Advanced Aquaculture Technology
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Lecture 30
Feed Additives, Food Conversion Ratio (FCR).

Welcome you all, in the last lecture material of the module six aquafeed technology. My name is Professor Gourav Dhar Bhowmick I am from the agricultural food engineering department of IIT, Kharagpur.

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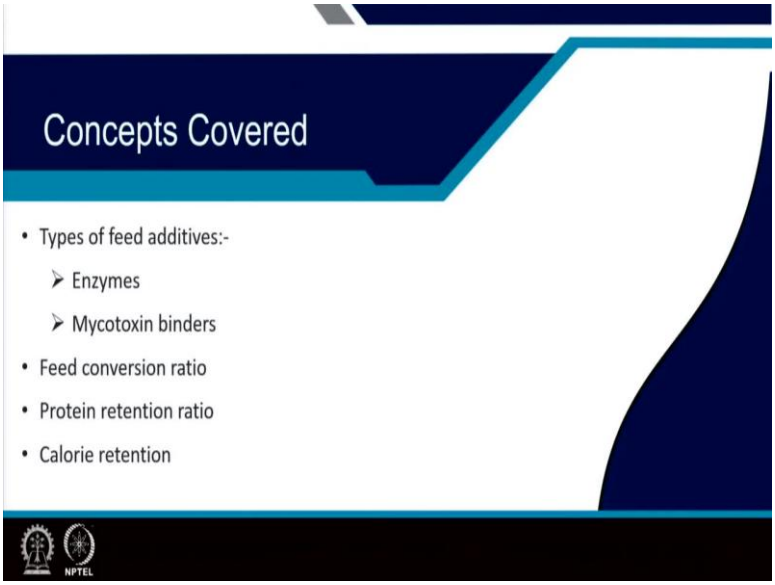

So in this particular lecture, the concepts that we will be covering are the continuation of the feed additives, enzymes and the mycotoxin binders. We will discuss about the feed conversion ratio, protein retention ratio, and the calorie retention ratio and what are these units and how we can it can quantify and qualify the feed availability of feed and the availability of the nutrient present in your fish or in your aquatic species.

So, we will start with the feed additives we already discussed about four different types of feed additives in the earlier lecture. So in this lecture, we will discuss about the rest of the enzymes and mycotoxin binder.

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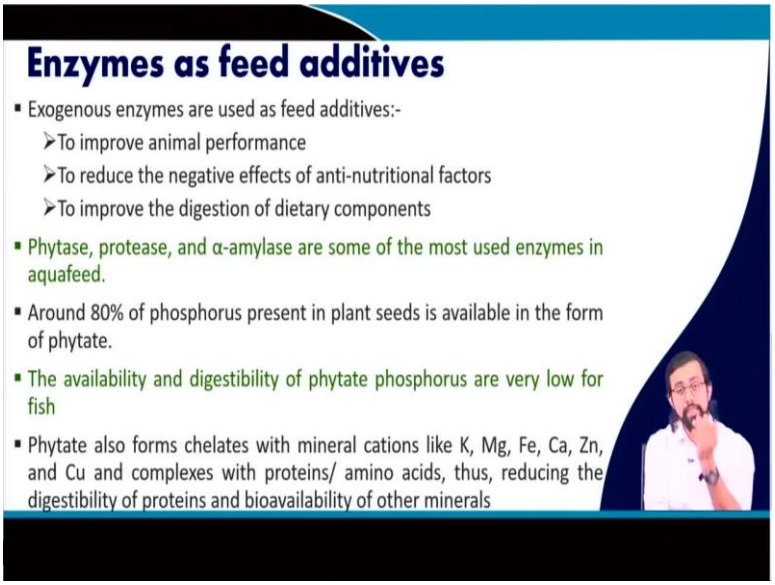

First, the enzymes as a feed additive, in general, we supply different exogenous enzymes, which is used as a feed additives, it uses to increase the animal performance in terms of their, cause the food convert and feed conversion and all it can reduce the negative effects of the anti-nutritional factors and it also it can improve the digestion of the different dietary components.

I will discuss about all these things with different examples in coming slides and slides as well. So, first of all, say I am giving you some example of the most commonly used enzymes phytase, protease and alpha amylase. So, these are some of the most used enzymes in aquafeed why we supply this okay? We will discuss it about it.

Mostly around 80 percent of the phosphorus present in the plant seed is available in the form of phytate. The availability and the digestibility of phytate phosphorus are very low for fish. This phytate also forms chelates with mineral cations like calcium, potassium, magnesium, ferrous, calcium, zinc and copper and complexes with the proteins and amino acids thus reducing the digestibility of the protein and bioavailability of other minerals. So, what to do with this phytate?

In order to reduce it in order to properly digest this phytate for you know to increase the phosphorus intake and also to minimize this harmful effect if it's it will be as it is in your feed, we supply it with different enzymes just because of the enzymatic activity this phytate is reduced and because it is, it can be used for increased phosphorus availability for your

microorganisms plus it will help you to get rid of formation of these different chelates with different mineral cations and all. So, you understand right.

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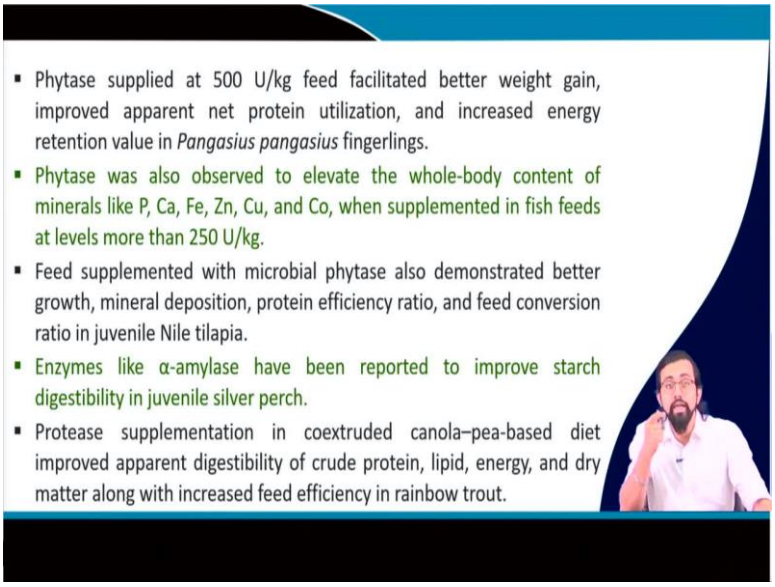

So, phytase supplied at 500 units per gram per kg of feed facilitates the better weight gain and it improved the apparent net protein utilization and also it increase the energy retention value of the pangasius pangasius fingerlings. So, this is just to give you an example of how this different enzymes are actually helping in different other aspects as well as.

Phytase, it is observed to elevate the whole body content of minerals like phosphorus, calcium, ferrous, zinc, copper, cobalt, etc, when supplemented at a level more than 250 unit per kg. Feed which is supplemented with this microbial phytase. It also demonstrated better growth, mineral deposition, protein efficiency ratio and feed conversion ratio in juvenile Nile tilapia and all.

So, these are all the examples you see like why the presence of these enzymes can be helpful. Whereas initially this phytate which is generally presents in this plant seeds and all we are not with, the animal cannot able to utilize it properly, though if the presence of phosphorus is there, they can be a nuisance for them in general in their body.

But presence of this addition of this enzymatic formulas, additional enzymes can help in reducing the help in increasing the performance in different aspects. Enzymes like alpha amylase have been reported to improve the starch digestibility in the juvenile silver perch.

The protease supplementation in coextruded canola pea based diet, it improved the apparent digestibility of the crude protein, lipid and energy and dry matter increased energy high energy production and also the dry matter along with increased feed efficiency in rainbow trout. So, these are some of the examples we have the scientists have observed when you supply your aquatic species with the enzyme supplement and all.

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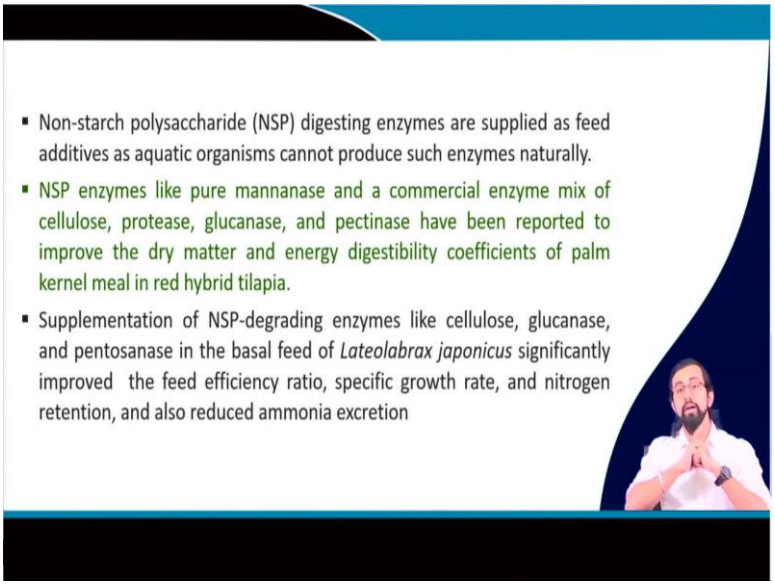

Non starch polysaccharide or NSP in short, digesting enzymes are supplied as feed additives as aquatic organisms cannot produce such enzymes new naturally. So, this non starch polysaccharides are very helpful and but when you get it is there in the feed but if you do not supply it with the proper digesting enzymes it cannot be these enzymes because it is not produced naturally they cannot digest this non starch NSP and all.

NSP enzymes like pure mannanase and the commercial enzyme mix of cellulose, protease, glucanase, and the pectinase have been reported to improve the dry matter and the energy digestibility coefficient of palm kernel meal in red hybrid tilapia. So you get the point well.

These are all the examples I am always giving you examples of different cases where the production capacity is increased by means of by some means, like maybe from improved growth microorganisms content, improved proper digestion of the different compounds and all. So, enzymes can help in different aspects when it given in it very specific amount in along with your feed and all.

Supplementation of the this NSP degrading enzymes like cellulose, glucanase, and this pentosanase on the basal feed of this lateolabrax japonicas, it significantly improves the feed

efficiency ratio, specific growth rate and the nitrogen retention and also it can reduce the ammonia excretion and all. It is a very important thing, see, if we can reduce the ammonia excretion, what will happen it will reduce the pollutant load of the dwelling water body right.

If it is reducing the pollutant load of dwelling water body, it will reduce the freshwater exchange, it will reduce the requirement of re-circulatory aquaculture systems. So, it will not reduce it can at least reduce the load, in general, overall load. So, by means of because you can understand right like by all this means enzymes are very much helpful depending like the beneficial enzymes that you are supplying.

It can be very much helpful for your rearing species for survival and there it is for your own farm growth and yield as well.

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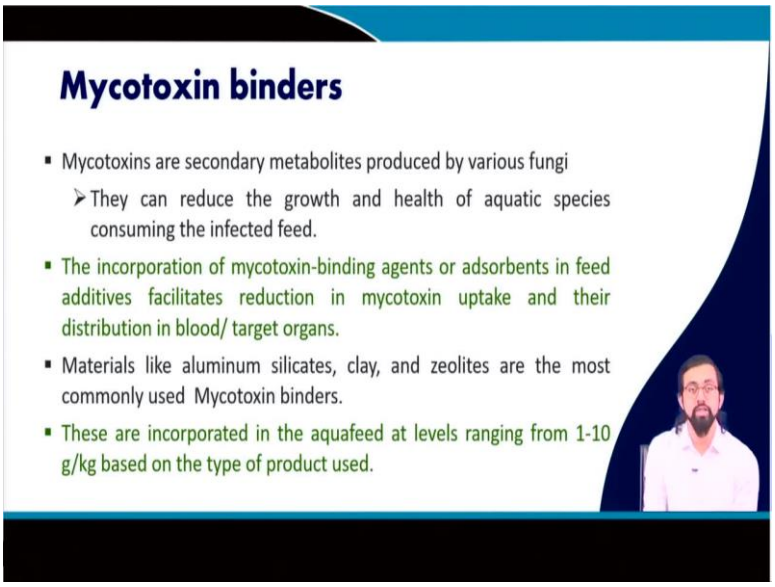

The last feed additives that I will be discussing today it is called a mycotoxin binder. Mycotoxins are actually the secondary metabolites produced from various fungi. They can reduce the growth and health of aquatic species consuming, aquatic species consuming the infected feed. What do you understand from this what is mycotoxins? Mycotoxins are the metabolites secondary metabolites, we can harvest or we can we can get it from the various fungis and fungi types and all.

How it is helpful, it can reduce the growth and health of aquatic species consuming the infected feed. What does that mean? the incorporation of this kind of mycotoxin binding agents or the adsorbents in feed additives it facilitates the reduction in the mycotoxin uptake and their distribution in blood and target organisms. Not only that the materials like

aluminium silicates, clay, and zeolites are the most commonly used mycotoxin binders and all.

So, when you supply it with this anchor brush different micro toxin binders and all what it will do it will it can increase the one you supplied with this mycotoxin binder and all that will reduce the uptake of mycotoxins in the cellular body in the cellular organisms and by means of that it can help the health surviving this aquatic species and all.

So, because with help them to even they infected in, when they consume the infected feed still they can survive. So, sometimes we supply this aluminium silicate this kind of binders this like aluminium silicate, clay, and zeolite along with the feed, so that it will act as a mycotoxin binder. So, this mycotoxin are not being this cannot be as harmful as it is, in the absence of mycotoxin binders. These are incorporated in the aquafeed at levels ranging from 1 to 10 gram per kg based on the type of product used and all.

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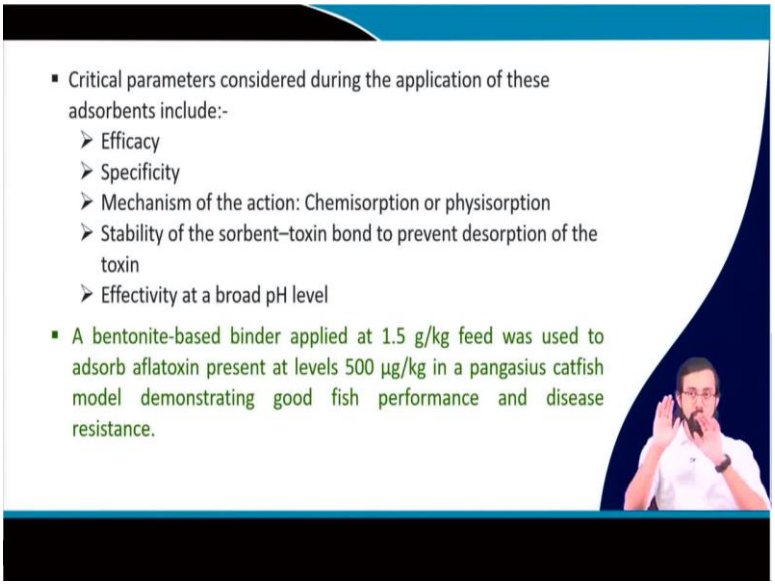

Critical parameters which are normally has to be considered when we will be choosing the application of this adsorbent, adsorbent include the efficacy, specificity, mechanism of the action, stability of the sorbent and the efficiency effectivity at a broader pH level. What is that mean? What are these different criterias mean? You get the point.

Mycotoxins are some harmful secondary metabolites coming out of fungi. If they are present in your system, it is harmful, what mycotoxin binders are doing this different adsorbents they are adsorbent you know the difference between adsorbent and absorbent right? This is the adsorbent criteria that I am talking about. In case of adsorbent this different mycotoxins

binder they actually because of their specific ionic present ionic level at its at its wall or at its membrane or I mean like this, their surface, different surface ionic charge, this mycotoxins are getting attached to its surface.

In general, how it works in like you know chemical in chemically if I speak. So, then they attach to the surface of this adsorbent because of that, we can get we can reduce the presence even the infected feed even the feed is infected, still that can be utilized for your production for your supplement as a feed and all. So, it can reduce the overall load.

How the efficacy is important? Because, how much effective that adsorbent is if you are supplying your adsorbent in a big chunk, it will have a less surface area. So, their adsorbent will be minimal, how to increase it provided in a chunk in a very small chunks or small as micro particle or nano particle. So, what will happen because of that, it will have higher surface area right?

If you have like same amount of say I want like big chunk like a three centimeter big sphere, and the same way same metal up like you know, piece into like you know thousands of pieces with a very small diameter spheres, in which case the specific area will be higher, specific surface area, in the case of small chunks, right.

So, when the specific surface area is higher in case of small chunks, so, it can adsorb more amount of mycotoxins, you understand the point so, if it can adsorb more amount of mycotoxin in its body in its surface area. So it can it is more effective. So, that is how the efficacy is coming into the place.

Specificity you have to understand that where you are utilizing it is likes more like, sometimes some drugs are to be delivered at a particular location of our body the drug has to be has to have this capacity that it will act on that specific organ or on that specific place only of your body it will not act in other spaces other region this is called a specificity and all these things. In one way it is called specificity because it will go and it will act on that particular organ or a particular place only, that you have to make sure.

Mechanisms of the action it can be chemisorption it can be physisorption. Physisorption the one that I was talking about on its surface, chemisorption are also possible when there are like you know, they are chemically bonded with another each other. Chemisorption are more neat, why I say neat because chemisorption are like kind of their still, its adsorption process.

So there is a possibility of reversing the process as well. But it is much more well bounded than the physisorption in general, I am talking about.

Stability of the sorbent toxin bond to prevent the desorption of the toxin. So, this is the stability of the sorbent toxin bond. If I talk about chemically, it is nothing but suppose your sorbent or absorbent has a negative, say like an anionic charge present in its surface and the toxin which is a mycotoxin has a cationic charge present on its surface. So they will definitely bind with each other.

Now, it will depend whether they will bound to each other, we using hydrogen bond using like you know the covalent bond or different covalent bond or not because it is possible I am sorry like covalent bond it is not possible like in general electrovalency is possible, but this electrovalent only how deeply they are bonded to each other. Based on that this stability is performed, stability is actually calculated.

If it is like very loosely bounded. I can discuss about in in details but because of the time we cannot go ahead much but I am just giving you overall expression how it works. If it is loosely bound, then if you supply it with a very basic if there is a presence of any antidesorption and all, it will again detach to each other.

So, if it is like bind with each other very firmly, very strongly what will happen? this, even if the presence of some desorption, desorption agent, it will not be easily detached from each other, this is beneficial for us. So, that is why the stability of the sorbent toxin bond is very important.

The fifth point is the effectivity at a broader pH level is definitely important because we will be supplying it to your system when along with the feed during the production process, during the application process, the pH can be vary drastically up and down. Your adsorbent has to have the capacity to retain its adsorption capacity at this broader pH level. This is very important, zeolite and all that is the major concern about different application of zeolite. Anyway, so you will know more in details in later stage when you will be doing experiments on it or maybe you will work on it in future.

A bentonite based binder applied at like 1.5 gram per kg of feed was used to adsorb aflatoxin present at levels of 500 microgram per kg in pangasius catfish model demonstrating good fish performance and disease resistance. I have already told you, I am always, it is always better to give you one example of how it works.

So, here is one example that I have given like, how it works for this particular type of pangasius catfish, this pangasius catfish they use we use this bentonite based binder at particular concentration like 1.5 gram per kg and it helps we saw that it helps in adsorbing aflatoxin at the level of 500 microgram per kg to almost zero, that means they are very good adsorbent. So, because of that, the fish performance is increased and disease resistance can be attained. These are all the discussions that we have on feed additives and all.

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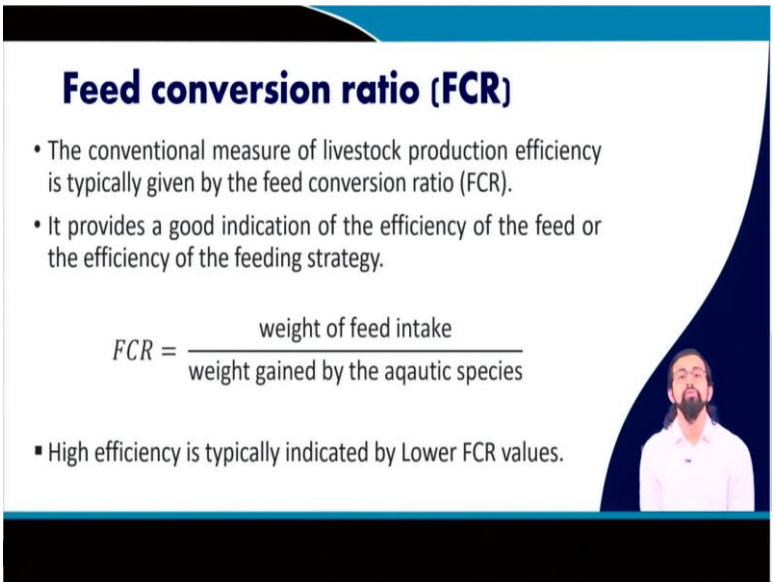

Now to like kind of conclude this module, we will discuss about couple of ratios, a couple of number system like this units that we use to quantify the applicability of the feed and efficacy of the feed and efficacy of the feeding strategy. So the first one is the food feed conversion ratio or FCR in detail, we have already discussed about it in earlier lectures also, in short, but now I will be discussing in general how it works.

So, the conventional measures of livestock production efficiency is typically given by feed conversion ratio. It is a good indication of the efficiency of the feed, which you are supplying plus the strategy, the feeding strategy that you have an applicant that they have applied.

What do I mean by feeding strategy, it can be broadcasting method just simply take the feed and you know throw it, it can be a specific region based method like you have you know, that this is the shadow regions where normally your aquatic species will dwell and you have your feeder set on it on your you already set the feeder on that region so, fish will come and have the feed.

Depending upon the upstream and downstream regions depending upon this raceway tank at particular place you will put the feed where fish normally try to come and have it. So, this is a different feeding strategy just to give you a gross idea about what do I mean by the feeding strategy and the efficiency of the feed.

Feed conversion ratio though it is actually the weight of the feed intake divided by weight gained by the aquatic species. From the ratio itself, can you tell me is it possible to have the FCR less than one or greater than one which is more reliable? Definitely greater than one right because the weight of feed intake divided by weight gained by the aquatic species it should always be more than one it cannot be less than one, if it is less than one that means there are feed already available they are all somehow they got some natural feeds.

Because the amount of feed that you will supply that it is 100 percent used, but like it is completely converted into biomass then the repeat conversion ratio will be one which is like maximum efficient one, the maximum efficient cases it can be one. All the other cases it will be as high as possible. The lesser the number is, the better the efficiency. You get my point, is not it? The lesser the number, more near to one is the better the efficiency of the strategy or your feed or your species.

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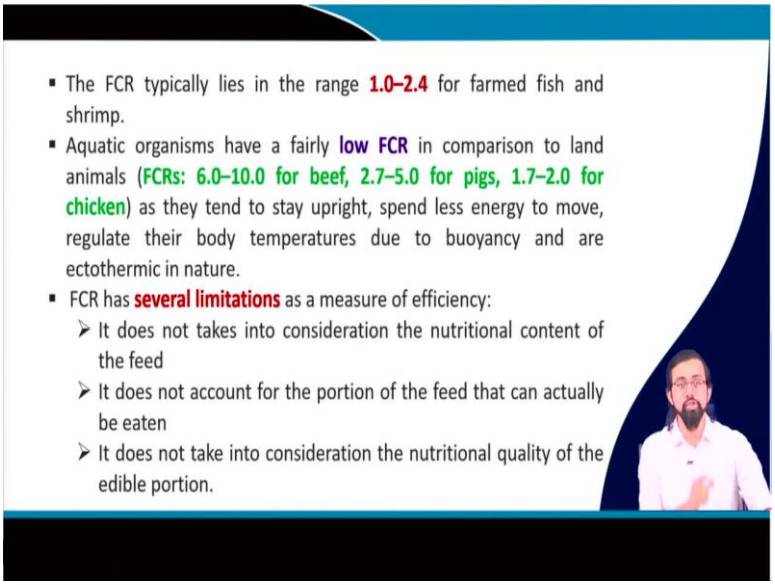

So, just to give you more in details, so, in general it ranges from 1 to 2.4 for farmed fish and shrimp. Aquatic organisms have fairly low FCR in comparison to the land animal. If you see in case of like the cow, pigs, and chicken, in case of cow it can go up to 6 to 10 what does

that mean you are supplying 10 kg of feed actually one kg is actually utilized by them out of them. So, that means the ratio is 10 by 1 which is 10.

So, after supplying 10 kg of feed, they can only be utilized 1 kg of it to convert it to into their biomass. At the same time, the fish has a very low FCR which means the aquatic species are much more efficient. So it will cause less harm to the environment in all senses, so, that is why the global warming most of the, aquaculture and agriculture sectors especially livestock sector is feeling very, like it is not as something good to say but it is actually major reason for global warming and all.

Because they cause a huge environmental impact, this livestock farming and all. So, when we go for this, these different catalysts and all this, this is very harmful in general, the amount of feed conversion is very low, I mean, like, feed conversion ratio is very high, that means the efficiency is very low, it also excretes a lot of obnoxious gases and all which are also harmful.

So, in general overall, harmful greenhouse production is also very high in case of this land animals. In case of aquatic species, it is less, but still as because you are, kind of culturing it in a very high amount, it can be as similar to that you know, do not pull like it is not it is non go ahead with the do not pull yourself with a number.

In case of land animals the number is less, the number of rearing species is less in per unit area, but in case of aquatic species, the number of species per unit area is very high. So, even though the feed conversion ratio is like near to 1 or select 2 or 3, still it can cause huge environmental impact. And it does cause actually, huge environmental impact that people are still working on how to improve the feed conversion ratio?

How to improve the overall efficiency of the system, so that it will cause less greenhouse impact less global warming effect. In general, what is the reason why the aquatic organism has low FCR because they tend to stay up. They spend less energy to move and also they regulate their body temperature due to buoyancy and ectothermic in nature, you know what is exothermic or in general we call cold blooded animals.

This ectothermic are these animals they have a very poor regulation system thermal regulation system in their body, they normally depend upon the depend on the environment to which you are they are dwelling. So, because of that they have to utilize less amount of energy for thermal regulations and like not like us, not like the land animals. So, that is why

they are called ectothermic in nature, and because of this nature, they utilize maximum amount of feed and because of that very low FCR is witnessed.

FCR has several limitations as a measure of efficiency, it does not take into account the nutritional content of the feed, it does not account the portion of the feed that is actually been eaten and also it does not take into consideration the nutritional quantity, quality, quality and quantity both okay first one is quantity and thing the third one is the quality of the edible portions.

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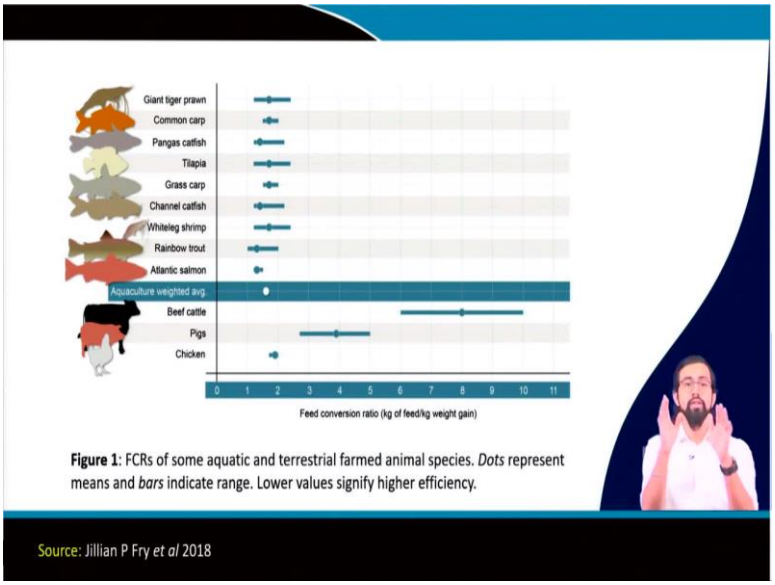

If you see this figure you can have a better idea about the what we have discussed about the aquatic and terrestrial pond animal species. Terrestrial if you see the aquatic ones, the giant tiger prawn, common carp, this pangas catfish, tilapia, grass carp, channel catfish they have FCR of around more or less 1 to 2 or sometimes a little bit higher than 2 so which says it is a higher it is a good one so the efficiency is much better when it is near to 1.

In case of beef cattle it can go up to 8, 10 in case of a pig it is like 4, 5 in case of chicken also it is around 2. So it is like more efficient than the aquatic species and you know the lesser value signifies the higher efficiency we already discussed.

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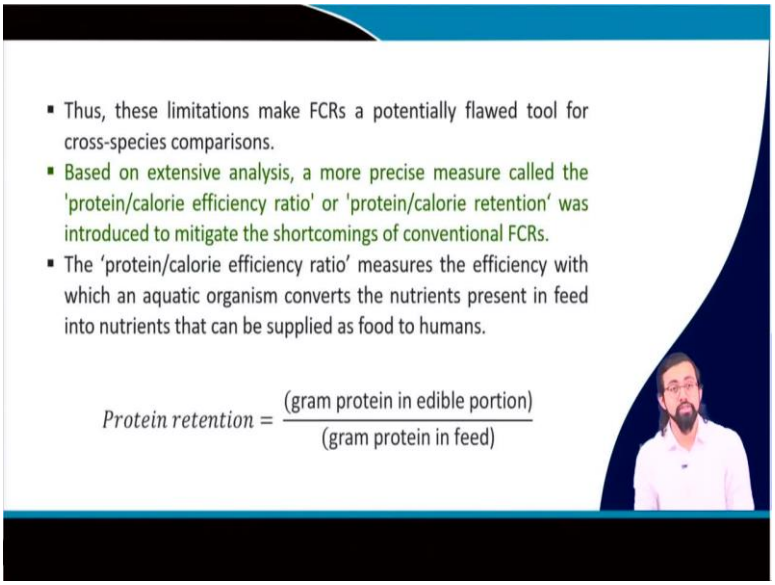

Thus, these limitations that we discuss for FCR are potentially a flawed tool sometimes for cross species comparison. So, when we go for this cross species comparison, it is always better to have a much more reliable tool as we discussed about the other limitations right. Based on the extensive analysis done by different researchers all over the world, a more precise measure called the protein or calorie efficiency ratio is coming out.

So, what is a protein efficiency or calorie efficiency ratio? This ratio it measures the efficiency with which an aquatic organisms convert the nutrient present in feed into the nutrients that can be supplied as food to humans. What does that mean? The gram of protein in edible portion divided by gram of protein in feed. This gram of protein we considered human as you know, like kind of base.

So if it is like this nutrient can be supplied to as a food to human, good one, that is the perfect one that is actually the one that we required. So, because in general whenever we talk about all these nutrients and all about all this body biomass and all these things about this aquatic species, final target is most of the cases human consumption, it is for our purpose only that is what we do.

So, protein retention or calorie retention, when we talk about it, we can have a based animal like us humans, and we can consider the grams of protein of the edible portion, which can be consumed by the human divided by the grams of protein available in the feed that is called the protein retention which is more important than the FCR and all.

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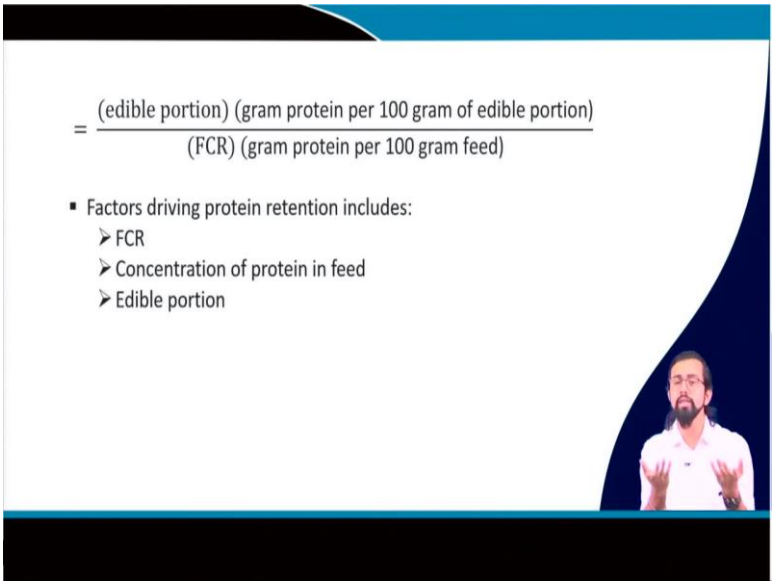

Because that is the one that we normally worry about right. So, how we can do that edible portion multiplied by the gram of protein per gram of per 100 gram of edible portion divided by food conversion ratio multiplied by gram of protein presence in 100 gram of feed. So, from this equation, we can have idea about the amount of protein that is actually available for the human to up take.

Protein retention = (gram protein in edible portion)/ (gram protein in feed)

= [(edible portion) ×(gram protein per 100 gram of edible portion)] / [(FCR) ×(gram protein per 100 gram feed)

The factors which are driving the protein retention includes the FCR definitely, also the concentration of protein in feed and also the edible portion of the feed. So, this actually includes all the disadvantages of FCR in this equation.

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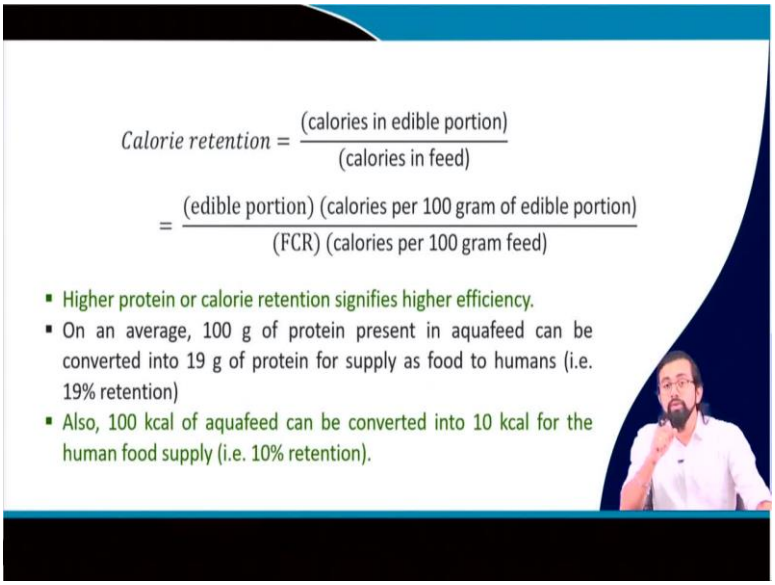

Another one that we normally go ahead some experts believe that this is more precise calculation of efficiency of any aquatic species on the food conversion is the calorie retention what does that mean the edible portion first of all, you have a suppose aquatic species and among them they have different parts which are not applicable which are not which we cannot use it in general, we just throw it at the end of, like the bones and other parts.

We normally say like fine flesh or sometimes the oil sometimes the liver anyway, so, just giving you an example, you have to know the edible portion multiplied by the calorie per 100 gram of edible portion divided by food conversion ratio multiplied by calorie per 100 gram of actual feed.

Calorie retention = (calories in edible portion)/(calories in feed)

= [(edible portion)× (calories per 100 gram of edible portion)]/ [(FCR)× (calories per 100 gram feed)]

This equation will give us the exact value of calorie that is actually present for human consumption isn't it and that can give you a give us an exact comparison between all these all these aquatic species and the land species or any like, obviously land and aquatic species.

So, but in this case, unlike FCR, higher protein and calorie retention signifies higher efficiency. So, on an average, 100 grams of protein present in aquafeed can be converted into 19 grams of protein for supply as food to human that means, it has 19 percent retention at the same time, if suppose you have 100 kilo calorie of aquafeed that can be converted into 10 kilo calorie of the human food supply that means, the calorie retention is 10 percent.

This is the example and a very standard values almost. So, that means the around 19 percent protein retention and 10 percent calorie retention can take place when it is aquafeed.

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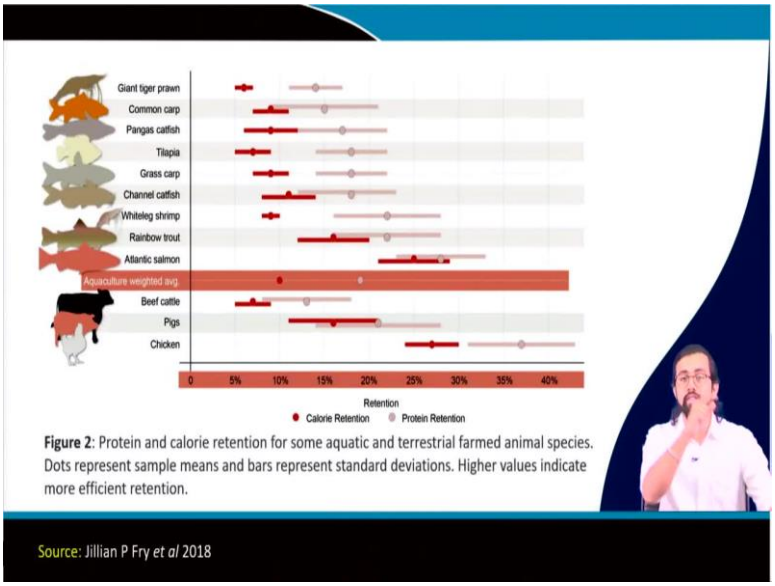

Now, let us have a look about what happened to the other species. If you see this picture, the this red, deep red one are showing the calorie retention and the light red one are showing the protein retention unlike FCR. Here, the more the efficiency, the better the indicates the more efficient retention right. So higher the value is better unlike FCR.

In this case, if you see the scale of giant tiger prawn, common carp, all aquatic species has a pretty much almost 15 to 25 percentage even in case of Atlantic salmon it can go up to 30 percentage of protein retention, which is very high. So that is why I put atlantic salmon is considered as a very rich source of protein for human consumption.

Same time calorie intake also very high in case of atlantic salmon compared to prawn, carp and all the other things. So, rainbow trouts and all, so this rainbow trouts, atlantic salmon are the one which are very sought after species that is why in aquatic species because they can have very high amount of calorie intake and calorie retention, capacity and also protein retention capacity, which will give actual benefit to us to human for human consumption.

Whereas, if you talk about the beef, pig and the chicken, chicken has a very high very high protein conversion, that is why it is a very standard practice to have chicken in, in a meal and all, most of the non-vegetarian people love to have chicken but depending upon the place and the religious belief, people can go ahead with the beef and pigs as well.

In general, it can be easily supplemented by the aquatic species is like atlantic salmon, or rainbow trout and even channel catfish and all. So that is what that is possible by only fish you can somehow replicate somehow replace the land animals and all so, anyway.

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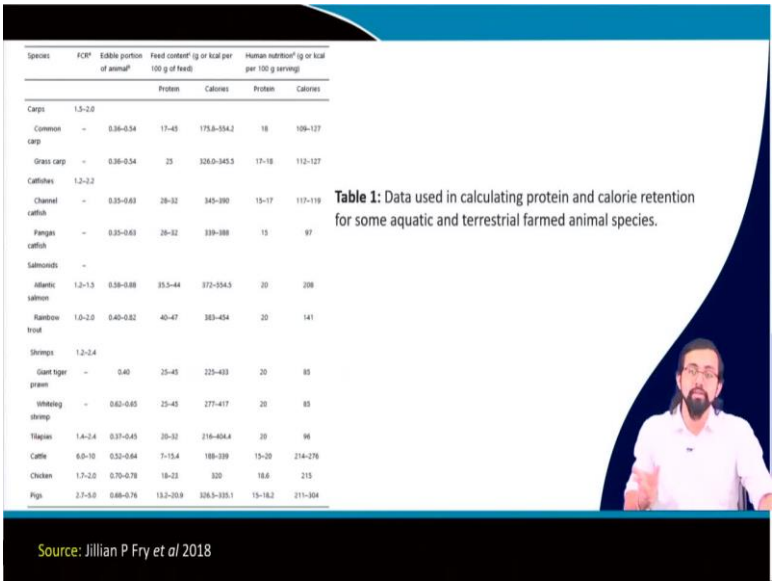

So, this is the information that I want to give. So, give you a better idea about that, how we can properly distinguish between or compare between different animals in terms of ratio. So, protein and calorie intake ratio is much more efficient way of judging than the feed conversion ratio. So, you should know this fact.

This is the this is a table where the data used in calculating the protein and the calorie retention for different aquatic and terrestrial farmed animal species like carps or different kinds of carps, trout fishes, prawn, cattle, chicken, pig and these values are given this what is the FCR ratio what is the edible protein available, you can take a picture and you can pause the video and you can give it a look for your understanding.

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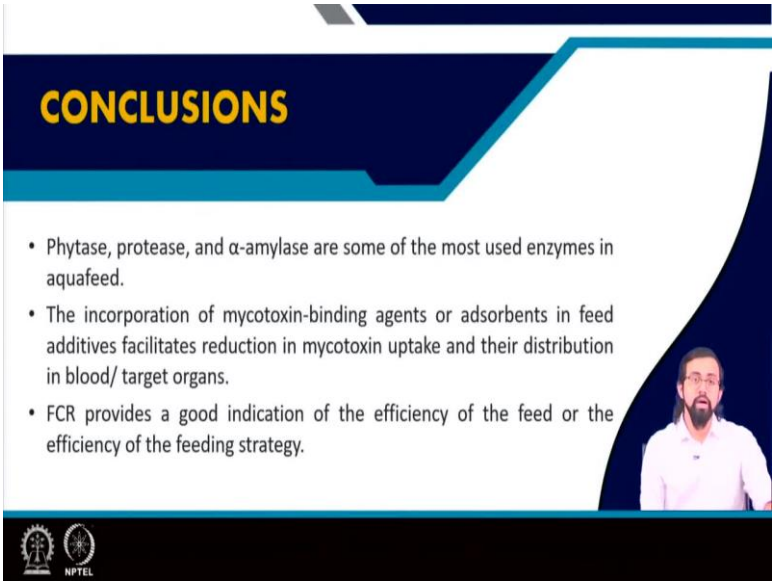

So, in conclusion, this phytase, protease and alpha amylase are some of the most used enzyme in aquafeed. And also the incorporation of mycotoxin binding agents or adsorbent infeed additives can facilitate the reduction of mycotoxin uptake, uptake which is harmful and also distribution in the blood and target organs. FCR provides a good indication on the efficiency of the feed or however, there are better options as well, which are the protein and the calorie efficiency ratios calorie efficiency and all.

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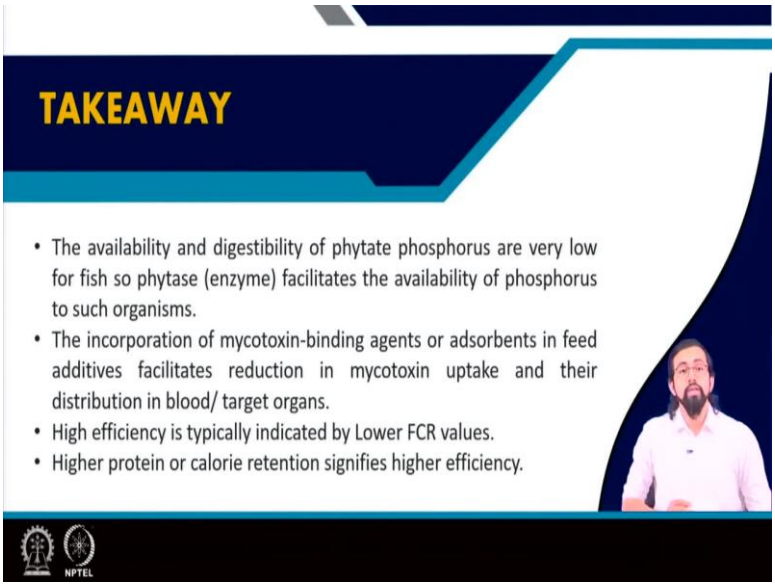

In case of the what is a takeaway message from this lecture, and that this phytate, availability and the digestibility of this phytate phosphorus are very low in fish for fish. So, phytase as enzyme it is used to facilitate the availability of phosphorus to such organisms, not only that, the incorporation of mycotoxin binding agents and adsorbents can facilitate the reduction in the mycotoxin uptake and their distribution in our organs.

And high efficiency is typically indicates a lower FCR value. However, higher protein and calorie retention, it can signify very high efficiency for that particular animal for in taking for human intake purpose and all.

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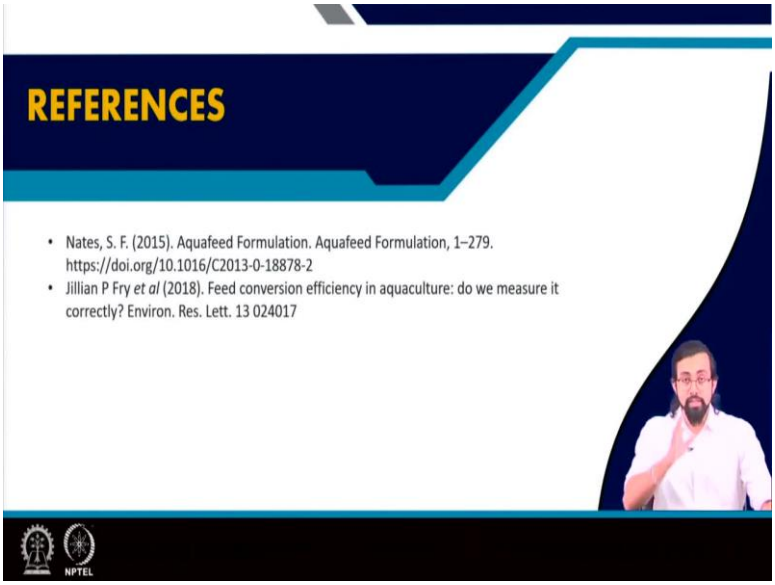

So, overall, this is the reference that you can check and you can go ahead for your own understanding on this subject. So, overall in this module, we have discussed very nicely about a very and also very overall discussion we did on the aquafeed and different aquafeed technologies that is available and what are the feed additives?

How to feed form formulate feed, what are the nutrients? Or what are the different ratios that we need to understand? So I hope it is helpful to you. That is it for now. We will come with the next module in the next session. Thank you so much.