Application of Nanotechnology: Prospects and Challenges

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Introduction

In the 1950's, physicist Richard Feynman, considered "the father of nanotechnology", launched the idea of the power of manipulating molecules and atoms, resulting in components so small they are invisible to the naked eye. However, Nano science is the study of particles on an atomic or molecular scale, whose size is measured in nanometres. A nanometre is a billionth of a meter. Thus, nano technology can be described as a collection of methods and techniques for processing materials at an atomic and molecular scale to create products with special physicochemical properties about conventional products (Antonio *et al.*, 2014).

It is emerging as a rapidly growing field with its wide application in science and technology to manufacture new materials at the nano-scale level, where unique phenomenon enables novel applications. The resulting materials and systems can be designed to exhibit novel and significantly improved optical, chemical, biological and electrical properties such as nano tubes, nano materials, nano wire, etc.

Therefore, it is clear that the new nano-scale products replace the old ones because of their efficient functions. Nanotechnology has the potential to revolutionize agriculture and food systems. The nano-scale level of foods can affect the safety, efficiency, bioavailability and nutritional value properties and the molecular synthesis of new products and ingredients (Aguilera, 2005). The nano-scale food additives are used to influence texture, flavour, provide functionality and even detect pathogens, detect food spoilage and release nano-antimicrobials to extend the shelf life.

Impact of Nanotechnology

Nanotechnology is a fascinating field of science dealing with the manipulation of an atom by atom. Thus, processes and products evolved from Nano science are the most precise ones that are impossible to achieve by the conventional system. Nano technology applications are expected to revolutionize the food sector in the future.

The potential applications include

- Superior processing techniques.
- Improved food contact materials.
- Better quality.
- Shelf-life of food products.
- Novel packaging materials with better mechanical barriers.

By manipulating matter on an atomic, molecular and supramolecular scale, antimicrobial properties can improve the properties of bioactive compounds like delivery properties, solubility and absorption through cells.

Nanotubes are utilized in partial hydrolysis of the milk protein a-lactalbumin by a protease from *Bacillus licheniformis* can be made to self-assemble into similar nanotubes under appropriate environmental conditions.

Nanosensors detect gases, pathogens, or toxins in packaged foods and electrochemical glucose biosensors are nanofabricated by layer-by-layer self-assembly of polyelectrolyte for the detection and quantification of glucose and a risk assessment report has been published about Magic. So, a list of factors potentially affecting human health and ecological risks of nanoparticles. Recently, there is considerable interest in exploring the potential of nanotechnology in encapsulation of bioactive materials such as compounds with poor water solubility, peptide, protein, drugs and large hydrophilic molecules and delivery of biologically active substances, also enhancing the flavor and other sensory characteristics of foods and introduce antibacterial nanostructures into packaging.

Clay nanocomposites are being used to provide an impermeable barrier to gasses such as oxygen or carbon dioxide in lightweight bottles, cartons and packaging biodegradable films. Storage bins are being produced with silver nanoparticles embedded in the plastic. The silver nanoparticles kill bacteria from any material previously stored in the containers, minimizing health risks from harmful bacteria. Nano-coatings and films are currently used on various foods, including fruits, vegetables, meats, chocolate, cheese, candies, bakery products and French fries. Now a day's Nanoemulsions are also used in food industries. And the application of nanotechnology in the food industry focuses specifically on applications that are most likely to be commercialized in the immediate future.

Application of Nano technology in Food Industry

a. **Nano-tubes:** Nano tubes are essentially buckyballs that have been on two sides with other atom groups added in the characteristic hexagon shape to form a hollow carbon tube. In comparison, partial hydrolysis of the milk protein α-lactalbumin by a protease from *Bacillus licheniformis* results in building blocks that self-assemble into nanometer-sized tubular structures at appropriate conditions and increase stability can be controlled. These nano structures promise various applications in food, nanomedicine and nanotechnology. Single walled-carbon nanotube field-effect transistors (SWNT-FETs) functionalized with olfactory receptor-derived peptides (ORPs) which can recognize trimethylamine, so it helps determine the quality of three kinds of seafood (oyster, shrimp and lobster), but were also able to distinguish spoiled seafood from other types of spoiled foods without any pre-treatment processes. And also, Carbon nanotube composites dendrimer can be used as an effective adsorbent for removing dyes from coloured effluents from aqueous solutions in a batch system and avoiding pollutants produced in many industries and have different adverse effects on water resources.

b. **Nano-sensors :** The development of novel sensors and biosensors with interest for the food industry is one of the key fields for recent days nano biotechnology and nano material science. The functionalized nano materials are used as catalytic tools, immobilization platforms, or optical or electroactive labels to improve biosensing performance, exhibiting higher sensitivity, stability and selectivity. Nanomaterials are playing an increasing role in the design of sensing and biosensing systems with interest for applications in food analysis. Nanosensors for detections of gasses in the package, small molecules and pathogens in food. And also, specific detection of sucrose and fructose in several commercial fruit juice samples and the results were compared with those obtained with a commercial spectrophotometric enzymatic kit (Antiochia, 2014).

c. **Nano-composite :** Fish protein isolates FPI/ fish skin gelatin FSG-ZnO nano-composite films, especially those prepared at pH3, exhibited strong antibacterial activity and thus could be used as an active food packaging material (Arfat, 2016). Nanosilicon dioxide particles effectively hydrolyzed olive oil with modified stability, adaptability and reusability. Antimicrobial activity by silver nanoparticles on the above-mentioned microorganisms proposes the possibility of a more cost-effective solution antibacterial agent against dysentery-causing microbes.

d. **Nano-coatings:** Active food coating plays a role of a barrier to the outside environment to protect food products. Whereas gold was coated (Nanolayers of 40-nanometer thickness) on one side of apple, cucumber, lettuce and tomato, by Physical Vapor Deposition (PVD) method, in high vacuum condition at room temperature. The deposition angle of gold nanoparticles were vertical to all species. After coating, we kept them in normal room temperature and it leads to increases in the shelf-life products in average room temperature (Kangarlou and Shirvaliloo, 2012).

e. **Nano-emulsions :** Nano-emulsions are colloidal dispersions that contain small oil droplets ($r<100$ nm) that may be able to overcome many of the challenges of fortifying foods and beverages with omega-3 fatty acids. The composition and fabrication of nano-emulsions can be optimized to increase the chemical and physical stability of oil droplets and increase the bioavailability of omega-3 fatty acids. And also, in food products can facilitate the use of less fat without compromising creaminess, thus offering the consumer a healthier option. Products of this type include low-fat nanostructured mayonnaise, spreads and ice creams.

Challenges

The nanoparticles are more reactive, more mobile and likely to be more toxic. Toxicity is the most important issue that must be addressed before the commercial exploitation of nano particles. Whereas to determine the effects of these materials on the normal micro flora of the alimentary canal of the consumers. Currently, no regulations exist for specific control or limit for nano-sized particles production. Particle size, mass, chemical composition, surface properties, and aggregation of individual particles are the properties of nano materials that determine the impact on the body.

Conclusion

Nano materials used as food additives or food packaging materials must not cause any health risks for consumers or to the environment. Further, research studies are required to investigate the hazards of nano materials, taking the size as the main factor even though some of the chemical materials in the form of large particles are safer than when they are in the nano state. Hence, commercial application of nanotechnology-derived products can be made only after the safety issues are resolved. There is also an immediate need for regulation of nano materials before their incorporation into food and dairy processing, including packaging. In addition, nanotechnology-derived products need to demonstrate their economic competitiveness before commercialization. Until now, information related to the economic competitiveness of nano technology-derived products is almost lacking.

References

- Aguilera, J. M. (2005). Why food microstructure? J. *Food Eng*., 67(1–2): 3–11.
- Antiochia, R., Gorton, L. and Mannina, L. (2014). Rapid determination of sucrose in fruit juices: a new sensitive carbon nanotube paste osmiumpolymer mediated biosensor. *Journal of Food Research*, 3(4): 101-112.
- Antonio, J. R., Antonio, C. R., Cardeal, I. L. S, Ballavenuto, J. M. A. and Oliveira, J. R. (2014). Nanotechnology in dermatology. *Anais Brasileiros De Dermatologia*, 89(1): 126-136.
- Arfat, Y. A., Benjakul, S., Prodpran, T., Sumpavapol, P. and Songtipya, P. (2016). Physico-mechanical characterization and antimicrobial properties of fish protein isolate/fish skin gelatin-zinc oxide (ZnO) nanocomposite films. *Food and Bioprocess Technology*, 9(1): 101-112.
- Kangarlou, H. and Shirvaliloo, S. (2012). Protection effect of gold nanoparticles coated on fruit and vegetables using PVD method. *Journal of Applied Sciences*, 12(17): 1782-1791.

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