Middle-East Journal of Scientific Research 22 (4): 499-501, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.22.04.21920

Application of Nanotechnology in Agriculture and Food Production: Opportunity and Challenges

[1]S.K. Samantarai and [2]Abdul Kabir Khan Achakzai

[1]P.L. Nayak Research Foundation, Synergy Institute of Technology, Bhubaneswar, Odisha, India
[2]Department of Botany, University of Balochistan, Quetta - Pakistan

Abstract: Nanotechnology will leave no field untouched by its ground breaking scientific innovations. The agricultural industry is no exception. So far, the use of nanotechnology in agriculture has been mostly theoretical, but it has begun and will continue to have a significant effect in the main areas of the food industry: development of new functional materials, product development and design ofmethods and instrumentation for food safety and bio-security. The effects on society as a whole willbe dramatic.

Key words: Nanotechnology · Agriculture · Food · Industry · Application

INTRODUCTION

The current global population is more than 6 billion with 50% living in Asia. A large proportion of those living in developing countries face daily food shortages as a result of environmental impacts or political instability, while in the developed world there is a food surplus. For developing countries the drive is to develop drought and pest resistant crops, which also maximize yield. In developed countries, the food industry is driven by consumer demand which is currently for fresher and healthier foodstuffs [1].

The potential of nanotechnology to revolutionise the health care, textile, materials. information and communication technology and energy sectors fact several products enabled by nanotechnology are already in the market, such as antibacterial dressings, transparent sunscreen lotions, stain-resistant fabrics, scratch free paints for cars and self cleaning windows. The application of nanotechnology to the agricultural and food industries was first addressed by a United States Department of Agriculture roadmap published in September 2010. The prediction is that nanotechnology will transform the entire food industry, changing the way food is produced, processed, packaged, transported and consumed [2].

Nanotechnology in the Food Market: Nanotechnology has been described as the new industrial revolution and both developed and developing countries are investing in this technology to secure a market share. At present the USA leads with a 4 year, 3.7 billion USD investments through its National Nanotechnology Initiative (NNI). The USA is followed by Japan and the European Union, which have both committed substantial funds (750 million and 1.2 billion, including individual country contributions, respectively per year). 3 The level of funding in developing countries may be comparatively lower, however this has not lessened the impact of some countries on the global stage. For example, China's share of academic publications in nanoscale science and engineering topics rose from 7.5% in 1995 to 18.3% in 2004, taking the country from fifth catching up with a focus on applications specific to the economic growth and needs of their countries. Iran for example has a focused programme in nanotechnology for the agricultural and food industry [3-5].

Nanotechnology in Agriculture: The EU's vision is of a "knowledge-based economy" and as part of this, it plans to maximize the potential of biotechnology for the benefit of EU economy, society and the environment. There are new challenges in this sector including a growing demand for healthy, safe food; an increasing risk of disease; and threats to agricultural and fishery production from changing weather patterns. However, creating a bio economy is a challenging and complex process involving the convergence of different branches of science.

Corresponding Author: Dr. S.K. Samantarai, P.L. Nayak Research Foundation,
Synergy Institute of Technology, Bhubaneswar, Odisha, India.

Nanotechnology has the potential to revolutionize the agricultural and food industry with new tools for the molecular treatment of diseases, rapid disease detection, enhancing the ability of plants to absorb nutrients etc. Smart sensors and smart delivery systems will help the agricultural industry combat viruses and other crop pathogens. In the near future nanostructured catalysts will be available which will increase the efficiency of pesticides and herbicides, allowing lower doses to be used. Nanotechnology will also protect the environment indirectly through the use of alternative (renewable) energy supplies and filters or catalysts to reduce pollution and clean-up existing pollutants [6].

Precision Farming: Precision farming has been a long-desired goal to maximise output (i.e. crop yields) while minimising input (i.e. fertilisers, pesticides, herbicides, etc) through monitoring environmental variables and applying targeted action. Precision farming makes use of computers, global satellite positioning systems and remote sensing devices to measure highly localised environmental conditions thus determining whether crops are growing at maximum efficiency or precisely identifying the nature and location of problems. By using centralised data to determine soil conditions and plant development, seeding, fertilizer, chemical and water use can be fine-tuned to lower production costs and potentially increase production- all benefiting the farmer. 8 Precision farming can also help to reduce agricultural waste and thus keep environmental pollution to a minimum. Although not fully implemented yet, tiny sensors and monitoring systems enabled by nanotechnology will have a largeimpact on future precision farming methodology [7].

Smart Delivery Systems: The use of pesticides increased in the second half of the 20th century with DDT becoming one of the most effective and widespread throughout the world. However, many of these pesticides, including DDT were later found to be highly toxic, affecting human and animal health and as a result whole ecosystems. As a consequence they were banned. To maintain crop yields, Integrated Pest Management systems, which mix traditional methods of crop rotation with biological pest control methods, are becoming popular and implemented in many countries, such as Tunisia and India.

In the future, nanoscale devices with novel properties could be used to make agricultural systems "smart". For example, devices could be used to identify plant health issues before these become visible to the farmer. Such devices may be capable of responding to different situations by taking appropriate remedial action. If not, they will alert the farmer to the problem. In this way, smart devices will act as both a preventive and an early warning system. Such devices could be used to deliver chemicals in a controlled and targeted manner in the same way as nanomedicine has implications for drug delivery in humans [8].

Other Developments in the Agricultural\ Sector Due to Nanotechnology: Agriculture is the backbone of most developing countries, with more than 60% of the population reliant on it for their livelihood. As well as developing improved systems for monitoring environmental conditions and delivering nutrients or pesticides as appropriate, nanotechnology can improve our understanding of the biology of different crops and thus potentially enhance yields or nutritional values. In addition, it can offer routes to added value crops or environmental remediation. Particle farming is one such example, which yields nanoparticles for industrial use by growing plants in defined soils. For example, research has shown that alfalfa plants grown in gold rich soil, absorb gold nanoparticles through their roots and accumulate these in their tissues [9].

Nanotechnology in the Food Industry: The impact of nanotechnology in the food industry has become more apparent over the last few years with the organization of various conferences dedicated to the topic, initiation of consortia for better and safe food, along with increased coverage in the media. Several companies which were hesitant about revealing their research programmes in nanofood, have now gone public announcing plans to improve existing products and develop new ones to maintain market dominance. The types of application include: smart packaging, on demand preservatives and interactive foods. 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. 24 Most of the food giants including Nestle, Kraft, Heinz and Unilever support specific research programmes to capture a share of the nanofood market in the next decade [9].

Packaging and Food Safety: Developing smart packaging to optimise product shelf-life has been the goal of many companies. Such packaging systems would be able to repair small holes/tears, respond to environmental conditions (e.g. temperature and moisture changes) and alert the customer if the food is contaminated. Nanotechnology can provide solutions for these, for example modifying the permeation behaviour of foils, increasing barrier properties (mechanical, thermal, chemical and microbial), imdeveloping active antimicrobic and antifungal surfaces and sensing as well as signaling microbiological and biochemical changes proving mechanical and heat-resistance properties [10].

Food Processing: In addition to packaging, nanotechnology is already making an impact on the development of functional or interactive foods, which respond to the body's requirements and can deliver nutrients more efficiently. Various research groups are also working to develop new "on demand" foods, which will remain dormant in the body and deliver nutrients to cells when needed. A key element in this sector is the development of nanocapsules that can be incorporated into food to deliver nutrients. Other developments in food processing include the addition of nanoparticles to existing foods to enable increased absorption of nutrients. One of the leading bakeries in Western Australia has been successful in incorporating nanocapsules containing tuna fish oil (a source of omega 3 fatty acids) in their top selling product "Tip-Top" Up bread. The microcapsules are designed to break open only when they have reached the stomach, thus avoiding the unpleasant taste of the fish oil [10].

CONCLUSION

Coming nanotechnologies in the agricultural field seem quiet promising. However, the potentialrisks in using nanoparticles in agriculture are no different than those in any other industry. Through therapid distribution of nanoparticles to food products – whether it be in the food itself or part of thepackaging – nanoparticles will come in direct contact with virtually everyone. The environmentalgroup ETC (Action Group on Erosion, Technology and Concentration) is deeply concerned with theimplications and regulation of nanotechnology used in food. Currently, there are none. Their main concern is that of the unknown. In a publication in November 2004, the ETC stated that "the merger of nanotech and biotech has unknown consequences for health, biodiversity and the environment".

Since there is no standardization for the use and testing of nanotechnology, products incorporating the\nanomaterials are being produced without check. The ability for these materials to infiltrate the human =body is well known, but there is really no information on the effects that they may have. While there is no evidence of harm to people or the environment at this stage, nanotechnology is a new and evolving area of study that could cause a great deal of harm due to its still ambiguous chemical properties.

REFERENCES

1. Winans, B., 2011. European Nanotechnology Landscape Report, Observatory NANO.
2. Hunter, T., 2011. Global Funding of Nanotechnology and its Impact, Cientifica.
3. Nanotechnologies Industry Association, 2007. NIA Forecast of Emerging Technologies: Nanotechnologies.
4. Kuzma, J. and P. Verhagen, 2006. Nanotechnology in agriculture and food production: Anticipated applications, Project on Emerging Nanotechnologies.
5. http://www.foresight.org/about/index.html (31.03.2012).
6. Moskvin, G., E. Spakovica and A. Moskvin, 2008. Development of Intelligent Technologies and Systems in Agriculture, Engineering for Rural Development. Proceedings of the International Scientific Conference, Jelgava, 29.30.05: 108-113.
7. Moskvin, G. and E. Spakovica, 2002. New Method and Low-Cost Intelligent Instruments for the Fraud Detection and Conformity Control of Agricultural Products. ASAE Annual Meeting and CIGR WORLD Congress. July 29-July 31, Hyatt Regency, Chicago, IL, USA, ASAE Paper Number 023077.
8. Moskvin, G. and E. Spakovica, 2006. Intelligent Technology for the Conformity Assessment of Agricultural Products. Advances in Computer, Information and Systems Sciences and Engineering. Hardcover ISBN: 1-4020-5260-X, Springer Berlin - Heidelberg - New York, 109-114.
9. Harper, T., Y. Hailing and M. Jordanov, 2011. Using Emerging Technologies to Address Global Risk, Cientifica.
10. EFSA, 2012. Technical Report: EFSA Scientific Network of Risk Assessment of Nanotechnologies in Food and Feed.