Advanced Aquaculture Technology
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Lecture 51
Fish and Fish Products Preservation

Hello everyone. Welcome to the first lecture of 11th module of aquaculture industries. So, here we will be discussing about the Fish and Fish Products Preservation and my name is Professor Gaurav Dhar Bhowmick. I am from the Department of Agriculture Food Engineering of Indian Institute of Technology, Kharagpur.

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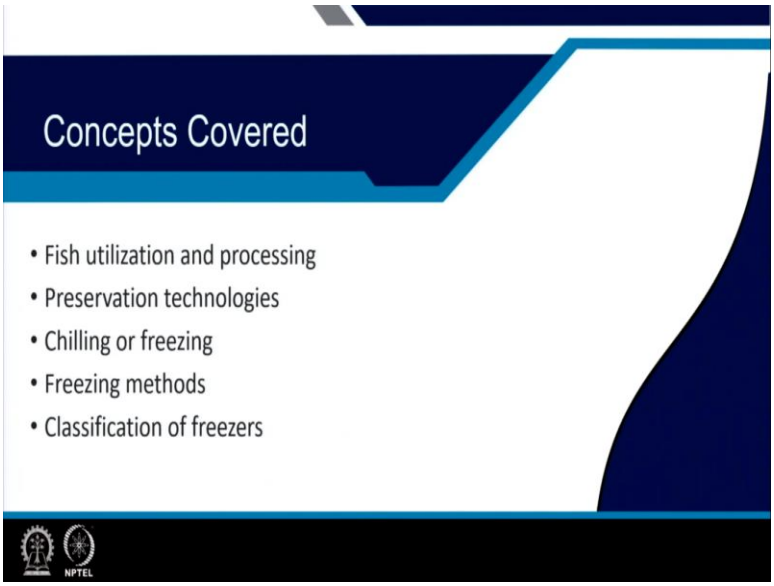

The concepts that I will be covering in this particular lecture material are the fish utilization and processing, different processing technologies, chilling or freezing, freezing methods and classification of freezers.

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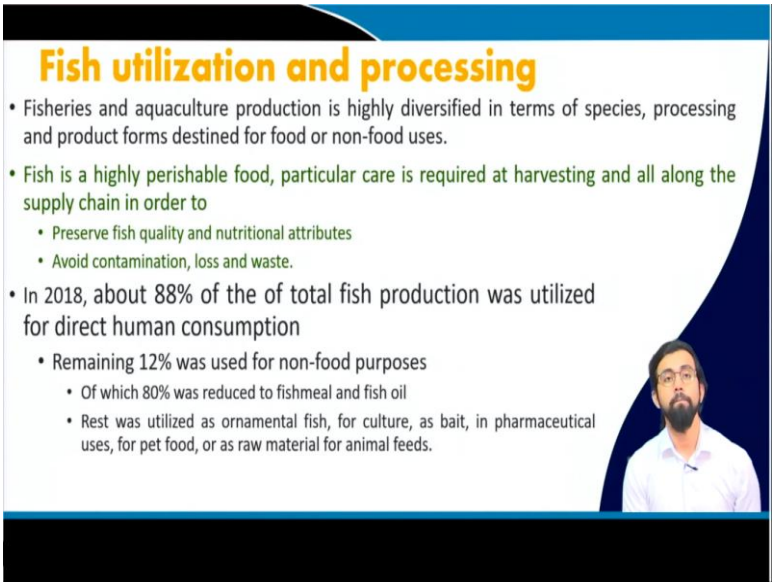

First of all, to start with in this module, the whole module I will be discussing about different fish preservation techniques in details and also you know like till now whatever we have discussed it is mostly focusing on aquaculture and all these things. I mean like aquaculture, how we develop, how we farm and all. But just realize that farming is not at the, not like the whole.

You have to in order to complete the process, once you have, once you harvest your fish harvest your aquatic species then it has to reach to the customer, it has to reach to the plate of the consumer. So, this process actually, it is like one of the major burden in aquaculture industries.

Why I am saying burden because this is highly perishable item, all the aquatic spaces. The moment you are taking it out of the aquatic, this water body, it is highly perishable. The moment they will die there will like there are different enzymatic activities going on in their body and all because of that they will it is a very highly perishable items. So, what we need to do?

We need to process it precisely and in such a way, so that it will be readily available and it can be available to the customer or say like you can directly put into the plates of the consumer but in a manner which they want. So, suppose I am just giving you one example. In Indian context we really like the hilsa fish and all. So, it is like one of the delicacy and all.

But the one major problem is it has a lot of bones which is not a very standard way of eating in the western world. So, what they normally try to have food which have fish which is already deboned. So, in order to export the material from here to say like in a western country, if you want them to eat your food, eat the food from the Indian scenario Indian context, what we need to do?

We need to debone it and then only we can supply it or we can do it other way. We can just supply it and then they can have the deboning in instrument there itself and all. However, it is very important that you know your customer you know your market, based on that you let alone this, not only the all the produce but all the catch from the seller capture fisheries, all the produce from your cultural fisheries has to be well managed.

So, first of all because it is a perishable item, so, you have to preserve it. That is one of the major problem. You have to preserve it properly and then only you can do further processing and all for further expectation to meet the market expectation or. So, first and foremost thing is preservations and all. So, that is very important.

We will discuss about all these things during these five lectures in this module. So, I hope you will be having at least some basic idea that what are the procedures that we need to follow when we go ahead with the, what we do with the aquaculture produce, what we do and what are the process that involves after we harvest them from the aquatic body.

You know this aquaculture; it is like highly diversified in terms of species processing and the product forms distined for food or say non-food users and all. And also, as I discussed, it is a perishable, highly perishable food and because of that we need to preserve in order to we need to go ahead with this proper fish utilization and processing units to preserve the fish quality and the nutritional attributes and also, we have to avoid any microbial contamination or any other foreign species called contamination, loss and waste of our harvested produce, harvested rearing animals.

So, rearing aquatic spaces. In general, in 2008 like almost 88 percent of the total fish production was utilized for direct human consumption. Remaining 12 percent is for the non-food purposes. What are the non-food purposes? First is out of those 12-percentage 80 percent is actually used for fishmeal and the fish oil. Just see the irony like you have to produce fish to replenish institutional provide the food for, as a feed for another type of fish.

Like, if you realize like it is said that it is a, they just say that if you go to the Scandinavian countries around their fishes are very good and all they do all the things in a very organical, organic way and all. However, those fish when they are cultured, all the culture, like when the culture is done for them they need the fishmeal. So, where this fish are coming from?

They are coming from all this a non-regulated capture fissure is way. So, they this capture fisheries is happening in the Atlantic region, in the Mediterranean regions which are unregular, which are like not under, which is not like proper jurisdictionary way. So, that has been done.

It is not all that it is just if you see the report, if you see the proper survey, it is being done for long and that fish actually been transported to these Scandinavian part, Scandinavian partners and all. So, they use it as a fishmeal and all. So, see in one way you are saying organic but it is actually in one way you are saying you are adhering to all the regulatory bodies, rules and all.

But in the other way it is actual detrimental for the ecosystem. Because it is actually utilizing a huge amount of fishmeal and for that it goes for, it captures a huge amount of captured fisheries a culture it uses a huge amount of culture capture fisheries. Anyway, to just to give you an idea like how like most of this fish is utilized for other fish culture itself. And rest of the 20 percent of this 12 percent of total value is actually utilized for, utilized as ornamental fish for culture as bait or in pharmaceutical uses, for pet food or for raw material for animal feeds and all.

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What is the fish product utilization? As we discussed on human consumption and non-food purposes. Almost 44 percent of these human consumptions are the live form or fresh or chilled form. Because they in this three form like either it is a live fish, it is a fresh and like or like just chilled fish then it is the most preferred and you will get maximum amount of economic benefit or return from the market if your fish is having this considered under this categories.

35 percent of the share is frozen fish products. 11 percent prepared or the preserved fish and 10 percent use the cured fish, after curing is done. Freezing is like you might have a know about what is live fish, what is definitely what is live fish and what is chilling and all. So, freezing is another technique.

Freezing represents the main like one of the main method for preserving the fish like we do it in refrigeration to preserve our food, the same way. But there is difference between chilling freezing and different different type of freezing as well. I will come to you come, I will discuss about all this thing in coming slides. However, in this freezing, it accounts for almost 62 percent of all processed fish for human consumptions.

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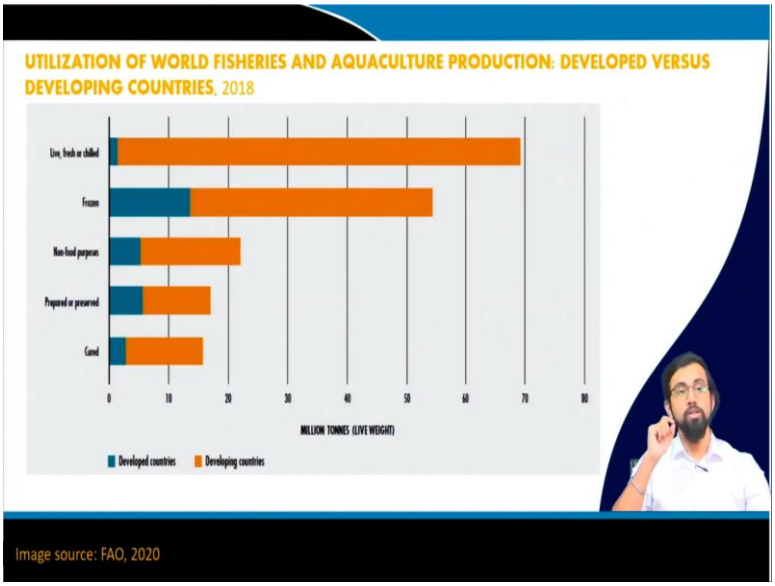

So, in general, if you see this graph given by this Food and Agriculture Organization 2020, this is the utilization of the fisheries and aquaculture production in developed versus developing country. If you see this orange line, it is actually showing the one which is been done in the developing countries, in the blue line is showing the, it is representing the developed countries.

In developing countries, they are utilizing the fish at its best form, most of the cases. They have it in either live, fresh or chilled form. In for developed countries, most of them are situated in the temperature or like polar region, so, because I mean like near polar region, because of that what happened?

They do not have access to much of, like they have access, they have their specific type of fish and all but they prefer to go for these frozen fishes and all. Frozen fish, cured fish or prepared or prepared food, prepared fish and all. That is what in general developed countries they prefer.

But in our case, we know in Indian context, if I talk about the live food is, live fish is much more preferred than the cured one or say like the frozen one. So, it is very typical that we find it awkward to when we go outside and we have we are buying stuff from the supermarket which are frozen fish and which is like there for like long and it is pocketed and it is coming from far away and you collect it and you have it.

So, it is like very normal outside India but in India it is we normally go for live fish. We go in the morning and we buy it like it is becoming more normal though times are changing. In metropolitan cities it is not possible so, they do it. They go to this different retail markets and all they buy it from there.

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Anyway. So, let us discuss about different preservation technologies. So, what are the technologies that is available and why we gonna do that? First of all, you know that fish body; it contains proteins, fats, minerals, vitamins, amino acids, iodine, phosphorus and also large amount of water.

Because of the presence of all these things they can, once they are dead, they can be spoiled very easily because of the process called decomposition. That is the reason, in order to get rid of this decomposition process; we need to go ahead with the different preservation techniques or methods.

However, like one of them on another major reason is the fish in, it does have some living bacteria in its scale. However, they are not, they cannot attack the when it is in living condition. The moment it died, what happens they attack their various body constituents, the moment it dies, this fish.

So, that is also another one of the major reason that we need to get rid of this, all this microbiota that is present in their scales also, we need to make them either dormant condition and also somehow by using this different preservation technologies. In general, in our

country the preservation technology that we normally follow the chilling or freezing, curing like drying, salting or smoking, canning.

So, these are the technologies that we normally follow. I hope from I before going into details from this name itself you could understand. Chilling, first chilling or freezing. You do low temperature preservation and techniques you use it. Then you do the curing by either dry it. Because once you dry it, one of the major reason of curing is what? In order to you have to get reduce the water activity. The moment you will reduce the water activity. How we can do that?

You can do for go for drying. So, it will reduce its water content. Salting, you can do this smoking and all. So, all these things, what will happen because of that? Its water activity will be reduced. Because of that there is a less chance of contamination. Then the canning. You put it in the can. You put it in the proper packaging of your product for maximum amount of; you can preserve it for maximum amount of time.

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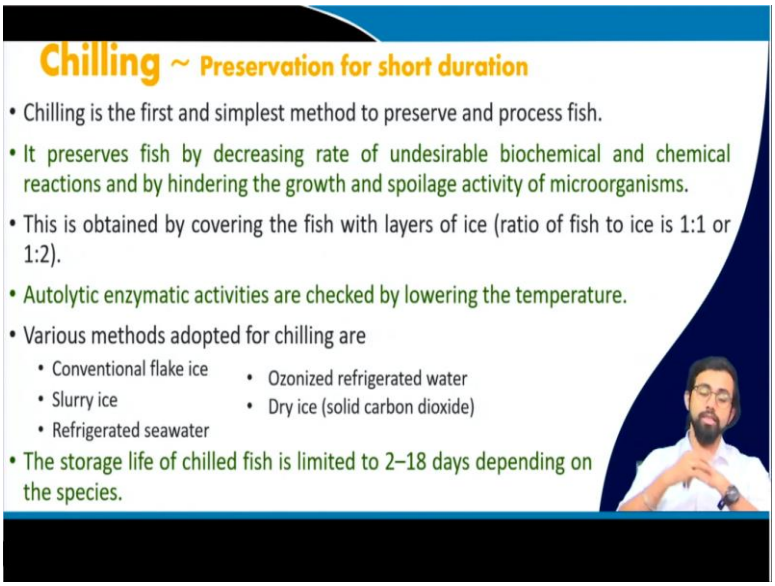

So, to start with, let us start with the chilling. So, chilling is like one of the fast and the simplest method to preserve and process fish. It preserves the fish by decreasing the rate of undesirable biochemical and the chemical reactions and also it hinders the growth and spoilage activity of different microorganisms, specially, the different enzymes. How it is done?

It is normally done by covering the fish with a layer of ice. The ratio of fish to ice is 1 is to 1 to 1 is to 2. Remember, so, this is very important. Especially, for capture fisheries when these trailers, the fish trailers they go for capturing the fish from the like the deep sea and all. So, they have to arrange, they have to ready with this ice blocks and all.

So, the moment they capture the fish they go for chilling because this is the one of the lowest energy consuming process of preservation. Then this, because of that what happened in case of chilling? These automatic enzymatic activities are also checked because of this lower temperature is assumption and all. What are the methods that we can adopt during this chilling process?

Conventional flake ice, slurry ice, refrigerated seawater; you can go for ozonized refrigerated water or dry ice or solid carbon dioxide. This conventional flake ice sometimes, we add it with the salt, certain percentage of salt, sodium chloride. What will happen? It reduces freezing temperature because of that it can stay for long.

So, that is also another way of preserving it. So, this is the different methods that we normally adopt during the chilling procedure. The storage life of chilled fish is limited to 2 to 18 days depending on the species because you cannot expect it to stay any longer, they even if it is in the chilling temperature but still different kind of cyclophilic microorganisms and also different kind of reactions, the chemicals that is secreting inside the fish body.

So, I will discuss with you details. Like what are those chemicals and what how it happens. So, in general, it is self-detrimental. It is like self-cleaning killing kind of activity. I mean like it will start decomposing even at chilling temperature also. So, that is why the next thing that we need to realize that we need to go for some preservation techniques which can preserve it for much longer time.

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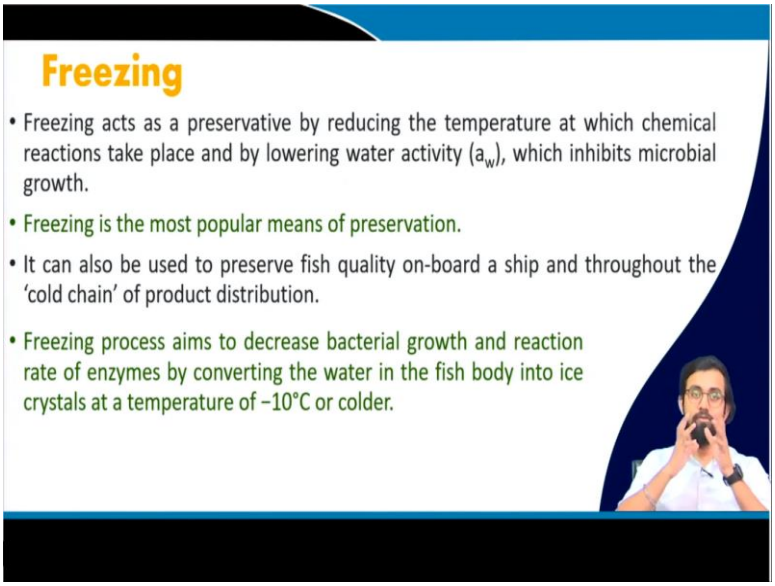

Freezing is one of this. In case of freezing, what is happening? It is by reducing the temperature at which any chemical reaction can take place and also by lowering the water activity which inhibits the microbial growth, we introduce freezing. Which is like at least minus 10 or colder minus, 10 degree Celsius or colder.

Freezing is one of the most popular means of preservations and it can also be used for preserving fish quality on board a ship and throughout the cold chain of product distribution. Freezing process aims to decrease the bacterial growth and the reaction rate of enzymes by converting the water in the fish body into ice crystal. So, now, the available water for the enzymatic activity to take place is 0. So, because of that it will not take place at all. So, because of that it will not go decompose very easily.

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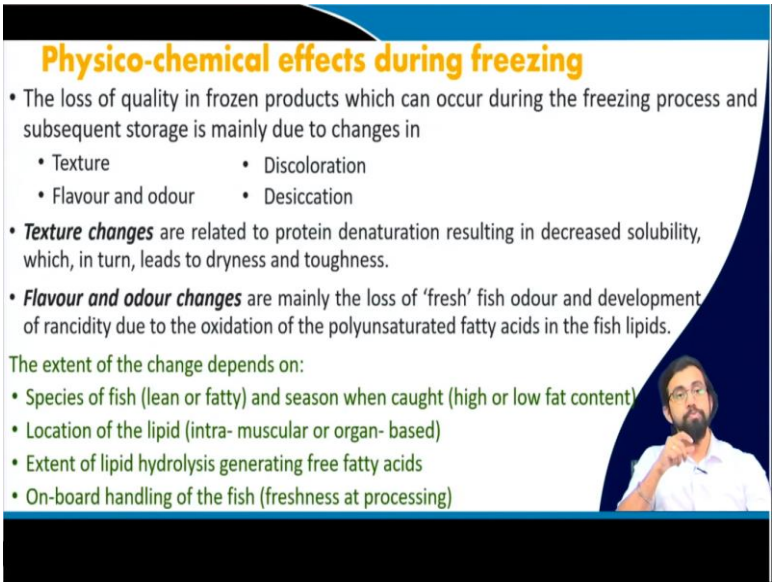

What are the effects, physical chemical effects that is happening inside the fish body, when we go for freezing? First is change in texture. Second is flavor and the change in odor, color change and desiccation. So, when you, it is not always like the best process. There is nothing called the best process. There is something that there is, any process comes with their pros and cons.

Freezing also comes with your cons part or the disadvantages. So, here what is the disadvantage? First of all, you see, the loss of quality in case of frozen product. It is there. If you freeze any product for like very long amount of time, you will say, you will feel the difference in the texture of the material. What is it?

First of all, the texture change is related to the protein denaturation, which is results in decreased solubility which actually in turn leads to dryness and the toughness of your product because of the protein denaturation. Second thing, the second changes is its flavor or odour changes. It mainly happens because of the loss of fresh fish odor or development of rancidity due to the oxidation of polyunsaturated fatty acids in the fish lipid. This is one of the major reason that even in the freezing condition also there is a chance that it may go wrong after a couple of days or weeks of preservation.

However, it depends upon the different factors that will be discussing you now. But believe me this to our major changes that also you might have witnessed also whenever you will put your aquatic any animal like seafood or this fresh water fish or something. You put it in the deep freeze.

You try to put it for a long period of time, you will see the difference. It will not taste the same, though people say like, okay; so, we can put it in the deep fridge, it will stay for like weeks and weeks. No. You do not do that. You try to have it as soon as possible. Unless and until, you are staying in a northern pole and you need to have your meat for your polar bear or ready for next 6 months.

So, try to have your fish as soon as possible, even if it is in the fridge. Because it will lose the texture and it does not taste that the same way that it normally tastes. What is the extent of these changes and what are the depending factor of it? First, the species of fish. So, first the species of fish. Is it a lean body or is it having a fatty body?

And the season when caught is like at that time whether it has high fat content or low fat content. How does it matter? You realize the changes in flavor and odor happens because of the polyunsaturated fatty acids. What is fatty acid? It is a fat. So, the more the fatty the fishes or the aquatic species, there is a high chance of it gets grants it. It very easily.

Second thing is the location of the lipid. Is it intramuscular or organ based? If it is organ based still you can just remove the organ, you can still have the its taste left. But if it is like intramuscular. No, Definitely no. It will competence it complete aquatic species. Extent of the lipid hydrolysis generating free fatty acids. What is the percentage of this kind of lipid hydrolysis generating free fatty acids present in your fish? Fourth is onboard handling.

Like how fresh it was when you put it for freezing. If do you wait for like whether it was captured from the deep sea and were in the chilled condition for like 4 or 5 days? By that time, it will already start decomposing. There will be like some decomposing very initial stage of decomposition will start. After then if you preserve it and the same time if you directly catch it and start put it in the freezer, these two situation is different. In the first case, there is a high chance it will go bad very soon. In the second case, it will stay for long.

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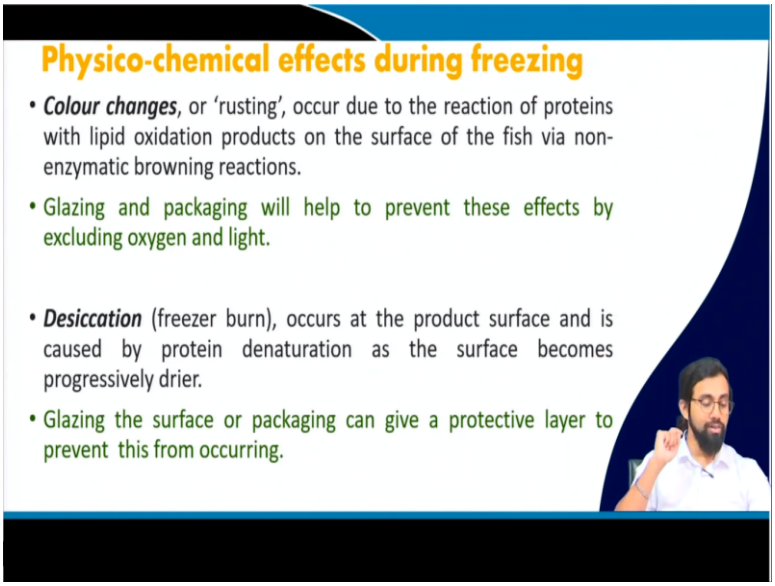

Third changes that you can witness is like the color change, mainly we call it rusting also. Though it is not the same rusting with the metal body, it is different rusting. It occurred due to the reaction of the proteins with the lipid oxidation products on the surface of the fish via non-enzymatic browning reactions.

In general, whenever this kind of non-enzymatic ground reactions happen, it changes the color of the fish. I mean like the surface color of the fish. This glazing and proper packaging can help prevent these effects by excluding oxygen and light. Most of the cases, this rusting happen. Why it is called rusting?

Which is similar to the metal body. Because it requires oxygen and light. If you preserve it perfectly in a dark condition with no oxygen condition, I mean like it is reduced oxygen condition, it can stay for long. Fourth is like the desiccation on the freezer burn. It occurs at the product surface and is caused by the protein denaturation as the surface becomes progressively drier and drier.

So, this desiccation you know like desiccation, desiccation means like in it is like it is a process by which we try to dry the, dry our sample and all. You might have heard in your lab, chemistry lab the desiccators and all. So, it has these crystals and all which will consume the moisture from your sample and it will make your sample intact without the presence of any moisture, it will not go bad. Same way, this desiccation happens. And we can how we can help it? We can glaze it with glaze the surface or package it properly and so, to give it a protective layer to prevent this kind of incident to happen.

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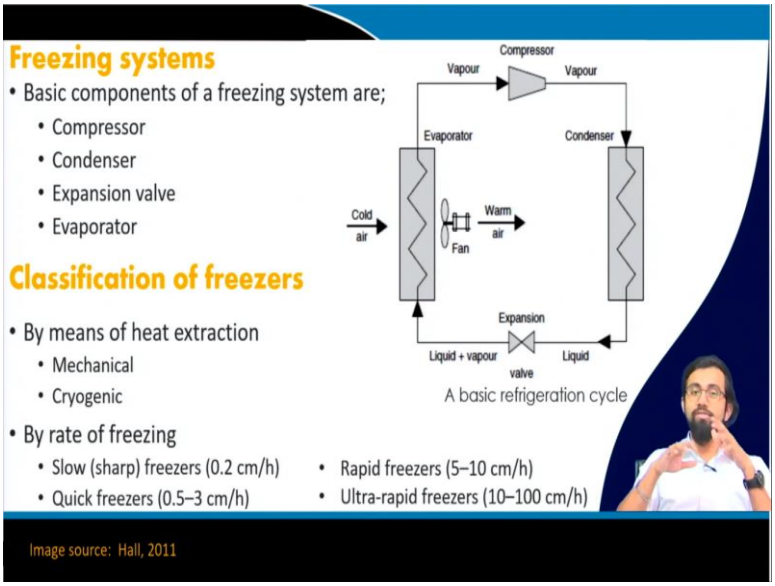

What are the freezing systems? You know, in the Carnot cycle on a refrigeration you have heard about it. Like it has these different units' compressor, condenser, expansion valve and evaporators. I really request all of you to go ahead and Google it how refrigeration works. So, you will be very happy, you will be in a Google if you search it how refrigeration systems works.

So, you will get to know a lot of videos and all that will definitely help you to understand it much better like how this phrasing system works. What are the classification of freezers? Like by means of heat extractions, we call them mechanical or cryogenic. By the rate of freezing, sometimes, we call them slow freezers like 0.2 centimeter per hour only, rapid freezer 5 to 10 centimeter per hour, quick freezer 0.523 and ultra-rapid freezes which 10 to 100 centimeter per hour. It consumes a huge amount of energy though.

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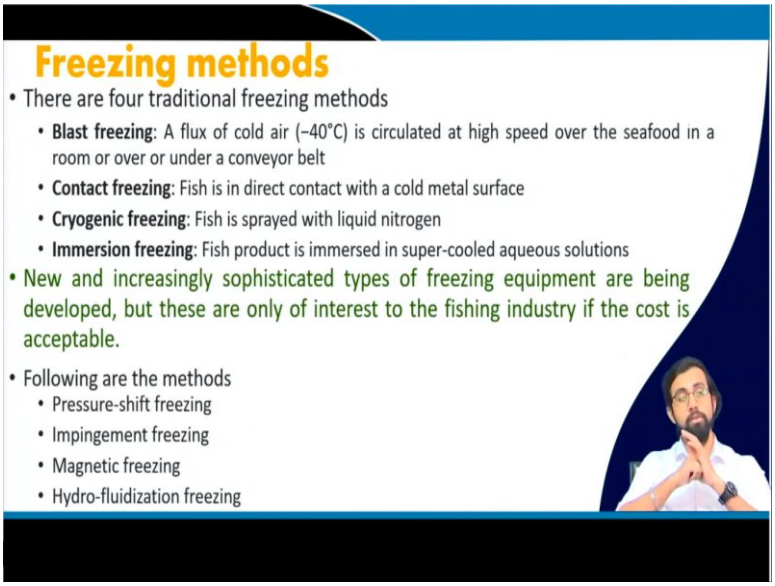

What are the different methods that is available? First, blast freezing, which is like you are providing a flux of cold air, minus 40 degree Celsius cold air at a very high speed over the seafood in a room or over or in a under a conveyor belt. What will happen? The moment suppose, it will go, the conveyor belt is moving, there is like one chamber just like when you go to the airport, they check your baggages and all. It is like the same.

So, the structure is the same. So, the conveyor belt will moving. It will come into the, it will stay in the, they will be having certain retention time inside the chamber. And in the inside chamber, it will thrust the high flux of cold air and because of that it is called blast freezing. And because of that it will get freezed very fast. Contact freezing. Fish is in direct contact with the cold metal surface.

A cryogenic freezing. We use the liquid nitrogen for freezing it cryogenically. You know liquid nitrogen is like minus 120, 190 degree Celsius and all. So, it is like it is in very ultra-freezing state. Immersion freezing. Fish product is immersed in a super cooled aqua solution sometimes. So, all these processes are there by which we can do the freezing of your aquatic species.

Now, it is all more and more sophisticular techniques are coming out. But it has to be acceptable to the fishing industry and has to be as low cost as possible. What are the methods, in general, we provide while doing the freezing? It is like pressure shift freezing, impingement freezing, magnetic freezing, hydrochloride freezing etcetera.

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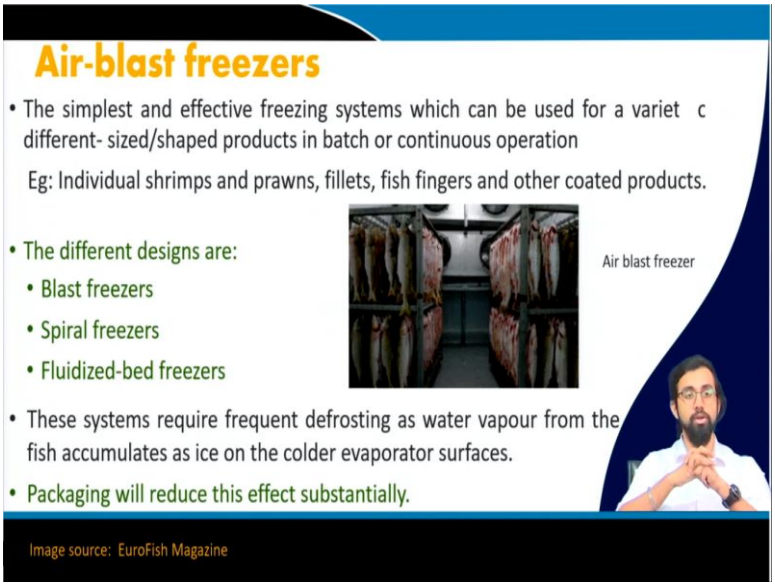

So, how does air blast freezing works? It is one of the simplest and effective freezing systems which used like different varieties of shaped products in a batch or in continuous operation. You provide this air blast and some at very low cost, low temperature and all. It will be used for individual shrimps, prawns, fillets, fish fingers and other coated products also.

The different designs can be blast freezers, spiral freezers, fluidized bed fridges and etcetera, etcetera. So, if you want to know more in details, I think in this stage, you do not have to know more in details. The moment you will become, you will do any specialized course on food processing or like aquatic species processing industries and all, then you can start understanding; you can start learning all these things in details.

The packaging is very important to reduce this kind, this unnecessary. The defrosting thing to happen. What is defrosting things? There is a chance like the systems required very frequent defrosting. Because the water vapor which is coming from the fish it accumulates as ice on the colder evaporator surfaces and all.

This evaporator surfaces has to be, because of that it has to be, you have to keep on defrosting it. Defrosting means you have to go warm it, warm it very frequently in order to get rid of this, all this moisture and all. Packaging. If you do the proper packaging and then you put it in the air blast freezer, it will reduce this effect drastically.

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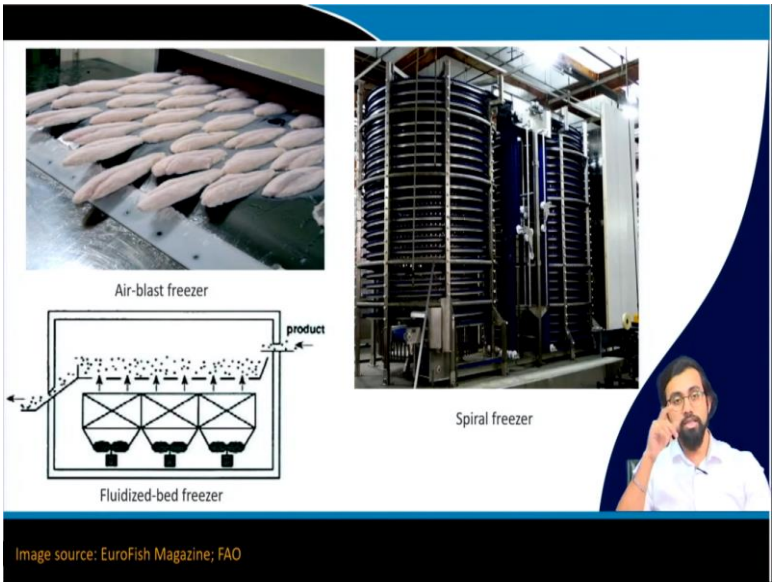

See this air blast freezer. I told you this conveyor belt it is coming out of these systems and it becomes very solid in nature and because of all the moisture present in its body is converted into ice. The fluidized bed freezes. You can see the air, the cold air is flowing from the bottom and because of its like it is a fluidized condition. So, why is a fluidized condition?

Because of its because of this air, it will be in air, it will be, so, larger surface area of the product will be in touch with this cold air and because of the efficiency can be much higher. These spiral freezers are there. There it will get, you will get much more contact time based on your species and requirements of your market demand.

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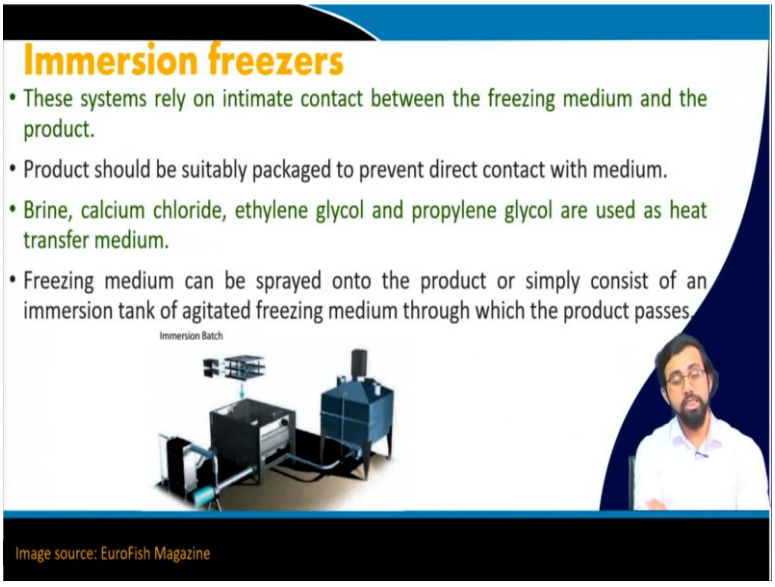

Immersion type of freezes that we discussed, it needs to be you need to provide some proper contact time between the freezing medium and the product and its modal product has to be properly packed to prevent the direct contact with the medium. We can provide brine, calcium chloride, ethylene glycol or propylene glycol which is used as it is heat transfer medium. And this freezing medium can be spread onto the product or simply consist of immersion tank of hydrated freezing medium which throw, which the product will pass.

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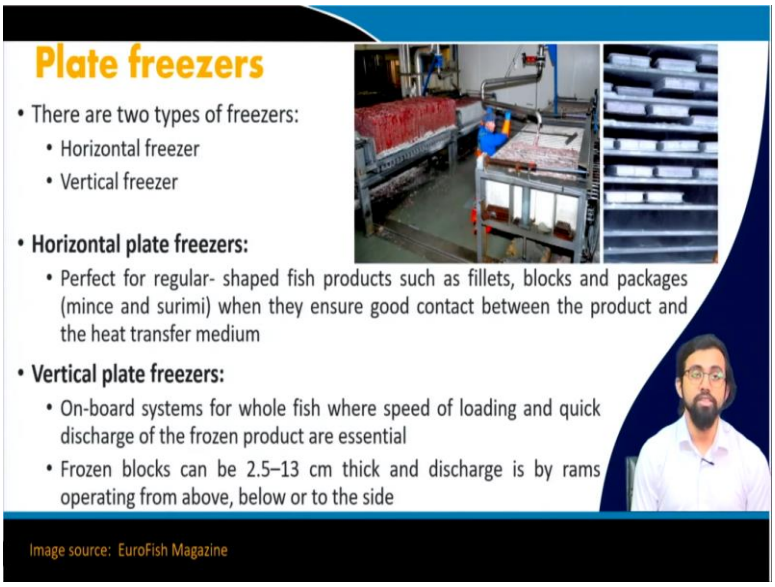

Then there comes the plate freezers which can be horizontal. If you see the right ones or the vertical in the left one. So, horizontal plate freezers like perfect for regular shaped fish products such as fillets, blocks, packages mince or surimi type of. And vertical plate freezers I like onboard systems for whole fish where the speed of loading and the quick discharge of the frozen product are essential. And frozen blocks can be 2.5 to 13-centimeter-thick and discharges by the ramps operating from the above below or by the side.

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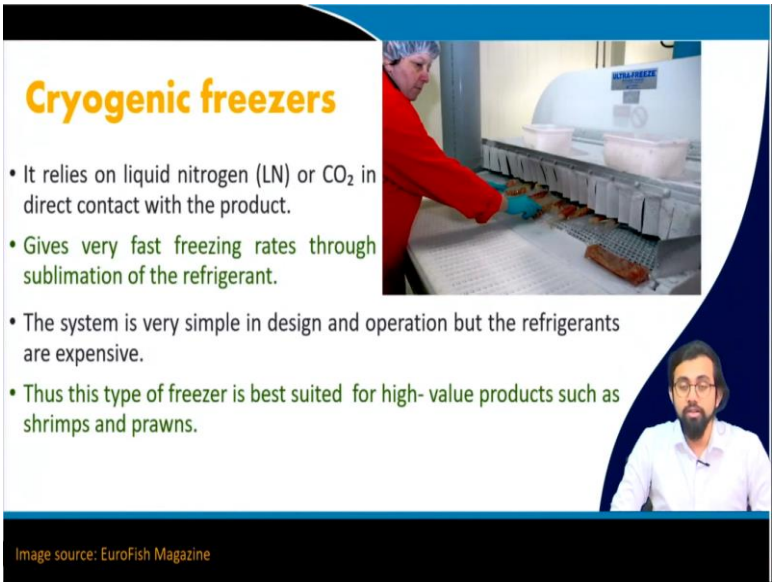

Then there comes the cryogenic freezers. We use a liquid nitrogen or the liquid carbon dioxide or in direct contact with the product. It gives a very fast freezing rates through sublimation of the refrigerant and the system is very simple in design and operation. But the refrigerants are expensive. So, the system, though the system design is very easy but sometimes is because the refrigerants are so expensive, it may increase the cost of your product, final product. However, it is best suited for high value product like shrimps and prawns.

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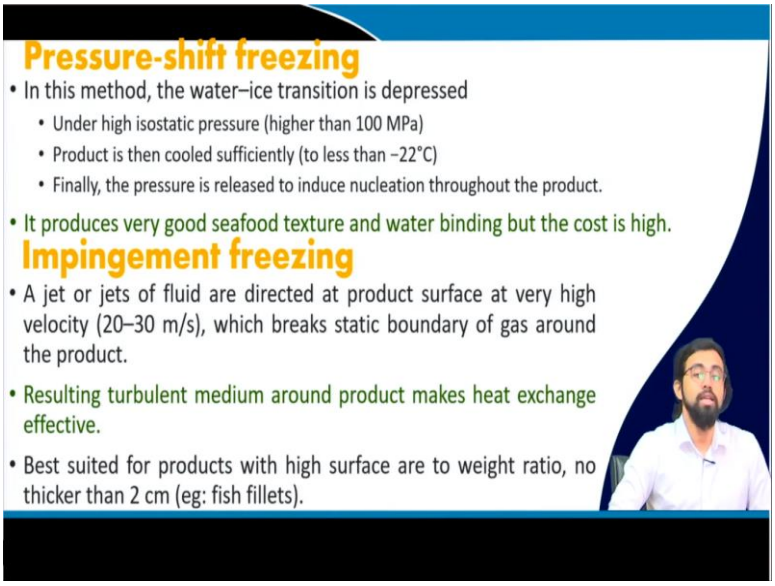

What are the other types of freezings? Like pressure shift freezing. In this method like high, like it is waterized transition is depressed by using high isostatic pressure like almost more than 100 Mega Pascal, almost like 100, like 10 to the power 6 Pascal. So, product can be cooled sufficiently using this process like almost minus 22 degree Celsius, even more.

And which is beneficial. Because, and at the end the pressure is released to induce the nucleation throughout the product. So, it gives the final your product a very nice texture and water binding. But with the cost is very high. Because you have to provide some equipment which can cause very high pressure to your systems.

Impingement freezing or jet or jets of fluids are directed at product surface at a very high velocity 20 to 30 meter per second and which breaks the static boundary of gas around the product, resulting turbulent medium around the products which makes the heat exchange much more effective. It is best suited for products with a very high surface area to weight ratio. No thicker than 2 centimeter.

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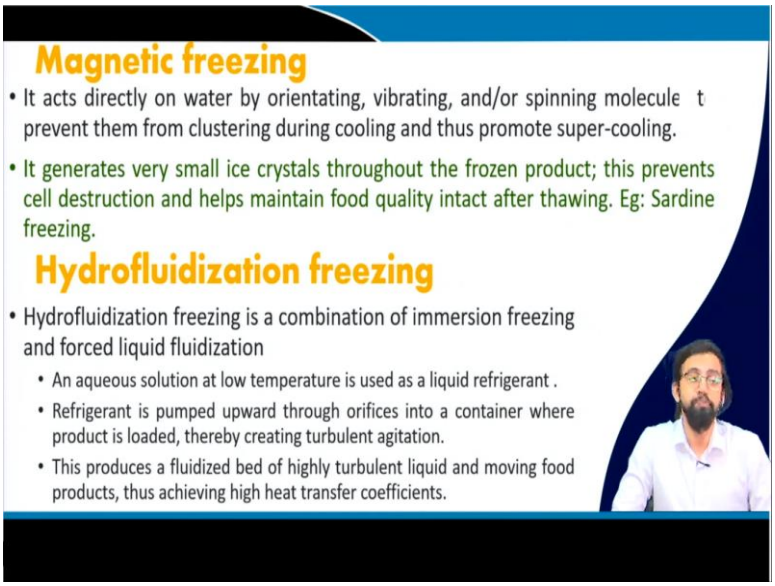

What are the other type of freezing methods? Like the magnetic freezing. What we are doing here the magnetic freezings, they the water molecules, all the molecules they constantly in a different state of locomotions. We call them orientation like in a vibration state, spinning states and all. So, all these things like this transitional and all.

So, anyway. So, here, what we do? We use these water molecules which water molecules in magnetic structure, in a magnetic reactor where they are used this water molecules to orient,

deorient and orient and vibrate and also spin, to prevent the clustering during the cooling process. And because of that it promotes the super cooling phenomena.

Because of the super cooling which generates a very small ice crystals throughout the frozen product, it prevents the cell destruction and helps to maintain the food quality intact after, even after thawing. Like sardine freezing and all. Another important thing, another important technology is like hydro fluidization freezing. In case of hydrofluidization freezing which is actually this like kind of combination of immersion freezing and forced liquid fluidizations.

Normally any aqua solution with a very, at a very low temperature is used as a liquid refrigerant and it is pumped upwards through the orifice into a container where the product is loaded and thereby creating a turbulent agitation. Now, the product, this produces a hydro fluidized bed of highly turbulent liquid and moving food products. Thus, achieving a very high heat transfer efficiency because of higher specific surface area exposed to it.

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So, all these methods that is available. So, I am not going into details of it. Just to give you a very brief idea, very overall idea, what are the procedures that we normally follow in case of these freezings and all, so that you will get to know some basic informations. The more detailed information if you want, you can go ahead and Google it.

You can find very interesting informations about each and every process and I would really prefer you to do that, so that it will enhance your own knowledge about this particular subject. In general, as a conclusion I can say fish and fish products, they are very much

perishable and we need to go ahead with different processing and preservation techniques and freezing is one of the most effective one.

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And however, in general, this freezing, it modifies the structure and the chemical properties of muscle and it increases the fatty acid, free fatty acid content and the liquid oxidation production. And because of that like what will happen? So, actually it will be the decreasing. So, decreasing this free fatty acid content and the lipid oxidation products and because of that it will be much more effective in case of when you go for this freezing and all. So, main objective is minimize the microbial load, reduce the enzymatic activity and preserve the flavor and the nutritional property of your species.

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These are the references that you can follow and thank you so much. I hope you get to know some very basic details about how it works the different preservation techniques and all. We will for the next four modules also, for lecture material for this module also I will be discussing more in details about different other preservation technologies and all. So, to give you some overall idea how the fish processing industries work and how different aquatic spaces processing and preservation technology works. So, thank you. So, much see you in the next lecture.