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Role of nanoparticles in shrimp culture: A nanotechnology perspective

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Abstract

Aquaculture is a emerging significant global food industry. This sector not only creates jobs but also contributes to increased global food security, particularly in countries with weak economies. The productivity and sustainability of shrimp farming have significantly increased with the introduction of species like *Litopenaeus vannamei*, the Pacific white shrimp. Aquaculture could benefit greatly from the application of nanotechnology since it presents novel approaches to disease control, fertilizer delivery, and water quality management. To fully understand the long-term consequences of nanotechnology in aqua field on the environment and human health, further research is necessary as it is still relatively new in this field. As a result, we have covered the many applications of nanotechnology in the aqua sector in this review chapter and have also provided information on the nanoparticles used in fish and shrimp farming.

Keywords: *Litopenaeus vannamei*, nanoparticles, nanotechnology, shrimp farming

Introduction

Aquaculture is the fastest-growing food production industry in the world. It is expanding, spreading, and intensifying in almost every region of the earth. The increasing worldwide population is driving the demand for aquatic food items. Capture fisheries output has stabilized, and most major fishing grounds are operating at full capacity. Because of this, maintaining fish stocks from catch fisheries will not be able to fulfill the rising demand for aquatic food worldwide. In most parts of the world, aquaculture is seen as a potential solution to close the gap between the supply and demand of aquatic food (Subasinghe *et al.*, 2009) [65]. In addition to providing food necessities for human consumption, fisheries and aquaculture offer fantastic job and revenue-generating prospects, particularly in the more impoverished rural areas (Jayasankar, 2018) [35]. The world's aquaculture industry has grown significantly over the past few decades, providing a significant portion of the world's fish supply for sustenance (Ochoa-Meza *et al.*, 2019) [52]. With fish and other aquatic products rich in protein, vital fatty acids, vitamins, and minerals, aquaculture contributes significantly to the global fight to end hunger and malnutrition. By raising incomes, creating jobs, and maximizing the returns on resource utilization, aquaculture can also significantly contribute to development (FAO, 2006) [23].

Global shifts in consumer demand, disruptions in the market, and the logistical challenges of enforcing strict containment measures such as lockdowns, curfews, physical separation in operations and onboard vessels, and port restrictions have all contributed to the COVID-19 pandemic's significant effects on fisheries and aquaculture. Lockdowns have reduced demand in certain nations, which has lowered the cost of fisheries and aquaculture products. When their labor became unprofitable, several fishing fleets and aquaculture operations ceased to exist or scaled back, especially during the 2020 pandemic waves (FAO, 2022) [24]. Pacific white leg shrimp (*L. vannamei*) and gigantic tiger shrimp (*P. monodon*) are the two main shrimp species used in shrimp production worldwide (Leung and Engle, 2008) [42] accounted for more than 90% of the market for shrimp. Because wild catches have decreased over the previous 30 years, aquaculture is the main source of shrimp for the market.

Worldwide scenario of shrimp aquaculture

Worldwide aqua production in 2020 was 214 million tonnes which include 178 million aquatic animals and 36 million tonnes of algae, the combined production from fisheries and aquaculture. This is a minor increase over the previous record of 213 million tonnes set in 2018. Asia accounted for 70% of the world's fisheries and aquaculture production in 2020, with the Americas (12%), Europe (10%), Africa (7%), and Oceania (1%), in second and third place, respectively. At 35% of the global contribution to capture fisheries and aquaculture production, China continued to be the leading producer (FAO, 2022) ^[24].

Aquaculture scenario in India

India's 8,118 kilometers of coastline make it a prime location for aquaculture. In that, 3.15 million hectares of reservoirs, 2.44 million hectares of ponds and tanks, 0.798 million hectares of abandoned water bodies, 1.24 million hectares of brackish water regions, and 0.29 ha of estuaries are among the natural resources left behind by India (Datta, 2011; Anonymous, 2020) ^[18, 2]. Additionally, India possesses 0.5 million hectares of floodplain wetland resource, which has enormous potential for culture-based fisheries (Sarkar *et al.*, 2020) ^[60]. India currently ranks third in fisheries production and second in aquaculture, contributing 1.07% to the national GDP and 5.30% to the agriculture GDP (Ngasotter *et al.*, 2020) ^[50]. 3.05 million tonnes of marine fish were estimated to have been landed along the coast of the Indian mainland in 2021. This represents an increase of roughly 11.8% over landings in 2020, when landings decreased primarily as a result of fishing days lost due to the closure of the fishery due to the COVID-19 pandemic. In comparison with the typical fishing year of 2019, the landings in 2021 were 14.4% lower. The states that will contribute the highest percentages to the national total in 2021 are Gujarat (5.76 lakh tonnes), Tamil Nadu (5.62 lakh tonnes), Kerala (5.55 lakh tonnes), and Karnataka (5.51 lakh tonnes) (CMFRI, 2021) ^[14]. India exported 13,69,264 MT of seafood valued US\$ 7.76 billion during the fiscal year 2021-2022, setting a record for highest-ever export values. India's top seafood imports are the United States and China. Shrimp that was frozen remained the main exported item (Anonymous, 2022) ^[3].

Overview of Pacific white leg shrimp (*Litopenaeus vannamei*)

The western Pacific coast of Latin America, extending from Peru to Mexico, is home to the Pacific white shrimp, *Litopenaeus vannamei*, where year-round ocean temperatures consistently exceed 20 °C. From 1978 to 1979, it was experimentally brought into Asia; however, it has only been commercially released in China and Taiwan since 1996, and then into numerous other nations in Southeast and South Asia (Liao and Chien, 2011) ^[43]. For the Asian shrimp farmer, *L. vannamei* is superior to *P. monodon* in many ways. Fast growth rate, resistance to high stocking density, low salinity and temperature tolerance, reduced protein requirements (and consequently, production costs), some disease resistance (associated with SPR stocks), high survival during larval rearing, and certain marketing benefits are some of the specific benefits. *L. vannamei*, even in conditions of intensive culture, are highly effective in harnessing the inherent productivity of shrimp ponds. Additionally, because *L. vannamei* has a reduced protein

demand (18-35 percent compared to 36-42 percent), feed expenditures are typically cheaper for them than for the more carnivorous *P. monodon* (Crespi and New, 2009) ^[17]. The western white leg shrimp, or *L. vannamei*, has been introduced worldwide and has largely replaced the tiger shrimp produced through aquaculture, reducing the reliance on the farming of a single species, namely the tiger shrimp (*P. monodon*), in the brackish water aquaculture sector. Thus, the culture of *L. vannamei* is now synonymous with shrimp aquaculture. Based on the findings of a risk analysis carried out by the National Bureau of Fish Genetics Resources (NBFGR) and the Central Institute of Brackish Water Aquaculture (CIBA), which suggested the introduction of *L. vannamei* cultivation on a pilot scale in India under stringent regulatory guidelines, the Government of India (GOI) first approved the species' introduction on a pilot scale in 2003 and then approved the culture of the species in 2009. As a result, the nodal research and development organizations have worked together to produce comprehensive criteria for importing *L. vannamei* brood stock and producing seeds (Kumaran *et al.*, 2012) ^[40].

Nutritional requirements of *L. vannamei*

The general categories of nutrients needed by cultivated species include lipids, proteins, carbohydrates, vitamins, and minerals. The ideal concentrations of these nutrients differ depending on the species.

Proteins

Muscle is primarily composed of protein, which accounts for 65-70% of a shrimp's dry weight. The amino acids found in protein are what make up the proteins that shrimps make for themselves of the 20 amino acids included in the diet, only 10 are thought to be necessary. From the ten essential amino acids, the shrimp can synthesis the remainder (Van Wyk, 1999) ^[70]. Protein content ranges from 35 to 50% in the majority of commercial shrimp feeds designed for intensive production systems. Growth rates will be lowered if there is insufficient protein in the meal. In fact, if the proteins in shrimp muscle tissue are utilized for other essential processes, severe protein deficits may cause weight loss. Overconsumption of protein in the diet can potentially prevent growth (Lim and Persyn, 1989) ^[44].

Lipids

Triglycerides, oils, waxes, phospholipids, sterols, and free fatty acids are all classified as lipids, or fats. For shrimp, lipids are a vital source of energy. Essential fatty acids are found in lipids. Since the four fatty acids in shrimp are necessary for proper diet and cannot be produced from other substances, they are regarded as essential fatty acids. The following are the essential fatty acids: docosahexaenoic acid (22:6n3), eicosapentaenoic acid (20:5n3), linoleic acid (18:2n6), and linolenic acid (18:3n3) (Kanazawa and Teshima, 1981) ^[37]. Lipids are frequently added to fish diets in the form of soybean, fish, and even squid oil (Van Wyk, 1999) ^[70].

Carbohydrates

Among the three nutritional classes that provide energy, carbohydrates are the least expensive source of energy for animals. However, dietary carbohydrates are not as thoroughly and efficiently utilized by aquatic animals as they are by fowl and mammals, despite being the primary

and instant energy source (Wilson and Poe 1987) ^[75]. Furthermore, increased dietary carbohydrate intake frequently results in slower growth and other adverse effects (Shiau *et al.* 1991b) ^[63]. Shrimp diets use carbohydrates as a cheap source of energy. The three primary types of carbs are fiber, sugars, and starches. The capacity of various organisms to use carbohydrates as an energy source varies. High-protein diets cause carnivores to use protein as an energy source and frequently have trouble properly metabolizing carbs. Fish and shrimp that are both herbivorous and omnivorous make efficient use of carbohydrates (Van Wyk, 1999) ^[70].

Vitamins

Vitamins are organic components necessary for appropriate growth and development in the diet in relatively modest amounts. A vitamin premix containing all 16 important vitamins is typically added to meals that include fish and shrimp. Numerous factors, such as shrimp size, age, development rates, and ambient conditions, influence the vitamin requirements of marine shrimp (Akiyama, *et al.*, 1991) ^[1]. Compared to adult shrimp, young juvenile shrimp may need 50% more vitamins in their food. Generally speaking, shrimp cultivated in intensive production methods need far higher concentrations of vitamins than shrimp maintained at moderate densities. Symptoms of vitamin shortages include physical abnormalities, blindness, unpredictable swimming behavior, lethargy, and poor growth. The physical manifestations vary according to the vitamin that is lacking in the diet (Van Wyk, 1999) ^[70].

Minerals and their importance

Minerals are inorganic substances needed for a number of metabolic functions. Major minerals are those that must be present in significant amounts. These consist of sulfur, sodium, potassium, calcium, phosphorus, magnesium, and chloride. Muscle contraction, osmoregulation, and the development of the exoskeleton all require calcium. Because they can directly absorb calcium from the water, shrimp that live in saltwater don't require extra calcium in their diets (Davis, 1991) ^[21]. However, up to 2.5% of the diets of shrimp raised in near-freshwater environments should contain calcium. Higher calcium levels should be avoided as they seem to interfere with phosphorus's bioavailability at high doses (Davis, 1990) ^[20]. Minerals are necessary for shrimp development and basal metabolism. These are essential for maintaining the equilibrium between acid and base and osmotic pressure, which in turn controls the pH of blood, hemolymph, urine, and other bodily fluids. They are also necessary for the contraction of muscles and the transmission of nerve impulses. They are also important components of soft tissues, enzymes, some vitamins, hormones, and respiratory pigments. Most crustaceans have minerals in their cuticles, mostly calcium carbonate (CaCO₃) and trace amounts of magnesium. Approximately 99 percent of the exoskeleton's total inorganic content varies greatly depending on the species, anatomical location, and molt cycle stage (Conklin, 1981) ^[15]. Despite the importance of minerals, little research has been done on the mineral needs of shrimp. The fact that shrimps are aquatic animals and may obtain some of their needs from the food and water they eat may be the cause of this. Because they constantly consume tiny amounts of water and live in a hypertonic environment, marine shrimps' mineral needs, including

calcium, are partially satisfied. Because phosphorus is scarce in seawater, it must be obtained from food consumed. Consequently, the amount of certain minerals that shrimps need in their diet will depend on how much of them are found in the aquatic environment (Cowey and Sargent, 1979) ^[16]. Due to their frequent moultings, which induce mineral loss, penaeids may require dietary supplies of 17 minerals for growth (Kanazawa, 1984) ^[38]. Shrimp's ability to access minerals depends on a number of factors, including the type and source of the mineral that is consumed, how much is stored in the body, how it interacts with other substances found in the gastrointestinal tract and other body tissues, and how it interacts with other dietary ingredients or metabolites (Tacon, 1987) ^[66]. Nanoscale dietary minerals may enter cells more easily than their bigger counterparts. This quickens the fish's assimilation process of them. Nanoscale addition of mineral nutrients to the fish's normal diet may have a significant effect on the fish's general health as well as growth (Chris *et al.*, 2018) ^[13].

Role of Nanotechnology in Aquaculture

Nanotechnology is defined as the "understanding and control of matter at the nanoscale, at dimensions between approximately 1 and 100 nm, where unique phenomena enable novel applications" by the US National Nanotechnology Initiative (NNI). These days, the market is home to over a thousand items that include nanomaterials, demonstrating the multibillion dollar and quickly growing nature of the nanotechnology business. More than 300 nanofood products are now offered in foreign markets throughout the last ten years (Ramsden, 2018) ^[55]. As a requirement affecting our ability to feed the planet's population of almost 7 billion people, nanotechnology offers immense potential to deliver creative enhancements to aquaculture systems in farm management, increase efficiency, and lessen our influence on the environment (Chen and Yada, 2011) ^[11]. Because of their small size, nanomaterials have a large exposed surface area per unit volume, which boosts their chemical reactivity. It has also been claimed that they remain extremely stable in high-pressure and temperature environments. These are more effective than bulk materials at lower doses because they are readily absorbed by animals' gastrointestinal tracts (Feng *et al.*, 2009) ^[25].

Drug delivery

One of the biggest challenges to aquaculture's sustainability and growth is disease outbreaks (Rather *et al.*, 2011) ^[56]. Nanotechnology can play a significant role in this context by offering new insights into the diagnosis and treatment of diseases (Handy, 2012) ^[29]. Controlled release delivery systems and diagnostic sensors based on nanoparticles have been created in the last few years to modify their structure and properties in response to environmental stimuli such pH, temperature, enzyme activity, and ionic strength. pH-sensitive nanoparticles, for instance, have been employed in the pharmaceutical sector to deliver anticancer drugs (Nile *et al.*, 2020) ^[51]. Recently, Lee *et al.* (2020) created a novel technique that may be applied to aquaculture as an oral vaccine. Nanoplus @CIFA Selenium-Zinc As an ingredient for fish feed, Nanoplus is a formulation made from zinc sulfate and sodium selenite nanoparticles, two significant trace minerals. These two trace minerals work in concert to

improve fish development, feed utilization, and disease resistance when added to fish feed in the form of nanoparticles. It enhances egg development and breeding performance. It encourages quick wound healing and maintains the fish's scales and fins in good condition. Additionally, it lessens the toxicity of other minerals and water contaminated by heavy metals.

Pathogen detection by Nano sensors

Presently, Nano biosensor systems are being developed to enable the detection of extremely low concentrations of waterborne pollutants as well as bacteria, viruses, and parasites (Chen *et al.*, 2016) ^[10]. This is especially crucial when it comes to outbreaks in commercial aquaculture systems since it might take a long time for the etiological agent to manifest symptoms and be detected, which delays the pathogen's treatment and has a significant financial impact. According to reports, nano-barcode can be used as individual tracking devices since they store information that can be checked remotely to identify the tags automatically. These tags might be used to track animals as well as keep an eye on their eating habits, swimming patterns, and even metabolism (Rather *et al.*, 2011) ^[56].

Microbial disinfection

Numerous metal nanoparticles (NPs), including copper, titanium, and silver, have been utilized to treat and prevent disease. Metal nanoparticles (NPs) exhibit diverse mechanisms of action against bacteria. One of their most potent impacts is on the cell membrane and cell wall, where they bind by electrostatic contact and cause disruption. Additionally, it has been shown that metal nanoparticles (NPs) can elevate the state of oxidative stress by producing more reactive oxygen species (ROS), which can harm DNA, lipids, and proteins. One of the primary nanotechnology products used to combat a variety of pathogens, such as bacteria, fungus, viruses, and parasites, is silver nanoparticles. For instance, titanium dioxide nanoparticles have potent antibacterial properties and can eradicate fish infections *in vitro* (Cheng *et al.*, 2009) ^[12]. Presently,

fishponds can be cleaned with a commercially accessible nanotechnology device called NanoCheck. This device uses 40 nm-sized lanthanum-based particles, which prevent algae growth by absorbing phosphates from the water (Rather *et al.*, 2011) ^[56].

Delivery of dietary supplements and nutraceuticals

The notion that nanoparticles can enhance fish development is mostly predicated on their capacity to augment the amount of nutrients that are assimilated throughout the gastrointestinal system. When added to aquaculture meals in the form of nanoparticles, micronutrients can enter cells more effectively and increase the rate of absorption (Ogunkalu, 2019; Zhou *et al.*, 2009) ^[53, 76]. Iron nanoparticle feeding has been shown to accelerate the growth rates of juvenile carp and sturgeon (ETC, 2003) ^[22]. Diets enriched with nanoselenium can improve the final weight of crucian carp (*Carassius auratus gibelio*), antioxidant status, muscle selenium content, and relative gain rate (Zhou *et al.*, 2009) ^[76]. Manganese oxide nanoparticle diet (16 mg/kg), significantly enhanced antioxidant defense system and growth in freshwater prawn (*Macrobrachium rosenbergii*) (Asaikkutti *et al.*, 2016) ^[4]. Although the use of nutraceuticals is still low due to their expensive cost, applications of nanomaterials as nutraceuticals in aquaculture (shellfish and fish) are now being studied at an early level. Nutraceuticals are linked to added value products, stress reduction, and health management (Ogunkalu, 2019) ^[53]. Magnesium nanoparticles have a significant role in antioxidation and boost immunity in addition to acting as a cofactor for a variety of enzymatic and metabolic processes including proteins, carbohydrates, and fats. Calcium NPs support immunological response, blood coagulation, cellular function, growth, and bone formation. Interest in nanotechnology and the commercial use of nanoparticles has grown in the last few years. But little is known about the behavior and fate of synthetic nanoparticles in the environment (Moges *et al.*, 2020). The list of nanoparticles used in various fish species and their findings were given in Table 1.

Table 1: Nanoparticle based system for micronutrient delivery in aquatic animals

NP types	Size	Used technique	Fish species	Observation	References
Se NP	30-45 nm	Use as a feed material	Common carp (Juvenile)	Used 1 mg nano-Se per kg diet: improved growth but at 2 mg/kg displayed toxicity.	Ashouri <i>et al.</i> , 2015 ^[6]
Ag NP	Unclear	Synthesized AgNP from <i>Aloe vera</i> leaf extract was mixed with feed materials	<i>Catla catla</i>	Showed enhanced weight, length and specific growth rate (SGR).	Vineela <i>et al.</i> , 2017 ^[73]
ZnO NP	32-57 nm	ZnO NP mixed with fish feed.	Tilapia (<i>Oreochromis niloticus</i>)	Improved SGR and growth hormone.	Tawfik <i>et al.</i> , 2017 ^[69]
Cu NP	50 nm	The dough with CuNP was cooked at 105 °C, cooled mixed with egg albumin and cod liver oil and pelletized.	<i>Macrobrachium rosenbergii</i>	Improved survival, growth, digestive enzyme activities, biochemical components and haemocytes level	Muralisankar <i>et al.</i> , 2016 ^[49]
Fe ₃ O ₄ NP	<50 nm	Fe NP and Fe ₂ SO ₄ Mixed in basal diets, then extruded and dried	Rainbow trout, <i>Labeo rohita</i>	RBCs level, immunity, bactericidal and myeloperoxidase activity, and haemoglobin levels, improved.	Behera <i>et al.</i> , 2014 ^[9]
Chitosan NP	62.4-86.5 nm	Chitosan NP mixed with feed extruded, and air-dried at RT,	Tilapia, <i>Oreochromis nilotica</i>	Improved daily weight gain, final weight, and feed conversion ratio	Wang and Li, 2011 ^[74]
Mn ₃ O ₄ NP	40-50 nm, pineapple peel	Feed palletization and drying at 40 °C	<i>Macrobrachium rosenbergii</i>	Improved growth, final weight, FCR	Asaikkutti <i>et al.</i> , 2016 ^[4]
Vitamin C Nano encapsulate	<300 nm	Iontropic gelation and injected directly in <i>S. senegalensis</i> larvae	<i>Solea senegalensis postmetamorphic larvae</i> , Rotifers, <i>Brachionus plicatilis</i>	Two times higher vitamin C uptake	Jiménez-Fernández <i>et al.</i> , 2014 ^[36]

Types of Nano materials

Depending on their morphology, size, and chemical characteristics, NPs are divided into numerous groups. Some of the most well-known classes of NPs are mentioned below, based on physical and chemical attributes (Khan *et al.*, 2019) [39].

Carbon based nanomaterials: includes Diamond, Amorphous Carbon, Graphite, C 60 and C 70 and Carbon Nanotube.

Metal based Materials: Includes Quantum Dots, Nano Gold, Nano Silver, Nano calcium, Nano Magnesium.

Dendrimers: Polymers with branch unit

Composites: Nano sized clay Bio-Organic complex

Classification of nanomaterials

Based on a variety of factors, nanomaterials (NMs) can be categorized into several classes. In general, NMs are classified based on their chemical composition, dimensionality, shape, and condition (Gleiter, 2000) [28]. This classification also depends on their size, which ranges from 1-100 nm in at least one dimension. NMs can be further classified into four kinds based on the dimensions and general shape of these materials. Nanomaterials classified as zero-dimensional (0D) possess all of their dimensions at the nanoscale, meaning they are smaller than 100 nm. 0D encompasses quantum dots (QDs) and spherical NMs, cube, nanorod, polygon, hollow sphere, metal, and core-shell NMs. One dimensional nanomaterials (1D) are materials with one dimension not in nanoscale while the other two dimensions are in nanoscale. 1D comprises nanowires, nanofibers, metallic, polymeric, ceramic, nanotube, and nanorod filament or fiber. Only one dimension exists at the nanoscale in two-dimensional nanomaterials (2D), while the other two do not. Single- and multi-layered, crystalline or amorphous thin films, nanoplates, and nanocoatings are examples of 2D materials. Beyond 100 nm, three-dimensional (3D) materials come in a variety of sizes (Pokropivny and Skorokhod, 2007; Aversa *et al.*, 2018) [54, 7]. Multiple nanocrystals are combined in opposite directions using 3D NMs. Foams, fibers, carbon nanobuds, nanotubes, fullerenes, pillars, polycrystals, honeycombs, and layer skeletons are a few examples of similar materials (Asghari *et al.*, 2016; Shiao *et al.*, 2018) [5, 62].

Magnesium as Nanomaterial

An important component of several metabolic processes is magnesium (Mg). Proteins, negatively charged phospholipids, and nucleic acids are the major molecules that contain magnesium (Vormann, 2003) [73] and a crucial component of numerous enzyme systems. Crustaceans need magnesium, an essential mineral, for proper growth and development (Davis and Lawrence, 1997) [19]. Magnesium is involved in osmoregulation, protein synthesis, and growth in addition to being a cofactor in 26 different enzymatic activities that are necessary for normal function (Furriel *et al.*, 2000) [26]. It improves immunity and is crucial for antioxidation (Tam *et al.*, 2003) [67]. It has been documented that adding magnesium to the diet decreased the production of free radicals and oxidative stress, as well as enhanced the

quality of the meat in Pacific white leg shrimp *L. vannamei* (Roy *et al.*, 2007a; Roy *et al.*, 2009) [59, 58]. In crustaceans, magnesium is necessary to maintain both intra- and extracellular homeostasis (Mantel and Farmer, 1983) [56]. Magnesium is also necessary for phosphate transfer events involving adenosine tri-, di-, and monophosphate as well as for cellular respiration. It is involved in the metabolism of lipids, carbs, and proteins and is an activator for all thiamine pyrophosphate processes. Moreover, the production of superoxide (O₂⁻) anions on the surface of nano MgO confers strong bactericidal activity in aqueous conditions (Huang *et al.*, 2005) [31, 32]. MgO nanoparticles exhibit significant potential as an antibacterial agent (Tang and Feng, 2014) [68]. On the physiology and biochemistry of crustaceans, there is, however, less information available regarding MgO NPs.

Calcium as Nanomaterial

One of the most prevalent cations in a fish's body is calcium. Although it is crucial for the development of bones and the upkeep of skeletal tissues, calcium ions are also widely distributed in soft tissues. Other uses of calcium include the contraction of muscles, the formation of blood clots, nerve transmission, the preservation of cell membrane integrity, and the activation of numerous vital enzymes. In the cell membrane, calcium is closely bound to phospholipid, where it regulates the permeability of the membrane (Lall, 2002) [41]. The most widely used form of calcium supplements is calcium carbonate. It is also possible to synthesize calcium carbonate, a mineral molecule having the formula CaCO₃. By changing the water's hardness, calcium carbonate can have an impact on the biological processes of crustaceans, including growth, peeling, and reproduction (Mente, 2003 and Huong *et al.*, 2010) [47, 34]. Being a key component of the shell (exoskeleton) in the form of calcium carbonate, calcium is a vital mineral for shrimp (Venkataramaiah *et al.*, 1978) [71], and also plays a role in osmoregulation (Shewbart *et al.*, 1973) [61]. Applications for calcium oxide (CaO) nanoparticles include water filtration, adsorption, catalysis, and antibacterial agents (Madhusudhana *et al.*, 2012; Roy *et al.*, 2013; Bai *et al.*, 2009) [45, 57, 8]. The rate of calcium absorption and use may be greatly increased if the calcium carbonate was crushed to the nanoscale (Huang *et al.*, 2015) [33]. CaCO₃ facile accessibility and slow biodegradability make it useful for encapsulating many medications, including bioactive proteins in pharmaceuticals, and for controlled drug delivery (Garg *et al.*, 2021) [27].

On the fundamental physiology and biochemistry of crustaceans, there is, however, less information available on MgO NPs and CaCO₃ NPs (Srinivasan *et al.*, 2017) [64]. Hence, the present study was conducted to understand the importance of MgO NPs and CaCO₃ NPs on survival and growth of *Litopenaeus vannamei*.

Conclusion

In conclusion, aquaculture is a rapidly expanding food sector globally, playing a vital role in bridging the gap between the growing demand for aquatic food products and the limitations of capture fisheries. In the aqua culture systems, the Pacific white shrimp (*Litopenaeus vannamei*) is one of the major cultivable species, offering numerous advantages over traditional species and enhancing the productivity and sustainability of aquaculture operations. Additionally, the nanomaterials, with their unique

properties, offer innovative solutions in areas such as disease management, nutrient delivery, and water quality control in shrimp culture systems. Along with that, nanomaterials also could enhance the feed utilization efficiency, immune responses, and enabling more precise pathogen detection. Therefore, nanotechnology holds the potential to significantly boost the productivity and sustainability of aquaculture practices.

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Conflict of interest

Authors declare no conflict of interest

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