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Utilization of Nanotechnology in Aquaculture and Seafood Sectors

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Abstract

Nanotechnology is described as a newly developed technological aspects of science which combines the physical, chemical and biological properties and results in an Improve technology. The Unique ability of nanotechnology includes: Improvement of fish packaging techniques, enhancement of quality, tastes, texture, flavor, improve fish nutrients absorption and ability to detect pathogen in the system. Nano encapsulation is technologically designed to contain substances in minute and functional way to monitor the release of the core. Hydrophobic beta-carotene is applied for preservation of bioactive compounds like lipids, vitamins, proteins and also carbohydrate, Nanotechnology is applied to get color, taste, and odour ,Improve bioavailability of functional compounds, elimination of decomposition; Encapsulation and monitoring the release of food materials; Improve bioavailability; stability, and shelf-life of delicate ingredients;
Preservation of food products from microbial attack; carrier channels of nutrients, nutraceuticals, food additives and food antimicrobials; The aquaculture and seafood sectors can be transformed with the application of nanotechnology, this techniques helps in detection of disease quickly and improve the ability of fish to absorb hormones, vaccines, controlling diseases, and biofouling control processes all these are enhanced to achieve maximum advantages of nanotechnology. It also helps in water filtration and thereby making more successful feed for aquaculture. Positive results have been recorded for nanotechnology as Antifouling in fishing and aquaculture nets, antibacterial material for aquaculture tanks and it's a newly developed packaging materials for seafood products.

Keywords: Aquaculture, Nanoemulsion, Nanomaterial, Nanotechnology, Seafood products

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INTRODUCTION

Fish is an essential aquatic animal impacting human life at all stages, it is highly rich in nutrients. Fish provides various nutrients such as proteins, vitamins (A, D and E), fats and several other macro nutrients (Brasky et al., 2010). The minerals contents of fish include calcium, Iron, Iodine, Magnesium, sodium, Phosphorus and many others (Melanson et al., 2005). Fish Proteins contains the amino acids that are not available in plant proteins. Fisheries products are essential both nutritionally, medically and economically. Several species of fish are very rich in Omega 3 fatty acids which are Eicosapentaenoic acid (EPA) and Docosahexanoic acids (DHA) (Khawaja et al., 2012). Aquatic products are of great benefit to humans due to its positive Impacts on health, nutrition and economics, this has led to scientific and technology development to produce an acceptable products. Nanotechnology is a newly developed technology widely applied in many sectors (Can et al., 2011). Nanotechnology incorporates various discipline such as, chemistry, engineering, physics and biotechnology, hence, it is called the application of nanomaterial with nanoscale whose structure is between 1-100nm (Chandra and Segal, 2016). Several dimensions of structural elements, crystallites, molecules and clusters are manifest in Nanomaterials which includes zero dimension (nanoparticles, nanoclusters, and quantum dots), one dimension, (nanorods and nanotubes), two dimensions (nano-thin films), and three dimensions (nanomaterials) in the 1-100nm ranges (Pathakoti et al., 2017). Several sectors are largely into application of nanomaterials which include agriculture, food, cosmestics, medicine, clothing and public health as a result of their special ability to expand solubility and bioavailability and also to preserve bioactive components during processing and storage(Fu, 2014).The physiochemical and antimicrobial ability of nanomaterials results in its widely application against various pathogenic microbes and in healthcare, water treatment and food preservation (Baranwal, et al., 2018). Nanoencapsulation is technologically designed to contain substances in minute and functional way to monitored the release of the core. Hydrophobic beta-carotene is applied for preservation of bioactive compounds like lipids, vitamins, proteins and also carbohydrate (Sekhon, 2010). Nanoencapsulation has potentials to provide several opportunities to food industry by improving the stability of the encapsulated material, offers buffering effects against severe pH, temperature, ionic strength differences (Yurdugul & Mozafari, 2004). The aquaculture and seafood sectors can be transformed with the application of nanotechnology, this techniques helps in detection of disease quickly and improve the ability of fish to absorb hormones, vaccines, controlling diseases, and biofouling control processes all these are enhanced to achieve maximum advantages of nanotechnology. The daily nutritional requirement of fish feed components which are carbohydrates, fats, proteins, minerals and vitamins are easily absorbed by the nanotechnology. A new suggestion on nanoparticles is that it will improve aqua feeds through enlargement of fish feed nutrients proportion which pass across gut tissue to the fish system, rather than direct movement of the fish feeds nutrients without digestive system (Bhattacharyya et al., 2015).

The use of nanotechnology is aquaculture and fisheries sectors

- Nanotechnology is applied to get colour, taste, and odour.
- Improve bioavailability of functional compounds, elimination of decomposition;
- Encapsulation and monitoring the release of food materials; Improve bioavailability; stability, and shelf-life of delicate ingredients;

- Preservation of food products from microbial attack; carrier channels of nutrients, nutraceuticals, food additives and food antimicrobials;
- It helps in water filtration and helps in making more successful feed for aquaculture (Reza Mozafari et al., 2008).
- It serves as Antifouling in fishing and aquaculture nets, antibacterial material for aquaculture tanks and it's a newly developed packaging materials for seafood products (Can et al., 2011).

Nanostructucture

The structure of fish proteins are globular ranges between 1-10 nm in their sizes, fish protein consists of a significant quantity of lipids and many polysaccharides, and the sizes of these polysaccharides showed to be linear polymers having a thickness less than nanometers. Nanotechnology can be applied in the extraction of protein and fish lipids particles and could be organized specifically to obtain better end results products, the Omega 3 acids can be extracted and be used as coating materials on other food products such as biscuits and other ready to eat food (Shiv Mohan Singh et al., 2018).

Nanoemulsions/Nanoencapsulation

Fish contain several phenolics compounds which includes catechin, caffeic acid, tannic acid and ferulic acid, with poor oral bioavailability in form of capsules and tablets, hence, a delivery system which is effective is required to improve the bioavailability of the compounds, such a delivery system must be generally recognized as safe and should be capable to transfer the active components to the expected location through the channel of the gastrointestinal tract(Shiv Mohan Singh et al., 2018). Emulsion is described as a mixture of two or more several liquids which does not easily incorporate into one another, hence nanoemulsion is an emulsion with diameters of the distributed droplets with measurement of 500nm or less (Ravichandran, 2010). Nano emulsion has specific characteristics which showed a point of attraction, as a result of their miniature size and high kinetic energy (Murata et al., 1997). Encapsulation of fish oil and the stabilities of freeze-dried oil was carried out in research due to its health benefits, along with strong odors and quick oxidation processes, these led to the investigation of beta-cyclodextrin (this polymer is soluble in water and polycaprolactone a polymer insoluble in water). It was aimed to determine the rate at which fish oil releases at separate relative humidities and storage of temperatures, it was deduced that water- insoluble polymer showed better preservation of fish oil as a result of its water- insolubility (Choi et al., 2010).

Nanocomposites films

Nanotechnology can be applied in seafood as preservation to delay enzymatic and microbial spoilage as conservation and packaging techniques to ascertain food safety. Nanocomposites films are incorporated into foods along with active packaging (antimicrobial films) and edible coating techniques, Nanocomposites films which include polysaccharides, protein and lipid are derived from natural biopolymers. These substitutes packaging materials are widely adopted as replacement of petrochemical source of plastics, as a result of their edibility, environmental –friendly and anticarcinogenic nature they possessed (Dursun , et al., 2010).

Nanofiltration was applied to reverse osmosis processes and to reduce the salinity of drilling water used in washing and processing units of seafood, nanofiltration was employed as pre-treatment approach before thermal the membrane of the seawater desalination process was carried out(Walha, et al., 2008).

masking undesirable flavors and Tastes

Harvested fish from rivers and oceans often possessed undesirable flavors and tastes, this novel technology (nanotechnology) can be employed in masking the undesirable flavors or tastes to increase consumer interest in its consumption (Shiv Mohan Singh et al., 2018).

Nanodelivery of nutraceuticals

The application of Nanomaterial as neutraceutical in fish and shellfish health managements, stress reduction, and value addition are currently at early stage in aquaculture sectors, the disadvantage associated with the use of nutraceutical is high cost. A delivery system consists of various purposes which includes transportation of functional ingredients to its destination, It also help in enhancement of food attributes like taste, texture and shelf life (Ravichandran, 2010). Hence, its application require control of resources to prevent wastage for effective utilization and products economically feasible (Rather et al., 2011).To achieve this nutraceutic material as a nanodelivery system for these types of molecules, consideration should be given to the complication that may arise during its application in aquaculture usage especially for commercial purpose. Several feeds formulated base on nanomaterial helps to sustain good stability and enhancement of feed tastes (FOE, 2008).

Nanoparticles for improvement of fish development

Nanoparticles of iron fed to juvenile carp and sturgeon fish showed a rapid rate of development between (30% &24%) development report is according to a Russian Academy of science, (ETC, 2003)Their research illustrated that separate selenium of different sources(nano-Se and selenomethionine) augmented in the basal diet may enhance the relative weight rate, final weight, and the antioxidants condition and also glutathione Peroxidase (GSH-Px) activities and concentration of Se on crucian carp muscle (*Carassius auratus gibelio*) (Rather,et al.,2011).additionally, nano-Se showed to be efficient than natural selenomethionine improving the content of selenium muscle (Roy, 1997), comparably, the development and yield of the trial fishes was rated higher at nano level delivery of nutraceuticals. This whole idea is that nanoparticles will enrich fish feeds by increasing the quantity of nutrients that move across the gut material to fish body instead of allowing it to pass through the digestive tract without been absorbed (Handy, 2012). Aquafeeds in form of nanoparticles could penetrate cells easily than bigger size and thereby increase the rate of absorption (Zhou et al., 2009).

DNA nano–vaccines

The major problems in the growth and sustainability of aquaculture is the occurrence of diseases, several strategies have been employed to overcome this disease obstacle in the aquaculture sector, one of the major steps is DNA nano vaccination, The application of oil emulsion to administer the vaccine could lead to a significant setback in which some fish and shellfish reacted negatively to the effects it caused.

Thus, the application of nanoparticles carriers such as chitosan and poly-lactide-co-glycolide acid (PLGA) (Rajeshkumar, et al., 2009) of vaccine antigens incorporated with mild inflammatory inducers which could supply strong protection to fisheries products against many bacterial diseases and viral diseases. More so, an extensive vaccination of fish and shellfish can be carried out with the application of nanocapsules which consist of nanoparticles (Rather et al., 2011). Normally, polymeric nanoparticles has various benefits in vaccine delivery; it provides reliable delivery of vaccines, they provides a dissolved drugs for intravascular delivery, they can enhance solvent of vaccine antigens against enzymatic deterioration (Bhattacharyya, et al., 2015. Nanoencapsulated vaccines acts against the bacterium *Listonella anguillarum* could be applied in Asian Carp. A trials system on mass vaccination of fishponds filled with fish application of ultrasound was carried out by the United State Department of Agriculture. It consists of nanocapsules of small strands of DNA added to the fish tank in which the fish cells take up the DNA, the nanocapsules was burst with the mechanisms of the Ultrasound, the ruptured capsuled in turns allows the DNA and then triggers the fish immune to respond (Can et al., 2011). Clearsprings food (Idaho US) have successfully applied these Techniques on rainbow trout (Mongillo, 2007).

Nanofiltration

Water treatment and purification is very essentials in all sectors and it includes elimination of toxic ions, organic contaminants, microbes, and other pollutants. The elimination of organic pollutants from the water is of great concerns to industries, the disintegrated organic compound results in bacterial growth, odour, and biofouling and this can alter the water quality (Bhattacharyya et al., 2015). The research was conducted successfully with the application of titanium dioxide, a nano-sized particles applied as films on the ceramic for treatment of water in the fish bowls. Ceramics coated with titanium dioxide nano-particles has potential to remove moss and bacteria in fish tank. These techniques can be used in commercial fish farms and Aquariums as it will reduce water treatment cost (Can et al., 2011). Also, helps in the elimination of water contamination and filtration making more successful feed for aquaculture, Nano-particles in the appearance of active materials such as carbon or aluminum incorporated with zeolite and iron compounds, these can be applied in aquaculture for influencing aerobic and anaerobic biofilm in order to be able eliminate ammonia, nitrites, and nitrates contaminants(Reza Mozafari et al., 2008). Nanotechnology has potential to protect fishponds that are free from diseases and pollution, Nano check was manufactured by Altair Nanotechnologies for cleaning and purifying the water, this Nano Check operates with 40-nanometer particles of lanthanum-based compounds which absorbs and prevent algae growth through absorptions of phosphate from the water (Mongillo, 2007).

Chemical/Toxins elimination

Nanotechnology can be applied to eliminate dangerous chemicals and toxins presents in the fish harvested from polluted rivers which may be highly concentrated with dangerous chemicals like pesticides and natural toxins like tetraodotoxin in puffer fish, nano techniques can be applied to effectively eliminate such chemicals without affecting the fish nutrients (Murata et al., 1997).

Gene delivery techniques

The occurrence of advanced carrier systems for delivering gene appears as a potential techniques for treatment of several genetic problems. Although, critical obstacles for successful gene treatment proofs as the effective and safe methods of delivering the gene (Rather, et al., 2011). Non-viral delivery systems have been greatly recommended as solutions to viral vectors as a result of their protection, strength and potentials to be manufactured in larger quantities. (Tomlison, E. and Rolland, A.P.,1996) several perspectives employed DNA complexes consist of protein, peptides, lipids, the reports of the research were encouraging in the formation of complexes between chitosan and DNA yet, chitosan resulted in the improved transformation effectively, A great and effective gene delivery is achieved with the combination of DNA-chitosan complex through receptor- mediated endocrytosis (Murata, et al.,1997)This outcome assumes that chitosan has comparable potentials without the combination of the toxicity of other synthetic vectors, thereby, it could be an efficient gene-delivery channel in vivo.

Nanotechnology as tagging and nano-barcoding

The application of nanomaterial in the form of a nanoscale component which bears an identification code inscribed in it with a chip of radio circuit called Radio frequency ID (Rfid). The chip identity is use as a tag which is applied from a distance to scan a product to verify the information embedded in it, the tags has the potential to occupy several information and it can be operated automatically at any distance for tracking and also as a device for monitoring fish feeding behavior, swimming metabolism patterns. It also serves as nano-barcode which is a device for monitoring an objects, it made up of metallic stripes with nanoparticles in which the differences in the striping patterns supply the techniques for encoding information. The incorporation of nanobarcoding makes the monitoring of processing industry and exporters to be achieved easily and movement/status of aqua product can be tracked to the point of its delivery to the sales or distribution center. Furthermore, nanosensors and synthetic DNA tagged along with nanobarcodes and color coded probes have great potential to discover pathogens and also monitor the changes in temperature and leakages thereby enhance the product quality (Rather et al., 2011).

CONCLUSION

Nanotechnology is widely applied in all sectors which includes food technology, medicines, pharmacy, Aquaculture and seafood technology applied as nanoparticles, nanofiltration and also in fish packaging and processing. These techniques assured various opportunity for advancement and stability of fisheries resources, Nanotechnology is still underemployed at the moment in the aquaculture and fisheries sector, but with researches and continuous usage of nanotechnology the importance will be acknowledged and it would be applied by the industries as a solution to developments.

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