Advance Aquaculture Technology
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Lecture – 26
Balanced Diet

Hello, everyone welcome to the sixth module on the Aquafeed technology. My name is Professor Gourav Dhar Bhowmick, I am from the Agriculture and Food Engineering Department of Indian Institute of Technology, Kharagpur. So in this particular lecture we will be discussing about the balanced diet not for us but for the aquatic species.

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The major concepts that I will try to cover is like introduction to the aquafeed, what is that aquafeed, what are the major constituents and major like ingredients of an aquafeed. Introduction to balanced diet, components of a balanced diet, protein, lipids and fatty acids and the carbohydrates.

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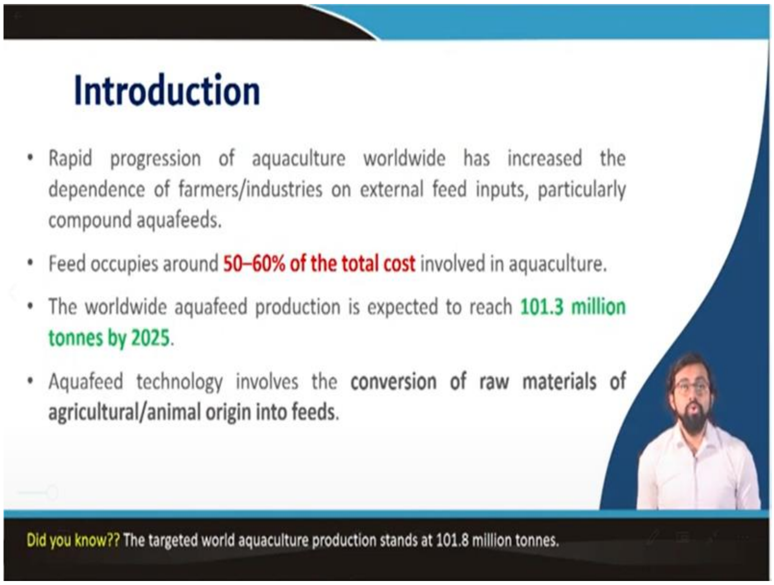

So in general if you talk about the aquafeed, you know that recently the aquaculture is getting bloomed all over the world. And now it is almost at 50 - 50 percent, like 50 percent of the capture fishery and 50 percent of the culture fisheries. So this culture fisheries is nothing but the aquaculture in general when we talk about. So it is blooming like anything even like in last couple of decades.

So and because of that aquaculture comes from its extensive to the intensive aquaculture systems in open to closed aquaculture systems. So how does it matter? What are the factors that it involves like when we talk about conversion of technology like this? In general when we were discussing about the when we were reading our aquatic animals when we were capturing the aquatic species from the nature itself we do not need to…

We do not have to worry about the feed. We do not have to worry about what it takes, what it eats and all. But when we talk about when we start thinking about taking all the culture system, all these capture fisheries to the culture fisheries and when we start culturing this aquatic species by ourselves in optimal conditions, providing the optimal conditions and mimicking the natural environment.

We need to provide them with the feed. And what they are going eat? So this is the basic thing, the food that it requires for the aquaculture species to grow is very important. And it generally it constitutes as high as 50 to 60 percent of the total cost involved with the aquaculture. Because this is the major recurring cost. Because when we talk about the capital cost like the non-recurring cost when we develop the structure itself and all.

But recurring cost is very important it comes like day-to-day basis, even hourly basis also like based on the culture species. So in general the aquafeed production is expected to be around 101.3 million tons by 2025, which is like very huge, and you can easily identify you can easily understand like how good of a market, still it lies in the con in countries like India.

If you go ahead and start thinking about the proper chemical compositions and if you can develop your own business model in aquafeed technology it is actually one of the major thrust area of aquaculture now a days in India. And people are really looking for the cheap and highly nutritious and properly balanced diet or the feed available for their aquatic species to grow.

In general aquafeed technology it involves the conversion of raw material of agriculture and animal origin into the feed.

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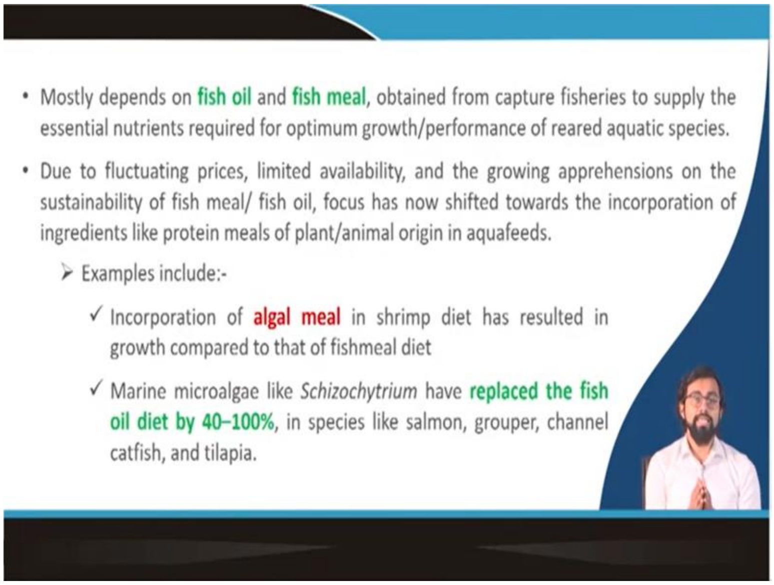

So mostly we depend upon the fish oil and fish meal. So it is very surprising that when we go for aquaculture most of the aquaculture species they are carnivorous or say like omnivorous in nature. So what they do they only take food which is highly, which contains high amount of fish meal or fish oil. And to get this fish meal and fish oil you have to culture again or you have to catch it from the here.

So this is the vicious circle it is you go for aquaculture and for the aquaculture you have to make feed, you have to give them feed and the feed is what fish itself, so that also you have to culture or otherwise you have to capture again. So that is why this balance you have to maintain. Either you have to culture the fishes which can be utilized for as a fish meal for other type of fishes or either you have, you go for capture fishes and which will, which does not make sense.

So at the end you have a imbalanced, you are actually not like properly balancing your, the environmental condition. So in general what we need to do, we need to think about the optimal condition, optimal diet manner that we can prepare for your culture species, where there is as minimum as fish meal as possible, from the capture fisheries rather than the fish meals which are coming from the culture fisheries or the waste fish products or waste fish materials or like that can be somehow used.

I am not saying it is just an example I am giving I will give you one details how the how all these things actually does matter and how fishmeal and fish oil is essential. And how they prepare and how they are actually being prepared and how they can they are actually utilized by other fishes and for their growth, other aquatic species for their growth.

In general due to the fluctuating prices, limited availability and the growing apprehensions on the sustainability of fishmeal and fish oil, nowadays the focus has been shifted to the incorporation of ingredients like protein meals of plant and animal origin in the aquafeed. What is the option for that like say algal milk.

Seaweed, seaweed is very important, nowadays people are working on it, like how the seaweed can be like, when we suppose extracted the important essentials like some important essential nutrients or the byproducts for it. And then that extracted biomass, how that can be used or say like not extracted biomass directly that seaweed only, how they can be utilized say like they can be dry, they can be make it in the powder form and they can be supplied with the diet for a shrimp.

And it is found out that they are actually much more beneficial than fish diet in some cases, because they are also reaching the essential nutrients available for a new, needed for the culture species growth. So this is the alternate, algal meal is the alternate. Micro algal meal is the alternate. Macro algal mean like seaweeds are alternate to the fish meal diet.

What are the other alternate like as we discussed the microalgae like the size of schizochytrium you can see they have replaced the fish oil diet by 40 to 100 percent and in species like salmon, grouper, channel, catfish and tilapia, et cetera.

This is what we need, this is what we need to think about we need to, this is the futuristic feed module, feed model that we need to focus on developing. And countries like India it is very essential for us to find out a proper feed formulation technique, so that that can be utilized by the even poor of the poorest farmers without hampering their economic benefit.

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So when we discuss about all these things like diet and all it is very important to discuss about balanced diet. So it is like same as when we go for exercising or even like when your health is not go down when we want to become a healthy person. When we do we go for best when we go to the nutritionist and ask them to provide us with what will be the best dietary routine that I can follow. So it will be considered as a balanced diet it will provide me all the calories required for my all the aerobic respiration process to finish.

And also it will surplus me with some additional amount of, calorie additional amount of meals to which will be stored in my muscles or in my stored in different parts of my body. So that is how the balance diet is actually been developed. Same way when we go for culturing a fish or culturing an aquatic species you have to develop a balanced diet.

So aquaculture in general when we go for high density indoor farming or say like in a confined cages you have to involve with the balanced diet or proper complete diet you have to supply. Otherwise what will happen it will be it will be like lack of nutrient that available for them for to survive for you because like see you are anyway you are culturing them in captivity. When you are culturing them in captivity it does not have any access to natural the food system.

So what it will do it is completely relying on the supply by you by the producer, by the farm owner. So that is why this feed, it has to have like all the essential nutrients possible for your fish to have. So that is how the, that is how it is to be maintained, that is how the, that is why complete diet or the balance diet is necessary for your aquatic plant and for your aquatic species and for proper development of your farm.

In general when we go for this outdoor raceways or the within ponds we only go for the supplementary diet sometimes. Because supplement diet do not possess all the required vitamins or minerals but only use the supply extra carbohydrate protein and lipid. Carbohydrate is not much important for as a fish meal but protein and lipids it. I will discuss about in a detail say how does it how does all these things matter.

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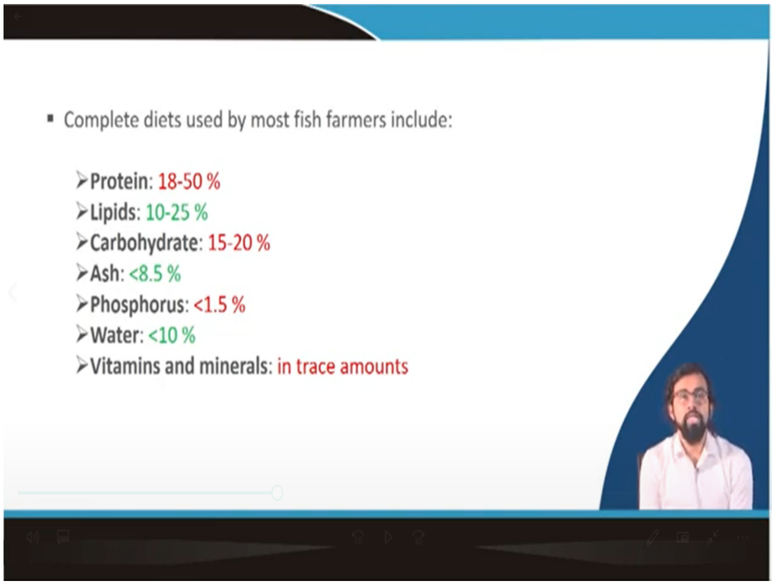

So in general complete diet used by most of the fish farmers it includes in general this is in general I am talking about it is like protein is like 18 to 50 percent lipid is like 10- 25, carbohydrate 15 to 20, ash content like m less than 8.5 preferably phosphorus less than 1.5. Water content should be less than 10 percent as well it depends upon the type of the pellet or the type of feed. Vitamin and minerals in trace amounts but optimal all the vitamin essential vitamins and minerals has to be there.

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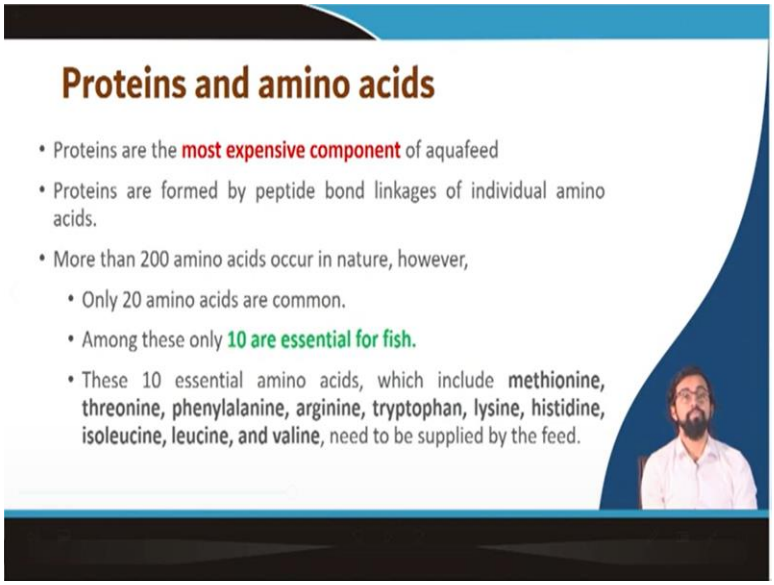

So let us talk about the individual components in nutrients in general. Just to give you a perspective about how fish feed is formulated what are the essential nutrients that it requires and like why it is important for their for their healthy being, for making them a healthy being. First thing is the protein and amino acids, I think you already know, this is the most important and most expensive component of aquafeed.

Because this is the source which we are getting from either fish feed or algal feed or like micro algal or macro algal feeds in general. So this is the source that we normally extract from other fishes or other living beings only it is like mostly possible from the living being. And because of that it makes it a very costly product or costly component of aquatic feed.

So in general proteins are formed by the peptide bond linkage of individual amino acids, so this amino acids are the unit of protein. So there are more than 200 amino acids occur in nature however 20 amino acids are common or the kind of essential for us. But for fishes it is some around only 10 amino acids which are considered to be essential for fishes.

What are these essential amino acids methionine, threonine, the phenylalanine, arginine, lysine, etcetera. So these are the very essential amino acids which are very much responsible or very much needed when we are supplying feed to them.

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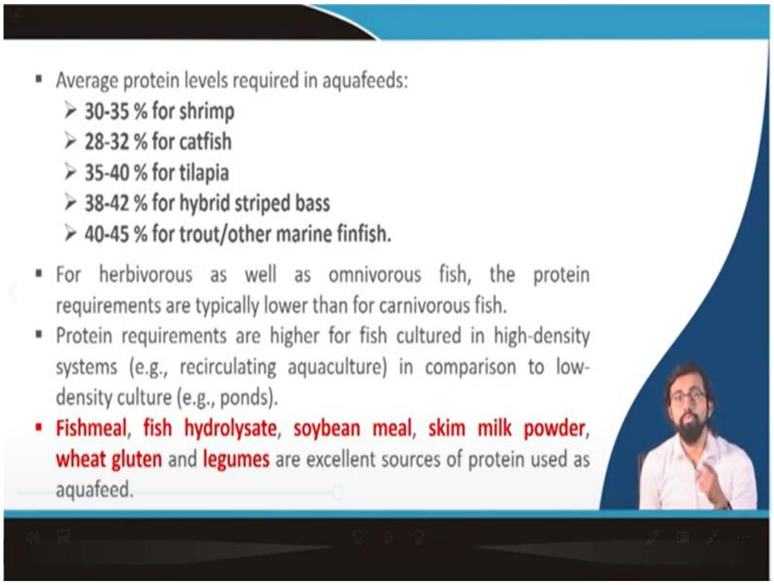

So average protein level in the aquatic feed, it differs from species to species. For shrimp it can be 30 to 35, catfish 28 to 32, tilapia 35 to 40, for trout and many fishes can go as high as 45 percentage. So for them you have to provide them with a very high content high amount of protein in the formulated feed. For herbivorous as well as for the omnivorous fish the protein requirements are literally like typically lower than the carnivorous fish in general.

However, it can be higher for fish cultured in high density systems likely recirculatory aquaculture systems in comparison to the low density culture systems. Why? because in high density you they are completely relying on your food on your systems on your feeding behavior and all. But in terms of low density culture they are still relaxed they are still in less stress condition and less relaxing in a relaxed condition.

So that is why the recirculatory aquaculture system does require very high quantity of balanced diet which contains huge amount of protein at least much higher than compared to the low density culture systems. Fish meal, fish hydrolysate, soybean meal, skim milk powder, wheat gluten and the legumes are excellent sources of protein used in the aquafeed. So these are the source that we normally use for as a protein source for the aquafeed formulation that you may remember you can think you these are the very standard sources actually.

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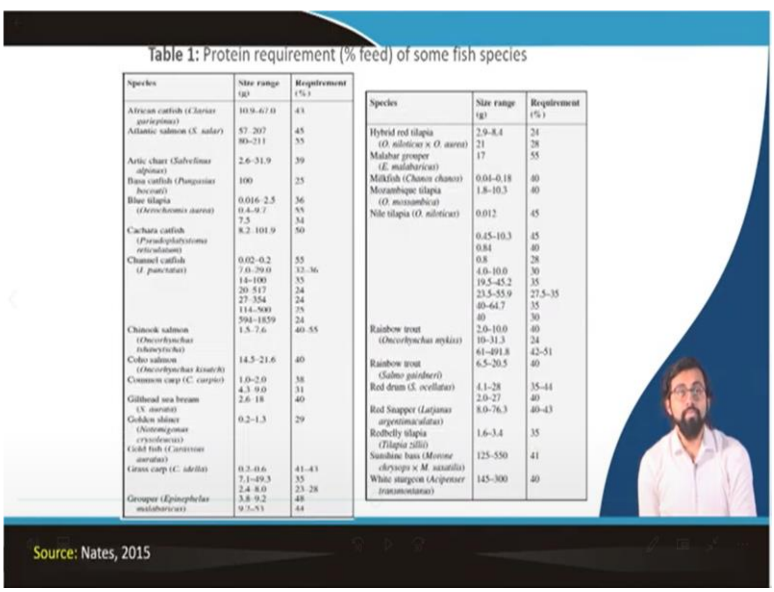

So this table actually is showing you the requirement of protein for different fish species as per the Nates et al 2015. I will share it with the paper also in the reference section at the last at the end of this lecture that how this different, if you go ahead with this paper you can understand, you can really not a note down for when suppose you culture a specific type of culture species and what will be the requirement for its protein. So based on that you can formulate your feed or you can choose your feed from the available market products.

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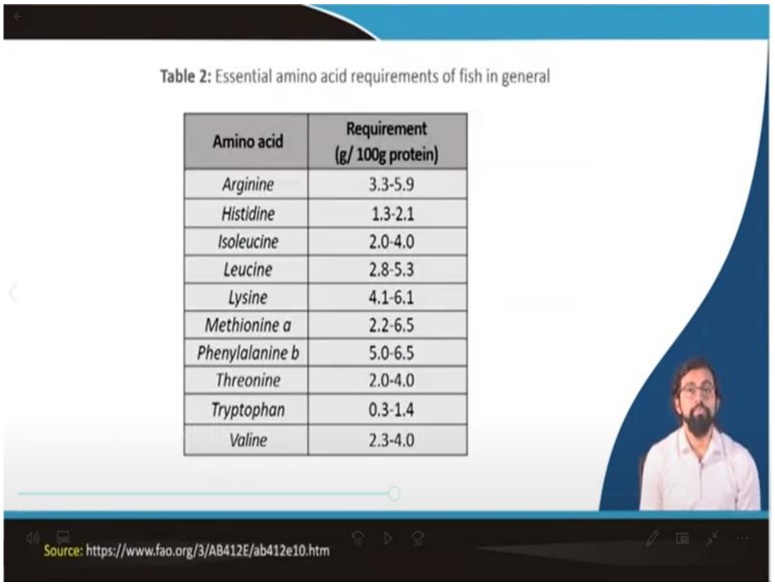

Amino acid	Requirement (g/ 100g protein)
Arginine	3.3-5.9
Histidine	1.3-2.1
Isoleucine	2.0-4.0
Leucine	2.8-5.3
Lysine	4.1-6.1
Methionine a	2.2-6.5
Phenylalanine b	5.0-6.5
Threonine	2.0-4.0
Tryptophan	0.3-1.4
Valine	2.3-4.0

In general the essential amino acids like this arginine, histidine, leucine, lysine, all this valine and etcetera. So all these cases the requirement in general it lies between say like the ranges are given it is in their unit in gram per 100 gram of protein. So say like you are providing them 100 gram of feed out of them 40 gram is protein in general it has to have out of those 40 gram.

So if you can you can use the unitary method to find out what will be the concentration of amino acid arginine amino acid what will be the concentration of lysine what will be the concentration of threonine what will be the concentration of the valine etcetera. So this is the, this is a very in general one.

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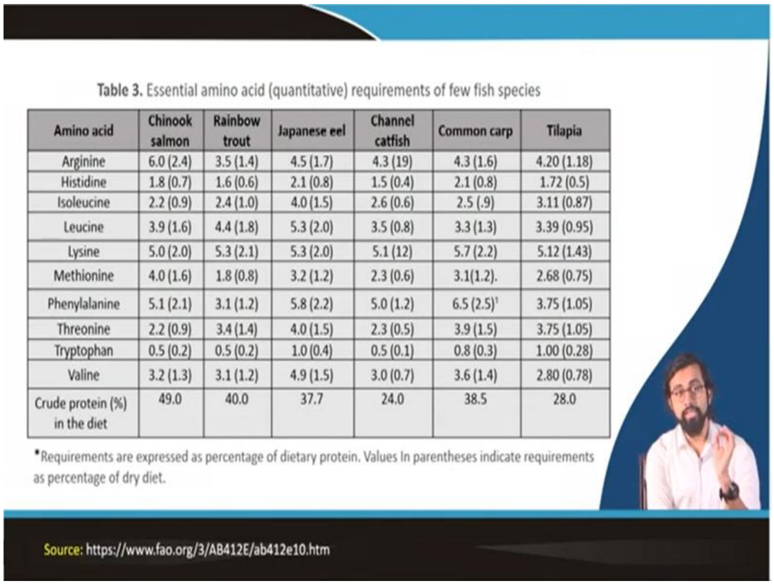

Table 3. Essential amino acid (quantitative) requirements of few fish species

Amino acid	Chinook salmon	Rainbow trout	Japanese eel	Channel catfish	Common carp	Tilapia
Arginine	6.0 (2.4)	3.5 (1.4)	4.5 (1.7)	4.3 (19)	4.3 (1.6)	4.20 (1.18)
Histidine	1.8 (0.7)	1.6 (0.6)	2.1 (0.8)	1.5 (0.4)	2.1 (0.8)	1.72 (0.5)
Isoleucine	2.2 (0.9)	2.4 (1.0)	4.0 (1.5)	2.6 (0.6)	2.5 (.9)	3.11 (0.87)
Leucine	3.9 (1.6)	4.4 (1.8)	5.3 (2.0)	3.5 (0.8)	3.3 (1.3)	3.39 (0.95)
Lysine	5.0 (2.0)	5.3 (2.1)	5.3 (2.0)	5.1 (12)	5.7 (2.2)	5.12 (1.43)
Methionine	4.0 (1.6)	1.8 (0.8)	3.2 (1.2)	2.3 (0.6)	3.1(1.2).	2.68 (0.75)
Phenylalanine	5.1 (2.1)	3.1 (1.2)	5.8 (2.2)	5.0 (1.2)	6.5 (2.5)[1]	3.75 (1.05)
Threonine	2.2 (0.9)	3.4 (1.4)	4.0 (1.5)	2.3 (0.5)	3.9 (1.5)	3.75 (1.05)
Tryptophan	0.5 (0.2)	0.5 (0.2)	1.0 (0.4)	0.5 (0.1)	0.8 (0.3)	1.00 (0.28)
Valine	3.2 (1.3)	3.1 (1.2)	4.9 (1.5)	3.0 (0.7)	3.6 (1.4)	2.80 (0.78)
Crude protein (%) in the diet	49.0	40.0	37.7	24.0	38.5	28.0

*Requirements are expressed as percentage of dietary protein. Values In parentheses indicate requirements as percentage of dry diet.

Source: https://www.fao.org/3/AB412E/ab412e10.htm

In this chart it is given more in depth and more accurate values that is found out by the FAO in there in the source is also given you can check it I will show you in the reference section you can take a picture or you can go ahead with the google it and get all the details of.

Suppose you are targeting a Japanese eel when you are targeting to culture a Japanese eel what will be the concentration of arginine, histidine, isoleucine, leucine, lysine etcetera. And exact values are already given so this is the standard value and optimized value that is true that should be there in your formulated feed in your feed and to supply it for the balanced diet composition.

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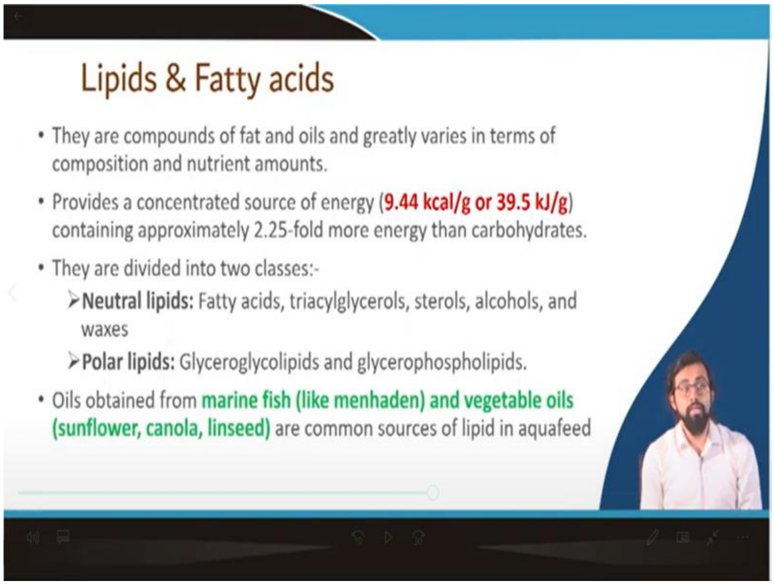

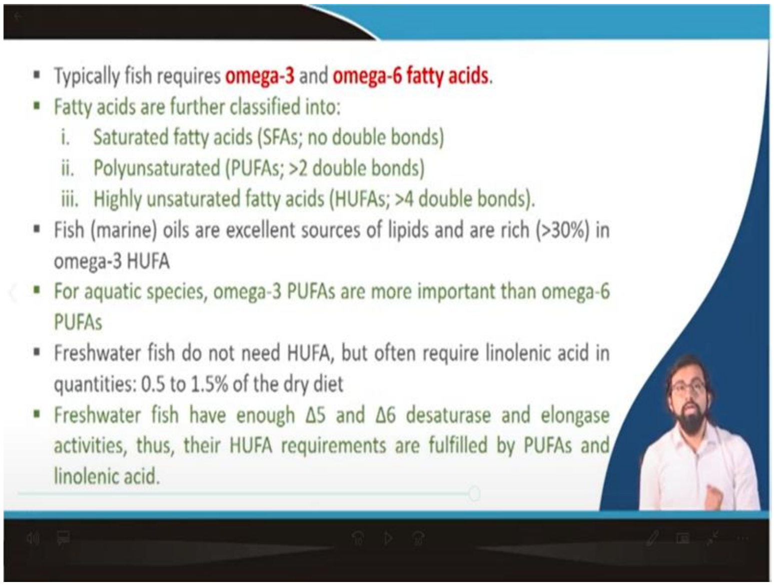

Second thing is the lipids and the fatty acids. There are compounds of lipids, there are compounds of fat and oils and the great, actually it greatly varies in terms of composition and the nutrient amounts. In general it is a very concentrated source of energy fat has a very high source of energy it can be as high as 9.44 kilo calorie per gram.

If you convert to the kilo joule it is like around 40 kilo, 39.5 kilo joule per gram of energy that it can per gram of dry weight it can supply that. This is a very high, actually this is a one of the major source of energy for the aquatic species, which is like almost 2.25 fold higher than the carbohydrate source. What are the neutral lipid concentration lipid those are available? The fatty acids, triglyceride, glycerols, sterols, alcohols or waxes, etcetera. The polar lipids, the glycerol glycolipids, the glycero phospholipids etcetera. So this are the type different type of the class of lipid that is mandatory for your, is to be available to your feed so that they will be supplied with ample amount of this peak concentration there is like this particular lipid concentration.

In general oil are obtained from the marine fish like menhaden and all. However, the vegetable soils are also common source, like sunflower oil, canola, and linseed oil are also a very common source of lipid for the aquatic for aqua feed formulation. Typically fish requires omega-3 and omega-6 fatty acids. However, the fatty acids can further be classified into three different types, first one is saturated fatty acids or in short we call SFS.

It does not have any double bond okay if you go for this chemical composition it does not have any double bonds in it. Second is polyunsaturated or PUFA we call it polyunsaturated fatty acids it has more than two number of double bonds. Third is highly unsaturated fatty acids or HUFAS or in general we call it in general it does have more than four number of double bonds.

So when this is in general classification of fatty acids. So you have to remember the saturated fatty acids polyunsaturated and highly unsaturated fatty acids. So SFS, PUFAs and HUFAs. It is very important for you to remember this terminologies it will be useful for you. And in general fish oils like when it is coming from a marine source, like menhaden and it is excellent source of lipids and very rich, more than 30 percent of it contains omega-3 HUFAs, omega-3 highly unsaturated fatty acids.

So in case of aquatic species or say like omega 3 PUFAs are more important than omega 6 HUFAs. So omega 3 is important but omega 3 polyunsaturated fatty acid is much important than omega 6 polyunsaturated fatty acids. Fresh water fish do not need HUFAs. If you are culturing fresh water fish it can survive without the presence of highly unsaturated fatty acids.

Why I will tell you in soon, I will tell you soon. In general they are often, but often they require the linoleic acid in general, linolenic acid in quantities like 0.5 to 1.4 percent of the dry diet. And why they do not need HUFAs? They have enough delta 5 and delta 6 desaturated or elongase activities these are the kind of enzymatic activities which are responsible for the PUFAs or linoleic acid to be fulfill the requirement of the HUFAs.

So in the only if you can supply it with the polyunsaturated fatty acids and the linolenic acid it is more than enough for the freshwater fish to survive. However for marine fish for the sea water fish you have to supply it with HUFAs as well.

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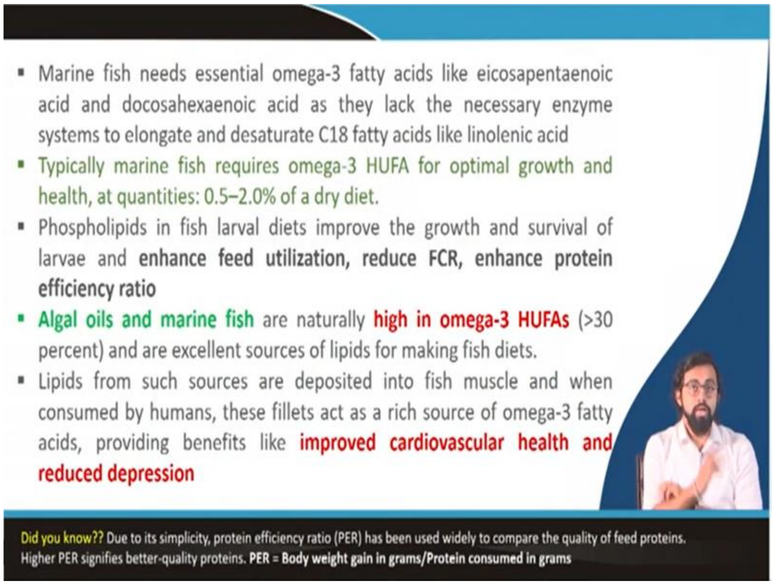

I will tell you in detail. So marine fish it needs essential omega-3 fatty acids like the eicosapentaenoic acids and docosahexaenoic acid. So because they lack in, they lack the necessary enzyme system to elongate and desaturate the C18 fatty acids like linolenic acid. So linolenic acid is only available, only should be available for the freshwater target species.

But in case of marine culture you do not have to go ahead with the linolenic acid. Rather you can go ahead with, you need to supply with the different omega-3 fatty acids. Typically it requires omega-3 HUFA for optimal growth and health at quantities like around 0.22 percent of their dry weight. Phospholipids in fish larval diets improves the growth and survival of the larva and it enhances the feed utilization, reduces the food conversion ratio and enhance the protein efficiency ratio.

You know what is food conversion ratio? It is a amount of food that you are supplying on amount of food that is converted into its biomass that it actually utilized that is called the food conversion ratio. Same way protein efficiency ratio, the protein that it consumes in gram and the body weight gain in grams is this ratio, body weight gain in grams divided by protein consumed in grams is called the protein efficiency ratio. So it means the amount of protein that is actually being utilized and to the protein that is supplied.

So this ratio is called the protein efficiency ratio. This can be highly increased if you are supplying with the different kind of phospholipids and all. Algal ions and the marine fish are naturally very high in omega three HUFAs as I already told you and so these are excellent source for making the fish diets, for whom, for marine species itself because they only need the HUFAs.

Lipids from other sources are deposited into fish muscle and when consumed by humans these fillets are act as a rich source of omega-3 fatty acids providing benefits like very improved cardiovascular health and also reduce the depression and different other anxiety related problems and all. This is only a very few examples that I can give at this moment there are other beneficial benefits as well.

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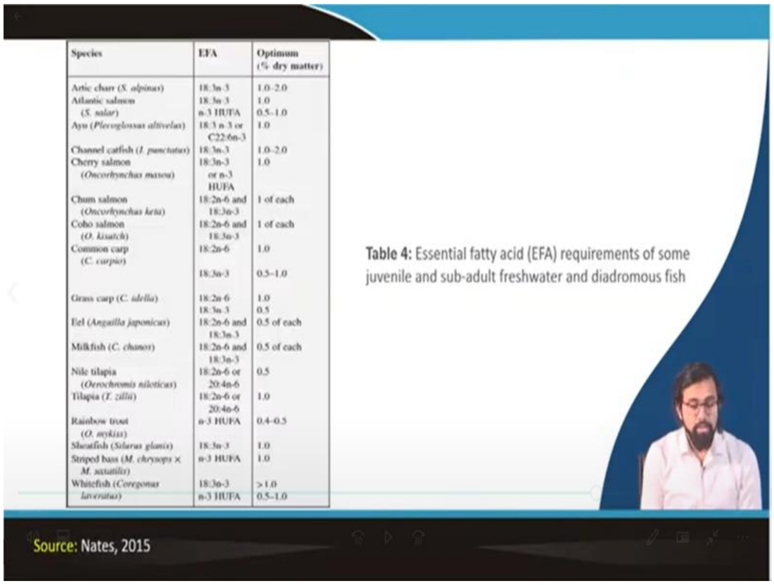

Species	EFA	Optimum (% dry matter)
Artic charr (*S. alpinus*)	18:3n-3	1.0-2.0
Atlantic salmon (*S. salar*)	18:3n-3 n-3 HUFA	1.0 0.5-1.0
Ayu (*Plecoglossus altivelas*)	18:3 n-3 or C22:6n-3	1.0
Channel catfish (*I. punctatus*)	18:3n-3	1.0-2.0
Cherry salmon (*Oncorhynchus masou*)	18:3n-3 or n-3 HUFA	1.0
Chum salmon (*Oncorhynchus keta*)	18:2n-6 and 18:3n-3	1 of each
Coho salmon (*O. kisutch*)	18:2n-6 and 18:3n-3	1 of each
Common carp (*C. carpio*)	18:2n-6 18:3n-3	1.0 0.5-1.0
Grass carp (*C. idella*)	18:2n-6 18:3n-3	1.0 0.5
Eel (*Anguilla japonicas*)	18:2n-6 and 18:3n-3	0.5 of each
Milkfish (*C. chanos*)	18:2n-6 and 18:3n-3	0.5 of each
Nile tilapia (*Oerochromis niloticus*)	18:2n-6 or 20:4n-6	0.5
Tilapia (*T. zillii*)	18:2n-6 or 20:4n-6	1.0
Rainbow trout (*O. mykiss*)	n-3 HUFA	0.4-0.5
Sheatfish (*Silurus glanis*)	18:3n-3	1.0
Striped bass (*M. chrysops* × *M. saxatilis*)	n-3 HUFA	1.0
Whitefish (*Coregonus laveratus*)	18:3n-3 n-3 HUFA	>1.0 0.5-1.0

This is the very in details about the essential fatty acids requirement of some juvenile and the sub-adult freshwater and the diadromous fish. I hope you guys know what is diadromous fish. Diadromous fish is like like with the combination of anadromous and catadromous fish. Anadromous fish if I give you an example hilsa fish.

So how it is very famous in Bengal and this particular part of the, particular part of the India. What is this hilsa fish? Why they are called anadromous? Because they normally they normally stay in a sea water or they surely reason like I mean like they normally survive in a high salinity water. They normally survive, they normally dwell in a high saline water.

But whenever they want to spawn or they want to hatch the egg or like the hatchling their, one the very starting period of their life is actually being spent in the fresh water. So they can go up to a like say like around up to 500 to 600, even thousand kilometer upstream to the river to lay egg. So this is called the anadromous type of anadromous type of fish which survives in seawater but their starting life starts in the fresh water.

Same way there is another time of type of fish which we call this catadromous. Catadromous like American eel. They normally survive in fresh water, they normally stay in fresh water, they normally dwell in fresh water, but when the time spawning comes they go to the sea water to lay eggs. And there are different scientific reasons behind it there is kind of there are different biological the reasoning behind it I am not going into details you can Google it you can think you can search for, it will definitely enlarge your idea knowledge about these systems.

So this different kind of diadromous species and different freshwater features is given this their essential fatty acid requirement.

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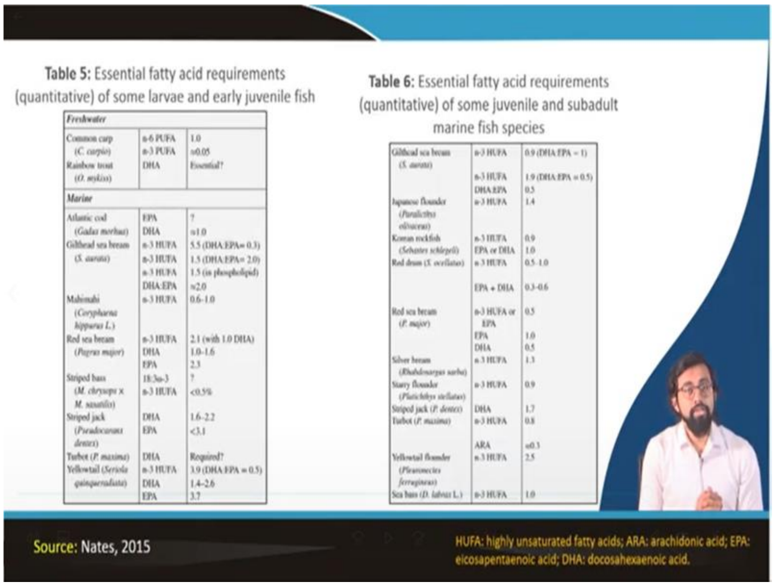

The further details are given on the some larva and the juvenile fishes quantitative fatty acid requirement. And for the fresh water in the left side for the in the first two fishes and there is marine fishes. So this is only for you to understand the percentage of like HUFAs or the PUFAs or the SFS that is required for them to survive.

And the percentage is very important when you are targeting a specific type of culture species for your farm or for your hatchery for like for your farm. So you have to remember you have to study this like what is the exact amount of fatty acids that it requires and how you utilize them in your fish for the feed that you formulated.

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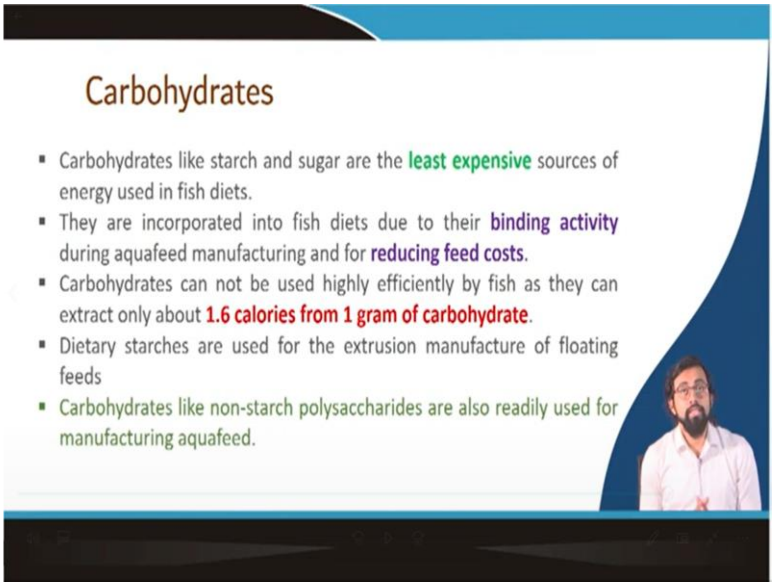

The third thing is like the carbohydrates. Carbohydrates like starch and sugar are the least expensive source of energy used in fish diet. But they actually kind of act as a binding activity during the aquafeed manufacturing which reduces actually the feed cost also.

So but however it cannot provide them, it is not very high efficient because it can only extract let us say like around 1.6 calorie per one gram of carbohydrate which is like nothing. In case of dietary structures that are used for the extrusion manufacturing of the floating feeds, they are normally used. The carbohydrates like non-starch polysaccharides are also readily used for manufacturing aquafeeds and all.

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Ingredients	Starch	Total dietary fiber	Cellulose	Soluble NSP	Insoluble NSP	Total NSP
Alfalfa	68	457	139	77	113	329
Barley: hulled	587	221	43	56	88	186
Barley: hull-less	654	146	19	50	58	127
Corn whole grain	690	108	20	9	66	119
Corn gluten meal	282	383	75	242	34	351
Cottonseed cake	18	340	92	61	103	257
Cottonseed meal	19	375	90	66	127	283
Faba beans	407	210	81	50	59	665
Linseed meal	27	423	53	138	112	303
Lupins	14	416	131	144	139	405
Oats: hulled	468	298	82	40	110	232
Oats: hull-less	557	148	14	54	49	116
Palm cake	11	602	73	32	361	466
Peas	454	192	53	52	76	180
Rapeseed cake	15	295	59	43	103	205
Rapeseed meal	18	354	52	55	123	220
Rice polishing	180	131	112	5	213	218
Rice pearled	770	4	3	3	6	60
Rye bran	87	490	39	63	321	422
Rye whole grain	613	174	16	42	94	152
Sorghum[a]	712	93	34	99		67
Soybean meal	27	233	62	63	92	217
Sunflower cake	10	448	123	57	136	315
Tapioca	768	106	27	23	33	84
Wheat whole grain	651	138	20	25	74	119
Wheat bran	222	449	72	29	273	374
Wheat middlings	36	201	19	71	101	190

So this is this is the this is the table that you can follow for non-starch polysaccharide content that it requires per gram like gram per gram kg of dry matter. For different ingredients are also given like these ingredients like what is the starch content dietary fibers, soluble and the non-soluble non-starch polysaccharide content and the total non-starch polysaccharide content which is present in various ingredients used for making the fish feed.

And you just collect this particular feed, collect this particular components ingredients for making your fish feed based on your fish demand based on your aquatic species demand and all.

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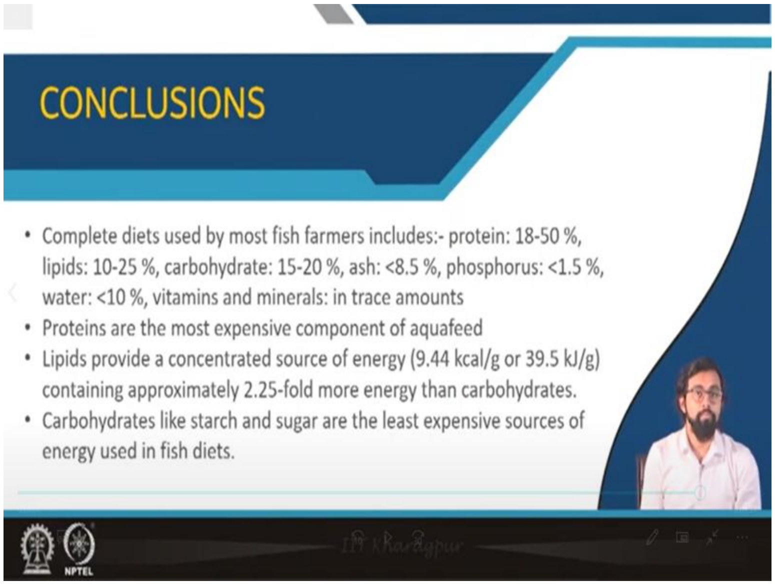

So in conclusion I can say the complete diets are used by mostly the fish farmers including the protein, 18 to 50 percent, lipid, carbohydrate, ash, phosphorus, water, vitamins and essential minerals, etcetera. Proteins are the most expensive ones but most important one. Lipid are the concentrated source of energy and which is like 2.25 more energy than the carbohydrate.

And what are the type of lipid it requires, it depends on the marine species or the freshwater species. Catadromous or anadromous species based on their dwelling nature and all. Carbohydrates like starch and sugar are least expensive source of energy used in fish source and their released utilizable energy sources as well.

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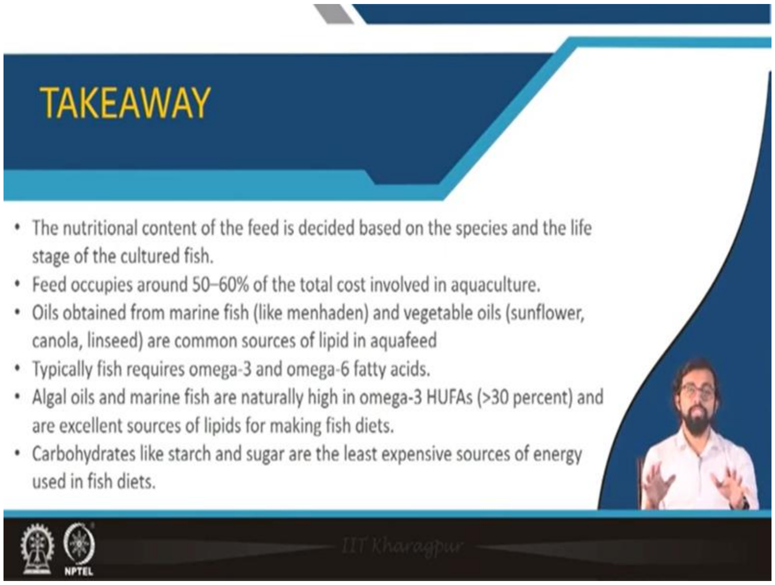

So what is the take away message from this lecture material? We got to know about the nutritional content of the feed. What are the essential ingredients that it requires? What are the different proteins what are the different amino acids that it requires? What are the basic 10 amino acids which are important for the fish growth?

We got to know about the omega-3 and omega-6 fatty acids like that normally fish requires. We got to know about the different type of fatty acids like unsaturated HUFAs, PUFAS and SFS and how they can be they can be utilized based on the type of the culture species.

And carbohydrate like the starch and sugar can also be utilized sometimes they use to bind the feed material so which will be which will reduce the cost of feed. But it is non-expensive and unlike it is with the least expensive and least utilizable sources of energy for the fish diet.

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So we got to know a lot of information from this lecture material about the fish feed formulation and this is the reference that you can follow. You can take a picture of it and you can Google it will give you more in details the idea about how it works and all. So that is it for today we will meet again in the next lecture video. Thank you so much.