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Popular Article

Ways to reduce vibrio load in shrimp farming

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Abstract

The shrimp industry has expanded significantly in various countries over the last 20 years, providing humans with nutritious seafood and protein. Therefore, shrimp producers have attempted to improve shrimp culture facilities to increase production rates. Intensive farming, however, might increase the likelihood of emergent viruses entering the environment, which would drastically lower shrimp culture profitability and inflict considerable economic losses. Shrimp vibriosis is a devastating bacterial illness that frequently affects various shrimp species. *Vibrios* are gram-negative, ubiquitous in marine and estuarine ecosystems as well as in aquaculture farms, and are one of the major microbiotas of these ecosystems. Vibrio spp. is the most common cause of vibriosis, which is the leading cause of death for fish and other cultured species globally Major *Vibrio* sp. *viz. V. harveyi, V. alginolyticus, V. vulnificus, V. parahaemolyticus. V. anguillarum,* and *V. splendidus* are usually associated with shrimp diseases. The review study that is being presented here is noteworthy because it summarizes the most recent research on the uses and advantages of prebiotics, postbiotics, synbiotics, and the use of bivalves to boost shrimp immunity and reduce vibriosis-related deaths in several shrimp species.

1. Introduction

The shrimp industry has experienced tremendous growth as a result of increasing demand in the global market (Harlıoşglu and Farhadi, 2017). It is projected that there will be more than nine

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billion people on the planet by 2030. Shrimp fisheries are expected to grow along with the population to meet the world's food needs of people living in both developed and emerging nations (Kumara et al., 2023). Issues with shrimp disease are common in the rapidly expanding shrimp production sector, severely hurting the bottom-lines of affected farms. For instance, according to Shinn et al. (2018), between 2009 and 2018, shrimp infections caused an annual loss of up to US$ 4 billion to the Asian shrimp sector. Furthermore, the FAO calculated those epidemics caused annual economic losses of more than US$ 9 billion (FAO, 2019). Many Vibrio species are the source of shrimp vibriosis, an important and devastating bacterial disease affecting a variety of shrimp species (Kumara et al., 2023). According to Lee et al. (2002) and other studies, Vibrio is a gram-negative, motile, facultative anaerobic bacterium belonging to the Vibrionaceae family that poses a serious threat to shrimp growers. Vibrio harveyi, Vibrio parahaemolyticus, Vibrio alginolyticus, Vibrio campbellii, Vibrio vulnificus, Vibrio anguillarum, and Vibrio splendidus have all been isolated and identified from infected shrimp (Chatterjee and Haldar, 2012). According to previous reports, shrimp aquaculture suffers significant financial losses as a result of vibriosis and other infections. For example, Flegel (2012) found that the white spot syndrome virus was responsible for 60% of the expected shrimp production losses, while bacterial infections (mostly caused by Vibrio spp.) accounted for 20% of the losses. According to previous reports, shrimp vibriosis is a persistent and dangerous issue to the shrimp industry worldwide (Abdel-Latif et al., 2022).

The majority of countries have banned the use of antibiotics in aquatic food sources, such as fish and shrimp, for a variety of reasons, including their negative effects on humans, the emergence of antibiotic-resistant strains, reduced antibiotic efficacy due to repeated use, and environmental contamination. This article provides information on different ways to reduce Vibrio load in shrimp farming.

2. Control of shrimp vibriosis using prebiotics

Prebiotics are indigestible fiber components that boost the quantity of advantageous bacteria in the host's digestive tract, thus boosting the host's overall health and well-being (Song et al., 2014). According to Merrifield et al. (2010), Prebiotics are also described as "a substrate" that the host gut microorganisms specifically use to produce health advantages. Prebiotics are active ingredients used in aquaculture that help activate bacteria found in the gastrointestinal tracts (aquatic), which increases the number of these bacteria (Abdel-Latif et al., 2022). A variety of prebiotic products, including β-1,4-mannobiose (MNB), mannan oligosaccharide (MOS), Xylooligosaccharide (XOS), fructooligosaccharide (FOS), β-glucan (BG), and others, have been effectively used in aquaculture to boost fish and shrimp immunity and increase their resistance against the invasive pathogens (Dawood et al., 2020)

According to Sang and Thuy (2014), feeding *P. monodon* 0.15% MOS for eight weeks improved its immunity (THC and granulocyte percentage), and after being challenged with *V. alginolyticus*, it raised the shrimp Survival rate (SR%). Furthermore, in the hepatopancreatic and intestinal tissues of *L. vannamei*, supplementing diets with MOS enzymatically extracted from copra meal for six weeks markedly increased bactericidal activities and expression of immune-related genes such as ALF, penaedin, and LYZ genes (Rungrassamee et al., 2014). Additionally, researchers discovered that shrimp raised in the control group were less likely to survive an immersion bath challenge with pathogenic *V. harveyi* than those on diets supplemented with MOS.

2.1 Control of shrimp vibriosis using postbiotics

Postbiotics are defined by Aguilar-Toal´a et al. (2018) as metabolic by-products or cell wall components secreted (or released) by a variety of probiotic bacteria following their lysis, which have the potential to improve the health of treated hosts. These products also exhibit biological activities for the host and can be categorized as non-viable bacterial products created from microorganisms (Nataraj et al., 2020). Peptides, enzymes, exopolysaccharides, cell surface proteins, peptidoglycan-derived muropeptides, short-chain fatty acids, and teichoic acids are examples of postbiotics (Aguilar-Toal´a et al., 2018). Postbiotics may have a number of significant and advantageous uses for boosting immunity and preventing infectious illnesses in aquaculture, according to recently published research (Abdel-Latif et al., 2022).

Most bacterial cell walls are formed by a mesh-like layer of a polymer called peptidoglycan (PG), which is composed of amino acids and sugars. Multiple probiotic bacterial species, including Bifidobacterium thermophilum and Brevibacterium lactofermentum, have been used to generate (or extract) PG (Ang et al., 2020). As a special immunomodulatory drug, PG has been successfully applied in shrimp (Song et al., 2013) and fish (Zhang et al., 2014).

In a previous investigation, Itami et al. (1998) found that, in comparison to control shrimp, dietary supplementation with PG-derived muramyl dipeptide derived from the probiotic Bifidobacterium thermophilum effectively increased the phagocytic activities of *P. japonicus* granulocytes and the survivability of shrimp following an experimental water-borne challenge with pathogenic *V. penaeicida*.

The authors postulated a strong correlation between the heightened immune responses of shrimp and the improvement in shrimp survival rates following the *V. penaeicida* challenge. The improvement in phagocytosis (Itami et al., 1996) or activation of immune-related genes (Song et al., 2013) may be the mechanisms of action of PG-derived Bifidobacterium thermophilum in boosting shrimp immunity.

2.2 Control of shrimp vibriosis using Synbiotics

A synbiotic is a mix of live microorganisms and substrate(s) that host microorganisms use to deliver health benefits (Swanson et al., 2020). According to Abdel-Latif et al. (2022) and Yilmaz et al. (2022), "synbiotics," defined in aquaculture as "a dietary supplement that contains a blend of probiotic and prebiotic," boost fish and shrimp immunity and resistance to challenging infections. Their combined action creates dual additive beneficial effects on the parameters. Several studies have demonstrated the possible functions of synbiotics in regulating the immune system of farmed shrimp and enhancing their ability to fend off Vibrio infection.

Previous research has revealed that adding a synbiotic mixture containing *B. licheniformis* and/or *B. subtilis* as probiotics and 0.2% isomaltooligosaccharide as a prebiotic to *P. japonicus* diets for two weeks significantly increased intestinal TBC, decreased intestinal *Vibrio sp*. count, and improved immune parameters (PA, LYZ, and nitric oxide synthase activities) (Zhang et al., 2011). They also discovered that shrimp raised in the control group were less resistant to *V. alginolyticus* infection than those fed diets enriched with synbiotics. Furthermore, compared to shrimp raised in the non-synbiotic control group, the study by Bolívar Ramírez et al. (2013) showed that *L. vannamei* fed diets supplemented with a mixture of 0.5% inulin and *L. plantarum* for 6 weeks had an increased gut LAB count, reduced intestinal *Vibrio sp*. count, and higher resistance against *V. alginolyticus* infection.

Widanarni et al, (2018) reported that the SR% of *L. vannamei* challenged with *V. harveyi* infection (=83.3%) was significantly higher than 31.7% in the infected control group after 30 days of dietary supplementation with a synbiotic mixture consisting of 1% *V. alginolyticus* SKT-b (as a probiotic bacterium) and 2% sweet potato oligosaccharides (SPO) (as a prebiotic). When compared to animals raised in the non-synbiotic control group, the same synbiotic mixture also increased the THC count and PO and RBA activities.

Munaeni et al. (2014) conducted a study that revealed that feeding *L. vannamei* a microencapsulated synbiotic mixture consisting of SPO and Bacillus sp. NP5 for 40 days resulted in a significant increase in intestinal TBC, along with a decrease in *V. harveyi* and total Vibrio counts when compared to the animals reared in the control group. Furthermore, the growth performance measures, immunological responses (THC, differential hemocyte count, and PO), and resistance of *L.*

vannamei to challenge with *V. harveyi* infection were all enhanced by 3% encapsulated synbiotics made up of SPO and Bacillus sp. NP5 (Zubaidah et al., 2015). Similarly, *L. vannamei* co-infected with WSSV and V. harveyi showed significantly higher THC, PO, RBA, and resistance upon food supplementation with a micro-encapsulated synbiotic (Bacillus NP5 and MOS).

The 90-day administration of a synbiotic mixture of B. subtilis S11 and ripe banana extract in the diet of *L. vannamei* resulted in a considerable increase in both PO and THC levels. Additionally, following an immersion challenge with *V. harveyi*, they reduced the CMR% of shrimp (Boonmee and Rengpipat, 2015). Additionally, Huynh et al. (2018) found that supplementing *L. vannamei's* digestive tracts with a synbiotic mixture consisting of 0.4% galactooligosaccharide and *L. plantarum* 7–40 for two months markedly raised the number of LAB and lowered the number of *Vibrio sp*.

According to recent research, feeding *L. vannamei* diets supplemented with a synbiotic mixture containing 1% Bacillus NP5 and 0.75% honey prebiotics for 60 days increased the expression of immune-related genes (SP, PE, and LGBP genes), immunological indices (such as THC, PO, and RBA), and resistance against experimental IM infection with *V. parahaemolyticus* (Muharrama et al., 2021). It is interesting to note that adding a synbiotic mixture—probiotics B. subtilis and S. cerevisiae and prebiotics BG and MOS—to *L. vannamei's* diet for 56 days dramatically increased the animals' capacity for antioxidant defense (CAT and T-SOD increased along with decreased serum MDA levels) and boosted their immune responses (LYZ and ACP) (Yao et al., 2021).

2.3 Control of shrimp vibrio using bivalves

Filter feeders remove excess nitrogenous waste accumulated from the feed and feces, and the reduction of nutrients by filter feeders inhibits the growth of microorganisms (Kumara et al., 2023). Bivalves can obtain exogenous bacteria in their tissues (Rathod et al. 2023). Xing et al. (2013) reported that the co-culture of *P. vannamei* and *C. gigas* improved health status and reduced the prevalence of Vibrio in the gut of *P. vannamei*. According to Omont *et al.* (2020), the gut bacterial populations of oysters from co-culture systems showed greater diversity of microorganisms than oysters in the monoculture system. Kumara et al. (2023) reported that bivalves reduced the growth of Vibrio in IMTA systems compared with the polyculture of shrimp farming. Rathod et al. (2023) and Naskar et al. (2022) also reported that the integration of bivalves in aquaculture systems can reduce the Vibrio load.

2.4 Control of shrimp vibrio by water exchange

Widiyanto et al. (2020) reported that water exchange and siphoning might help decrease organic matter in shrimp aquaculture ponds. Alfiansyah et al. (2018) explained that good water management, such as removing sludge and maintaining pH and salinity, might avoid abrupt water quality changes and could minimize the organic matter and anaerobic area, which are suitable nutrients for the growth of Vibrio sp. Higher water exchange rates with clean water can lessen *Vibrio* loads and decrease the impact of stressors by washing out organic material and other metabolites such as ammonia and other inorganic nutrient parameters.

3. Conclusion

Shrimp has become a major global sector over the last 20 years, providing humans with healthy seafood and protein in several countries. As a result of this issue, shrimp farmers have attempted to upgrade shrimp culture facilities in order to increase production rates. However, extensive cultivation may increase the likelihood of new viruses entering the environment, reducing shrimp production profitability and resulting in severe financial losses. To avoid the disease most of the farmers are using antibiotics, the consequences of antibiotics like horizontal gene transfer, bacterial resistance, multidrug resistance, and environmental pollution. However, for these reasons, many antibiotics have been banned in most countries; therefore, the use of prebiotics, postbiotics, synbiotics, and bivalves in shrimp farming can reduce Vibrio load and enhance shrimp production.

References

Abdel-Latif, H.M., Yilmaz, E., Dawood, M.A., Ringø, E., Ahmadifar, E. and Yilmaz, S., 2022. Shrimp vibriosis and possible control measures using probiotics, postbiotics, prebiotics, and synbiotics: A review. *Aquaculture*, *551*, p.737951.

Aguilar-Toalá, J.E., Garcia-Varela, R., Garcia, H.S., Mata-Haro, V., González-Córdova, A.F., Vallejo-Cordoba, B. and Hernández-Mendoza, A., 2018. Postbiotics: An evolving term within the functional foods field. *Trends in Food Science & Technology*, *75*, pp.105-114.

Alfiansah, Y.R., Hassenrück, C., Kunzmann, A., Taslihan, A., Harder, J. and Gärdes, A., 2018. Bacterial abundance and community composition in pond water from shrimp aquaculture systems with different stocking densities. *Frontiers in microbiology*, *9*, p.360865.

Ang, C.Y., Sano, M., Dan, S., Leelakriangsak, M. and Lal, T.M., 2020. Postbiotics applications as infectious disease control agent in aquaculture. *Biocontrol science*, *25*(1), pp.1-7.

Bolívar Ramírez, N., Seiffert, W.Q., Vieira, F.D.N., Mouriño, J.L.P., Jesus, G.F.A., Ferreira, G.S. and Andreatta, E.R., 2013. Dieta suplementada com prebiótico, probiótico e simbiótico no cultivo de camarões marinhos. *Pesquisa Agropecuária Brasileira*, *48*, pp.913-919.

Bolívar Ramírez, N., Seiffert, W.Q., Vieira, F.D.N., Mouriño, J.L.P., Jesus, G.F.A., Ferreira, G.S. and Andreatta, E.R., 2013. Dieta suplementada com prebiótico, probiótico e simbiótico no cultivo de camarões marinhos. *Pesquisa Agropecuária Brasileira*, *48*, pp.913-919.

Bolívar Ramírez, N.C., Rodrigues, M.S., Guimarães, A.M., Guertler, C., Rosa, J.R., Seiffert, W.Q., Andreatta, E.R. and Vieira, F.D.N., 2017. Effect of dietary supplementation with butyrate and probiotic on the survival of Pacific white shrimp after challenge with Vibrio alginolyticus. *Revista Brasileira de Zootecnia*, *46*, pp.471-477.

Chatterjee, S.H.A.L.D.A.R. and Haldar, S., 2012. Vibrio related diseases in aquaculture and development of rapid and accurate identification methods. *J. Mar. Sci. Res. Dev. S*, *1*, pp.1-7.

Dawood, M.A., Metwally, A.E.S., El-Sharawy, M.E., Atta, A.M., Elbialy, Z.I., Abdel-Latif, H.M. and

Paray, B.A., 2020. The role of β-glucan in the growth, intestinal morphometry, and immune-related gene and heat shock protein expressions of Nile tilapia (Oreochromis niloticus) under different stocking densities. *Aquaculture*, *523*, p.735205.

FAO, 2019. State of Fisheries and Aquaculture in the World. Rome, Italy, Food and Agriculture Organization of the United Nations. ISBN 9781424464968.

Flegel, T.W., 2012. Historic emergence, impact and current status of shrimp pathogens in Asia. *Journal of invertebrate pathology*, *110*(2), pp.166-173.

Harlıoğlu, M.M. and Farhadi, A., 2017. Feminization strategies in crustacean aquaculture. *Aquaculture international*, *25*, pp.1453-1468.

Huynh, T.G., Chi, C.C., Nguyen, T.P., Tran, T.T.T.H., Cheng, A.C. and Liu, C.H., 2018. Effects of synbiotic containing Lactobacillus plantarum 7–40 and galactooligosaccharide on the growth performance of white shrimp, Litopenaeus vannamei. *Aquaculture Research*, *49*(7), pp.2416-2428.

Itami, T., Asano, M., Tokushige, K., Kubono, K., Nakagawa, A., Takeno, N., Nishimura, H., Maeda, M., Kondo, M. and Takahashi, Y., 1998. Enhancement of disease resistance of kuruma shrimp, Penaeus japonicus, after oral administration of peptidoglycan derived from Bifidobacterium thermophilum. *Aquaculture*, *164*(1-4), pp.277-288.

Itami, T., Kondo, M., Uozu, M., Suganuma, A., Abe, T., Nakagawa, A., Suzuki, N. and Takahashi, Y., 1996. Enhancement of resistance against Enterococcus seriolicida infection in yellowtail, Seriola quinqueradiata (Temminck & Schlegel), by oral administration of peptidoglycan derived from Bifidobacterium thermophilum. *Journal of Fish Diseases*, *19*(2), pp.185-187.

Kumara, R., Chithira, P., Meharoof, M., Bhargavi, S.S., Doddamani, P.L., Prasad, M.S., Debroy, S., Dheeran, P. and Pai, M., 2023. BIVALVE AQUACULTURE–A POSSIBLE WAY TO SUSTAINABLE BLUE REVOLUTION. *Journal of Experimental Zoology India*, *26*(1).

Kumara, R., Syamala, K., Shyne Anand, P.S., Chadha, N.K., Sawant, P.B., Chithira, P. and Muralidhar, A.P., 2023. Halophyte and bivalve-based integrated multi-trophic aquaculture (IMTA): effect on growth, water quality, digestive and antioxidant enzymes of Penaeus monodon and Chanos chanos reared in brackishwater ponds. *Aquaculture International*, pp.1-27.

Lee, K.K., Liu, P.C. and Chuang, W.H., 2002. Pathogenesis of gastroenteritis caused by Vibrio carchariae in cultured marine fish. *Marine biotechnology*, *4*(3), pp.267-277.

Merrifield, D.L., Dimitroglou, A., Foey, A., Davies, S.J., Baker, R.T., Bøgwald, J., Castex, M. and Ringø, E., 2010. The current status and future focus of probiotic and prebiotic applications for salmonids. *Aquaculture*, *302*(1-2), pp.1-18.

Muharrama, A.R.W., Widanarni, W., Alimuddin, A. and Yuhana, M., 2022. Gene expression and immune response of pacific white shrimp given Bacillus NP5 probiotic and honey prebiotic and Vibrio parahaemolyticus infection. *Journal of Applied Aquaculture*, *34*(3), pp.625-641.

MUNAENI, W., YUHANA, M. and WIDANARNI, W., 2014. Effect of micro-encapsulated synbiotic at different frequencies for luminous vibriosis control in white shrimp (Litopenaeus vannamei). *Microbiology Indonesia*, *8*(2), p.5.

Naskar, S., Biswas, G., Kumar, P., De, D., Sawant, P.B., Das, S. and Roy, U., 2022. Effects of estuarine oyster, Crassostrea cuttackensis as the extractive species at varied densities on productivity and culture environment in brackishwater integrated multi-trophic aquaculture (BIMTA) system. *Aquaculture*, *554*, p.738128.

Nataraj, B.H., Ali, S.A., Behare, P.V. and Yadav, H., 2020. Postbiotics-parabiotics: The new horizons in microbial biotherapy and functional foods. *Microbial cell factories*, *19*, pp.1-22.

Omont, A., Elizondo-González, R., Quiroz-Guzmán, E., Escobedo-Fregoso, C., Hernández-Herrera, R. and Peña-Rodríguez, A., 2020. Digestive microbiota of shrimp Penaeus vannamei and

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oyster Crassostrea gigas co-cultured in integrated multi-trophic aquaculture system. *Aquaculture*, *521*, p.735059.

Rathod, K., Karthireddy, S., Anand, P.S., Chadha, N.K., Sawant, P.B., Prasad, M.S., Doddamani, P.L. and Muralidhar, A.P., 2023. Effect of bivalves on water quality, microbial load and growth performance of P. vannamei and M. cephalus in halophytebased integrated multi-trophic aquaculture reared under pond conditions. *Indian Journal of Animal Research*, *57*(8), pp.988-994.

Rungrassamee, W., Kingcha, Y., Srimarut, Y., Maibunkaew, S., Karoonuthaisiri, N. and Visessanguan, W., 2014. Mannooligosaccharides from copra meal improves survival of the Pacific white shrimp (Litopenaeus vannamei) after exposure to Vibrio harveyi. *Aquaculture*, *434*, pp.403-410.

Sang, H.M. and Thuy, N.T.T., 2014. Effects of Mannan Oligosaccharide (MOS) on the Survival, Physiological, and Immunological Response of the Black Tiger Prawn (Penaeus monodon Fabricius, 1798) when Challenged with two Different Stressors.

Shinn, A.P., Pratoomyot, J., Griffiths, D., Trong, T.Q., Vu, N.T., Jiravanichpaisal, P. and Briggs, M., 2018. Asian shrimp production and the economic costs of disease. *Asian Fish. Sci. S*, *31*, pp.29-58.

Song SeongKyu, S.S., Beck BoRam, B.B., Kim, D., Park, J., Kim JungJoon, K.J., Kim HyunDuk, K.H. and Ringø, E., 2014. Prebiotics as immunostimulants in aquaculture: a review.

Song, X., Zhang, Y., Wei, S. and Huang, J., 2013. Effects of different enzymatic hydrolysis methods on the bioactivity of peptidoglycan in Litopenaeus vannamei. *Chinese Journal of Oceanology and Limnology*, *31*(2), pp.374-383.

Widanarni, W., Taufik, A., Yuhana, M. and Ekasari, J., 2018. Dietary mannan oligosaccharides positively affect the growth, digestive enzyme activity, immunity and resistance against Vibrio harveyi of Pacific White Shrimp (Litopenaeus vannamei) Larvae. *Turkish Journal of Fisheries and Aquatic Sciences*, *19*(4), pp.271-278.

Widiyanto, T., Rusmana, I., Febrianti, D., Shohihah, H., Triana, A. and Mardiati, Y., 2020, July. Profiles of Vibrio and heterotrophic bacteria in the intensive Vanamae shrimp culture using bioremediation technique in Karawang. In *IOP Conference Series: Earth and Environmental Science* (Vol. 535, No. 1, p. 012019). IOP Publishing.

Xing, M., Hou, Z., Yuan, J., Liu, Y., Qu, Y. and Liu, B., 2013. Taxonomic and functional metagenomic profiling of gastrointestinal tract microbiome of the farmed adult turbot (Scophthalmus maximus). *FEMS microbiology ecology*, *86*(3), pp.432-443.

Yao, W., Li, X., Zhang, C., Wang, J., Cai, Y. and Leng, X., 2021. Effects of dietary synbiotics supplementation methods on growth, intestinal health, non-specific immunity and disease resistance of Pacific white shrimp, Litopenaeus vannamei. *Fish & Shellfish Immunology*, *112*, pp.46-55.

Yilmaz, S., Yilmaz, E., Dawood, M.A., Ringø, E., Ahmadifar, E. and Abdel-Latif, H.M., 2022. Probiotics, prebiotics, and synbiotics used to control vibriosis in fish: A review. *Aquaculture*, *547*, p.737514.

Zhang, C.Y., Chen, G.F., C Wang, C., Song, X.L., Wang, Y.G. and Xu, Z., 2014. Effects of dietary supplementation of A3α-peptidoglycan on the growth, immune response and defence of sea cucumber Apostichopus japonicus. *Aquaculture nutrition*, *20*(2), pp.219-228.

Zhang, Q., Tan, B., Mai, K., Zhang, W., Ma, H., Ai, Q., Wang, X. and Liufu, Z., 2011. Dietary administration of Bacillus (B. licheniformis and B. subtilis) and isomaltooligosaccharide influences the intestinal microflora, immunological parameters and resistance against Vibrio alginolyticus in shrimp, Penaeus japonicus (Decapoda: Penaeidae). *Aquaculture Research*, *42*(7), pp.943-952.

Zubaidah, A. and Yuhana, M., 2015. Encapsulated synbiotic dietary supplementation at different dosages to prevent Vibriosis in white shrimp, Litopenaeus vannamei. *HAYATI Journal of Biosciences*, *22*(4), pp.163-168.