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Nanotechnology- A Novel Approach to Process Fish and Fishery Products

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Abstract: In the context of seafood, Nanotechnology can be meant as the understanding and control of matter at a nanoscale where unique phenomena enable novel applications in fishery industry. Nanomaterials are further defined as substances between 1 and 100 nm in size showing physical, chemical and biological properties that are not found in bulk samples of the fish and fishery products. Applications of nanotechnology have emerged with increasing need of nanoparticle uses in various fields of fishery sciences and fish microbiology, including fish processing, fish and fishery products packaging, functional fish as food development, fish safety, detection of foodborne pathogens, and shelf-life extension of perishable fish and fish products. This review summarizes the potential of nanoparticles for their uses in the fishery industry in order to provide consumers a safe and contamination free fish and to ensure the consumer acceptability of the fish with enhanced functional properties. Aspects of application of nanotechnology in relation to increasing in fish nutrition and organoleptic properties of fishes have also been discussed briefly along with a few insights on safety issues and regulatory concerns on nano-processed food products.
Keywords: Nanotechnology, Nanoparticle, Fish and Fishery Products.

1. Introduction:-

Nanotechnology is the ability to observe measure, manipulate, and manufacture things at the nanometer scale (1-100nm), the size of atoms and molecules. The National Science Foundation of USA predicts that the global marketplace for goods and services using nanotechnologies will be worth a trillion dollars by 2015. Nanotechnology is the versatile technology, which will affect everything from the clothes we wear, to the energy we use, to the way we detect and treat cancer and other diseases in near future. Nanotechnology, also called as Molecular Manufacturing based Nanotechnology (MNT) involves experimenting and manipulating with particles, called nano-particles that have dimensions in the scale of properties, in order to design and build materials and devices, where the basic structure of latter is specified in the scale of nanometer. The term nanotechnology encompasses a range

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of technology that operates at the scale of the building blocks of biological and manufactured materials- the ‘nanoscale’.

Nanotechnology is an advanced branch of science that has already impacted field’s *viz.*, medicine, cosmetics, agriculture, and food. Particular in the food area, nanotechnology is being used as a means to understand physico-chemical characteristics of nanometric materials which change the structure, texture, and quality of foodstuffs. Food nanotechnology encompasses attribute like taste enhancement, flavor, color, texture, consistency of foodstuffs, increased absorption and bioavailability of nutraceuticals, food antimicrobials development, packaging materials with improved mechanical, barrier, and antimicrobial properties, traceability and monitoring the condition of food during transport and storage by nanosensors, and food components or additives encapsulation (Chaudhry *et al.*, 2008).

Nanoencapsulation can offer various advantages to food industry by enhancing the stability of the encapsulated material, providing buffering against extreme pH, temperature, and ionic strength variations, as well as with masking of unwanted odors or tastes (Yurdugul and Mozafari, 2004). Availability of various types of encapsulation technologies like surfactant micelles, nanospheres, nanoparticles, nanoemulsions, nanocochleates, liposomes, and nanoliposomes can be employed in the food industry.

It allows many things to be manufactured at low cost and without pollution (National Science Foundation, USA). Nanotechnology can have various direct, indirect and miscellaneous applications in fisheries industry.

2. Application in modern food industry

The term ‘nanofood’ describes food which has been cultivated, produced, processed or packaged using nanotechnological techniques or tools, or to which manufactured nanomaterials have been added (Joseph and Morrison, 2006). Nanofood is related to the improvement of food color and flavor, prolongation of shelf life and preservation, detection of germs and antibacterial characteristics, and intelligent packaging materials One important application of Food Nonoprocessing is to develop novel functional food ingredients with improved water solubility, thermal stability, oral bioavailability, sensory attributes and physiological performance.

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Nanoencapsulation is a technology to pack substances in miniature and functionality like controlled release of the core. Use of hydrophobic beta-carotene in the protection of bioactive compounds, such as vitamins, antioxidants proteins, and lipids as well as carbohydrates may be achieved (Sekhon 2010). Encapsulated forms of ingredients have longer shelf life. Nanoencapsulation may develop designer probiotic bacterial preparations that could be delivered to certain parts of the gastro-intestinal tract where they interact with specific receptors which can serve function of vaccine (Vidhyalakshmi *et al.*, 2009).

Nanoemulsions can be used in the decontamination of food. A typical nanomicelle-based product removes pesticide residues from fruits and vegetables, as well as the oil/dirt from cutlery. Nanoemulsions clarity makes it enable in the addition of bioactives and flavors to a food without a change in product appearance. Nanoemulsions are effective against Gram-negative bacteria. Given physicochemical properties of the microencapsulated fish oil, it can be considered as an alternative to milk proteins. (Gharsallaoui 2007; Drusch 2008)
Nanocoatings have been reported to be very efficient packaging technologies by keeping out oxygen and retaining carbon dioxide (Garland 2004). Nanotechnology is enabling the development of edible coatings (Azeredo 2009) sometimes reported to have antibacterial property (Naoto 2009).

Nanocomposites improving polymer properties through increased barrier properties, increased mechanical strength and improved heat resistance compared to their neat polymers and conventional composites. Arora and Padua (2010) mentioned the use of nanosized montmorillonite clay to improve mechanical and thermal properties of nylon. Incorporation of nanoparticles of clay into an ethylene-vinyl alcohol copolymer and into a poly (lactic acid) biopolymer has been reported to increase barrier properties to oxygen. Electron microscopy shows strong adhesion between the clay nanoparticles and the polymer matrix factor thereby impeding the diffusion of gases through the composite membrane. This type of packaging may extend shelf life of food products. Doyle (2006) reported a polymer-silicate nanocomposite which is shown to improve gas barrier properties, mechanical strength, and thermal stability. Developments like nanocomposites (characterized by extremely high

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surface-to-volume ratio) which can improve mechanical strength; reduce weight; increase heat resistance; and improve barrier against oxygen, carbon dioxide, ultraviolet radiation, moisture, and volatiles of food package materials (Brody 2006). Fine nanoparticulates (100 nm or less) are incorporated (2%–8% by weight) into plastics to improve the properties over those of conventional counterparts. Sondi (2004) reported nanocomposites to possess antimicrobial activity. Iron- and iron/zinc-containing nanostructured compounds improve bioavailability and color changes minimization in finished products.

3. Applications in the Fish Processing Industry

3.1. Nanostructures in fish- meat

Fishes are rich source of protein. Fish proteins are often globular structures 1-10 nm in size. Beside protein fish also contains considerable amount of lipids and some polysaccharides, which are linear polymers with thickness less than nanometers in size. The self-arrangement of these particles greatly decides the taste and nutritional benefits of any food. Nanotechonoly can be used to carefully extract these particles and precisely arrange them to get better finished products. The idea is also to use these extracted proteins and fatty acids (such as Ω3) to add them or coat them on other food products, such as biscuits, wafers or others, such that even the vegetarians would also be able to relish them.

3.2. Nano clay

Layered composites (usually transparent, but can be coloured) containing nanoparticles are being used to generate long path lengths through materials to reduce gas diffusion and prolong the shelf- life of products. Beside this, the idea is to use nano-clay to increase the appeal of fishery products by enhancing their colour and texture and as antimicrobial coatings.

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3.3. Nutraceuticals and Functional foods-

3.3.1. Food additives

Currently, some food additives with nanoingredients (according to claims by the producers) are being sold in the USA and Germany. These additives may imply that nanoparticles are present in the food. The additives are mainly aimed at the diet, sports and health food markets and contain minerals with a nano-formulation, such as silicon dioxide, magnesium, calcium, etc. The particle size of these minerals is claimed to be smaller than 100 nanometre so they can pass through the stomach wall and into body cells more quickly than ordinary minerals with larger particle size.

Nano-additives can also be incorporated in micelles or capsules of protein or another natural food ingredient. Micelles are tiny spheres of oil or fat coated with a thin layer of bipolar molecules of which one end is soluble in fat and the other in water. The micelles are suspended in water, or conversely, water is encapsulated in micelles and suspended in oil.

The nutrients or "nutraceuticals" are contained within the aqueous interior. Nutraceuticals that have been incorporated in the carriers include lycopene, beta-carotene, lutein, phytosterols, CoQ10 and DHA/EPA. The Nutralease particles allow these compounds to enter the bloodstream from the gut more easily, thus increasing their bioavailability. Such nanocapsules can for example contain healthy Omega3 fish oil (fatty acid) which has a strong and unpleasant taste and only release it in the stomach such as in "Tip Top Up"® bread sold in Australia.

New types of membranes including micro and nano-sieves can be applied in fish processing. They can be used for encapsulating valuable food ingredients such as minerals and vitamins in a coating of another ingredient to boost take up by the body or to avoid these ingredients being lost during cooking.

Building on the concept of "on-demand" food, the idea of interactive food is to allow consumers to modify food depending on their own nutritional needs or tastes. The concept is that thousands of nanocapsules containing flavour or colour enhancers or added nutritional elements (such as vitamins), would remain dormant in the food and only be released when triggered by the consumer.

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It will be also possible of enhancing the nutritional quality of food through selected additives and improvements to the way the body digests and absorbs food.

3.4. Fish protein- based nanotubes.

Protein nanotubes are open- ended hollow tubular structures formed through the self-assembly of polypeptide chains (Okamoto *et al.*, 2001). Electronic and molecular properties of proteins determine the characteristics of the final product (Fukasaku *et al.*, 1998). Some examples of these structures observed in nature are virus capsids, microtubules, actin filaments, and amyloid fibrils (Valery *et al.*, 2004). They can be designed artificially by protonating cyclic polypeptides, which leads to the formation of nanotube structure with hundreds to thousands nanometers in length and tens to hundreds of angstroms in the inner diameter (Ghadiri *et al.*, 1993).

These nanotubes can be used in various fishery products by using their properties as thickening and gelling agents to increase food matrix integration. The nano- cavities can be utilized to encapsulate a variety of food molecules. Furthermore, reversible assembly of the nanotubes with the variation in Ca^{2+} concentration of the medium can be used to control the release of the encapsulated material (Graveland-Bikker *et al.*, 2004).

3.5. Nanoemulsions

Many of the phenolic compounds from fishes (like catechin, caffeic acid, ferulic acid and tannic acid), in capsules and tablets, have poor oral bioavailability. Therefore, novel delivery systems are necessary in order to enhance the bioavailability of these compounds.

As an effective food delivery system, the delivery vehicle should be GRAS (Generally Recognized as Safe) and able to transfer the active ingredients to the desired sites through the gastrointestinal tract. Nanoemulsions are particularly attractive because of their small sizes and high kinetic stability (Nakajima 1997).

The idea is that the unstable or poorly bioavailable compounds will be conjugated to food polymers such as hydrocolloids. These hydrophobic compounds will self-assemble to form cores, while the water-soluble polymers will form a surrounding shell. With the help of food

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polymers, the blood circulation time of these compounds inside the body increases; therefore, the desired pharmaco-kinetics (PK) of these compounds may be achieved.

3.6. Masking undesired flavours:-

Nanotechnology can help to improve the consumer acceptance by masking the undesired flavour, commonly encountered in freshwater and marine fishes.

3.7. To overcome allergies

Many people have reported to have allergy from various food products including fish and other processed fishery products.

The idea is to use nanotechnology and nanodevices to precisely remove the specific allergens from fishery products, without compromising their flavour or nutritive value.

3.8. To remove harmful chemicals and toxins

Fishes caught from polluted waters may contain high concentration of harmful chemicals like pesticides and some may contain natural toxins, like tetradotoxin in puffer fish.

The idea is to use nanotechnology to effectively remove these chemicals or toxins, without compromising other food parameters.

4. Health Concerns on Nanomaterials

There have been experimental evidences of the toxicity of selected nanomaterials which are in use by the food industry. Nanoparticles of Silver (Braydich-Stolle *et al.*, 2005; Hussain *et al.*, 2005) and zinc (Wang *et al.*, 2007; Brunner *et al.*, 2006) at different nano-size reported to be harmful to living organisms.

5. Conclusion

Over past years the popularity of the uses of structures on the nanometer scale in the fishery sector is increasing, therefore, interest and activities in this research area have greatly focused. As nanobiotechnology steps forward, devices or material based on this technology become smaller and more sensitive. Its applicability in the areas of fish and fishery products

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packaging and fish safety are well known. Additionally, promising results have been achieved in fish preservation using nanomaterial where they might protect the fish from moisture, lipids, gases, off-flavors, and odors. They offer excellent vehicle systems to deliver bioactive compounds to the target tissues. Although the advances in nanotechnology are paving new paths day by day, there still persist many challenges and opportunities to improve the current technology and also issues about the consequences of nanotechnology that must need to be addressed in order to alleviate consumer concerns. The transparency of safety issues and environmental impact should be the priority while dealing with the development of nanotechnology in fish and fishery products and therefore compulsory testing of nano foods is required before they are released to the market.

References

1. Chaudhry, Q., Scotter, M., Blackburn, J., Ross, B., Boxall, A., Castle, L., & Watkins, R. (2008). Applications and implications of nanotechnologies for the food sector. *Food additives and contaminants*, *25*(3), 241-258.

2. Yurdugul, S. E. Y. H. U. N., & Mozafari, M. R. (2004). Recent advances in micro- and nanoencapsulation of food ingredients. *Cell Mol Biol Lett*, *9*(S2), 64-65.

3. Joseph, T., & Morrison, M. (2006). *Nanotechnology in agriculture and food: a nanoforum report*. Nanoforum. org.

4. Sekhon, B. S. (2010). Food nanotechnology–an overview. *Nanotechnology, science and applications*, *3*, 1.

5. Vidhyalakshmi, R., Bhakyaraj, R., & Subhasree, R. S. (2009). Encapsulation "the future of probiotics"-a review. *Adv Biol Res*, *3*(3-4), 96-103.

6. Gharsallaoui, A., Roudaut, G., Chambin, O., Voilley, A., & Saurel, R. (2007). Applications of spray-drying in microencapsulation of food ingredients: An overview. *Food Research International*, *40*(9), 1107-1121.

7. Drusch S, Berg S (2008) Extractable oil in microcapsules prepared by spray-drying: localisation, determination and impact on oxidative stability. Food Chem 109:17–24

8. Garland A, editor. Commercial applications in nanotechnology. UK: Pira International Limited UK; 2004. Nanotechnology in plastics packaging; pp. 14–63.

UGC Approved Journal ISSN: 2348-1358
NAAS Rating: 3.77 Impact Factor: 6.057

9. Azeredo HC, Mattoso LH, Wood DF, Williams TG, Avena-Bustillos RD, Mc Hugh TH. Nanocomposite edible films from mango puree reinforced with cellulose nanofibers. J Food Sci. 2009; 74(5):N31–N35.

10. Naoto S, Hiroshi O, Mitsutoshi N. Micro- and nanotechnology for food processing. (Food Safety Series) Resource: Engineering and Technology for a Sustainable World. 2009 Sep 1; American Society of Agricultural Engineers. 2009; 16(6):19.

11. Arora, A., & Padua, G. W. (2010). Nanocomposites in food packaging. *Journal of food science*, *75*(1).

12. Doyle ME. 2006Nanotechnology: A brief literature review Food Research Institute Briefings [Internet]June2006Available from: http://www.wisc.edu/fri/briefs/FRIBrief_Nano-tech_Lit_Rev.pdf

13. Brody A. Nano and food packaging technologies converge. Food Technol. 2006; 60(3):92–94.

14. Sondi I, Salopek-Sondi B. Silver nanoparticles as antimicrobial agent: A case study on *E. coli* as a model for Gram-negative bacteria. J Colloid Interface Sci. 2004;275:177–182.

15. Braydich-Stolle, L., Hussain, S., Schlager, J. J., & Hofmann, M. C. (2005). In vitro cytotoxicity of nanoparticles in mammalian germline stem cells. *Toxicological sciences*, *88*(2), 412-419.

16. Hussain, S. M., Hess, K. L., Gearhart, J. M., Geiss, K. T., & Schlager, J. J. (2005). In vitro toxicity of nanoparticles in BRL 3A rat liver cells. *Toxicology in vitro*, *19*(7), 975-983.

17. Brunner T, Piusmanser P, Spohn P, Grass R, Limbach L, Bruinink A, Stark W. 2006. In Vitro Cytotoxicity of Oxide Nanoparticles: Comparison to Asbestos, Silica, and the Effect of Particle Solubility. Environ Sci Technol **40:**4374-4381.

18. Wang B, Feng W, Wang M, Wang T, Gu Y, Zhu M, Ouyang H, Shi J, Zhang F, Zhao Y, Chai Z, Wang H, Wang J. 2007. Acute toxicological impact of nano- and submicro-scaled zinc oxide powder on healthy adult mice. J Nanopart Res **10(2):**263-276

19. Okamoto, H., Takeda, K., & Shiraishi, K. (2001). First-principles study of the electronic and molecular structure of protein nanotubes. *Physical Review B*, *64*(11), 115425.

20. Fukasaku, K., Takeda, K., and Shiraishi, K. (1998). First-principles study on electronic structures of protein nanotubes. J. Phys. Soc. Jpn., 67, 3751–3760.

UGC Approved Journal
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21. Valery, C., Artzner, F., Robert, B., Gulick, T., Keller, G., Grabielle-Madelmont, C., & Paternostre, M. (2004). Self-association process of a peptide in solution: from β-sheet filaments to large embedded nanotubes. *Biophysical journal*, *86*(4), 2484-2501.

22. Ghadiri, M. R., Granja, J. R., Milligan, R. A., McRee, D. E., & Khazanovich, N. (1993). Self-assembling organic nanotubes based on a cyclic peptide architecture. *Nature*, *366*(6453), 324.

23. Graveland-Bikker, J. F., Ipsen, R., Otte, J., & de Kruif, C. G. (2004). Influence of calcium on the self-assembly of partially hydrolyzed α-lactalbumin. *Langmuir*, *20*(16), 6841-6846.

24. Nakajima, H. (1997). Microemulsions in cosmetics. In: C. Solans and H. Kunieda (eds.), *Industrial Applications of Microemulsions*. Marcel Dekker, Inc., pp. 175–198.