Thermal Operations in Food Process Engineering: Theory and Applications
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Lecture - 06
Fundamentals of Food Processing and Preservation Why and how do food spoil

Good morning. In the previous class we had done on different aspects of food and we wanted to relate it with this course through Thermal Operations. I think a little we have left over and left over in the sense, left over is not the, 'right' word should we have little more to say about the totality of that concept of the food. So, that you can afterwards correlate, because that the fundamental things if they are not clear, then in the future you may be in trouble to relate why and how things are there? 'right'.

So, that is why we are in this Thermal Operations in Food Process Engineering Theory and Applications. In this course Fundamentals of Food Processing and Preservation which we had continued. Now, I would like to also say that why and how do food spoilage, 'right', why and how food do spoil?

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So, to do that what we need to know the why the food and what is the spoilage? What do you mean by spoiling of food? The spoiling of food of-course, can be done by many ways spoilage of food can be done by many ways.

But, primarily one side is because of the microbes and that is the most dominant one and the other side is, may be some other associated with chemical processes; we had given you an example that enzymes do act on the food. For example, when you cut apple, when you cut potato things like that there are some enzymatic browning.

And which is of course, cannot be said that the food is totally spoiled, but it is also true that the changes in color and other changes which is not acceptable. So, it may not be totally spoiled in the word spoilage used, but affectively it is because you will not if you keep apple cut outside for the day. Obviously, though if assuming there is no microbial contamination, but still since the color change to black and will not like to have those.

So, that is equivalent to spoilage, 'right'. So, in the word spoilage we can say that by the action of microbes or by chemical actions, if the food materials are not acceptable for consumption. Then in whatever way, it could be that it is due to the microbes, it got transformed into some other thing which is not acceptable, it is color got changed or it texture got changed, anything any change happening with that we can say that it is spoiled.

Then how it is being spoiled? If, it is by their organisms in the previous classes we had also given you some idea about the chemical, biochemical spoilages, 'right', if you remember.

Now, if you go to those microbial spoilages, then, microbial spoilages are happening primarily due to bacteria yeast and mold that is the basic microbes. Many other microbes are also there, but these this 3 types of organisms are of our interest and for that let us also know a little about how these organisms behave or what they are, 'right'.

So, if we look at that bacteria, that is generally the Lactic Acid Bacteria or which we called LAB, which we other day we have said that is lactobacillus species, or pediococcus species or leuconostoc species etcetera or pseudomonas species and many others they come under the family of bacteria, 'right'. Fungi they are normally of two types; one is called both are under the umbrella of fungi and one is mold and the other one is yeast,'right'.

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And how the spoilage microbes enter into the food? It is entering into the food through contamination before pre harvesting or pre harvest contamination before pre harvest or at the time of harvest, contamination during processing or fungi and bacteria are everywhere. So, they can contaminate the food material.

Now, for this I let me tell you your personal and our personal experiences, that those you are now young very young. So, you do roam over or you do go to different trees and others. So, you try to get fruits like apple like pears like, papaya or like your orange guava all these fruits you go to the tree and get it, 'right'

Now, you have notice that, if you take say guava, 'right'. And by chance it is almost matured in the tree itself and it got dropped from the tree and if you do not take care, then because of this drop there are some Bruce's in the fruit. And these Bruce's do, because as I said the other day nature gives it is best protection to it is all everything, 'right', that is one side other side also I said nature is the best friend and also the best enemy. So, best friend is that it gives protection automatically. And the other side is that it also has many enemies which we can call natural enemies like these microorganisms.

So, when that Bruce's was there then these microorganisms which are all over surroundings they do invade, because for them it has because this microorganisms need very little quantity of the carbon source, hydrogen source, nitrogen source, oxygen source or all these. So, food is complete source of all these.

So, for them surviving into or multiplying into the food material is not definitely difficult thing, but what is difficult? If the food material there is no Bruce or things like cut or things like that, then it be it is not that easy for the organism to invade. To invade it has to have some places by which it can invade into the food. So, this Bruce and cuts so, they do help. And since it is micro we cannot see under normal eye or naked eye. So, we do not know how much minimum Bruce or how much minimum damage is good enough for the organisms to invade and start acting on that, 'right'.

Fungi whether it is mold or yeast and bacteria is all over the world and everywhere that you can say everywhere in the nature. So, it may be contaminated before harvesting or during harvesting or during is processing. If you have processing the food material then also I gave example of fruit yes it because you being very young. So, you have this experience of writing over the trees and getting the fruits by your own hands and we enjoy that. So, that is why I gave that example, but the all other foods are also alike.

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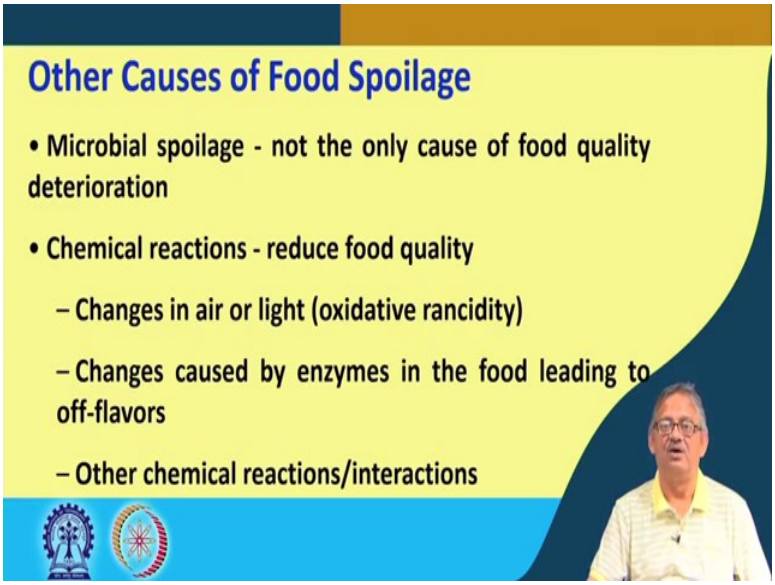

So, it can be that in vision of organisms can take place due to the Bruce and cuts, 'right'. Other causes of spoiling of the food material are ok, like microbial spoilage which we have already said a little not the only cause of the food quality deteriorations, other causes are chemical reactions which reduce the food quality, changes in air or light which could be due to oxidative rancidity, or changes caused by the enzymes in the food

leading to off flavors. And other chemical reactions or interactions all these put together can also bring the spoilage or the food not acceptable for consumption, 'right'.

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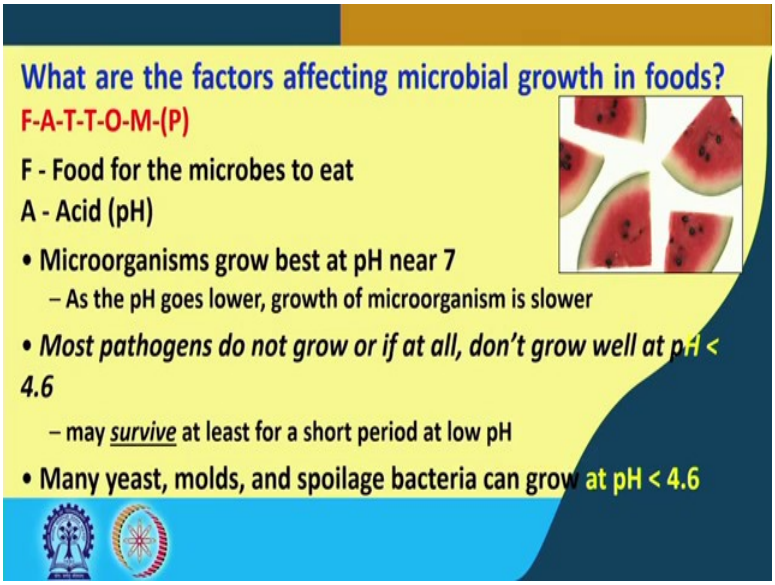

So, what is the factors which affect the microbial growth in the food material? Simply, we can say that FATTOM and then with the support of P so, FATTOM. So, let us expand them, 'right'; F for food for the microbes to eat, A for acid that is the pH. So, microorganisms grow best at pH near to 7. So, in the no acidic no alkaline, that is in the neutral zone it is very-very likely organisms grow the best, 'right'.

As the pH goes lower growth of the organism is lower, that is why I give the other day this example that drinks like cold drinks they do have the pH around 3 plus minus 3. So, at that low pH high acid organisms cannot grow, that is why you have seen that these materials like these drinks, soft drinks are open in the nature, open in the sense they are not kept inside the refrigerator or somewhere, 'right', and nothing happens to that. This is primarily due to the low pH of the solution of the drink, 'right'.

So, they have the pH is very low. So, this statement that has the pH goes down growth of the organisms is also slower down. Most pathogens do not grow or if at all do not grow well at pH less than 4.6. So, 4.6 and above the pH is good for the pathogenic organisms, that is the organisms causing the illness or the disease in the human body.

So, it may survive at least for a short period at low pH at the most. Many yeast molds and spoilage bacteria can grow at pH less than 4.6, 'right'.

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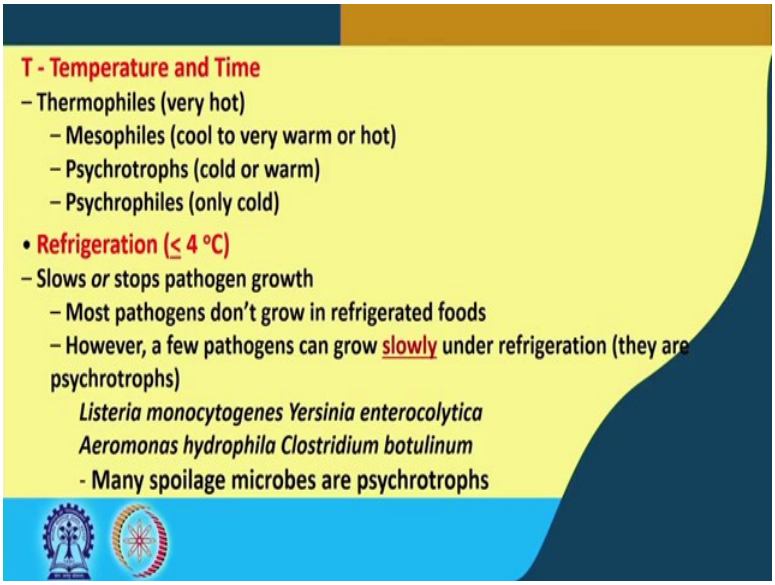

Yes, for then pH less than 4.6 many bacteria a little then yeast and mold for them it is easy to survived, for some time and that depends at the there is also said, that the nature of the organisms are different for different types even same even in the bacteria umbrella, that different types of bacteria which are psychrophilic, thermophile, mesophilic, some could be your halophile some could be other. So, many are there.

So, second one was the T that is temperature and time so, here it is thermophiles which are as we said which grows or loves high temperature. A mesophiles which are liking moderate temperature cool to very warm or hot temperature, psychrophiles which are loving cold or little cold or slightly warm like that and then psychrophiles that only grow on the in the during the cold, 'right'.

Psychrotrophs mesophiles or these things are of different types. So, that is the temperature 'right' time of course, required is different, but if you are. If you are allowing refrigeration to be provided, then it slows down or stops the growth of the pathogen and most pathogens do not grow in refrigerated foods.

So however, a few pathogens can grow slowly under refrigeration and they are normally psychrotrophs or psychrophiles, 'right'. Listeria monocytogenes and may be the other

one which is Yersinia enterocolytica or aeromonas hydrophila or clostridium botulinum these are some of the really organisms which come under this. Many spoilages microbes are also psychrotrophs or psychrophiles.

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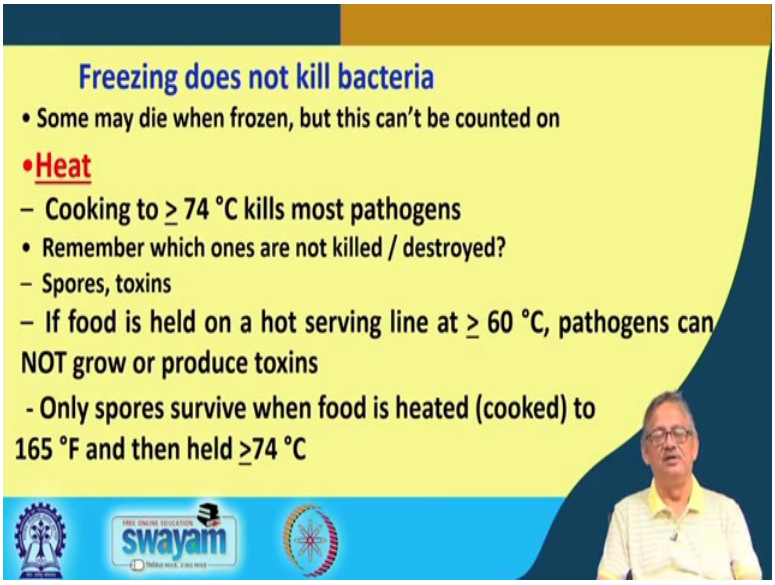

Of course, freezing does not kill bacteria, because the other day also we said that if you have to kill then you have to add the heat, you have the if you subtract heat or if you reduce the heat or if you extract the heat, then that will not kill the organisms. For killing it is the best thing is to use the heat source, 'right'.

Some may die when frozen, but this cannot be counted on out of several lakhs may be few if we dies during freezing for some more other reason. So, that cannot be counted that freezing as kill the organisms. This comes under the before freezing if you take the microbial count and after freezing if you take the microbial count, there could be a difference in microbial count and that does not mean that freezing kills, it may be because of some other reason beyond your control.

Next is the heat. So, if you are heating like when you are coolly cooking to greater than or equal to 74 degree centigrade, that kills most of the pathogens. You remember we are said for pasteurization the temperature is one was 63 another was 72 and the time was half an hour and 15 seconds. So, it is a whenever you are heating it is not the single parameter temperature; it is time temperature combination.

Yes, but as far as temperature is concerns 74 and above is good enough to kill all the pathogenic organisms ‘right’. Remember which ones are not killed destroyed normally spores or toxins; they are normally very difficult to destroy or kill. A food is held on a hot serving line at 60 degree centigrade pathogens cannot grow or produce toxins ‘right’. So, if food is held on a hot serving line at greater than equal to 60 degree centigrade, pathogens cannot grow or produce toxins at that high temperature 60 degree and above, that is why you might have seen in many restaurants or in many servings during different functions, when things are being served for food. So, they have some heating element down below.

So, that the temperature is at a little bit high. It is not only that helps you to get the appropriate test, but also it prevents the pathogens to grow up, ‘right’. Only spores survive when food is heated or cooked to around 165 Fahrenheit and then held at greater than equal to 74 degree centigrade, 165 Fahrenheit you convert it into centigrade, you will see that it is coming around 75, 76 I mean in the range of 70’s, ‘right’.

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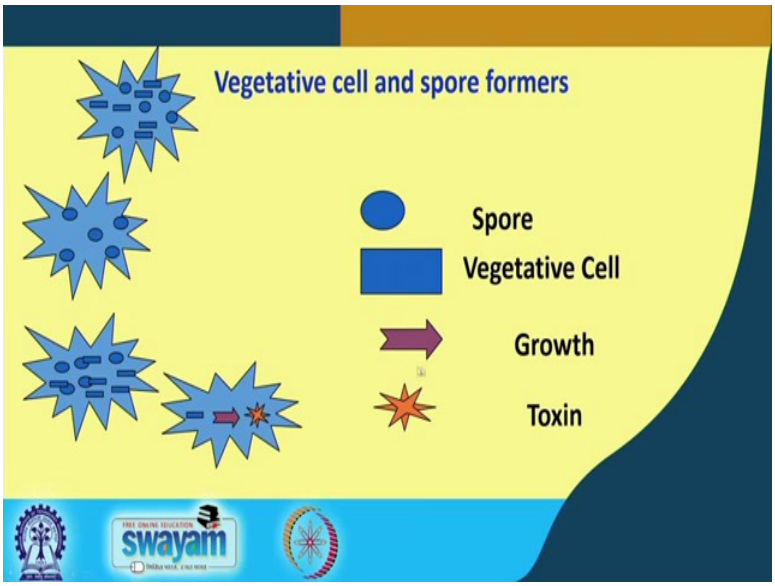

Then there are vegetative and spore formers, ‘right’ from this figure you see that the circle is like ok. Like this one this is the spore this is the vegetative cells and this is the growth and these are toxin which are produced, ‘right’. So, you see these contain some spore and some vegetative cells, these also do content spores, these do content vegetative and spore formers and then they are growing and then producing the toxin.

So, these way that cycle goes up, ‘right’.

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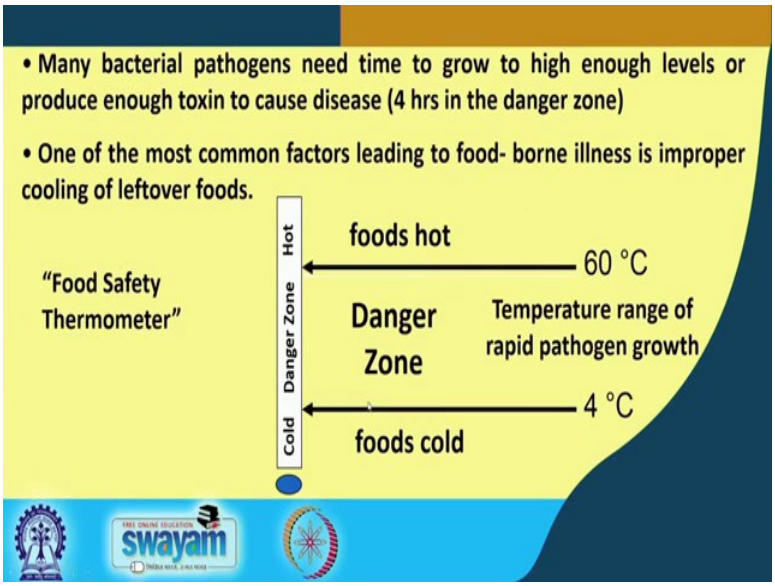

Many bacterial pathogens need time to grow to high enough levels or produce enough toxin to cause diseases, ‘right’. Generally, 4 hours in the danger zone. And that is why you will hear that many of the doctors or whenever somebody sick they do say that after preparing try to consume it within 2 hour. So, this is one of the reason that up to 4 hour maximum it can survived without any further infection or further deterioration or maybe that organisms penetration, ‘right’.

So, one of the most common factors leading to food borne illness is due to improper cooling of improper cooling of leftover foods ‘right’. So, food safety, if we look at the thermometer then you see that foods hot when it is hot around 60 degree centigrade and above is good the danger zone is the temperature range of rapid pathogen growth between 4 to 60 degree centigrade. So, neither very low nor very high is the waste zone for the organisms to grow in particular pathogens, ‘right’ that is the danger zone.

And obviously, cold where food is preserved it is best at or below 4 degree centigrade, generally below 4 degree centigrade.

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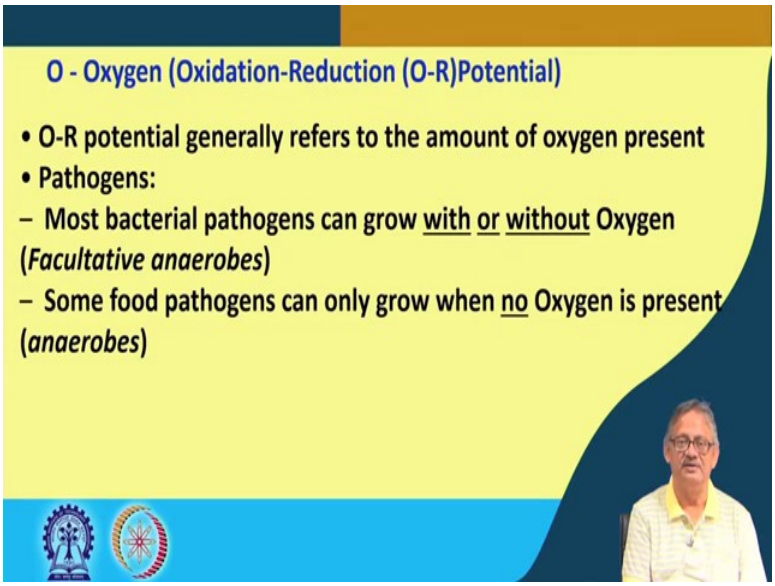

And by the way that you should also know that in your house hold refrigerator, there is a freezer cabinet on the top. And this freezer cabinet temperature is somewhere around minus 10 degree depending on the manufacturer depending on preserving temperature, but by and large it is around minus 10 degree. And down below that there are many stacks and down below absolutely bottom there is a holder for fruits vegetables keeping, that up to that there is a temperature gradient. So, top was minus 10 and down below it is gradually growing up.

To the tune of max the better the temperature better is the freezing or better is the keeping quality, but it is not below 4 degree centigrade up to plus 4 degree centigrade, that you hold refrigerator may have, but yes the higher the height lower I mean closer to the cabinet freezer cabinet, lower is the temperature. And if the distance goes up the higher is the temperature, 'right'.

So, next one which we have seen the letters O oxygen and this oxygen corresponds to oxidation reduction, 'right' O R potential, 'right' O R potential. Generally refers to the amount of oxygen present and this directly or indirectly helps n pathogens also. Most bacterial pathogens can grow with or without oxygen. So, if it is with or without they are called facultative anaerobes, 'right'.

So, it may grow this side with oxygen, it may grow that side without oxygen. So, they are called facultative anaerobes some food pathogens can only grow when no oxygen is present which are called anaerobic pathogens, 'right'.

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Spoilage microorganisms are obligate aerobes pseudomonas species, molds, how do you think food process or food processors used the information about obligate aerobe spoilage microbes? So, there microaerophiles are also there who have in which lactic acid bacteria falls or anaerobes where desulfoto maculum species and this is also a which is responsible for spoilage of the cane and many others.

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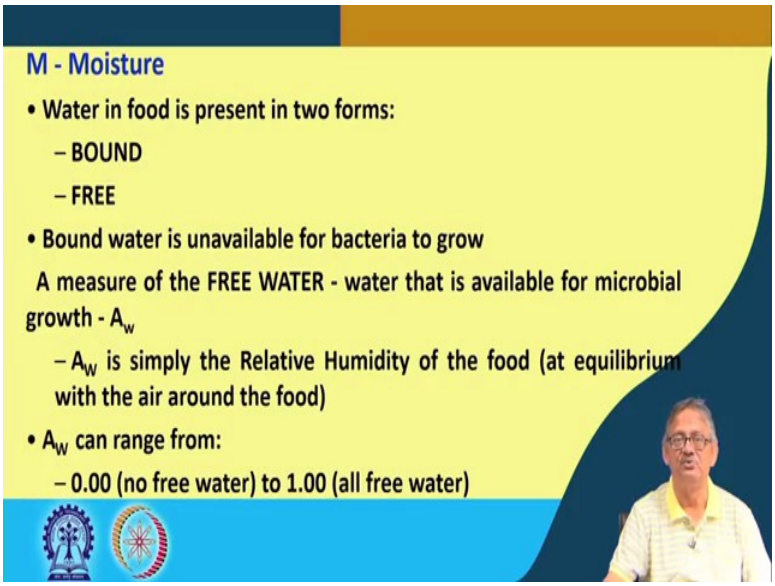

M stands for moisture where in foods present in two forms bound form or free form which I said the other day. And it corresponds to a measure of the free water, what are that is available for the microbial growth that is water activity A_w. A_w is simply the relative humidity of the food at equilibrium with the air around the food. So, A_w can range from 0 no free water to one all free water, 'right'.

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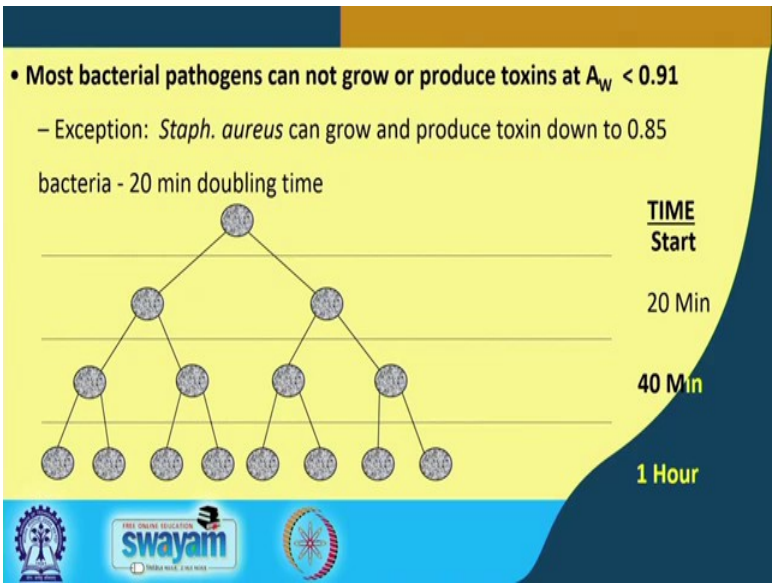

Then, most bacterial pathogens cannot grow or produce toxins at A_w or water activity level less than 0.91 exceptions are staphylococcus aureus can grow and produce toxin

down to 0.85 water activity level. Bacteria normally multiplied in this way that able 20 minutes is doubling, ‘right’. So, from 1 to 20 minute it becomes 2, then another 20 minutes it becomes from this 1 to 2 from this 1 to another 2, then another 20 minutes this 1 to another 2 this 1 to another 2.

So, when the time starts in 20 minutes you have double in 40 minutes you have quadruple and in another 20 minutes or whatever you have 6 8 2 4 and 8, 8 numbers like that ‘right’. So, this way we can say the organisms are growing and you can also think that organisms the growth is to the tuned 20 minutes per one organism to become double. This is typically bacterial it is not true for yeast or mold. So, this is just an example for organisms like bacteria how they are growing? ‘right’.

So, with this let us conclude about the preamble part and yes we have given some idea about how foods are spoiled, what are the factors, what how it is related to the heat operations or thermal operations? So, now in the next class we will go to the real part of the heat transfer ok.

Thank you.