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Using lactic acid bacteria as an immunostimulants in cultured shrimp with special reference to *Lactobacillus* spp.

Mohammed A. E. Naiel[1] · Mayada R. Farag[2] · Ahmed G. A. Gewida[3] · Mahmoud A. Elnakeeb[3] · Mahmoud S. Amer[4] · Mahmoud Alagawany[5]

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Abstract

Shrimp aquaculture is the rapidly growing sector of fish culture producing sectors in the world due to its rising demand in developed countries. Moreover, the intensive and extensive shrimp culture systems are affected mainly by infection diseases caused by several pathogenic agents and resulting in high economic losses. Nowadays, controlling and preventive infection diseases are the major concern to develop this sector. Besides, the highly extensive usage of chemotherapeutics and antibiotics induced numerous drawbacks in shrimp farming, developed antibiotic resistance bacterial strains, and threatens the aquatic life. Recently, improving the immunity status and controlling infectious diseases using biological methods have become beneficial, environment friendly, and risk-free options in aquaculture. Probiotics have gained much attention as immunostimulants in aquaculture owing to their inhibitory properties on pathogenic microorganisms via creation of an unfriendly atmosphere to cease their growth. *Lactobacillus* species as probiotics was used in shrimp aquaculture to prevent viral infections due to their positive promoting effects on survival and health. Additionally, *Lactobacillus* species possesses sturdy antimicrobial activity against various pathogenic microorganisms such as *Photobacterium* and *Vibrio* infections. This review threw the light on the applications of *Lactobacillus sp*. as probiotics in cultured shrimp which could be of great impact from a sustainable, intensive, and ecofriendly aquaculture opinion.

Keywords *Lactobacillus* · Immunity · Health · Production · Shrimp

✉ Mohammed A. E. Naiel
mohammednaiel.1984@gmail.com

Extended author information available on the last page of the article

Introduction

Shrimp culture is one of the most important subsectors of aquaculture that gains more attention due to shrimp vulnerability to stressful situations and undesirable environmental conditions and its high economic value (Al-Hakim et al. 2013). However, the development of intensive shrimp cultured systems has several drawbacks and economical losses because of diseases which are the main restriction on the productivity of several types of shrimp. As a result, large amounts of specifically antimicrobial compounds have been used in shrimp farming to manage and control diseases (Lakshmi et al. 2013; Mahrose et al. 2019). Nevertheless, several kinds of probiotics showed high efficiency towards diminishing the risk of diseases in addition to their economical properties such as *Lactobacillus* sp. (Iyapparaj et al. 2013; Ayyat et al. 2020).

In aquaculture, *Litopenaeus vannamei* (Pacific white shrimp) is considered the main important crustacean species and represents about 70% of the total shrimp production worldwide. Also, many species of probiotics could be isolated from *L. vannamei*, such as *Lactobacillus* spp. which is a widely applicable probiotic belonging to the *Lactobacillus* and *Bifidobacterium* genera (Chauhan and Singh 2019). Besides, they are classified as Gram-positive lactic acid–producing bacteria that modulate the majority of normal gut microbiota in humans and animals (Abd El-Naby et al. 2020; Arif et al. 2020). Characteristically, *Lactobacilli* are rod-shaped, non-spore forming bacteria (El-Shall et al. 2020). Their nutritional requirement is complex, and they are strictly fermentative, anaerobic or aerotolerant, and acidophilic or aciduric (Alagawany et al. 2018; Abd El-Aziz et al. 2020). In addition, *Lactobacilli* are found in various habitats particularly the substrates rich with carbohydrate such as animal and human mucosal membrane, plants or other plant-derived materials, fermented milk, spiled food, and sewage (de Vrese and Schrezenmeir 2008; Naiel et al. 2020b). Most of *Lactobacillus* species have the ability to produce strong antimicrobial molecules against many pathogenic microorganisms. The antibacterial activities of *Lactobacilli* may be due to their ability to produce a variety of antimicrobial substances including hydrogen peroxides, antimicrobial peptides, and organic acids (Fooks and Gibson 2002; Vieira et al. 2008; Abdel-Latif et al. 2020). For instance, Li et al. (2018) found that supplemented *L. vannamei* diets with *Lactobacillus* spp. significantly improved the performance, through enhancing the dominance of beneficial intestinal microorganisms and preventing the development of pathogenic bacterium. Awareness about the shrimp defense mechanisms is prospective to be useful in developing and adopting new effective strategies to resolve the current and future pathogen-related problems (Naiel et al. 2020c). For this purpose, there are various kinds of living microorganisms utilized for biocontrol typically applied in shrimp cultures. Currently, there are few commercial "intestinal" probiotics utilized specifically for the larval stage of different aquatic organisms (Vine et al. 2006; Abdel-Latif et al. 2020; Elgeddawy et al. 2020).

This review will discuss the recent findings of the vital roles of probiotics particularly; lactic acid species specifically *Lactobacillus* spp. in promoting the shrimp immune responses against common pathogens and understanding their impacts against ammonia production in rearing environment. In addition, the functional characterization of lactic acid bacteria on the sustainability of shrimp farming, biodiversity modulation action, and controlling pathogenic disease in aquatic environment.

The immunomodulatory role of lactic acid bacteria

There are several immune responses induced in shrimp like physical barriers, encapsulation, bacteria clearance, antimicrobial activity, pro-phenol-oxidase system, clotting reactions, and reactive oxygen intermediates. The innate immune response was induced under a diversity of PRR (pattern recognition receptors) on the hemocyte membranes to discover the PAMP (pathogen-associated molecule pattern) and reduce signals during the attack of pathogens. Then, hemocytes are activated, and the defense molecules are degranulated against the defined pathogens (Song and Li 2014).

Nowadays, there is recent trend towards using immunostimulatory natural products in the prevention and controlling diseases outbreaks in aquatic invertebrates, farmed shrimps, and fish (Abd El-Ghany et al. 2020; Khafaga et al. 2020). They have an extensive margin of safety than chemotherapeutics, and their spectral of efficacy is more than vaccination (Abdullateef et al. 2016; Naiel et al. 2020a).

Several kinds of lactic acid bacteria (LAB) have immunomodulatory properties and could be utilized as probiotics (Alagawany et al. 2020), in which common lactic acid bacterial strains have been presented in Table 1. Chomwong et al. (2018) found that the use of *L. lactis* and *L. plantarum* could promote the shrimp immune response against VP_{AHPND} infection and increase survival rate. Also, Le and Yang (2018) reported that *L. sakei* induced higher coaggregations and immunomodulatory activities than *L. plantarum* in gastrointestinal tract. Besides, Maeda et al. (2014) investigated the immunomodulatory role of LAB in the enhancement of the kuruma shrimp (*Marsupenaeus japonicus*) immune system and recommended its use as active probiotics in shrimp aquaculture.

In shrimp, some bacterial strains stimulated both the humoral and cellular immune defense systems. Fed white shrimp, *Litopenaeus vannamei*, supplemented diets with 10^{10} CFU (kg diet^{-1}) of *Lactobacillus plantarum* enhance the immune responses and upregulated immune relative gene expression for 168 h. This may be attributed to the role of *L. plantarum* in activation of the pro-phenol-oxidase (Pro. PO), phenol-oxidase (PO), and superoxide dismutase (SOD) activities, respiratory bursts (RB), and peroxinectin mRNA transcription and increased the rate of survival after *V. alginolyticus* challenge (Chiu et al. 2007). Also, *Lactobacillus bulgaricus* improved both the humoral and cellular immune defense activities in the white shrimp, *Litopenaeus vannamei*, in terms of increasing hemocyte counts, PO, and RB activity and reduced shrimp mortality after challenged with *V. parahaemolyticus* (Roomiani et al. 2018). Huynh et al. (2018) suggested that *Lactobacillus plantarum* could modulate the immune system of *Litopenaeus vannamei* by increasing the levels of several metabolites such as inosine monophosphate (IMP), valine, and betaine.

Table 1 Several strains of lactic acid bacterial that commonly used in shrimp culture systems

Probiotic strains	Species	Reference
Bacillus subtilis, *Bacillus megaterium*	*Litopenaeus vannamei*	Olmos et al. (2011)
Bacillus sp. S11	*Penaeus monodon*	Rengpipat et al. (1998)
Bacillus sp.	*Penaeus monodon*	Moriarty (1998)
Lactobacillus spp.	*Penaeus monodon*	Phianphak et al. (1999)
Bacillus sp.	*P. vannamei*	Balcazar (2002)
Bacillus P64	*P. monodon*	Alavandi et al. (2004)
Lactobacillus plantarum	*Litopenaeus vannamei*	Vieira et al. (2010)

Likewise, feeding of *Penaeus vannamei* on diets supplemented with the LAB (*Bacillus subtilis* and *Lactobacillus rhamnosus*) enhanced the antioxidative status by increasing the antioxidant enzymes activity in shrimps (Kumar et al. 2013). Thus, shrimp diets treated with bio-friendly agents such as *Lactobacillus* spp. could be used as effective alternatives to antibiotics for treating bacterial infections especially *V. harveyi* infection in shrimp aquaculture (Ahmmed et al. 2018). In addition, feeding of kuruma shrimp (*Marsupenaeus japonicus*) at larval and post-larval stages on diets supplemented with heat-killed *Lactobacillus plantarum* (HK-LP) could reduce the harmful impacts induced by unsuitable manipulation and environmental conditions (Thanh Tung et al. 2010). The improvement of survivability in both larvae and post-larval stages and the growth performance in the post-larvae may be due to the effect of HK-LP administration in promoting the uncompleted innate immune defense at the early stages. Besides, Zheng et al. (2017) suggested that dietary administration of *Lactobacillus plantarum*, particularly cell-free extract, could enhance the capacity of *L. vannamei* shrimp against stress and upregulate the Pro. Po, SOD, and lysozyme gene expression, thereby helping shrimp to counteract the surrounding environmental stressors. The immunostimulatory role of *Lactobacillus plantarum* as a probiotic makes it to be recommended as a dietary supplement to enhance the shrimp defense against pathogenic agents such as *Vibrio harveyi* (Vieira et al. 2010).

The protective role of lactic acid bacteria against viral diseases

Viral diseases are one of the major problems which lead to economic losses and decrease the productivity in shrimp farms (Israngkura and Sae-Hae 2002). Probiotics in addition to be beneficial bacteria they also have antiviral activities. Therefore, the exploitation of probiotics in the prevention and treatment of viral infections in shrimp aquacultures is an efficient novel method. Besides, the immunological and protective effects of lactic acid bacterial strains against infection diseases had been illustrated in Table 2.

The antiviral activity of probiotic lactic acid bacteria mainly depends on bacterial strain. Also, the antiviral affects may be attributed to the interaction between bacterial cell and virus, to the ability of bacterial cell to produce the antiviral bacterial derivatives, or to the immunomodulatory role of probiotic towards activation of the immune system (Al Kassaa et al. 2014). The interaction between bacterial cell and virus could be possible through absorbed and/or trapped mechanisms which inhibited virus's proliferation (Al Kassaa et al. 2014). Furthermore, the probiotics are well verified to exert several compounds such as interleukins, natural killer cells, macro-phages, immunoglobulins, and T helper cells action that can promote the defensive immune system defenses against the virus (Cha et al. 2012). Besides, the bacterial strains could produce several constitutes including hydrogen peroxide (H_2O_2), lactic acid, bacteriocins and bacteriocin-like substances, short-chain fatty acids, and polysaccharides that helped for detecting viral infection and enhanced the antiviral activity (Conti et al. 2009; Arena et al. 2018). All the above-mentioned molecules are exerted into culture intermediate; thus, the bacterial cell-free supernatant (CFS) might include such products. Certainly, CFSs are commonly defined to preliminarily illustrate the probable antagonistic ability of bacteria (Wang et al. 2013; Arena et al. 2016).

One of the most important virulent pathogens in *penaeid* shrimps is the WSSV (white spot syndrome virus). It caused strong economic losses in the shrimp industry worldwide because it can induce up to 100% accumulative mortalities within 3–10 days. Peraza-Gómez et al. (2009)

Table 2 Impact of *Lactobacillus* species on the disease resistance and immune response in the shrimp

Lactobacillus species	Isolated from	Doses/duration	Biological role	References
Lactobacillus sp.	Intestine of Pacific white shrimp	10^7 CFU g^{-1}/27 days	Increased the resistance against WSSV	Zuo et al. (2019)
Lactobacillus bulgaricus	Intestine of Pacific whiteshri-mp	10^7 and 10^9 CFU g^{-1}/30 days	Increased the immune response and disease resistance	Roomiani et al. (2018)
Lactobacillus sp. AME-T1506	Curd	10^6 CFU g^{-1}/30 days	Boosted the resistance against *V. harveyi*	Karthik et al. (2014)
Lactobacillus sp. AME-T1506	Curd	10^5 CFU g^{-1}/30 days	Augmented the total heterotrophic bacterial load and LAB counts in the intestine. Decreased the bacterial load of *Shigella* spp., *Salmonella* spp., and *E. coli* in the intestine	Karthik et al. (2014)
Lactobacillus pentosus	The gut of wild shrimp	10^6 CFU g^{-1}/4 weeks	Increased the survival, adhesive activity, expression of PEN-3α and Pro. PO	Sha et al. (2016)
Lactobacillus lactis	Pacific white shrimp intestine	2–4 × 10^8 cells g^{-1}/16 days	Induced hemolymph phenoloxidase (PO) activity, relative mRNA expression of *Lv*proPO1, *Lv*proPO2, and resistance against *V. parahaemolyticus*	Chomwong et al. (2018)
Lactobacillus plantarum	home-made	Korean-style cabbage pickles	10^8 CFU kg^{-1}, 60 days	Enhanced immune responses,
		immune-related gene expressions, and disease resistance in *Litopenaeus vannamei*	Huynh et al. (2018)	
Lactobacillus plantarum	Shrimp isolate	10^7 and 10^{10} CFU kg^{-1}/168 h	Increased the immune response, resistance against *V. alginolyticus* and the gut microbiota	Chiu et al. (2007)
Lactobacillus plantarum	Pacific white shrimp	2 × 10^{10} CFU kg^{-1}/8 days	Decreased Vibrio counts in the gut	Vieira et al. (2008)
Lactobacillus plantarum	Broodstock shrimp	1.5 × 10^8 CFU g^{-1}/60 days	Increased the total LAB counts and the resistance against *V. harveyi*	Vieira et al. (2010)
Lactobacillus plantarum	Commercial	3.3 × 10^{11} CFU g^{-1} feed; 0, 0.1, and 1 g/30 days	Increased the stress resistance with the inclusion of 1 g Increased the survival with 0.1 g	Thanh Tung et al. (2010)
Lactobacillus plantarum	Pacific white shrimp	2–4 × 10^8 CFU g^{-1} feed/42 days	Increased the disease resistance against *V. harveyi*	Kongnum and Hongpattarak-ere (2012)
Lactobacillus plantarum	Pacific white shrimp intestine	10^7 mL^{-1}/4 weeks	Increased the PO activity, intestinal LAB and resistance against *V. alginolyticus*	Ramírez et al. (2017)

Table 2 (continued)

Lactobacillus species	Isolated from	Doses/duration	Biological role	References
Lactobacillus plantarum	Commercial probiotic	20×10^3 cells mL^{-1} and 1×10^8 (CFU) mL^{-1}/45-days	Reduce shrimp diseases and environmental effect	Pacheco-Vega et al. (2018)

indicate that the LAB and yeast could protect the *Litopenaeus vannamei* culture against the WSSV infection. Moreover, Jiravanichpaisal et al. (1997) recommended the use of *Lactobacillus* sp. as probiotic in *Penaeus monodon* Fabricius (the giant tiger shrimp) as an effective treatment against white spot diseases and vibriosis.

Pooljun et al. (2020) confirmed that enriched juvenile shrimp (*Penaeus vannamei*)-fed diets with *L. acidophilus* and *S. cerevisiae* mixture (1:1, at 10^8 and 10^9 CFU kg diet^{-1}) impaired the adverse effects induced by *Vibrio parahaemolyticus* infection (acute hepatopancreas necrosis disease, AHPND) via improved hemocyte parameters, including the total hemocyte count, granular hemocytes percentage, and phenol-oxidase activity as well as highly upregulated hemocytes genes (Crustin and penaeidin) and led to high survival rate. Recently, de Souza et al. (2020) investigated that allocated pacific white shrimp, *Litopenaeus vannamei*, in biofloc system (water contain beneficial bacterial strain) improved immune response against white spot syndrome virus (WSSV) infection through upregulated calreticulin, β-tubulin, and prophenol-oxidase genes in hepatopancreas cells. Besides, Li et al. (2020) amplified that fortified pacific white shrimp, *Litopenaeus vannamei*, diets with 4 mg/kg arabinoxylan-oligosaccharide (AXOS) increased lactate production levels in gastrointestinal tract thus enriched *Bacillus*, *Pseudomonas*, *Bacteriovorax*, and *Lactobacillus* development and subsequently remarkably upregulated immune-related genes (chitinase, cathepsin L, chymotrypsin, MyD88, and PO) in shrimp infected with *Vibrio alginolyticus* (white spot syndrome virus).

Various *Lactobacillus* species exerts extracellular glycoproteins and inhibiting pathogen from attachment with intestinal epithelia cells (Liu et al. 2020). Moreover, attachment, while diminishing mobility, is vital for biofilm formation process (surface cell–attached microbial communities) (Johnson-Henry et al. 2007). The development of adherent cells in biofilms can also encourage the fast elimination of nonadhesive cells from the microbiota (Knipe et al. 2020). For instance, fed penaeid shrimp with *L. plantarum* strains (at 10^7 CFUs ml^{-1} seawater)–supplemented diet protected shrimp against *V. parahaemolyticus* infection (acute hepatopancreatic necrosis disease, AHPND) (Thammasorn et al. 2017).

Antibacterial role of the lactic acid bacteria

In addition to viruses, bacterial diseases are one of the major infectious agents that cause high mortality and morbidity in shrimp industry. Gram-negative bacteria and several *Vibrio* species are more virulent than others in shrimp aquaculture (Vieira et al. 2008). (Abdullateef et al. 2016). Thus, improving the health status of culture organisms using beneficial microbes as probiotic is the better method to control the pathogens (Karthik et al. 2014).

Several studies had proved the antibacterial role of *Lactobacillus pentosus*) AS13(dietary administration against vibriosis and its efficiency on enhancing performance, feed utilization, and the activities of digestive enzymes in the white shrimp, *Litopenaeus vannamei* (Zheng and

Wang 2017). Additionally, Nguyen et al. (2018) presented the evidence on the positive effects of the probiotic *Lactobacillus plantarum* on growth and resistance of *Litopenaeus vannamei* against *Vibrio parahaemolyticus* which causes acute hepatopancreatic necrosis disease (AHPND). Similarly, Le and Yang (2018) stated that *Lactobacillus* strains could prevent *Vibrio* infection in the shrimp cultures. In addition, Chomwong et al. (2018) confirmed the antimicrobial activity of two LAB (*Lactococcus lactis* strain SGLAB02 and *Lactobacillus plantarum* strain SGLAB01) against gram-negative and gram-positive bacteria, including the *Vibrio parahaemolyticus* (VP_{AHPND}) which cause the virulent acute hepatopancreatic necrosis disease (AHPND). Likewise, *L. acidophilus* exhibited antibacterial activities against *Vibrio cholera*, *Vibrio parahaemolyticus*, and *Vibrio Harveyi* (Natesan et al. 2012).

Moreover, Rengpipat et al. (2000) showed that *Bacillus Sll* provided protection against diseases by activating *P. monodon* immunological responses. Also, Maeda et al. (2014) indicated that LAB induced or increased the expressions of innate immune genes and enhanced the resistance of kuruma shrimp (*Marsupenaeus japonicus*) to bacterial pathogens. The *Lactobacillus* spp. (JK-8 and JK-11) was reported to be able to completely remove both nitrogen and pathogens (Ma et al. 2009). Furthermore, *Lactobacillus plantarum* has already been reported to decrease the rate of mortality of *Litopenaeus vannamei* larvae and improved their resistance against *Vibrio harveyi* infection (Vieira et al. 2007).

The supplementation of diet with *Lactobacillus plantarum* reduced the mortality rate, modified the intestinal microbiota, decreased the abundance of *Vibrio* spp., and increased the abundance of LAB in shrimp raised in a commercial farm (Vieira et al. 2016a). This mode of action may be due to that the prevalent bacteria can survive by exerting antimicrobial molecules which may kill or prevent all their bacterial competitors (Sivakumar et al. 2014). Huynh et al. (2019) found that feeding of white shrimp on *Lactobacillus plantarum* supplemented diets encouraged the colonization of *Lactobacillus plantarum* and decreased the prevalence of pathogenic microorganisms, such as *Vibrio* and *Photobacterium* in gastrointestinal tract. The dietary supplementation of *Lactobacillus* increased their count in the *L. vannamei* intestine and significantly reduced the load of pathogenic bacteria (e.g., *Vibrio*) (Karthik et al. 2014). At the same trend, Vieira et al. (2016b) confirmed the ability of *Lactobacillus plantarum* to modify the microbiota in the *L. vannamei s*hrimp mid gut by increasing the number of LAB and decreasing *Vibrio* spp. Phianphak et al. (1999) also stated that *Lactobacillus* sp. reveals potential of control *Vibrio harveyi* infection in the shrimp gut and provides healthy shrimp protected against such diseases.

The inhibition of *Vibrio alginolyticus* by dietary LAB (*Lactobacillus acidophilus*, *Streptococcus cremoris*, *Lactobacillus bulgaricus*, and *Lactobacillus bulgaricus*) may be related to their roles in promoting the nonspecific immune activities resulting in resistance to disease in *Penaeus indicus* shrimp (AJITHA et al. 2004). Consequently, it could be concluded that several *Lactobacillus* strains such as *Lactobacillus acidophilus* will be of great importance in the management of *Vibrio alginolyticus* and other related bacterial diseases in juvenile, *Penaeus monodon*, tiger shrimp (Uma et al. 1999).

In addition, fortified *L. vannamei* shrimp diets with *Lactobacillus* developed the *Lactobacillus* sp. count in gastrointestinal tract and subsequently reduced the total pathogenic bacterial count (e.g., Vibrio) (Li et al. 2018). Thus, the *Lactobacillus* sp. (AMET1506) strain can be a probable probiotic for *L. vannamei* to prevent and control vibriosis infections in shrimp farming; this phenomenon arises partially by enhancement of gastrointestinal microbiota biodiversity (Kumar et al. 2016).

The application of LAB in shrimp cultured systems

The concentration of total ammonium nitrogen (TAN) is often a key limiting water quality parameter in the intensive systems of aquaculture. Therefore, removing of ammonia (NH3) by biological activities is thus an important aim in recycled and conventional aquaculture system designs (Grommen et al. 2002). In shrimp pond, controlling the ammonia production depends on other water quality elements such as pH, dissolved oxygen, and water temperature. Herein, fortified shrimp-fed diets with probiotic would be a beneficial strategy to promote shrimp health under several aquatic stressful conditions (Wongsasak et al. 2015). *Lactobacillus* species have been recognized for their nutritional and health benefits in addition to their fermentative ability. In all respect, Sivakumar et al. (2014) stated that the utilization of *Lactobacillus* sp. is beneficial in improving the water quality and the environment in the shrimp aquaculture. Additionally, Ma et al. (2009) investigated that both *Lactobacillus* strains (JK-8 and JK-11) had the ability to remove up to 400 μM from NH^{4+}, NO^{2-}, and NO^{3-} in vitro. The *Lactobacillus* species could exerts several compounds during the lactic fermentation process, such as organic acids, di-acetyl-hydrogen peroxide, and bactericidal proteins that subsequently led to decrease the pH value from 7 to 5.4, which might be adequate to prevent the development of many pathogenic bacteria and nitrification process (Farzanfar 2006; Ma et al. 2009). Also, Zubaidah et al. (2012) revealed that the charpness decreased in pH values may be due *Lactobacillus* spp. activity which is naturally occurring during fermentation process (fermented carbon resource such as rice bran).

With regard to the harmful effects of ammonia, Liu and Chen (2004) stated that ambient ammonia reduced the resistance of *Litopenaeus vannamei* to *Vibrio* infection by decreasing the phagocytic and SOD activities and increasing the superoxide anions which may be toxic to the host (Ma et al. 2009). Hence, supplemented *L. vannamei* diet with 10^{10} CFU (kg diet^{-1}) *L. plantarum* enhanced immune response and promoted the immune activity towards *V. alginolyticus* infection via stimulating PO and SOD activity (Chiu et al. 2007). Therefore, *Lactobacillus* spp. (JK-8 and JK-11) will be helpful for improving the quality of water, facing bacterial infections and highly reduced nitrogen content in shrimp farms.

Furthermore, the application of lactic acid bacteria on shrimp rearing water, gastrointestinal microbiota, and decreasing the water salinity levels are a wide spreading methods having importance in controlling pathogens in shrimp farming (Krishnaprakash et al. 2009). At the same trend, supplied rearing water with 1×10^3 CFU/ml *Bacillus vallismortis* W120 showed the ability to control pathogenic bacteria, *Aeromonas hydrophila* WS1, in fairy shrimp culture (Purivirojkul 2013). Treated shrimp ponds with lactic acid bacteria had less prevalence of pathogenic bacterium such as *Vibrio* as well as reduced toxic gases production like ammonia, nitrite, and hydrogen sulfide, compared with untreated ponds (Jha 2011). Also, Kumar et al. (2014) reported the synergistic effects between two probiotic bacteria strains that promoted growth and biochemical and immunological status of *Litopenaeus vannamei*.

With regard to the aquamimicry systems, it needs to sustain the beneficial heterotrophic bacterial stains such as *Bacillus* spp. to maintain the desired water quality parameters, fermented the available carbon resource, and suspended high amount of biofloc farming. Despite of the heterotrophic bacteria should not be dominated in this system. Some farmers have noticed that adding lower quantities of fermented rice bran daily (2 mg/l) could enrichment the development of some zooplankton, microalgae, and flocs that daily regulate the pH instabilities (Romano 2017). The higher concentration of heterotrophic bacteria led to rapidly convert dissolved free nitrogen into natural microbial biomass. Actually, heterotrophic bacteria can be developed fastly up to 10 times more than nitrification bacterium and thus markedly minimized the time required to remove the toxic from of ammonia-N (reduced nitrite-N levels) (Hargreaves 2006). The aggregates floc community produced by heterotrophic bacteria may lead to higher fish performance, amplified the activity of digestive enzyme, and/or improved the resistance against infectious disease (Dauda et al. 2018). In addition, De Paiva-Maia et al. (2013) showed that the probiotics (*Bacillus* spp. and *Lactobacillus* yeasts) caused alterations in the total heterotrophic microbiota in the sediments and percentages of Pyrrophyta concentrations and improved the environmental quality of water and sediment in grow-out intensive shrimp ponds (*Litopenaeus vannamei*) with closed recirculation system. In another study, the biodiversity of bacterial community in aquacultures and the relationships between potential pathogenic bacteria and aquacultures environment in sediment and water samples from culture ponds of *L. vannamei* were analyzed by sequencing of the 16S rRNA gene through Illumina MiSeq and Roche 454 sequencing platforms, and this provided novel information about improving the microflora in aquaculture environment and inhibition of pathogen to reduce the infection by *L. vannamei* disease through the regulating of the environmental conditions (Zhang et al. 2016).

Conclusion

This review provided useful insights for the use of *Lactobacillus* sp. in cultured shrimp. Enhancing the health status of cultured shrimp by using beneficial microbes as a probiotic is the best approach to control pathogens. *Lactobacillus* sp. showed an effective role in producing resistance to infectious agents and in creating antibacterial substances that stop pathogenic microorganisms from getting into the organism. Thus, administration of *Lactobacillus* sp. in cultured shrimp can improve the quality of rearing water and enhance the immune response of the shrimp. Future studies need to be further extended by investigating the involvement of *Lactobacillus* sp. in the modulation of adaptive immune response.

Authors' contribution All authors contributed equally to the work.Data availabilityThe data that support the findings of this study are available on request from the corresponding author.

Compliance with ethical standards

Competing interests The authors declare that they have no competing interests.

Code availability Not applicable.

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Affiliations

Mohammed A. E. Naiel[1] · Mayada R. Farag[2] · Ahmed G. A. Gewida[3] · Mahmoud A. Elnakeeb[3] · Mahmoud S. Amer[4] · Mahmoud Alagawany[5]

[1] Department of Animal Production, Faculty of Agriculture, Zagazig University, Zagazig 44511, Egypt

[2] Department of Forensic Medicine and Toxicology, Veterinary Medicine, Zagazig University, Zagazig 44511, Egypt

[3] Department of Animal Production, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt

[4] Laser Application in Biotechnology Department, National Institute of Laser Enhanced Science, Cairo University, Cairo 12613, Egypt

[5] Department of Poultry, Faculty of Agriculture, Zagazig University, Zagazig 44511, Egypt