Cooling Technology: Why and How utilized in Food Processing and allied Industries

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Lecture 53
Freezing Curve

Good morning, my dear boys and girls and my dear friends. We have already seen that how the quality is getting affected in freezing, right, and that manifestation was in terms of drip loss right. Without spending much time on that, because, we are really running short of time, lot of things are still remaining. So, let us go to freezing curve, but before that, let us look into also another very important definition, and that is, called eutectic solution, right. So what is that? Eutectic solution, before, again, let it be because, but, I do not know afterwards, yeah, by one chance, we could. So eutectic point or eutectic temperature, that is very important, why? Because, the ice cream lollies, which you consume, they are manufactured in this type of refrigeration system.

So, if we look at the definition of eutectic point, or eutectic temperature, it can be said that, as the freeze concentration process progresses, solutes reach or exceed their respective saturation concentration, and simultaneous crystallization of ice and solute becomes possible. The temperature at which a crystallized solute can exist in equilibrium with ice and unfrozen phase is known as the eutectic point, or eutectic temperature of the solute. So, I repeat, the temperature at which a crystallized solute can exist in equilibrium with ice and unfrozen phase, is known as the eutectic point or eutectic temperature of the solute. For example, sodium chloride has an eutectic point of minus 21.13 degree centigrade, sucrose has minus 14 degree centigrade, glucose minus 5 degree centigrade, sodium carbonate minus 2.1 degree centigrade. So, suppose from here if you want to have a solution, whose eutectic point is minus 5, sorry, minus say 17, then what you will do you will take some part of sodium chloride and some sucrose so that resultant becomes minus 17 right. So, this way if you have some other solutes, whose temperatures or eutectic temperature is much lower, maybe minus 25, minus 30, minus 40 ^{o}C, things like that, then, a combination of different solutes, you can have your desired temperature, where you see that, from the definition it is coming that you have an eutectic temperature, where all three states are in equilibrium, means till that point it is in the liquid state in the solution, right. And we know the heat transfer coefficient of liquid is much more than that of solid, or gas.

So, this is why in lolly making, the refrigerating part is with the eutectic solution. We will come there afterwards, ok. Now, let us look into time temperature curve, or plot, that

is called freezing curve, right. This again, we are running short of time. I will not spend in detail, as you see, from here, we started from a point A, we are lowering down the temperature, right and this lowering down of temperature, this type of heat transfer is known as change in sensible heat, or this is the sensible heat, right, ok. Now, once it comes to the point S, that is, this is time versus temperature, right. So, the point S is the super cooled, it is a food material, say, and its initial temperature is somewhere, at the level A, anything, could be 20, could be 50, could be 30 or could be 10 ^{o}C, any anything you can have, but that is above freezing point, right.

So, from there, you are lowering down the temperature with a sensible heat change, right, coming to the point S, which is the sub cooled point, or super cooled point, right. So, once it attains this point, as we said in that curve of nucleus formation. So you have to come down a little, so that, you remember, that end started from here, and it went like this, right. So, you are lowering down the temperature to the point, which is known as, that, super cooled point, right. So, from there, super cooled point, you are again lowering down temperature, but the temperature is increasing from point S to point B, where point B is the initial freezing point, right.

So if initial freezing point is say B, so from point S to point B, the temperature is increasing why? Obviously, the question comes why? So, when it is said that, why, it is because, that, here you are forming the nucleus. So, crystallization is happening and crystallization formation is an exothermic process, right, exothermic process. So exothermic process means, temperature will increase. So, that is why, this rise in temperature from the point S to the point B, right. Once, that is the initial freezing point, once it reaches, initial freezing point, ideally, whatever freezable water is there, whatever freezable water is there, that freezes up to point C, right.

So, if product has say 80 percent water, and 20 percent other solid, then, it may have 90 percent freezable water, and 10 percent unfreezable water. So that, 90 percent freezable water is frozen to the point C. Then, if you lower down further, the temperature, it will go down to point, wherever you want, this may be minus 18, this may be minus 20, whatever you feel, right. So, that is point D, where, it is the again sensible heat, and this heat was latent heat, where the temperature did not change, right. But, this is typically, an ideal time temperature relationship, or freezing curve.

In reality, as we know, I have said earlier, also shown, that from the point B, when in some portion has been frozen, in remaining unfrozen part, the concentration of solute goes up. So, since concentration goes up, the freezing point gets lowered, right. So, we get a freezing curve like this, instead of this, we get a freezing curve like this, and then from this C, again you go back to D, as much you want. So, instead of this plateau, there

may be an inclined freezing curve, because, the more it gets concentrated, the more the remaining solution will have lowering of freezing point, right. So that, it is coming like this.

So, actual freezing curve is this, and real, I mean, this is actual, and ideal freezing curve is this right. So, this is how we can explain the freezing curve for real and ideal, right. So, now, we do not read out this part, you have already seen, and perhaps you can also read out, the detail, I have already said, our time is very limited. So, let us go to the next. Some definitions we need to know, that is called denaturation. You know that denaturation happens with protein, right.

So, an alteration of protein, in which intermolecular cross linking take place, that permanently changes the physical and chemical properties of the protein, is known as denaturation. Then, drip loss or drip, drip, we have already said, the expressible fluid, from say, fish flesh, or any other, right. So, the volume of drip increases denaturation. So, the loss, which is coming, because of that, your freezing technique, it is the drip loss, which is occurring, right. Then, we come to fatty fish, of course, fatty fish and lean fish. Fatty are those, which are having high fat content, around say, 20% and lean fish is around, maybe 2% percent, right.

So, lean fish, haddock and catfish, is known as lean fish, right and fatty fish, we know, many, for example, now a days it is plenty available, that is hilsha, and many others, right. Then, freezer burn, which is very important, subsequently also we will see that freezer burn. This describes the area of a frozen product, in which, the ice has sublimed, leaving the product dehydrated, and spongy, rather dehydrated, rather porous, the process, sorry, porous, and spongy. The phenomena can affect the entire surface and penetrate deeply into the product. In this regard, let me tell you, I do not know, whether you have done mass transfer, and in mass transfer, there is a mass transfer diffusion coefficient. In its determination, there is one experiment, right, in which, say you have tube, and you have some colored solution, right, and there is a travelling microscope, there is a travelling microscope, which can see the level, right, and with the help of a fan, you are blowing air, right. So, with time, what will happen? This layer will gradually come down, like this, then like this.

So, from this change in the height, you can determine, the diffusion coefficient, but this is not part of it, but, I have given this example, because, just to know that you are blowing some air. In freezer burn, it is also happening with the blast of air. So, what is happening, your frozen material is this, right, you are blasting some air for cooling. With low air temperature, you are freezing or chilling or whatever, you are doing, and there is a blast of chilled air or low temperature air. So, what will happen? Gradually, the moisture

will migrate to this and the moment it comes to the surface, because, as we have seen there, it was this, you know, and this vapors are formed here, and you are blasting it away, so, there is no water vapour here, right, and that way, this is coming down, this was our that experiment for diffusion coefficient measurement, but, here also your material is frozen, you are blasting with air. So, the moment some air is blown, some water molecules are there, that is blasted off. The vapour of the water molecule is blasted off.

So, there is a continuous concentration difference between the air molecule, sorry, between the water sublimed, or water, which is on the surface, and from the interior. So from interior water is coming out, and after sometime, it appears, that this surface is very very dry, right. I don't know, you have seen burning with the heat, right. So, there is a, maybe, this kind of boil, on the, wherever you are getting, that, whosoever is getting that burn, right. So, it gets some boil like this, but if you have ever come across with freezer burn, that is with low temperature burning, then you will not see that kind of elevated boil kind of thing.

So, there the surface, where it is getting burn, that will become very very dry, right, and this is called freezer burn. I got one, while I was working with liquid nitrogen, and yes, there was a burning on the hand, and when I went to the doctor, said nothing can be done, you have to just wait, naturally it will be taken care of. However, it was like that and it happened also naturally. So, this is freezer burn, and freezer burn is not acceptable by the consumer. So, if you come across with a freezer burn material, you will like to discard that, right. So, some more definitions, we would like to have like gaping, right.

So, gaping is another, which is exhibited by the cut surface of uncooked fillet, in which the connective tissues fails to hold the muscle block together. The surface presents a split, or cracked appearance, and in severe cases, the fillet will disintegrate, if skinned, right. So, this is one. Then, another thing very important is called tempering, right. I hope, you are little kid, may not be little, may not sorry, may not be kid, but yes, little aged.

So, maybe senior people are also there. So, for everybody, when, at our home, we do some or other kind of thing, our parents used to scold us. This is true for everybody, right and may not be at that time, but after sometime, the same parents, may be showing their affection to you in some or other way, right. So, that means, sometimes it is giving you scolding, and sometimes, they are giving you the affection and other things. So, these two are opposite in nature, and you are gradually getting tempered, right.

So, you are getting both hot and cold, and by that you are becoming tempered. Same is happening everywhere, that rising the temperature of the frozen fish or product, between

minus 5 and minus 10 degree centigrade, to permit mechanical processes, such as slicing etc. this tempering is done, right. If you are from agricultural background, or even mechanical also, chemical also, may be that the bullock cart, right that bullock cart is made of maybe metal or wood or whatever, it has one rubber covering right. How that rubber covering is made done, you have any idea? It is done, say you have the wheel, the wheel temperature is lowered, the wheel and the rubber, that like tire, similar to rubber tire, that is to be fitted. So, what is done, that wheel is lowered with its temperature.

The moment you are lowering the temperature, by nature more or less, all materials, while cooling, or if it is cooled, it contracts. Whereas, exceptions were very few, whereby, lowering it expands, right. So, by lowering, you are contracting the wheel, and when it got contracted, the rubber, that covering, or tyre is then put into that, and then, after some time, when, the same wheel is heated up, it gets expanded. So, the thing is getting very tightly fixed. The same is true when we said, the other day, about the fin, right.

In that fin also, if this is the material, so, it is cooled, and the thing which is to be pulled like this, whose radius or diameter is same as this material. So, the cooling of this is reducing the size or diameter, and then you are putting the fin, right. Because, your objective is that, all the points of this, because circle, or cylinder, they are of point contact, so, every point is in contact with the material, where you are extending the area. So, that is how, it is done, right, and this is how we know, it is called, similar to tempering, or annealing also it may be said. Then glazing, again it is another very very important thing, but important why, because, most of the cases, those, who are fooling people during the business, it is more for them, and for our knowledge, right.

So, you went to buy, say a fish, and this fish, by appearance, you are finding very good. You brought it back to home, and then everything got warmed up and you saw that this is not a good fish, right. How it happened? Suppose, the person, who is doing this business, he purchased that fish, right, he purchased that fish, and fish of poor quality, then he frozen it, he got it frozen. So, maybe minus 18, minus 20, whatever temperature, right, and it is appearing very shabby or may not be good. So, what he is doing? He has taken some water, or some similar, water may be cold, and dipped this fish into that, right and taken out.

So, there will be a fine layer of water, and because the fish was frozen, and you have put a fresh water liquid, which is having a very slight or very mild thickness of water. So, that gets frozen, and you know ice is a very good reflecting medium, and that is why, when you go to high altitude, you are asked to put your, I mean, spectacles, I mean, the other thing, right. So, goggles rather, so typically you have to take care of your eye,

because, the ice is reflecting the light severely. So here also, that glazed, and this is called glazing, that glazed material is reflecting a light and it is appearing very nice right. So that glaze material is sold, so you are fooled.

So this is for typically, for the people who do business, or fooling the other one, right. So, perhaps, our time is over, for today's this class, and we could not have finished the freezing part. We will do it in the next class. So thank you for listening.