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Nanotechnology and food: brief overview of the current scenario

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Abstract

The rapidly expanding sector of nanotechnologies has applications in every industrial sector. The production of food of animal origin recognizes several possibilities for technological development through the use of nanomaterials, at animal farming, food processing and product storage levels. Direct use of nanomaterials during these production stages, as well as the uptake from the environment, can lead to the presence of such materials in the final product. In this context analytical methods for the detection and characterization of nanomaterials in complex food matrices and toxicological data are strongly needed to assess the risk for consumers.

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1. Introduction

Nanotechnologies are considered to hold a great promise for the development of new products in almost all industrial sectors and many applications are currently marketed worldwide. Among different sectors where a potential for application is recognized, ranging from electronics to health care, from textiles to environment, food has a relevant position.

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". This conservative definition comprises all material containing nanoparticles, irrespective of whether their presence is voluntary or not. A different evaluation was made two years before by EFSA in the first opinion regarding nanotechnologies (The EFSA Journal (2009) 958, 1-39) where the Authority, transposing the terminology of SCHENIR (http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_012.pdf), was less concerned about the exact dimensions of particles, but more about their origin. The opinion was actually limited to engineered nanomaterial (ENM) defined as "any material that is deliberately created such that it is composed of discrete functional and structural parts, either internally or at the surface, many of which will have one or more dimensions of the order of 100 nm or less".

Accordingly, the present discussion will be limited to ENM to focus on deliberate use of such materials.

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Having stated that nanomaterials should compel with the previous definition, it is important to describe why their use is steadily increasing and why this trend is expected to continue in the following years.

The main classification of nanomaterials is according to their organic or inorganic nature.

The great advantage of materials at this dimensional state is that they show unique functional properties from bulk materials, properties that can be exploited for a wide range of applications. These properties are mainly due to a high surface to mass ratio that results in a higher reactivity for interactions, ion delivery, or contact. However, other physical-chemical characteristics such as shape, composition, charge, and solubility can change their behavior in an unpredictable way.

2. Nanotechnology in agriculture and food

Nanotechnology offers new opportunities also for the food and agricultural industries and several applications can be found at different stages of the food production chain [1,2]:

- agrochemicals delivery;
- nanomaterials for detection of animal and plant pathogens;
- Food and Feed: food additives as color and flavor enhancers, food supplements (e.g. to increase iron or other trace element bio-availability), novel food structure (e.g. nanoemulsion to reduce fat content), nanoparticles for selective binding and removal of contaminants and pathogens from food;
- Food contact materials: nanoparticles with antimicrobial or antioxidant characteristics to boost preservation of foodstuffs, nanoparticles to detect chemicals or foodborne pathogens, biodegradable nanosensors for temperature and moisture monitoring, nanoclays and nanofilms as barrier materials;
- Food supplements: nanoparticle suspensions as antimicrobials, nanoencapsulation for target delivery of nutraceuticals.

This list of applications derives from the recently published "Inventory of nanotechnology applications in the agricultural, feed and food sector" (EFSA Supporting publication (2014): EN-621) aimed at defining the current state of art and the future developments of nanotechnology exploitation in food and agriculture. In particular, it has emerged that 276 nanomaterials (NMs) are currently available on the market; nano-encapsulated, silver and titanium dioxide have the highest number of records in the Nano Inventory and food additives and food contact materials are the most frequent applications. As far as future developments are concerned, it seems that a potential shift from inorganic materials like silver to organic materials like nano-encapsulates and nanocomposites might occur, suggesting that applications in novel foods, feed additives, biocides and pesticides have been so far only at a R&D stage. In this context, there are several applications that could be of interest for products of animal origin, during farming practices, during processing of meat products and during storage and marketing. The use of nanomaterials in the animal production system is described in Fig. 1.

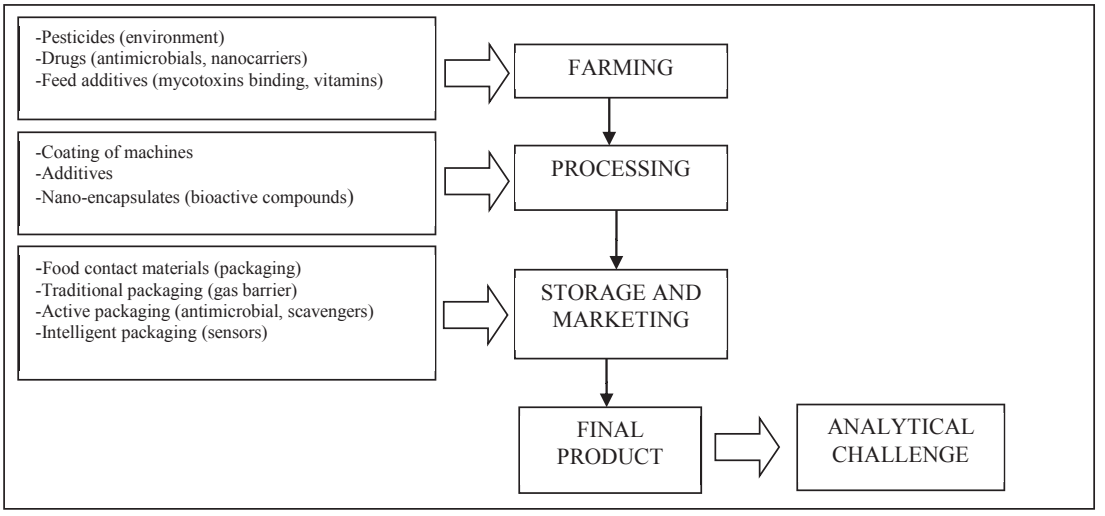

Fig. 1. Example of potential/existing applications in the animal production sector

However, if the benefits of nanomaterials drive their commercial applications and open new scenarios, some concerns arise from the food safety point of view. In this context, the key question is whether nanomaterials are still present in the final products as a consequence of direct use during the production system, uptake from environment or migration from food contact materials. These data, in addition to toxicological information are essential to understand potential risks. For this, research on toxicological properties and the development of analytical methods able to detect and characterize nanomaterials, especially in complex matrices (like food products), are needed.