Novel Technologies for Food Processing and Shelf Life Extension
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Lecture - 42
Active Packaging

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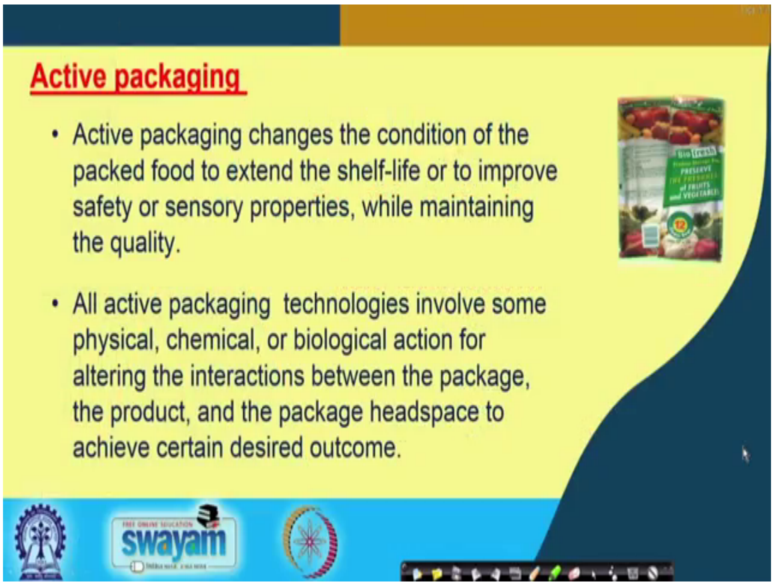

Hello everybody. Today, we will study Active Packaging technology. In the earlier class, we studied modified atmosphere packaging. Now today, we will see another part of the modification of the packaging environment or environment inside the packaging or environment inside the storage facility. So, active packaging changes the condition of the packed food to extend the shelf life or to improve safety or sensory properties while maintaining the quality. All active packaging technologies involve some physical, chemical or biological action for altering the interactions between the package, the product and the package headspace to achieve certain desired outcomes.

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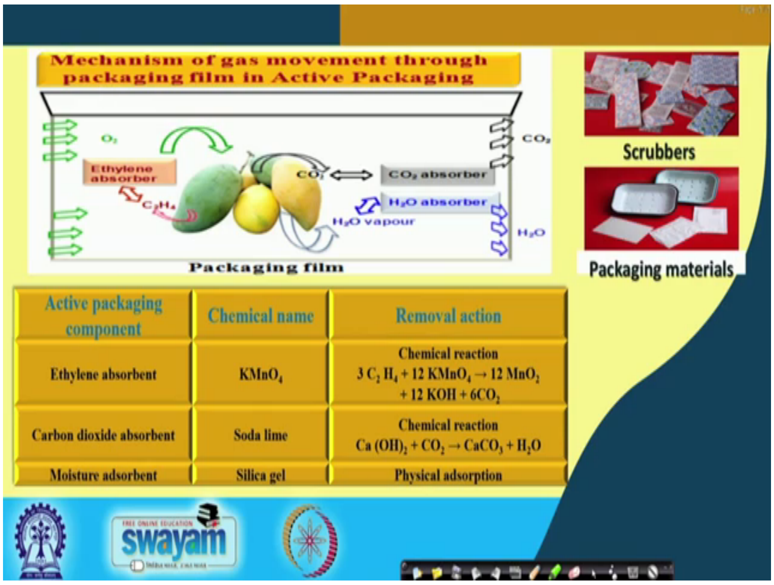

In this slide just you can see in the top portion of the slide, we have shown you how the gas movement inside the material inside the package takes place. In the active packaging as narrated in the earlier class also; in the last class while we studying modified atmosphere packaging that the modification of atmosphere; in modified atmospheric packaging is basically because of the natural process that is interplay between the food product as well as vapour transmission and other transmission properties of the packaging material.

But here in the case of active packaging basically we try to use some active agents to get the desired concentration of gases or to manipulate the gaseous composition inside the package to the desired level. So, like different absorbers or emitters are used in this case maybe ethylene absorber, carbon dioxide absorber or moisture absorber whatever depending upon the type of the food material; its respiration rates, its transportation rates etcetera. We calculate the amount of the these absorbers or emitters required and put these materials these absorbers or emitters in the required quantity inside the package and which help in maintaining the desired gaseous composition.

Like you can see here in this that is the ethylene; ethylene is consumed by the food materials or fruits etcetera. It is a ripening hormone or it also releases the ethylene. So, ethylene absorber may help in controlling the ethylene concentration in the packet. Therefore, to control the ripening process. Similarly CO2 absorbent or water absorbent they can they can move in and out from the their respective package to the food or vice versa.

So, ethylene for example, potassium permanganate is used as a potassium permanganate is used as a ethylene absorber. So, when it is put so, the ethylene reacts with KMnO4 and gets MnO2 KOH and carbon dioxide. So, if you use ethylene absorbent the chemical reaction shows that the concentration of carbon dioxide will also be increased. So, maybe that carbon dioxide scrubbers; carbon dioxide absorbers also might be required to be used. So, soda lime or many other such carbon dioxide absorbers are there which we will see in the other slides so, that can be used.

So, when soda lime is used calcium hydroxide, it reacts with carbon dioxide and gives carbon calcium carbonate and water. Similarly moisture absorbent silica gel or many other moisture absorbers are there which can be used. Silica gel actually it is a physical adsorption process.

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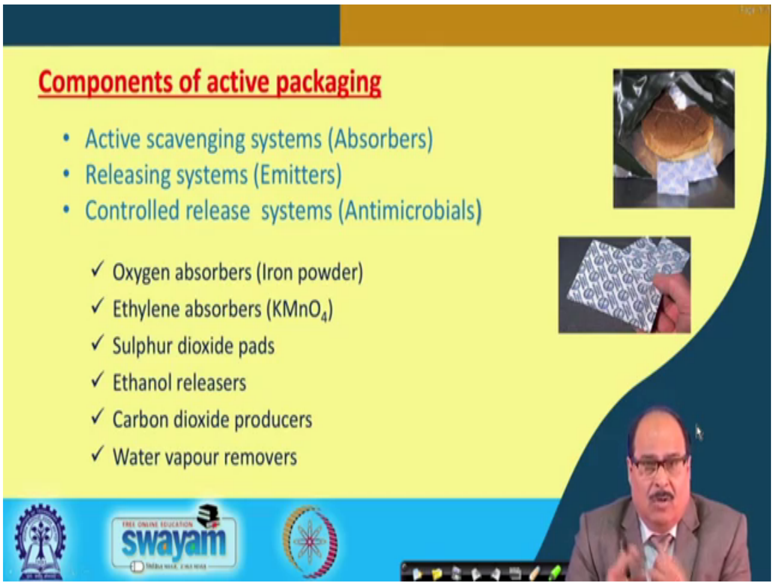

So, by now I think these things are clear that is inside the packaging package active packaging. Certain active components may be active scavenging systems which we call absorbers or active releasing systems such as emitters or controlled release system maybe antimicrobial etcetera are used. You can see here in this bracket like there is in bread to control the humidity or to control the atmosphere. This sachets containing moisture absorbers etcetera are used.

So, depending upon that what we want actually whether we want to increase the shelf life or we want to increase the ripening rate or we want to reduce the ripening time or you want to that control microorganisms etcetera are the depending upon the desired effect in the effect that needed.

Accordingly select the relevant releasers or relevant emitters and put in the towards the last of this lecture. I will take some example and tell you how to calculate the required amount of emitters or absorbers for the desired functions.

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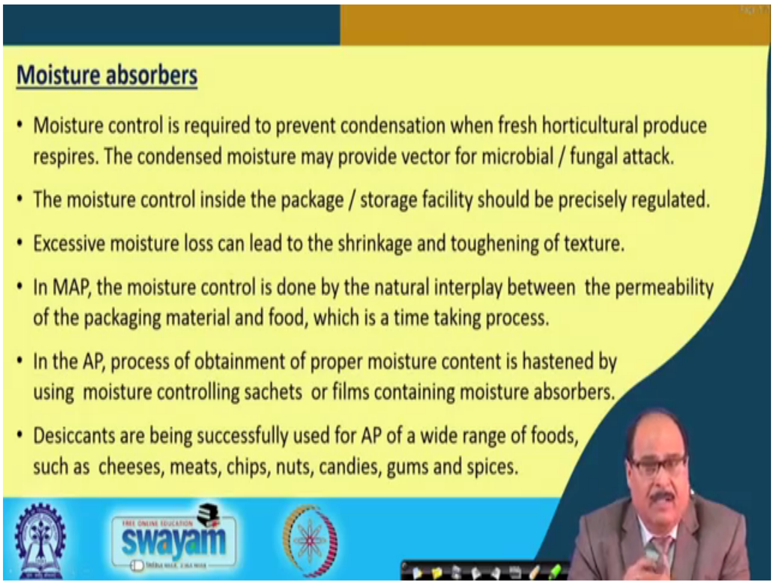

So, before that let us see let us elaborate briefly the different absorbers. So, first of all moisture absorbers you all know that moisture control is required to prevent the condensation when the fresh horticultural produce respires otherwise if it is it condenses. So, if the condensed, moisture may provide vector for microbial or fungal attacks etcetera and the commodity may spoil soon.

So, the moisture control inside the package or storage facility should be precisely regulated, but at the same time care should be taken that it should not excessively loose moisture material; excessive moisture loss can lead to the shrinkage and toughening of the texture or the material. And in the modified atmosphere packaging as I was telling that the moisture control is done by natural interplay between the permeability of the packaging material and food which is a time taking process.

So, in active packaging this process of obtainment of the optimum moisture is hastened by using moisture controlling sachets or films containing moisture absorbers. Desiccants are being used successfully for the active packaging of a wide range of food materials such as cheese, meats chips, nuts, candies, gums and spices etcetera.

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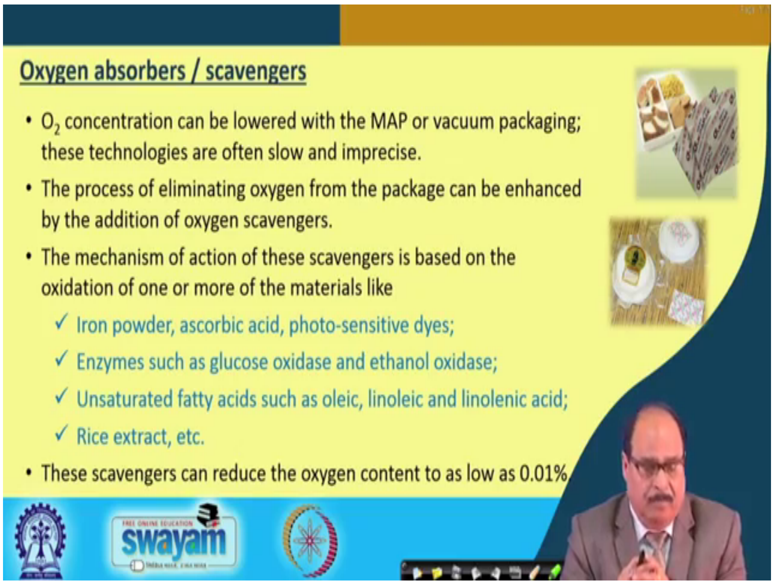

Oxygen absorbers are scavengers is another important aspects oxygen concentration can be lowered down by vacuum packaging as we have studied in the last class in the MAP. That is vacuum packaging can be used or even gas flushing etcetera can be used, but again these technologies are often slow and imprecise.

So, the process of eliminating oxygen from the package can be enhanced by the addition of oxygen scavengers and thse oxygen scavengers perform their activities. Normally the oxidation takes place oxidation of the scavenger for example, iron compounds , iron powder, ascorbic acid, photo sensitive, dyes etcetera. When they are used, they may get oxidized and in the process they that is absorbed oxygen that is they use oxygen of the environment for the oxidation of these compounds. Also enzymes like glucose oxidase and ethanol oxidase unsaturated fatty acid like oleic acid, linoleic acid, linolenic acid, rice extract etcetera. They are used for the control of or absorption of oxygen.

In fact, these scavengers depending upon the type of the food or depending upon the other conditions that are prevailing inside the storage facility, they can reduce the oxygen content to as low as point 01 percent.

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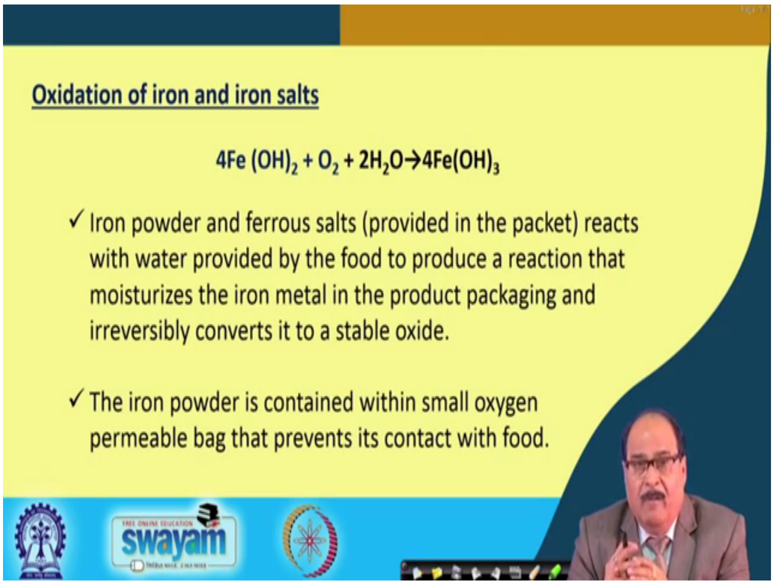

Here in this slide just I have shown you how the iron compound, the iron powder, how it oxidises right the ferrous salts or iron powders. They react with the water that is provided by the food to produce reaction that moisturizers the iron metal in the product packaging and irreversibly converts it to a stable oxide.

So, the iron powder is contained within a small oxygen permeable bed to prevent the; to prevent its contact with the food. So, in some sort of bed that is it has a good oxygen permeability. These iron powders are packed and that packet is kept inside the food package.

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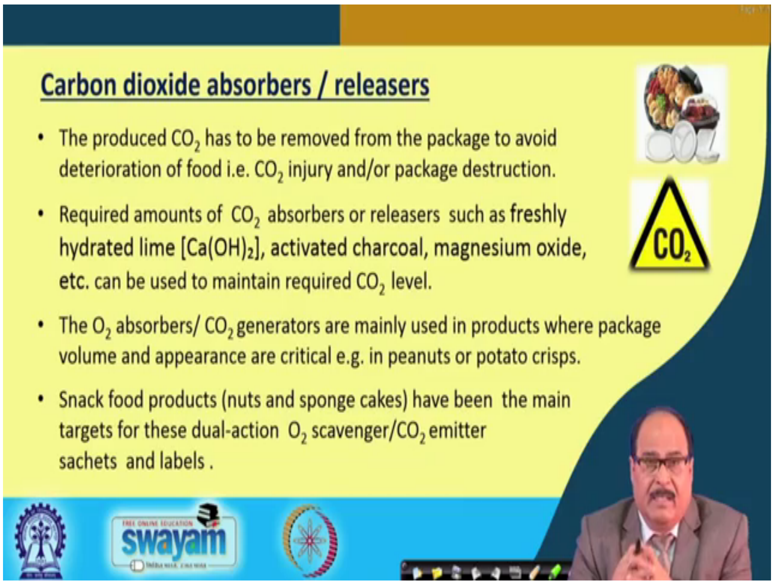

Similarly carbon dioxide releasers or carbon dioxide absorbers also important. The carbon dioxide produced during the respiration of the gas etcetera is to be removed from the package to avoid deterioration of the food like for such as carbon dioxide injury and or package destruction.

Required amount of carbon dioxide absorbers or releasers such as hydrated lime, activated charcoal, magnesium oxide etcetera can be used to maintain required CO 2. These oxygen absorbers or CO 2 generators are mainly used in products where the package volume and the appearance of the product which is packed inside the packet are the important considerations. For example, in the case of peanuts or potato chips extra. Snack food products have been the main target for this dual action like oxygen scavenger or CO 2 emitter sachets and labels.

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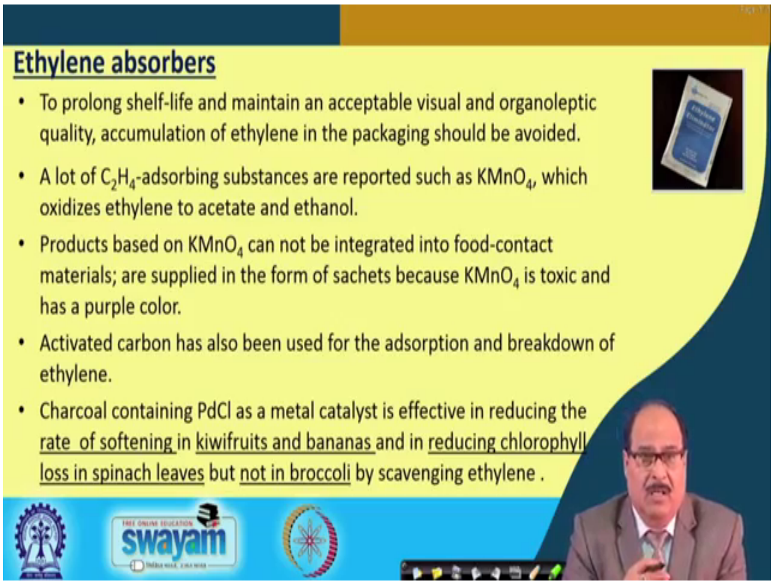

Similarly, ethylene absorbers depending upon if you want to hasten the ripening process one has to have ethylene emitters, if you want to control the ripening process extend the shelf life of the fruits; ethylene absorbers can be put into the packaging material or packaging side.

So, a lot of ethylene adsorbing substances are reported like KMnO 4 which oxidises ethylene to acetate and ethanol. So, and products based on KMnO 4 cannot be integrated into the food contact materials, they are generally supplied in form of sachets because KMnO 4 is a sometimes toxic and it has a purple colour. So, it may influence the colour of the food material, it may provide some toxicity to the bed. So, the care is taken that is the packet in which these ethylene absorbers are put. They should be providing required permeability to ethylene, but they should definitely stop the contact of the food with carbon that is a potassium permanganate.

Charcoal containing PdCl as a metal catalyst is effective in reducing the rate of softening in kiwi fruit and banana. It is also effective in reducing chlorophyll losses in spinach leaf, but it is not that much effective in broccoli.

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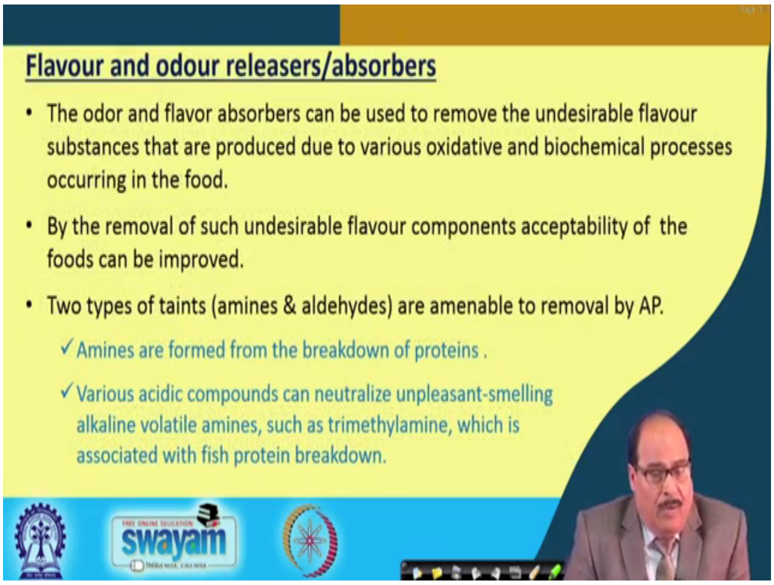

Flavour and odour releasers or absorbers are required to be added because the odour and flavour absorbers, they can remove the undesirable flavour substances that might be produced due to various oxidative and biochemical processes occurring in the food. By the removal of such undesirable flavour compounds acceptability of the food material can be improved.

Two types of taints that is amines and aldehydes are generally or they can be easily removed by the active packaging various acidic compounds can neutralize unpleasant smelling alkaline, volatile such as trimethylamine etcetera or flavour and odour scavengers have been utilised for debittering of citrus fruit juices or grape juices etcetera.

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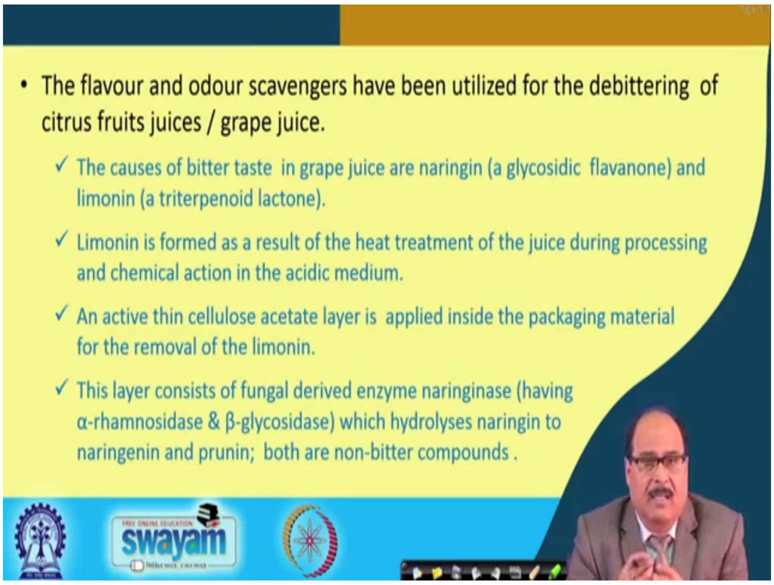

If you take the example of grape juice you find that the cause of the development of bitter taste in the grape juice is mainly two compound that is naringin and limonin. Limonin is formed as a result of heat treatment of the juice. When the juice is exposed to heat during its concentration thermal processing or such other process then heat and also the acidity or other chemical action acidic medium; chemical action which results into the formation of limonin.

So, an active thin cellulose acetate layer is applied inside the packaging material for the removal of the limonin. This layer consists of certain fungal enzymes which is called naringinase and this naringinase, it has alpha rhamnosidase or beta glycosidase.

So, these enzymes hydrolysed naringin to naringenin and prunin and both these naringenin and prunins are non bitter-compounds. They are flavouring compound, but non-bitter compounds.

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So, this is how the developed or undesirable example of undesirable bitterness how can be removed. Similarly preservatives or antimicrobial releasers many a times the to control the growth of undesirable microorganisms in foods antimicrobial such as nisin, pimaricin etcetera are incorporated in or coated into the food packaging materials. Antimicrobial packaging helps to extend the lag phase of the microbial growth or it reduces the growth rate of microorganisms resulting into the prolonged shelf life and better food safety. Antimicrobial active packaging film releases the antimicrobial agent and to the food in a controlled way and maintains its concentration on the food surface above the minimum inhibitory concentration for the target microorganisms. And in that way that is the microorganism particularly which are present on the surface of the food material. They are not able to grow or multiply.

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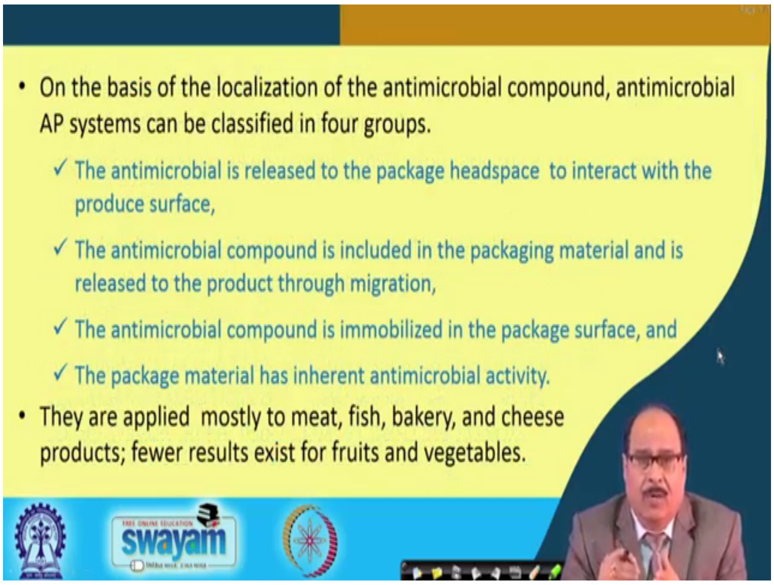

On the basis of the localization of the antimicrobial compound, this antimicrobial active packaging systems may be grouped into different categories classified into four groups; that is in one group; the antimicrobial is released to the package headspace to interact with the product surface. In other case, the antimicrobial compound is included in the packaging material and is released to prolonged to release to the product through migration. Another case maybe where the antimicrobial compound is immobilized in the packaged surface.

And the otherwise in another case, the package material has inherent and antimicrobial activity. So, either of these case may be true, but the fact is that is this antimicrobial agents are provided by the there is a continuous interaction between the surface of the food as well as the surface of the packaging material and its antimicrobial agent then do not allow the microorganism to grow. They are applied mostly to product like meat, fish bakery products, cheese; however, there are not many examples of use of this antimicrobial coated films etcetera for packaging of fruits and vegetables.

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Another very important aspects of active packaging is temperature control packaging there is one suitable approach is to prevent the temperature changes. Because during transportation or during storage, if there are temperature fluctuations this fluctuation in temperature may result into the quality loss or other. So, these controller temperature controller either the self way, heating package or self cooling packaging is used in the picture you can see that and they are commercially available that is whether they can lower down the temperature inside the package or they can increase the temperature inside the package as the case may be.

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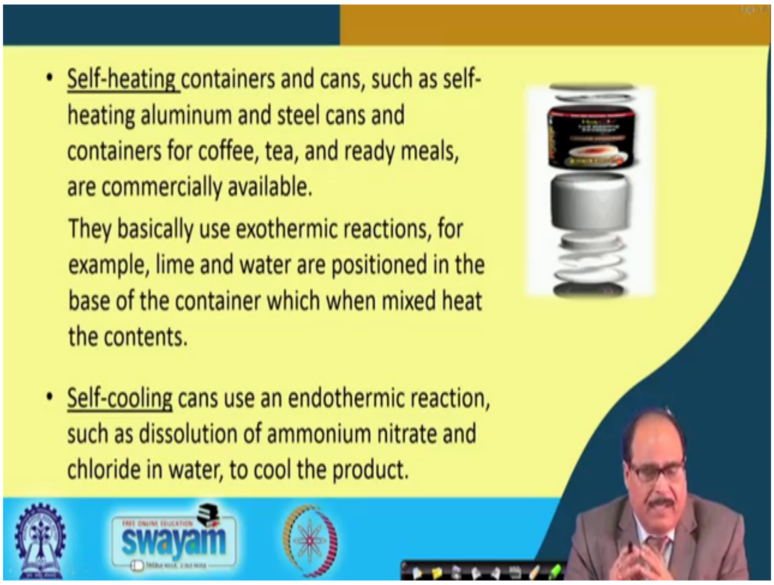

So, self heating containers and cans like for example, self-heating aluminium and steel cans and containers which are used for coffee, tea and ready meals etcetera. They are commercially available you can see in the picture here.

So, these containers such type of containers. They basically used exothermic reactions. For example, the lime and water, they are positioned in the base of the container and during. When you put some food material when this lime and; when these lime and water when they come in contact with each other the reaction exothermic reaction takes place and heat is generated. And other hand self-cooling cans use endothermic reactions such as this dissolution of ammonium nitrate and chloride in water which takes heat from the products and ultimately cools the product.

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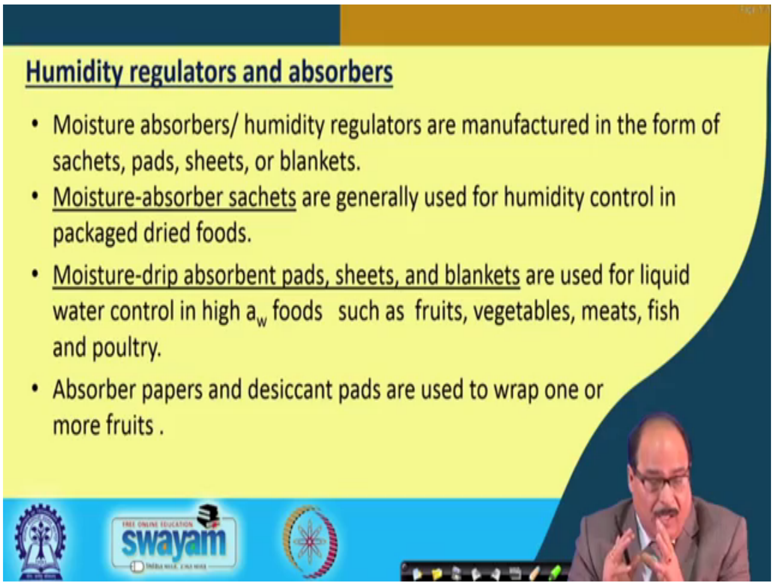

Humidity regulators and absorbers are other very very important aspect to prevent the condensation. So, moisture absorbers are humidity regulators are accordingly manufactured either in the form of sachets. Pad, sheets or blankets moisture absorber sachets are generally used for humidity control in packaged dried foods whereas, moisture drip absorbent pads sheets and blankets used for liquid control that is the food which have high water activity like fruits, vegetable, meat, fish, poultry etcetera absorber papers and desiccant pads are used to wrap one or more fruits together.

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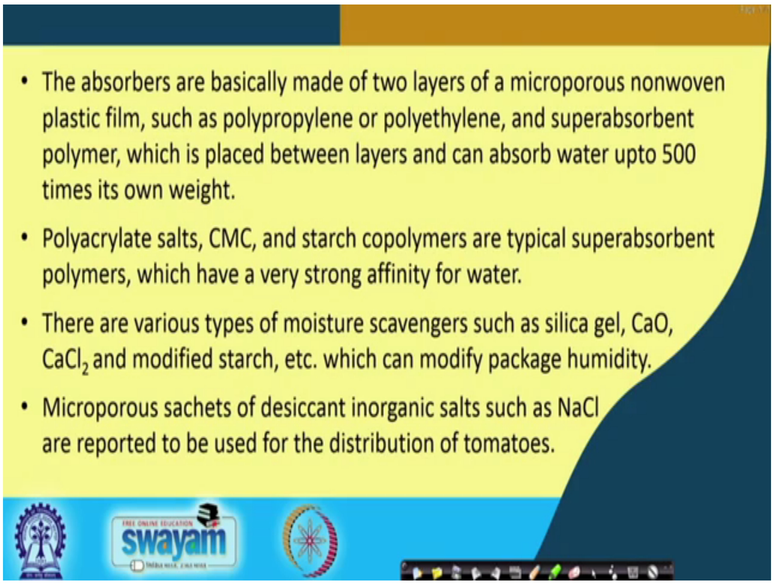

So, the absorbers are basically made of two layers of a microporous nonwoven plastic film such as polypropylene or polyethylene and some superabsorbents polymers are put into it. These superabsorbents they are placed between the layer and they can absorb moisture even up to 500 times of their own weight. Polyacrylate salts, CMC, and starch copolymers are typically used superabsorbers. They have a very long affinity for water very strong affinity for the water. These are there are various types of moisture scavengers such as silica gel, calcium oxide, calcium chloride and modified starch etcetera which can modify package humidity. Microporous sachets of desiccant inorganic salts such as sodium chloride are incorporated to be are reported to be used for the distribution of tomato etcetera in several cases.

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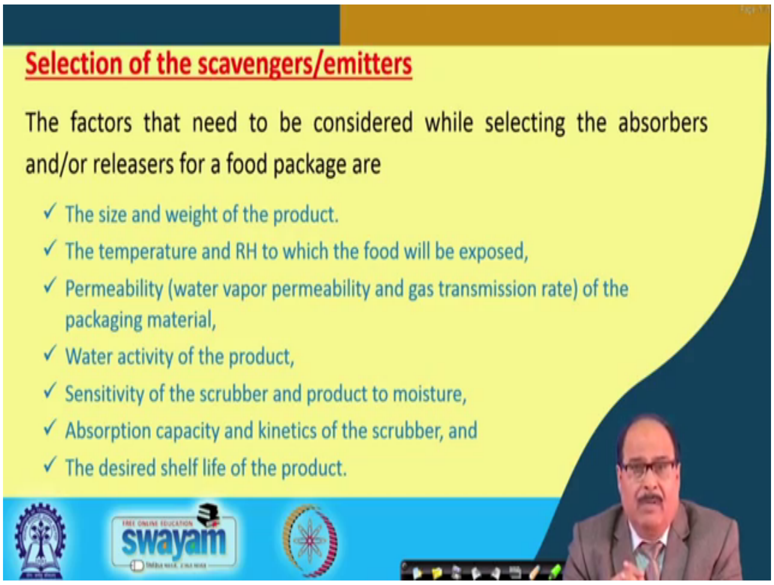

So, after having discussion on this that the another important thing is the selection of scavenger or emitters and certain factors need to be taken into consideration right while selecting the absorbers or emitters or releasers for a food package and these factors include size and weight of the product the temperature relativity to which the food will be exposed after packaging permeability. That is the water vapour permeability or gas transmission rate etcetera of the packaging material water, activity of the product, sensitivity of the scrubber and product to moisture absorption capacity and kinetics of the scrubber and the desired shelf life of the product. So, these are the important considerations which one should look into while selecting a suitable absorbent or releasers emitters.

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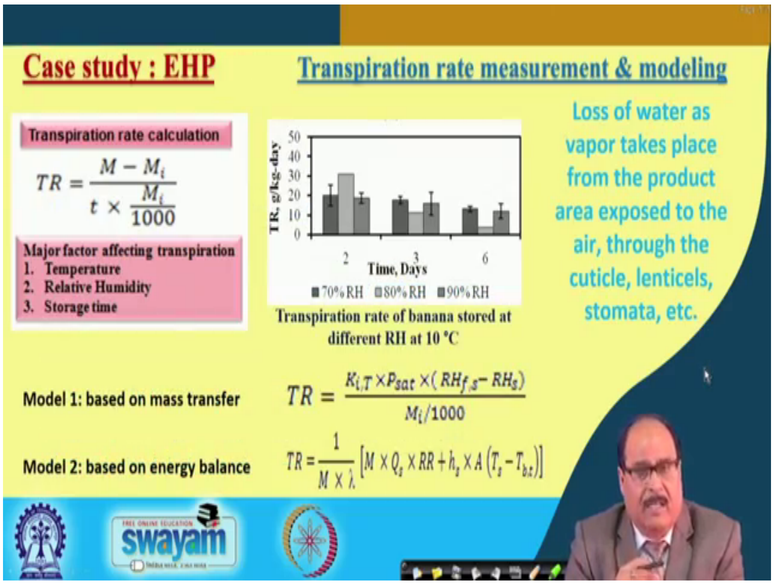

So, I will take up now one case study and give you an example this is the on the basis of the work done in my laboratory where we have a optima agency related active packaging conditions for fruits like banana, guava etcetera. So, I will give you that banana active packaging or banana here that one important aspect as I told you the transpiration rate that is the we should model properly, the rate of the transpiration.

So, so actually the last that is transpiration in transpiration there is a loss of water right that is when the product is placed inside the atmospheric atmosphere. If there is a humidity difference gradient in within the inside the package and outside the package, then there will be a transpiration of the water will be evaporated from the food surface through the cuticle, lenticels, stomata etcetera. So, the transpiration rate is dependent upon the temperature relative, humidity, storage time.

In this picture you see we have our results on the transpiration rate of the banana which is stored at different relative humidity from 70 to 90 percent and temperature at 10 degree Celsius. And you can see in the picture figure how the transmission rate varies with the relative humidity as well as with the storage time.

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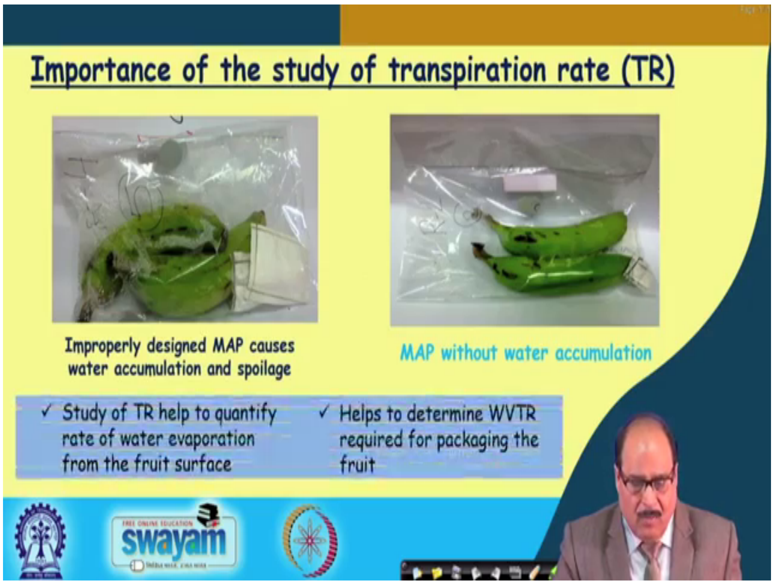

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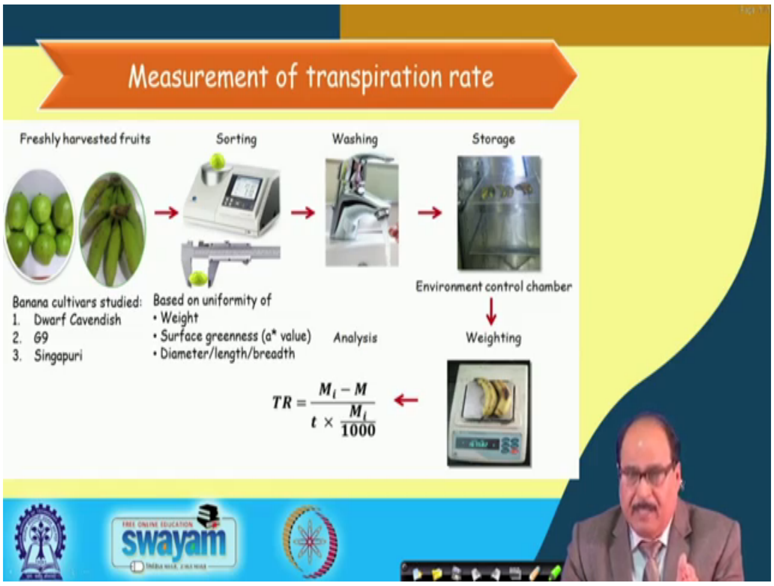

So, one can keep the material in the next slide. We will show you that transpiration rate how it they can be measured that is freshly harvested materials they can be put after of course, after sorting weighing etcetera. Then washed and it is packaged and kept into a suitable environment or control unity and the weight loss at a regular interval is taken and this weight loss data is used to calculate the transmission transpiration rate.

So, there are few models of for the calculation of the transportation rate which are suggested in the literature the model are based on the mass transfer that is the weight loss or it one can also calculate the transpiration rate on the basis of the energy balance TR and these are the equations one can do that.

So, but these transpiration rate measurement is very very important as I told you earlier also. Here you can see this is our result there is a package one package where there was a humidity gradient inside and outside the packet and it resulted into condensation of the moisture. In another case where the modified atmosphere package packet wise properly designed, there was no humidity gradient, there is no condensation of the moisture. So, this proper study of the transpiration rate helps to quantify the rate of water evaporation from the fruit surface and also it helps to determine the water vapour transmission rate required for the packaging of the fruit.

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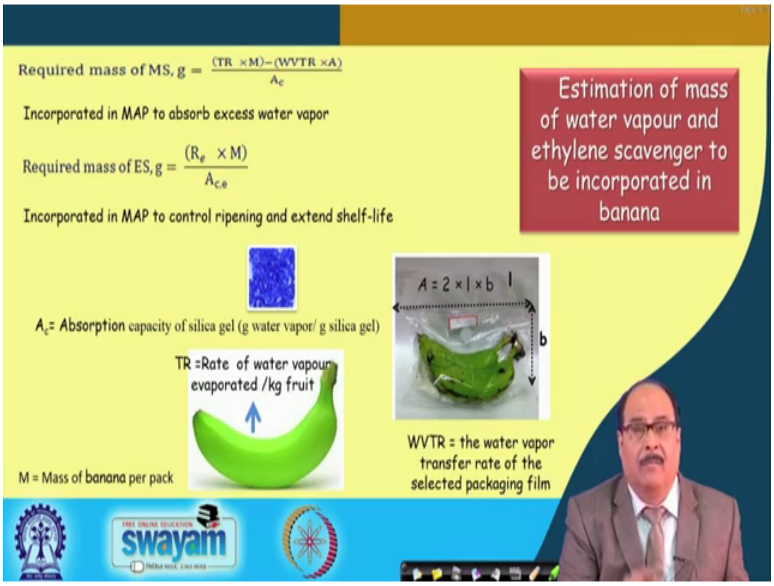

So, we conduct experiment, we can measure the transmission rate and these data; the transpiration rate data can be used to calculate the moisture absorbers required using this formula that is moisture absorbers. In gram is equal to TR multiplied by M minus WVTR multiplied by A divided by A c. Similarly that required mass of ethylene scrubbers required to be kept inside the map can be calculated by the equation R e multiplied by M divided by ace and where these values A c e; M ,TR,WV TR, they can be experimentally measured right. The TR is the rate of water vapour evaporator per kg of fruit.

Then WVTR can be used like if you have that areas of the water vapour transfer rate of the selected packaging film. A c is the absorption capacity of silica gel that is gram water vapour per gram of the silica gel.RE is the ethylene generation rate u l per kg per hour.

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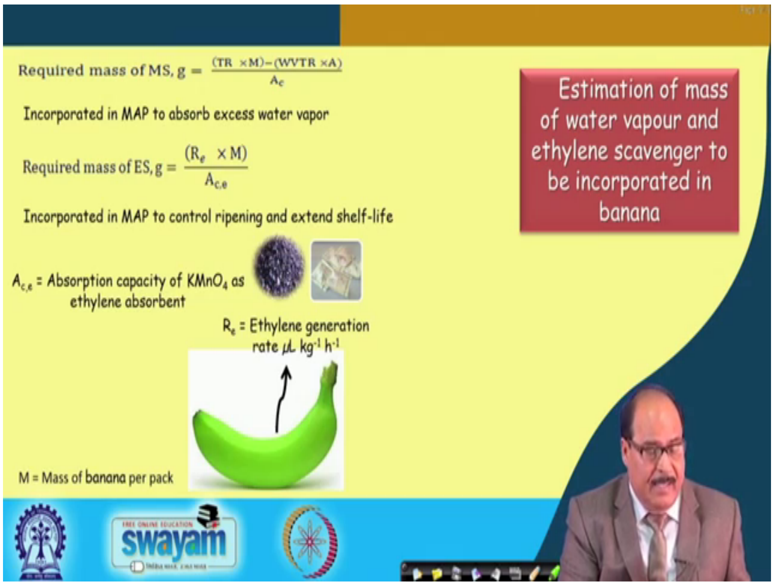

A c e is the absorption capacity of KMn O 4 as ethylene absorbent. So, from these data can be measured from the experimentally or you can take from the literature and accordingly one can calculate.

So, depending upon the type of fruits and vegetable what will be the moisture absorbers required what will be the ethylene scavengers required and accordingly one can calculate carbon dioxide releasers or oxygen scavengers depending upon the permeability of the packaging material temperature and other factors.

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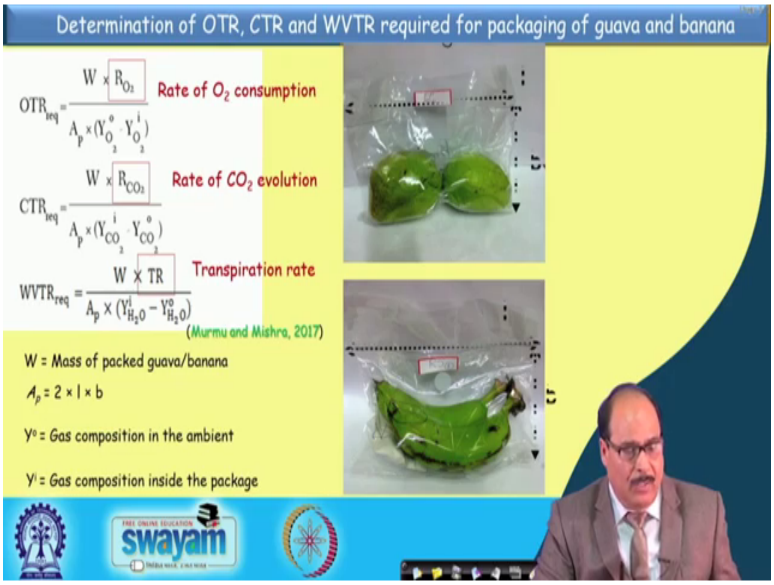

So, we have published this data that is we have given this model that rate of O 2 consumption rate of CO 2 evolution and transmission rate for the banana can be calculated that is using these equations that is OTR, CTR and WVTR are required for the packaging of guava and banana. All these we have provided these equations and data is available.

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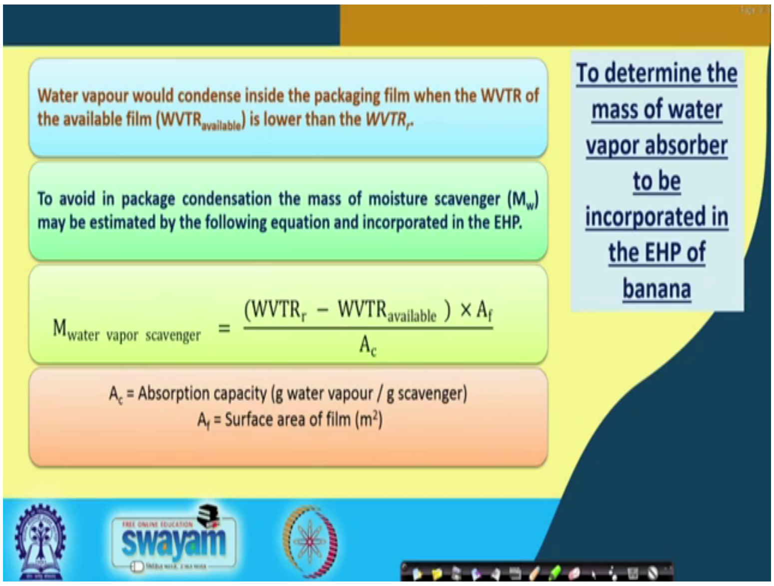

So, once you have these data it becomes easier for example, the now the what is the water vapour that is the would condense inside the packaging film only as I told you when the water vapour transmission rate of the available film that is WVTR available is lower than the WVTR required. So, you need a specific WVTR inside the packaging material, WVTR r of the packaging film to maintain that humidity or to allow the interchange of the water vapour from inside to outside or outside to inside. So, that the humidity is equilibrated little bit is maintained.

So, suppose by your experimental you found that what is WVTR available if it is less, then the WVTR r; obviously, there will be so, you have to calculate and you have to add some moisture absorber because whatever moisture more is there inside the package that has to be absorbed by the moisture absorber. So, the moisture M water vapour scavenger. So, moisture scavengers required can be calculated from the formula WVTR minus WVTR r that is the WVTR required minus WVTR available multiplied by A f divided by A c.

So, A f is the surface area of the film in square metre where Ac is the absorption capacity gram water vapour per gram of the scavenger. So, in this way, one can calculate the how much amount of how many grams or how many kilograms depending upon the size of the packet, depending upon the other condition, depending upon the transmission rate that is water vapour water scavengers. Water vapour scavengers or similarly other calculation can be made to decide the quantity of ethylene scavengers quantity of oxygen scavengers flavour scavengers absorbers etcetera and they can you put inside the package.

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So, this is the accordingly methodology of the active packaging. So, impart that is you need to material which you one wants to pack using standard procedures. It has to be washed, graded and then the next aspect is while you does it, you should have a packaging film that is the proper selection of the packaging films should be made to PVC, PPC, PP film, poly propylene whatever films are there and one should know what is the permeability of all these films gas permeability, water permeability.

So, accordingly that is the depending upon the permeability depending of the material depending upon the food, fruits, vegetables etcetera. You need to select the scavenger and this is scavengers like they may be for moisture scrubber for other scrubbers. They to be put into the some sort of sachet or they come in the form of film, in the form of sachet in the form of. So, they should also be packed and it is kept inside the package calculated amount for the an amount which is stored or for the required value effect needed.

So, with this I thank you by now I hope you have got a good idea about what the modified atmosphere packaging is there, what is active packaging and, I will again like to say that major difference in that in modified atmosphere; it is a natural process which controls the atmosphere inside the package. In the active packaging we include that is we hasten the control process either by putting active scavengers or emitters or releasing system and this ultimately helps in improving the shelf life, in improving the quality, in reducing the microbial load and so on.

Thank you.