Role of Nanotechnology in Crop Improvement

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Abstract

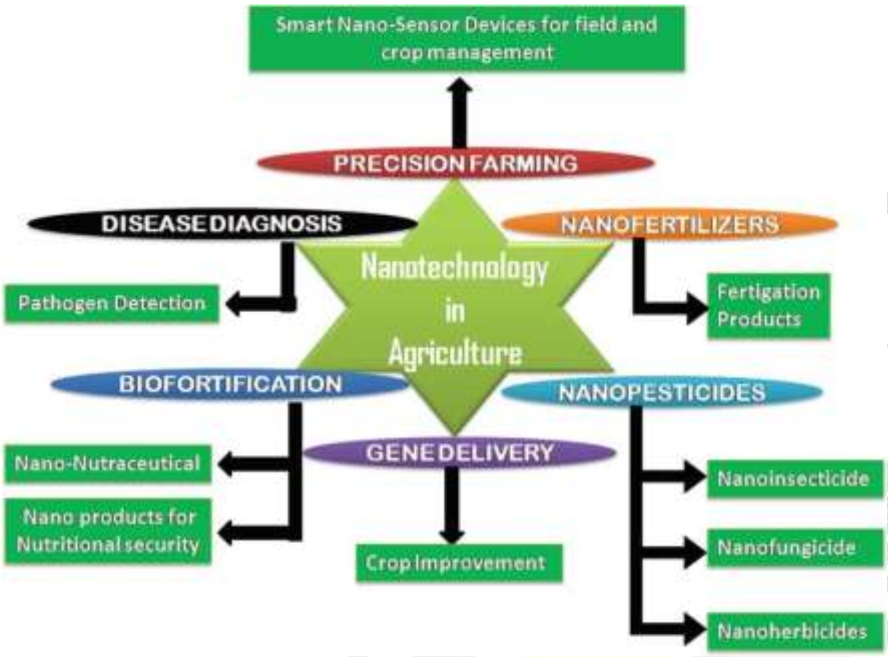
Despite the fact that nanotechnology is a revolutionary approach for addressing various problems in a variety of fields in this century. Nanotechnology keeps track of one of the most important agricultural control processes, due to its small size. Furthermore, several possible improvement, such as improved food quality and protection, reduced agricultural inputs, enhanced absorption of nanoscale nutrients from the soil, etc., are made.In agriculture, the aim of nanomaterials is to decrease the volume of chemicals distributed. Nutrient losses in fertilization are reduced, and insect and nutrient control increase production.By designing novel nanotools for disease control, nutrient absorption capability, and other applications, nanotechnology has the potential to transform the agriculture and food industries. Relevant applications such as nanofertilizers and nanopesticides to monitor goods and nutrients levels to increase production are among the main interests of using nanotechnology in agriculture by improving productivity and providing protection against pests and diseases Nanotechnology may be used as sensors to track the soil condition in agricultural fields, ensuring the health of the plants.

Key words: Nanotechnology, Improvement, Nanofertilizers, Nanopesticides

INTRODUCTION

Nanotechnology is a noble technological technique that involves the use of nanoparticles.
Nanotechnology involves manupulating of substances at molecular level. (Veronica.et.al.,2015). Nanotechnology is the modification of matter on a nanoscale (1/109 meter) from which a prominent substance can be used.Agriculture not only boosts production, but it also boosts profits even makes food that is healthy to eat. Nanomaterials in agriculture are designed to minimize the amount of chemicals used in agriculture as well as nutrient losses during fertilization. Pest and fertilizer treatment resulted in a higher yield. Several Potential advantages include improved product consistency and reduced food waste, a decline in agricultural inputs, and an enrichment of absaorbing nanoscale nutrients from the soil,forexample(Prasaram,et.al.,)

Agriculture growth is a necessary phenomenon for eradicating poverty and hunger, which must be eradicated from the current situation. As a result, we should take one brave move forward in agriculture production. In this country, the majority of people live in poverty, and they are concentrated in rural areas where agricultural expansion has been ineffective. Without a doubt, modern and groundbreaking approaches such as nanotechnology are critical to agriculture's long-term success.The nanoprocess is now in full swing, according to Feynman's 1959 lecture "Plenty of Space at the Bottom" (Feynman, 1996). The term
"nanotechnology" was first coined by Professor Norio Tanaguchi in 1974. (Bulovic et al., 2004). Later, nanotechnology progresses in a more vibrant manner, as new tools are developed to accurately consider or separate nanomaterials (Bonnell and Huey, 2001; Gibney, 2015). Nanotechnology is regarded as the sixth most innovative technology of the industrial period, with multidisciplinary implementations (Knell, 2010). Among the previous innovations, the Green Revolution of the 1960s and, more recently, nanotechnology have had a significant impact on the agricultural sector (NAAS, 2013).



Increased reliance on artificial pesticides and fertilizers before and after the Green Movement has resulted in significant concerns about biodiversity, environmental effects, and health risks. As a result, a groundbreaking solution was developed to ensure biosafety by using environmentally sustainable biofertilizers/biopesticides as an alternative to agrochemicals (Mishra et al., 2015).Surprisingly, nanoparticle-based formulations also outperformed bioformulations in addressing both of these problems (Navrotsky, 2000; Auffan et al., 2009). As a result, contemporary agriculture is adopting nanotechnology's revolutionary approach to combat global problems such as crop production, food security, biodiversity, and climate change (Nair et al., 2010; Ghormade et al., 2011; Mishra et al., 2014a). In addition to agriculture, nanotechnological applications have shown their utility in all fields of food science, including food manufacturing, food protection by better packaging, food nutrition, and high-quality food materials (Amenta et al., 2015; Handford et al., 2015).

The future benefits of nanotechnology in the agricultural sector have piqued interest, as it has the potential to boost agricultural production while requiring minimal cost and energy input. Importantly, nanotechnology has tremendous potential applications in the agriculture industry, including nanofertilizers, nanopesticides, nanoherbicides, nanosensors, and smart distribution systems for controlled release of agrochemicals (Salamanca-Buentello et al., 2005; campos et al., 2014; Oliveira et al., 2014; Grillo et al., 2016).

Plant breeding and genetic engineering was now carried out using nanotechnology-based instruments (Jiang et al., 2013).Several reports have looked at how nanotechnology is helping the agriculture industry in a variety of ways. For example,Pesticides encapsulated in nanoparticles for long-term release; nanoparticles controlled distribution of genetic material for crop improvement; carbon nanotube aided seed germination of rain-fed crops; nanofertilizer for improved crop nutrition and crop protection. Nanopesticides for plant disease prevention, nanoherbicides for weed control, and nanosensors for pathogen identification and forecasting, as well as soil surveillance (Li et al., 2007; Wilson et al., 2008; Barik et al., 2008;Nair et al., 2010;Gan et al., 2010; Ghormade et al., 2011; Grillo et al., 2014; Mishra, 2015).

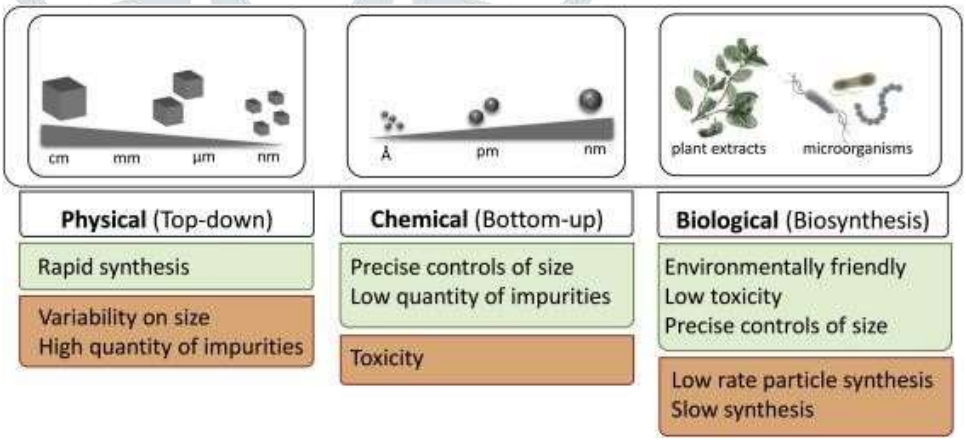
Aside from these, a new trend is the potential effect of nanomaterials exposure on the fate and aggregation of other organic and inorganic co-contaminants (added to agricultural systems such as chemicals, fertilizers, heavy metals, and so on) (Servin and White, 2016). According to a previous study by De La Torre-Roche et al. (2013), pesticide absorption by plants is decreased as a result of their interaction with carbon nanomaterials. This result suggests that such associations have a positive effect on lowering pesticide residues in plants and edible bits.

Biosensor research is a strong area for using all of nanotechnology's capabilities, so nanotechnology is present and plays an important part. On the one hand, nanomaterials' unique properties could dramatically improve the sensitivity and performance of biosensors in their applications ; on the other hand, nanomaterials' unique properties could significantly improve the sensitivity and performance of biosensors in their applications. Nanomaterials have also allowed the miniaturization of many (bio)sensors into lightweight, compact/smart devices such as nanosensors and other nanosystems that are critical in biochemical analysis (Viswanathan and Radecki, 2008; Fraceto et al., 2016).It also aids in the detection of mycotoxins found in a variety of foods, and their functions are very fast (Sertova, 2015).

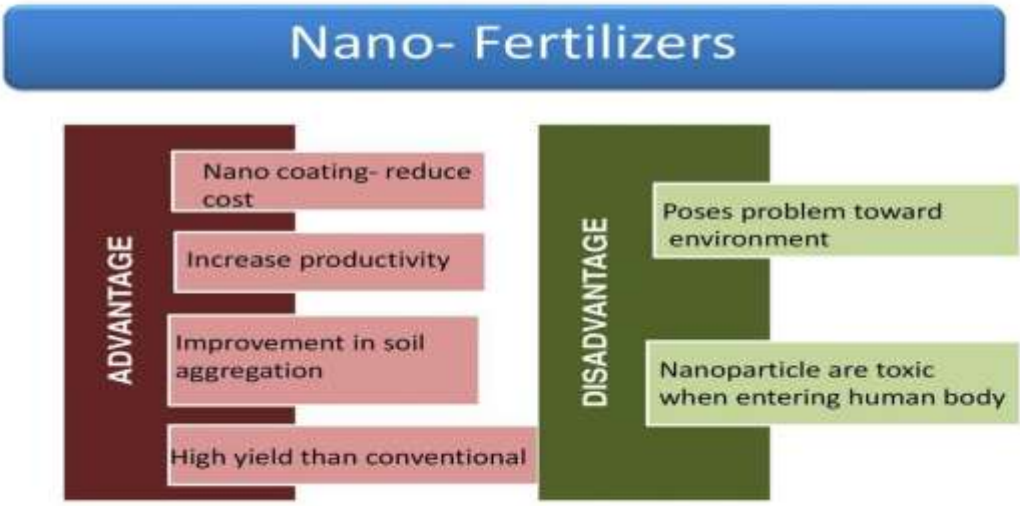
Nano Fertilizers:

Nano-fertilizers play a critical role in increasing crop yields across a wide range of crops. Conventional fertilizers have a nutrient utilization efficiency of just 30–35 percent.For N, P, and K, the percentages are 18–20 percent, 35–40 percent, and 18–20 percent, respectively.For many decades, it has been unchanged.Nanofertilizers are known to release nutrients slowly and gradually over a period of more than 30 days, which can help to improve nutrient usage quality without causing any negative side effects. Since then,The nano-fertilizers are made to release slowly over a long period of time.The degradation of nutrients is significantly decreased over time.in terms of environmental protection. (Subramanian Ks, et.al.)Improper use of phosphorus and nitrogen in the form of fertilizers has resulted in several instances of leaching and eutrophication. The Royal Society claims that"Nanotechnologies are the architecture, classification, and processing of nanoscale objects."through constructing, deploying, and deploying infrastructure, equipment, and systems at the nanometer scale, you can manipulate form and size" (Chinnamuthu CR,et.al.).

Nano-fertilizers are designed to increase nutrient usage efficiency by using nanoparticles' special properties. The nano-fertilizers are made in a lab.putting nutrients on the skin one by one or in groups nano-dimensioned adsorbents.Nanomaterials are made using both physical (top-down) and chemical (bottom-up) methods, and the targeted nutrients are filled like they are for food.nutrients that are cationic (NH4), +K, Ca2+, and Mg2+) before and after the surface.(Chinnamuthu CR,et.al.).



One of these recent facilities is the encapsulation of fertilizers inside nanoparticles, which can be achieved in three different forms. a) The nutrient may be encapsulated inside nanoporous materials; b) distributed as particles or covered with a thin polymer film C)nano-scale emulsions(Rai V,et.al). Nanofertilizers have been widely available in the industry in recent years, but large chemical industries have yet to mold agricultural fertilizers.NInP/ZnS core shell QDs, anozinc, silica, lead, and titanium dioxide are examples of nanofertilizers, as are ZnCdSe/ZnS core shell QDs, Mn/ZnSe QDs, gold nanorods and core shell QDs, amongothers.



Many metal oxide NPs, such as FeO, Al2O3, CeO2,TiO2and ZnONPs, have been studied extensively for agricultural processing over the last decade, including their absorption, biological fate, and toxicity (Dimkpa, 2014; Zhang et al., 2016).

In the alkaline condition of soils, zinc deficiency has been documented as sone of the key problems restricting agricultural productivity (Sadeghzadeh, 2013).

Name of Nanofertilizer	Contents	Manufacturing Company
Nano Ultra-Fertilizer (500) g	organic matter, 5.5%; Nitrogen, 10%; P2O5, 9%; K2O,14%; P2O5, 8%; K2O, 14%; MgO, 3%	SMTET Eco-technologies Co., Ltd., Taiwan
Nano Calcium (Magic Green) (1) kg	CaCO3, 77.9%;Na, 0.03%; K, 0.2%; ; P, 0.02%;MgCO3, 7.4%; Fe-7.4 ppm; SiO2, 7.47%; Al2O3, 6.3 ppm; Mn,172 ppm; Sr,804 ppm; sulfate, 278 ppm; Zn, 10 ppm; Ba, 174 ppm	AC International Network Co., Ltd., Germany
Nano Micro Nutrient (EcoStar) (500) g	Zn, 6%; B, 2%; Cu, 1%; Fe, 6%+; EDTA Mo, 0.05%; Mn, 5%+; AMINOS, 5%	Shan Maw Myae Trading Co., Ltd., India
PPC Nano (120) mL	M protein, 19.6%; Na2O, 0.3%; K2O, 2.1%; (NH4)2SO4, 1.7%; diluent, 76%	WAI International Development Co., Ltd., Malaysia

Nano Max NPK Fertilizer	Amino acids, organic carbon, organic micronutrients/trace elements, vitamins, and probiotics are all chelated with several organic acids.	JU Agri Sciences Pvt. Ltd., Janakpuri, New Delhi, India
TAG NANO (NPK, PhoS,cal,Zinc,etc.) fertilizers	Proteino-lacto-gluconate chelates micronutrients, vitamins, probiotics, seaweed extracts, and humic acid. and p alm	Tropical Agrosystem India (P) Ltd., India
Nano Green	Corn, grain, soybean, potato, and coconut extracts	Nano Green Sciences, Inc., India
Biozar Nano-Fertilizer	Combination of organic materials, micronutrients,and	Fanavar Nano-Pazhoohesh Markazi
	macromolecules	Company, Iran
Nano Capsules	N, 0.5%; P2O5, 0.7%; K2O, 3.9%; Mg, 0.2%;Ca, 2.0%;Mn, 0.004%; S, 0.8%; Fe, 2.0%;Cu, 0.007%; Zn, 0.004%	The Best International Network Co., Ltd., Thailand
Nano-GroTM	immune booster and Plant growth regulator	Agro Nanotechnology Corp., FL, United States

Biosensors

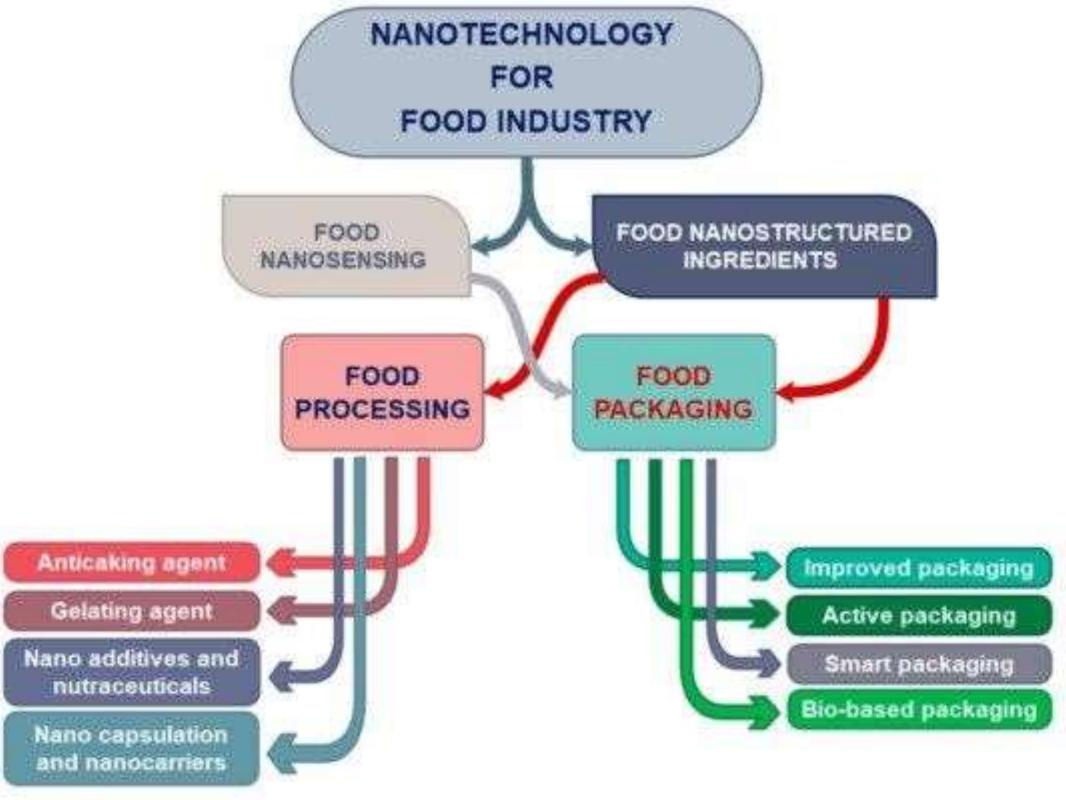
Sensors have been developed as methods and techniques for fabricating, measuring, and imaging nanoscale structures have improved. the metal NPs (gold, silver, cobalt, etc.) and other nanomaterials CNT, magnetic NPs, CNT,and QDs have also been extensively studied for use in biosensors, which has been an interdisciplinary convergence between biological recognition and material science.As a result, a biosensor is a system that incorporates a biological recognition feature as well as physical or chemical concepts. It incorporates biological and electronic components in order to produce a detectable signal component, and The transducer mechanism is used to identify biological signals. Signal transmission is achieved by electronic means.

Many of the benefits of nanoscale materials' physical–chemical properties can be used in the construction of biosensors. According to Sagadevan and Periasamy (2014),that biosensor sensitivity and efficiency can be improved by the use of nanomaterials in the form of new signals transmission technologies.The enormous progress in

Nanobiosensors are a high-tech product in critical areas of human activity such as health care, agriculture, gene testing, food and beverage, process industries, environmental management, safety, and defense for rapid, sensitive, and cost-effective nanobiosensor systems.Nanotechnology-based biosensors are still in the early stages of growth (Fogel and Limson, 2016).The AuNP-based micro cantilever-based DNA biosensor has been developed and commonly used to detect low levels of DNA concentration during a hybridization reaction (Brolo, 2012).Enzymes, dendrimers, thin films, and other natural and artificial bioreceptors have recently been developed and implemented. As a result, a biological reaction is converted into an electrical signal by a biosensor, an analytical instrument. It is associated with biological components such as antibodies, enzymes, proteins, and nucleic acids. The transducer, as well as any accompanying electronics or signal processors primarily responsible of detecting the functions (Rai et al.,2012).

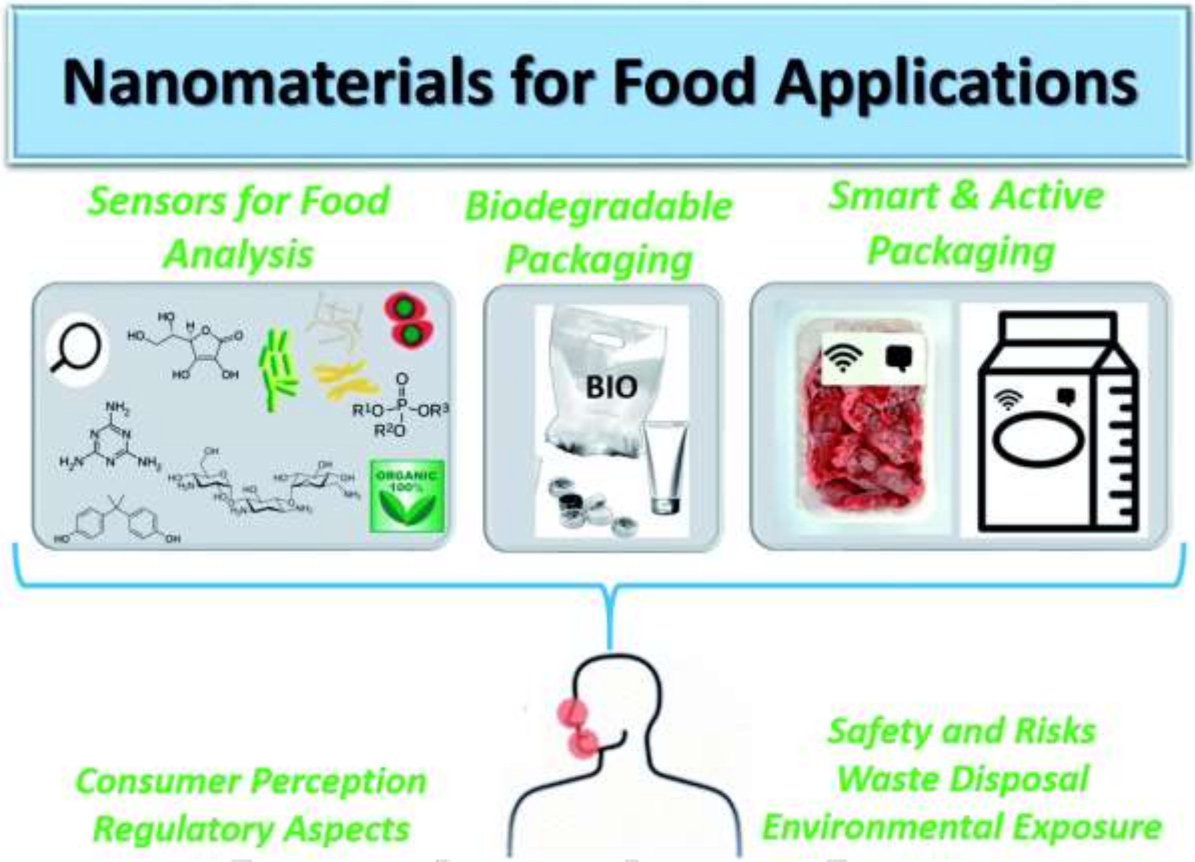
Nanotechnology in food processing industries

Nanotechnology has the ability to provide hosts with bioactive ingredients in foods while also increasing knowledge about food materials at the nanoscale (Martirosyan and Schneider, 2014).Pathogen identification and diagnosis can be aided by nanoscale biosensors. It also assists in the development of nanoscale filtration systems for food texture adjustment. Nano biosensors communicate with food and have an enticing surface, so they keep the food fresh by maintaining food colors and glaziers, magnetic nanocomposite for tags detectors.Any essential aspects of food quality testing should be addressed, such as label and package sensing capacity, in situ sensors, and food quality monitoring (e.g., color, smell, taste, texture), Regulation and distribution of nutraceuticals, compact DNA/protein chips and so on. The majority of the time, nanomaterials are manufactured by using the bottom up procedures (Siegrist et al., 2008).

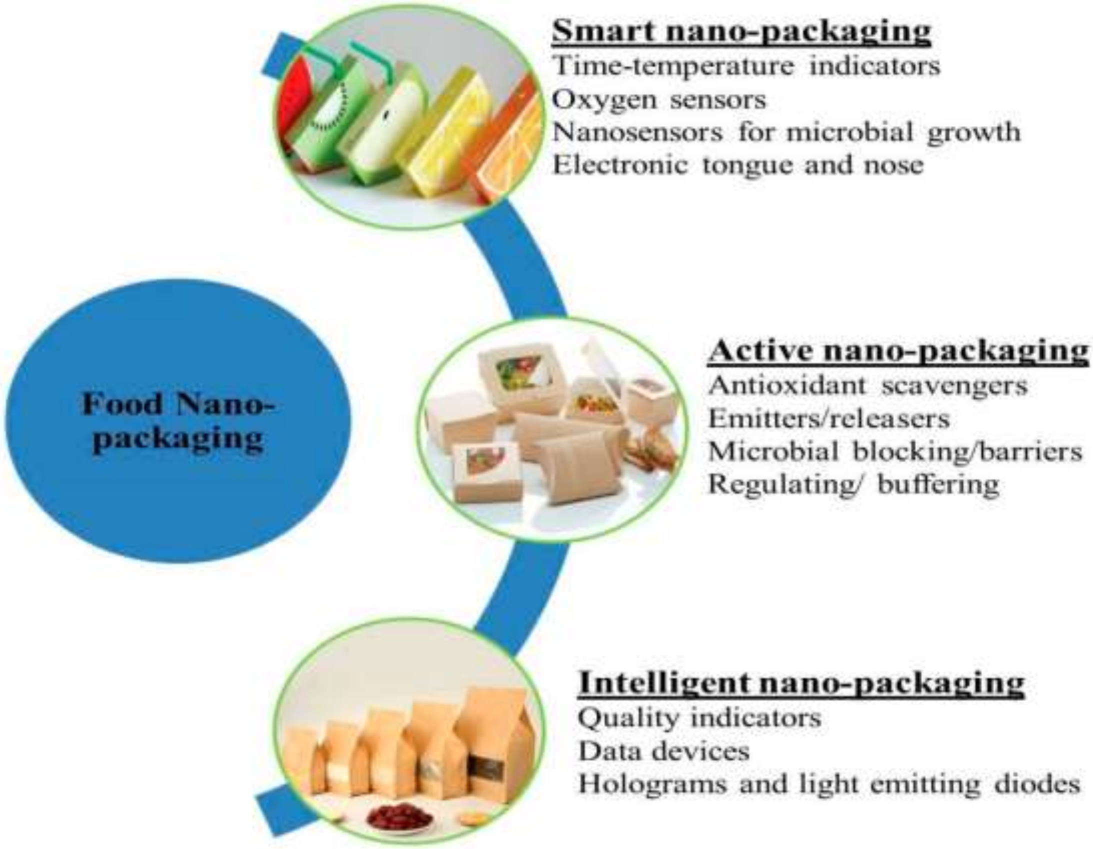


Commonly nanotechnology has recently been used in food processing, such as nanocarrier systems for nutrient and vitamin transport, herbal nano-sized food additives, and supplements as well as animal feed. Many foods now contain NP in their natural state. Milk contains casein, a nanoscale type of milk protein, and meat is made up of protein filaments that also fall in the nanomaterial category. NP emulsions are used in ice cream, and nanoemulsion spreads can improve the texture and uniformity of the ice cream (Berekaa, 2015).

In the food industry, packaging materials with "nanosensors" to track the oxidation process in food have recently been developed and tested. When oxidation happens in a food container, NP-based sensors show a color shift and provide details about the quality of the packaged foods.This technology has been used to pack milk and meat with great results (Bumbudsanpharoke and Ko, 2015).



The use of NPs in packaging is another form of exploitation, and this technology can help to prolong the shelf-life of food products by slowing down certain metabolic processes such as oxidation, decay, and so on. The most widely used materials in the food packaging industry are plastic polymers that can be incorporated or coated with nanomaterials for improved mechanical or physical properties (Berekaa, 2015). Nanocoatings on food touch surfaces often have antimicrobial and barrier properties. Silver nanoparticles have been effectively inserted in plastic to build food storage containers, and this works as a disinfectant, eliminating harmful bacterial development. As a result, nanotechnology is a forward-thinking process that also serves as a kind of agricultural biosecurity (Bumbudsanpharoke and Ko, 2015). Antibacterial effects of NPs have been discovered against both Gram-negative and Gram-positive bacteria. ZnO NPs have been shown to inhibit Staphylococcus aureus (Liu et al., 2009), and AgNPs have concentration-dependent antimicrobial activity against Escherichia coli, Aeromonas hydrophila, and Klebsiella pneumoniae (Aziz et al., 2016).



Nanosensors help with food labeling and, when combined with NP-based intelligent inks or reactive nanolayers, can allow smart food product recognition.Temperature, time, pathogens, freshness, humidity, and other detail can be found on the product package's printed labels. It is possible to synthesize nanobarcode particles with numerous gold patterns that can act as models, as well as silver stripes.Finally, we can speculate that contaminant or nutrient sorption on NPs surfaces has piqued researchers' interest, leading to additional soil chemistry studies showing that NPs have high sorption capacities for metal and anionic contaminants (Li et al., 2016).

Conclusion:

Nanotechnology's incredible capabilities have and will continue to revolutionize the world, especially in the field of agriculture. Agriculture, as the sole source of human food, can produce from intermediate and final inputs using well-established technologies. As a result, modern agricultural knowledge is needed in agriculture. Despite the fact that there is an abundance of knowledge about individual nanomaterials, the toxicity level of some of these NPs is still uncertain, restricting their use due to a lack of awareness of risk evaluations and human health consequences. For this technology to be exploited, it would require the development of a robust database and warning system, as well as international regulatory and legislative cooperation.

References

★ Auffan, Mélanie, et al. "Towards a definition of inorganic nanoparticles from an environmental, health and safety perspective." *Nature nanotechnology* 4.10 (2009): 634641.

★ Aziz, Nafe, et al. "Leveraging the attributes of Mucor hiemalis-derived silver nanoparticles for a synergistic broad-spectrum antimicrobial platform." *Frontiers in microbiology* 7 (2016): 1984.

★ Berekaa, Mahmoud M. "Nanotechnology in food industry; advances in food processing, packaging and food safety." *Int J Curr Microbiol App Sci* 4.5 (2015): 345-357.

- ★ Bonnell, Dawn. "Scanning probe microscopy and spectroscopy." *Theory, Techniques, and Applications* 289 (2000).
- ★ Brolo, Alexandre G. "Plasmonics for future biosensors." *Nature Photonics* 6.11 (2012): 709-713.
- ★ Bulovic, V., A. Mandell, and A. Perlman. "Molecular memory device." *US 20050116256 A* 1 (2004).
- ★ Bumbudsanpharoke, Nattinee, and Seonghyuk Ko. "Nano-food packaging: an overview of market, migration research, and safety regulations." *Journal of food science* 80.5 (2015): R910-R923.
- ★ Chinnamuthu, C. R., and P. Murugesa Boopathi. "Nanotechnology and agroecosystem." *Madras Agricultural Journal* 96.1/6 (2009): 17-31.
- ★ De La Torre-Roche, Roberto, et al. "Multiwalled carbon nanotubes and C60 fullerenes differentially impact the accumulation of weathered pesticides in four agricultural plants." *Environmental Science & Technology* 47.21 (2013): 12539-12547
- ★ de Oliveira, Jhones Luiz, et al. "Application of nanotechnology for the encapsulation of botanical insecticides for sustainable agriculture: prospects and promises." *Biotechnology advances* 32.8 (2014): 1550-1561
- ★ Dimkpa, Christian O. "Can nanotechnology deliver the promised benefits without negatively impacting soil microbial life?." *Journal of basic microbiology* 54.9 (2014): 889-904.
- ★ Feynman, Richard Phillips. *No ordinary genius: the illustrated Richard Feynman*. WW Norton & company, 1995.
- ★ Fraceto, Leonardo F., et al. "Nanotechnology in agriculture: which innovation potential does it have?." *Frontiers in Environmental Science* 4 (2016): 20.
- ★ Fogel, Ronen, and Janice Limson. "Developing biosensors in developing countries: South Africa as a case study." *Biosensors* 6.1 (2016): 5.
- ★ Ghormade, Vandana, Mukund V. Deshpande, and Kishore M. Paknikar. "Perspectives for nano-biotechnology enabled protection and nutrition of plants." *Biotechnology advances* 29.6 (2011): 792-803.
- ★ Gibney, Elizabeth. "Buckyballs in space solve 100-year-old riddle." *Nature News* (2015).
- ★ Goin, S. "Microencapsulation: industrial appraisal of existing technologies." *Food Sci. Technol.* 15 (2004): 330-347.
- ★ Grillo, Renato, Purushothaman Chirakkuzhyil Abhilash, and Leonardo Fernandes Fraceto. "Nanotechnology applied to bio-encapsulation of pesticides." *Journal of Nanoscience and Nanotechnology* 16.1 (2016): 1231-1234.
- ★ Handford, Caroline E., et al. "Awareness and attitudes towards the emerging use of nanotechnology in the agri-food sector." *Food Control* 57 (2015): 24-34.
- ★ Jiang, Lim Chaw, et al. "Green nano-emulsion intervention for water-soluble glyphosate isopropylamine (IPA) formulations in controlling Eleusine indica (E. indica)." *Pesticide biochemistry and physiology* 102.1 (2012): 19-29.
- ★ Knell, Mark. "Nanotechnology and the sixth technological revolution." *Nanotechnology and the challenges of equity, equality and development*. Springer, Dordrecht, 2010. 127143.
- ★ Li, Xin, et al. "Patent citation network in nanotechnology (1976–2004)." *Journal of Nanoparticle Research* 9.3 (2007): 337-352.
- ★ Liu, Y.J. and He, L.L., Mustapha. A.; Li, H. and Lin, M.(2009): Antibacterial activities of zinc oxide nanoparticles against Escherichia coli O157: H7. *J Appl Microbiol*, *107*(4), pp.1193-201.

★ Mishra, Vijendra Kumar, and Ashok Kumar. "Impact of metal nanoparticles on the plant growth promoting rhizobacteria." *Dig. J. Nanomater. Biostruct* 4 (2009): 587-592.

★ Mishra, Sandhya, et al. "Integrated approach of agri-nanotechnology: challenges and future trends." *Frontiers in plant science* 8 (2017): 471.

★ Nair, Baiju G., et al. "Aptamer conjugated magnetic nanoparticles as nanosurgeons." *Nanotechnology* 21.45 (2010): 455102.

★ Nayak, Avinash P., et al. "Pressure-modulated conductivity, carrier density, and mobility of multilayered tungsten disulfide." *ACS nano* 9.9 (2015): 9117-9123.

★ Prasad, Ram, Atanu Bhattacharyya, and Quang D. Nguyen. "Nanotechnology in sustainable agriculture: recent developments, challenges, and perspectives." *Frontiers in microbiology* 8 (2017): 1014.

★ Rai, Vineeta, Sefali Acharya, and Nrisingha Dey. "Implications of nanobiosensors in agriculture." (2012).

★ Sadeghi, Mohammad, and Fatemeh Soleimani. "Synthesis of pH-sensitive hydrogel based on starch-polyacrylate superabsorbent." (2012).

★ Sadeghzadeh, Behzad. "A review of zinc nutrition and plant breeding." *Journal of soil science and plant nutrition* 13.4 (2013): 905-927.

★ Sagadevan, Suresh, and Mathan Periasamy. "Recent trends in nanobiosensors and their applications-a review." *Rev Adv Mater Sci* 36.2014 (2014): 62-69.

★ Salamanca-Buentello, Fabio, et al. "Nanotechnology and the developing world." *PLoS Med* 2.5 (2005): e97.

★ Saravanan, M., Anil Kumar Vemu, and Sisir Kumar Barik. "Rapid biosynthesis of silver nanoparticles from Bacillus megaterium (NCIM 2326) and their antibacterial activity on multi drug resistant clinical pathogens." *Colloids and Surfaces B: Biointerfaces* 88.1 (2011): 325-331.

★ Sertova, N. M. "Application of nanotechnology in detection of mycotoxins and in agricultural sector. J Cent Eur Agric 16: 117–130." (2015).

★ Servin, Alia D., and Jason C. White. "Nanotechnology in agriculture: next steps for understanding engineered nanoparticle exposure and risk." *NanoImpact* 1 (2016): 9-12.

★ Siegrist, Michael, et al. "Perceived risks and perceived benefits of different nanotechnology foods and nanotechnology food packaging." *Appetite* 51.2 (2008): 283290.

★ Subramanian, Kizhaeral S., et al. "Nano-fertilizers for balanced crop nutrition." *Nanotechnologies in food and agriculture*. Springer, Cham, 2015. 69-80.

★ Taniguchi, Norio. "On the basic concept of nanotechnology." *Proceeding of the ICPE* (1974).

★ Veronica, N., et al. "Role of Nano fertilizers in agricultural farming." *Int. J. Environ. Sci. Technol* 1.1 (2015): 1-3.

★ Viswanathan, Subramanian, and Jerzy Radecki. "Nanomaterials in electrochemical biosensors for food analysis-a review." *Polish journal of food and nutrition sciences* 58.2 (2008).

★ Wilson, Michael A., et al. "Nanomaterials in soils." *Geoderma* 146.1-2 (2008): 291-302.