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Application of Nanotechnology in Food Research

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Abstract—*Nano-science and nanotechnology are new frontiers of this century. Their potential application to the agriculture and food sectors is relatively novel as compared with their use in engineering and medical science. Driven by the flourishing demand for healthier and safer food products and the keen desire for edible systems led to the introduction of nanotechnology to encapsulate, protect, and release functional compounds, to address necessary concerns applicable to food and nutrition. Hereby food nanotechnology opens up state of the art prospects for the development of innovative food products. Nanotechnology has already brought revolutionised advancement in packaging, processing, cleaning and sensors for detection of contaminants. It will also provide new dimensions in correlation with the food safety and nutritive value of food products. In this chapter, we intended to compile the applications and future utilisation of nanotechnology in relevance to food and nutraceuticals together by analysing the foreseen challenges. Also, it outline the advancement in the current food laws in both national and international market for nano foods.*

Keywords : *Nano- technology, healthy and safe foods, nano foods, nutrition.*

1. INTRODUCTION

Nanotechonlogy is a de novo ascending technique, which comprises of the structures, devices or materials from 1-100 nm in length by using characterization, fabrication or manipulation as a technique. Nano-materials broadly falls on the nanoscale, and are clustered into three classes, namely nanoparticles, nanofibers and nanoplates [2]. In contrast to macro scale particles nano-materials showed unique properties making them eminent, these properties includes high surface to volume ratio, colour, solubility, optical, toxicity strength, solubility etc [3]. According to the EU Commission (Recommendation 2011/696/EU) "nanomaterial means a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm-100 nm"[4]. Therefore, nanotechnology has come up as a most gifted mechanism to revolutionize convectional food science and the food sector.

Many researchers have unfolded the dormant use of nanotechnology in every section of the food industry which involves from agriculture to food processing to food packaging to nutrient supplementation. Broadly applications of nanotechnology are listed in Fig 1.

2. NANOTECHNOLOGY AND FOOD PROCESSING

The preservation of food by utilisation of certain technique is the elementary fundamental of food processing. Irrespective of whatsoever technique is preferred for the preservation, it is highly essential that food quality and flavour should not be hindered and should remain as intact as feasible. In the current scenario nano-materials are used in many ways of food processing like nutraceuticals incorporation, viscosifying and deletion agents, nutrient delivery and mineral and vitamin fortification etc [8]. Fresh foods are no longer the exclusive intent of food processing, production of healthier foods is also a far reaching facet, which has bring a new array of processed foods in the market with fortified micronutrients to satisfy many consumers [9,2].

2.1 Nano encapsulation

Nanoencapsulation is defined as the technology of packaging of nanoparticles of solid, liquid or gas, also known as the core or active, within a secondary material, named as a matrix or shell, toform nanocapsules [2]. Foodprocessing method boosted by nanocapsules has additional packages. i.e. it is simple to handle, protects against oxidation, enhances ..

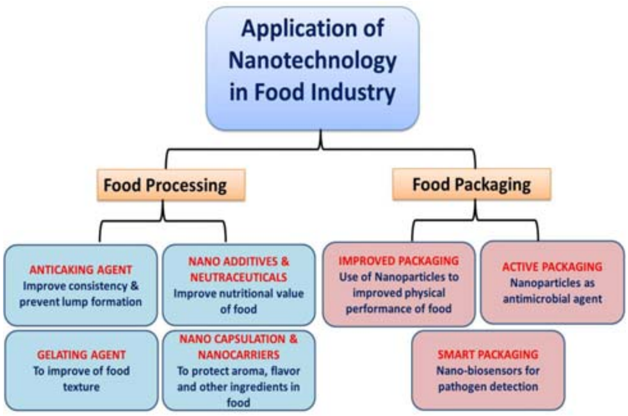

Fig 1: Schematic diagram showing role of nanotechnology in different aspects of food sectors. [3]

stability, its ability to retain the highly volatile ingredients, it makes taste better, triggered by moisture fluctuation, extended delivery of multiple active ingredients, pH-triggered controlled release, its organoleptic transition continues for longer span, and has an increased bioavailability [5]. Nanocapsules enact food preservation by entrapping odour and any other unwanted ingredients in food as it transport the component to the target area. Nanocapsule has the competence to transmit its components through the gut. It can also be employ for the distribution of lipophilic health supplements, vitamins and minerals, in food hereby upgrading the nutrient content of the food [6,1,10].

2.2 Nano-emulsions

Nanoemulsions are engaged in the preparation of food products for sweeteners, salad dressings flavored oils, beverages and other processed foods. Various stimulants are used such as heat, pH, ultrasonic waves for the release of different types of flavours [7]. They precisely hold the attributes and inhibit enzymatic reactions and oxidation in them. Nano emulsions are thermally more stable and smaller in size than the convectional emulsions. Due to this property they can interact with many biological active components such as enzymes in the gastrointestinal tract. Zarif and Hogan et al. found that nano emulsions are easily digested by the lipase in GIT and ice-cream uniformity is also maintained if the nano emulsions are made in the form of carbohydarate or protein respectively [12,11]. Nano materials also contain antimicrobial agents therefore they can be utilized for decontamination of food packaging material [13]. Nanoemulsions made from tributyl phosphate, soybean or nonionic surfactants have been used to check microbial growth hence reducing the extent of food-spoilage [14,1,10].

2.3 Nutraceuticals

Nano materials in the form of bioactive proteins or compounds is frequently used as functional foods which contribute to the health benefits along with the nutrition of the food. In the recent times many bioactive compounds are isolated which includes beta carotene from carrots, lignans form sesame seeds and oils, cur cumin from turmeric, lycopene from tomatoes, alpha linolenic acid from flax seeds, omega 3 from salmon oil, isoflavons from soybeans etc. Reducing the particle size of bioactives may improve the availability, delivery properties and solubility of the bioactives and thus their biological activity. The stability of the substance decides the biological activity and the ability to transfer through across intestinal membranes into the blood. Some of the nutraceuticals fused in the carriers include lycopene, lignans, beta carotene, curcumin etc are used to enhance the shelf life and to prevent the accumulation of cholesterol of the healthy foods. The likelihood of the manufacturing of nutraceuticals at the nanoscale will expand the stability of the products throughout the processing chain. It will also open the horizons for the food processors to maximise nutrient content and conclusively benefitting the consumers [2].

3. NANOTECHNOLOGY IN FOOD PACKAGING

The key role of food packaging is to enhance the shelf life of the food by preventing spoilage from bacteria and loss of the nutrient. Nanotechnology attempt to give very high optimistic goals in food packaging in terms of extended shelf life and improved traceability of food products. Lot of research is going on towards developing newer aspect of food packaging material with upgraded mechanical, barrier and antimicrobial properties to increase shelf life. Beside antimicrobial characteristics, nanoparticles can be used as vehicle to deliver antioxidants, enzymes, flavors, anti-browning agents and other materials to extend shelf life, even after opening [2].

Nano packaging has the probable potential to for manufacturers by contributing with ample range of benefits, including the ability to keep packaged food fresher for longer [16]. This can permit food to travel farther and have place in storage godowns for a prolonged period of time, with an outcome of more thus resulting in a more reliable food supply.

Implementation of nanotechnology in food packaging can be divided into :

3.1 Improved packaging

Improved packaging materials are described as incorporation of nanoparticles in the matrix of the polymer with enhanced packaging properties such as temperature/moisture stability, durability, gas barriers, flexibility and antimicrobial properties (e.g. nano composites, nano silver and silicate nanoparticles) [15].

Fig 2: Packaging functions including its advanced packaging systems, active and intelligent packaging [17]

3.2 Active packaging

The use of nanomaterials in packaging allows packages to interact with food and the environment and also play a dynamic role in food preservation. Several nanomaterils like nanocopper oxide, nanosilver, nanotitanium dioxide, nanomagnesium oxide and carbon nanotubes can provide antimicrobial properties. Presently, the use of silver nanoparticles as antibacterial agents in food packaging is increasing.

3.3 Intelligent/smart packaging

The use of nano-devices in the polymer matrix can monitor the condition of packaged food. This packaging is designed for sensing biochemical or microbial changes in the food. It can detect specific pathogen developing in the food or specific gases from food spoiling. Some smart packaging has been developed to be used as a tracing device for food safety or to avoid counterfeit [2,17].

4. NANOTECHNOLOGY AND SAFETY ISSUES

Nanotechnology has brought transformation in food industry as it considerable function in all areas of food science, from agriculture to food processing including packaging [18]. Despite the fact that nanotechnology like other technologies is associated with many hazards and risks. Some researchers believe that nanotechnology due to its nano size can led to the development of contaminants making it ultra hazardous [19]. Though these particles are not harmful but their interactions with other products can lead to harmful outcomes [20]. As nanoparticles are very reactive, unstable, mobile and toxic these ingredients must go through with full safety assessment by the relevant scientific advisory association before these are permitted to be used in food industry [18].

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