Vol. 3 Issue-12, August 2023 (e-ISSN: 2582-8223)

Postbiotics: The Dawn of a New Age in Aquaculture

Subam Debroy[1], Paramita Banerjee Sawant[1*] And Vikas Kumar Ujjania[1]

[1]Division of Aquaculture, ICAR- Central Institute of Fisheries Education, Versova, Mumbai – 400061, Maharashtra, India

ARTICLE ID: 62

Introduction

Aquaculture is the fastest growing food production sector with 5.3% annual growth rate (FAO, 2020; Yamamoto et al., 2020). The estimated global aquaculture production was 114.5 MT in 2018 (FAO, 2020). Simultaneously, wild capture fisheries are now reaching to the ecosystem limit (Beveridge et al., 2013). Thus, aquaculture has become a potential alternative to these problems, and it continuously supplies a lion share in global animal protein intake to alleviate malnutrition and hunger of the ever-growing population. However, the constant expansion of aquaculture creates a widespread outbreak of infectious diseases, which may be caused by movements of hatchery generated stocks, the introduction of new cultured species, and trade liberalization (Subasinghe, 2009). 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 immunisation was primarily utilised as a preventative measure and was confined to immune compromised organisms (Subasinghe, 2009). Therefore, alternative disease control methods using prebiotics, probiotics and postbiotics are being explored during present times. 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. Postbiotic is a non- viable bacterial product or metabolite secreted by live bacteria or compounds released after chemical or mechanical lysis from live bacteria (Mantziari et al., 2020). Currently, application of postbiotic in pharmaceutical products, commercial food-based products and terrestrial agriculture have been reviewed (Aguilar Toalá et al., 2018). Despite the substantial literature addressing the use of short chain fatty acids and organic acids, peptides, teichoic acids, peptidoglycan, exopolysaccharides, cell surface proteins, and vitamins in aquaculture, there is a limited assessment of postbiotic use

JUST AGRICULTURE
multidisciplinary e-Newsletter

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.

Classes of postbiotics and characteristic features

In general, postbiotics can be distinguished by their elemental composition, which includes lipids (butyrate, propion ate and dimethyl acetyl- derived plasmalogen), proteins (lactocepin and p40 molecule), carbohydrates (galactose- rich polysaccharides and teichoic acids), vitamins/co- factors (vitamin C) and organic acids (propionic, 3- phenyllactic acid, complex molecules such as peptidoglycan- derived muropeptides and lipoteichoic acids).Furthermore, Shenderov (2013) revealed that postbiotics have benefits in absorption, metabolism, distribution, and excretion qualities, suggesting that they have a high potential to connect with numerous host tissues and organs, eliciting a wide spectrum of biological responses. Furthermore, postbiotics have been shown to imitate the health benefits of probiotics without requiring the administration of live microbes.As a result, employing postbiotics may be a safer option to avoiding the hazards associated with live probiotic bacteria; adding postbiotics may be a viable therapy against pathogenic illnesses in aquaculture (Puccetti et al., 2020)

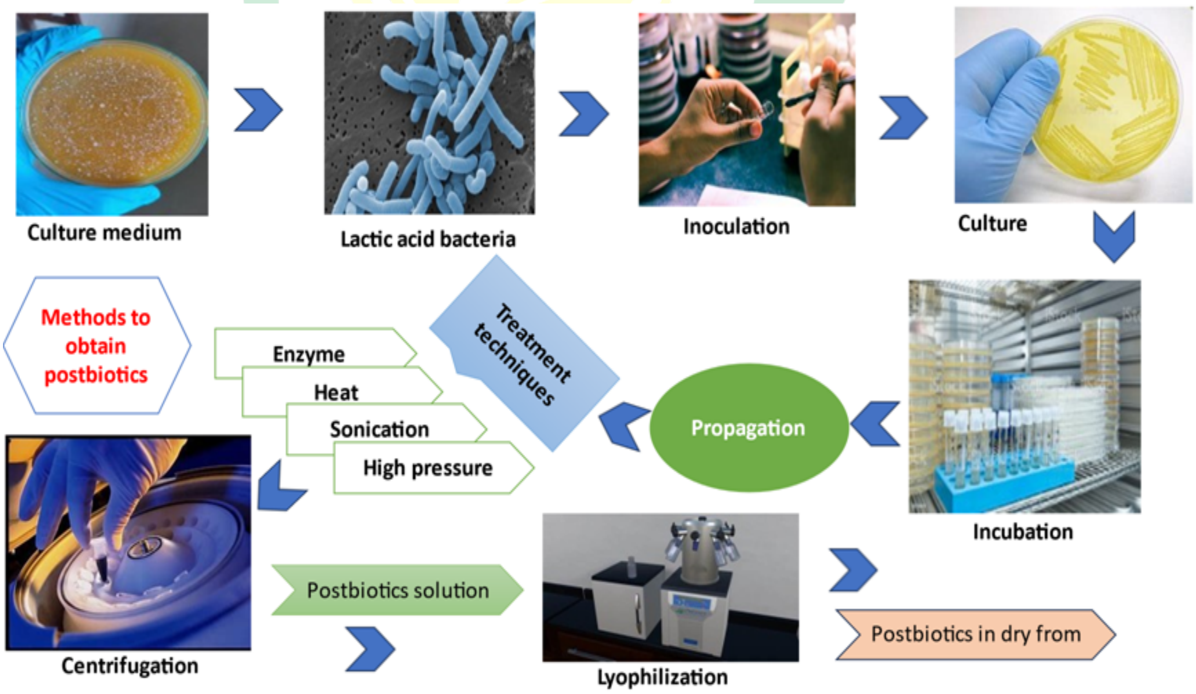

Fig. 1 Method to obtain Postbiotics

Potential mechanism of action of postbiotics and effect on immunity

The molecular processes underlying the effects of postbiotics appear to be mediated by a host- microbial product interaction. This, in turn, can activate the host immune system, resulting in anti-inflammatory responses. The action of postbiotics on aquaculture to control the outbreak of fish-associated diseases may be considered as an alternative treatment strategy over immunization and the use of chemotherapeutics. The molecular mechanism of this process is still being explored.

Broad classification of postbiotics and their role in aquaculture

Short-chain fatty acids:

Short-chain fatty acids (SCFAs) and their salts are usually considered as safe compounds and also have a unique property that nowadays is also regarded as antimicrobials in the livestock feed industry (Defoirdt et al., 2009) and presently a promising alternative as feed additive in farmed animals including fish (Table 1). SCFAs are the most significant bacterial metabolites, which are mostly created during the anaerobic process inside the gut by the fermentation of dietary fibre and resistant starches. SCFAs are low molecular weight aldehyde-containing compounds having one or more carboxyl groups and six or fewer carbon molecules, such as acetate, propionate, butyrate, pentanoic acid, and hexanoic acid(Jian Tan et al.,2014).

These SCFAs modulate the physiological status of the host in three ways: either through the effects of the feeds that are being administered, through effects in the gastrointestinal tract of the animal or through direct effects on metabolism (Freitag, 2007). Generally, most of the SCFAs are capable of reducing the pH of the feed, thus inhibiting microbial growth. The modes of action of SCFAs in the intestinal tract include reduction of the pH level in the stomach and in the small intestines and also inhibition of the growth of Gram-negative bacteria through the dissociation of the acids and production of anions in bacterial cells.

Bioavailability of dietary minerals is greatly influenced by acidification through the use of SCFAs in several ways. Due to the importance of these SCFAs in fish nutrition, research efforts have been directed to carefully examine the roles and effects of SCFAs and their salts on animal production over the past several years (Liu et al.,2014).

JUST AGRICULTURE
multidisciplinary e-Newsletter

Table no.1. Short chain fatty acid and their role in Aquaculture

Bacteriocin	Producer Strain	Inhibited Strain	References
BLIS	*Roseobacter* sp.BS107	*Vibrio*	Ruiz-Ponte et al.,1999
Carnocin U149	*Camobacterium* sp	*Lactobacillus*, Lactococcus &*Pediococcus*	Stoffels et al., 1992
Divergicin M35	*Camobacteriumdivergens* M35	*Camobacterium, Listeria*	Tahiri et al.,2004
BLIS	*Vibrio* sp. NM 10	*Photobacterium*	Sugita et al.,1997
BLIS	*Vibrio harveyi* VIB 571	*Vibrio*	Prasad et al.,2005
Harveyicin	*Vibrio harveyi*	*Vibrio*	McCall and Sizemore ,1979
Garvivin A	*Lactococcus garvieae* 21881	*Lactococcus*	Maldonado-Barragán et al.,2013

Peptides (Bacteriocins)

Bacteriocins are ribosomally synthesised antimicrobial peptides produced by bacteria that can target bacteria of the same species or bacteria of different species. Bacteriocin producers protect themselves by creating specific immunity proteins, and because bacteriocins are gene- encoded, they may be genetically modified. The first bacteriocin identified was actifensin, which is produced by a strain of *Actinomyces ruminicola*. Bacteriocins, such as lantibiotics, can affect host target cells by creating holes in the membrane, interacting electro statically, and blocking biosynthesis.

Vitamin C

Ascorbic acid (AA) is a vitamin that is required for regular physiological processes in animals, including fish. It is the most significant water-soluble antioxidant and a cofactor in numerous hydroxylating processes. The majority of fish are unable to synthesise AA due to a lack of L-gluconolactone oxidase, which is responsible for AA de novo synthesis (Fracalossi et al.,2001). Therefore, an exogenous source of AA is required in fish diets (Ai et al.,2004). The consequences of its absence or deficiency have been documented in various fish species, and deficits have been linked to slower development, skeletal abnormalities, poor collagen production, and internal haemorrhaging (Gouillou-Coustans et al.,1998). Immunosuppression (Verlhac and Gabaudan,1994) and increased susceptibility to bacterial diseases (Druve and Lovell,1982). In addition, megalevels of AA in the diet enhances immune status and disease resistance in channel catfish (Li and Lovell, 1985), Indian major carp (Sobhana et al., 2002), rainbow trout (Wahli et al., 1998), Atlantic salmon (Hardie et al.,1991), grouper (Lin et al.,2004) and Japanese seabass (Ai et al.,2004).Furthermore, a stable form of AA, when added to a common fish diet at a rate of 500mg/kg for 4 weeks, can be used as a prophylactic feed additive in catfish farming to boost the innate immune system and health status of Asian catfish prior to a predictable stress and diseased condition/situation. (Kumari and Sahoo,2005). Higher vitamin C supplementation in the fish diet may increase growth and dietary utilisation, modulate the non-specific immune response and increase survivability against pathogenic agents in the Rohu culture system, according to Tewary and Patra (2007).

Cell surface proteins

Cell surface proteins, such as outer membrane proteins (OMP), are commonly used as vaccines in aquaculture. The OMP of *A. hydrophila, V. harveyi, Stenotrophomonas maltophilia* and *V. alginolyticus* was assessed in aquatic species such as rohu, channel catfish, turbot, and tiger shrimp, which demonstrated the upregulation of immune genes and specific antibodies, lowering mortality and bacterial load (Abdelhamed et al., 2017; Vijayaragavan, 2015; Wang et al., 2016; Yadav et al., 2018).

Teichoic acid

The peptidoglycan layers of many Gram-positive bacteria are substantially functionalized with anionic glycopolymers known as wall teichoic acids (WTAs). These polymers have a vital role in Gram-positive bacteria in regulating cell shape, controlling cell division, and other aspects of bacterial metabolism. WTAs are also important in pathophysiology and contribute to antibiotic resistance. WTAs protect bacteria against many threats and adverse conditions by modifying cell surface characteristics (Brown et al., 2013). 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 immunise against other Gram-positive infections, and it has the potential to be used as a vaccine (Maiti et al., 2012). WTAs 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 aquaculture. (Brown et al., 2013).

Lipopolysaccharides (LPS)

LPS is a cell wall component of Gram-negative bacteria. LPS has been shown to be useful in avoiding different bacterial illnesses and boosting innate immune response in rainbow trout culture system (Nya and Austrin, 2010).

Exopolysaccharides

Exopolysaccharides, also known as extracellular polysaccharides, are a kind of metabolite produced by red microalgae (Nwodo et al., 2012). It is a non-toxic biodegradable organic metabolite that can be employed as an immunostimulant in aquaculture. PS of *Bacillus cereus* and *Brachybacterium* sp. isolated from Asian seabass showed antimicrobial properties (Orsod et al.,2012). However, EPS of *B. licheniformis* strain of marine sponge (Sayem et al.,2011) and *Pseudomonas stutzeri* (Wu et al.,2016) showed anti- biofilm properties, with EPS from *P. stutzeri* reduced virulence factor of *P. aeruginosa*. Therefore, EPS could decrease the risk of pathogenic infection to aquaculture animals.

Characteristics of an ideal postbiotic

Safe for the environment and human health, biocompatible and biodegradable.

- Promote a healthy body status by triggering the immune system of the host.
- 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.

Identification of postbiotics

According to the literature, UPLC has been recommended for postbiotic separation and identification due to its higher separation and identification capacity (Choi et al., 2006).

Method of administration

Postbiotics can be applied directly to the culture tank or mixed with food (Antunes et al., 2011).

JUST AGRICULTURE
multidisciplinary e-Newsletter

Conclusion

Postbiotic molecules might play a function in pathogen inhibition. The effects of postbiotics components on human health have been extensively researched. The application of postbiotics in aquaculture, on the contrary, is a treasure to be explored. Infectious illness is a major concern in the aquaculture industry. Alternative disease management agents in aquaculture could include metabolites derived from postbiotics.

References

Kumari, J., & Sahoo, P. K. (2005). High dietary vitamin C affects growth, non-specific immune responses and disease resistance in Asian catfish, Clarias batrachus. *Molecular and cellular biochemistry*, *280*, 25-33.

Orsod, M., Mugambwa, J., &Huyop, F. (2012). Characterization of exopolysaccharides produced by Bacillus cereus and Brachybacterium sp. isolated from Asian Sea Bass (Lates calcarifer). Malaysian Journal of Microbiology, 8, 170–174.

Sahoo, T. K., Jena, P. K., Patel, A. K., & Seshadri, S. (2016). Bacteriocins and their applications for the treatment of bacterial diseases in aquaculture: a review. *Aquaculture Research*, *47*(4), 1013-1027.

Sayem, S. M. A., Manzo, E., Ciavatta, L., Tramice, A., Cordone, A., Zanfardino, A., De Felice, M., &Varcamonti, M. (2011). Anti-biofilm activity of an exopolysaccharide from a sponge-associated strain of Bacillus licheniformis. Microbial Cell Factories, 10, 1–12.

Tewary, A., & Patra, B. C. (2008). Use of vitamin C as an immunostimulant. Effect on growth, nutritional quality, and immune response of Labeo rohita (Ham.). *Fish physiology and biochemistry*, *34*, 251-259.