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Safety aspects of nanotechnology applications in food packaging

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Abstract

Although the application of nanotechnology provides numerous advantages related to food safety and quality, at the same time it may present a potential risk not only to human health, but can affect animals and the environment as well. Recent studies have shown that indeed there are reasonable grounds for suspecting that nanoparticles may have toxicological effects on biological systems. Food-contact materials (FCMs) are already on the market in some countries, therefore more data about the safety of engineered nanotechnology materials and nanoproducts affecting human health are necessary in the future to ensure adequate regulation and their useful application for FCMs.

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1. Introduction

Along with others novel technologies, nanotechnology has found its way into the food industry and can be applied in all aspects of the food chain in order to improve food safety and quality control, and as novel food

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supplements, additives or nutrients[1]. Nanotechnology may be used to produce packages with improved mechanical and thermal properties, while nanosensors may be incorporated in the packaging systems to alert consumers if a food product is no longer safe to eat[2]. Nanotechnology may also be used to produce more healthy foods. In contrast to beneficial effects and potential use of engineered nanotechnology materials (ENMs), which are very well described, there is a lack of knowledge about potential (eco) toxicological effects of nanoparticles[3]. This is a one of the reasons which is there are many concerns over consequences of nanoparticles use for human and also environmental health[1]. ENMs contain many different substances, in many forms and sizes and with a variety of surface coatings. The health assessment of such diverse materials is complex process and requires validated analytical methods both for their characterization. It is important not only to determine their presence and concentration in bulk samples, but in workplace air as well, because this is one of the most important ways of nanoparticles entrance into human body[3]. In order to evaluate the risk of exposure to nanoparticles, several parameters including size and shape, crystalline form, functionalisation and purity should be considered[4].

2. Exposure to nanoparticles and effect of nanoparticles on human health

Nanoparticles from engineered or other nanomaterials can enter the body by inhalation, ingestion or by dermal penetration[1,5]. Nanotechnology-based medical devices and drugs injection and release from implants also may be the way of nanoparticles entrance[5]. From aspect of food industry, the inhalation and skin penetration is almost exclusively related to workers in the nanomaterials producing factories, but main exposure of concern for final consumers occurs by ingestion[1,4]. Presences of nanoparticles in food are mainly result of direct contact of nanopackaging and food and migration of nanoparticles from nanopackaging materials[1,5].

The liver and the spleen are the two major organs for distribution of nanoparticles after ingestion and passing from intestines to circulation[1,6]. There are only few studies which investigated nanostructured materials in the gastrointestinal tract and results of this study showed that nanoparticles pass through intestines and are eliminated rapidly[7]. Contrary to ingestion as a rout of nanoparticles entry, inhalation and skin exposure routes are more explored. Elder et al.[8] showed that inhaled magnesium oxide nanoparticles can have an entry into the olfactory bundle under the forebrain via the axons of olfactory nerve in the nose and that they can reach other parts of the brain also through systemic inhalation. Moreover, Nurkiewicz et al.[9] demonstrated that inhalation of nanosized titanium dioxide ENM reached systemic circulation in rats. At the moment there are not conclusively data about penetration of nanoparticles through human skin and results are controversial[10]. Results obtained in the study conducted by Tinkle et al.[11] showed that latex particles smaller than 1 μm penetrate the outer layers of a skin sample during constant flexing. On the other hand some studies indicate that nanostructured particles could not penetrate healthy, intact skin[12].

The effect of nanomaterials on human body also depends of properties of nanomaterials. Data shown that circulation time increases drastically when the nanoparticles are hydrophilic and their surface is positively charged[1,6]. Influence of nanoparticles on circulation is not enough investigated but results of some studies indicate that these particles may have adverse effects on circulation, especially affecting microcirculation. Particles that enter the bloodstream may affect the blood vessel lining or function and promote blood clot formation or may abe associated with cardiovascular effects linked to inhaling ambient ultrafine particles[13]. Results obtained by Nurkiewicz et al.[9] showed that inhalation exposure of rats to low concentrations of nanosized titanium dioxide ENM augments particle-dependent microvascular dysfunction, while Radomski et al.[14] reported that SWCNT and MWCNT induce platelet aggregation and vascular thrombosis. It is necessary to obtain more data about influence of nanomaterials and nanoparticles on blood and vessels, because once in the blood stream the ENM can potentially induce negative effects in any organ in the body[8]. The well vascularised organ which evokes most concerns is brain[7,8]. Long et al.[15] have observed increased production of reactive oxygen species in immortalized brain microglial cells but convincing evidence on effects of ENM in the brain of a whole animal is very limited. Data show that some nanoparticles are capable of crossing the blood brain barrier, and may enter cells and organs and interact with metabolism or migrate in the foetus [1,6].

It is supposed that ENM toxicity is based on oxidative stress, although the exact mechanism how nanoparticles induce formation and generation of reactive oxygen species (ROS) is not completely understood. Toxicity of nanoparticles depends on their properties and rout of entrance in the body, concentration and duration of exposure to nanoparticles, but also on individual susceptibility and state of organism[4,16,17]. Results when oral route of transmission was studied showed that signs of toxicity were noted only with relatively high doses of nano-silver or nano-TiO2 applied[4].

In order to the asses toxicity of ENM it is important todetermine physicochemical characteristic ofnanomaterial, and this complex process many factors, including agglomeration state, surface chemistry, material source, preparation method, and storage should be taken a count[16].

Activation of oxidative stress-responsive transcription factors cause inflamation which is important because chronic inflammation and oxidative stress may cause a number of particle-specific effects such as fibrosis, genotoxicity and cancer caused by fibres or secondary mutation[4].

Apart from toxicity, genotoxicity and carcinogenicity are one of the posible adverse effects of nanopaticles which draws the most attention. ZnO nanoparticles have a genotoxic potential in human epidermal cells even if bulk ZnO is non-toxic, which suggests the impact of particles' diameter [1,18]. Carcinogenic effects of persistent particles such as asbestos have been suggested to be due to the local generation of granulomas and fibrosis in the lungs[19,20]. Also lung tumors have been reported following chronic inhalation of very high doses (10 mg/m^3) of nano-TiO_2 [4].

3. Perceived risks and perceived benefits

Analyses of individual data showed that the importance of naturalness in food products and trust were significant factors influencing the perceived risk and the perceived benefit of nanotechnology foods and nanotechnology food packaging. Past surveys showed that the public is not familiar with the term nanotechnology[21]. Nanotechnology packaging is viewed as less problematic in the public view. Consumers may be more likely to accept innovations related to packaging than those related to foods. The two factors which mainly determine the individual perception of nanotechnology used in food were labeled as nano-outside (e.g., packaging) and nano-inside (e.g., foods). [21] A results of some studies suggest that nanotechnology packaging is perceived as being more beneficial and presents a less health risk than nanotechnology foods[22].

4. Conclusion

The benefits of nanotechnology use are numerousand this technology offer lot of possibilities in different fields. In spite of different ways of application of nanotechnology in food products, main focus, especially in regard to meat and meat products, are food packaging, such as ”active” and ”intelligent” packaging. On the other hand, lack of knowledge about the impact of these nanomaterials on human health is a major obstacle for nanotechnology implementation. In order to improve the existing methods for assessing risks to human health, risk management, as well as legislation in the field of nanotechnology, to improve the existing risk assessment methodology, good governance and regulatory framework of the application of nanotechnology within food should be implemented. This clearly needs close collaborations between nanoparticles (and products) developers, risk assessors, regulators and researchers.

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