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Effects of Yeast Antimicrobial Peptide in Aquaculture

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Abstract

The aquaculture industry has increased over the years. However, development of the aquaculture industry is couple with challenges. Among them is increased cost of fishmeal and disease outbreak. The use of antibiotics has led to increase in disease causing bacteria in aquatic organism. Antimicrobial peptide (AMP) contains nutrient such as protein, and vitamins, immune-stimulants, and oligosaccharides. AMPs are an essential microbial product that improves health and growth of many animals. In aquaculture also, AMP boost the immune and improve disease resistance in fish. Yeast AMPs products are suitable because they have have been used as feed ingredient to replace fishmeal in fish feed. In this review, we discussed the importance of using AMPS (Yeast products) sustainably in aquaculture as an excellent alternative to fishmeal, supplement to improve the immune system and disease resistance in an aquatic animal to enhance the sustainability of aquaculture. From studies, it was confirmed that 40% of yeast can be used to replace fishmeal in fish diet and also supplementing 1% of yeast in fish diet increased disease resistance in fish. This will help address reduce feed cost and also increase disease resistance of aquatic animal in aquaculture to improve profitability and sustainability in the industry.

Keywords: Antimicrobial peptides; Diseases; Feed; Growth; Yeast; Fish; Shrimp.

Introduction

The aquaculture industry has increased tremendously in recent years [1]. The development of the aquaculture industry is facing some challenges such as increased cost and unsustainable fishmeal production, disease outbreak and climate change. The outbreak of diseases in aquaculture industry is one of the significant challenges facing the industry, and the cause of the problem is as a result of the inappropriate use of antibiotics and antibiotic resistance genes among some pathogens such as Vibrio [2-4]. Overuse of antibiotics and excesses can lead to resistance of bacteria [5]. Scientists and researchers have been studying on AMPs to replace antibiotics in recent times [6,7]. Most of these AMPs is an essential innate immune system found in many organisms such as mammals, fish among others. These peptides have a different system of the mechanism of action and can all microorganisms [7]. Antimicrobial peptides (AMPs) are minor proteins (<40 amino acids) that can kill most pathogens in many organisms. Most AMPs isolated from many fish species predicting a change in fish immunity [8-12]. Yeast is one of the best peptide isolated from the eukaryotic origin. It can inhibit gram-positive and negative bacteria, and fungi [13]. AMPs (yeast products) can be used to control diseases outbreak in aquaculture. These AMPs encoded in the gene system, and as a result of that, produced at a low cost with characterized expression procedure. When adequately developed with all systems in place and well followed, they can direct the peptide, such a way that it can be used in feed-based production as well. According to [14], yeast can be expressed from the eukaryotic origin and has the ability and advantage to be turned in the o AMP with the appropriate strains been isolated and combined. The objective of this review

is to discuss the effects of AMPs (yeast products) such as *Candida utilize* (CU), *Tachyplesin,* and *Saccharomyces escerevisiae* in aquaculture.

The effects of antimicrobial peptide and its benefits in aquaculture

[15] stated that over 5000 AMPs had been produced through the separation process so far. AMPs produced from species such as eukaryotes (fungi, animals) and prokaryotes (bacteria). Tissues and organs in animals usually contain AMPs because they are exposed to the air while the air contains pathogens and for that matter need to kill those harmful pathogens to protect organisms [16,17] from bacteria and fungi [18]. Moreover, AMPs plays a significant role in defending organisms from any disease-causing pathogens. AMPs produced from particular cells, and its production is usually inducible such as using silkmoth as a model system and confirmed that P9B and P9A could induce in hemolymph vaccination with *E.cloacae* [19]. Many eukaryotic cells have been used to produce AMPs such as yeasts lymphs, epithelial cells, phagocytes among others. Lymphocytes of the immune system are also included [18,20-23]. AMPs can be produced or induced in mammals when lipopolysaccharide (LPS) molecules from bacteria treated with antibiotics [24]. Therefore, AMPs can reduce the inflammatory response. As it is well known, antibiotics do not have this characteristic by AMPs to regulate inflammatory response of the host organisms' immune system. Also, the over-reaction of the immune system is causing when LPS secreted following treatment. [24,25]. Furthermore, AMPs are active in mammals and can kill bacteria effectively. They are not affected by antibiotic resistance by bacteria, able to neutralize endotoxins without causing harm to the host organism. Despite the benefits of AMPs, issue of high production cost must be tackle. The peptide has a high molecular weight compared to antibiotics, and this makes its production cost high. Injection of AMP (CAP 18) in trout can increase the survival rate in trout culture [26]. This peptide boosts the innate immune system of trout, thereby increasing the rate of disease resistance and increase survival rate when there is a disease outbreak. In aquaculture, there are two popular methods of applying AMPs effectively to ensure high utilization. These methods include medication through water and medication through the feed. With yeast products, it is best to apply through the feed so it can be absorbed into their system easily [27].

The use of yeast (CU) in aquaculture

Candida genus has asexual *Ascomycetous* species that is not classified. Other species are also sexual or asexual belonging to different families. In the food processing industry, Candida species in the natural and artificial environment is useful in the production of fermented food and wine, and beverages, milk production, and meat processing. Some of their characteristics such as osmotolerance and a wide range of temperature make them suitable to be used in the food processing industry [28]. Candida genus of yeast is handy in the food industry because of the beneficial microorganisms it contains. CU yeast includes microbial proteins made up of amino acids such as lysine and methionine. It also contains microbes such as β-glucans, glucomannan, and mannoproteins, and anti-oxidative characteristics which make it best candidate to be used in the food industry. Candida yeast cells can obtain elements from cultivation medium, which is mostly more than the amount that is needed thereby producing bioplex with selenium or magnesium. Candida yeast cells with their properties make it a suitable candidate in the production of feed additives in for an aquatic feed. Animal protein (65%) replaced with a mixture of plant proteins and CU in tilapia, growth performance was not affected. Also, the composition of the experimental diets did not affect feed utilization, feed conversion ratio, and protein efficiency ratio in tilapia [29]. A study done by [30] reported that yeast could be used to replace fishmeal at 25% without having any adverse effect on the growth performance in trout. Furthermore, candida yeasts can produce extracellular metabolites such as citric acid, xylitol, polysaccharides. Many industries such as the food industry, pharmaceutical industry rely on these substances to deliver their product [31]. Most of these microorganisms can grow everywhere, low nutritional requirement and can thrive in harsh environmental conditions making it easy to culture [32].

The figure 1 below shows the general properties of yeast AMPs used in aquaculture

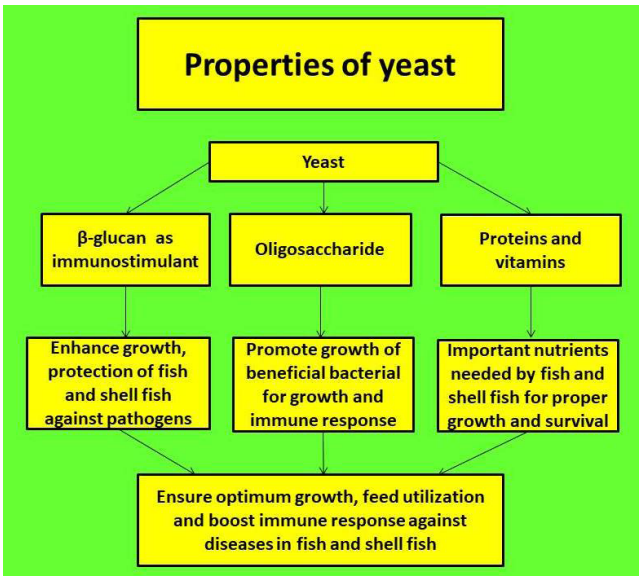

Figure 1: Properties of yeast.

The nutritional value of yeast processing product

In other to determine the nutritional value of protein, its amino acids composition must be a consideration. Protein found in yeast products is high due to its efficiency ratio and biological

significance. The table below shows the nutritional value of the yeast protein. Due to its high concentration ion of amino acids, candida yeast is the best candidate that can be used as a protein supplement in the aquatic feed to increase growth and boost the immune system.

Adopted from [33].

Amino acids	FAO	Yeast protein (CU y-900)
LYSINE	4.2	9.1
MET	2.2	1.2
CYS	2	0.6
ILEU	4.2	4.5
LEU	4.8	9
PHE	2.8	5.2
TRY	1.4	-
THR	2.8	5.5
VAL	4.2	5.5

Table 1: The nutritional value of the yeast protein.

Yeast as an alternative feed ingredient to replace fishmeal

Fishmeal is a primary protein source used in feed for aquatic animals. Increase in the aquaculture industry over the years has resulted in the insufficient supply of fishmeal due to overfishing, overexploitation and climate change such as El Nino leading to high cost of feed production. Due to these challenges, there have been concerns to replace fishmeal with an alternative protein source to reduce the pressure on fish consumption for feed production [34,35]. The use of animal by-product as an alternative to replace fishmeal is a good option but due to health issues matters it has raised many concerns about its to use, and this has paved the way for the use of plant protein as the best alternative to replace fishmeal because it is safe according to researchers [36,37]. Yeast products contain proteins and vitamin B-complex which makes it suitable to supplement it in fish feed to complement amino acid and vitamins composition when cereals are used in animal feed production [38]. Yeast products such as Candida tropicalis, CU and C. lipolytic, when used as a feed ingredient for Cyprinus carpio diet can produce better results than soybean or animal by-products.

A study conducted by [39], confirmed that yeast could be used to replace 50% of fishmeal in tilapia feed without having any adverse effects on growth performance. This yeast helps reduce feed cost in tilapia farming and also increase profitability and sustainability. In aquaculture, one of the critical challenges that need to be tackled in other to ensure sustainability in the industry is to find a sustainable way of producing feed at a low cost. Use of yeast in fish culturing can be a suitable alternative in replacing fishmeal with another protein source to reduce production cost and increase sustainability in the aquaculture industry. As a result of this, the economic analysis needs to be done to determine the cost-benefit analysis on producing yeast as a protein source in fish feed for commercial consumption [40].

Effects of yeast in the fish culture

Work done by [41] confirmed that 65% animal protein mixed with plant protein and supplemented with yeast in young tilapia diet could obtain optimum growth, boost the immune system, and profit. Given this, it helps in increasing food security and also increases the chance of attaining sustainable development goal (SDGs). In trout farming, when yeast together with essential amino acids such as methionine and arginine supplemented in its feed, it boosts their immune system which results in increased disease resistance in trout [42]. In trout culturing, diseases easily spread when fishes are not well cared for so boosting their immune system by supplementing yeast in their feed may help increase disease resistance and increase their chance of survival. Enhanced CU used as AMP in fish feed can inhibit the growth of pathogens, boost the innate immune system and improve disease resistance in fish. Yeast helps increase survival in fish culturing and profit making the aquaculture industry grow and develop [29]. In a feeding trial where CU was used to replace fishmeal in Atlantic salmon, the study showed that there was no significant difference in the digestibility of crude protein and energy as compared to the control diet. This study shows that CU can be used to replace 40% fishmeal without any adverse effects on the shrimp [43]. More research is needed to determine and increase the nutritional quality of yeast as AMP in aquaculture to help increase diseases resistance in fish to ensure growth and development in the industry.

Effects of yeast products in the shrimp diet

Candida species used as AMP in shrimp diet such as tachyplesin is effective in boosting the immune system of shrimp and also adjusting the intestinal flora of shrimp which makes it able to survive harsh environmental condition in the marine environment. Tachyplesin can inhibit the growth of some bacteria and parasite such as *P. marinus* in the digestive system of aquatic animals and increase disease resistance as well [44,45]. Diseases resistance in aquatic organisms has been achieving by treated with AMP obtained from eukaryotic expression system such as *P. pastoris,* through their feed [14]. In artemia culturing CU and *Pseudomonas stutzeri*, it is essential to supplement these AMPs in their feed because they inhibit the growth of pathogen during culturing and also boost immune system thereby, increasing their survival rate during culturing [46]. These AMPs, when supplemented in feed, can provide extra vitamins and mineral in aquatic animal feed to increase disease resistance and survival rate [47]. Crustaceans have benefi-

cial bacteria that help provide them with vitamins, amino acids, and fatty acids, so it is better to study the interaction of these bacteria when supplementing this product in their feed for better utilization and growth [48,49]. Shrimp fed 1% yeast showed high weight gain, specific growth rate, and feed conversion ratio than the control diets. These confirm that yeast contains nutrients such as a protein that is needed by shrimp to increase growth performance and survival [50]. Optimum growth and disease resistance in artemia culturing achieved when CU, is used as AMP and supplemented in its feed. AMPs resist the growth of pathogens such as *Pasteurella haemolityca* and *Vibrio alginolyticus* and increase artemia survival rate during culturing [46]. As a result of some microbes found in the yeast cell wall, it makes their immune system healthy and able to kill harmful pathogens in artemia such as B-glucans, and chitin [51,52]. The increase in disease resistance and survival rate in Artemia culture are related to that fact that naupliar gastrointestinal tract in artemia can resist bacteria attack after hatching. Such makes artemia more improved when AMPs are supplemented in their feed to help in the development of the naupliar in to fight and kill pathogens to increase survival in Artemia culture [46]. A study conducted by [53] stated that marine yeast could be used as a supplement in shrimp feed to obtain optimum growth performance and survival in shrimp culture.

Yeast products used in gene expression

One of the essential yeast species is *Saccharomyces cerevisiae*. It has the ability in expressing proteins for research in many industries such as aquaculture industry and the food industry. It is also good in the pharmaceutical industry as a food organism [54]. Yeasts can be cultured in simple or complex media, and its genetics developed than eukaryote. With these characteristics, it can be manipulated easily as *E. coli*. Many yeast products contain multiple plasmid and sequences for the growth of *E. coli* for quality transcription of foreign genes. In recent years, the study of yeast molecular genetics has produced more results about its composition, and this knowledge has helped in the expression of foreign genes in yeast products. Gene expression is a complicated procedure which results in many challenges at different stages such as transcription and protein stability. Eukaryote yeast offers an opportunity to ensure a successful expression without many challenges and helps to solve some problems in appearance such as the power of classical. From the works of [54], it has become comfortable in the expression system even including other organisms such as prokaryotes. According to [54], yeasts have characteristics such as having plasmid DNA vectors, and some essential tools for constitutive expression and correction of protein folds and have been using as a protein source in feed for aquatic animals [41,55]. These characteristics might prevent the use of yeast effectively and efficiently. An investigation by [50], stated that immune-related genes such as (dorsal, relish, and proPO) was expressed more in shrimp that fed with 1% yeast supplementation in shrimp diet. They also added that 1% supplementation of yeast in a shrimp diet expressed high immune-stimulatory effects. Therefore there is the need for a further research study to reduce the occurrence of these microbes found in yeast.

Conclusion and Recommendation

The benefits of yeast products as AMP in aquaculture are outstanding. Feed manufacturing companies, aquaculture nutritionist, scientists and other stakeholders should study more about yeast products as antimicrobial peptide because it will help develop the aquaculture industry and also help address some challenges facing the industry such as high feed production cost, increasing disease resistant in aquatic organisms. It was confirmed that yeast could be used to replace 50% of fishmeal in tilapia feed without having any adverse effects on growth performance. Moreover, marine yeast could be used as a supplement in shrimp feed to obtain optimum growth performance and survival in shrimp culture. Yeast products as antimicrobial peptide being the best ingredient as protein source and supplement in fish feed, continuous studies need to be done to determine the optimum level that can be used in feed for aquatic organisms in aquaculture to ensure high profit and sustainability in the industry.

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