Fundamentals of Food Process Engineering
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Lecture - 57
Non Thermal Processing (Contd.)

Hello everyone, welcome to the NPTEL online certification course on Fundamentals of Food Processed Engineering. We are continuing today with the topic of non thermal processing. In a last class we have discussed about the high pressure processing technique that is a very upcoming and novel technology for non thermal preservation of food and today will going to the next one.

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So, high pressure processing we have covered we discussed today pulse electric field technology. Then eventually pulse light irradiation, ozone, and cold plasma we will discuss. And at the last we will discuss about the hurdle technology which is a combination of all this technique.

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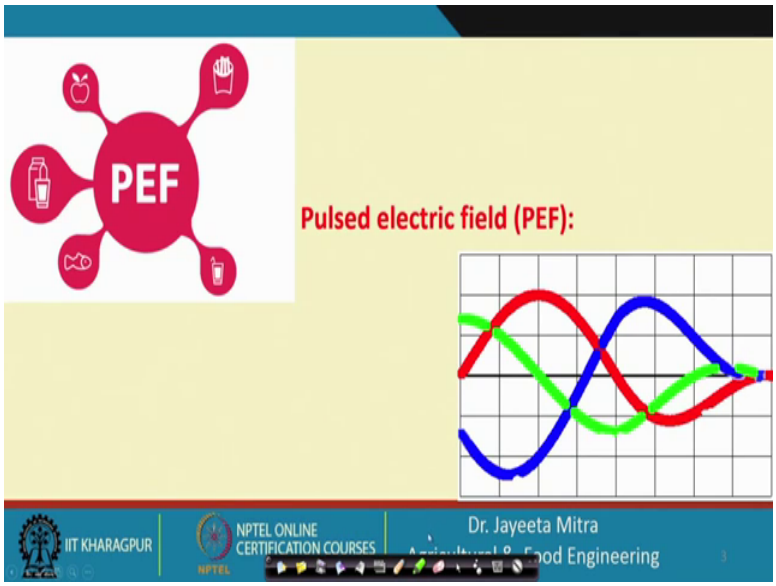

So, first is the Pulse electric field. How the pulse electric field will inactivate the microorganism that is the main purpose of this discussion.

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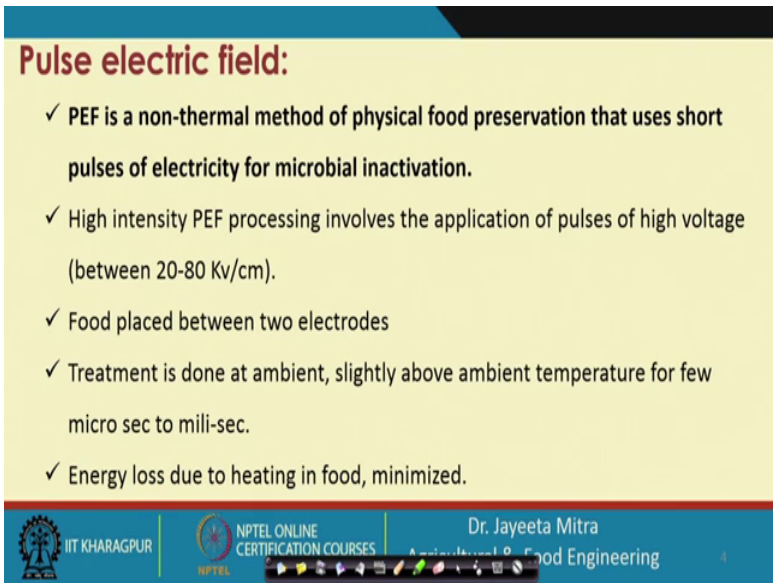

So, pulse electric filed is a non thermal method of physical food preservation that uses short pulses of electricity for microbial inactivation ok. So, this is the non thermal method and a physical method for preservation of the food by the pulses of electricity for microbial inactivation. So, very short pulse is transferred across the food so, that it will act on the microbes and they will have a detrimental effect on that.

High intensity of pulse electric field processing involves the application of pulses of high voltage between 20 to 80 kilovolt per cemi and food placed between the two electrodes. Treatment is done at the ambient slightly above ambient temperature for few micro second to millisecond. So that means, we take two electrode across which we want to create a very high you know voltage I mean electric field. And then we connect them with the non conductive material we keep the food between the two electrodes and then we send a pulse of high voltage between this 20 to 80 kilo volt. And this can be done in ambient or slightly above ambient temperature. And the time required is also very short micro second to millisecond.

So, energy loss due to heating in food is minimized. So, that is one advantage as most of the non thermal method has this that the energy loss because of the heating is minimized and also the effect on the food because of that heat treatment that is the nutritional loss flavor loss color loss. So, all these appearance and sensory and nutritional losses is minimized because of this technique.

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So, application of Pulse electric filed processing generally have been seen on the mostly the liquid product. For example, the fruit juices, apple sauce, milk then liquid egg products, yogurt, yogurt drink then tomato juice liquid whole egg. So, basically the pulse electric field has been applied on this kind of liquid products mostly.

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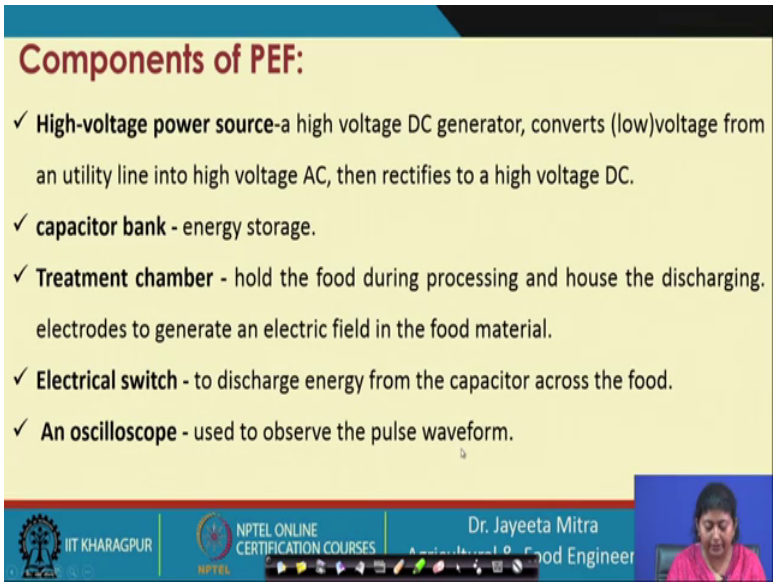

It consist of high voltage power source which is the DC generator or and convertor which is the low which convert the voltage convert the low voltage from an utility line into a high voltage AC line ok, then rectifies to a high voltage DC.

There is a capacitor bank that stores the energy. And there is a treatment chamber, which hold the food during the processing and house the discharging electrodes to generate an electric field in the food material ok.

So, the treatment chamber has two thing, they have the food during the processing and also house the discharging electrodes that generates the electric field in the food material. Then there is a switch so, that to discharge the energy from the capacitor that we have already stored the energy to the chamber so, that it can go across the food. There is an oscilloscope that is used to observe the pulse waveform that is in what form the pulse is heating the food and so, that that can help to access the detrimental effect in the microorganism.

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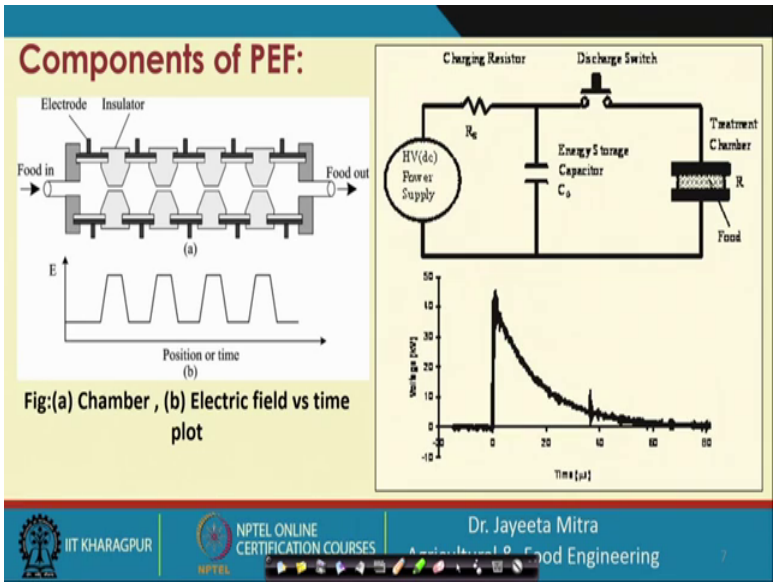

So, this is the component of pulse electric field where food enters from this section. As we can see. And there are electrode as you have seen that the chamber has house the electrodes and the food is entered through this and across this we send the pulse of the high voltage electric field ok. There are insulators also so, that it will not be you know conducted through this materials. So, therefore, the non conductive materials are added so, that the pulse will only go through the food material and have the effect on the desired effect on the microorganism. And eventually this is released from the other end.

So, what happen that, each time the food is exposed to this electrode the pulse is generated and the pulse is going to the food material. So, this oscillator that we have we have their in the system that will maintain the, what that will observe that what kind of curve is generated what kind of pulse is generated. So, the figure is which is showing the chamber and figure b which shows the electric field versus time plot. And this is the system where we have a high voltage D C power supply ok. There is a charging resistor here we have a capacitor that stores the energy and there is a switch. So, it after storing when we join the switch when we hit the switch, it will send the electric field pulse electric field a small time duration of the field which is of very high voltage to the or across the food.

So, one pulse is generally it is given and then it generally decays with time. So, this is how the plot will look like.

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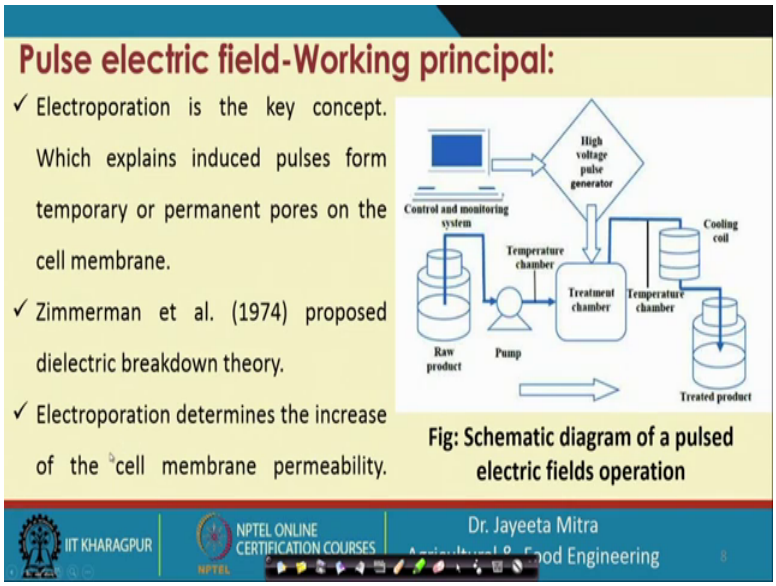

So, basically if we see the schematic diagram of a pulse electric field operation. We have a raw product tank generally because we have observed this technology, Pulse electric field on the liquid food products mostly. So, we are showing a case of that where the raw liquid product is there in a tank and through a pump it is you know going to the treatment chamber ok. And there is a temperature chamber as well before going to the treatment chamber because if we need to increase the temperature a bit for the proper functioning of this method we can do that before entering into the chamber. And the high voltage pulse generator is attached to the chamber through the electrodes we send that high voltage pulse of short duration ok.

And then the temperature chamber is there againso, that if we want to have change of temperature there then there is a cooling coil which can reduce the temperature and we have a treated product holding section or collection section the other end.

So, the main function by which this PEF treatment works on the microorganism that is called the electroporation ok. So, this explains induced pulses from temporary or permanent pores on the cell membrane. So, because of this electroporation actually this electroporation only determines the increase of the cell membrane permeability ok. So, this determine the increase of the cell membrane permeability. And if the permeability increases then the disruption of the cell and the inter cellness material will come out from those pores and the cell destruction analysis will be there. So, Zimmerman proposed this

dielectric breakdown theory. So, when we send the high voltage pulse across the food for a short duration period, it will make the pores in the cell membrane and because of that this destruction of the cell will be occurring.

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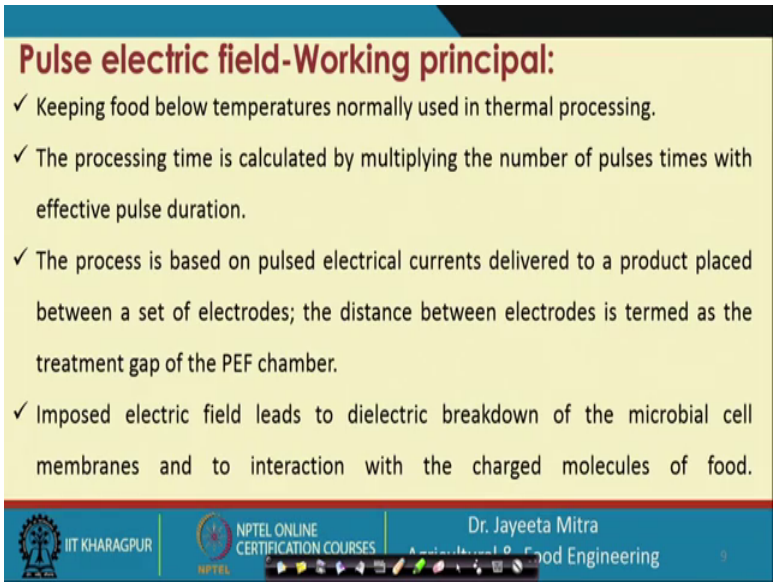

So, the main thing is keeping the food below the temperature normally used in thermal processing. So, that is one advantage. Then the processing time is calculated by multiplying the number of pulses suppose we are sending many. So, all pulses have some short duration of time.

So, number of pulses times with the effective pulse duration. So, therefore, we can calculate the total process time. Now the process is based on pulse electrical currents delivered to a product placed between a set of electrodes and the distance between the electrode is termed as the treatment gap of the PEF chamber. So, we have seen that there are many electrodes in the chamber and the two electrodes are kept at the certain distance and that is constant for all the electrodes right so, that gap is called the treatment gap.

Now imposed electric field leads to dielectric breakdown of the microbial cell membrane and to the interaction with the charged molecules of the charged molecule of the food.

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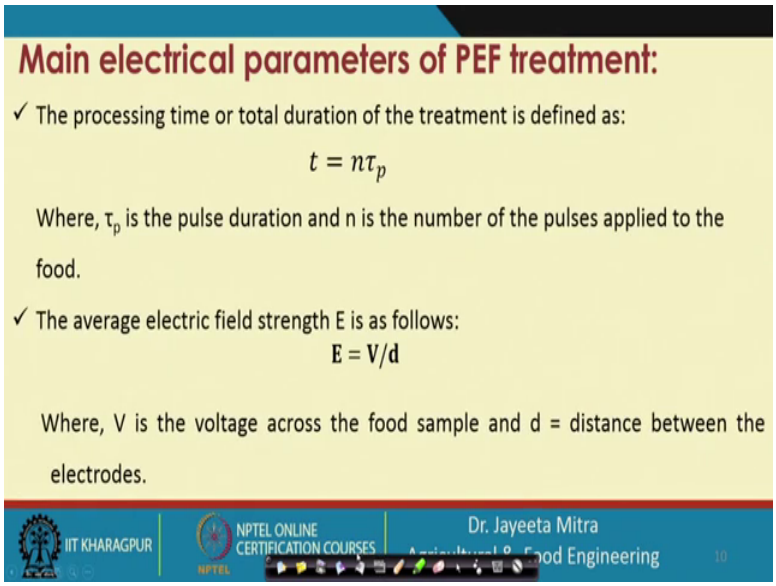

So, the processing time or the total duration of the treatment is defined as t equal to n into tau p. Where tau p is the pulse duration and n is the number of the pulse applied to the food.

So, t is the total time. Then we have the average electric field strength E is as followed that is e equal to V by d. So, V is the voltage across the food that we have send and d is the gap which is the distance between the two electrodes.

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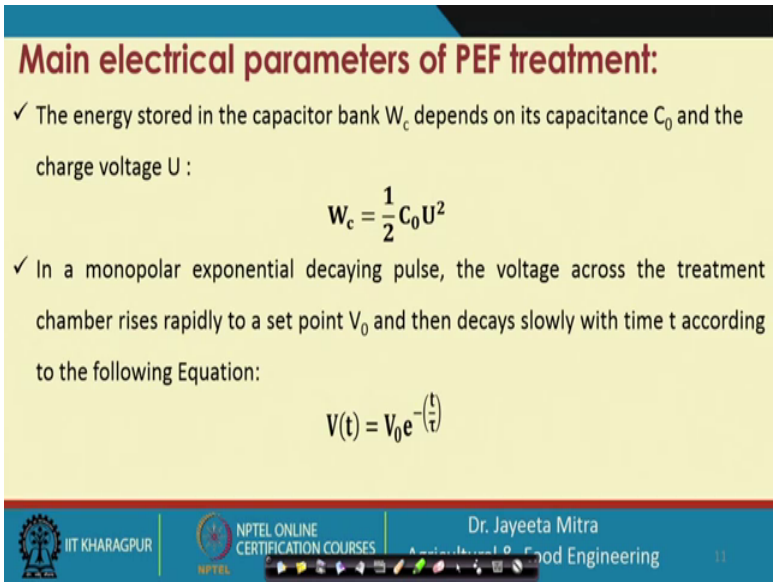

The energy stored in the capacitor bank W c depends on the capacitance C 0 and the charge voltage U ok.

So, the energy stored in the capacitor because when we have generated that energy that has been stored in the capacitor. And when we out on the switch then only it is going to the electrode and across the food it is applied ok.

So, this stored energy that is equal to half of the capacitance C 0 and the charge voltage that we are providing so, half C 0 into U square. In a monopolar exponential decaying pulse, the voltage across the treatment chamber raises rapidly to a set point V 0 and then decays slowly with time t according to the following equation. So, we have seen that those are the exponential decaying curve.

So, V t that is equal to V 0 that is the initial pulse that is the rapid raise of the pulse into e to the power minus t by tau.

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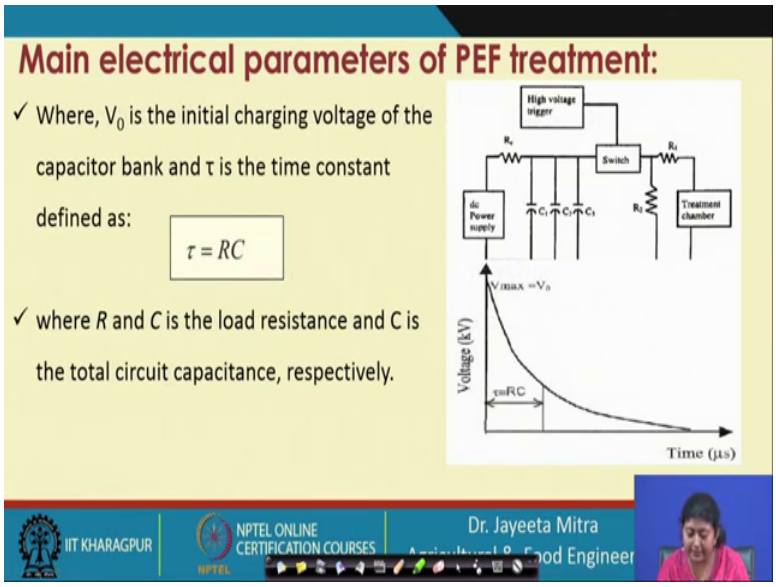

So, this is the D C supply. And this is the resistor there is a capacitance where we have strode this energy. And then there is a switch when it occurs when we put on the switch then it is going to the treatment chamber the high voltage is passing through the food ok.

So, and this is the V 0 where initial high pulse and then it decays exponentially. So, where V 0 is the initial charging voltage of the capacitor bank; V 0 is the initial charging voltage of the capacitor bank and tau is the time constant defined as tau equal to R into

C. So, R and C is the load resistance and C is the total circuit capacitance respectively. So, R is the total resistance and C is the total capacitance circuit capacitance. So, tau is equal to R into C.

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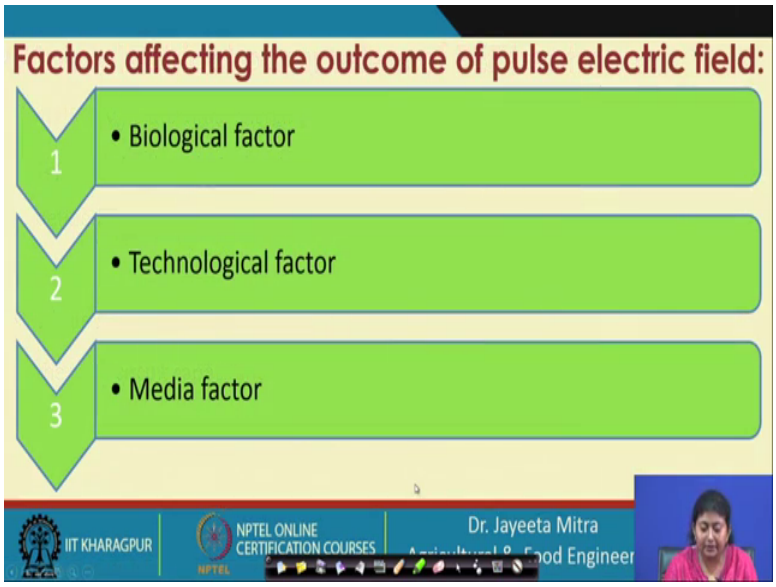

So, factor affecting the outcome of the pulse electric field that basically depends on the biological factor, technological factor and media factor. So, in the biological factor in the sense what kind of microorganism we are using because not all microorganism going to affect in the same way. For example, as in the previous class we have discussed the high pressure processing. So, in the high pressure processing we have seen that gram positive bacteria are easily inactivated than the gram negative bacteria ok.

Similarly, we have seen that the spore formation enzymes they took more you know intense pressure. Similarly here also for the pulse electric field treatment we have seen that the gram positive has higher resistance over the gram negative one. And also the it has effect on the virus mole fungus etcetera. So, it has an effect on all, but at what rate the effect will be at what intensity will be applicable. So, that depends on species to species or what kind of microbe we are using because for everyone their growth rate and these parameters may change and inactivation rate and growth rate these are these may change. So, it depends on specifically what kind of microorganism we are using.

Then technological factor. This is related to the material the technical parameter that we include in our treatment. For example, the intensity of the voltage pulse that we are

sending, the time for which we are we are sending what is the gap between these two you know the two electrodes that we are giving how much pulses in our in each process we are giving to the material giving to the food.

So, all these are you know your technological parameters and lastly the media factor. So, media factor is that means, we are dealing with many kind of food. Normally by pulse electric field as we are treating the liquid food so, that may be acidic food that may be the water that may be different the property of that food may also vary ok.

So, on that what kind of affect it will be, that depends on you know case to case it may vary. So, therefore, these three are the controlling factors. So, that we cannot say that if suppose pulse of a certain intensity ok. Let us say pulse of a 40 kilo volt per cm will be affected on milk sample that may not be affected in the same rate on a fruit juice sample right. So, the media factor is also very important. So, biological technological and media factor we have to look for experimentally when we want to implement any pulse electric field plant or treatment in either in lab scale or for industry purpose.

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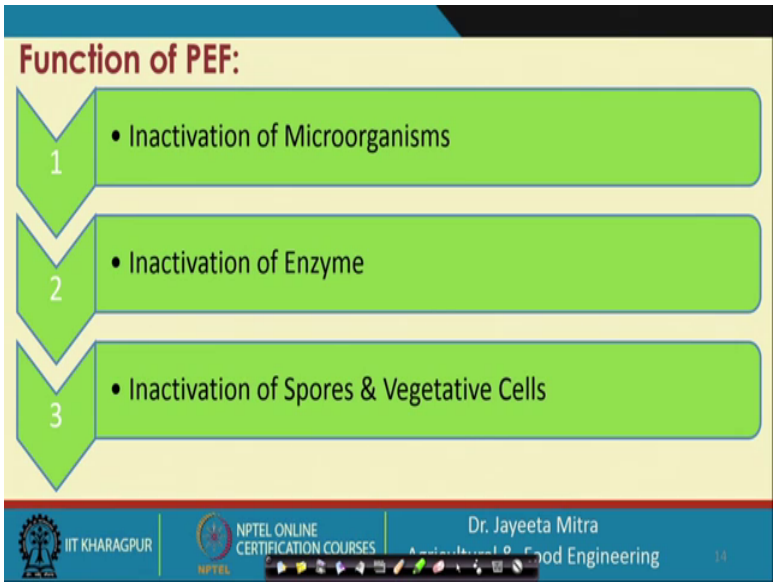

And function of pulse electric field. So, the function is inactivation of microorganism then inactivation of enzymes and inactivation of sports and vegetative cell.

So, it works on all of them it inactivate the microorganism as well as enzymes and also the spores and vegetative cell now we will see that how this effect will occur.

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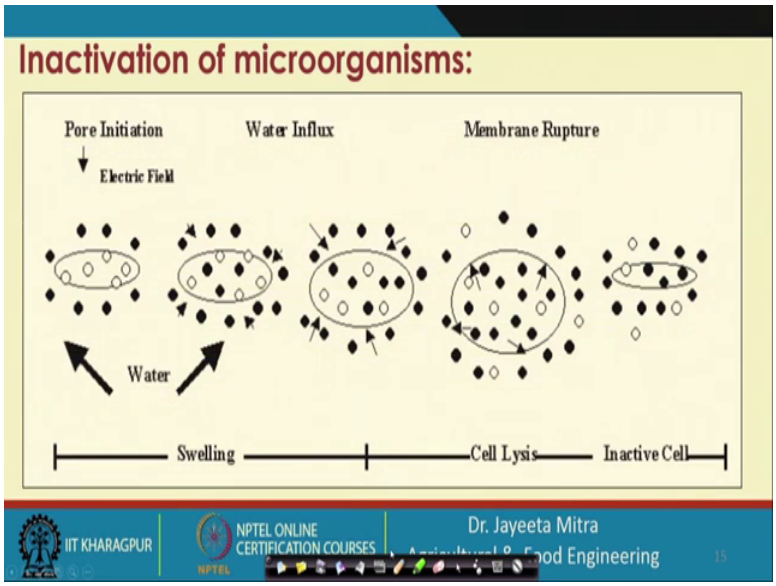

Firstly what happen that when the electroporation mechanism will work that means, the spore formation in the cell membrane of the microbes will be there in their cells. So, the pore initiation will be there in the electric field because of that high voltage electric pulse. And the water influx to the material to the cell will be there ok. So, when this pore has been formed pore initiation has been formed the next step is the swelling will start occurring from the onset of the electroporation.

So, the water influx will be there to the cell of the microbe and the cell Lysis will start. So, the swelling will be there after that cell Lysis will be there. So, then the intracellular material will also come out from the cell ok. So, when this will happen. So, inactivation of the cell will be there. And most of the cases this inactivation is permanent, because we have seen in some cases of the ground negative bacteria that they can generate their cell membrane after this if it has been a very little damage, they can you know the they can regain that ok.

But in this particular case the inactivation mechanism of the microorganism by electroporation takes place in this method. So, first swelling then cell Lysis then inactivation of the cell.

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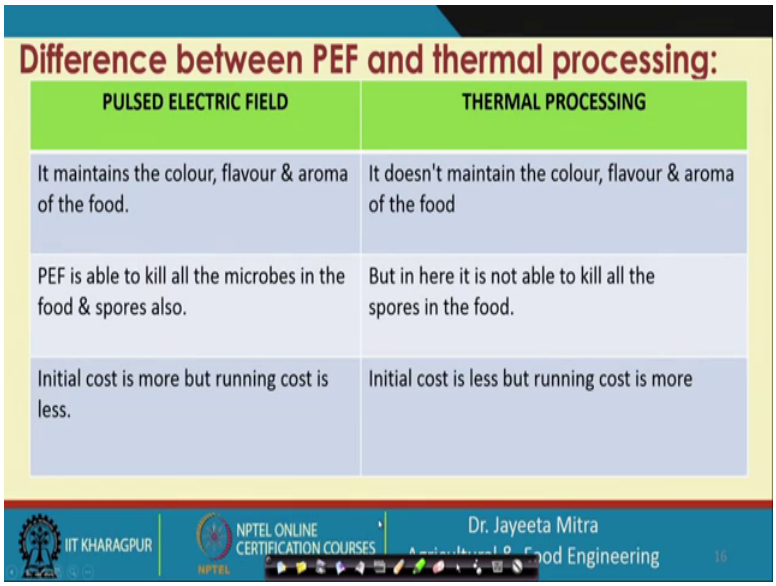

So, difference between the pulse electric field and the thermal. So, first is the color flavor aroma. All this will be intact compared to the thermal effect. PEF is able to kill all the microbes in the food and spores also. So, that way it is very much effective because this spores destroy or the destruction of the spores is very tough in the thermal process. So, they mostly remain in the food, but pulse electric field they can also be destroyed.

In the initial cost is more, but running cost is less in case of pulse electric field. And thermal processing initial cost is less, but running cost is more. So, that is the end of the pulse electric field processing technology. So,.

Thank you.