Application of Nanotechnology on Food and Agriculture: A Review

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***ABSTRACT:**The exponential growth of nanotechnology has encouraged the transformation of conventional food and agricultural industries, including the discovery of smart and active packaging, nanosensors, nanopesticides and nanofertilizers. Numerous novel nanomaterials have been produced to enhance the quality and protection of food, crop growth and environmental monitoring conditions. The most current advances in nanotechnology are explored in this analysis and the most difficult tasks and exciting prospects from selected recent studies are presented in the agriculture and food industries.We believe that nanotechnology provides a multitude of possibilities in the food and agriculture industries by offering a novel and renewable solution.The future use of biosynthesized and bio-inspired nanomaterials for sustainable production has been highlighted. However, in order to fuel successful production and deployment of nanotechnology, fundamental issues about high performance, low toxic nanomaterials need to be answered. In order to govern the production, manufacturing, application and disposal of nanomaterials, regulation and legislation are also of utmost importance. Efforts to enhance consumer understanding and acceptance of novel nano-enabled food and agricultural products are also required.*

***KEYWORDS:** Agriculture, Crop, Food, Nanotechnology, Nanomaterial.*

INTRODUCTION

In our daily lives, nanotechnology is commonly applied and transforms the whole of society. Since 2003, when the U.S. Department of Agriculture released the first blueprint on September 9, 2003, it has started marching into the farm and food sectors. Over the last decade, study on this subject has skyrocketed. It includes almost every part of the food and agricultural field, including agriculture, filtration of irrigation water, food manufacturing and packaging, animal feed, and aquaculture.

A major multi-trillion dollar market is the food and beverage market. A new estimation of the global economic impact of nanotechnology is estimated to be at least $3 trillion by 2020, causing 6 million workers to be employed in the growing nanotechnology industries worldwide. This is very enticing and has motivated many food companies to produce and sell innovative products based on nanomaterials and to increase production quality, food characteristics, taste and safety. Incredibly, there are hundreds of products that over the last decade have now been sold and used in the food industry.The bulk of these items are designed "out-of-food" but "inside" the food industry, i.e. goods that touch food but are not eaten directly by individuals. No new nanomaterials containing products have yet been placed directly into human food, with the exception of titanium dioxide and iron oxide, which have also been used as food pigments and colourants. The fundamental explanation is that nano-food regulations and laws are very small, especially because of the complexities of nanomaterials and case-by-case legislative procedures[1].

The poor knowledge of toxicity and danger that novel nanomaterials could offer is a deeper reason for the restricted regulation. Many research concentrate on the in vitro toxicity of nanomaterials, although relatively little evidence is available on in vivo toxicity, not to mention the chronic impact of nanomaterials (especially metal nanoparticles, NPs). It is important to fill at least some gaps: toxicity of nanomaterials to mammalian cells, tissues/organs and chronic effects on the human body; migration of nanomaterials to food; deterioration or environmental fate of nanomaterials; bioaccumulation and influence of nanomaterials on ecosystems.Public approval, which is frequently neglected by scholars, producers, and regulators, is another significant factor. Ultimately, it defines whether or not clients will potentially submit and/or embrace nanotechnology. In any area of the food industry, from food agriculture, manufacturing, storage and transport to our dishes, nanomaterials can and have been widely applied. The waste would inevitably be disposed of in the atmosphere and have a clear effect on flora, fauna and wildlife, independent of the population and those that adopt these novel nano foods.This piece of knowledge is, sadly, very thin. To make matters worse, either a writer, food corporation or government department has not yet listed the right disposal process. In addition, there is a considerable lack of in vivo evidence on nanomaterial toxicity, in particular the possible chronic impact on human organs[2][3].

From food nanotechnology to the commodity being sold, or from basic issues of nanotoxicity to policy and regulations, or from understanding of food nanotechnology to general recognition and adoption, there is a need for a great deal of information and commitment, both of which are strictly interrelated. There are ample comments in each segment and reviews are available for any one of them. This chapter briefly covers recent developments on all these aspects and highlights the critical need to obtain insight into the risk management and toxicity evaluation of novel nanomaterials for regulatory and general acceptance purposes.Under these conditions, bio-synthesized (or 'green synthesised') nanomaterials can provide an alternative solution to the comparatively 'reasonable' negative effect of the application of novel nanomaterials in the food industry.

DISCUSSION

Current status on food and agriculture nanotechnology

Nanotechnology deals with nanomaterials ranging from 1 to 100 nm that have at least one dimension. Inorganic (silver and metal oxide NPs), organic (primarily natural product NPs) and combined nanomaterials tested in the food industry are (i.e. clay). Silver NP is the most commercially developed and used of all metal NPs because of its antimicrobial activity, whereas gold NP is commonly studied as a sensor/detector. As a disinfecting agent and also a food additive (white colour pigment) and flavour enhancer, titanium dioxide NPs are also well studied. Normally, natural product NPs are designed as a distribution mechanism and are often included in the food industry as additives or supplements[4].

Current status on food nanotechnology

Food nanotechnology, such as food processing, additives, and food storage, has penetrated many facets of client items. Food manufacturing and storage has advanced the identification of this novel technique in maintaining food safety. Several traditional chemicals added as food additives or coating materials have also been shown to be partly present on a nanometer scale. For instance, food-grade TiO_2 NPs in the nanometer range have now been found to be up to approximately 40 percent. While low toxic nanomaterials such as TiO_2 NPs are commonly recognised under environmental conditions, long-term exposure to such nanomaterials can cause adverse harm[5].

Along with the presence of nanoscale chemicals, the use of novel food nanotechnology has also drawn general attention to the possible dangers. In this section, we carefully review recent progress with regard to the application of food nanotechnology. The key references of laws and regulations on food nanotechnology are chosen nanomaterials used in food products licensed by the United States Food and Drug Administration (U.S. FDA) and the European Commission (EC). Some authorizations made by the U.S. The FDA and the EC are focused on a risk calculation of the traditional particle size of a product, so engineered NPs could be needed on a case-by-case basis by the Authority.A few Research and Development (R&D) programs are often meant to suggest possible future implementations[6].

Current status on agriculture nanotechnology

In agriculture, nanotechnology is used to improve food production, with nutritional benefit, efficiency and protection being equal or even higher. The most effective approaches to increase crop production are the productive use of fertilisers, pesticides, herbicides, and plant growth factors/regulators. With the use of nanocarriers, controlled release of pesticides, herbicides and plant growth regulators can be accomplished.For example, as a herbicide carrier for atrazine, poly (epsilon-caprolactone) nanocapsules have developed in recent years. Compared to industrial atrazine, the therapy of mustard plants (Brassica juncea) with atrazine loaded poly (epsilon-caprolactone) nanocapsules improved herbicidal activity, showing a dramatic decrease in net photosynthetic rates and stomatal conductance, a major increase in oxidative stresses, and eventually weight loss and growth reduction of the plants studied. Likewise, as an adjusted controlled release, other nanocarriers such as silica NPs and polymeric NPs have also been developed to transport pesticides in a controlled way.Nanoscale carriers can be used to accomplish these species' distribution and gradual release exactly. These methods are referred to as "precision farming," which increases crop yields but does not harm soil and water. Most notably, the use of nanoencapsulation will reduce the herbicide dose without any loss of productivity that benefits the ecosystem. Nanoparticle mediated gene or DNA transfer in plants has been used for the production of insect-resistant varieties in addition to nanocarriers. In previously written reviews, more information can be found[1][7].

In addition, some per se nanomaterials can serve as pesticides with improved toxicity and sensitivity. Because of their inherent toxicity, metaloxide nanomaterials such as ZnO, TiO2, and CuO are commonly studied to shield plants from pathogenic infections. We take NPs from ZnO as an instance. ZnO NPs have been shown to successfully inhibit the production of microbes like Fusarium graminearum, Aspergillus flavus, Aspergillus niger, Aspergillus fumigatus, F. F and Culmorum. Oxysporium, which shows good antifungal and antibacterial action[8].

Public awareness and acceptance

There have been incidents of silver NPs being applied to packaging products because of their antimicrobial activity, and these materials have been commonly used in many packets of food (such as milk). These objects were eaten by the general population without understanding the addition of nanoparticles. That may be a problem that is both legal and regulatory. In order to make the public conscious of what they eat, adequate marking is now mandatory. The duty of the producer is to keep this knowledge open and accessible to the public.Public knowledge and recognition is an integral aspect of a food producer, but is sometimes overlooked. In reality, most food manufacturers maintain their new "underground" product development and do not want to share it with the public (maybe partly due to the competition and trade secret). This can clash with the fact that the public wants to know what a new product is being marketed by the food manufacturer and why.

The Singapore case study has already shown that ignorance of nanotechnology and its negative impacts on nanotechnology tends to increase the general public negative view.It is also worse because, as revealed by a study on the island of Ireland, agri-food organisations (stakeholders) still have very little knowledge of nanotechnology.

The public voice is twofold, with nanotechnology in the food industry, approval and opposition (or altruism and scepticism). The mood of the public depends heavily on the particular applications. Food nanotechnology received 49 percent support in 2005 and 32 percent in 2008 (one of the lowest of all nanotechnology applications), while 73 percent of respondents represented food packaging applications monitoring the situation in 2008[9].

The highest concern about the use of nanotechnology, especially in food, was expressed (28 percent). Utilizing canola oil as an instance, customers are only capable of paying very little for canola oil that is refined or packed with nanotechnology-modified seeds or technologies, according to a national online survey in the U.S. For canola oil with health-enhancing nano-engineered oil drops, no substantial difference was noticed. It seems like the public has a neutral stance towards nano-engineered canola oil, while all nano-foods are not present in nano-engineered canola oil.

"Organic" is perhaps the most widely recognised standard for safe food so far. Many people prefer conventional and "organic" food, especially when compared to genetically modified foods. Genetically modified foods are often also mistaken for nano-engineered foods by the media. Poor access to food nanotechnology knowledge and services for the general public is the primary cause. The application of nanotechnology in the food industry is not yet a mature technique. Less proof from a science point of view renders it impossible or perhaps illegal to openly market this unknown technology[10].

CONCLUSION

Nanotechnology demonstrated positive prospects for extensive application in all areas of the food industry. This is focused on minimal expertise that is primarily derived from laboratories. The realistic implementation of nanotechnology and the selling of nanomaterial-based products remains uncertain, given the limited ability to monitor the properties and interactions of nanoscale materials, as well as the ambiguous effects on the atmosphere and the nearly empty inventory of toxicity. This further restricts the growth of the regulatory body and of the regulations, thereby further becoming barriers to the sale of new goods.

Low understanding of food nanotechnology is seen by the public although their mindset is tunable based on how nanotechnology is used and encouraged. The dispute tends to be because the public needs to be told about the state of food nanotechnology (in particular the production of similar new products), while food producers want to be notified about the progress of food nanotechnology because their technology is proprietary. A appropriate database and evidence should be developed for the knowledge of both the public and food producers and act as logistical support, which is desperately required.

Since the introduction of environmentally sustainable practises has become increasingly important for success in today's biotechnology industry, in biological science and many other related fields, bioinspired approach is becoming popular. However, the research and production of bio-inspired nanomaterials for use in the food and agricultural industries is currently very limited relative to the biomedical industry.Numerous commodities incorporating novel nanotechnology have been sold around the world, widely in the area of food contact materials/technologies (such as packaging materials/monitors), powered by the food industry, which is a trillion-dollar sector. Due to protection code enforcement by the legislative branch of a jurisdiction, this will continue to be a battleground for the producer.

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