NANOTECH – Application in Food Industry-An overview

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Abstract— **Food nanotechnology is an area of emerging interest and opens up a whole universe of new possibilities for the food industry. The basic categories of nanotechnology applications and functionalities currently in the development of food packaging include: the improvement of plastic materials barriers, the incorporation of active components that can deliver functional attributes beyond those of conventional active packaging, and the sensing and signalling of relevant information. 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 flavours and colour quality, and safety by increasing the barrier properties. Nanotechnology holds great promise to provide benefits not just within food products but also around food products. In fact, nanotechnology introduces new chances for innovation in the food industry at immense speed, but uncertainty and health concerns are also emerging. EU/WE/global legislation for the regulation of nanotechnology in food are meagre. Moreover, current legislation appears unsuitable to nanotechnology specificity.**

Keywords: nanotechnology, Nano food, food packaging, nanoparticles, Nano encapsulation

I Nano Technology – An Introduction

Nanotechnology or "nanotech" is the manipulation of matter on an atomic and molecular scale. The earliest, widespread description of nanotechnology referred to the particular technological goal of precisely manipulating atoms and molecules for fabrication of macro scale products, also now referred to as molecular nanotechnology. A more generalized description of nanotechnology was subsequently established by the National Nanotechnology Initiative, which defines nanotechnology as the manipulation of matter with at least one dimension sized from 1 to 100 nanometers. This definition reflects the fact that quantum mechanical effects are important at this quantum-realm scale, and so the definition shifted from a particular technological goal to a research category inclusive of all types of research and technologies that deal with the special properties of matter that occur below the given size threshold. It is therefore common to see the plural form "nanotechnologies" as well as "Nano scale technologies" to refer to the broad range of research and applications whose common trait is size. Because of the variety of potential applications (including industrial and military), governments have invested billions of dollars in nanotechnology research. Through its National Nanotechnology Initiative, the USA has invested 3.7 billion dollars. The European Union has invested 1.2 billion and Japan 750 million dollars.

B) Nano technology in Food Sector

Nanotechnology is having an impact on several aspects of food science, from how food is grown to how it is packaged. Companies are developing

nanomaterials that will make a difference not only in the taste of food, but also in food safety, and the health benefits that food delivers.

Nanotechnology has begun to find potential applications in the area of functional food by engineering biological molecules toward functions very different from those they have in nature, opening up a whole new area of research and development. The food industry is the largest manufacturing sector in the world, with an annual turnover approximating US $4 trillion. But it presents a very different innovation scenario than the chemical and pharma industries do, and introducing new processing technologies (e.g., high hydrostatic pressure [HHP] technology, -ohmic heating, irradiation) has been challenging. Globally, a large proportion of foods are consumed after only minimal processing (e.g., fresh fruits, vegetables, nuts, some cereals) and with high post-harvest losses (particularly with fruits and vegetables). In most places worldwide, particularly in urban centers, food is abundant and relatively cheap.

Nanotechnology is a technology based on the understanding of what happens at the scale of 10-9 meters, the scale of atoms and molecules, and also the scale at which food, like everything else we see about us, acquires its recognisable properties of flavour, aroma, texture and so on.

C) Key Areas:

There are several key areas where the food industry is particularly working on the development of new techniques, including the following:

- Novelty (new textures, tastes and colours)
- Processing (better and cleaner equipment and surfaces)
- Safety (reducing the likelihood of contamination)
- Healthier foods (adding and enabling the release of nutrients)
- Sports foods and drinks
- Smart packaging.

Nanotechnology is the basis of many novel and functional foods. For example, food colours, flavours and textures can all be manipulated and altered at the nanoscale.

An important Nano technique is encapsulation, which has been derived from the pharmaceutical industry. Encapsulation is critical to the delivery of flavours or nutrients in products tailored to suit consumer preferences or health requirements. Encapsulation is also used to improve the stability of a mix of ingredients, and to create novel textures and tastes, as well as disguising unpleasant flavours, such as fish oil. Nanotechnology also has a role to play in altering the colour and flavour of foods. For example, differently ‘twisted’ molecules (the direction of chirality) can determine whether the flavour imparted is ‘lemon’ or ‘orange’.

Another example is the use of mineral Nano particles. For those of us that love the taste of salt but are worried about its health implications, Nano particulate salt gives a salty taste to foodstuffs, but much less is required than if conventionally sized salt grains are used. This has been the subject of much research by Leatherhead Food Research, which is supporting the use of Nano scale salt by food companies in their bid to bring their products in line with daily intake guidelines.

Flavour Burst

Many foods and beverages contain naturally occurring nanoscale colloidal components (dairy for example), and these components can also be manipulated by food companies to add novelty and/or improve the longevity, taste, flavour and calorific content of their products.

Nano also has a role to play in providing a burst of a specific flavour. At the University of Nottingham, scientists investigating nanoscale aroma release have shown that this ‘flavour burst’ is related to the physical and chemical characteristics of the flavants at the nano and micro scale.

Food processing nanotechnologies also offer many improvements for the food processing industry. One example is in relation to the customisation of emulsions, important in many areas such as sauces, ready-made meals and puddings. Nanoparticles can also be used as thickeners. Some processing utilises

nano-structured, porous membranes to create specific-shape holes that allow the size of, say, oil droplets to be controlled to a very high degree, for example, in emulsification. This enables manufacturers to develop double, triple or even multiple emulsions as the basis for many new products, allowing multiple components to be enclosed in a single oil droplet.

Nanoscale membranes can also provide filtration and purification for air and water, and nano-modified surfaces, coatings and finishes provide antibacterial properties and dirt repellency, all very useful in food preparation.

Food safety

With regard to safety, nanofilters can also be used to remove toxins such as pesticides. The Dutch company Aquamarijn produces microsieves with fine-tuned nanopores that act as filters for a variety of applications.

The critical need for food safety provides an opening for many new techniques based on nanotechnology. For example, in food preparation areas, nano filters are used to clean the environment, and there are nano-enhanced antibacterial surfaces, while nano coatings on tools and equipment make them sharper, longer lasting and easier to clean.

Novel nanobiosensors, developed by other industries including medicine and defence, can rapidly detect the presence of pathogens, pollutants and toxins in the processing of foods. These tiny sensors are cheap to produce, have high sensitivity, specificity, robustness, reliability and are more easily integrated into food production systems.

They are replacing bit-by-bit, the more expensive and time-consuming analytical methods that involve sending samples to a laboratory.

Nanosens in the Netherlands is already making portable sensing systems for the rapid detection of biological and chemical contaminants in food and other application areas.

Encapsulation techniques

There is a large and increasing market for foodstuffs with enhanced vitamin and other supplements, where nano encapsulation can again have a major impact.

Through using encapsulation techniques, nanotechnology enables the production of ‘healthy’ foods such as low-fat dairy and non-dairy oils, low salt and sugar products, and foods that can counteract certain diseases by the incorporation of specific vitamins and minerals, and by making them more easily absorbable in nanoparticulate form. Other nanoscale phenomena, such as those included within the term ‘colloid science’, are also exploited in nutraceutical and functional food formulations, manufacturing and processing.

A number of companies are active here, for example Nutralease, based in Israel, has created nano-sized concentrates of vitamins E, D, A, K and isoflavones.

Sports foods and drinks

The active ingredients in sports drinks need to be absorbed quickly to assist performance and maintain the health of the athlete. These benefits can be achieved by including these ingredients in nanoparticulate form (this is also the way that less soluble medicines are administered).

The kinds of nano techniques used in sports foods and drinks, such as improved bioavailability of vitamins and minerals and encapsulation and release of energy-generating foodstuffs, are also widely used in those drinks that offer a quick ‘kick’, and in certain foods where the release of fats, sugars, proteins, vitamins and minerals can be programmed to suit the activity levels of the consumer.

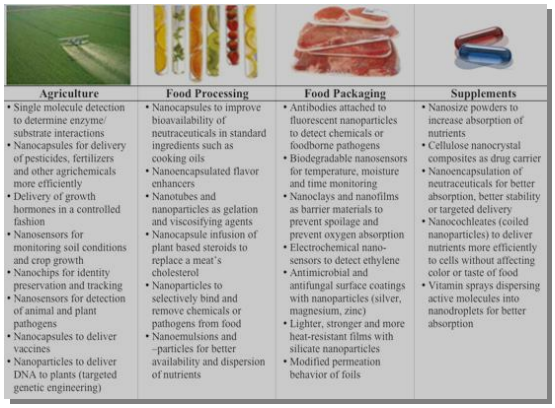
Advanced Sports Nutrition (ASN) is one company that offers a sports drink with nanoscale ingredients. Its product, HPC - High Performance Creatine ‘uses nanotechnology, and ingredients that have been scientifically proven to maximise uptake of creatine into muscle cells and also provide optimal hydration and support for maximum performance during exercise and nutrient uptake after exercise’.

Food packaging is an area of the industry where nanotechnology has been most rapidly embraced, as it offers many benefits ranging from improving

barrier properties, thus preventing contamination of foodstuffs by specific gases (eg oxygen) or unwelcome scents, to using in-built nano sensors that can detect when perishable contents are spoiling and change colour to warn consumers.

Similarly, 'smart' packaging can maintain an internal ambient temperature for longer, increasing the lifespan of the contents. Some packaging also has antibacterial and sun-blocking properties based on the application of nanotechnology, and nano devices placed in packaging would enable easy tracking of large quantities of product and act as a deterrent to counterfeiters.

There are significant challenges for the food industry in its adoption of the technology in terms of potential legislative and consumer acceptance hurdles. However, nanotechnology may hold the key to solving many critical issues facing the world's food supply today. Only time will tell how this technology will continue to develop in the future.



Agriculture	Food Processing	Food Packaging	Supplements
• Single molecule detection to determine enzyme/ substrate interactions • Nanocapsules for delivery of pesticides, fertilizers and other agrichemicals more efficiently • Delivery of growth hormones in a controlled fashion • Nanosensors for monitoring soil conditions and crop growth • Nanochips for identity preservation and tracking • Nanosensors for detection of animal and plant pathogens • Nanocapsules to deliver vaccines • Nanoparticles to deliver DNA to plants (targeted genetic engineering)	• Nanocapsules to improve bioavailability of neutraceuticals in standard ingredients such as cooking oils • Nanoencapsulated flavor enhancers • Nanotubes and nanoparticles as gelation and viscosifying agents • Nanocapsule infusion of plant based steroids to replace a meat's cholesterol • Nanoparticles to selectively bind and remove chemicals or pathogens from food • Nanoemulsions and –particles for better availability and dispersion of nutrients	• Antibodies attached to fluorescent nanoparticles to detect chemicals or foodborne pathogens • Biodegradable nanosensors for temperature, moisture and time monitoring • Nanoclays and nanofilms as barrier materials to prevent spoilage and prevent oxygen absorption • Electrochemical nano-sensors to detect ethylene • Antimicrobial and antifungal surface coatings with nanoparticles (silver, magnesium, zinc) • Lighter, stronger and more heat-resistant films with silicate nanoparticles • Modified permeation behavior of foils	• Nanosize powders to increase absorption of nutrients • Cellulose nanocrystal composites as drug carrier • Nanoencapsulation of neutraceuticals for better absorption, better stability or targeted delivery • Nanocochleates (coiled nanoparticles) to deliver nutrients more efficiently to cells without affecting color or taste of food • Vitamin sprays dispersing active molecules into nanodroplets for better absorption

Food Science: Nanotechnology Applications under Development

Researchers at the Technische Universität München have demonstrated a method of spraying carbon nanotubes onto flexible plastic surfaces to produce sensors. The researchers believe that this method could produce low cost sensors on surfaces such as the plastic film wrapping food, so that the sensor could detect spoiled food.

Researchers are using silicate nanoparticles to provide a barrier to gasses (for example oxygen), or moisture in a plastic film used for packaging. This could reduce the possibly of food spoiling or drying out.

Zinc oxide nanoparticles can be incorporated into plastic packaging to block UV rays and provide anti bacterial protection, while improving the strength and stability of the plastic film.

Nanosensors are being developed that can detect bacteria and other contaminates, such as salmonella, at a packaging plant. This will allow for frequent testing at a much lower cost than sending samples to a lab for analysis. This point-of-packaging testing, if conducted properly, has the potential to dramatically reduce the chance of contaminated food reaching grocery store shelves.

With improved technology and scientific advancements a lot of milestones have been achieved in this filed which can heel a lot of problems arising for mankind in the present century as well as coming generations.

Research is also being conducted to develop nanocapsules containing nutrients that would be released when nanosensors detect a vitamin deficiency in your body.

Basically this research could result in a super vitamin storage system in your body that deliver nutrients that you need ,when you need them.

"Interactive" foods are being developed that would allow you to choose the desired flavour and colour.Nanocapsules that contain flavour and colour enhancers are embedded in the food; inert until a hungry consumer triggers them. The method hasn't been still publically announced, so it will be interesting to see how this particular trick is accomplished and can be taken into act.

Researchers are also working on pesticides encapsulated in nanoparticles; those only release pesticides within an insect's stomach, minimizing the contamination of plant themselves.

Another development being pursued is a network of Nano sensors and dispensers used throughout a farm field. The sensors recognize when a plant needs nutrients or water, before there is any sign that the plant is deficient. The dispensers then release fertilizers, nutrients or water as needed , optimizing the growth of each plant in the field one by one.

Food Science: Nanotechnology Company Directory

Here is a list of some internationally recognized companies which are leading their research projects in the vast sea containing knownledge of nanotech.

Now it has been considered as a world welfare subject.

Company	Product
Nancor	Bottles, cartons and films containing clay nanocomposite that act as a barrier to the passage of gasses or odors
Nano Science Diagnostics	Rapid testing for contaminates in food
Inmat	Nanocomposite coatings for transparent plastic films used in food packaging that provides a barrier to oxygen or moisture