**Novel Technologies for Food Processing and Shelf Life Extension**

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**Lecture – 41**
**Modified Atmospheric Storage (MAP)**

Hello everybody, today let us study another very, very important topic for extension of shelf life of either the fresh produce or the processed food products where biological processes are likely to continue or even chemical process like oxidation etcetera may take place after processing in the products.

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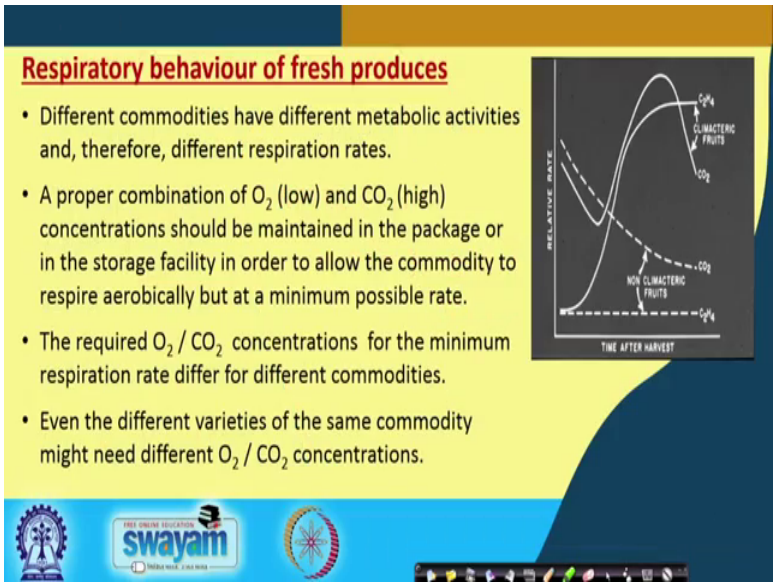


So, for the packaging and shelf life extraction of such products a very useful technology is modified atmosphere packaging. So, today we will discuss about the basics principles or application aspects of modified atmosphere packaging. In the earlier class, we discussed about the respiratory behaviour of fresh produces. And we have seen that the different commodities, different fresh produces have different metabolic activities, and therefore, they have different respiration rates. So, it is very important that a proper combination of oxygen which is normally lowered and carbon dioxide which is increased.

And this proper combination of oxygen and carbon dioxide concentration in the storage atmosphere or inside the package is necessary or it should be maintained in order to

allow the commodity to respire aerobically but at a minimum possible rate that is important mind it. If aerobic respiration is stops, the commodity will respire unaerobically and it will spoil soon.

So, the aerobic respiration of such produces is important during storage. So, the minimum O 2 or maximum CO 2 concentration is required to be maintained. And this required O 2 and CO 2 concentrations further minimum respiration rate may differ or may vary from commodity to commodities. Even the different varieties of the same commodity might need different O 2, CO 2 combinations for its minimum respiration rate.

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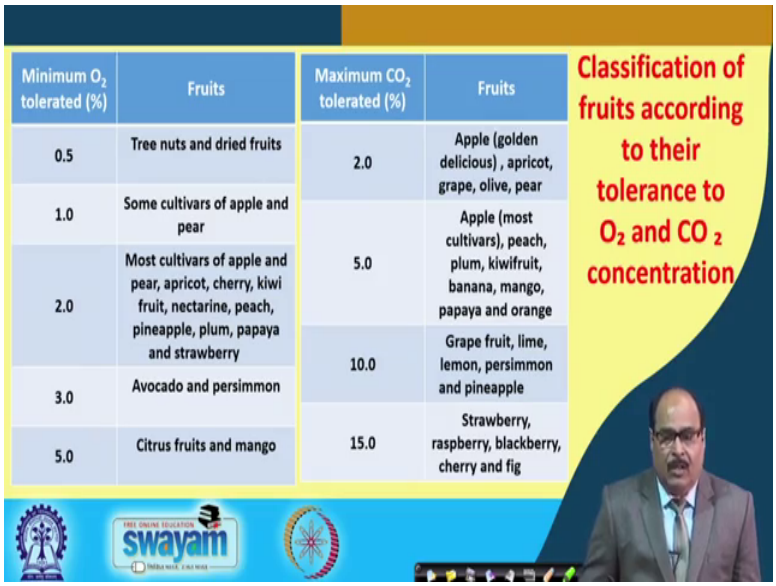


In this slide, I have just try to give you the minimum O 2 tolerance limit or maximum CO 2 tolerance limit for some important fruits. And this minimum O 2 tolerance limit or minimum oxygen tolerated by different fruits ranges from even 0.5 percent to as high as 5 percent concentration. The maximum carbon dioxide gas tolerated by the fruits, important fruits, may vary from 2 to as high as 15 percent.

Like some of the apples like golden delicious, apricot, grape, olive, pear etcetera their maximum CO 2 tolerances 2 percent. Whereas the fruits like a strawberry, raspberry, blackberry, cherry and fig, they can tolerate maximum carbon dioxide into storage atmosphere are inside the package as high as 15 percent. Similarly, the minimum oxygen

the tree nuts and dried fruits, they can tolerate oxygen as low as 0.5. And the citrus fruits mango etcetera they may be stable as they can tolerate up to 5 percent oxygen.

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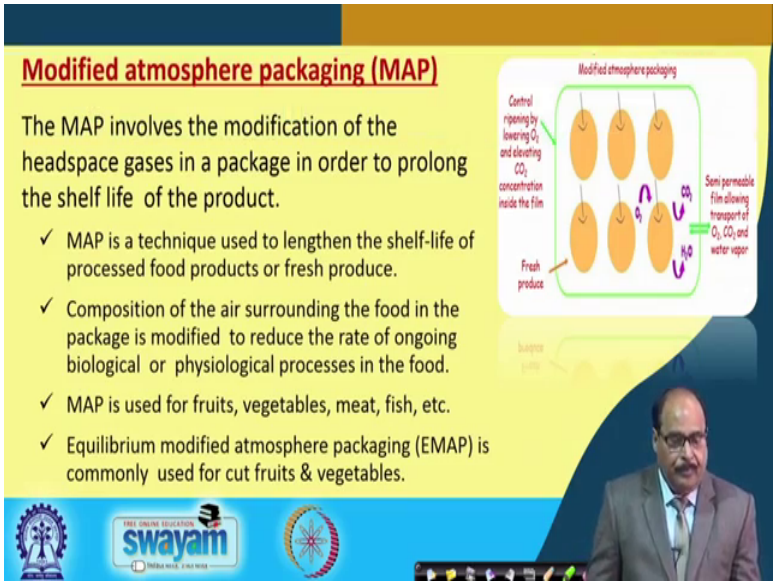


So, this aspect that is the their tolerance limit minimum O 2 and maximum CO 2 as well as other even some chemical processes etcetera like oxidation and all those things, they are used, they are manipulated further advantages in this processing. Like, so the concept of the modified atmosphere packaging is the modification of the headspace gases in package in order to prolong the shelf life of the product. As you can see in this picture right, it is a technique used to lengthen the shelf life of processed food products are fresh produced.

And the composition of the air surrounding the food in the package is modified to reduce the rate of ongoing biological or physiological processes in the food as I told you. MAP is commonly used for packaging of fruits, vegetables, meat, fish etcetera. For packaging of cut fruits and vegetables, equilibrium modified atmosphere packaging. So, the modification of atmosphere involves as you have you can see in this picture there is the fresh produce.

In the earlier class, we studied that they consume oxygen give out carbon dioxide, give out water, and this is the aerobic respiration. So, the fruits or vegetables or other products, they are packaged in some sort of you can say semi permeable membrane, and this semi permeable means that is this allows a control in and outer control permeation of

the gases that carbon dioxide, oxygen and water vapor. And with this having a packaging material of suitable characteristics, the modified atmosphere, packages etcetera are formed.

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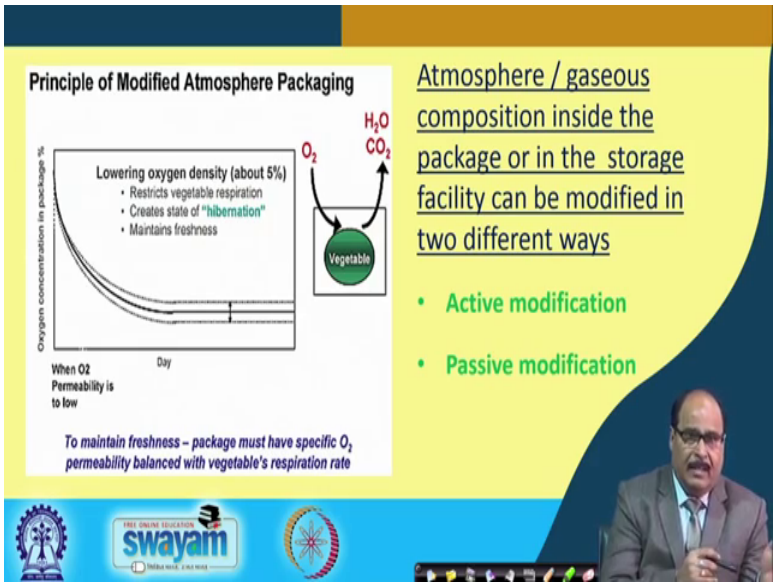


So, lowering the oxygen density as you have seen in the earlier slides that is may be up to 5 percent, it restricts the vegetables respiration. It creates state of hibernation and maintains the freshness of the fresh produce or of the fruits or vegetables. And it is as I told you earlier, it is very important to maintain freshness package must have a specific oxygen permeability balanced with the vegetables respiration rate.

So, the atmosphere or gaseous composition inside the package or inside the storage facility can be modified in two different ways, that is it may be active modification or it may be passive modification.

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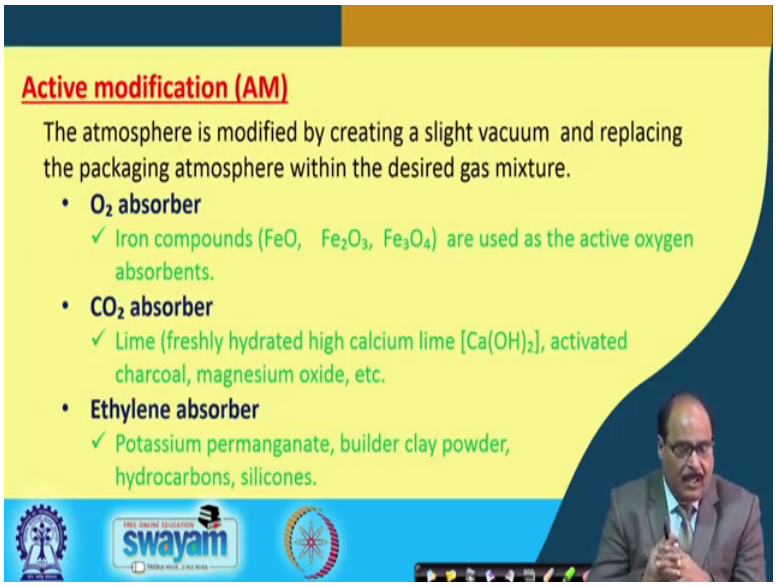


Active modification involves the modification of atmosphere by creating a little slight vacuum little or more vacuum depending upon the type of the food being packaged or depending upon the various processes respiration or oxidation processes which are likely to spoil the food ok. So, it might be creation of slight vacuum or it may also be modified by replacing the package atmosphere, atmosphere inside the package with the desired gas mixture and various.

As I told you depending upon the whether we are going for active modification or passive modification, or type of the food materials that is a different absorbers or emitted emitters are like oxygen absorbers, CO 2 absorbers, ethylene absorbers etcetera are used active modification is done by putting calculated amount of absorbers maybe oxygen absorbers or carbon dioxide absorbers, ethylene absorbers etcetera which help in maintaining the atmosphere or concentration of these gases inside the package.

Iron compound such as Fe O, Fe 2 O 3, and Fe 3 O 4 are used as active oxygen absorbents. Lime maybe freshly hydrated high calcium lime, lime calcium hydroxide, or activated charcoal magnesium oxide etcetera are used or CO 2 absorber. And ethylene absorbers are potassium permanganate, builders clay powder, hydrocarbons, silicones, and so on.

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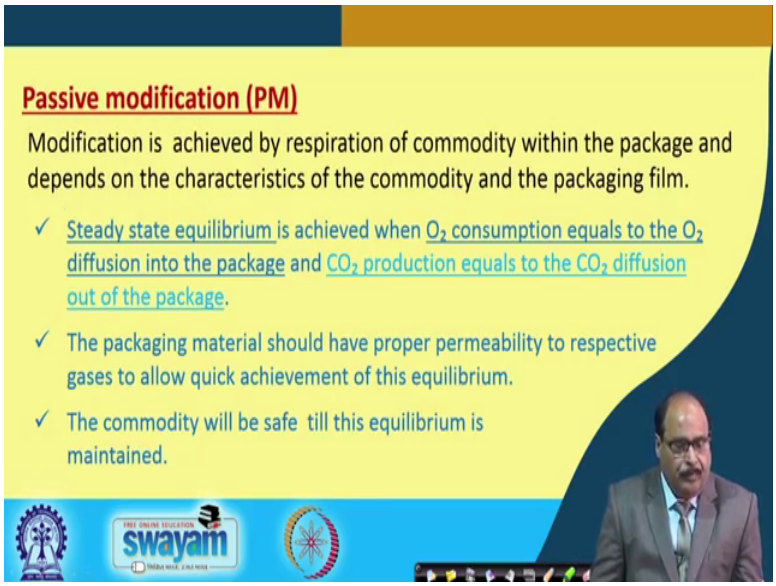


So, while in the active modification case, we create conditions or we that is by putting these absorbers are emitteds emitters. The passive modification is achieved by respiration, it is a natural process you can say the so the respiration plays a major role in creating the desired atmosphere. So, the respiration of the commodity within the package, and it depends on the characteristics of the commodity and the package film packaging films and that is obvious and that is what is the permeability of the packaging material, and what is the characteristics of the food product that is it is a like food or vegetable, whether it is climatic in nature or non-climatic in nature and that I will show you in the next slide that is how that is fast or slow is the active and passive modification.

So, in the case of passive modification, obviously, depending upon the type of the food material depending upon the characteristics of the packaging film little quicker or later, a steady state equilibrium is achieved. And when this equilibrium is achieved that is when oxygen consumption equals to the oxygen diffusion into the package, and CO 2 production equals to the CO 2 diffusion out of the package.

So, it is very important that is the packaging material, they should be selected in such a way that it should its permeability should be befitting. It should have required permeability to respect to gases to allow a quick achievement of this equilibrium. And the commodity will be safe till this equilibrium is maintained.

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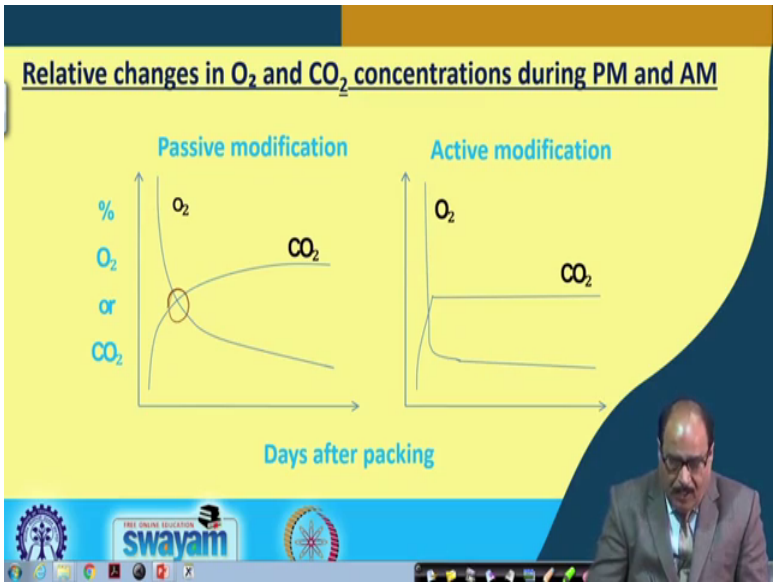


In this figure you can see that relative changes in oxygen and carbon dioxide concentrations during passive modification and during active modification on the x-axis, these after packing is shown. And in the y-axis, it is the rate of the change of oxygen and carbon dioxide because of respiration there is oxygen uptake or carbon dioxide release rate.

So, you can see here in the case of passive modification that is these rates are little slow, and it takes little more time to achieve to the desired there is O 2 and CO 2 concentration that is which is required to the maintain to have the minimum respiration rate or where this O 2 conjunction, and CO 2 production that is the equilibrium that is maintain.

And even after this equilibrium that is there is because it is the natural phenomena or the processes based on natural respiratory behavior though concentration maintenance of concentration of O 2 and CO 2. You can see depending upon the conditions inside the storage environments etcetera, it can be little there might be little fluctuations, but that is very important that these fluctuations should be as may low as possible.

But in the case of active modification where that is this external agencies are used to maintain the environment. You can see that oxygen as well as carbon dioxide required concentrations are these gases is quickly obtained. And also the maintenance of these gaseous concentration is that is almost it there it is a straight line showing. So,

maintenance is also good, so that is the you can say major difference between active and passive.

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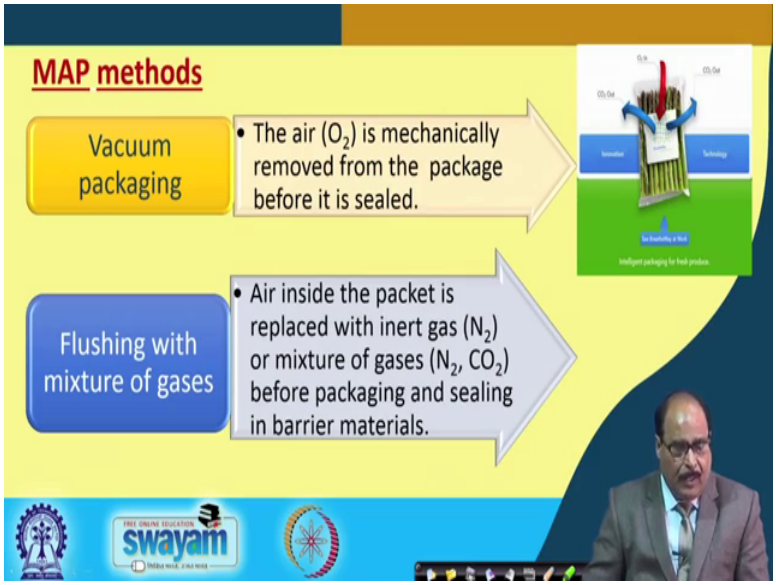


Now, regarding the methods of modified atmosphere packaging as I have told you that is whether it is a respiring commodity or it is other commodity where the spoilage of the food might be because of the chemical oxidation etcetera. So, depending upon the characteristics of the food, depending upon the other that is the changes which may likely to take place in the material and resulting its spoilage, we can use different packaging methods. And the vacuum packaging is particularly more suitable, where for those products process products etcetera where there is spoilage is likely to be more due to oxidation etcetera that is the oxygen right.

Of course, it may be beneficial for respiring materials also because the oxygen can be lower down selectively, but for the vacuum packaging means that is the oxygen or air particularly oxygen is mechanically removed from the package before it is sealed. Whereas, the second method flushing with gases in this process, air inside the packet is replaced with either inert gas like nitrogen or mixture of gases maybe nitrogen, carbon dioxide, etcetera, before packaging and sealing in the barrier materials.

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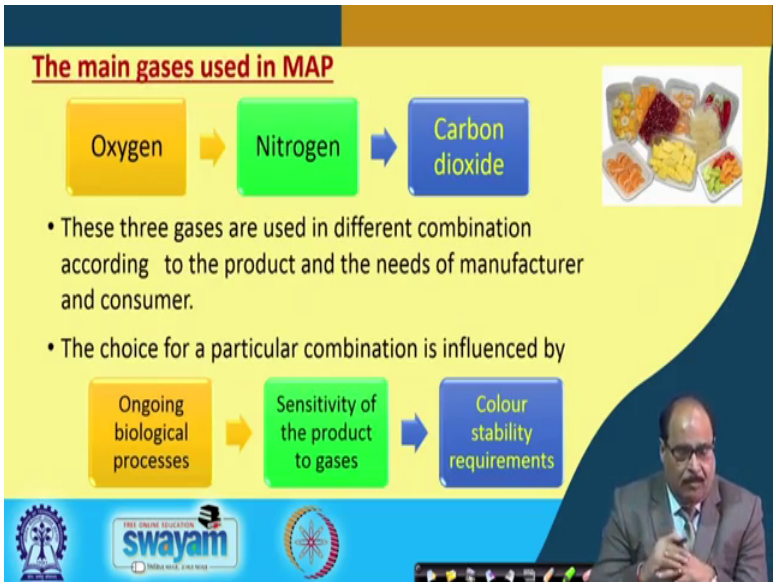


And as I already told you earlier that the main gases used in the MAP include oxygen, nitrogen and carbon dioxide. And these three gases are used in different combinations according to the product and the needs of the manufacturer or the consumers. And the choice of a particular combination is influenced by ongoing biological or chemical processes in the food materials, even sensitivity of the food material to these gases, and finally the stability of the food components like colour stability or flavor stability and other such requirements.

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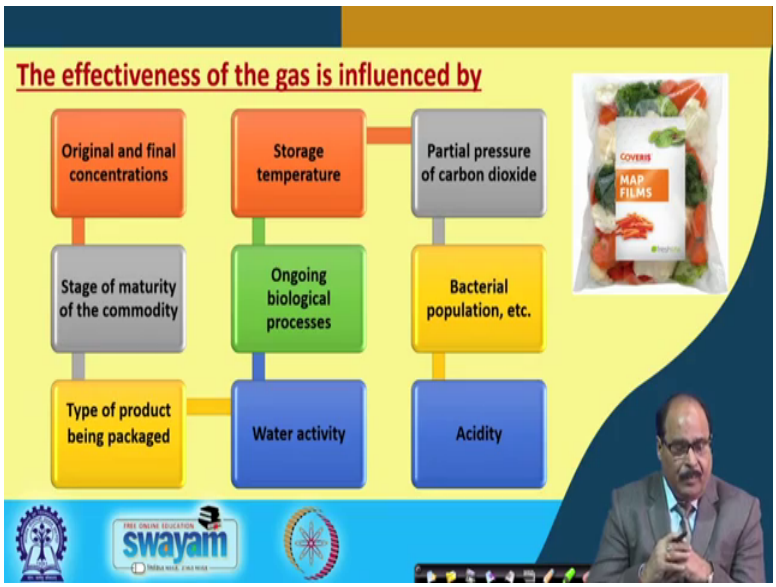

The effectiveness of the gas is influenced by various factors such as original and final concentrations of the gases that is maintained inside the package, stage of maturity of the commodity, the type of the product being packaged, water activity of the food material, ongoing biological processes inside the food, storage temperature, partial pressure of carbon dioxide, bacterial population, acidity of the material and so on. So, all these need to be considered while selecting the either suitable packaging materials or the methodology for of are suitable packaging technology method for packaging the food.

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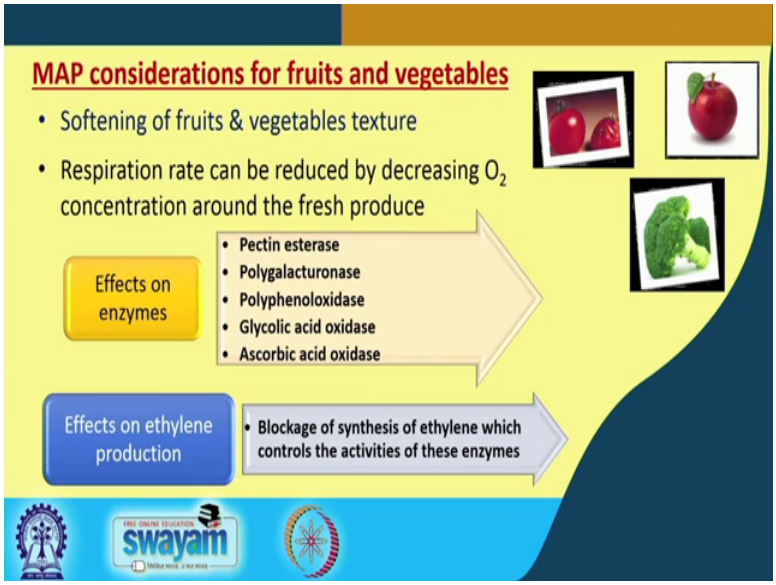


The obviously, the considerations for MAP of fruits and vegetables you know that is during storage during handling that is the fruits and vegetable they are actively respiring I told you earlier that. So, the biological agents like enzymes are the major culprits which bring about textural changes or cause softening of fruits and vegetables texture. And here there is the, you know pectin esterases, polygalacturonse, pectin methyl esterases etcetera are the enzyme which play major roles, because the pectins are they provide they are the structural material they provide texture to the fruit and vegetables.

So, after you may there in the post harvest process, once the fruit or vegetable plug from the tree, then if the atmosphere in which they are handled, they are kept if it suits or it is suitable for the activity of these enzymes. Then this enzyme will act on the pectin and such other component they may hydrolyze it, they may remove the calcium from the pectin molecules etcetera are such other changes may take place and which ultimately. It

may cause the change of there is the insoluble form of pectin into soluble form of pectin have many other changes and which finally ultimately results into the softening of the texture or even other changes in the material. And the respiration rate can be reduced by decreasing the concentration of oxygen around the fresh produce.

So, again these are that is your packaging material, the gaseous composition inside the package, it should be effective enough to control the activity of the enzymes as well as this would be effective to control the ethylene production effective in controlling the ethylene production, because the ethylene is the ripening hormone. So, the blockage of the synthesis of ethylene will also control the activity of these enzymes. And therefore, ripening process of the fruit is delayed or textural changes in the vegetables etcetera is delayed, and its shelf life is extended.

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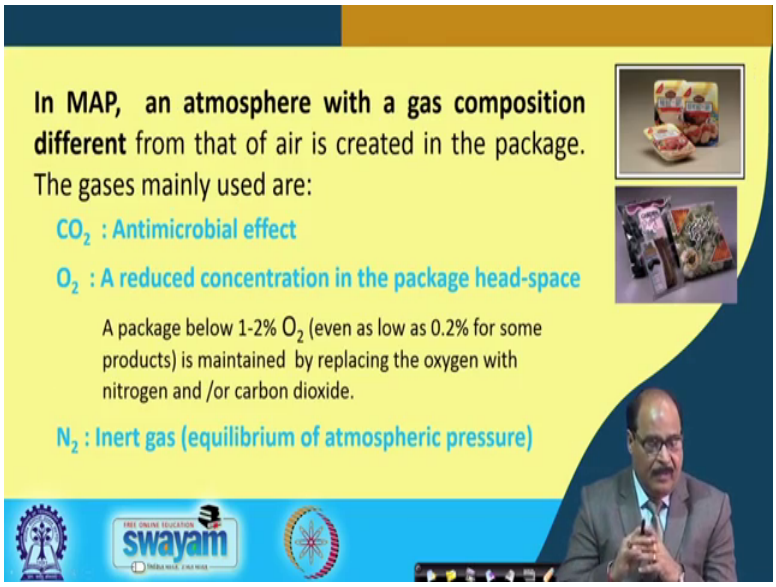


So, the CO 2 in fact some time also has antibacterial effect and oxygen that is a reduced oxygen concentration in the headspace of the package, it may lead to the reduction in the oxidation or chemical oxidation processes etcetera also. And sometime in the sub materials like coffee powder etcetera even is low very very low concentration of the oxygen inside the packet also is deteriorate, because when we use that mechanical means of oxygen removal or vacuum creation depending upon the efficiency of the machine etcetera, sometime complete exclusion may not be available.

So, in such cases nitrogen flushing is used by nitrogen flushing oxygen is removed and this is replaced by a inert gas nitrogen and equilibrium for the atmospheric pressure, equilibrium of the atmospheric pressure is maintained.

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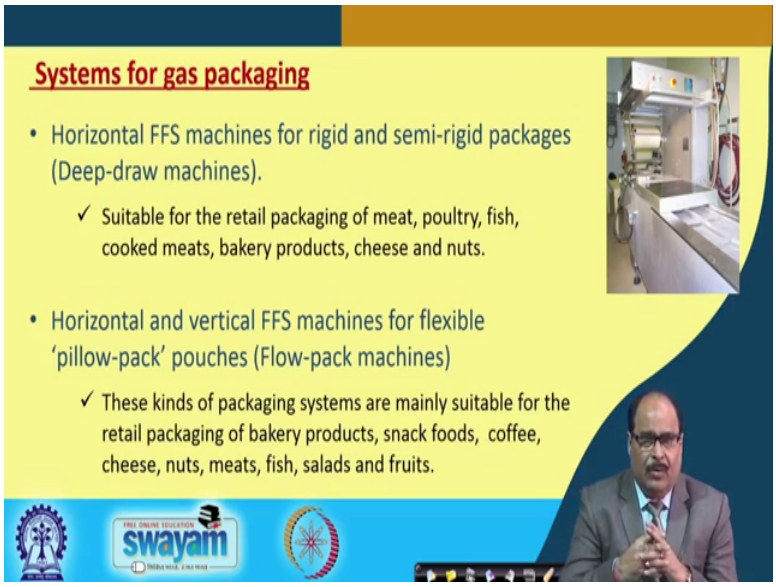


So, having known these processes, let us now see what are the systems for gas packaging. And in fact this developments whatever it developments we have seen in the modified atmosphere packaging or such other methods of the packaging of the fruits active packaging etcetera, this has been made possible because of the development of FFS machines that is the form fill and seal machines. And now variety different types of form fill and seal machines are available which can allow packaging of food here making the packages of different shape, different sizes of different forms having different characteristics and so on. So, this has really facilitated to great extent in this technology.

So, the major systems of gas packaging include horizontal FFS machines or rigid and semi rigid packages which are so called deep draw machines. They are suitable for the retail packaging of products like meat, poultry, fish, cooked meat, bakery products, cheese and nuts etcetera horizontal and vertical FFS machines for flexible pillow-pack pouches or the so called flow-pack machines.

They these kind of systems are mainly suitable for the retail packaging of bakery products, snack foods, coffee, cheese, nuts, meats, fish, salads and fruits, because even meat products or such other products that is the liquid oxidation, there is the chemical

oxidation of these materials in here of major concern. So, by using by manipulating this that is oxygen concentration, the chemical oxidation processes are also controlled.

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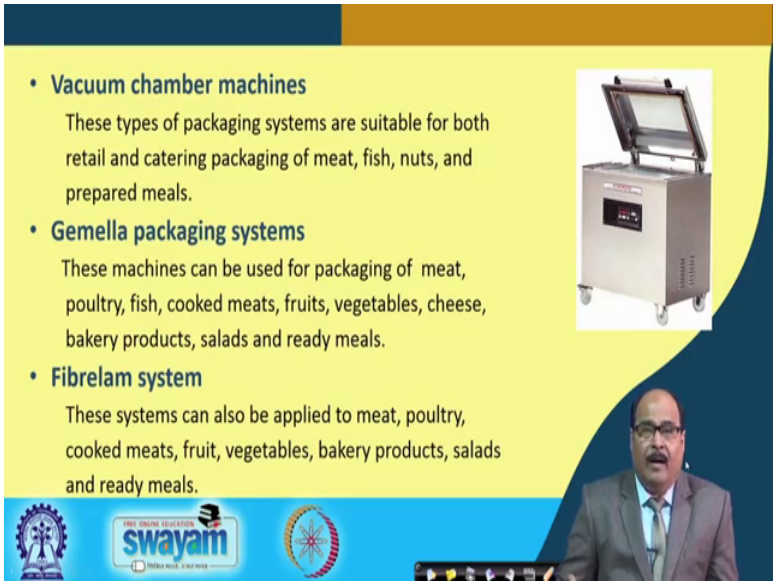


The vacuum chamber machines, these type of systems are suitable for both retail as well as catering packaging of meat, fish, nuts, prepared meals and so on. Gemella packaging systems can be used for packaging of meat, poultry fish, cooked meat, fruits and vegetables, salads and ready meals etcetera. The fibrelam systems can be applied to pack meat, poultry, fruits, vegetables, bakery products, salad and ready meals etcetera.

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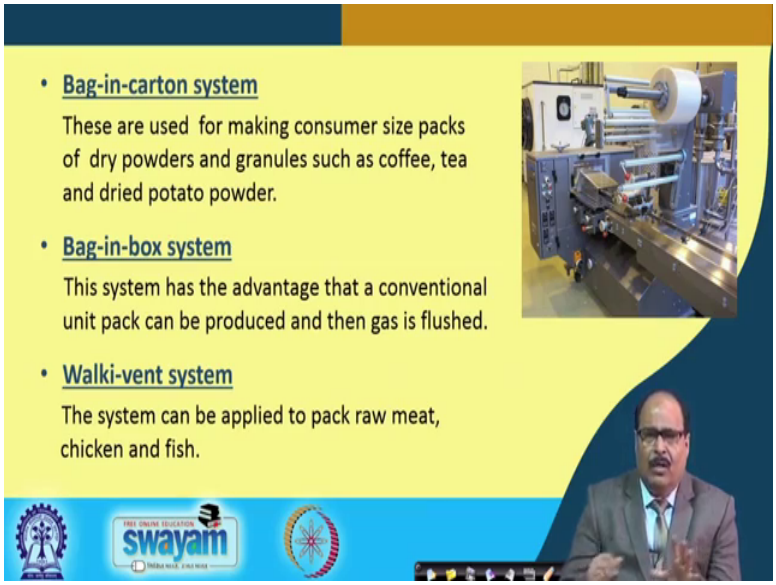

Also the bag-in-carton systems are available which can be used for making consumer size packs of dry powders and granules like coffee, tea, dried potato powder. Bag-in-box systems can be used for the preparation of the materials different food materials, and these systems have the advantage that conventional unit pack can be produced first and then gas can be flushed. Walki-vent system can be applied to pack raw meat, chicken and fish, etcetera. So, in the there are different types of form fill and seal machines which can be used for making these many modified atmosphere packages.

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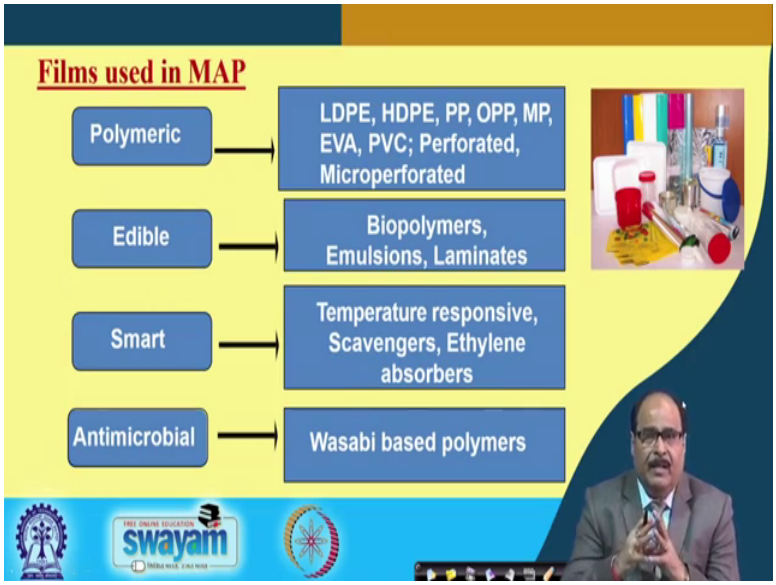


Generally the films which are suitable or which can be used for making MAPs for different food materials or polymeric films like LDPE, HDPE, PP, OPP, metalized polyester, PVC; both perforated, micro perforated or non-perforated, having less permeability, having more permeability all these things depending upon the material etcetera they are used.

Similarly, edible films like biopolymers, emulsions, laminates etcetera can also be used for modified atmosphere packaging of different materials. A smart packaging materials is smart packaging films like temperature responsive films, the films coated with the scavenger or emitters, the packet containing the polymeric material containing ethylene absorbers, oxygen absorbers, carbon dioxide absorbers etcetera like you can say functional films that are there are many such films available in the market using they are prepared using nanotechnology and such other methods. So, they can be used.

Even the functional film which are made antimicrobial there is the some antimicrobial substance in (Refer Time: 27:11) etcetera, they can be quoted in the packaging material. So, when these packed food materials are packed in such type of packages or polymers, then this it causes the surface system realization of the food etcetera and it shelf life. So, wasabi based polymers etcetera are example of this.

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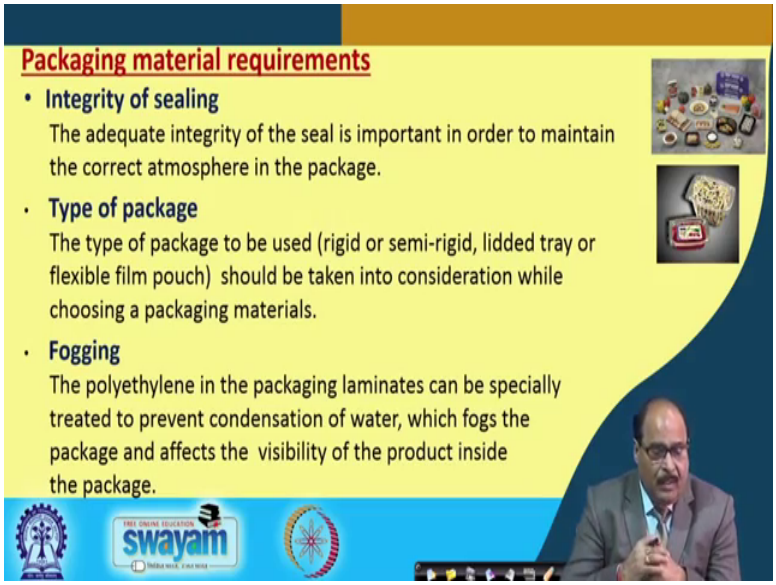


As far as the requirements of the packaging materials are concerned, very important that the material should be sealable and not only sealable that is it should be easily seal, but its integrity of the seal it should be able to maintain the integrity of the seal of the package during storage during handling or when the packet is put to the different stress conditions. Because, if this seal is not proper, if there is some leakage etcetera; it will disturb the atmosphere inside the package.

Similarly, the type of the package that is the type of the package to be used, what is the nature of the packaging packet to be made, that is the is consumer pack, retail pack or all those things that is a rigid or semi-rigid, lidded tray or flexible film pouch so that also taken should be taken into consideration while choosing a packaging material.

Another important property is the fogging. The packaging material should be of such nature that the it should at least prevent it should not promote or it should not allow the condensation of the moisture inside the packet. Because if the moisture inside the packet condense, so it adversely affects the visibility of the product inside the package and

which is not desirable. So, the packaging material like polythene in the packaging laminates etcetera, they can be especially treated to prevent condensation of water.

So, has to improve the visibility because this is considered an important particularly if it is a consumer pack. So, the consumers like the food material which is inside the packet, it is visible, so that they can visualize the quality of the or freshness of the food before its purchase.

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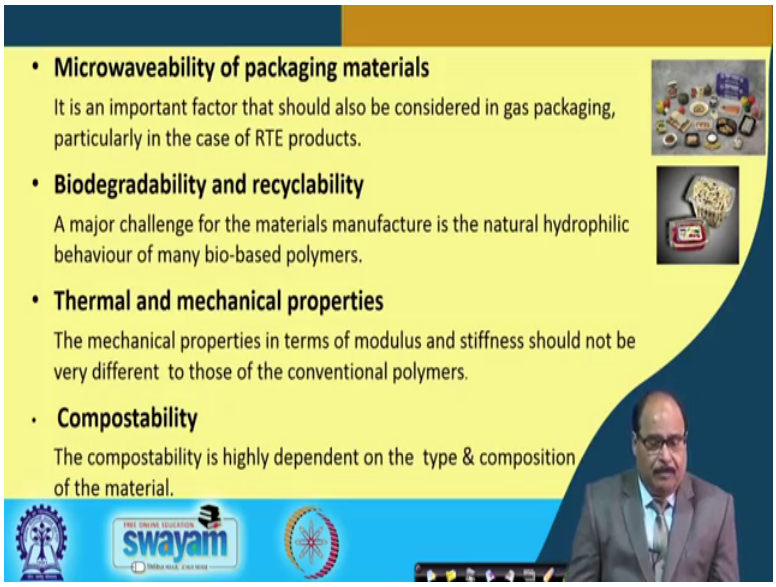


Similarly, microwaveability of the packaging material is another important consideration, particularly for the packaging of ready to eat food products. So, the it is better that if the poly for such food products, the polymeric material or packaging material which is selected it is of such in nature that the packet can be directly put into inside the microwave oven.

Then other important considerations include biodegradability and recyclability that is important that is the packaging material should be easily degradable, because that is and it should we recyclable or that is the one even plastic films etcetera are creating the major havoc to the environmental problem. So, the packaging material the material to be used or polymer to be used for the it should be biodegradable, it should be easily recyclable, or it should be easily compostable, it can be easily destroyed.

And of course, the other important characteristics should is that the mechanical properties its strength its modulus its stiffness etcetera should be that is the desired, it should be it should not be very much different from those of the conventional polymers. So, the functional polymers or polymers to be used for modified atmosphere packaging, they should have proper are required mechanical properties or strength etcetera.

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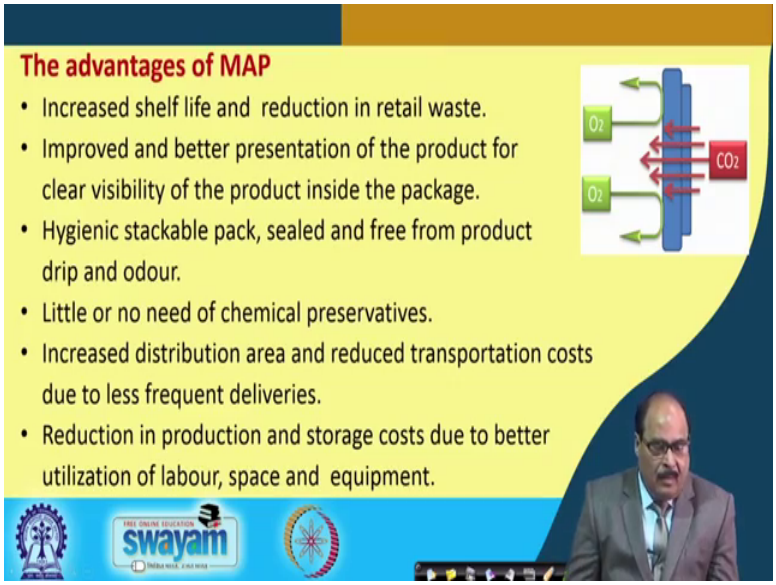


So, the modified atmosphere packaging have the several advantages like it results in the increased shelf life and reduction in detail waste. It improves the product quality, improved and better presentation of the product for clear visibility of the product inside the package. Hygienic stack wise pack, sealed and free from product drip and odour.

It results into little wastage or there is no requirement of chemical preservative etcetera inside this package. It can it result into increase distribution area and reduce the transportation cost due to less frequent deliverables or deliveries. Reduction in the production and its storage costs are there due to better utilization of labour, space and equipment.

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But at the same time there are certain drawbacks or another words you can say the challenges in the modified atmosphere packaging technology which need to be resolved that the cost it should not be costlier. The, so the cost of the gaseous packaging machinery, maintenance of the gaseous environment inside the packet as well as the packaging material cost, all these things should be kept to the minimum at present it is comparatively and higher side.

Even the cost of the instrumentation analytical instrument to measure the gaseous composition etcetera should be should not be issue, it should be maintained that is so in order to facilitate the use of this technology such facility that is instrumentation etcetera should be made easily available.

Then cost of quality assurance systems to prevent distribution or leakers that is very important that is that the packet should not be leaking. Because if the packet is a leak leaker, then inside atmosphere will composition of gases will not be maintained, and the material will spoil quickly. Then the in fact as I told you, benefits of MAP are lost once the package opened or if it leaks.

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So, overall we can conclude by saying that modified atmosphere packaging is a very effective technology for the packaging of fresh produces, particularly for extending the shelf life of fruits and vegetables whether whole or cut fruits and vegetables. It is useful for both for extending the shelf life as well as for maintaining the quality of the produce.

So, however, the MAP that is the hurdle technology concept can be applied in this. It has a big potential that is application of other preservation techniques in combination with modified atmosphere packaging is an interesting area of research and development, and work should be done in these regards so as to increase the benefit or advantage of this technology to the consumer and well as to the processers.

Thank you very much.