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Significance of Nanotechnology in Food Industry

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Abstract

Magical spell have the ability to turn everything touched into gold, in real time scenario one such spell is "Nanotechnology" which has the mysterical power to revolutionize every field touched by it. Nanotechnology is now invading the food industry and establishing great potential.Nanotechnology applications in food industry include: encapsulation and delivery of substances in targeted sites, increasing the flavor,introducing antibacterial nanoparticles into food, enhancement of shelf life, sensing contamination, improved food storage, tracking, tracing and brand protection. Nano food processing and products can change the color, flavor, or sensory characteristics; they also change the nutritional functionality, removes chemicals or pathogens from food. Nano food packaging materials may extend food life due to high barrier packaging, 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. Nanobarcodes are used for safety labeling and monitor distribution of food products. Nanosupplements can be easily incorporated by encapsulation techniques for nutritional and drug delivery systems effectively. And as health plays a major role in food the disadvantages of the technology is to be concerned.

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1. Introduction

Nanotechnology is the study of manipulation of matter in atomic and molecular scale. It is also explained as the control of matter on an atomic and molecular scale with at least one characteristic dimension measured in nanometer. It ranges from 1to 100 nm in scale, it extends its potential from mechanics to medicine and able to create new devices and techniques. Nanoparticle is defined as the small object that acts as a whole unit in terms of transport and properties. They are classified according to their characteristics, size and structures. Nanomaterials is a field that takes a materials science approach to nanotechnology. The features of the materials are studied on the nanoscale and developed with novel characteristics [1]-[3].

Food nanotechnology has its history from Pasteurization process introduced by Pasteur to kill the spoilage bacteria (1000 nanometers), made the first step of revolution in food processing and improvement in quality of foods. Later, Watson and Crick's model of DNA structure which is about 2.5nm opened the gateway of applications in biotechnology, biomedical, agricultural and production processes. Further, the invention of carbon nanotubes "buckyball fullerene" which is 1nm in size served as the cutting edge discovery to the world of innovation and led to the era of nanoscience [4]. Carbon shows an enormous potential in all fields including food sectors.

1.1. Food Processing

Food processing is the conversion of raw ingredients into food and its other forms by making it marketable and with long shelf life. Processing includes toxin removal, prevention from pathogens, preservation, improving the consistency of foods for better marketing and distribution. Processed foods are usually less susceptible to early spoilage than fresh foods and are better suited for long distance transportation from the source to the consumer. All these are made more effective by the incorporation of the nanotechnology nowadays .Nano capsules delivery systems plays an important role in processing sector and the functional property are maintained by encapsulating simple solutions, colloids, emulsions, biopolymers and others into foods [5]. Nano sized self assembled structural lipids serves as a liquid carrier of healthy components that are insoluble in water and fats called as nanodrops. They are used to inhibit transportation of cholesterol from the digestive system into the bloodstream [6].

1.2. Food Packaging

Food packaging for food requires protection, tampering resistance, and special physical, chemical, or biological needs. It also shows the product that is labelled to show any nutrition information on the food being consumed. The packing has a great significance in preserving the food to make it marketable. Innovations in packaging have lead to quality packing and consumer friendly approach in determining the shelf life, biodegradable packing and many more. Nanotechnology in packaging is categorized based on the purpose of the application.

1.3. Barrier Protection

The food products are preserved by maintaining it in an inert and low oxygen atmosphere for inhibiting microbial growth and spoilage, thus the material used should be impermeable to gases. Nanocomposites are incorporated in the polymer matrix of the substances due to their large surface area which favors the filler-matrix interactions and its performance. Also the nanoreinforcement's acts as small, barriers for gases by complicating the path of the material, both are known as polymer nanocomposites .Nanoclays are composite

materials having complex metallic ores. They are naturally obtained from volcanic ash as Montmorillonite [7], provides barrier to permeation of gases or polymer based clays prepared by nylons, polyolefin, PET, PA, epoxy resin, poly methane are used for polymer matrix in food packaging to get higher quality. But polyamide based nanoclay have been developed largely and commercialized under the trade names Durethan, Imperm, Aegis and noted for their durability and protection. Various researches have been developing in nanocomposites from cells and carbon nanotubes since packaging plays a backbone for commercialization of products.

1.4. Antimicrobial Packaging

The barriers include natural Nanoparticle to control microbial growth which leads to pathogens or spoiling. Silver nano particles are used in all forms including biotexiles, electrical appliances, refrigerators, kitchenware's. Silver nanoparticles show needed action in bulk form, and its ions have the ability to inhibit wide range of biological processes in bacteria [8]. Zinc oxide's antibacterial nature increases with decreasing particle size, it can be stimulated by visible light, and they are incorporated in number of polymers including polypropylene. E. coli contamination can be controlled using Titanium dioxide as a coating in packing material. It is also combined with silver to improve disinfection process. Chiston is a biopolymer derived from chitin recently reported antimicrobial properties additional to material for encapsulation. Antimicrobial packaging would be highly healthy and consumer friendly products.

1.5. Biodegradeable

Pollution is the most concerning factor which affects the environmental characteristics. The effect of non-degradable plastics changes the soil nature and accumulation of toxic gases in atmosphere leads to global warming, hence bio degradable plastics came into effect but they lack mechanical strength and permeable to water and gases .These disadvantages are prevailed over by nanotechnology incorporated packaging material made of natural or synthetic nanoparticles having properties like bio-degradable, renewable resources having high mechanical strength. Nanoparticles are obtained as the proteins, carbohydrates, lipids from animal and plant materials, also metal oxides nanoparticles and carbon nanotubes are used [9]. In addition collagen, zein, cellulose from corn is synthesized into nanofibers it is highly porous in nature .These nano materials are added along with nanoclays and used for comfort packaging. They also have additional novel properties like sensors, antibacterial action and as biocatalysts.

1.6. Smart Packaging

Sensors are devices used to detect the physical quantity of substances and converts into observer readable signals. They are used to regulate the internal environment of the food stuffs and their properties are sensed regularly which is indicated by sensors. A recent report shows that the current smart packaging segment is dominated by oxygen scavengers, moisture absorbers and barrier packing product, accounting for 80% of the market. Whereas the bakery and meat products having attracted most nano-enabled packaging technology to date.

The food environment is continuously sensed for oxygen content, temperature, pathogens and indicators are used for proper alarming. They also show the shelf life of the products with the help of the nanosensors. Some examples include gold nano particle incorporated enzymes for microbes detection, gas sensing related to condition of food products : nanofibrils of perylene-based fluorophores indicates fish and meat spoilage by detecting gaseous amines. Others include zinc oxide and titanium oxide nanocomposites for the detection of

volatile organic compounds. Nanobarcodes are used for tagging and also for security [10]. Thus the use of smart sensors is beneficial to the consumers in terms of better quality identification and producers for rapid distribution and authentication of the food products.

1.7. Nutritional Supplements

According to a survey, the total market value of nanofood would reach US$5.8 billion (food processing US$1303 million, food ingredients US$1475 million, food safety US$97 million and food packaging US$2.93 billion) in 2012.Thus making heavy profit to economy [11]. Nanoceuticals, Nutrition-be-nanotech, are commercial names for supplements. Nanosized powders are used for increasing absorption of nutrients, nanocochleates are considered as effective tool for nutrient delivery to cells without affecting color and taste of food products. Vitamin sprays disperse nanodroplets are used for better absorption of nutrients. Supplementary aspect main involves encapsulation techniques where the needed probiotics, and other products are targeted into the human system with the help of iron and zinc nano structured capsules [12]-[14]. Thus, nanotechnology in food supplement is very effective than common supplements because they react more effectively with human cells due to their size.

2. Conclusion

Food is any substance which contains nutritional value, when consumed they are ingested by the organism they breakdown to produce energy and sustain life .The energy is produced at the cellular level due to many pathways. Healthier the food is, more energy is produced to maintain the metabolism of the body. The basic secret of nanotechnology and food industry is that the cellular level of human cells and food products components which are of nanoscale and microscale can easily interact with the nanoparticles which incorporates nanotechnology in all sectors of the food industry which includes, processing, packaging, safety and security.

Packaging is revolutionized due to the integration of nanocomposites, nanosensors, bio-degradable nanocomposites for leakage proof, gases free, and pathogen less food packaging. They act as barrier for exchange of gases and maintain the quality of food using nanoclays, the formation of bacterial and fungal organisms or any kind of pathogens and toxins are terminated using antimicrobial packaging using silver, titanium oxide, zinc oxide and other bionanoparticles. Biodegradable nanocomposites packaging are of great potential to environment. Smart packaging allows the consumers to choose right products which have good shelf life and also by indicating the nature and other characteristics of the food. This technology also paves way to food safety and security.

Nutritional supplements with the combination of nanotechnology deliver the drugs efficiently. Also many commercial nutraceuticals are available. These supplements interact most powerfully with cells and easily acceptable. Even though nanotechnology came to effect in foods by producers' it is yet to be recognized by the consumers, due to the ethical issues and unawareness. The potential use of nanotechnology and its benefits in industry and consumers health has to be spread. Prospective research in nanotechnology in food industry and its incorporation have the capability to reinvent food world. Likewise certain regulations have to be made by the food administration department of the countries government to establish proper and safe commercialization of nano food. The interaction of nanoparticles and cells leads to debate about some pessimistic approach to nanofoods .But the wide potential of nanotechnology in overall food industry and its benefits in providing rich nutritional value, quality packaging, smart sensing are to be borne in mind and relevant research for more safer techniques for incorporation of nanotechnology in food industry has to be implemented.

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