**FOOD SCIENCE AND TECHNOLOGY**

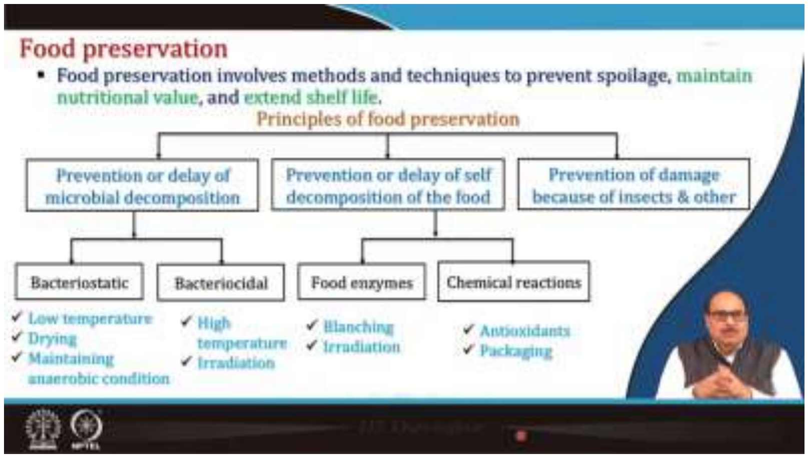
**Lecture41**

**Lecture 41: Traditional Food Preservation Technologies**

Hello everyone. Namaste.

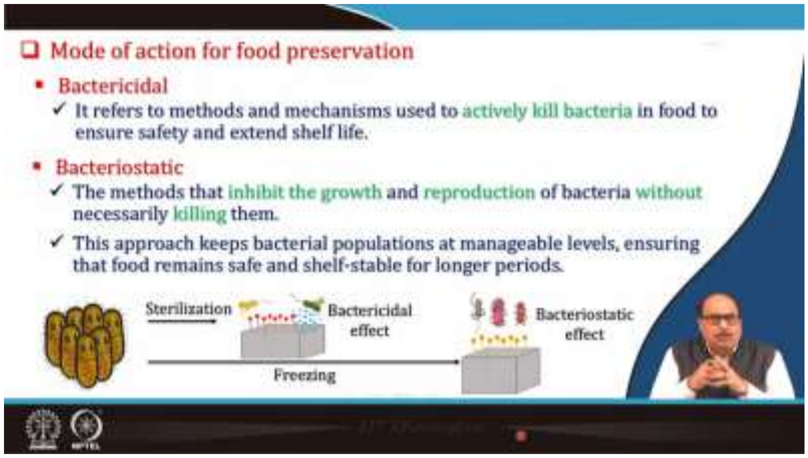

Now we are in the ninth module of this course. In this module, the next five classes will be devoted to food preservation principles. In today's lecture, we will talk about traditional food preservation technologies.


We will discuss the concept of food preservation. Preservation technologies act by inhibiting or inactivating the growth of microorganisms, combining heat treatment, control of water activity, and pressure to preserve foods. And then, towards the end, we will also talk a little bit about packaging materials and technologies. So, you know, in the earlier class, we discussed the various factors, the various causes that lead to the spoilage of food. So, we need to prevent these spoilages.

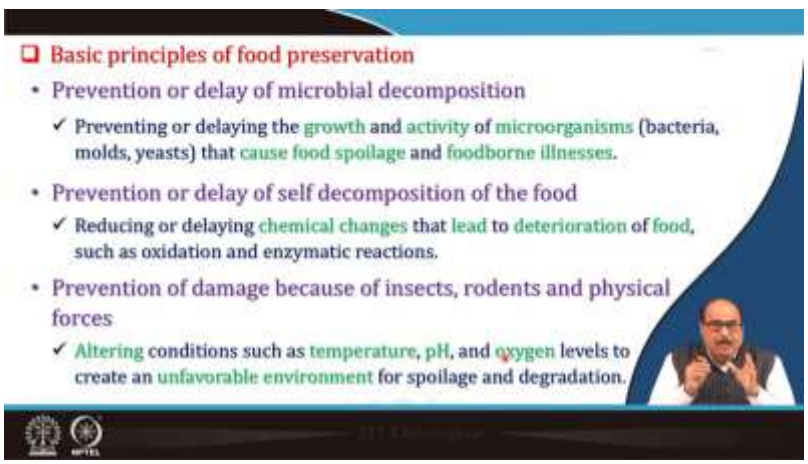



So, that is where food preservation comes into the picture. Food preservation involves methods and techniques or treatment given to the food to prevent spoilage, maintain nutritional value and extend shelf life. There are various ways to preserve food. This can be done by delaying microbial decomposition. or prevention of the microbial decomposition of the food or prevention or delay of self-decomposition of the food. Also, there are many times spoilage of the food because of the insects and other factors, physical damage, etcetera. So, in preservation, another method is applied to delay, reduce, or minimize the prevention of damage caused by insects and other factors.

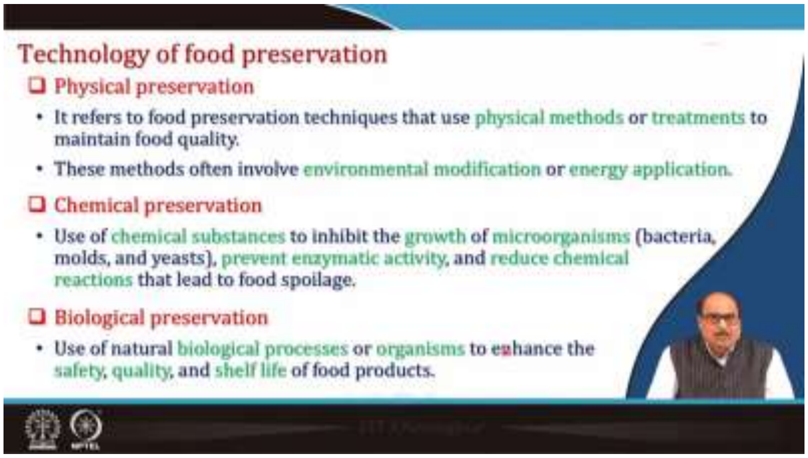
So, the mode of action of food preservation if we talk about there might be two majors particularly the preservation methods which act upon the microbial inactivation or microbial destruction, keeping in view the microorganism growth in the food. So, there are methods to control microbial growth or completely remove microorganisms from food. The action may be either bactericidal or bacteriostatic. So, bactericidal means that the methods and mechanisms which are used to actively kill bacteria in foods to ensure safety and extended life. So, bactericidal means the bacteria are completely killed, whereas the bacteriostatic methods inhibit the growth and reproduction of the bacteria or other microorganisms, but they do not kill.




This approach keeps the bacterial population at manageable levels, ensuring that food remains safe and sustainable for a longer period of time. Here you have seen two examples. Let us see, for example, sterilization where heat or such other radiations, etcetera, are given that energy is given. So, this completely has the So, it completely kills the microorganism. So, it has a bactericidal effect, whereas when you are giving low-temperature preservation like freezing, etcetera. So, in this case, microorganisms are not killed, but they are just put into the stationary phase or dormant stage. So, that means the bacteriostatic bacteria come under static conditions.




As I told you, the basic principles of food preservation are either prevention or delay of microbial decomposition, that is, preventing or delaying the growth and activity of microorganisms that cause food spoilage or foodborne illnesses. Then, prevention or delay of self-decomposition of the food. which reduces either by reducing or delaying the chemical changes like oxidation or such other processes that may result in the spoilage of the food. So, in one way or another, we try to reduce or delay the deterioration of such foods by preventing the oxidation process or enzymatic activity, etcetera. The third factor is the prevention of damage caused by insects, rodents, and physical forces that alter conditions such as temperature, pH, and oxygen levels. So, these create an unfavourable environment for the growth of insects and other factors, and the food becomes preserved.



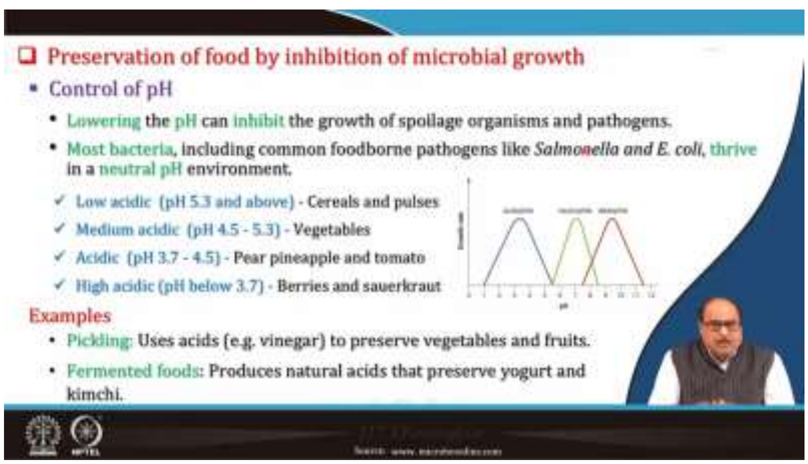

So, the technology of food preservation, that is, the methods of food preservation, particularly traditional methods, include similar physical preservation, physical methods, and techniques that use physical methods or treatments to maintain food quality. These methods often involve environmental modification or energy application, as we will see in the later slides with a few examples of details of a few of these methods. The chemical methods use chemical substances to inhibit the growth of microorganisms or prevent enzymatic activity to reduce the chemical reactions that lead to food spoilage. Meanwhile, the biological preservation method uses natural biological processes or microorganisms to enhance food products' safety, quality, and shelf life.

So, in the earlier class, we discussed the various factors that affect microbial growth, the factors that affect the enzymatic processes or other chemical reactions, etc. So, obviously, when we go for food preservation or select the treatment of the food. So, these factors play a significant role. So, accordingly, because our aim in food preservation is to create a condition which is not favourable for the growth of


microorganisms or for the activity of enzymes for the continuation of oxidation processes, etcetera. So, for that, you must first know what the various factors are that influence these reactions. So, obviously, our jobs as food engineers and food processors make it easy to manage those factors in such a way that they become unfavourable to the. So, here are the factors that need to be considered or that are generally considered in one or the other food preservation methods. These factors can be broadly divided into two groups: intrinsic factors and extrinsic factors. Intrinsic factors may include the factors related to the food material like moisture and water activity of the food, pH and acidity, nutrient content, biological structure of the food, redox potential if there are any growth inhibitors, etcetera present or overall microbial spectrum of the food. Extensive factors are the factors which are operating on the food from the outside. So, environmental factors have been used, such as oxygen present in the environment where the food is being handled, treated, processed, temperature, relative humidity, or type of packaging material.

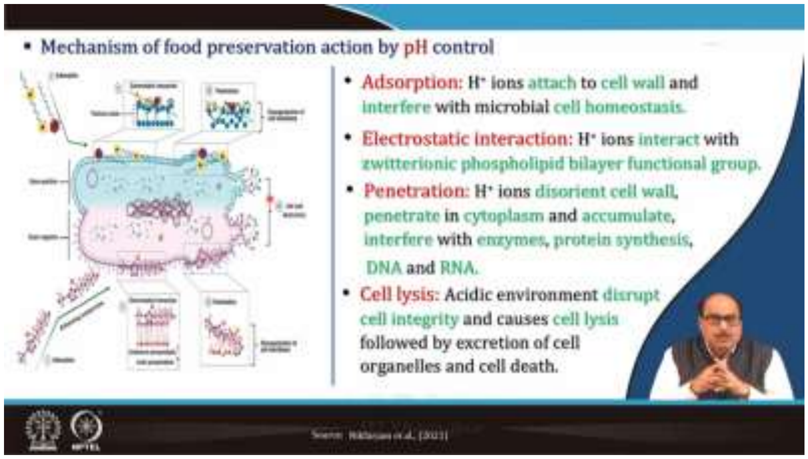
So, for an effective application of food preservation, as we said earlier, it is essential to delay the start of microbial growth. That is particularly the lag phase when we are talking about microbial growth in the earlier module. Then we see that this lag phase. So, if you can delay this lag phase by one or the other method, obviously, it will slow down the rate at which the microorganism will grow as well as also allow you to use certain methods to slow down the exponential phase rate of the exponential phase, the positive acceleration phase, to prevent spoilage effectively. So, how do we do that? Number one: by maintaining unfavorable conditions, that is, obviously, the less favorable the conditions like pH and temperature, the longer the lag phase will be, that is, the more unfavorable the conditions.

So, if you see that even the bacterial culture which has been used from the previous history, also, if you use actively growing bacteria to inoculate etcetera, it may take longer. So, that is by avoiding the addition of actively growing organisms that is avoiding the possible contamination of microorganisms from log feeds. Then, by keeping as few spoilage organisms as possible means reduction of the amount of the microorganisms for longer log feed period at deal, reducing the contamination level. And then by actual damage to the microorganisms, that is treating the food to inactivate the microorganisms to make the food microorganisms present in the food inactive.

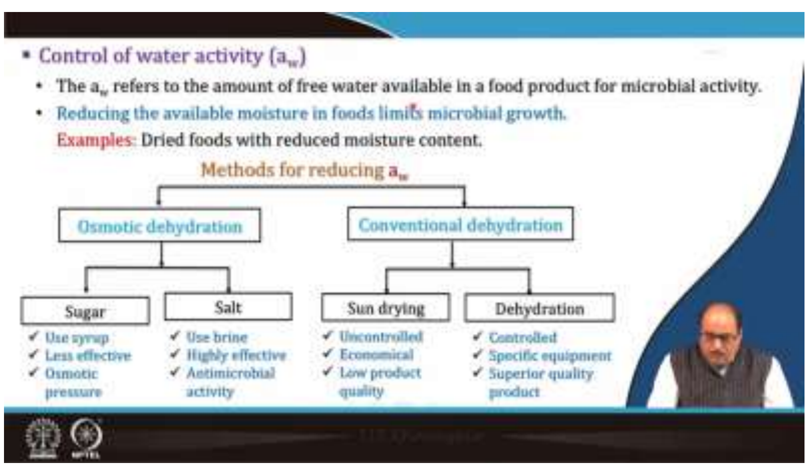



So, let us now talk about one by one, that is one or two of these factors, etcetera, that is, the preservation of food by inhibiting microbial growth. So, that is and has to be seen. We are talking about traditional food preservation technologies. So traditionally, water activity, pH, and other factors have controlled the microbial spoilage of food. So, control of the pH. In the earlier class, we have seen the various pH level requirements for that are is microorganisms, such as acidophiles, which normally grow in the pH range of 1 to 5.5, etcetera, then neutrophils or alkalophilic, etcetera. This we discussed earlier. So, obviously, lowering the pH, bringing it below this level or even going to the upper side, like for acidophiles, which have a favourable pH between 1 to 5.5. If you bring the pH down to less than one or even increase it to more than 5.5, the growth of the related microorganism will be prevented. So, most bacteria, including common foodborne pathogens like Salmonella, E. coli, etcetera, thrive in a near-neutral pH environment, that is around 6.5, or say maybe 6.5 to 7.5, etcetera, all right. So, bringing the pH above these ranges, that is, the upper limit or lower limit, will cause the reduction of spoilage by these bacteria and suppress the growth of such microorganisms. Similarly, cereals and pulses normally are low-acidic, and vegetables are medium-acidic, with a pH of 4.5 to 5.3. There are certain fruits, like pear, pineapple, tomato, etcetera; they are acidic. Fruits and berries, sauerkraut, high-acidic fruits. So, accordingly, if you know the pH and acidity of the food, you can very well find out which type of microorganism it is. So, microbial requirements for the pH for their growth are very specific. So, accordingly, in the preservation and processing methods, one can consider and decide the pH factor, bringing the acidity. So, you can take examples like pickling. It is a traditionally used preservation process. So, basically, either by the fermentation method or by adding acid from outside, the pH of the food, particularly fruits and vegetables, is brought to lower levels, and this causes the suppression of microbial growth. Vinegar is an acetic acid that is used particularly for preserving foods, fruits, vegetables, etc. Then, in fermented food products, fermentation produces natural acids that preserve yoghurt, kimchi, etc. That is when milk is converted into. Curd or yoghurt, then lactose is converted into lactic acid by the action of microorganisms.

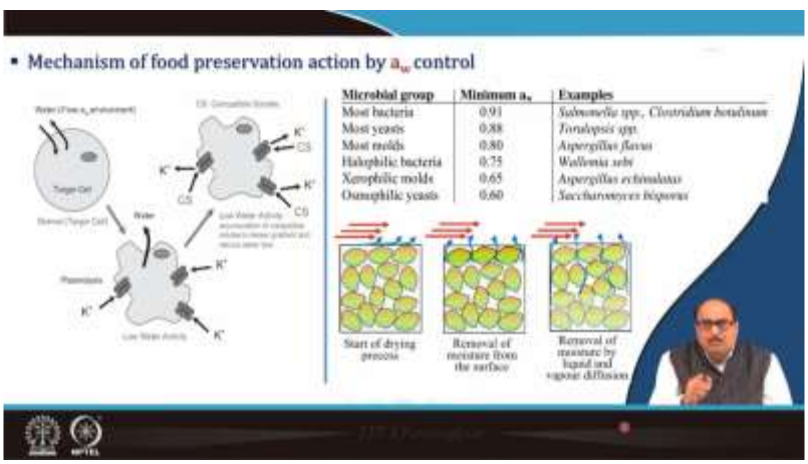
So, these all become the preservation process whereby your own control of the pH is performed. So, what happens is that the pH is basically hydrogen ion concentration. So, how does that pH reduce the acidity by changing the pH or increasing the acidity? So, you are basically changing the hydrogen ion concentration. There is a. This hydrogen ion concentration is changed; there may be higher hydrogen ion concentration or lower hydrogen ion concentration. In either case, there is a mechanism; if you talk about what has been shown here, surely there is an adsorption-like hydrogen ion attached to the cell wall that interferes with the microbial cell homeostasis, that is, disturbs the homeostasis of the cell. Mind it, the bacteria or any microorganism will be in a full state of stage of growth till its homeostasis is maintained, which means all cellular organs are correctly working properly, and this is maintained under proper environmental conditions. So, and



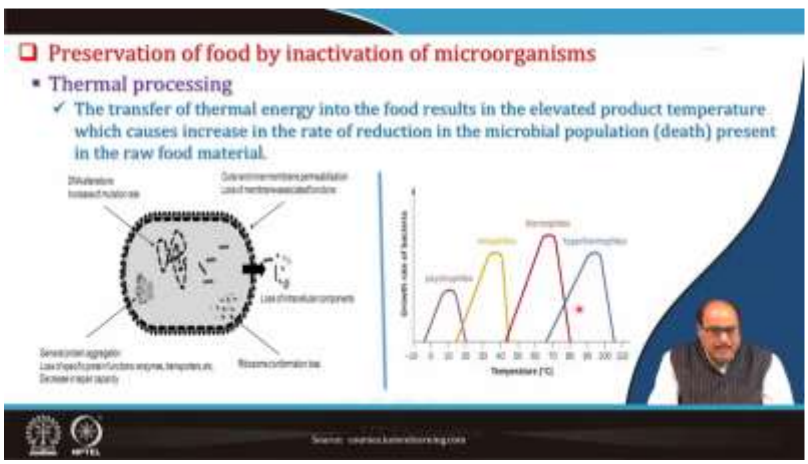

then we see there is electrostatic interaction, like hydrogen ions interacting with the deuteronic phospholipid bilayer functional groups. The penetration, that is, hydrogen ions disorient the cell wall that is they cause breakage in the cell wall, etcetera, and they penetrate into the cytoplasm and accumulate and interfere with the ah enzyme protein synthesis, other DNA and RNA-related activities, etcetera inside the cell, and ultimately their is an analysis of the cell. So, I have jar swan, electrostatic interaction, penetration and then finally, cell lysis, which is an acidic environment that disrupts the cell integrity and causes cell lysis, followed by the excretion of the organelles from the cell that is cytoplasm material oozes out of the cell, etcetera and which ultimately causes the cell death. So, the process that is given for a longer period of time is shown in the diagram. You have seen that in the earlier class when we were talking about microbial growth and then after being in the stationary phase, that comes to the death phase.



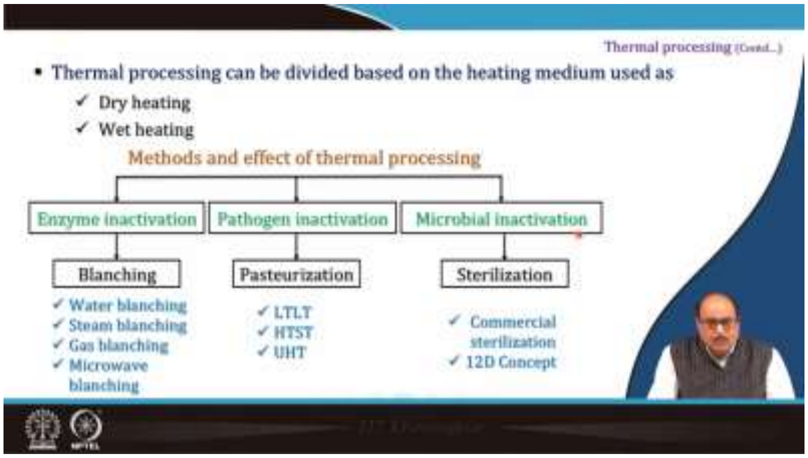

Then the other commonly used methods that is traditionally followed is the control of water activity. Water activity, again, was discussed in the earlier class. It refers to the amount of free water available in a food product for microbial activity. So, reducing water activity means you are reducing the available moisture in food to control microbial growth. It is a main example, such as the drying of food. So, drying the food reduces the moisture content and reduces the free moisture available for microbial growth. So, there are two major methods you can use to reduce water activity: one may be osmotic dehydration, and the other is conventional dehydration. In osmotic dehydration, either sugar or salts are used to maintain the osmotic pressure and disturb it when you are using sugar syrup, etcetera. Although it controls the osmotic effect, it causes osmotic concentration to increase, osmotic concentration increases, osmotic pressure, etcetera. At times, it is comparatively less effective than salt preservation. That is salt. Normally, we use sodium chloride brine solution, which is more effective than sugar, but here, the salt also has some antimicrobial activity. Then, in the conventional dehydration method through sun drying, there is, of course, uncontrolled, but it is an economical process. Here, the final dried product, because you are just exposing the food, just spreading thinly, etcetera, in the open sun, may result in inferior dehydration quality in the dried product. So, whereas dehydration is a controlled process, now, it is very sophisticated and good, and highly controlled equipment is there, specifically equipment for drying. So, obviously, it results in even, sometimes, many times, quicker drying, giving a senior or superior product quality.




So, again here, the mechanism of food preservation by action by water activity control. So, basically, water activity control means you are removing the free moisture that is available for growth, and therefore, it is increasing the osmotic concentration. So, these microorganisms are not able to survive or thrive in a high concentration of salt, etcetera, or solute concentration. This is the minimum water activity for the growth of various microorganisms. Earlier, we also discussed this. So, obviously, if you bring down the water activity level below this, then these respective microorganisms will not be able to grow, and particularly if you reduce the water activity to 0.6 or below, that it may be 0.5. So, the food will become completely safe from the microbial spoilage point of view. As far as when you are drying, that is, depending upon the moisture content, you know that the free moisture content in this might even be physically interacting in the cellular matrix, etcetera. So, first, that is, moisture is removed from the surface, that is, when you provide the heat energy, either solar energy or any mechanical dryer, etcetera, to provide the dry heated air. Then, it causes the temperature of the material to increase, and then first, it takes the removal of moisture from the surface, and then this moisture from the interior, that is, the liquid that is the movement of the liquid from the interior to the surface, comes as vapor diffusion and then failure. So, accordingly, there may be two stages, one of which is constant drying. period as well as the falling rate period, falling rate, and constant rate. So, you get a static rate until the moisture surface moisture content is removed. So, there is a constant drying rate, and then after that, the drying rate decreases. So, decreasing the slow drying rate, you get.

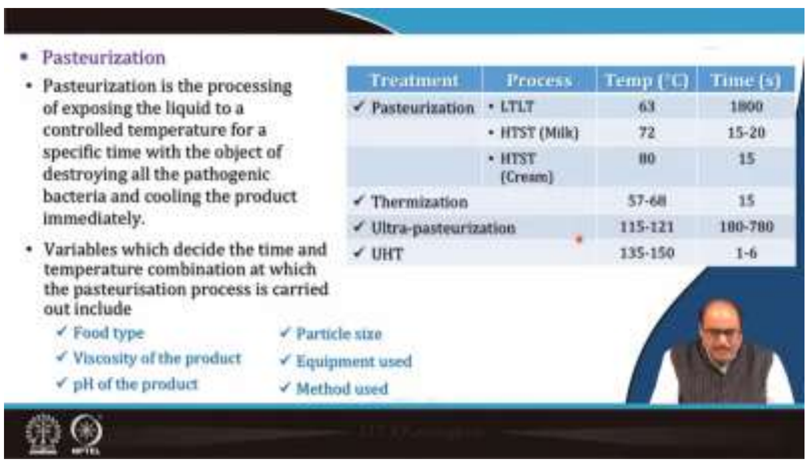



Then, food can be preserved by the inactivation of microorganisms. So, mind it, that is, the control of water activity, control of pH, etcetera. There are many other methods, such as by which the microorganisms are not completely killed. So, these are the methods by which the bacteria become static. So, if you remove those factors, the bacteria or microorganisms will again. But there are certain, particularly sometimes, when toxin-producing microorganisms are there, and then we need to say yes, that is this. Particularly, the microorganism's presence or its growth might be. Not favorable. So, they have to be completely removed. So, for such types of foods, you have to give certain energy inputs, which may be either thermal processing, heat processing, radiation processing, or even pressure processing, etc. So, by this, you give certain energy and that completely calms. causes the killing of those microorganisms. In thermal processing, we basically transfer thermal energy into the food, and that obviously results in elevated product temperature, which causes an increase in the rate of reduction in the microbial population. So, because of this higher pressure, high temperature, radiation, etcetera, there may be DNA alterations. That is, they may cause an increase in them. mutation rate, etcetera, general protein aggregation resulting in the loss of specific protein functions, enzymes, transporters, etcetera, decrease in the repair capacity or ribosome conformation loss, or even there may be outer or inner membrane permeabilization, loss of membrane-associated functions. That is, whatever temperature one is giving, how much is this? So, cellular dysfunction may be caused by either of these materials. Finally, there may be a loss of intracellular components if cell breakdown takes place. The cell's intracellular components are lost, and the cell finally loses its biological activity and ultimately dies. Then, in the earlier class, we again discussed food microorganisms, temperature, and temperature requirements for the growth of the microorganisms. So, if you expose, suppose thermophiles or mesophiles, their optimum is around 37 or so. So, if you expose them, they have a range up to maybe 15 to 45. So, when you increase these microorganisms above their temperature requirement for growth, then it causes death, which may be due to the denaturation of proteins, cellular disruptions, and various other functions.

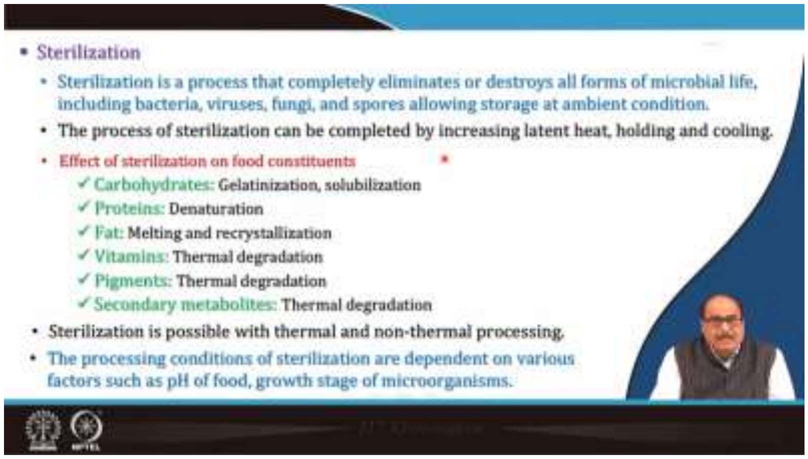



So, thermal processing can be divided based on the heating medium used as dry heating

or wet heating. So, these methods may be enzyme inactivation, pathogen inactivation, or even microbial inactivation. The enzyme inactivation is basically blanching. Pathogen inactivation process, which we call pasteurization and sterilization, occurs when the complete elimination of the microorganisms occurs. So, blanching is basically a mild heat treatment you can give, or it is a pretreatment given to the microorganisms. Freezing, canning, and drying processes, particularly for fruits and vegetables, they are exposed to very low heat conditions, and the purpose or objective of this process is basically to inactivate enzymes. Modified texture, preserved colour, flavour, and nutritional value, as well as removing the trapped air, particularly before the cleaning process when we activate it, remove the entrapped air. So, the blanching may be either water blanching or steam blanching, air blanching or microwave blanching. In water blanching, it may be LTLT or STST. Normally, 70 to 100 degrees Celsius temperature, and in steam blanching, air blanching, or microwave blanching, the various methods that will be 100 degrees Celsius are that it may be direct steam injection, or it may be air injection, or even a combination with the water, and then it is the microwave processing.

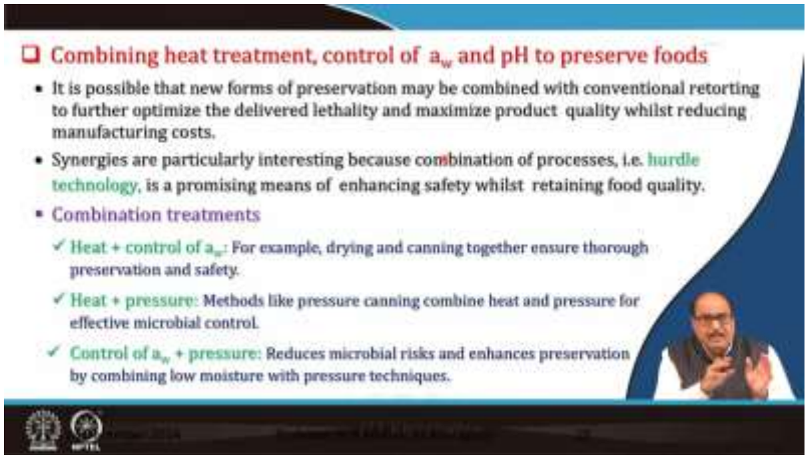



Pasteurization is the process of exposing the liquid to a controlled temperature for a specific time with the objective of destroying all the pathogenic microorganisms from it. The variables which decide the time and temperature combination at which the pasteurization process is carried out depend on the food type, viscosity of the product, pH of the product. size, equipment used, method used, etcetera. Here, I have given you the various processes. There is a time-temperature combination like pasteurization. The LTLT process takes 63 degrees Celsius and 1800 seconds. Ultra pasteurization: 151 to 121 degrees Celsius or 180 to 780 seconds. Pasteurization is done in two types of setups: batch pasteurizer and continuous pasteurizer. The continuous system has various zones, such as heating, holding, cooling, and recirculating, as you can see here in this figure. Preheating with hot pasteurized liquid improves the energy efficiency of the pasteurizer. It destroys all common disease-producing microorganisms, such as those for tuberculosis, typhoid, diphtheria, etc. Pasteurization destroys approximately 99 percent of bacteria and most fungi.

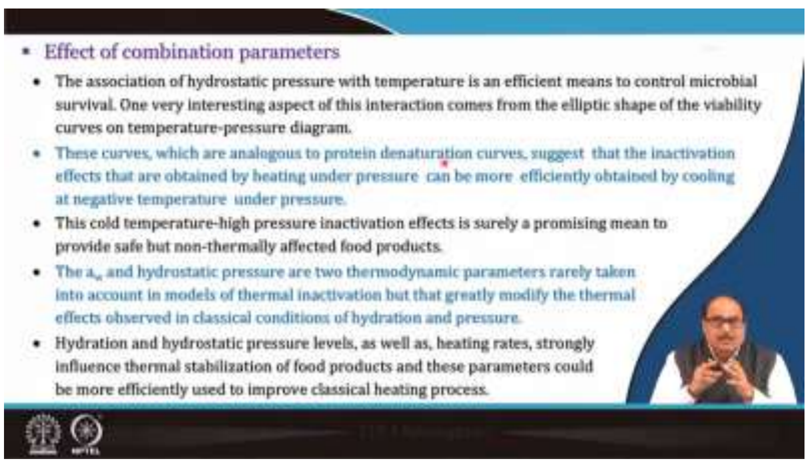



Then, obviously, sterilization is a process that completely eliminates or destroys all forms of microbial life, including bacteria, viruses, fungi, etc. The process of sterilization can be completed by increasing the latent heat. Holding or cooling and cooling then. So, this sterilization process obviously has its effect on the various food components it may cause gelatinization or solubilization of carbohydrates, denaturation of proteins, melting and recrystallization of fat, or it may result in the thermal degradation of vitamins, colours, or other secondary metabolites. So, it has to be taken with precaution and care. Sterilization is possible with thermal and non-thermal methods. The processing conditions of sterilization are dependent on various factors such as the pH of the food, growth stress of microorganisms, etcetera.

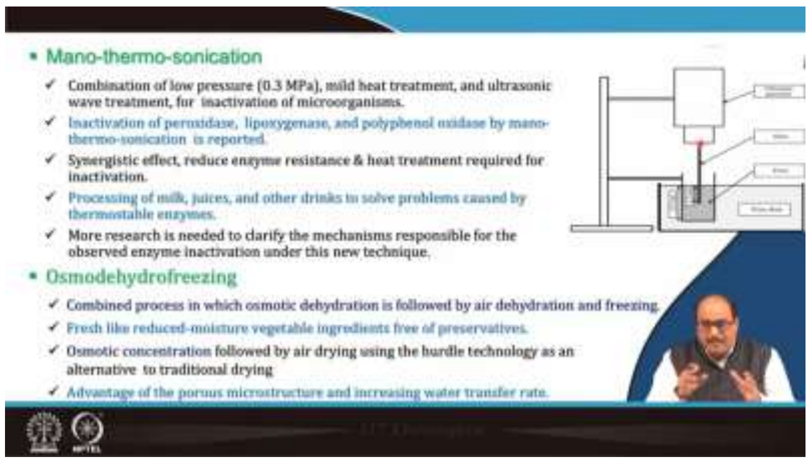
Now, let us talk about combining heat treatment, control of water activity, and pH to preserve food, which is particularly nowadays one of the emerging technologies, also called multiple-factor treatment or hurdle technology. That is where different factors like controlling the heat and water activity together, controlling the heat and pressure, controlling water activity and pressure, etcetera. So, instead of exposing the food to simply one factor and causing a severe process, which results in the destruction of various nutrients or quality factors.



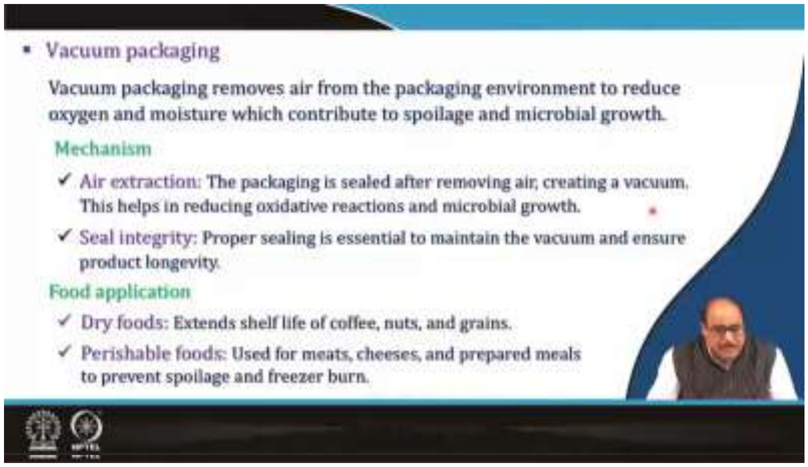

Now, the trend is to expose the food to more than two or three factors and then a combination of different factors, which enables the lowering of the severity of one particular factor or one particular process, and though this results in better product quality while giving the desired shelf life while controlling the microorganisms.




So, obviously, the combination parameters may often act synergistically, particularly, for example, the association of hydrostatic pressure with temperature is an efficient means to control microbial survival. If you look at one very interesting aspect of the interaction, it is the interaction of the shape of viability, that is, the viability curve, that is, the temperature-pressure diagram, and it gives an elliptical shape. An elliptical shape means that these curves are also similar to those observed in protein denaturation. This suggests that the inactivation effect obtained by heating under pressure can be more efficiently achieved by cooling at negative temperatures under pressure. Thus, this cold temperature high-pressure inactivation effect is surely a promising means to provide safe, but non-thermally affected food products, and this is the basis on which high-pressure processing, etc., has emerged into the field. Water activity and hydrostatic pressure are two thermodynamic parameters that are rarely considered in thermal inactivation models. However, they significantly modify the thermal effects observed under classical conditions of hydration and pressure. Therefore, hydration and hydrostatic pressure levels, as well as heating rates, strongly influence the thermal stabilization of food products, and these parameters could be more effectively utilized to improve classical heating processes. For example, two instances of this are mano-thermo-sonication and osmodehydrofreezing.



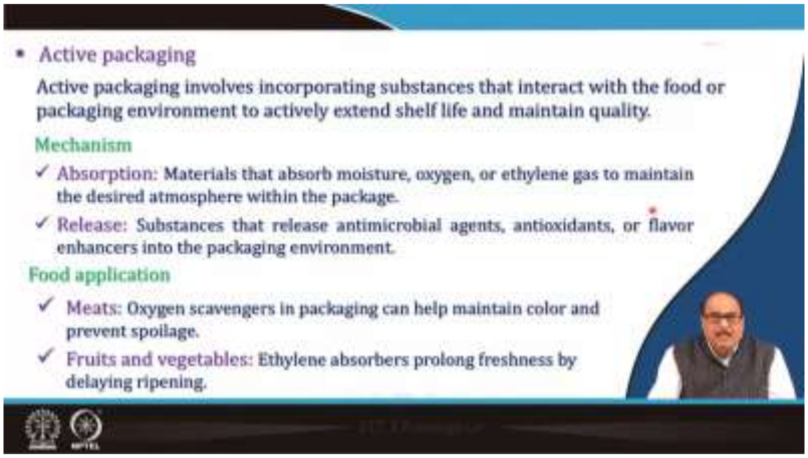

In mano-thermo-sonication, the controlled combination of low pressure may be 0.3 mega Pascal mild heat treatment and ultrasonic wave treatment for the inactivation of microorganisms. It also results in the inactivation of peroxidase, lipoxygenase, polyphenol oxidase, etcetera. It has a synergistic effect, that is, it reduces the enzyme resistance, and heat treatments are reduced enzyme resistance methods, and lower heat treatment is required. There are many examples, like the processing of milk, juices, and other drinks, where mono-thermo-sonication has the potential to solve the problem of spoilage. However, more research is needed to clarify the mechanism responsible for the observed enzyme inactivation under these new techniques. Similarly, osmodehydrofreezing is a combined process in which osmotic dehydration is followed by air dehydration and freezing. Here, you get a fresh-like, reduced-moisture vegetable ingredient free from preservatives and osmotic concentration, followed by air drying using the hurdle technology as an alternative to traditional drying. The advantages of this method are the porous microstructure that we get in the dried product as well as the increased water transfer rate during drying. So, this gives a better product.




Now, let us briefly talk about packaging because the purpose of the whole effort of processing will be defeated if post-processing contamination is not avoided during handling, storage, etcetera, and the food is not properly handled. So, here packaging is a method that should be done properly; it provides protection. That is, good packaging seals the food from physical damage, contamination, and environmental factors during handling and storage, etcetera. It also extends the shelf life by maintaining quality and safety, and it provides convenience, that is, ease of handling, storage, and use. So, different types of packaging materials that can be used are glass, metals, plastic, paper, etcetera. The packaging technology is, again, this is an area in my other NPTEL classes, that is, the NPTEL lecture; I have described these methods in detail. So, here I will give a very brief overview of the modified atmosphere packaging. Basically, as you can see here, that is the environment. around the food within the packet, that is the change. It is modified by certain means, that is, normally, oxygen is reduced, or it is slowed down, and the carbon dioxide is increased. So, it results in the reduction of oxygen, which leads to a decreased oxidation rate, or both less $O_2$ and a high $CO_2$ environment. causes a lower respiration rate, etc., and that can increase the shelf life of the food material. So, fresh produce, particularly, uses the modified atmosphere method to extend the freshness of fruits and vegetables. It even helps maintain the color, texture, and safety of meat and fish. and it preserves the freshness and prevents staleness in bakery products.

Then, vacuum packaging. Again, here, vacuum, in this case, means that the air from the packaging environment is completely removed. So, it obviously reduces the oxygen and moisture, which are the major factors in microbial growth and spoilage.

Basically, the air extraction from the package removes what is it creates a vacuum, and this helps in reducing the oxidizing reactions and microbial growth. But in this case, one has to ensure that the proper seal integrity, proper sealing is essential to maintain the vacuum level and ensure the product's safety and longevity. Nowadays, you find that many ready-to-eat high-value foods, etcetera, are packed using vacuum technology, or sometimes even Nitrogen flushing is also done to remove the oxygen from within the packet. So, in the case of dry foods, it extends their shelf life—coffee, nuts, grains etcetera. Even perishable foods, since vacuum technology is used for meat, cheese, prepared meals, etcetera. So, whatever foods are likely to be spoiled by the oxidation process or by aerobic microorganisms. So, by using vacuum technology or nitrogen flushing, one can prevent this growth.

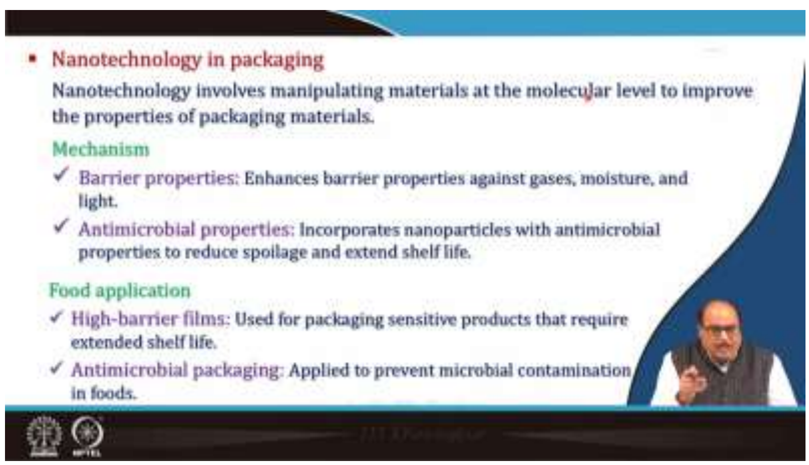



Then, active packaging, again, involves incorporating substances that interact with the food or packaging environment to extend shelf life actively. So, in the packaging material, various adsorbents or releasers, like moisture absorbers or even ethylene releasers, depend on carbon dioxide releasers, etcetera. So, oxygen absorbers various absorbents, etcetera are used, and they basically so, you can say here it is also a form of modified atmosphere storage, but in this case, modified normally, it is the natural control process. is used, but here we use some releasing agents or absorbent agents, etcetera. So, absorbent materials absorb moisture, oxygen, and ethylene gas to maintain the desired level or release substances that maintain antimicrobial agents, antioxidants, flavour enhancers, etcetera. So, oxygen scavengers in the packaging of meat can help maintain colour and prevent spoilage. In the case of fruits and vegetables, the ethylene absorber prolongs the freshness or delays the ripening, etcetera.

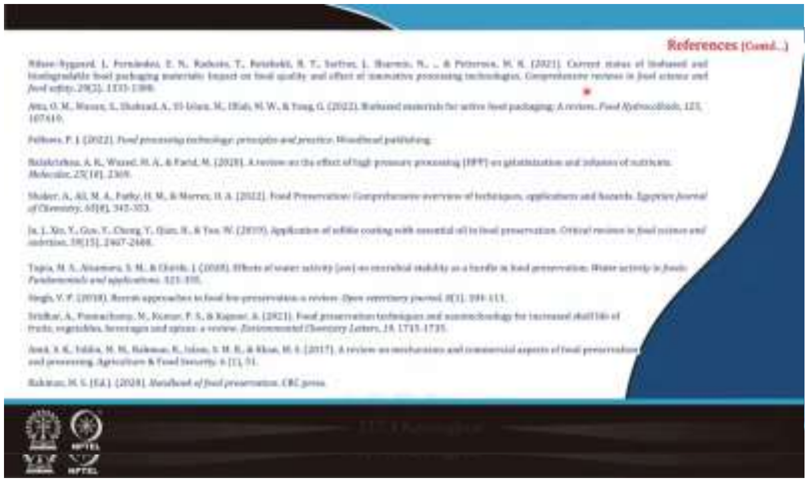

Then, intelligent packaging again, in the intelligent packaging, here the sensors, etcetera, are used, or indicators are used, which provide real-time information about the condition of the food inside the package. In the packaging, I have realized the packaging requirement, the indicators you type: temperature indicator, leakage indicator, it may be moisture indicator, it may be microorganism indicator, any type of indicator, freshness indicator, etc. So, again, in the perishable goods, as they can be used for the real-time monitoring of the freshness of dairy products, meat products, seafood, etcetera, or even these indicators even barcoding, etcetera they can be used for supply chain monitoring, which ensures proper handling and storage conditions during transportation.

Edible coating or edible packaging here at the top of the fruits or vegetables, a biodegradable material or some sort of food-grade edible material is provided as a coating.


So, again, you are basically using it as a barrier material. It prevents the entry of oxygen and carbon dioxide from outside. So, it maintains the $O_2$ and $CO_2$ levels, and sometimes even this edible material can be used for coating or as a packaging material package, etcetera. So, like biodegradable materials, these are made from natural ingredients like starch, gelatin, or seaweed. They can be integrated directly into the food product or used as a coating, and then they are direct single-serve products for items like sauces, condiments, etc., or even innovative solutions. They can also be used in high-end culinary applications for speciality foods, etc.




Also, nanotechnology in packaging now involves manipulating materials at the molecular level to improve the properties of the packaging material. It improves the barrier properties or even antimicrobial properties, etcetera. It can be used like high-barrier films for packaging sensitive products that require extended shelf life. Or even antimicrobial substances by using nanotechnology, that is, these are applied. Antimicrobial packaging is applied to prevent microbial contamination in foods.




So, now I summarize this lecture by saying that, yes, there are various methods of food preservation, that is, the treatment given to food to extend its shelf life and maintain its quality. Preservation technologies inhibit microbial growth by controlling pH, water activity, and other such factors. Even modern packaging methods can be used to extend the shelf life or to control contamination in processed or preserved food. Packaging technology uses advanced materials like barrier films and active and smart packaging to enhance food preservation.


So, these are the references used in preparing this lecture.


Thank you very much for your patience while listening. Thank you.