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

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Module No 12

Lecture 59
Ice Cream

Good morning, my dear students and friends. We are at the really fag end of the course, we have two more classes, and as I said earlier that we have said about, why we need cooling, we have said how to produce cooling, now we are on the application of the use of cooling, right, and as I said earlier that my favorite is ice cream, because I worked also in ice cream industry. So, these two classes will be with ice cream. Now, in ice cream production, you need refrigeration, in ice cream storage you need refrigeration, in ice cream transportation, you need refrigeration, that is why it is pertinent. It is not that it is out of the course or outside of the course, but yes as an application, I would like to share my experience with you in ice cream, ok. Now, first thing which we need to know that, why ice cream is so, of course, popular, the reason being ice cream is very very popular all over, not India all over the world.

I am not going to that statistics, that in India per capita consumption is much below than that for the developed country people, their consumption is much much higher than, of course, that of India, and I do not know, I am just joking, that may be one of the reasons, why they are so fatty right. And most of the developed country's people, you nowadays see that, their fundamental problem is obesity, one of the, right. However, that is different. Now, we come to the manufacturing of ice cream or some information, which is relevant, that is ice cream, what it is made of? right. It is made of milk fat, generally, 10 to 12 percent, but, nowadays, either fat free or very less fat ice cream is also available.

As I just said that, people have become very much concerned about the obesity, and other things. So, the fat content in that is also reduced right, but by and large, as of now, in India, it is around 10 to 12 percent, except, where it is specifically written that low calorie, low fat ice cream right. So, then milk solid not fat, right. If you separate milk fat from the remaining if you separate milk fat, from the remaining milk, that is if it is dried, then that is called milk solid not fat, right, where all other than fat, like protein, carbohydrate, vitamins, minerals everything are present. So, that is called milk solid not fat. Sugar usually, we get, sugar everybody we consume sugar.

So, that is around 0.2 sorry, 14 to 16 percent and milk solid not fat is 11 to 13 percent. Stabilizers and emulsifiers, these two are required because, if you try at home, take in one

cup water and little drops of oil and if you want to mix them you will see, you cannot mix them, whatever try you do, you just cannot mix them, right. So, that is why, the stabilizer and emulsifiers are needed because, milk fat which, we have said, has to be stabilized, by stabilizer and emulsifiers, remaining is water. So, that has to mix with the water and get it stable.

So, that is done by both emulsifier and stabilizer, when we say about the usefulness of these, then will come in detail. So, stabilizers and emulsifiers are used around 0.2 to 0.3 percent and over 0.1 to 0.2 percent, respectively. Water and air, you see, you add all these, it comes somewhere around 60 to 64 percent, or rather, the other way round, it is around 36 to 40 percent, right, if you add rest of the things, which are above it. So, they are 36 to 40 percent. So, water required is 60 to 64 percent and air is 90 to 105 percent. This I will tell separately, why it is 90 to 105 percent, right and some flavor and color are also added to it. Then what do these constituents do? Right. Milk fat, which we said 10 to 12 percent, out of which, 80 percent is fat. So, it may come from the source as cream, or butter. You know, the butter, which you take every day at home with bread and many other things.

So, that butter contains around 83 percent of fat, right, and around roughly, 12 to 13 percent, or I should not say 83 percent, that is why I said it around. So, it is 81 to 83 percent, and water is also around 17 percent and a little salt is also given, that is why butter is salty, if you the taste, butter is salty because salt is also given there right. So, the source being either cream or butter obviously, butter price is more than cream, because butter is a processed product. So, obviously, processing charge will be added. If you take cream, then that is not there, right. Then, the purpose of using milk fat is, it improves flavor, produces characteristic smooth texture, and the disadvantage associated with it is that, it retards rate of whipping and it is also high in calorie and cholesterol.

Now, again our new term has come, that is whipping. I hope you have seen at home your mummy or seniors or yourself doing omelet, right breaking the egg, putting in some container, maybe glass or cup wherever and with a spoon you are continuously stirring, like this right. Why you are stirring? If you ever measure in a cylinder, if you have broken that egg, take the volume, that may be this much, then you pour in that cup or wherever you can and then you do, this is called whipping, right. That stirring, which you are doing is called whipping, the purpose is to incorporate air. Now, you see the volume in the cylinder, you will see the volume has gone up much more than previous one.

So, this is called whipping right. So, it retards, we have, in the previous slide, we have shown you that, ice cream contains around 90 to 105 percent of air. So, if air is not

incorporated, right, properly, then you do not get the ice cream. Many people do say, we have prepared ice cream, but I always say that, you have not prepared ice cream, because, I, unless, you have an ice cream freezer itself, you cannot do the ice cream at home, because, what you do is more or less similar to cool fee, cool fee has very high solid content, right, very low air very very low air. So, cool fee you can make, but not the ice cream, because ice cream you have to have that 90 to 105 percent of air, which you cannot do at home. Whatever whipping you do, it will not be, you will do whipping during, before making the ice cream, right.

So, then you will keep it somewhere for freezing etc. there, no air will be incorporated. So, it is very, it is not possible, rather, I should say, to make ice cream at home. However, the second ingredient is milk solid not fat. It is around 11 to 13 percent. Obviously, the sources are protein, lactose, it contains protein lactose and minerals, all put together milk solid not fat, itself is a source, and it is coming from the milk solids as purpose is to provide food value, because you are adding protein, you are adding lactose, you are adding minerals. So, this adds the food value, improves palatability, I hope you have taken milk powder just like that, right and you have tasted it nicely.

There, it is also with fat, but without fat also, you see baby food, right. I hope, everybody, when a baby is being born or has born, everybody, who, say mother, father, grandfather everybody, they would like to have some scoop of that baby food because, it is palatable. So, it is increasing palatability, and also texture, but it has some disadvantages that, it resists melting. Now you assume, I hope you know the candies, right if you put a candy in your mouth, you, what you do? you take from this side to that side and gradually it gets dissolved over a long period of time, but you, as you just imagine that, you have taken a scoop of ice cream, put it in your mouth, and you are not able to melt it. How do you feel? it is simply like a candy, but that is not desirable, what is desirable, you put in your mouth, the warmth of the mouth, that will cause the ice cream to melt, and then you enjoy the ice cream, that is what.

So, if it is resistant in melting, it is not desirable, that is why disadvantage, right, but, somewhere, it is also advantageous. I will come afterwards, because other is, it will be repeating. It lowers freezing point that is also disadvantage, because the moment freezing point is going down, means more energy you have to extract. So, more cooling you have to produce. So, that is another disadvantage, and it causes salty, and taste, salty taste, and maybe it is causing some sandiness, right. It is sandy, salty, because, milk solid not fat contains minerals.

So, that may cause the salty taste. Sugar, close is 14 to 16 percent, source obviously, sugar. Purpose is to make ice cream sweet, and it improves the texture and flavour very

good, but it also has some disadvantage, that it also lowers whipping. We have already said whipping time and lowers the hardening temperature, again, if you are to harden it, say at minus 30 ºC, if it is lowering, and that lowering is, why because of again, your earlier also, we said that the law, which is lowering down the temperature or increasing the temperature, that is called Raoult's law, right. Lowering the hardening temperature is again incorporating some additional cost. Emulsifiers, it is around 0.2 percent maximum, generally by mono or diglyceride is the source, its purpose is to increase whipping quality, and it gives drier and smoother ice cream, and also it distributes air cells uniformly, that is what is required.

It should not be that, in a ice cream, say this is the ice cream scoop, you have taken out, of which, you have a air bubble, here and another air big bubble here, a small air bubble here, that is not desirable, it should have uniform distribution of the air bubbles, or air in the ice cream itself, right. So, these are disadvantages. Then emulsifier is maximum 0.2 percent. Generally, by mono and diglycerides are used. This use is that, it increases whipping quality again, so that, which were against whipping, now, counteracted by this, both, emulsifier and stabilizer, right.

So, increases whipping quality gives drier and smoother ice cream, distributes air cells also uniformly, right. So, this we have already said, if it is exceeded, then that causes slow melting and texture defects, that is not again desirable. Stabilizers, 0.2 to 0.3 percent by sodium alginate and and gelatin, agar and agar, all these are used obviously, purpose is to prevent coarsening.

Now, since again another term has come up coarsening, what we mean that? In the ice cream, your ice crystal size is this, we said 9 – 11, increasing right. So, that 9 - 11 has happened, and we also said that, at the ice crystal, already formed and surrounding water molecule, if they find that, it is not energy, in terms of requirements, it is not possible, then they will go and add up to that right. Now, while you are storing it in a, in a hard, in a that distribution box, or that exhibition box or not display box, I should say right. So, there your ice cream is there, for some reason, the temperature got closed, means supply of these are also with vapour compression refrigeration that cooling around minus 20 degree centigrade is done. But if by chance there is no, if by chance there is no electricity, for long time, then what will happen? this 9 – 11, again will be converted back to 9.

So, it will remain there, say again, when the thing will come, earlier the size of the ice crystal was this, now the ice crystal went up, that is what is coarsening right. So, that is not desirable, because you do not like bigger ice crystals in your mouth, that will become like candy and disadvantages, it causes heavy and soggy body, and also it resists melting,

not desirable. Water, around 60 to 64 percent, air 90 to 95 percent respectively, are used. Obviously, it increases the volume, disadvantages, that increase the transportation, cost of storage, it will not be out of place to say that, you know Gujarat is famous for milk or white revolution, right. Now, if milk contains roughly 90 percent water and 10 percent remaining roughly, right, with the source etc. it varies widely. Now, what you are doing, for say 1000 kg or 1000 litre of milk transporting from Gujarat to say Delhi, out of which 90 percent, that means 900 liters is water getting transported, and the other, that is 10 percent is 100 litre or kg whatever, right.

Now, if you can, if you can remove this 900 litre or minimize say 450, or say 200 liters, or even lower, then your cost of transportation will go drastically down, right. Till now, it is not being done. We are transporting the whole thing, and that is why the transportation cost being so high, the milk price is going up right. So, if we can do that, that is one of the remedy for increase of the price. Similarly, you are putting 90 to 100 percent, that is say, 50 percent ice cream, and 50 percent air. So, volume is increasing, weight is less, but volume is increasing, so your per unit transportation, your less quantity of material is moving, that is increasing the cost ok. Then, flavour and colour, flavour is normally used by fruits and nuts and permitted artificial flavours obviously, this will be, I mean, this will be selected by the company.

So, normally, they do not divulge it to others, its purpose is to increase the acceptability, but disadvantage is harsh flavour reduce acceptability and intense flavour satisfy the desire very quickly. You will see if you consume some high flavour material anywhere, then your satiety is almost over. So, you will not be able to consume more quantity of things because you have already gotten the taste and flavour. Colour, it is also secret of the company. Normally, permitted food colours are used and it improves acceptability, as see, and it aids in identifying flavor, say, tutti frutti, and in a cold room, where you have such a big thing. So, here maybe some quantity of ice cream, here maybe some quantity of ice cream, like that it is distributed.

Now, the fellow, by opening the door, who will be either keeping or taking out. So, he has to know, what is where, right, from the packet, if you hopefully you, have seen, from the packet you cannot identify. So that colour helps to identify the product itself right. So, if it is that, the process flowchart, we can say, like this, quickly, that solid raw materials are first received at one place from there it is manually or with the help of some automatic system, it is mixed, then it is pasteurised and after pasteurization, it is homogenized. Why? because the ice cream contains uniform fat size. So, that is why, it is homogenized, then it is chilled, after chilling it is aged, ageing is done at 4 degree centigrade for couple of hours, 4 to 6 hours, then flavour and colour materials are added, then it is taken to freezer for freezing, where fruits and nuts can be also added, then it is

packed either individual or bulk packing, goes to hardening room because, the ice cream, which comes out from here, is at minus 5 degree centigrade.

So, it is semi solid, it is having flow ability. To restrict that hardening room is required, for hardening, and then it goes to cold room and further it is going to the distribution market. So, this is how the flowchart is. We can say of ice cream manufacturing. Now quickly if we look at the this is the layout right this is the plant lead we can say, this is a plant layout how the machines and all other things are. Typically, we call it to be plant layout, right for ice cream manufacturing, where I used to work. This was at like Dr. A. B. Road or in Worli, at Bombay right ok. Then, we come to the ice cream, if you take, take one section, and this is taken from the book called, Aurbuckle, right this is taken from the book called Aurbuckle. it is taken, this book is taken as one of the bible of ice cream manufacturing right. Here you see A B C these are all dimensions and distributions of air cells, and ice crystals, sizes of the ice crystals etc. right. Then, we go to the how it is made? The making parameters are first, it is pasteurized, 70 degree centigrade for 30 minute, this is the prime thing, because normally, milk is pasteurized at 63 degree centigrade for 30 minutes, right. Then, it is homogenized, it is done by two stage homogenization, 2500 and 500 psig, why we are saying, because, this is the whole number, if we convert it into atmosphere or any other, it may not be a whole number, or decimal, that is why it is easy to remember, right.

Then, it is chilled, chilling is done again by ethylene glycol in a heat exchanger, ethylene glycol and water mixture, as a secondary refrigerant, primary can be either ammonia, Freon etc. right. Ageing, again it is done by Freon refrigerated vat and it is aged for 4 hour, why, because it improves the, it improves the viscosity, right. Otherwise, when I will show, the ice cream freezer. So, if the viscosity is high, then, what will happen? It will flow very fast, you want to retain it in the ice cream for some time. So, that the necessary cooling is done so, for which the viscosity has to be increased, that is done here.

Freezing is done with the ice cream freezer available in the market, around 300 to 700 liters per hour capacity, or any other, it is, but the outcome is minus 5 degree centigrade, because it is flowable. Then it is filled either manually or automatically in some packaging systems, then, goes to hardening room where air at minus 40 degree centigrade is blown over it and the temperature could be minus 30 around. So, it takes, depending on the size, shape etc. 2 to 8 hours for hardening. Then it goes to cold room obviously, cold room is around minus 18 or below, typically, say minus 25 ^{o}C, cold room is also refrigerated with either ammonia or Freon. Then, it goes to dispatch, where lot many possible way, which will come in the next class, possible way it is dispatched, right.

Dry ice pad, pad van, then mechanical refrigerated vans, etc. are used for transporting frozen ice cream, right. Now, our time is up. So, we stop our this class here itself. Thank you for listening.