# IMPACT OF FLOW OF FLUIDS IN FOOD PROCESSING AND PRESERVATION

## Lecture04

## LECTURE 04 : PRESERVATION BY REMOVAL OF WATER

Good afternoon my dear boys and girls and students. We have come to the fourth class today and some preliminary things we are discussing, which are required to be known as information, because, though the original class is on fluid flow or fluid flowing through either food or for processing, you need to know that, ok. So, this is again on food processing preservation, & this is the fourth class, where would like to discuss some in food processing and preservation. By removal of water, ok.

So, what do we understand by removal of water? Why it is important with this course? Because, here also, you see, you are removing water from the food material. So, for that either you have to use some heating medium directly or indirectly.

So, in that case, how you will be utilizing, depending on what type of technique you are using, you can do concentration, that means you have a slurry solution. So, you want to concentrate further. So, you can do it by evaporation, you can also do it by osmosis, you can do it by a membrane separation, in earlier class, I have said all these and you can also do it by freezing. In all the processes, this flow of fluid may or may not be directly or indirectly required, right?

Why I said, may or may not be? Because, depending on what type of instruments, what type of process you are following, you are utilizing, depending on that, directly or indirectly, you can, you are required to use the flow of fluid, right? Another is the drying process. So, in drying process, you can use vacuum, right? or you can use spray drying, you can use freeze drying, you can use drum drying or you can use tray drying, right?

In all of these again, you may need to use the flow of fluid again directly or indirectly. Like in tray drying, if we start from this end, in tray drying, what you are doing? In a tray, you are keeping the food material and over that you are blowing some hot air, right? So, it is also a fluid, air is also a fluid, right? fluid does not mean it has to be liquid, right?

So, air is also getting moved from one end to the other end and the temperature of the air is also moderated or controlled. So, that is how tray drying is done, ok. In the drum drying what you are doing? You are using a drum, where a slurry that is liquid,

a slurry is being put and is distributed over the surface and from inside a hot steam or a hot water can be used as a heating medium. So, there also the flow of fluid may be required depending on how you are using. It could also be done, that heating also could be done by electrical heating, right? So, that is why, may or may not be. Freeze drying,

here, what you are doing, you are freezing the material below its freezing point and then subliming, right? again it is a flow, because, subliming means, you are directly vaporizing the solid to vapor, just cutting the intermediate state of liquid, it is not going into the liquid phase, it is from solid phase to gaseous phase, that is what freeze drying is done. If you do not mind, ok. Then in spray drying what you are doing? You are atomizing the thing to be dried.

That could be milk, that could be any other material, right? Dried milk you have seen at home also, milk powder, right? In many cases this is done by spray drying. I don't say in all cases, in many cases it is done by spray drying. So, there you are, through atomization you are spraying that slurry and by hot air you are drying it.

Before it drops down to the bottom it gets dried. Accordingly the dryer is designed. Similarly, in concentration and evaporation also, you are doing, may be by directly or indirectly, with water or steam, you are doing evaporation. Osmosis, it is depending on the diaphragm, right? You are using a diaphragm where selective

material is allowed through that and you are separating the two. Similarly, membrane and in freezing, you are changing the phase, that is from liquid to solid, you are doing that of water in the food material, right? So, this we should know

little otherwise we will not be able to relate or correlate the two. So, if we look at concentration, it is almost all liquid foods are first concentrated before it is dried.

Some are also available in concentrated forms also as food material. For example, fruit juice, it is available in a concentrated form, canned soup that is also available in a concentrated form and condensed milk. This is highly concentrated. I hope you have

consumed at home, at least, during our childhood, if this condensed milk was available in the storeroom or somewhere, we also used to steal it and consume it. I hope you are also doing similar thing. Now, purpose of concentration is to preserve the food material by reducing the weight, and volume, Right?

Obviously, you are reducing the weight because you are removing some water from the food material. So, weight is reduced. Simultaneously, volume is also reduced. Its effectiveness is, if we look at, then, it is concentrated non-acid fruits, juice and vegetable puree, these undergo spoilage unless they are further processed.

However, so sugar syrups, sauces and jellies, they are relatively free from getting spoilage. How? It is the solutions of sugar and salt they are dissolved in the remaining water and give concentrates, which exert high osmotic pressure and it draws water from the microbial cells or prevent normal diffusion of water from the microbial cells or prevent normal diffusion of water into the microbial cells. So, both by preventing it,

flow of water into the cell or flow of water from the cell to the outside. So, doing that it is preventing the microbial concentrations. So, from the preservation point of view, solution containing 70 percent sugar or 18 to 25 percent of salt, this prevent the growth of the microorganisms. Now, there are different methods.

First one is evaporation, it is the simplest method and this is by, maybe, application of the solar energy. For example, salt, we obtain from sea water, that is by solar energy. Yeah, mechanism is very simple that evaporation concentrates a solution consisting of non-volatile solute and a volatile solvent. Types of evaporators, there are different types, kettle evaporator, which, I hope in most of the engineering institutes or science, food science institutes do have. It is simple, heated by direct flames or may be steam.

High temperature and long concentration times, these are the two factors, which damage most food materials, unless you take care in advance. The manufacture of syrups, because, high temperature heat treatments is desirable to produce the color from caramelized sugar and develop typical flavor. That may be some added advantage. Another evaporator could be flash type evaporator, where it is superheated steam. Roughly around 150 degree centigrade, is injected into the food, which boils.

For example, you use it for making puri. One of the most commercially applicable evaporator is the film evaporator. Where, this also, you will be learning in the fluid flow. Because, this is also part of that flow of fluid. That foods are concentrated using thin film evaporators.

Food is pumped into a vertical cylinder which has a rotating element that separates the food into a thin layer on the cylindrical wall. which is usually heated by steam. Water quickly flashes from the thin body layer of the food and the concentrated food is simultaneously wiped off from the cylinder wall. In this case, the product attains a temperature of around say, 85 degree centigrade.

But since the concentrated food will be in contact with the heated cylinder for less than a minute, the damage is minimal. One thing you must also keep in mind, it is not a single parameter like either temperature or time. It is a combination of time temperature which affects. Now, here the temperature is not so high, it is around 85 degree centigrade and time requirement is also low.

So, that time temperature combination does not make because heating is the opposite of the cooling or freezing, right? And in heating, most of the food materials gets deteriorated from its original quality, unlike freezing, wherein it is the most retention of the quality. Because, you are not heating, heating damages. But, here, since your time-temperature combination is not so high, it is generally not that bad. Vacuum evaporator, which takes care of the high temperature of heating, because, when you are doing vacuum, your temperature requirement for evaporation is also low.

So, the time temperature combination becomes not so high. Mostly, heat sensitive liquid food, commonly, concentrated at low temperatures under vacuum Single or multiple effect evaporators are commonly used. In this process, the first

evaporator, under use or under vacuum is heated with steam. Subsequently, the water vapor, which boils up from the first one, and goes to the next evaporator.

The food is sent to the next evaporator kept at a higher vacuum than the first one. Water vapor acts as a heat source from the previous cylinder, or previous unit or evaporator, whatever you call. From that the vacuum is more than the previous one. And by that the vapor of water acts as a heat source to evaporate food in the second evaporator and it goes on like this. Generally, up to five effective evaporators

have been used. Generally, it does not have any such rule that by which you can use 3 evaporators or 5 evaporators or 7 evaporators or 6 evaporators even. Because, all depends on your time temperature combination and on this basis how the quality of the finished product, you are maintaining. Grape juice and tomato puri or juice are concentrated in this manner and this method results in energy conservation, because, you are using heat from the first effect.

right? Subsequent effects, the vapor which is being produced, that is being used as the heating medium, though you are using vacuum. This is a two-effect evaporator. Similarly, you can use the effects more and more, 3, 4, 5, like that, right? This is called double-effect evaporator or it can be

forward feed or backward feed right. Obviously, we have two effects, and defects also, because, depending on whether you are using forward feed, that has some good effect, & also some bad effect, and backward feed that also has some good effect, & also some bad effect, right? So, this is a vacuum evaporator typical, right? This is a laboratory model, we have used in our agricultural food engineering IIT Kharagpur lab, right? This is a film evaporator that also is there, right?

Where the films are being generated in different effects, right? Like these tubes, okay? And concentration by osmosis, this is a very different technique. So, in nature osmosis involves the movement of water through a semipermeable or that is called palm selective membrane from a region of higher concentration to a region of lower concentration. In other words, when miscible solutions of different concentrations are separated by a membrane, that is permeable to the solvent, but nearly impermeable to the solute, diffusion of solvent

occurs from the less concentrated to the more concentrated solution. Mind it. The movement. Because, you have two. One is your solute and another is solvent.

Then who is moving? That is the most fundamental. Who is moving? Here we are saying the diffusion of solvent occurs from the less concentrated to the more concentrated solution.

That means, if this is less concentrated and if this is more concentrated, so the solvent moves from less concentrated to the more concentrated solution, right? So, that means it gets concentrated and it gets diluted, right? Where, the solvent activity is lower, okay? Its occurrence in nature is in many plant and in many plant and animal cells.

If pure solvent is on one side of the membrane, the pressure required to equalize the pressure on the solvent, the solvent activity is the osmotic pressure of this solution that is pi, right? Next, if we look at this. You see we have one and that is separated by glass or membrane, right? This is called semi-permeable, as the bottom one, ok. What is this fellow?

Yes. So, this is the one and then semipermeable membrane, that is getting separated, right? You see the height in the first one was this much, right? And this semipermeable, so it is getting moved by the osmosis. Now, this takes us into three conditions.

One is called hypertonic solution, that is, it contains a high concentration of solute relative to another another solution. For example, the cell cytoplasm, when a cell is replaced in a hypertonic solution the water diffuses out of the cell and the cell gets shrivel, shrinkage, right? So, this way, the cell membrane gets damaged, and the cell is destroyed, that is how the inactivation of cell could be made. Another is hypotonic solutions, where, it contains low concentration of solute relative to another solution.

For example, the cell cytoplasm. When a cell is placed in a hypotonic solution, earlier was hypertonic. So, this one is hypotonic solution the water diffuses into the cell causing the cell to swell and possibly explode, right? Then third one is isotonic solutions.

These contain the same concentration of solute as another solution. For example, the cell cytoplasm, when a cell is placed in an isotonic solution, the water diffuses

into and out of the cell at the same rate. So, the fluid that surrounds the body cells is called isotonic, because, at whatever rate it is moving from here to there, same rate from there to here it is getting moved. So, it appears that it is under same situation, same condition. Very important is ultrafiltration, which I just gave example of your drinking water at home.

So, there, ultrafiltration could be used. So, widely employed, in the increasingly important biotechnology industry, for separation of fermentation product, particularly enzymes. Largest commercial use is in the dairy industry or recovery of proteins from cheese whey and for pre-concentration of milk for cheese making, right? Then freeze concentration, again.

This is a unique method, but as of now, not commercially exploited so much because of, I don't know, maybe because of the lack of research work or finding out the appropriate things. So, it is done what you have in the food material, water and its solution in that food. So, what you were doing? You were freezing the water.

Say, if you take milk, milk contains around say 90 percent water and 10 percent rest of the material. So, out of this 90 percent water, if you can freeze some part of water in first, say, you have multiple steps. In the first step, you have frozen some part of water, say around 10 percent, right? And then if you can separate this frozen water as crystal, from there to the other,

Then 10 percent gets separated. So, from 90 percent you are removing 10 percent. So, from remaining again, if you can freeze, because now your unfrozen material that becomes more concentrated, right? So, the temperature also will vary, freezing temperature. So, like that if you can make

unit which can be very very useful commercially, right? So, with this we conclude the inaugural or rather what should I say, this is the preamble of the course, which you are supposed to know, ok. Thank you so much.