.

In the first the cut beef is put into bags and then bag is vacuumized or vacuumed and then it is sent to the hot water shower tunnel for the shrinking and then it is cooled immediately by passing through the chilling water tank and then put into boxes for the transportation or storage. The most commonly used film for fresh meat vacuum packaging is PVDC. It offers low oxygen permeability and shrink characteristics so that large cuts can be kept for up to 21 days. With minimum loss of moisture, typical packaging material used are polyethylene copolymer coated cellulose film laminates. This is one film the polyester polyethylene film laminates another coating.

Then polyamide polyethylene laminates. The vacuum packaging is more a means of keeping meat a better level of quality than the means of increasing shelf life because it is virtually impossible to remove all the oxygen because small quantities remain trapped

within the product. Also some anaerobic organisms which are not affected by oxygen are not reduced. A shelf life up to 3 weeks for fresh meat is achieved by vacuum packaging, but it is not popular at retail level because of purple red color of meat. During the period of 3 weeks the enzymes in the meat continue the process of tenderization. At the end of the storage period the meat blooms.

Vacuum packaging ensures a life of 8 to 10 weeks at 0 degree Celsius temperature for buffalo meat. Lamb and pork meat have a short life as compared to beef. Lamb has higher pH while pork has higher initial load of bacteria. However, vacuum packed boneless joints are reported to have shelf life of 2 weeks at 1 degree Celsius temperature. Now, the skin packaging another development that offers advantages for presentation as well as packaging design variety for packaging design variety is skin packaging.

The process allows the packaging film to confirm exactly to the profile of the product. This gives to many opportunities for enhance product presentation as well as further improving the integrity of the pack itself. In a skin pack the product becomes the die for the thermoform packaging operation. The semi rigid bottom web may or may not be thermoformed. The top web is heated in an evacuating chamber until it is near its melting point at which it drafts over the product and forms a skin around all the contours.

Upon sealing and cooking it remains its new shape ensuring intimate contact with the product irrespective of surface irregularities. Skin packs are prepared with an oxygen barrier plastic film. Now, the modified atmospheric packaging vacuum packaging has the inherent disadvantage that both package and meat are subjected to mechanical strain. Mechanical pressure on the meat may increase drip loss and if bone is present and not adequately covered with the suitable material the pack may be injured or ruptured. As the alternative to vacuum packaging attempts have been made to store meat under various gases atmosphere a process referred to as modified atmosphere packaging or MAP.

The use of MAP technology in meat industry has shown increasing trend during the past decade. MAP extends the shelf life of meat and meat products under refrigerated storage and maintains color, texture and flavor of the product for a considerable longer time in flexible plastic films. Application of MAP improves shelf life of raw chilled meat with reference to color, delaying bacterial spoilage and minimizing exudates loss. MAP extends the shelf life of poultry meat due to oxygen permeable packaging for at least 5 days in comparison with aerobic packaging. Meat in MAP had a lower value of the total number of viable microorganisms, the number of Pseudomonas aeruginosa and the total number of coliforms compared with the control sample.

Theus MAP can have a significant effect on the lipid oxidation, color changes and

microbial growth and has potential application in cultured meat. By preventing the lipid oxidation, color changes and microbial growth the good cultured meat appearance can be maintained up to a long period of time and attract the consumer to purchase the products. This table gives the different temperature, oxygen level, carbon dioxide level and nitrogen level for packaging of different types of products like fresh meat, cured meat, pork and poultry. And the following that this table shows the changes in meat, fish and poultry as brought about by modified atmosphere. Like for example, the enzymatic aging process that results that that is unaffected in the that modified atmosphere packaging.

The microbial spoilage, the increased carbon dioxide reduces growth of aerobic spoilage organisms by penetrating membranes and lowering the intracellular pH. Whereas, the fat oxidation that is reduced oxygen reduces oxidation of fat although oxidation can still occur at low oxygen tensions. The oxidation of myoglobin, the increased carbon dioxide promotes met myoglobin formation and color darkening. This is the example of how packaging changes appearance and expiration date. Like for example, plastic wraps in that a sheet of plastic wrap is laid on the tray which is presented in this figure.

In this pack the product can be safely stored for 5 days and it looks reddish in appearance. Whereas, the vacuum packaging meat products where from air is removed to seal food in a vacuum condition that enhances the shelf life up to 11 days and it looks darker occasionally spilling juice. Whereas, the skin packaging where the plastic film is wrapped tightly around the food which is then vacuum packed to make the film fit even tighter that has got the maximum storage life up to 22 days and it looks darker and less juice spills. Thank you very much.