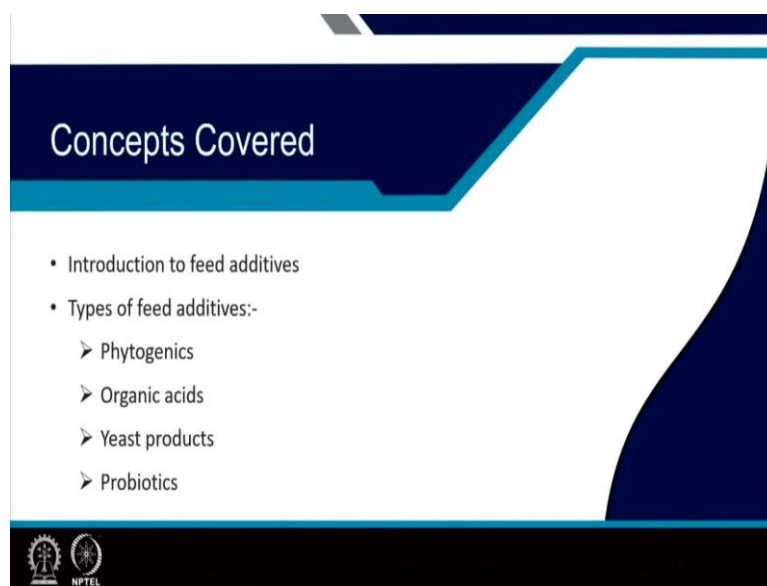


**Advanced Aquaculture Technology**  
**Professor Gourav Dhar Bhowmick**  
**Department of Agricultural and Food Engineering**  
**Indian Institute of Technology, Kharagpur**  
**Lecture 29**  
**Feed Additives**

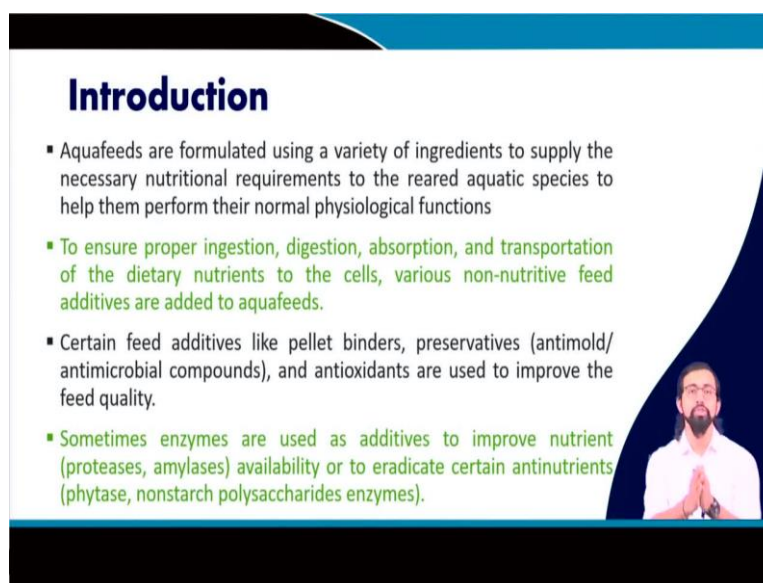
Hello everyone, welcome to the lecture 4 module 6 Aquafeed Technology. My name is Professor Gourav Dhar Bhowmick and I am from Agricultural and Food Engineering Department of IIT, Kharagpur.

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So in this particular lecture, the concept that I will be covering are the introduction to feed additives, what are the different types of feed additives, mainly I will be covering, phylogenics, organic acids, yeast products and probiotics in this particular lecture. It will be continued for the in the coming lecture as well with some additional different other types of food additives. So, in this particular lecture, I will be covering this part.

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**Introduction**

- Aquafeeds are formulated using a variety of ingredients to supply the necessary nutritional requirements to the reared aquatic species to help them perform their normal physiological functions
- To ensure proper ingestion, digestion, absorption, and transportation of the dietary nutrients to the cells, various non-nutritive feed additives are added to aquafeeds.
- Certain feed additives like pellet binders, preservatives (antimold/antimicrobial compounds), and antioxidants are used to improve the feed quality.
- Sometimes enzymes are used as additives to improve nutrient (proteases, amylases) availability or to eradicate certain antinutrients (phytase, nonstarch polysaccharides enzymes).

Video inset: A man with a beard and glasses, wearing a white shirt, speaking with his hands clasped.

So, in general, you know, aquafeeds, which are normally formulated using a variety of ingredients, the motto for, which is what like to supply the necessary nutritional requirement right, for your aquatic species or whatever the culture species that you are rearing for their normal physiological functions and all. It also ensured the proper ingestion, digestion, absorption and transportation of the dietary nutrients to the cell, various non-nutritive feed additives are normally added to the aquafeeds.

So, you can understand what is the reason behind this non-nutritive additive feed additives. Those are as from the name itself we can understand the non-nutritive like they are not supplied because of some nutritional purposes, but for some other purposes, okay. I will discuss with you the details like what is the reason behind it, why we supply this kind of non-nutritious feed additives along with the aquafeed.

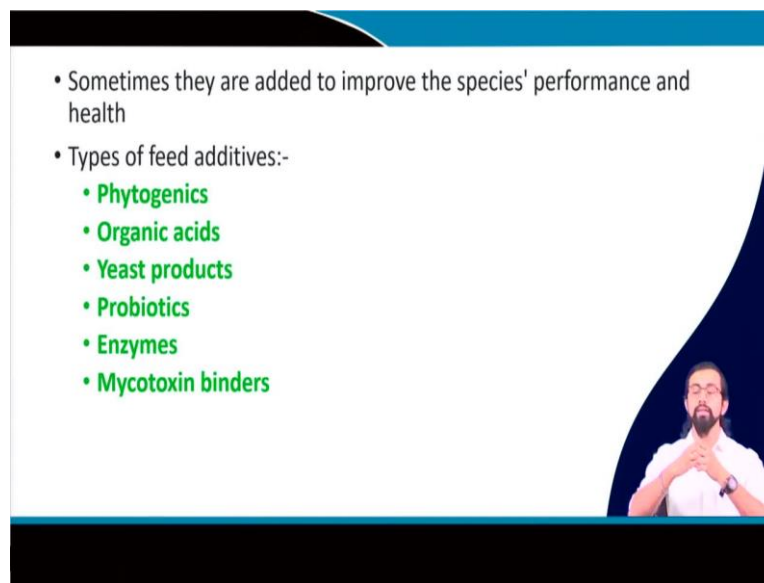
In general, certain feed additives like, pellet binders, the preservatives like anti-mold or anti-microbial compounds or antioxidants are normally used to improve the feed quality what I say first the pellet binders, different kinds of preservatives it can be anti-mold or antifungal it can be anti-microbial compounds and antioxidants. In general, these are the one of the major reason, one of the major purpose of providing with this non-nutritive feed additives to improve the feed quality.

Sometimes enzymes are also used as additives to improve the nutrient availability like what kind of edible nutrient I mean like protease, amylases. This kind of nutrient availability can

be increased, enhanced by using this specific type of enzyme that can be supplied along with the feed or in some cases to eradicate certain anti nutrients like you know phytase, nonstarch, polysaccharides enzymes and etc.

So, in order to eradicate the any possibility of having any anti nutrient like presence of phytase or nonstarch polysaccharide enzymes, we supply with some any beneficial enzymes along with the feed and all.

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Sometimes they are added to improve the performance and the health of the species of your rearing species. So, that these are like the moto of you know, why I already discussed like what is the reason, why we supply the food additives which are non-nutritive in nature, but still we supply it for the benefit of for some other benefits. So, what are these food additives that we are talking about?

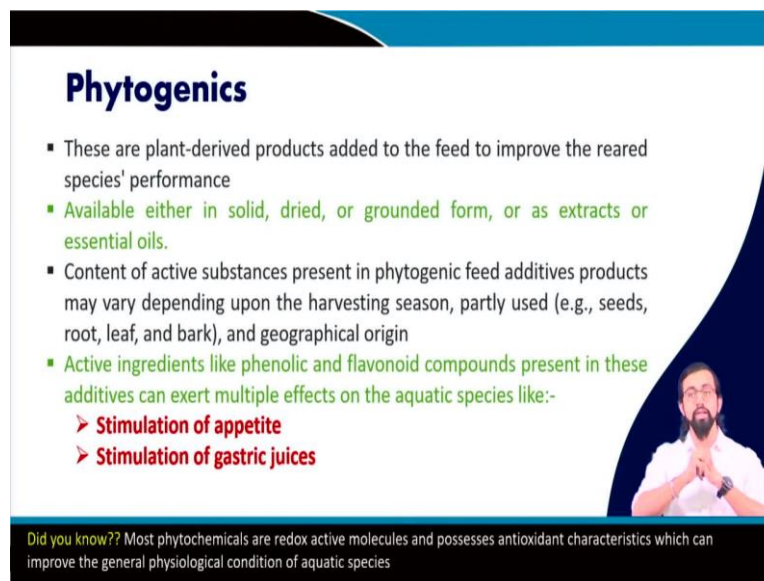
There are mainly six different type of food additives that we normally supply along with the feed. So, the feed is normally constitutes like I remember we already discussed what are the when we do the feed formulation or what are the core nutrients that we normally target for our any depending upon the rearing species, protein carbohydrate, lipid, vitamin, minerals, etc.

So, along with those, we have to supply this food feed additive as well. It actually based upon the type of species and also the rearing condition and also what is your farming requirements and all. So, what are these feed additives, it can be phytogenic, organic acids, yeast product,

probiotics, enzymes, mycotoxin binder, etc. Out of these six in this particular lecture, I will mainly be covering the top four the phytogetic, organic acid, yeast, and its products and probiotics.

In the coming lectures we will discuss and I will discuss about the enzymes and the mycotoxin binders. Listen to it very carefully, it is very important and will give you a very basic idea about some very basic nutritional phenomenon.

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**Phytogetics**

- These are plant-derived products added to the feed to improve the reared species' performance
- Available either in solid, dried, or grounded form, or as extracts or essential oils.
- Content of active substances present in phytogetic feed additives products may vary depending upon the harvesting season, partly used (e.g., seeds, root, leaf, and bark), and geographical origin
- Active ingredients like phenolic and flavonoid compounds present in these additives can exert multiple effects on the aquatic species like:-
  - Stimulation of appetite
  - Stimulation of gastric juices

Did you know?? Most phytochemicals are redox active molecules and possesses antioxidant characteristics which can improve the general physiological condition of aquatic species

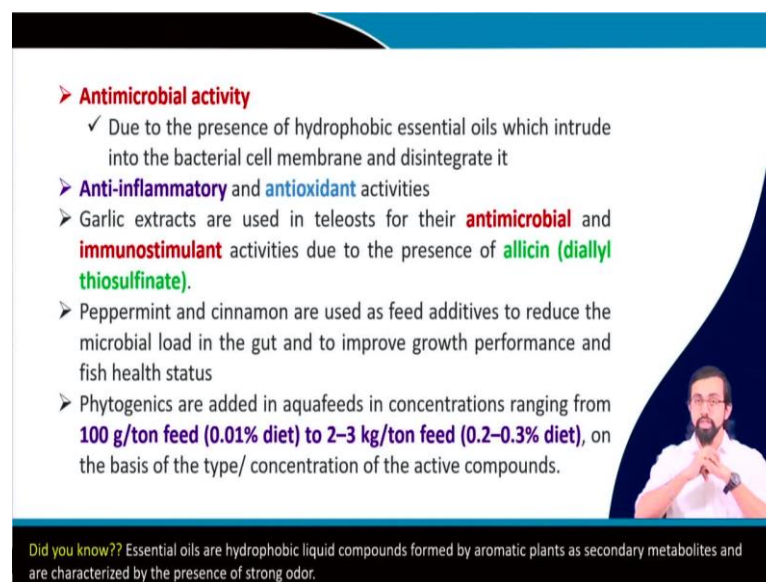
So first thing that I will be discussing about this different feed additives are the phytogetics. So what is phytogetics? It is actually a plant, phyto is you can understand phytogetics from its word you can understand it is actually something related to the plant, plant derived products. So, in general the plant derived products when it is added to the feed which is for the non-nutritive, for non-nutritional purposes then it is called the feed phytogetic feed additives and all.

They can either be supplied as a solid, dried or in grounded form or sometimes as an extracts or essential oil. So, in general this content on this active substances present in this phytogetic feed additives are depending upon the harvesting season among the based on the which part actually we are using like you know seed, root, leaf, or bark and also depending upon the geographic location. Please correct it, it is not partly used, it is the part which is used. So, like seeds, root, leaf or the bark and the geographic origin that particular additives and all.

Active ingredients like phenolic and flavonoid, flavonoid compounds present in this additives can extract in multiple effects, it can exert multiple effects on the aquatic species like first the stimulation of appetite, say again the stimulation of the gastric juices and all. So, these are the reason for which we supply this this phenolic and flavonoid compound which is present in the phytogetic, phytogetic feed additives and all.

In general, this phytochemical compounds or the redox active they are actually redox active compounds and they can increase the, they can process the antioxidant characteristics which can actually improve the general physiologic condition of your aquatic species.

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- **Antimicrobial activity**
  - ✓ Due to the presence of hydrophobic essential oils which intrude into the bacterial cell membrane and disintegrate it
- **Anti-inflammatory** and **antioxidant** activities
- Garlic extracts are used in teleosts for their **antimicrobial** and **immunostimulant** activities due to the presence of **allicin (diallyl thiosulfinate)**.
- Peppermint and cinnamon are used as feed additives to reduce the microbial load in the gut and to improve growth performance and fish health status
- Phytochemicals are added in aquafeeds in concentrations ranging from **100 g/ton feed (0.01% diet) to 2–3 kg/ton feed (0.2–0.3% diet)**, on the basis of the type/ concentration of the active compounds.

**Did you know??** Essential oils are hydrophobic liquid compounds formed by aromatic plants as secondary metabolites and are characterized by the presence of strong odor.

So, other than that, what is the purpose of this phytogetic compound, anti-microbial activity. Due to the presence of this hydrophobic, hydrophobic essential oils, if we supplied with some hydrophobic essential oils and all it can intrude into the bacterial cell membrane and disintegrate it. So, the bacteria which are non-essential which are like, disease causing microorganisms and all.

This disease causing microorganisms can be like say it is like a particular type of microorganism like say a particular type of bacteria, which you are not expecting to have in your feed and all. So, what you want to do you want to supply with the antimicrobial agents and what can be the anti-microbial agents in this particular case you can supplied with some phytogetic, add compounds and all which has this anti-microbial capacity or the activity which will actually cause the bacterial cell to damage how they will they are having this

hydrophobic essential oil which will intrude through the bacterial cell membrane and it will burst it and that because of that, it will disintegrate and it will die.

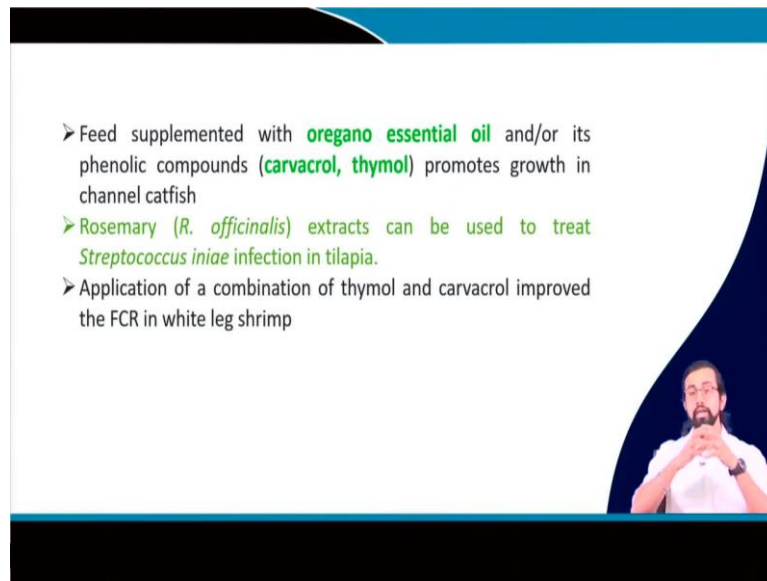
Other than that anti-inflammatory and antioxidant activities also can be triggered by using this kind of phytochemical and all, we can use garlic like it just to give you an example, if you use the garlic extract, in any case or any of your teleosts and all. So, what will happen it will, it has its antimicrobial and immunostimulant activities you know that garlic in general, even in for human consumption also we use it on for the same purpose it is also it can cause, because of the presence of allicin it can be considered as an immunostimulant and also it has antimicrobial properties as well.

So, the same can be utilized same can be, we can add we can same can be extract, the garlic extract that is why garlic extract can be added at a particular amount to the feed when you are supplying it to your rearing species. So, that they will be there they can be very, they can be having a very healthy body and all that they will be healthy, they have a very high amount of immune structure, immune structure and all.

So, they can easily get rid of all the unnecessary inhibition by any unnecessary microorganisms and all those okay. So, the peppermint and cinnamon and also use sometimes as a food additive, it can reduce the microbial load in the gut, and to improve the growth performance and the fish health status.

Phytochemicals are added in aquafeeds in concentration ranging from say like 100 gram per ton, or like 0.01 percent of diet to 2 to 3 kg per ton like up to 0.2 to 0.3 percent of the diet on the basis of the type and concentration of the active compound. So these are very important feed additives that you need to remember about these phytochemicals and all.

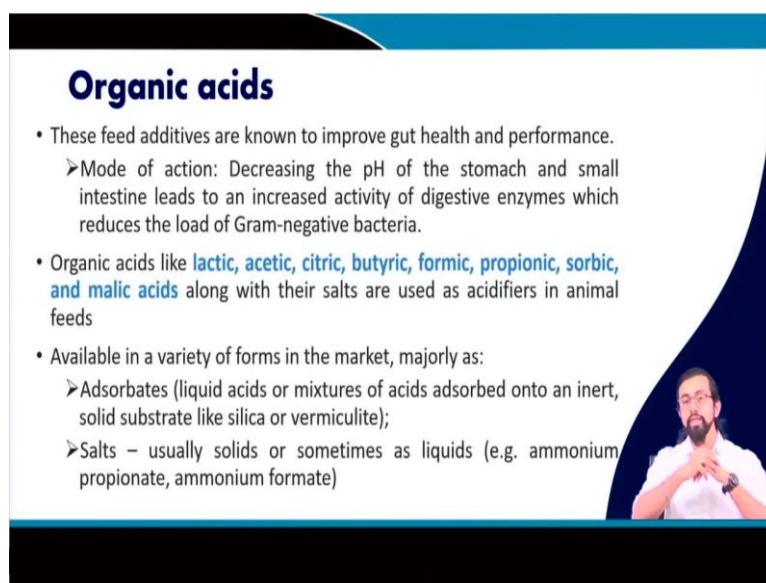
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Feed supplemented with oregano essential oil or because of its phenolic compounds present in its like carvacrol or thymol it can promote the growth of channel catfish and all. Rosemary extracts can be used to treat the streptococcus iniae infection in tilapia. Application of the combination of thymol and carvacrol, it can improve that food conversion ratio in white leg shrimps and all. You know, FCR, Food Conversion Ratio.

So already get a glimpse about it, how it is to be calculated, and we will discuss more in coming lectures. So, this all is essential, you know, all these phenolic compounds and all are very important which in turns actually help in getting rid of our different microbial load and all and it can improve the overall immune structure of the, of your target species.

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**Organic acids**

- These feed additives are known to improve gut health and performance.
  - Mode of action: Decreasing the pH of the stomach and small intestine leads to an increased activity of digestive enzymes which reduces the load of Gram-negative bacteria.
- Organic acids like **lactic, acetic, citric, butyric, formic, propionic, sorbic, and malic acids** along with their salts are used as acidifiers in animal feeds
- Available in a variety of forms in the market, majorly as:
  - Adsorbates (liquid acids or mixtures of acids adsorbed onto an inert, solid substrate like silica or vermiculite);
  - Salts – usually solids or sometimes as liquids (e.g. ammonium propionate, ammonium formate)

*(A small inset video shows a man with a beard and glasses, wearing a white shirt, speaking with his hands clasped.)*

The second type of food, feed additives that we will be discussing about today is the organic acids. From the name itself, we can understand why we use different kinds of acidic material like lactic acid, acetic acid, citric, butyric, formic, propionic, sorbic, and malic acid and all. So, why we use this organic acids? We use this organic acid to improve the gut performance.

So, in general the fish gut health and performance can be increased can be enhanced by adding the organic acids it can decrease the pH of the stomach and also it can not only it can decrease the pH of the stomach, but also its small intestine also and which leads to the increased activity of the digestive enzymes which reduces the load of gram negative microorganisms, gram negative bacteria and all.

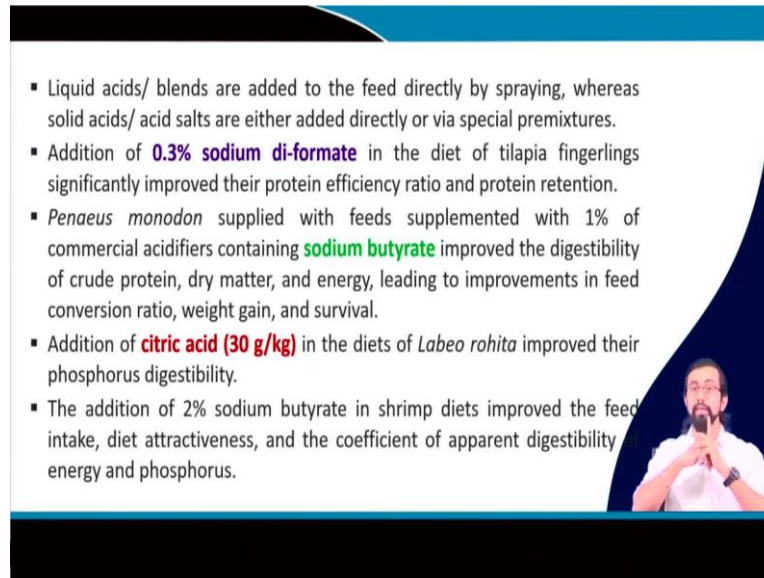
So, in general, these acids can enhance the, increase the performance of this gut microbiota. And because of that, in general it becomes your rare species will become more healthy and give much better performance. Available in a variety of forms general, like majorly in adsorbent form like liquid acids or mixture of acids, adsorbed into inert or solid substances like silica or the vermiculite.

So, in general, they can be found not only as an as an adsorbent, but also it can find it as a salt also usually solids or sometimes as liquid like ammonium propionate, or ammonium formate etc. So, either of this form you will get it majorly. There are other forms also you can get in one major you will get in in either in adsorbent form or in salt form okay, this kind of organic acids.



So, just remember why we need organic acids, it can decrease the pH of stomach and the small intestine. So, increase the activity of the digestive enzymes causing the reducing the load of the gram negative microorganisms. So unhealthy microorganisms to be precise.

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- Liquid acids/ blends are added to the feed directly by spraying, whereas solid acids/ acid salts are either added directly or via special premixtures.
- Addition of **0.3% sodium di-formate** in the diet of tilapia fingerlings significantly improved their protein efficiency ratio and protein retention.
- *Penaeus monodon* supplied with feeds supplemented with 1% of commercial acidifiers containing **sodium butyrate** improved the digestibility of crude protein, dry matter, and energy, leading to improvements in feed conversion ratio, weight gain, and survival.
- Addition of **citric acid (30 g/kg)** in the diets of *Labeo rohita* improved their phosphorus digestibility.
- The addition of 2% sodium butyrate in shrimp diets improved the feed intake, diet attractiveness, and the coefficient of apparent digestibility energy and phosphorus.

In general, the liquid acids or blends are added with a feed sometimes directly by spraying whereas the solid acids or acids salts are added directly via special pre mixture by making a very small fine texture. Addition of 0.3 percentage sodium di-formate in the diet of tilapia fingerlings significantly improve their protein efficiency ratio and protein retention.

So see this they very minimal amount it is actually very small, amount is very small the amount of acetic compounds that you are supplying these organic acids are supplements is that actually very small, but it can increase the performance of your aquatic species can increase the performance in terms of protein efficiency ratio, it can perform in case the performance in terms of food conversion ratios and all for your microorganisms.

So, it will give you maximum benefit in different sense, first of all, if you it increases the protein efficiency or the food conversion ratio, the less amount of uneaten feed will be there the most and the feed can, the feed to fish biomass conversion will be maximum the wastewater generation will be minimized. There are like there are bunches of, you know, positive things about it like when we have this kind of, we can add these kinds of feed additives and the minimum amount of addition can increase the production capacity and increase the yield increase the overall performance like anything for your product.

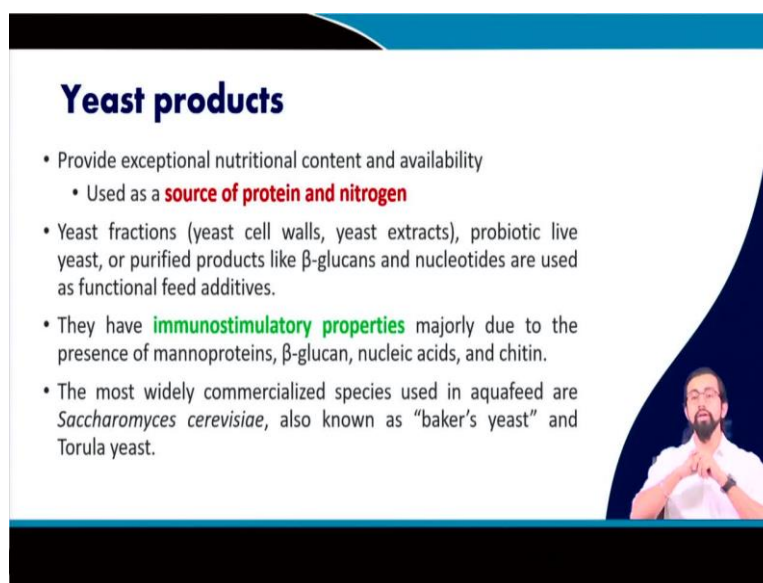
Like I am giving a couple of another other examples like penaeus monodon it is supplied with the feed supplement with 1 percent of commercial acidifiers like sodium butyrate and all. Can improve the digestibility of crude protein, dry matter, and the energy harvesting will be much here. Leading to the improvement in the feed conversion ratio, weight gain and survival for penaeus monodon species and all.

So if we supply the sodium butyrate at a given ratio like you can easily search google it and you can find the literatures available on it. Like what will be the percentage of sodium butyrate that you need to supply to when you are preparing the feed for your species. So based on that, once you know the number and when you prepare the feed for it or suppose your feed manufacturing company by yourself you are developing a feed manufacturing company by yourself how to do that.

So to increase the percentage. So, to increase the you know, the production of penaeus monodon and all. Addition of citric acid like a 30 gram per kg in the diets of Labeo Rohita or in general, we will call rohu fish. It improved the total their phosphorus digestibility like anything okay. So, how to do that we add a 30 gram per kg of citric acid concentration along with the diet that's it, you will your Rohu culture will be increased like production can be increased because their phosphorus digestability will be increased and that will help their overall performance and all.

Additional 2 percent of sodium butyrate in shrimps diet to improve the feed intake diet attractiveness and also the coefficient of apparent digestibility which in terms caused the energy and the phosphorus digestibility as well okay. So, that is why we normally supply this different our reared aquatic species with a different type of feed additive. So, we already covered about organic acids.

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**Yeast products**

- Provide exceptional nutritional content and availability
  - Used as a **source of protein and nitrogen**
- Yeast fractions (yeast cell walls, yeast extracts), probiotic live yeast, or purified products like  $\beta$ -glucans and nucleotides are used as functional feed additives.
- They have **immunostimulatory properties** majorly due to the presence of mannoproteins,  $\beta$ -glucan, nucleic acids, and chitin.
- The most widely commercialized species used in aquafeed are *Saccharomyces cerevisiae*, also known as “baker’s yeast” and Torula yeast.

The third thing that is another essential feed additives that I will be discussing today is about is the yeast product okay from the yeast itself you from you definitely you remember you know that *saccharomyces cerevisiae* or we which is like famously known as baker's yeast or is actually very essential even for a different human food preparation as well.

For animal feed preparation even specifically for aquafeed preparation also it is very important. This yeast product which provide the exceptional nutritional content and availability and it is used as a source of protein and nitrogen sometimes. I am telling you when it is used as protein and nitrogen content source directly, so, then it may consider as a feed okay like nutritional supplement, but when it is used as some other purposes like when you see yeast fractions and it is probiotic live like yeast, or purified products like beta glucans or the nucleotides are used as a functional feed additive.

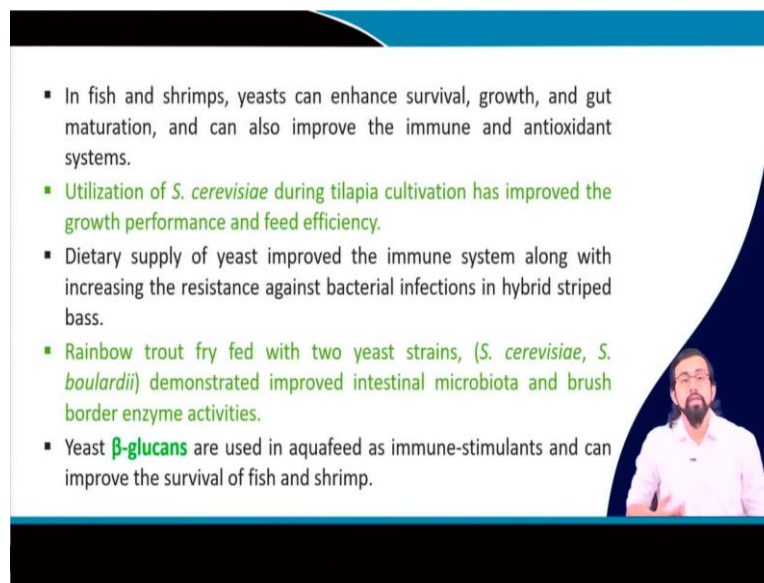
In this case, we are not utilizing exactly as for nutritional purpose, but rather than it is used for the immunostimulatory purpose okay immunostimulatory purpose means it is used to enhance the immunity of your fish or aquatic species, when it is used for this purposes, it is called the immunostimulatory properties and all. So in that sense it is in that case it is not considered as a nutritional source but rather non nutritional feed additives sources.

It will because why it has this particular type of characteristic because of the presence of mannoproteins, beta glucan, nucleic acids and the chitin. So, presence of this four products actually four products, four components are the reason why they have this specific type of

properties and why it is famously used as a probiotic as these yeast products are why famously use in as a feed additives and all.

The most commonly used aqua yeast species is *Saccharomyces cerevisiae* or the baker's yeast and the torula yeast. So, just remember this baker's yeast is very important, when you supplying it with your additives it will definitely give you much higher performance or like your fish will be more in healthy state.

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The slide contains a list of five bullet points. The first point is a general statement about yeasts in fish and shrimps. The second point, highlighted in green, mentions the utilization of *S. cerevisiae* in tilapia cultivation. The third point discusses the dietary supply of yeast to hybrid striped bass. The fourth point, also highlighted in green, mentions rainbow trout fry fed with two yeast strains. The fifth point states that yeast  $\beta$ -glucans are used as immune-stimulants. In the bottom right corner of the slide, there is a small video inset showing a man with a beard and glasses, wearing a white shirt, speaking.

- In fish and shrimps, yeasts can enhance survival, growth, and gut maturation, and can also improve the immune and antioxidant systems.
- Utilization of *S. cerevisiae* during tilapia cultivation has improved the growth performance and feed efficiency.
- Dietary supply of yeast improved the immune system along with increasing the resistance against bacterial infections in hybrid striped bass.
- Rainbow trout fry fed with two yeast strains, (*S. cerevisiae*, *S. boulardii*) demonstrated improved intestinal microbiota and brush border enzyme activities.
- Yeast  $\beta$ -glucans are used in aquafeed as immune-stimulants and can improve the survival of fish and shrimp.

So, in general the fish and shrimps, the yeast can help in survival, growth and the gut maturation and also can improve the immune and the antioxidant system and all. The utilization of *Saccharomyces cerevisiae* or the baker's yeast during the tilapia cultivation can improve the growth performance and feed efficiency here feed efficiency means the conversion efficiency can be improved.

Dietary supply with the yeast improves the immune system along with increasing the resistance again the bacterial infections in hybrid striped bass and all so, not only it helps in increasing the immune system in developing the immune system, but definitely once it is helps in developing the very higher strength immune system, it will definitely help in increasing the resistance against any bacterial infection.

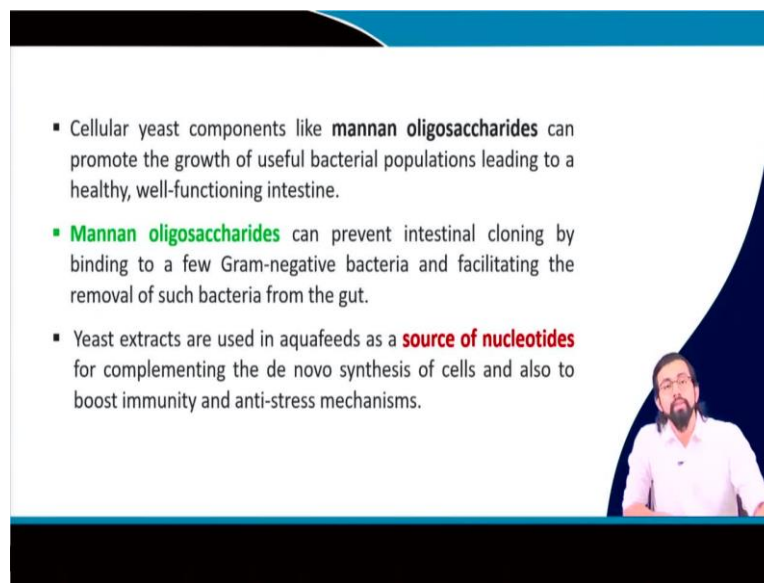
So, by this means, they can be utilized for hybrid striped bass and all the production productivity of this aquatic species can be increased. Rainbow trout fry they normally fed with two yeast strains *Saccharomyces cerevisiae* and second *saccharomyces boulardii*. So

what they do they it because of the presence of this yeast strains, along with the feed. It demonstrates improve intestinal microbiota and brush border enzyme activity.

So this enzymatic activity can be increased it will passively, and sometimes active and sometimes passively can also increase the overall consumption like you know improve the consumption efficiency and not only that it can help in grating giving them a much more immune boosting capacities.

Yeast has this beta glucans which are used in aquafeed as immunostimulant and can improve the survival of fish and shrimps. Just remember this is composition beta glucan, beta glucans are actually very much essential for a aquafeed in general we normally use it for most of the fish and shrimp culture. So, it can even be used for immunostimulants and can also improve the survival of fish and shrimps.

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- Cellular yeast components like **mannan oligosaccharides** can promote the growth of useful bacterial populations leading to a healthy, well-functioning intestine.
- **Mannan oligosaccharides** can prevent intestinal cloning by binding to a few Gram-negative bacteria and facilitating the removal of such bacteria from the gut.
- Yeast extracts are used in aquafeeds as a **source of nucleotides** for complementing the de novo synthesis of cells and also to boost immunity and anti-stress mechanisms.

Cellular yeast components like mannan oligosaccharides can promote the growth of useful microbial bacterial population leading to a healthy and well functioning intestine. This mannan oligosaccharides, it can prevent the intestinal cloning by binding a few gram negative microorganisms or bacteria and facilitating the removal of such bacteria from the gut. So, how we can get rid of this gram negative bacteria, they help they first of all they prevent the intestinal cloning by binding this microorganisms.

After the binding is done they make from a clog and they can be easily removed from the gut much better way by this way they can help in maintaining proper environment in the gut

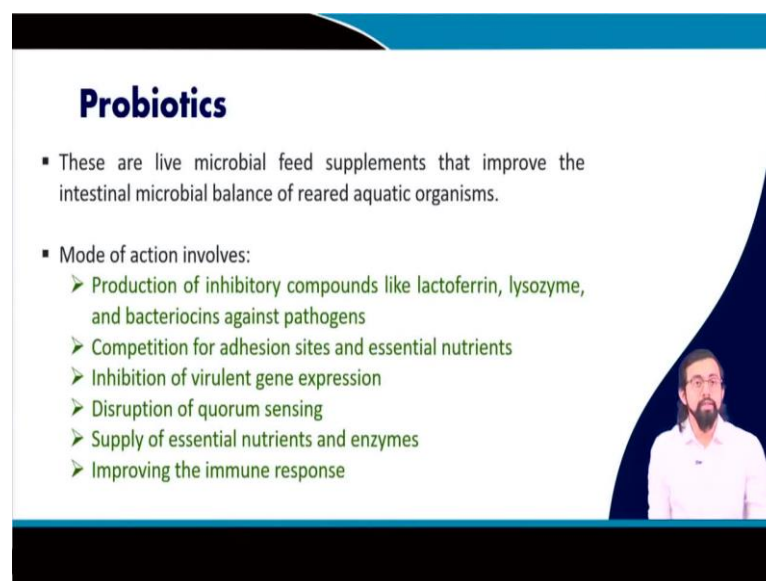
microbiota environment in the gut inside the gut and the intestines. So, to improve the performance of the aquatic species itself.

Yeast extracts are normally can be used as a source of nucleotides as well. For complementing the de novo synthesis of cells, what is the why the source of why the source of nucleotides are helping for complementing the de novo synthesis what is the de novo synthesis? de novo synthesis is like, in general in by terms de novo synthesis means synthesise of higher compounds say like a complex compound from the smaller compound or in a simple compound this is we call it de novo synthesis.

Do you understand like complex compound can be formed from the simple compound from simple to complex. So, this formation in generally sometimes occur in the inside the cell naturally like we use formats and all for different kinds of in case of amino acids synthesis and all. so, this in in case of yeast extract they and because they can supply with the nucleotides and all, which can replace this phenomenon.

So, because of this, so, this is actually a very beneficial phenomenon. So, once you are adding some additional components or additional material, which can replace not only replace, which can actually boost this phenomenon this de novo synthesis in cell. Definitely it can boost the immunity and the anti-stress mechanism of the cell itself. So, that is how the nucleotides are actually helpful. And these nucleotides can be supplied by using the yeast extract.

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**Probiotics**

- These are live microbial feed supplements that improve the intestinal microbial balance of reared aquatic organisms.
- Mode of action involves:
  - Production of inhibitory compounds like lactoferrin, lysozyme, and bacteriocins against pathogens
  - Competition for adhesion sites and essential nutrients
  - Inhibition of virulent gene expression
  - Disruption of quorum sensing
  - Supply of essential nutrients and enzymes
  - Improving the immune response

The fourth one that we will be discussing today is the probiotics you know, what is probiotics? it is like a microbial feed supplement, which helps in improving the intestinal microbial balance for any reared aquatic species, forget about reared aquatic species any living organisms even we also used to have probiotics based on our doctor's prescription when we have some irritations in our gut and also we have some problem with the digestion or anything. So, we supplied with some probiotics.

So, these are the microbial feed supplements which improve the intestinal microbial balance. So, that you have to remember about what is probiotics and all how it what is the action what it actually does, it helps in the production of inhibitory compounds like the lactoferrin, lysozymes and the bacteriocins and all, which can act again the against the pathogens, you know, what is pathogens, pathogenic microorganisms, if the organisms which are unwanted, which are the unwanted microorganisms, which somehow presents in the feed and somehow get into our system, so, these pathogens can cause the disease and all.

So, we need to get rid of the pathogenic microorganisms, how we can do that, we can have some inhibitant, produce some inhibitory compounds like lactoferrin, lysozyme, and bacteriocins, which can help us against fighting the pathogenic microorganisms, not only us, but the aquatic species as well. So, in this particular case, the probiotics are supplied in the for the base because of that all.

What are the other action what are the other involvement? competition for the adhesion sites and the essential nutrients, inhibition of virulent gene expressions, disruption in quorum sensing, supply of essential nutrients and enzymes and also improving the immune response in general. So, in general, you know what is quorum sensing out of all these things, I think quorum sensing is the one that you should, like, you know, know more in detail.

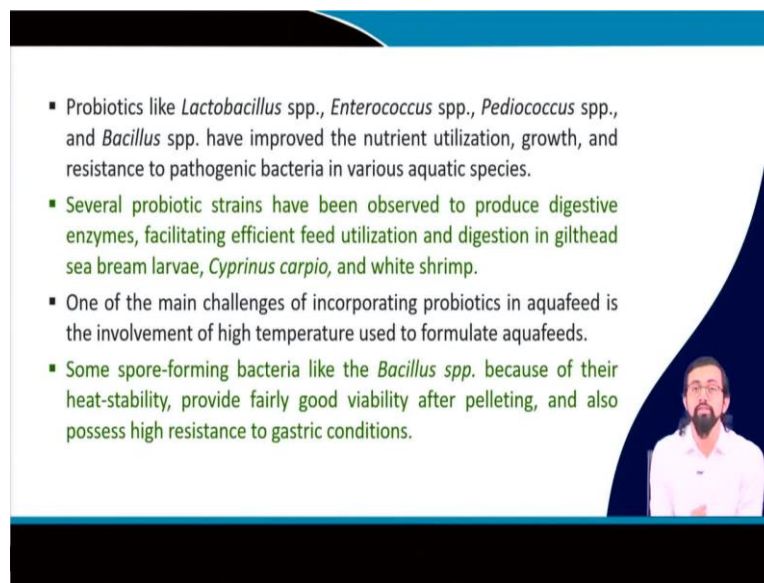
Quorum sensing is like, you know, kind of interacting mechanisms like way of communication in between the microbiota. In general, the bacteria, they just to say in very grossly it is a way of communication. The microorganism, the way of communication. So it is like, you know, one pathogen came and they say, like, so we have a very perfect environment here.

Let us increase the productivity and we can have let us go for the reproduction we can have a lot of reproduction we can will capture the whole system and all. So we will, they will also, , kind a communicate with other microorganism and they will also come and settle there. So it

is like, I am just giving you a very gross it does not go like this, they do not talk like this there, there are some chemical compounds which are responsible for that. Anyway, so this quorum sensing process can be disrupted by using the probiotics.

So, other than that, it can supply the essential nutrients in and to improve the immune response definitely, because of the presence of this, and the different inhibitory compounds as I already mentioned.

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▪ Probiotics like *Lactobacillus* spp., *Enterococcus* spp., *Pediococcus* spp., and *Bacillus* spp. have improved the nutrient utilization, growth, and resistance to pathogenic bacteria in various aquatic species.

▪ Several probiotic strains have been observed to produce digestive enzymes, facilitating efficient feed utilization and digestion in gilthead sea bream larvae, *Cyprinus carpio*, and white shrimp.

▪ One of the main challenges of incorporating probiotics in aquafeed is the involvement of high temperature used to formulate aquafeeds.

▪ Some spore-forming bacteria like the *Bacillus* spp. because of their heat-stability, provide fairly good viability after pelleting, and also possess high resistance to gastric conditions.

Probiotics like lactobacillus species, Enterococcus, Pediococcus or the bacillus species, it can improve the nutrient utilization growth and the resistance to pathogenic microorganism bacteria in various aquatic species. Several probiotic strains have been observed to produce a digestive enzyme which is also good see like it can, it is helping in producing some digestive enzymes, facilitating the efficient feed utilization and digestion in gilthead seabream larva, cyprinus carpio or the white shrimps and all

So, for them it is beneficial in other sense also, because it is helping them to produce the digestive enzymes. One of the main challenges of incorporating the probiotic in aquafeed is the involvement of high temperature used to formulate their aquafeed. Once you go for high feed formation, remember we discuss about the pellet formation and all how we do all those things.

In case of pellet, we go for high pressure high temperature utilization, when we go for this high pressure high temperature utilization, what will happen? it will reduce the activity of this

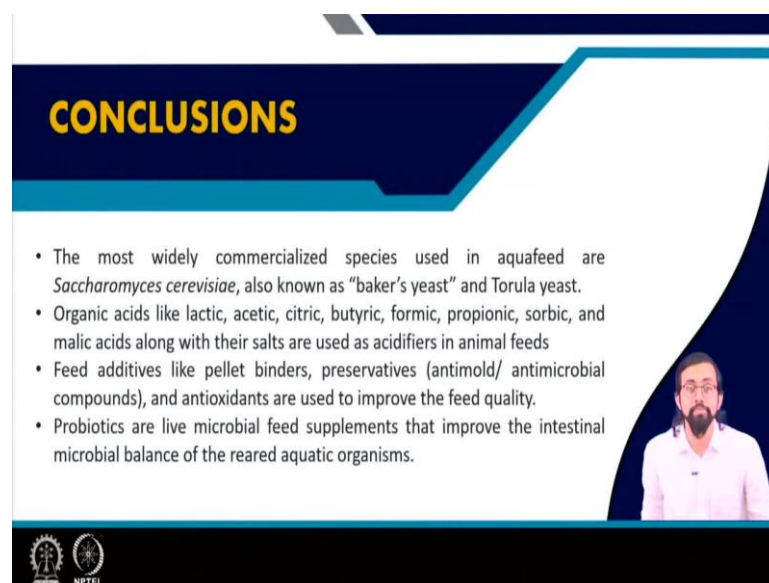


probiotic compound. But, there are some spore forming bacteria like bacillus species, because of their heat stability, it can provide fairly good viability even after pelleting after the pellet is found this small pellets are formed, because they are going through this extrusion process which involves very high temperature high pressure process.

Because of that still, because of this environment of this heat and pressure, some kind of bacillus species can still survive this spore forming microorganisms. They can still survive because of the making a specific type of shielding layer or over its body and it will still be present in the pellet and it also possess high resistance to the gastric condition, high and gastric low pH condition and all these things.

So there also they can easily sustain. So that can be used as probiotics in case of the pellet formation or where we will be using very high pressure and high heat, high amount of high temperature.

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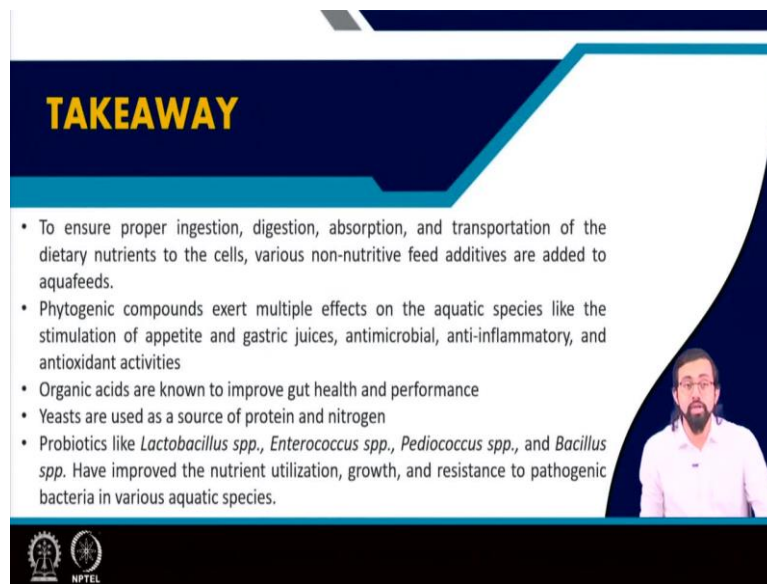
**CONCLUSIONS**

- The most widely commercialized species used in aquafeed are *Saccharomyces cerevisiae*, also known as "baker's yeast" and Torula yeast.
- Organic acids like lactic, acetic, citric, butyric, formic, propionic, sorbic, and malic acids along with their salts are used as acidifiers in animal feeds
- Feed additives like pellet binders, preservatives (antimold/ antimicrobial compounds), and antioxidants are used to improve the feed quality.
- Probiotics are live microbial feed supplements that improve the intestinal microbial balance of the reared aquatic organisms.

The slide features a dark blue header with the word 'CONCLUSIONS' in yellow. Below the header is a white area containing a bulleted list of text. In the bottom right corner of the slide, there is a small video inset showing a man with a beard and glasses, wearing a light-colored shirt, speaking. At the bottom left of the slide, there are two circular logos, one of which is labeled 'NPTEL'.


So in conclusion, the most widely commercialized species used in aquafeed are *Saccharomyces cerevisiae*, or the baker's yeast and torula yeast. Organic acids like lactic acid, acetic, citric, butyric, formic, propionic, sorbic and malic acid along with their salts can be used as acidifiers in animal feed. Feed additives like pellet binders, preservatives like anti-mold, antimicrobial properties, a compound and antioxidants can be used to improve the feed quality. Probiotics are live microbial feed supplements that improve the intestinal microbial balance of the reared aquatic organisms and all.


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**TAKEAWAY**

- To ensure proper ingestion, digestion, absorption, and transportation of the dietary nutrients to the cells, various non-nutritive feed additives are added to aquafeeds.
- Phytogetic compounds exert multiple effects on the aquatic species like the stimulation of appetite and gastric juices, antimicrobial, anti-inflammatory, and antioxidant activities
- Organic acids are known to improve gut health and performance
- Yeasts are used as a source of protein and nitrogen
- Probiotics like *Lactobacillus spp.*, *Enterococcus spp.*, *Pediococcus spp.*, and *Bacillus spp.* Have improved the nutrient utilization, growth, and resistance to pathogenic bacteria in various aquatic species.

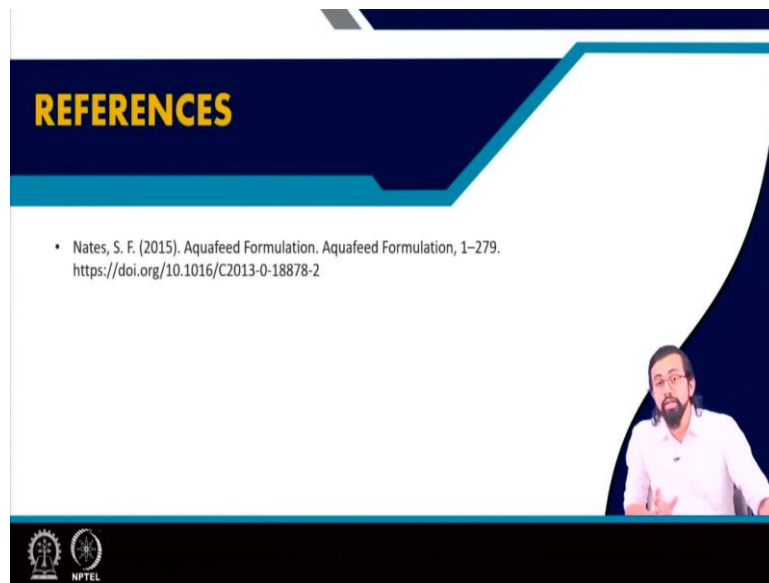




Takeaway message from this lecture, you know the feed additives are used to ensure proper ingestion, digestion, absorption and the transportation of the dietary nutrients to the cell. Phytogetic compounds like, like it can exert the multiple effects on the aquatic species like stimulation of their appetite and the gastric juice, anti-microbial, anti-inflammatory and antioxidant activities.

Organic acids are used to improve the gut health and performance. Yeast are used as a source of protein and nitrogen sometimes and also its extracts can be used for other purposes probiotics, like lactobacillus, pediococcus, enterococcus, bacillus species. It can improve the nutrient utilization, growth and the resistance to pathogenic microorganisms for various aquatic species or the species that you are culturing in your systems.

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So, I will continue about this feed additive in the coming lecture as well. So this is the reference that you can take a picture you can Google it. It will give you much more information in very precise manner about this aquafeed formulation and what are the information like different informations that you need.

So that is it for today we will discuss more in details about the different feed additives and all in the coming lecture. Thank you so much.