Journal of the Hellenic Veterinary Medical Society

Vol 70, No 3 (2019)

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doi: [10.12681/jhvms.21783](https://doi.org/10.12681/jhvms.21783)

J HELLENIC VET MED SOC 2019, 70(3): 1611-1616
ΠΕΚΕ 2019, 70(3): 1611-1616

Review article
Ανασκόπηση

Nanotechnology and its Considerations in Poultry Field: An Overview

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ABSTRACT. Nanotechnology *is an emerging science field that in the years to come could have countless beneficial effects on every aspect of everyday life including animal farming.* Recently*, research in this sector has shown the potential for* many different applications in Veterinary *practice. In poultry farming in particular, various nanoparticles have been experimentally used for several purposes such as: alternative to antibiotics as growth promoters, as* feed additives to enhance and improve the growth rate, performance, immunity, resistance to pathogens and increase the quality of meat. In *laying hens*, *they can have a positive influence* to both quantity and quality of eggs. Moreover, nanomaterials applied in embryonated chicken eggs *can improve* embryos development. The aim of this overview *is* to provide a description of potential *nanotechnology applications* for poultry sector and discuss *any* challenges or obstacles *including the matters of safety of application of these nanomaterials in animals, in humans and of course in the environment*.

Keywords: Nanomaterials, Broilers, Layers, *In ova*, Types

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Date of initial submission: 30-01-2019
Date of revised submission: 29-03-2019
Date of acceptance: 03-06-2019

INTRODUCTION

Nanoscience and nanotechnology have been implicated in Veterinary Medicine as a tool for improving animal nutrition, breeding and reproduction (Sagadevan and Periasamy, 2014), for diseases diagnosis, prevention and therapy (Muktar et al., 2015) as well as for food safety (Lee et al., 2011). In poultry industry, certain antibiotics are used as feed additives growth promoters, but their use *now faces certain restrictions* due to development of antibiotics-resistant human pathogenic bacterial strains and *the presence of residues in bird's meat* (Verma et al., 2012). Social pressure *leads the industry to minimize their use* in animal feeding. European community banned use of antibiotics as growth promoters since 2006. Therefore, there is *a lot of research* for other safe alternatives to *substitute their use*. Nanotechnology is a very *promising* new approach that has the potential to substitute the antibiotics as feed additive. *Research in this area has* led to many innovations in animal production sector.

DEFINITION OF NANOTECHNOLOGY

Nanotechnology can be referred to as an area of science and technology focused on the *study* and manufacture of nano-sized materials (Lövenstam et al., 2010 and Gruère, 2012). *In U.S.A.* National Nanotechnology Initiative defined nanotechnology as the procedures focused on the production of materials and structures *at a scale of approximately 1-100 nanometres in at least one dimensio*. These materials possess unique and novel physical, chemical and biological properties that differ fundamentally from their bulk form (Buzea et al., 2007 and Feng et al., 2009). Nanomaterials can be produced through the utilization of two broad approaches known as top-down and bottom-up. The top-down approach is mostly used for processing inorganic materials through traditional methods such as milling, grinding, sieving, and chemical reactions (Cockburn et al., 2012). The bottom-up approach involves the assembly of smaller molecules through self-organization, resulting in the formation of supra-molecular structures which possess novel functionalities (Cockburn et al., 2012).

NANOMATERIALS TYPES

It is difficult to classify nanomaterials due to their complex structures and diverse properties. They present in different forms including; metal and metal oxide nanoparticles nanoemulsions, nanoporous materials, such as nanoclay, nanoshells, nanorods, dendrimers, carbon nanotubes etc. (Sekhon, 2012). Bai et al (2018) presented different types of nanomaterials including liposomes nanoparticles, micellar nanoparticles, polymeric nanoparticles, dendrimer nanoparticles, metallic nanoparticles, and carbon nanoparticles that have been used for disease diagnosis, treatment, drug delivery, animal nutrition, animal breeding and reproduction.

MECHANISM OF NANOPARTICLES ACTION

The mode of action of nanoparticles depends mainly many factor such as particles size where sizes lesser than 300 nm spread in the blood, but particles smaller than 100 nm reach tissues (Hett, 2004). Other factors also like particles solubility and charges are important. Nanoparticles could be administrated either by ingestion or inhalation and exert their actions through different ways. Chen et al. (2006) explained nanoparticles mode of action by increasing the surface area for better interaction with biological support, prolonging the residence time in gut, reducing the intestinal clearance mechanisms, increasing tissues penetration, crossing epithelial lining fenestration, efficient cells uptake and effective delivery to target sites.

APPLICATIONS OF NANOTECHNOLOGY IN POULTRY INDUSTRY

IN BROILERS SECTOR

Certain studies were conducted previously to investigate the impact of dietary inoculation of some nano elements on performance parameters as well as their antimicrobial activities in broilers.

Nano-silver ionic particles showed destructive influence on pathogenic intestinal microorganisms and consequently induced better nutrients absorption, improvement in feed intake, weight gain and feed efficiency of broilers chicks (Andi et al., 2011). On other study of Ahmadi (2012), nano-silver feed supplementation with 20, 40 and 60 ppm for 42 days showed dose dependent reduction in lymphoid organs weights which may be correlated with the antimicrobial property of silver nanoparticles that induced favorable proportion of non-pathogenic organisms than pathogenic ones in the gut. Dobrzanski et al. (2010) detected that nano-silver particles reduced the number of *Escherichia coli*, *Streptococcus*, harmful *Salmonella* and total number of mesophilic bacteria in the litter of broilers indicating bactericidal activities of these particles. Pineda et al. (2012) demonstrated the antibacterial activity of silver nanoparticles in chickens. Basal broilers control diet supplemented with 4 ppm silver nanoparticles/kg for 5 weeks experimental period produced the best final body weight, body weight gain, feed conversion ratio, European production efficiency index and total serum antioxidant, while lowest levels of lipids and cholesterol as compared with other levels and control groups (El-Moustafa et al., 2015). In the same study, broilers fed different levels of silver nanoparticles (2, 4, 6, 8 and 10 ppm/kg) decreased the number of harmful bacteria as *E. coli* compared to control and had no effect on microflora as *Lactobacilli*. The harmful effect of using nano-particles in broiler was detected by Loghman et al. (2012) who concluded that higher levels of nano-silver (8 and 12 ppm) may induce severe pathological lesions in broilers liver.

Hu et al. (2012) studied the effect of dietary inoculation of 1.20 mg kg^{-1} nano-selenium (nano-Se) and found wider range between the optimal and toxic dietary levels with efficient body retention when compared with sodium selenite, increasing in the survival rate and improving both the average daily gain and feed to gain ratio.

Supplementation of broiler basal diet with 0.06 ppm organic zinc non-particles 0.06 ppm improved the bird's immunity and bioavailability as compared to inorganic zinc (Sahoo et al., 2014).

Some Egyptian studies were conducted to test the efficacy of using zinc oxide (ZnO) nano particles in poultry production. In the study of Hassan et al. (2013), it was found that feed treatments with different concentrations of ZnO nano particles inhibited the growth of mycotoxic fungi (A. *flavus, A. ochraceus and A. niger*) and consequently mycotoxicosis conditions. Ibrahim et al. (2017) suggested that replacing traditional inorganic ZnO source with nano-ZnO or combining nano-ZnO and Zn methionine at applied concentration, promoted the growth of broilers, enhanced Zn uptake and antioxidant status without negative influence on selected minerals distribution in broilers tissues. In addition, compared to inorganic-Zn form, supplementation and/or substitution with organic-Zn and/or nano-Zn form (20 ppm) had a positive influence on broilers body weight, body weight gain and feed conversion rate, Zn concentration in bird's serum and tissue, and increased return and net profit (Badawi et al., 2017). Feeding zinc nanoparticles to chickens encouraged chickens growth, immunity and reproduction (Swain et al., 2016).

A trial of Vijayakumar and Balakrishnan (2014) revealed that feeding of broilers with calcium phosphate non-particles to replace 50% of dicalcium phosphate requirement induced significant better feed conversion rate in comparison with control groups. Moreover, Hassan et al. (2017) concluded that using nano di-calcium phosphate (NDCP) in broiler diets allow successfully to reduce the dietary di-calcium phosphate (DCP) by 75%, diet formulated containing only 25% of the required non phytate P in form of NDCP could be used instead of 100% conventional DCP (CDCP) and using of dicalcium phosphate in nanoparticle size allow to reduce the excreted Ca and P by about 50% which reduce the impact of poultry on environmental pollution.

Using of copper nano particles in chickens was studied by Wang et al. (2011) who reported that copper nano particles loaded chitosan enhanced growth performance and immune status, enhanced protein synthesis and was beneficial to the caecal microbiota of broiler chickens. Copper silicate nanoparticles modified the intestinal microbiota of chicken, increasing counts of *Lactobacillus* species and decreasing *E. coli* (Minglei et al., 2013). Further, Miroshnikov et al. (2015) found improved growth, increased haemoglobin level, enriched copper and protein levels in serum and increased the arginine content in the chicken liver after intramuscular injection of copper nano particles. Nguyen et al. (2015) confirmed that addition of nano-crystalline metals of iron, copper, zinc oxide and selenium to chicken diet premix decreased inorganic minerals in diet premixes by at least four times, allowing chickens to absorb feed minerals more efficiently and consequently decreasing the risk of environmental pollution. Copper nano particles at level below 50mg/kg reduced intestinal coliform bacterial count in chickens than copper salts with concentration up to 200 mg/kg (EFSA, 2016).

IN LAYERS SECTOR

A study on nano-Se showed that supplementation with 0.3 mg kg^{-1} in dry diet induced better physiological effects of chicks (Mohapatra et al., 2014). In Egypt, Radwan et al. (2015) concluded that layer hen diet supplemental with nano-Se (0.25 ppm) showed improving in the productive performance and glutathione peroxides activity producing Se enriched egg which could supply 50% (35 μg) of the human Se recommended daily allowances.

Moreover, Ismail et al. (2016) observed that dietary supplementation of 32-44 weeks old layer turkeys with nano forms of zinc and Se induced significant ($P \leq 0.05$) increase in serum total protein and antibody titres against Newcastle disease virus, high level of blood haemoglobin, increase in relative weight of spleen and oviduct length, increase hen-day egg production rate and egg weight, better albumen and egg shell quality and improve feed conversion ratio compared with their control groups. Just recently, it was shown that supplementation of some minerals in nano form into turkey hen's diet, especially of Cu and Zn in the dose covering 10% of the demand is relevant to maintain homeostasis in turkey muscles, as indicated by the activity of the aminopeptidase (Jó´zwik et al., 2018).

IN EMBRYONATED CHICKEN EGGS

In-ova inoculation of copper nano particles at concentrations of 4, 8, 12 and 16 µg/egg, no bad effect was observed on chicken embryos (Joshua et al., 2016). It was recorded that copper nano particles at concentration of 50 mg/kg revealed an increase in oxygen consumption and heat production that are important regulators in different developmental stages of chicken embryos (Scott et al., 2016). Mroczek-Sosnowska et al. (2014 and 2015) demonstrated that copper nano particles at concentration of 50 mg/kg exhibit pro-angiogenic properties at a systemic level, with the promotion of blood vessel development during embryogenesis, and consequently, increase the body weight, improve feed conversion ratio and increase breast and leg muscles of broiler chickens. A concentration of 50 mg/kg silver nanoparticles chelated with amino acids, threonine and cysteine improved immune competence in embryos and chickens (Bhanja et al., 2015). Moreover, proliferating cell nuclear antigen positive cells in the long bones of broiler chickens was observed after *in-ovo* inoculation of copper nano particles indicating a stimulatory effect during embryogenesis (Mroczek-Sosnowska et al., 2017). Sawosz et al. (2012) showed that silver nanoparticles potentially improve muscle morphology without affecting broiler performance at embryo growth.

CHALLENGES FACING NANOTECHNOLOGY

The potential of nanotechnology in poultry production cannot be fully appreciated yet because of insufficient knowledge. *It can lead to many* beneficial effects, *but may also* have many adverse effects or unclear hazards to humans, animals and the environment (Huang et al., 2015). Kannaki and Verma (2006) mentioned the future challenges of nanotechnology as; improving feed efficacy, controlling nutrient absorption, counteracting pathogens, *targeted* drug delivery, growth promoter, modifying the contents of the egg like full protein or cholesterol free eggs, decreasing energy and protein wastage, and reducing the cost of poultry meat. Nanoparticles materials could be included in poultry feed as a trial for prevention of diseases. Nevertheless, there are certain obstacles facing feed inoculation of these particles including; particles processing, their distribution and their condition in case of feed storage as well as their low bioavailability (Gallocchio et al., 2015). The meat of animals fed on these particles showed poor quality due to low resistance to micro-organisms growth, poor water retention and poor carcass traits (Fang et al., 2015). In addition, there is a lack of knowledge on the fate of ingested nanoparticles in human body and it is essential to investigate routes of exposure and also it is important to *accumulate* basic knowledge *on* their absorption, distribution, metabolism, and excretion (Bai et al., 2018). Potential toxicity of nanomaterials *is* not fully studied and risk assessments including hazard identification, hazard characterization and exposure assessment are essential (Oberdörster et al., 2005).

CONCLUSION

Encouraging results from recent studies proved that supplementation of poultry with nano materials in different forms seems promising on the performance, health and immunity as well as reducing pathogen gut load. These nanomaterials are still in their infancy, so much work is still required to support the safety of application of them in animal nutrition, avoiding any harm to livestock, the environment and human beings and to reduce the gaps between the knowledge and application.

CONFLICT OF INTEREST STATEMENT

The author declares no conflict of interest.

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