POSTBIOTICS: A POTENTIAL DISEASE CONTROL AGENT IN AQUATIC HEALTH MANAGEMENT

Abstract

Aquaculture represents among the most rapidly expanding food production sector, with a 5.3% annual growth rate. In 2018, the estimated global aquaculture production was 114.5 MT. Simultaneously, wild capture fisheries are now reaching to the ecosystem limit. As a result, aquaculture has emerged as a viable solution to these issues, consistently supplying a lion's share of global animal protein consumption to reduce malnutrition and hunger among the world's rising population. However, the constant expansion of aquaculture creates a widespread outbreak of infectious diseases, which can be triggered by the movements of hatchery generated stocks, the entry of alien species, and trade liberalization etc. Chemotherapeutic therapy and control measures such as immunization have been utilized extensively to reduce disease outbreaks. However, the use of chemotherapeutants such as antibiotics resulted in the development of antibiotic resistant microbiological infections, and immunization was primarily utilized as a preventative measure and was confined to immune compromised organisms. As a result, novel control measures such as prebiotics, probiotics and postbiotics are being explored during present times to control the diseases. Despite a considerable literature addressing the use of teichoic acids, peptides, vitamins, peptidoglycan, cell surface proteins, peptidoglycan, short chain fatty acids and organic acids in aquaculture, there is a limited review of postbiotic usage in aquaculture. As a result, this study adds to the body of knowledge about the antibacterial and health-promoting effects of postbiotics derived from various bacterial species in aquaculture animals, either in vitro or in vivo.

Keywords: Postbiotics, disease, aquaculture, chemotherapeutants, antibiotics.

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I. INTRODUCTION

Aquaculture represents among the most rapidly expanding food production sector, with a 5.3% annual growth rate [1]. In 2018, the estimated global aquaculture production was 114.5 MT [1]. Simultaneously, wild capture fisheries are now reaching to the ecosystem limit [2]. As a result, aquaculture has emerged as a viable solution to these issues, consistently supplying a lion's share of global animal protein consumption to reduce malnutrition and hunger among the world's rising population. However, the constant expansion of aquaculture creates a widespread outbreak of infectious diseases, which can be triggered by the movements of hatchery generated stocks, the entry of alien species, and trade liberalization etc. [3]. Chemotherapeutic therapy and control measures such as immunization have been utilised extensively to reduce disease outbreaks. However, the use of chemotherapeutants such as antibiotics resulted in the development of antibiotic resistant microbiological infections, and immunization was primarily utilized as a preventative measure and was confined to immune compromised organisms [3]. As a result, novel control measures such as prebiotics, probiotics and postbiotics are being explored during present times to control the diseases. Because an imbalance in the intestinal microbiota may contribute to the development of various illnesses, the use of prebiotics, probiotics, and postbiotics to change the gut microbiome has recently sparked attention. Mantziari et al. (2020) define postbiotic as a non-viable bacterial product or metabolite produced by live bacteria or substances released after chemical or mechanical lysis of living bacteria. Intestinal microbiota plays a crucial role to maintain the healthy ecosystem inside the gut of animals including immune system development, inflammation, homeostasis and defense against pathogens [5]. The role of intestinal microbiota is not only limited to the host's gastrointestinal tract, but has been extended to the axis of gut-brain [6], gut-lung [7] gut-kidney [8]and gut-liver [9] with linkages suggesting the relevance of the microbiota of the animal growth and health. As a result, sustaining a stable intestinal microbiota is seen as a critical aspect in aquaculture health management. The GI tract of fish contains a diverse microbial population that is divided into two separate categories, allochthonous and autochthonous [10]. Autochthonous bacteria are able to invade the host's gut mucosal surface or are connected with the microvilli, whereas allochthonous bacteria are temporary, correlated with food particles, or found inside the lumen [11]. Since the GI tract is one of the key entrance points for certain pathogens, allochthonous bacteria are significant for assessing the influence of dietary components on the intestinal microbiota of fish [12]. The standard methods for modifying the intestinal microbial community are being used by many researchers to enhance the gut microbiota of fish by providing probiotics, paraprobiotics, and/or postbiotics that increase growth and activity of particular bacterial species. Though various bacterial and yeast species are being employed as probiotics, paraprobiotics, and/or postbiotics in aquaculture, the most common probiotic microorganisms used for aquaculture are Lactobacillus spp. and Bacillus spp [13,14]. Introducing advantageous bacterial species from one fish species to another in order to modify and stabilise the gut microbiota of the recipient is an important strategy for having a healthy microbiota, which results in a healthy gut [15]. Currently, the use of postbiotics in medicinal products, industrial food-based products, and terrestrial agriculture has been studied so far [16]. Despite a considerable literature addressing the use of teichoic acids, peptides, vitamins, peptidoglycan, cell surface proteins, peptidoglycan, short chain fatty acids and organic acids in aquaculture, there is a limited review of postbiotic usage in aquaculture. As a result, this study adds to the body of knowledge about the antibacterial and health-promoting effects of postbiotics derived from various bacterial species in aquaculture animals, either in vitro or in vivo.

II. POSTBIOTICS

The bacteria in the gut are fully dependent on their host for the nutrients, which help them for their growth. Bacteria create minuscule molecular weight compounds that play a significant role in self-growth, development, reproduction, supporting the growth of other beneficial species, cell-to-cell communication, and stress tolerance [17]. Some of the metabolites may be created by live bacteria or ejected into the environment upon bacterial lysis, offering further benefits by altering the host's cellular processes and metabolic pathways. Postbiotics offer various benefits over probiotics and prebiotics comprising availability in their purest form, simplicity of manufacture and storage, and a distinctive mechanism of action etc.

1. **Classes of Postbiotics:** Postbiotics can be classified according to their elemental composition, which includes protein (peptides and amino acids), lipids (SCFAs, butyrate, propionate etc.), carbohydrates (teichoic acids and galactose- rich polysaccharides), vitamins/co- factors (vitamin C and B group), organic acid, cell wall component and complex molecules.

2. **Characteristic Features of Postbiotics:** Shenderov (2013) demonstrated that postbiotics have benefits in terms of metabolism, absorption, excretion and distribution implying that they possess a high potential to link with a wide range of host tissues and organs and elicit a wide range of biological reactions. Furthermore, postbiotics are believed to mimic the health effects of probiotics without the use of live bacteria. Precisely therefore, utilizing postbiotics rather than live probiotic bacteria may be a safer option; adding postbiotics may be a viable treatment against pathogenic illnesses in aquaculture [18].

3. **Potential Mechanism of Action of Postbiotics and Effect on Immunity:** The molecular pathways driving postbiotic effects appear to be mediated via a host-microbial product interaction. As a result, the host immune system becomes activated, which results in anti-inflammatory responses. The use of postbiotics in aquaculture to limit the spread of fish-associated illnesses might be an alternate treatment method to immunization and the application of chemotherapeutics. However, the exact mechanism of probiotics is still under processed. Postbiotics, on the other hand, may have immune modulators properties. Pili and protein p40/p75, for example, are postbiotics generated by lactobacilli that have an immune modulator impact by increasing factor proteins, aggregation, S-layer proteins and bacteriocins, demonstrating antagonistic action against pathogens. Different bacterial species and strains appear to have different immunostimulant effects due to changes in cell wall components such as lipoteichoic acid and peptidoglycan.

III. BROAD CLASSIFICATION OF POSTBIOTICS AND THEIR ROLE IN AQUACULTURE

1. **Short-Chain Fatty Acids:** Short-chain fatty acids (SCFAs) and their associated salts are generally regarded as risk -free compounds with a unique property that is now also regarded as antimicrobials in veterinary feed sector [19]. And an appealing option for use as a feed additive in farmed animals including fish. SCFAs are the most significant bacterial metabolites, which are mostly created during the anaerobic process inside the gut by the fermentation of dietary fiber and resistant starches. SCFAs are aldehyde-containing substances with a few carboxyl groups and six or fewer carbon molecules,

such as acetate, propionate, butyrate, pentanoic acid, and hexanoic [20]. These SCFAs regulate the physiological condition of the host in three ways: through the impacts of the feeds supplied, through effects in the animal's GI system, or by direct effects on metabolism [21]. In general, most SCFAs can lower the pH of feed, preventing the growth of bacteria. SCFAs work in the intestinal system by lowering the pH in the stomach and small intestines, as well as inhibiting the development of Gram-negative bacteria by acid dissociation and the generation of anions in bacterial cells. On the other hand, acidification caused by the usage of SCFAs has a significant impact on the bioavailability of dietary minerals in numerous ways. Because of the significance of the aforementioned SCFAs in fish nutrition, research efforts have been devoted over the last several years to closely explore the functions and effects of SCFAs and their associated salts on animal production [22].

2. **Peptides (Bacteriocins):** One of the most common types of peptides used in aquaculture is bacteriocins. Bacteriocins are nothing but an antimicrobial peptide, which is produced by bacteria that can target bacteria of the same or other species. Bacteriocin producers protect themselves by producing specialized resistance proteins, and because bacteriocins are coded by gene, they can be genetically improved. Actifensin, which is made by a particular strain of Actinomyces ruminicola, was the first discovered bacteriocin. Bacteriocins, like lantibiotics, can harm host target cells by rupturing the membrane, engaging in electrostatic interaction, and obstructing biosynthesis.

3. **Vitamin C:** Vitamin C is also known as ascorbic acid (AA), which is very much crucial for regulating normal physiological activities in farmed animals as well as in teleosts. Vitamin C is come under in water soluble vitamin and plays a significant role in various hydroxylating processes. Due to a lack of L-gulonolactone oxidase, which is responsible for vitamin C de novo synthesis, the majority of fish are unable to synthesise AA [23]. As a result, fish diets require an external supply of Ascorbic acid [24]. Vitamin C shortage or deficiency has been associated to delayed growth, skeletal deformities, poor collagen synthesis, and internal haemorrhaging in many fish species [25] Immunosuppressant [26].and increased susceptibility to bacterial diseases [27]. Alternatively, higher Vitamin C supplementation in the fish diets shows good growth, stress tolerance, enhances immune status and disease resistance in case of several fishes [28, 29, and 30]. Kumari and Sahoo,2005 reported that, 500mg/kg Vitamin C supplementation for 4 weeks in magur culture system helps in to improve the innate immune response as well as health status. According to Tewary and Patra (2007), increased vitamin C fortification in the fish diet may boost growth and nutritional utilization, regulate the non-specific defense mechanism, and increase survival against infectious agents in the Rohu culture system.

4. **Cell Surface Proteins:** In aquaculture, cell surface proteins such as outer membrane proteins (OMP) are frequently utilized for vaccination purpose. In several aquatic species such as rohu, channel catfish, turbot, and tiger shrimp were tested with the outer membrane protein (source of OMP is A. hydrophila, V. harveyi, Stenotrophomonas maltophilia, and V. alginolyticus) and result shown that stimulation of specific immune genes and specific antibodies, reducing mortality and bacterial load in different culture system [33,34,35,36].

5. **Teichoic Acid:** Teichoic acid is usually found in Gram-positive bacteria. It is very much crucial for Gram-positive bacteria in regulating cell architecture, controlling proliferation and also helps in bacterial metabolism. Teichoic acid plays a significant role in pathophysiology and contributes to antibiotic resistance. It protects bacteria against many threats and adverse conditions by modifying cell surface characteristics [37]. The copolymers of bacteria associated with carbohydrates present between ribitol phosphate and glycerol phosphate, which produced antibodies against Enterococcus faecalis, an aquatic pathogen, demonstrated opsonization against other Gram-positive species, implying function to immunize against other Gram-positive infections, and it has the potential to be used as a vaccine [38]. It might be applied as a target for new medicines in the fight against antibiotic-resistant bacteria. However, further study is needed before it may be used in aquatic health management [37].

6. **Lipopolysaccharides (LPS):** LPS is a component of Gram-negative bacteria's cell wall. LPS has been proven to be effective in preventing various bacterial infections and enhancing innate defense mechanism in rainbow trout culture systems [39].

7. **Exopolysaccharides:** Red microalgae generate a kind of metabolite called exopolysaccharides, commonly referred to as extracellular polysaccharides [40]. Because exopolysaccharides are biodegradable in nature, it can be utilized as an immune stimulant in aquatic health management. Exopolysaccharides of Bacillus cereus and Brach bacterium sp. isolated from Asian sea bass showed antimicrobial properties [41]. Other than that, exopolysaccharides isolated from marine sponge shows anti-bio film property [42].

IV. CHARACTERISTICS OF AN IDEAL POSTBIOTIC

- Actually, they are biodegradable in nature and environmentally friendly.
- Microbial viability is not necessary
- It should be nontoxic to finfish and shellfish.
- Not genetically modified.
- Clear chemical composition should be written in the printed text.
- It must have the property to influence the metabolic activity.
- It should be remained stable and viable in any storage conditions.
- Easy to store.

V. IDENTIFICATION OF POSTBIOTICS

In general, ultra performance liquid chromatography has been used to identify the postbiotics product due to its superior separation and identification ability [43].

VI. METHOD OF ADMINISTRATION

Postbiotics can be applied directly to the culture tank or mixed with food [44].

Table 1: Short Chain Fatty Acid and their Role in Aquaculture

Authors	Findings
[45]	Dietary administration of 3-6 g/kg formic acid could decrease intestinal *Vibrio spp.* and total bacterial counts and enhance the survival rate of *Vibrio parahaemolyticus*-infected shrimp in laboratory conditions.
[46]	Reported that the total faecal bacteria reduced significantly in tilapia fed with an organic acid blend and KDF diets.
[47]	Indicated that acetate salt exhibits high inhibitory capacity against *Vibrio* species in marine shrimp (*L. vannamei*).
[48]	Observed that improved growth performance, feed utilization as well as non-specific immune response in white fish fed different levels of dietary sodium propionate (2.5, 5, 10 and 20 g/kg) compared to fish fed the control diet.

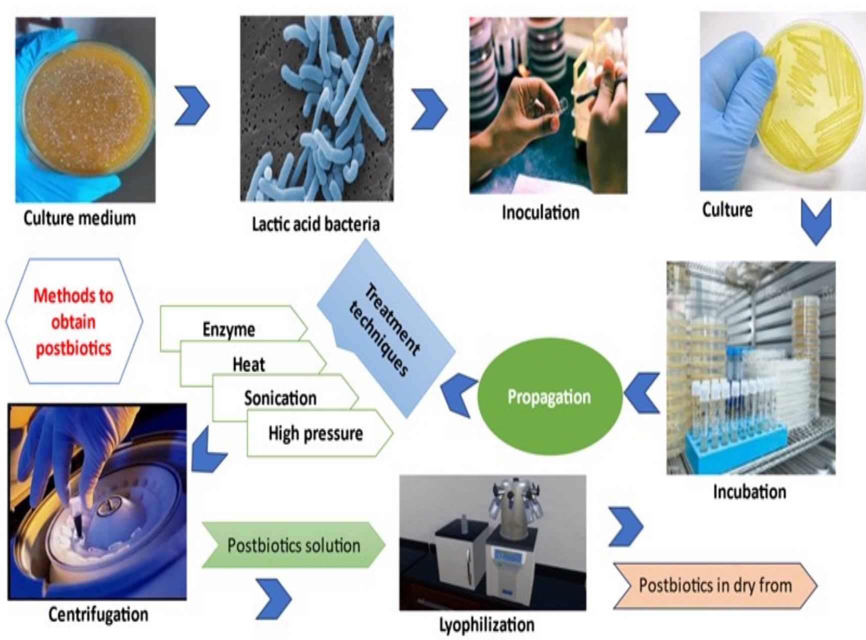

Figure 1: Method to obtain postbiotics

VII. CONCLUSION

Pathogen inhibition might be aided by postbiotic compounds. The impact of postbiotics components on human health has been widely explored. On the contrary, the use of postbiotics in aquaculture is a gem waiting to be discovered. Infectious disease is a serious problem in the aquaculture sector. Postbiotic metabolites might be used as disease control agents in aquaculture.

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