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Nanotechnology in Food Industries: Application and Safety

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A R T I C L E   I N F O

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Nanotechnology, as a scientific knowledge, is clearly defined as manipulation, fabrication, and application of particles with the size of less than 100 nm [1]. Although the use of nanotechnology in food has recently emerged, it has dramatically grown [2]. Nanoparticles which are generally divided into two categories (organic and inorganic) according to their composition can be used in food and food related-products in several domains, such as producing nano-formulated pesticides, fertilizers, and other agrochemicals; enhancing the safety and shelf life of products; improving tastes, colors, flavors, and bioavailability of vitamins and minerals; and preventing microbial corruption of packaged food [3, 4]. Inorganic nanoparticles which consist mainly of metal, especially metal oxides, have been suggested to be effective due to antimicrobial activity and preservation action [5]. Inorganic nanoparticles are generally composed of materials such as silver, titanium dioxide, zinc oxide, silicon dioxide, and iron oxide [6]. Among them, silver nanoparticles are generally used in food and food packaging materials owing to their antimicrobial effect [7, 8]. For instance, it has been claimed that some manufacturers used silver nanoparticles in a particular type of food container [9]. Several studies indicated that these nanoparticles can be transmitted to food from the containers; therefore, led to concerns that they could be ingested by human [9- 11]. Animal studies have revealed that these nano-silvers can be absorbed and then accumulated in various organs including the liver, small intestine, spleen, stomach, and kidneys [12, 13]. At present, there is little information on the toxicity potential of nanoparticles. On the one handsome studies have indicated no toxicity; but on the other hand others have reported noticeable toxicity of nanoparticles [4, 12]. For instance, it is reported that silver nanoparticles increase reactive oxygen species (ROS) production and decrease glutathione levels, as a major endogenous antioxidant scavenger, in human liver cells which lead to damage to cellular components and apoptosis [14]. Moreover, some studies have indicated that nanoparticles can generate ROS which are toxic in lung epithelial cells and alveolar macrophage cells [15, 16]. Furthermore, it is revealed that producing a large number of ROS which is induced by nanoparticles can be effective in the pathogenesis of neurodegenerative diseases, such as Parkinson and Alzheimer diseases [17, 18]. Whereas, some animal studies have reported no toxic effects of silver nanoparticles [19, 20].Therefore, further studies are needed to determine the case-by-case toxicity of nanoparticles.

It has been reported that many of the nanoparticles are naturally found in several common foods, for instance, casein micelles, a natural protein in bovine milk and other dairy product [21, 22]. Generally, there are three types of organic nanoparticles including lipid- based, protein-based and carbohydrate- based nanoparticles which is claimed that they are less toxic than inorganic ones due to their digestion within the gastrointestinal tract [4]. Among these three types of organic nanoparticles, lipid-based nanoparticles including micelles, oil droplets, vesicles, and fat crystals are the main nanoparticles which are currently exist in many commercial food products. They can be used to encapsulate compounds with different solubility and enhance the physical stability of the product [23- 25].

To sum up the most common application of nanoparticles are in food packaging. Indeed, the high surface area of nanoparticles empowers them to improve flexibility, stability, and texture of products [26]. However, the behavior of nanoparticles in the human body is different from other larger particles which are utilized as food ingredients and this is due to their small size. There are large discrepancies between the studies about the potential toxicity of nanoparticles [27, 28]. Therefore, further studies should be conducted to ascertain the safety of nanoparticles. Since there are different mechanisms of action for each nanoparticle, it is important to assess the potential toxicity of nanoparticles case-by-case based on their nature. For instance, the most important mechanism for organic nanoparticles is increasing the bioavailability of toxic substances. Whereas, inorganic nanoparticles can absorbed in the body, accumulate in various tissues, and produce cytotoxicity.

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