International Journal of Food Science and Nutrition
ISSN: 2455-4898; Impact Factor: RJIF 5.14
Received: 10-02-2019; Accepted: 12-03-2019
www.foodsciencejournal.com
Volume 4; Issue 3; May 2019; Page No. 46-51

A review on Nano-Technology and its application in food industry

Souvik Tewari[1*], Dnyaneshwar Babasaheb Shinde[2], Chandra Shekhar Mourya[3], Swati Shukla[4]
[1] Ph.D. Scholar in Food Science and Technology, Department of Warner College of Dairy Technology, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Allahabad, Uttar Pradesh, India
[2, 4] Ph.D. Scholar in Food Science and Technology, (SHUATS University), Allahabad, Uttar Pradesh, India
[3] Ph.D. Scholar in Dairy Technology, (SHUATS University), Allahabad, Uttar Pradesh, India

Abstract
Nanotechnology and nano science are new frontiers of this century and Food nanotechnology is an area of emerging interest and opens up a whole universe of new possibilities for the food industry. In food engineering, two major applications related to nanotechnology (i.e) food Nano sensing and food nano structured ingredients are being expected. In the former field, better food quality and safety evaluation can be achieved by using nanotechnology. Food packages embedded with nanoparticles can alert the consumer about the safety of product. It can release preservatives to extend shelf life of food in package. Currently, food packaging and monitoring are a major focus of food industry related nanotechnology research. It is hoped that nanotechnology has a great potential in food industries as it may be used to manufacture about 25% of all food packaging in near future. It remains unclear whether nanoparticles used in food packaging may migrate or leach into the food. The potential impact of nanoparticles on consumer's health should be well studied. Emphasis is given to assess the safety of ingredients in nanoparticles before their use in food products including packaging. Recently "Nanotechnology", is essentially a modern scientific field that is constantly evolving as a broad area of research, with respect to dairy and food processing, preservation, packaging and development of functional foods. Food and dairy manufacturers, agricultural producers and consumers could gain a more competitive position through nanotechnology.

Keywords: nanotechnology, nanoparticles, nano packaging, nano product, food safety and human health

1. Introduction

1.1 Nano-technology

Nanotechnology is a modern science, engineering, technology conducted at the nanoscale, which is about 1-100 nm.

In food technology which can increase the shelf life of foods, minimize the spoilage, ensure the food safety, repair the tears in packaging, reduce the problem of food shortage, and finally improve the health of the people.

Nano science and nanotechnology are new frontiers of this century and food nanotechnology is an emerging technology.

Food nanotechnology is an area of emerging interest and opens up a whole universe of new possibilities for the food industry. In food engineering, two major applications related to nanotechnology (i.e) food Nano sensing and food nano structured ingredients are being expected. In the former field, better food quality and safety evaluation can be achieved by using nanotechnology.

Recently "Nanotechnology", is essentially a modern scientific field that is constantly evolving as a broad area of research, with respect to dairy and food processing, preservation, packaging and development of functional foods. Food and dairy manufacturers, agricultural producers and consumers could gain a more competitive position through nanotechnology.

Nano food packaging materials may extend food life, improve food safety, alert consumers that food is contaminated or spoiled, repair tears in packaging, and even release preservatives to extend the life of the food in the package.

Nanotechnology applications in the food industry can be utilized to detect bacteria in packaging, or produce stronger flavors and color quality, and safety by increasing the barrier properties. Meanwhile, food nanotechnology as a new technology is requiring reviews of potentially adverse effects as well as many positive effects. In this review, we intended to cover some of the recent developments in nanotechnology and their applicability to food processing and packaging.

Food packages embedded with nano particles can alert the consumer about the safety of product. It can release preservatives to extend shelf life of food in package. Currently, food packaging and monitoring are a major focus of food industry related nanotechnology research. It is hoped that nanotechnology has a great potential in food industries as it may be used to manufacture about 25% of all food packaging in near future. It remains unclear whether nano-particles used in food packaging may migrate or leach into the food. The potential impact of nano-particles on consumer's health is well studied. Emphasis is given to assess the safety of ingredients in nano-particles before their use in food products including packaging.

1.2 History of nano-technology

He term 'nano' is derived from the Greek word for dwarf. The term "Nanotechnology" was first used in 1974 by the late Norio Taniguchi and concepts were given by Richard Feynman in 19592.

A nanometer is a thousandth of a thousandth of a thousandth of a meter (10-9 m). One nanometer is about 60,000 times smaller than a human hair in diameter or the size of a virus, a typical sheet of paper is about 100,000 nm thick, a red blood cell is about 2,000 to 5,000 nm in size, and the diameter of DNA is in the range of 2.5 nm.

Richard Feynman
(1918-1988)

1.3 Nano-Food

The definition of Nanofood is that nanotechnology techniques or tools are used during cultivation, production, processing, or packaging of the food.

Fig 1

Fig 2

1.3.1 Future of Nano foods

At this point in time the term nano food does not refer to foods produced directly using nanotechnology techniques. The future could bring dramatic changes in this area. Nano-machines might be able to produce foods molecule by molecule but this is many years away. Future developments in the short term could include packaging that reflects heat to keep ice cream frozen in a hot car, self healing packaging that repairs itself when perforated and packaging that can change it's properties under certain conditions e.g. a milk carton that changes colour if the milk has spoiled. A scientist with Kraft foods, Manuel Marquez-Sanchez, has outlined plans for a nanotechnology enabled drink, "The idea is that everyone buys the same drink, but you'll be able to decide its colour, flavour, concentration and texture".

1.4 Nanotechnology in the Food Industry

The benefits of nanotechnology for the food industry are many and are expected to grow with time. This new, rapidly developing technology impacts every aspect of the food system from cultivation to food production to processing, packaging, transportation, shelf life and bioavailability of nutrients. Commercial applications of nano-materials will continue to impact the food industry because of their unique and novel properties. Human exposure to nano-materials, as a result, is increasing and will continue to increase with time. Therefore, the health impact of nano-materials in food is of public interest and concern. Public acceptance of food and food-related products containing nano-materials will depend on their safety. Consequently, a uniform international regulatory framework for nanotechnology in food is necessary,

A. Food Packaging
B. Food Safety
C. Food Processing
D. Food Preservation
E. Food Distribution

A. Application of Nanotechnology in Food Packaging

Nanotechnology is the science of very small materials that has a big impact in food industry including packaging. A variety of nano-materials such as silver nano-particle, titanium nitride nano-particle, and nano-titanium dioxide, nano-zince oxide, and nano clay are introduced as functional additives to food packaging

A desirable packaging material must have gas and moisture permeability combined with strength and biodegradability. Nano-based "smart" and "active" food packaging's confer several advantages over conventional packaging methods from providing better packaging material with improved mechanical strength, barrier properties, antimicrobial films to nano sensing for pathogen detection and alerting consumers to the safety status of food.

The application of nano-particles is not limited to antimicrobial food packaging but nano composite and nano laminates have been actively used in food packaging to provide a barrier from extreme thermal and mechanical shock extending food shelf-life. In this way, the incorporation of nano-particles into packaging materials offers quality food with longer shelf-life. The purpose of creating polymer composites is to have more mechanical and the rmostable packing materials. Many inorganic or organic fillers are being used in order to achieve improved polymer composites. The incorporation of nano-particles in polymers has allowed developing more resist packaging material with cost effectiveness (Sorrentino et al., 2007). Use of inert nano scale fillers such as clay and silicate nano platelets, silica (SiO2) nano-particles, chitin or chitosan into the polymer matrix renders it lighter, stronger, fire resistance, and better thermal properties. Antimicrobial nano composite films which are prepared by impregnating the fillers (having at least one dimension in the nanometric range or nano-particles) into the polymers offer two-way benefit because of their structural integrity and barrier properties.

Types of food packaging

- Polymer Nano composites packaging
- Active packaging
- Intelligent/smart packaging
- Biodegradable and Edible packaging
- Nano Coatings

i) Polymer nano composites (PNCS)

Polymers used in packaging:

- Poly olefins
  - Polypropylene (PP)
  - Polyethylene (HDPE, LDPE)
- Poly ethylene terephthalate (PET)
- Polystyrene (PS)
- Polyvinyl chloride (PVC)

Functions

- Provides barrier against gas
- Provides excellent mechanical properties
- Thermal stability
- Flammability reduction
- Lighter in weight

ii) Active packaging

The use of nanomaterials is helpful to interact directly with food or environment to allow better protection of the product. Several nanomaterils like Nano copper oxide, Nano silver, Nano titanium dioxide, Nano magnesium oxide and carbon nanotubes can provide antimicrobial properties. Presently, the use of silver nanoparticles as antibacterial agents in food packaging is increasing.

Fig 3

Functions

- Oxygen scavenging
- Ethylene removal
- Ethanol release
- Temperature regulator
- Antimicrobial
- Nanocomposites

iii) Intelligent/smart packaging

It is designed for sensing biochemical or microbial changes in the food. It can detect specific pathogen developing in the food or specific gases from food spoiling. Some smart packaging has been developed to use as tracing device for food safety. Currently, Nestle, British Airways and Mono Prix Super market are using chemical sensors, which can easily detect color change.

- Improved packaging: Nanoparticles are mixed with polymer chain to improve the gas barrier properties, as well as, temperature, humidity resistance of packaging. The use of nanocomposite in contact with food is approved by United States Food and Drug Administration.

iv) Biodegradable plastics are polymers, which can be divided into three categories according to source.

- Polymers, which are directly extracted or removed from biomass include polysaccharides, proteins, polypeptides, polynucleotide.
- Polymers such as biopolyester, polyacetic acid are produced by classical chemical synthesis using renewable bio based monomers or mixed source of biomass and petroleum.
- Polymers are produced my microbes or genetically modified bacteria. The examples are bacterial cellulose, curdian, xanthan, pullan and poly hydro butyrate.

v) Nano coating

Incorporating Nano materials onto the packaging surface (either the inside or the outside surface, or as a layer in a laminate) to improve especially the barrier properties.

Fig 4: Nano-Silica coated high oxygen Barrier Nylon (OPA) Films for food packaging

B. Nanotechnology and Food Safety

Food safety is a growing public health concern of global significance. Foodborne microbial diseases account for about 20 million cases annually in the world. The primary objective of food safety is to assure that food will not cause any harm to the consumer when it is prepared and/eaten. It is important that all foods must be protected from physical, chemical, and biological contamination through processing, handling and distribution. Nanotechnology has brought revolution in food industry as it has several application in all areas of food science, from agriculture to food processing to security to packaging to nutrition and neutraceuticals Wesley *et al*. It extends the shelf life, enhances food safety and reduces packaging waste. It keeps the food fresh and flavor is maintained. The additional information on the impact of nanotechnology on the food safety can be gathered from the articles of. Application of nanotechnology in organic food products requires precaution, as little is known about their impact on human and environmental health.

C. In Food Processing

Nanotechnology is already making an impact in processed foods. Nanoparticles and nanocapsules are being added to various foodstuffs to increase shelf life, alter properties, enhance nutritional values and change taste. Tuna oil (a source of omega 3 fatty acids) in nanocapsules is being added to some types of bread. The capsules break and release the oil in the stomach so there is no unpleasant taste. In other areas nanotechnology enhanced emulsifiers are being developed to give low fat ice creams the flavour and texture of full fat ice creams.

1. Able to deliver the active compound precisely at the target place
2. Ensure availability at a target time and specific rate, and
3. Efficient to maintain active compounds at suitable levels for long periods of time (in storage condition).

Nanotechnology being applied in the formation of encapsulation, emulsions, biopolymer matrices, simple solutions, and association colloids offers efficient delivery systems with all the above-mentioned qualities. Nano polymers are trying to replace conventional materials in food packaging. Nano sensors can be used to prove the presence of contaminants, mycotoxins, and microorganisms in food.

Nanoparticles have better properties for encapsulation and release efficiency than traditional encapsulation systems. Nanoencapsulations mask odors or tastes, control interactions of active ingredients with the food matrix, control the release of the active agents, ensure availability at a target time and specific rate, and protect them from moisture, heat chemical, or biological degradation during processing, storage, and utilization, and also exhibit compatibility with other compounds in the system Moreover, these delivery systems possess the ability to penetrate deeply into tissues due to their smaller size and thus allow efficient delivery of active compounds to target sites in the body. Various synthetic and natural polymer-based encapsulating delivery systems have been elaborated for the improved bioavailability and preservation of the active food components.

The importance of nanotechnology in food processing can be evaluated by considering its role in the improvement of food products.

i) Food texture, taste, and appearance of food

Different types of nano-technological process are used to improve food texture, taste and improve the appearance of the food.

ii) Nutritional value

A majority of bioactive compounds such as lipids, proteins, carbohydrates, and vitamins are sensitive to high acidic environment and enzyme activity of the stomach and duodenum. Encapsulation of these bioactive compounds not only enables them to resist such adverse conditions but also allows them to assimilate readily in food products, which is quite hard to achieve in non-capsulated form due to low water-solubility of these bioactive compounds. Nanoparticles-based tiny edible capsules with the aim to improve delivery of medicines, vitamins or fragile micronutrients in the daily foods are being created to provide significant health benefits. The nanocomposite, nano-emulsification, and nanostructuration are the different techniques which have been applied to encapsulate the substances in miniature forms to more effectively deliver nutrients like protein and antioxidants for precisely targeted nutritional and health benefits. Polymeric nanoparticles are found to be suitable for the encapsulation of bioactive compounds (e.g., flavonoids and vitamins) to protect and transport bioactive compounds to target functions.

iii) Preservation or Shelf-Life

In functional foods where bioactive component often gets degraded and eventually led to inactivation due to the hostile environment, nanoencapsulation of these bioactive components extends the shelf-life of food products by slowing down the degradation processes or prevents degradation until the product is delivered at the target site. Moreover, the edible nano-coatings on various food materials could provide a barrier to moisture and gas exchange and deliver colors, flavors, antioxidants, enzymes, and anti-browning agents and could also increase the shelf-life of manufactured foods, even after the packaging is opened. Encapsulating functional components within the droplets often enables a slowdown of chemical degradation processes by engineering the properties of the interfacial layer surrounding them. For example, curcumin the most active and least stable bioactive component of turmeric (Curcuma longa) showed reduced antioxidant activity and found to be stable to pasteurization and at different ionic strength upon encapsulation.

- **Nanocapsules**

Nanocapsule is used to improve bioavailability of neutraceuticals in standard ingredients such as cooking oil.

Nanocapsules infusion of plant based steroid to replace a meat's chpolesterol.

Fig 6

It used as a flavor and aroma enhancers. The use of flavoring compounds such as essential oils (EOs) extracted from leaves, fruits, and seeds and preserved through emerging technologies of nanoencapsulation is an attractive investment that can bring major innovations in food industry. Nanoencapsulation involves a set of techniques that allow the formation of particles/emulsions with functional properties, consisting of an encapsulating matrix (carbohydrate, protein, lipid, and others) and an active material (essential oil) distributed within these systems. Nanoencapsulation provides protection to the compounds that make up EOs (triglycerides, hydrocarbons, phenols, ether, and others) against adverse conditions that can promote their volatilization and oxidation. This chapter aims to discuss the application of emerging technologies based on supercritical fluids and ultrasonication to form nanoparticles/nanoemulsions of EOs with application as flavor and aroma agents in food products, besides adding value to these products and promoting innovation in food industry through the provision of flavorings considered safe when obtained using clean technologies.

- **Nanotubes and nano particles**

It is used as a gelatin and viscosifying agents. Nanoparticles selectivity to bind and remove chemicals and pathogen from food.

- **Nanoemulsion and particles**

Used for better availability and dispersion of nutrients.

D. Nanotechnology in food preservation

Nanoscience emerges from the understanding of physical and chemical processes at the molecular or atomic level. The NANOFOODS initiative focused on translating such knowledge into food preservation.

A series of prototypes of micro-encapsulated compounds were developed using different combinations of core and capsule materials. Omega-3, encapsulated in starch complexes and integrated in a food product, should survive storage until the time of consumption.

Overall, the NANOFOODS project successfully exemplified the improvement in the processing stability of bioactive ingredients including silymarins and polyunsaturated fatty acids (PUFAs) through nano-encapsulation. The NANOFOODS approach could satisfy the requirements for food products with enhanced nutritional value, quality and safety.

1.5 As a Supplement

15.1 Calcium citrate

Calcium citrate nano-fortified milk powder increased absorption and bioavailability of calcium, as well as bone stiffness and bone strength in sham, ovariectomized, and ovariectomized-osteoporosis rats.

1.5.2 Selenium nanoparticles (SeNPs)

- Nanoencapsulation
- Selenium is an essential trace element in the diet.
- Selenium nanoparticles (SeNPs) represent a novel prospect of nutrition supplement.
- SeNPs also demonstrate anticancer and antimicrobial properties.

Selenium is an essential trace element in the diet, required for maintenance of health and growth; however, its toxicity could cause serious damage depending on dose and chemical form. Selenium nanoparticles (SeNPs) represent what we believe to be a novel prospect for nutritional supplementation because of their lower toxicity and ability to gradually release selenium after ingestion. In this review, we discuss various forms and types of SeNPs, as well as the way they are synthesized. We also discuss absorption and bioavailability of nanoparticles within the organism. SeNPs demonstrate anticancer and antimicrobial properties that may contribute to human health, not only as dietary supplements, but also as therapeutic agents

1.5.3 Pharmaceutical industry

People take vitamins for many different reasons but most often to compensate for compounds whose daily dose they typically cannot meet. While these supplements are supposed to provide the vitamins and nutrients people need, a number of studies have found that some of them can be futile or even harmful. Anti-supplement proponents argue that the content of the pills often cannot be absorbed by the body and used for its desired purpose. In the end the compound of interest (in the pill) is filtered through the renal system and ends up in urine.

1.6 Uses of nano technology in food

Nanoparticles may be able to detect bacteria, extend food shelf life, add health benefits, or improve flavor, reports Discovery.

While nanotechnology does not involve any genetic manipulation, many companies are keeping secret about their work their doing. While this can keep competitors off their trail, it can also make it difficult for regulatory agencies to manage risks and create laws for these emerging technologies.

- Nonetheless, nanotechnology offers some exciting potential benefits for the quality and safety of our foods.
  - Contamination sensor: Flash a light to reveal the presence of E. coli bacteria.
  - Antimicrobial packaging: Edible food films made with cinnamon or oregano oil, or nano particles of zinc, calcium other materials that kill bacteria.
  - Improved food storage: Nano-enhanced barrier keeps oxygen-sensitive foods fresher.
  - Green packaging: Nano-fibers made from lobster shells or organic corn are both antimicrobial and biodegradable.
  - Pesticide reduction: A cloth saturated with nano fibers slowly releases pesticides, eliminating need for additional spraying and reducing chemical leakage into the water supply.
  - Tracking, tracing; brand protection: Nano barcodes can be created to tag individual products and trace outbreaks.
  - Texture: Food spreadability and stability improve with nano-sized crystals and lipids for better low-fat foods.
  - Flavor: Trick the tongue with bitter blockers or sweet and salty enhancers.
  - Bacteria identification and elimination: Nano carbohydrate particles bind with bacteria so they can be detected and eliminated.

1.7 Advantages of nanotechnology

- Increases the shelf life of the food.
- Enhance the nutritional values and change the taste.
- Help in detection of food borne pathogens in the food.
- Acts as anti microbial agent.
- Polymer Nanocomposites offer high gas barriers, strength and flame retardancy.
- Nano sensor detec the gasses, small molecules and microorganism.
- Is also used in the making of nano food, helps during cultivation, processing, production, and packaging.

1.8 Disadvantages

The nanoparticles used can also cause a number of harmful health effects.

Eliminating the natural process of growing food and replacing it with food processed by nano robots is certainly how our natural system works. There is a natural intelligent process that works within the body, several complicated cells, and organs run according to this system. Consumption of excessive nutrient will leave toxic effects on your body

and create imbalance in functioning of body in future.

2. Conclusion

Nanotechnology has the potential to improve foods, making them tastier, healthier, and more nutritious, to generate new food products, new food packaging, and storage. However, many of the applications are currently at an elementary stage. Nanotechnology can be used to enhance food flavor and texture, to reduce fat content, or to encapsulate nutrients, such as vitamins, to ensure they do not degrade during a product's shelf life.

3. References

1. Brody AL. Case studies on nanotechnologies for food packaging. Journal of Food Technology. 2007; 7:52-54.
2. Chandra R, Rustgi R. Biodegradable polymers. Progress in Polymer Science. 1998; 23:1273-13335.
3. Chaudhry Q, Scotter M, Blacknurn J, Ross B, Boxall A. Applications and implications of nanotechnologies for the food sector. Food Additives Control. 2008; 25:241-258.
4. Dingman J. Nanotechnology: its impact on food safety. Journal of Environmental health. 2008; 70:47-50.
5. Neethirajan S, Jayas DS. Nanotechnology for the food and bioprocessing industries. Journal of Food Bioprocessing Technology. 2011; 4:39-47.
6. Pal M, Mahendra R. Sanitation in Food Establishments. LAMBERT Academic Publishers, Saarbruchen, Germany, 2015.
7. Pehanich M. Small gains in processing and packaging. Food Process. 2006; 11:46-48.
8. Sekhon BS. Food nanotechnology- an overview. Nanotechnology Science and Applications. 2010; 3:1-15.
9. Vermeiren L, Devlieghere F, Van Beest M, de Kruiff N, Debevere J. Developments in the active packaging of foods.. Trends in Food Science and Technology. 1999; 10:77-86.
10. Wesley SJ, Raja P, Sunder Raj AA, Tiroutchelvamae D. Review on- Nanotechnology applications in food packaging and safety. International Journal of Engineering Research. 2014; 3:645-651.