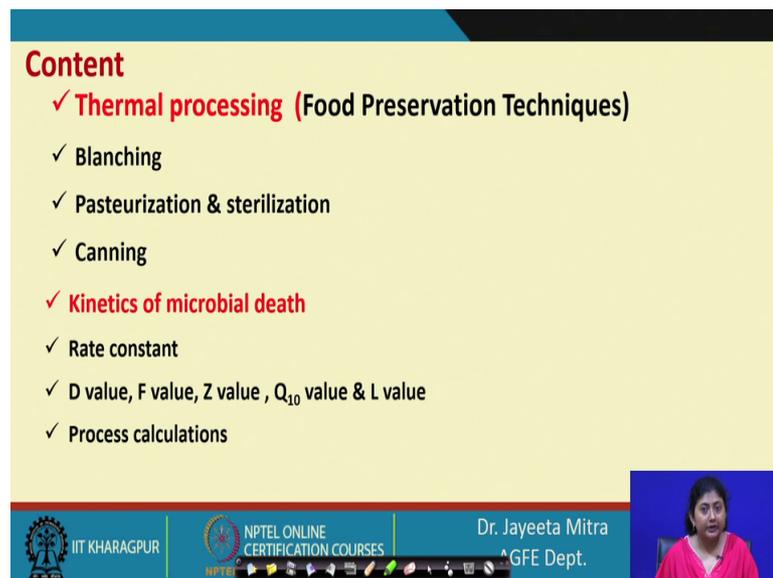


Fundamentals of Food Process Engineering
Prof. Jayeeta Mitra
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur

Lecture – 13
Thermal Processing and Kinetics of Microbial Death (Contd.)

Hello everyone. Welcome to NPTEL online certification course on Fundamentals of Food Process Engineering. Today, we will discuss the Thermal Processing and Kinetics of Microbial Death. In the previous class, we have discuss that how the processing and the heat transfer can be done, when we use thermal processing treatment for food preservation. And we have seen that how unsteady state kinetics can be used to determine the time which is required for heating the food materials during thermal processing. So, today, we will see what are the various thermal processing's available.

(Refer Slide Time: 01:16)



Content

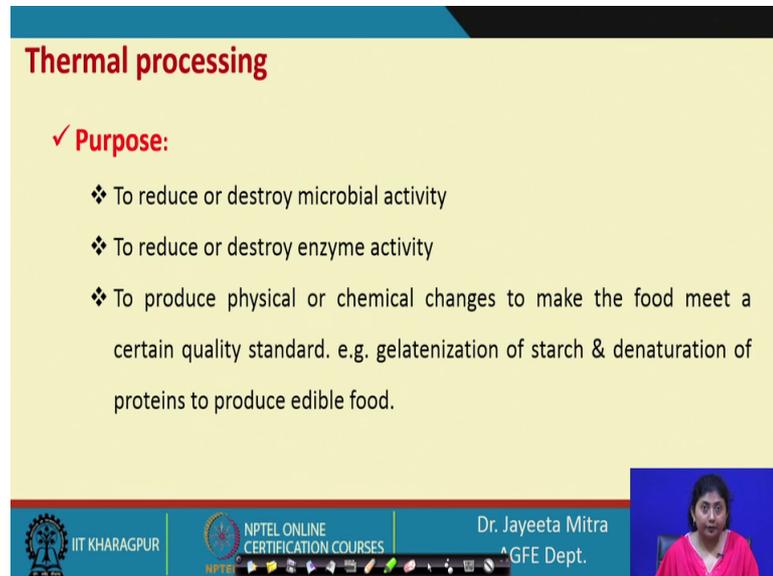
- ✓ **Thermal processing (Food Preservation Techniques)**
 - ✓ Blanching
 - ✓ Pasteurization & sterilization
 - ✓ Canning
- ✓ **Kinetics of microbial death**
 - ✓ Rate constant
 - ✓ D value, F value, Z value, Q_{10} value & L value
 - ✓ Process calculations

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Jayeeta Mitra
GFE Dept.

So, in the thermal processing, because we know that all the thermal treatment that we will going to learn in this chapter will be used for preservation purpose. So, it includes blanching, pasteurization and sterilization and canning. After that, we will discuss the kinetics of microbial death. In that, what is the rate constant and how the change of microbial count varies with time during thermal treatment that will be discuss in detail. We will also discuss the D value, that is the decimal reduction time; F value, that is the total process time; Z value, that is the temperature dependence of microbial destruction

rate; Q_{10} value and also the L value, that is the lethality. And finally, we will do the process calculation by different method and also will solve certain numerical problems.

(Refer Slide Time: 02:40)



Thermal processing

✓ **Purpose:**

- ❖ To reduce or destroy microbial activity
- ❖ To reduce or destroy enzyme activity
- ❖ To produce physical or chemical changes to make the food meet a certain quality standard. e.g. gelatinization of starch & denaturation of proteins to produce edible food.

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Jayeeta Mitra | AGFE Dept.

So, the first thermal processing, we will discuss is blanching. Then, we will move on to pasteurization and then sterilization. But before going to the detail discussion of all such methods first we will see what are the importance of these thermal treatment in the preservation of food. So, the purpose of this thermal processing is, first to reduce or destroy microbial activity. So, that is the prime importance of thermal processing given to food for preservation. Next is, to reduce or destroy enzyme activity.

Apart from this, we may also give thermal processing sometime to produce physical or chemical changes to make the food meet a certain quality standard; for example, gelatinization of starch and denaturation of protein to produce edible food. Gelatinization of starch, this happen during the hydro thermal treatment that we gives to paddy that is calling parboiling and it also change the appearance of the kernel, the rice kernel and it is a desirable change. And similarly, denaturation of protein is also a desirable change that is being done by thermal processing.

(Refer Slide Time: 04:27)

Thermal processing methods

- ✓ **Blanching:**
- ✓ It is a unit operation carried out at up to 100°C using hot water/steam at or near atmospheric pressure.
- ✓ Used as pre treatment prior to freezing, canning & drying
- ✓ **Primary purpose:** To destroy **enzyme activity** in fruit and vegetables.



IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Jayeeta Mitra
GFE Dept.

So, first thermal treatment that will discuss is blanching. Blanching is a unit operation carried out at up to 100 degree Celsius using hot water or steam at or near atmospheric pressure. So, normally, we perform it at atmospheric pressure and blanching is a very common phenomena that we normally do in house hold practice also for reducing the surface microbial contamination from the product and also mainly to reduce the enzyme activity.

But, blanching alone cannot be treated as a thermal processing that can, that can prevent the food from long term microbial contamination. It mostly used as a pre treatment prior to freezing canning and drying. The primary purpose of blanching is to destroy the enzyme activity in fruits and vegetable because this enzyme cause certain undesirable changes during storage or during exposure to temperature sometime and this cause browning and off level development to the fruits and vegetable. So, therefore, this enzyme such as polyphenol oxidase, etcetera should be inactivated prior to storing or freezing, canning, drying, etcetera.

(Refer Slide Time: 06:15)

Thermal processing methods

- ✓ **Blanching:**
- ✓ **Primary purpose:** To destroy **enzyme activity** in fruit and vegetables.
- ✓ **Other functions:**
 - ✓ Reducing surface microbial contamination
 - ✓ preserving colour, flavour, and nutritional value
 - ✓ Softening vegetable tissues to facilitate filling into containers
 - ✓ Removing air from intercellular spaces prior to canning



IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Jayeeta Mitra | GFE Dept.

So, apart from the main purpose that is destruction of enzyme activity, there are other function of blanching. These are reducing the surface microbial contamination. It also preserve the colour, flavour and nutritional value. And it imparts of softening of vegetable tissue and that facilitate the filling into container because most of the time, after this thermal pre-treatment that is blanching, we use this vegetable for storing in a container for drying or for freezing. So, softening of the tissue helps in filling those containers. Removing air from intercellular space prior to canning is another important aspect of blanching.

Because this is very important aspects; we need to remove the air from the intercellular spaces otherwise during canning. Because of the excess pressure generation, the cans may be damage ok. So, that is why these are the important function of blanching.

(Refer Slide Time: 07:38)

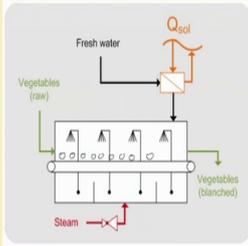
Blanching

✓ **Hot water blanching:**

- ✓ The food enters a slowly rotating drum, partially submerged in the hot water (70 to 100°C).
- ✓ Water blanching requires longer processing times,
- ✓ results in increased leaching of minerals

$Q_H = M_p(C_p\Delta T) + Q_L$ $M_s = \frac{Q_H}{\lambda}$ $\lambda =$ latent heat of vaporization of steam. ideal blancher, $Q_L = 0$;
steam requirements would be 134 kg/ ton vegetables.

✓ C_p 4.18 kJ/(kg.K) and $\lambda = 2330$ kJ/kg,



IIT KHARAGPUR NPTEL ONLINE CERTIFICATION COURSES Dr. Jayeeta Mitra AGFF Dent

Now, there are many method by which we can do the blanching treatment. One such method is hot water blanching which is very common. In this, the food enters a slowly rotating drum which is partially submerged in the hot water. The temperature of which is maintained at 70 to 100 degree Celsius.

Water blanching requires longer processing time and also the adverse effect of it is it results in increase leaching of minerals because vitamins and minerals which are water soluble, that may drain out or leach out with the water during the hot water blanching. We can see here the system which is used for continuous kind of hot water blanching. There is a conveyor belt is there on which the raw vegetables are put ok. So, raw vegetables are coming over this conveyor belt and water will be sprayed from the top and is being heated to desired temperature that is 70 to 100 degree Celsius by steam.

At the end of the blanching treatment, it is being taken out and all the nutritional losses that may happen because of this will because of the leaching of water soluble nutrient during this treatment. If you want to measure the requirement of the steam for this processing, so, there is a relation that is the total heat required for this processing is mass of water to be heated into specific heat of water into delta T, that is the temperature that we need to increase from the inlet water temperature plus Q_L , that is the loss of heat. And if the loss of heat is 0, Q_L equal to 0. So, the whole heat requirement that is will be

Q H and then, we can calculate the mass of steam M S by dividing Q H by lambda. Lambda is the latent heat of vaporization of steam.

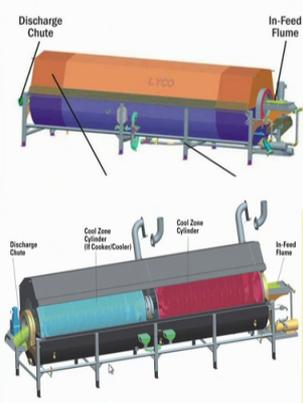
So, steam requirement would be 134 kg per ton of vegetables for hot water blanching if we consider Q L, that is the heat loss is 0. We have considered here lambda at 2330 kilo Joule per kg and C P that is specific heat of water as 4.18 kilo joule per kg Kelvin. So, by this, we can calculate the amount of heat energy needed and thereby amount of steam needed for this processing ok.

(Refer Slide Time: 11:07)

Blanching

- ✓ **Steam blanching:**
- ✓ Product carried on a mesh belt/rotating cylinder through a steam atmosphere, **residence time** is controlled by speed of the conveyor or rotation.
- ✓ Energy-efficient process, less water requirement, less nutrient leaching

Cooling -Spray cooling of water flushing is done



IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Jayeeta Mitra | AGFE Dept.

Then, will move on to steam blanching. So, in steam blanching, product carried on a mesh belt or rotating cylinder through a steam atmosphere. Residence time is controlled by speed of the conveyor or speed of rotation if we use the rotating cylinder or drum. And it is an energy efficient process because less water requirement is there.

And since it is a steam, so, leach out effect of the nutrients will be reduced to a maximum possible extent. And here, a system is there in which we keep the product on a perforated tray and then we send the saturated steam to do the blanching treatment. And after the certain time, after the required time of exposure to steam we take out the material from the discharge chute. After the treatment, we need to cool the vegetables by spraying cool water and the water flushing is also done in certain cases.

(Refer Slide Time: 12:33)

Blanching

Individual quick blanching (IQB): A single layer of product is conveyed through the steam chamber and each “individual” piece of product immediately enters in contact with the steam.



Individual quick blanching set up

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Jayeeta Mitra | GFE Dept.



The next method for blanching is individual quick blanching that is IQB. In that, what we do a single layer of product is conveyed through the steam chamber and each individual piece of the product immediately enters in contact with the steam. So, here, all the material that we enter, so, they will individually come in contact with the steam. So, better heat transfer and faster heat transfer will be there and also the effect of the leaching is minimal here.

(Refer Slide Time: 13:15)

Blanching

- ✓ **Microwave blanching:**
- ✓ Used alone or in combination with water blanching to further reduce heating time.
- ✓ Both batch and continuous systems are available.
- ✓ Improve product quality and minimise waste water production.



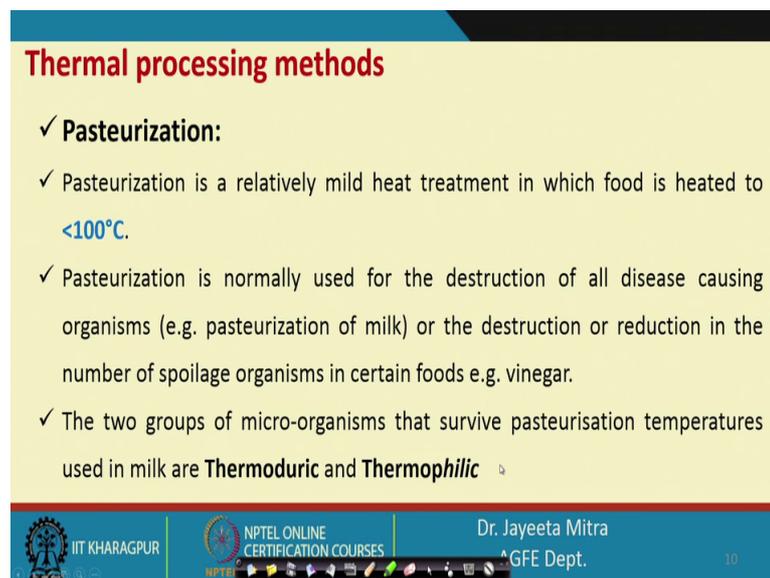
IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Jayeeta Mitra | GFE Dept.



So, the next method that we will discuss is Microwave blanching. This is comparatively newer technology as compared to the hot water blanching and steam blanching; however, this is becoming very effective. So, this is alone used or in combination with the water blanching used in household application and industrial application. And it further reduce the heating time. So, both batch and continuous systems are available for microwave blanching.

We know the principle of microwave heating and it is very rapid volumetric heating because the electromagnetic radiation is absorbed by the moisture in the fruits and vegetable. And these are high moisture product. So, very easily, they will absorb those radiation and because of the dipole rotation, the friction frictional heat is generated which is causing the volumetric heating and the quick processing is being done in the microwave blanching. It improve the product quality and minimise the waste water production that may happen in case of the hot water blanching.

(Refer Slide Time: 14:38)



Thermal processing methods

- ✓ **Pasteurization:**
- ✓ Pasteurization is a relatively mild heat treatment in which food is heated to **<100°C**.
- ✓ Pasteurization is normally used for the destruction of all disease causing organisms (e.g. pasteurization of milk) or the destruction or reduction in the number of spoilage organisms in certain foods e.g. vinegar.
- ✓ The two groups of micro-organisms that survive pasteurisation temperatures used in milk are **Thermoduric** and **Thermophilic**

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Jayeeta Mitra | AGFE Dept. | 10

Moving on to the next thermal preservation technique, that is Pasteurization. Pasteurization is the relatively mild heat treatment in which food is heated to less than 100 degree Celsius.

So, since we are heating it to less than 100 degree, we can perform this pasteurization operation at ambient temperature or atmospheric pressure. Pasteurization is normally used for the destruction of all disease causing organism that is being used like

pasteurization of the milk or the destruction or reduction in the number of spoilage organism in certain food as for example, vinegar. Pasteurization does not kill the spore formers. So, it is only effective for disease causing or pathogenic microorganism. And we can also mention that pasteurization since it is a mild heat treatment, it can store the product for lesser time after processing.

So, after processing within few days, we need to consume the pasteurized product otherwise the contamination will be there and pasteurization is better use with combination of several hurdle technologies. For example, after pasteurization, it can be immediately refrigerated or the condition may be lowered like PH maybe lowered. So, this kind of processing in combination of with the pasteurization is effective for storing of the food material. Pasteurization is also effective, when we want to remove the they in the surface sterilization if you want to do for the beer or wine. So, those cases pasteurization is effective.

The two group of microorganism that survive the pasteurization temperature used in milk are thermotolerant and thermophilic. So, in milk, we basically do pasteurization to kill the mycobacterium, tuberculosis, listeria, monocytogenes and salmonella. We also perform pasteurization in case of liquid ache to remove the salmonella and these microorganism that is thermotolerant. And thermophilic are as the name suggests that thermotolerant means, they can withstand high temperature that is given to the food material during pasteurization. However, thermotolerant organisms cannot grow at high temperature but they can live at high temperature. They can withstand that where as the thermophilic microorganism can grow and sustain at higher temperature.

(Refer Slide Time: 18:05)

Pasteurization

✓ Typical temperature/time treatments in pasteurisation

Food material	Temperature (°C)	Time (s)
Milk	72	15
Ice cream mix	80	20
Tomato juice	118	60
Honey	71	300
Fruit juice	88	15
Soft drinks	95	10

The slide also features a video inset of Dr. Jayeeta Mitra, NPTEL Online Certification Courses, and IIT Kharagpur logos.

So, Pasteurization, there is a typical time temperature treatment is required because we know that as we increase the temperature, the effect on the micro organism will be higher. So, that is why we can maintain a combination; that means, at different temperature, different duration of time will be there which is the exposure time in the pasteurization temperature.

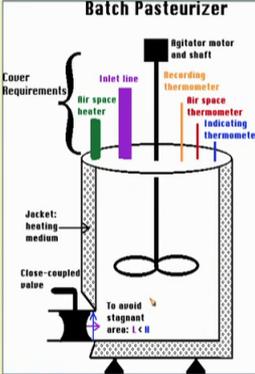
We can see that there is a chart for different food material that milk if you want to pasteurize it at 72 degree Celsius, the time requirement will be 15 second. For the ice cream milk, pasteurization ice-cream mix that temperature and time combination is 80 degree Celsius and 20 second. For tomato juice, temperature will be 118 degree Celsius, time is 60 second. For honey, it is 71 degree Celsius, 300 second; fruit juice it is 88 degree Celsius and 15 second, soft drink 95 degree Celsius, 10 second.

So, this is the time temperature combination that we need to maintain for pasteurization of these food products. And we can fix the duration for any particular product based on it is composition and the index microorganism that we want to kill in a particular process because, every microorganism may have different resistances to temperature.

(Refer Slide Time: 19:49)

Pasteurization methods

- ✓ **In bottle Pasteurization:**
 - ✓ Tightly sealed bottles filled with raw milk are held at **63-66°C for 30 minutes**. Then bottles are pass through the water sprays of low temperature to cool the product and bottles.
- ✓ **Batch pasteurization**
 - ✓ Milk is heated in water jacketed vat at 63.0°C, & held at that temperature for 30 minutes



Batch Pasteurizer

Labels in diagram: Cover Requirements, Inlet line, Air space heater, Recording thermometer, Air space thermometer, Indicating thermometer, Agitator motor and shaft, Jacket: heating medium, Close-coupled valve, To avoid stagnant area: L < H.

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Jayeeta Mitra | GFF Dent

Coming to Pasteurization methods, in bottle pasteurization where tightly sealed bottles filled with raw milk are held at 63 to 66 Celsius for 30 minutes. Then, bottles are pass through the water sprays of low temperature to cool the product in the bottle because as we mention that after pasteurization, we need to cool it to the refrigerator temperature for better storage stability. In batch pasteurization, milk is heated in water jacketed vat at 63 degree Celsius as we have mentioned here and held at that temperature for 30 minutes.

So, this is a setup, this is a setup where this is a steam jacketed vat where we have provide an agitator to have better heat transfer coefficient and there is a inside the jacket there is a steam that is giving the required heat treatment for pasteurization of the milk. There is a inlet line through which milk is coming into the container and there is a air space heater. There is a recording thermometer to measure the temperature of the milk sample. There is indicating thermometer and air space thermometer. So, here, we first heat this unless it achieve the desired temperature of pasteurization that is 63 to 66. Then we hold it there for the duration of 30 minutes. And then gradually, we heat this where gradually we cool the temperature to the refrigeration temperature.

(Refer Slide Time: 21:58)

Pasteurization methods

- ✓ **Continuous Pasteurization:**
- ✓ In HTST method milk is heated to 72 °C for 15 seconds and cooled to 5°C or below.
- ✓ Components:
- ✓ Regenerator (heating & cooling)
- ✓ Plate heat exchanger
- ✓ FDV

Dr. Jayeeta Mitra
GFE Dept.

So, after batch pasteurization, we will see now the Continuous pasteurization. So, in continuous pasteurization, in high temperature short time method milk is heated to 72 degree Celsius for 15 second and cool to 5 degree centigrade or below. This is the continuous pasteurization system. First, we will look into this tank that is the balance tank where all the milk collected in a processing section is stored first that is called the balance tank. And from here, milk is going to the first regenerator that is called Raw generator and here the temperature of the inlet milk is increased to some extent and then it is going to the heater.

So, in the heater, it is being heated to the desired pasteurization temperature that is 72 degree Celsius ok. And from heater, it is going to the holding tube. The design of holding tube that is the dimension of holding tube and the flow velocity is being selected in such a way, so that by the time it reaches from the outlet point of the heater to the controller sensor, it is being exposed to the desired time period at this temperature that is 72 degree Celsius. So, it will take 15 second from this point to this point. To reach from this point that is a exist of the heater to this controller, it will complete the requirement of time, exposure time.

So, after that there is a controller sensor that will sense or measure the temperature of the milk and if it is attained, if it has attained the desired temperature of pasteurization then, it is being send to the pasteurized regenerator. And from there, it is sending to the cooler.

If it does not achieve the required temperature, this flow diversion valve will redirect this inlet milk to the balance tank. Now, in the raw regenerator section, since it is regenerator; that means, this inlet milk is being heated by the exit, exit milk, that is already being pasteurized. So, the heat transfer between two fluid happens. In the heater, steam or hot water is used to heat the milk and again in the pasteurized regenerator, this heated milk is being cooled by the exit cool milk that is already chilled by the chill water in the cooler. And finally, in the cooler it is chilled by the chill water. So, this is the whole process that we perform in HTST pasteurizer.

So, we have discuss the component that is the regenerator, heating and for cooling and these are the actually plate heat exchanger. We will discuss in detail about all this heat exchanger. In the next chapter and flow diversion valve that we have discuss that it is function is to control the direction of the flow of milk, that is whether it is going to pass from the holding tube to the regenerator or it will be directed back to the balance tank for reprocessing.

(Refer Slide Time: 26:26)

Thermal processing methods

- ✓ **Sterilization:**
 - ✓ Destruction of all micro organisms
 - ✓ Product is heated above 100°C usually 110-121°C and kept for a defined period.
- ✓ **“Commercial sterility”** implies less than absolute destruction of all micro-organisms and spores, but any remaining would be incapable of growth in the food under existing conditions.
- ✓ **UHT sterilization:** 135-150° C for only few seconds

*15 psi
3.0 min*

Effect of time and temperature on food quality

The “red zone” represents the area of greatest product quality loss.

Temperature (°C)

Time (s)

Direct

Indirect

Dr. Jayeeta Mitra
AGEE Dept

IIT KHARAGPUR
NPTEL ONLINE
CERTIFICATION COURSES

Next treatment is the Sterilization. So, the purpose of sterilization is to cause destruction of all micro organism including spore formers. So, the product is heated above 100 degree Celsius, usually 110 to 121 degree Celsius and kept for a defined period. But the question must come that how we can heat it beyond 100 degree; so, obviously, we need

to increase the pressure. At atmospheric pressure the, maximum temperature of the water that we can enhance is 100 degree Celsius.

Now, in this case we heat this or we perform the sterilization by saturated steam. First, we use the saturated steam and then we can increase the temperature, we can use the superheated steam and the condition we normally maintain at 121 degree Celsius is 15 PSI pressure, 15 PSI that is pound per square inch for 30 minute duration ok. So, this is how we perform the sterilization. Now, what is Commercial sterility?

So, commercial sterility implies less than absolute destruction of all microorganism and spore, but any remaining would be incapable of growth in the food under existing condition; that means, we cannot fully nullify the number of the microorganism. But certainly we need to lower the probability than 1, so that that cannot contaminate the sterile lot of the food products ok. The next higher treatment that we can give is ultra high temperature sterilization where we maintain 135 to 150 degree Celsius for only few second. Now, as I told that the microorganism has a defined definite sensitivity to temperature. If we increase the temperature, so, the destruction of the microorganism generally may enhance.

So, they have a temperature sensitivity that is defined by the z value. We will discuss the z value in detail in our next class. But to understand the effect of this heat treatment on the product quality, we want to inform here is that the z value that is the temperature dependence of microbes is much more slower than the temperature dependence of enzymatic destruction or nutritional degradation. Therefore, if we enhance the temperature to certain degree, the microbes can be destroyed but not the nutrients or enzymes will be destroyed at that higher extend. Therefore, this design has been done that if we increase the temperature and reduce the time combination for sterilization, so, definitely the nutritional effect will be reduced.

So, that is why from the sterilization to ultra high sterilization, this has been performed. So, this will cause lower damage of nutrition than this may cause by the method of higher temperature lower temperature and higher duration ok. Also direct method that is in contact with the food is higher and has higher efficiency compared to the indirect processing.

(Refer Slide Time: 30:44)

✓ **Sterilization equipments**

- ✓ **Autoclaves or retorts**
- ✓ Batch or continuous type
- ✓ High temperatures are generated either by direct steam injection, by heating water up to temperatures over 100°C or by combined steam and water heating.
- ✓ **Ex: continuous rotary sterilizers, hydrostatic sterilizer.**

Retort machine

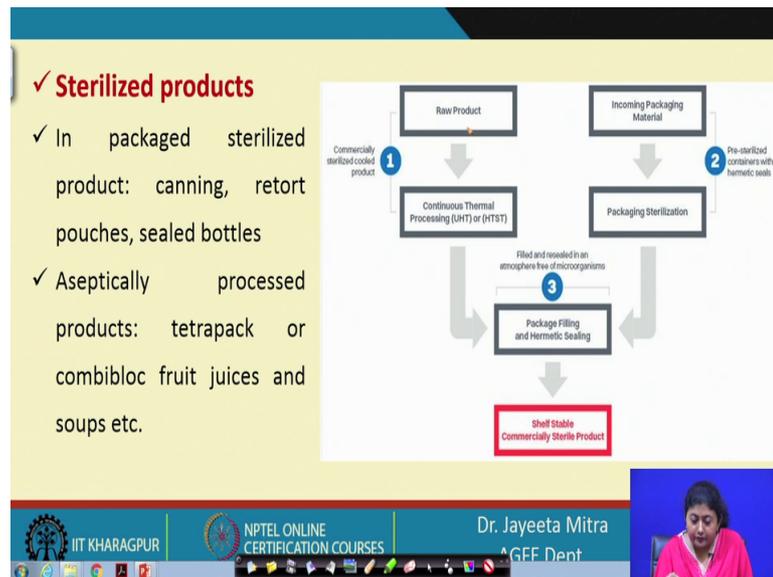
IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Jayeeta Mitra | GFE Dept.

The most common sterilizing equipment is Autoclaves or retorts. Its sterilization can be done in batch or continuous operation, high temperature are generated either by direct steam injection as we mentioned or by the heating water up to a temperature over 100 degree by combine steam and water heating. .

Normally, what we do in retort processing we first, put the material inside, close the lid, and then, we open the vent port from which the air will be taken out and the moist steam, that is the combination, that is the mixture of liquid water and gas that is a steam that is water vapour is mixed here. And it is fill in the chamber later on we provide more heat to make it from the moist heat to the dry heat. And we increase the temperature of that heat, we make it in the super heated condition and maintain the pressure for a certain duration.

After that, when we want to break the pressure and try to take the product out after processing, that time we first enter the liquid water into the chamber and also we a vent, we start venting the air through the port and gradually, we cool down the sterile product by water spray or water circulation, flushing of the water and in this with the whole operation is being done. So, there are continuous rotary sterilizer, hydrostatic sterilizer available.

(Refer Slide Time: 32:39)



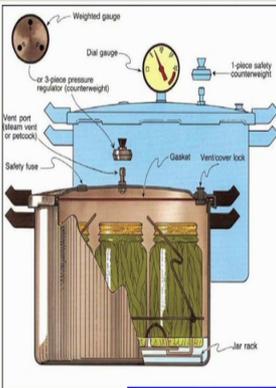
So, Sterilized product may be in package sterilized product like canning, retort pouches, sealed bottle etcetera. Aseptically, process products are there like tetrapack or combibloc, fruit juices and soups etcetera. So, in that what we do? The raw product which is commercially sterilized and cooled by the continuous thermal processing is being sent to the packaging section and the incoming packaging material that is pre sterilized containers with hermetically sealing.

So, they also after sterilization, sent to the packaging section and package filling and hermetic sealing is done. So, filled and released in an atmosphere, free of contamination, that is the whole process is being done aseptically. And therefore, it become the shelf stable commercially sterile product and for those product, no refrigeration requirement is needed.

(Refer Slide Time: 33:55)

Thermal processing methods

- ✓ **Canning**
- ✓ Process of sterilizing and sealing foods in airtight containers to preserve them.
- ✓ Pressure canning & Water bath canning
- ✓ **Hot Pack:** Heat food in syrup, juice or water before filling jars
- ✓ **Raw Pack:** Fill jars with raw food and cover with boiling hot syrup, juice or water



The diagram illustrates a pressure canner with various safety and monitoring components. It includes a weighted gauge and a dial gauge for pressure measurement, a 5-piece safety counterweight, a vent port (allowing vent or petcock), a safety fuse, a gasket, a ventcover lock, and a jar rack inside the chamber.

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | Dr. Jayeeta Mitra | GFE Dept.

The other method is Canning. This is almost similar to the sterilization method. Pressure canning and water bath canning is done, water bath canning is normally perform for the low acid, water bath canning is done for the acidic food. And here we do the hot pack method where we heat food in syrup, juice or water before filling into the jars ok.

Another is the raw pack where we first fill the jars with raw food, cover the lids with the boiling hot syrup, juice or water ok. So, these are the system where we do the canning. There is a jar rack where we keep the close container and there is a safety valves and there is a counterweight provided on that there is dial gauge which measure the pressure and by that we can able to measure that how long we want to keep that. There is a venting port also, there is a safety fuse. So, all such arrangement is being done during the pressure canning process.

Thank you we will continue in the next class.