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Review Article

Silver Nanoparticles in Poultry Production

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Abstract

Nanoparticles of silver (nano-Ag) is an emerging alternative feed supplement for poultry and likely for medical applications. As a result of nanosilver special characteristic of killing bacteria, antimicrobial materials containing nanosilver are becoming increasingly important because of their wide range of applications. Despite the widespread use of nanosilver products, relatively few studies have been undertaken to determine the biological effects of nano- silver exposure. The ultimate objective of this paper is to clarify the potential of nano-Ag as an alternative growth promoting supplement for chicken.

Keywords: Silver nanoparticles; poultry; production

Introduction

Nanotechnology can be defined as, an innovative technology, which is used to create materials and change structure, enhanced quality and texture of foodstuffs at the molecular level. This technology has a major impact on production, processing, transportation, storage, traceability, safety and security of food (Otles and Yalcin, 2008).

The potential of nano-technology in poultry meat industry cannot be fully appreciated yet because of lack of sufficient knowledge. If Nanotechnology continues to advance at its current pace, we could expect that soon we will be able to create unlimited amount of meat by synthesis at the atomic level, which would eradicate hunger (Carmen *et al*., 2003).

Metallic silver nanoparticles (up to 100 nm) allow for a higher antimicrobial effect than silver salts, and are more resistant to deactivation by gastric acids and have a low absorption rate through the intestinal mucosa, thus minimising its potential risk of toxicity. Besides, it has been shown that the doses that promote animal physiological and productive effects are very low (20 to 40 ppm), especially compared to the 10 to 100-fold higher concentration used with other metallic compounds such as copper and zinc, thus precluding a harmful environmental effect.

Nanoparticles of silver (nano-Ag) is an emerging alternative feed supplement for poultry and likely for medical applications. Nano-Ag may affect metabolic activity and health of animals.

This review describes the reasons why silver nanoparticles could be applied to broilers and layers feeding, and provides with some available data in this regard. In any case, its registration as feed additive is a previous requisite before being applied in practical conditions.

Hypothesis and objectives

There are several hypotheses on which the use of silver nano particles was established in the field of poultry industry

1- The antibacterial properties of nano-Ag may affect microbial populations without inducing resistance and may increase anabolic activity that may lead to the stimulation of development and growth of animals.
2- Nano-Ag would contribute to the oxygen demand and would increase the rate of metabolism; and in effect will lead to the improvement of the growth and development of embryos.
3- Nano-Ag can affect gene expression of Fibroblast Growth Factor (FGF), which stimulates pro-

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liferation and differentiation of blood vessels, muscles and fibroblasts cells, promotes angiogenesis; Vascular Endothelial Growth Factor (VEGF) - necessary for proliferation and organization of endothelial cells, promotes angiogenesis; Paired box gene (Pax7) - transcription factor, development of satellite cells in muscles; Proliferating Cell Nuclear Antigen (PCNA) - trimmer of DNA synthesis and repair; all essential during embryogenesis and important postnataly.

4- Nanoparticles of silver can increase activity of cell's immunity by stimulating heat shock protein (HSP) synthesis, without pro-inflammatory pathway activation.

Therefore, the ultimate objective of using silver-nanoparticles in poultry production research is to evaluate the potential of nano-Ag as an alternative growth promoting supplement for chicken.

Influence of Ag-nano on microbial GIT profiles

The possible effects of metallic silver and silver ions over microorganisms from the digestive tract are scarcely documented. The selective response of silver in such ecosystem, with a wide diversity of species that can exert either symbiotic (positive) or pathogen (negative) effects, deserves further attention.

Silver compounds have been historically used to control microbial proliferation (Wadhera and Fung, 2005). The antifungal and antibacterial effect of silver nanoparticles, even against antibiotic-resistant bacteria (Wright *et al*., 1994; 1999) has been demonstrated in vitro conditions.

Cho *et al*. (2005) showed that either gram-positive (*Staphylococcus aureus*) or gram-negative bacteria (*E. coli*) are sensitive to silver nanoparticles. They observed strong antibacterial activity of a Ag-nano solution stabilized with poly-(N-vinyl-2-pyrrolidone) with minimal inhibitory concentrations at 5 mg/kg and 10 mg/kg for *Staphylococcus aureus* and *E. coli*, respectively. Interestingly, both strains of bacteria had severely disrupted cell walls after treating with Ag-nano.

Quails given water with 25 mg/kg Ag-nano had significantly increased number of gram-positive bacteria (*Lactobacillus* spp, *Leuconostoc lactis Actinomyces naeslundii*) comparing to control birds. There was a tendency of increasing number of *Streptococcus bovis* colonies in samples taken from quails receiving 25 mg/kg Ag-nano. However, Ag-nano did not influence *Enterococcus faecium* population. Furthermore, there was no significant effect on the number of *E. coli* and other enterobacteriaceae (Sawosz *et al*., 2007).

Traditionally, silver has been used as salts (ionic form), mainly nitrate, sulphate or chloride. However, silver cation is converted into the less effective silver chloride in the stomach or bloodstream, and can form complexes with various ligands. Silver nitrate is unstable, and can be toxic to tissues (Atiyeh *et al*., 2007). In contrast, metallic silver in form of colloidal solution or as 5 to 100 nm nanoparticles is more stable to hydrochloric acid, is absorbed at a much lower extent by euchariotic cells and therefore is minimally toxic, and at the same time exert a higher antimicrobial effect (Choi *et al*., 2008), which explains why its use has been promoted in the last decades (Atiyeh *et al*., 2007). Lok *et al*. (2006) showed that, even though silver nanoparticles and silver ions in form of silver nitrate have a similar mechanism of action, their effective concentrations are at nanomolar and micromolar levels, respectively.

Yoon *et al.* (2007) observed a higher effect of silver nanoparticles on *Bacillus subtilis* than on *Escherichia coli*, suggesting a selective antimicrobial effect, possibly related to the structure of the bacterial membrane, although Singh *et al*. (2008) assume higher sensitivity of Gram-negative bacteria to treatment with nanoparticles.

Performance

No pathological symptoms or changes in behaviour of feed or water consumption were observed. Furthermore, daily intake of feed and water was almost similar in all groups (between 15.0 – 15. 9 g feed and 39.1–41.8 g water per quail). The initial body weight was 40 g and the final body weight after 12 d was between 98.9–102.2 g (Sawosz *et al*., 2007).

Ahmadi and Kurdestani (2010) reported that silver in the form of nanoparticles had no effect on weight gain of broilers. In contrast, Andi *et al.* (2011) recorded a significant improvement in the weight gain, feed intake anf feed conversion ratio of broilers fed Nanosil (silver nanoparticles). This action may be due to the effect of ionic silver on harmful bacteria in intestine and resulted in healthy hindgut and better absorption of nutrients.

Shabani *et al.* (2010) showed that birds fed a diet contaminated with Aflatoxins (AF) without Zeolite_Hydrocolloidal Silver Nanoparticles (NZ) had lower weight gain and higher feed conversion ratio than other groups. The utilization of NZ in diets contaminated by AF resulted improved broiler performance similar to control diet. Birds fed diet containing AF without NZ had significantly lower feed intake than control diet. Feeding of AF contaminated diets without NZ to broilers led to significant decrease of serum total protein and albumin.

Histological Parameters:

Analyses of histological sections of duodenum wall showed no evident changes between Quails fed with Ag-nano and the control group. There were no changes in the structure of enterocytes (epithelial tissue which act as first barrier for chyme elements), glands and connective tissue of intestinal villi. Also the number of leukocytes, which is typical for tissue inflammation, did not increase (Sawosz *et al.*, 2007).

Ahmadi *et al.* (2009) study the effect of four treatments four repetitions at 0, 300, 600 and, 900 ppm of silver nanoparticle levels on the structure of intestine and liver of broiler chicken. They recorded no statistically significant differences in the effects of different levels of silver nanoparticles about intestine and liver tissue. However, the height of brush borders increased after treatment of silver naniparticles and so this increase found for absorption and conversion ratio. The results showed that different levels of silver nanoparticles had no significant difference on cell changes of liver tissue.

Loghman *et al*. (2012) evaluated the toxicity of nanosilver and observed pathological and morphological changes in the liver of broiler chickens. The results clarified that, the control group showed healthy liver tissue with no specific lesion. In the first treatment (4 ppm), infrequent accumulations in the hepatocytes (cell swelling) and hyperemia. Second and third treatments (8 and 12 ppm) showed dilated central vein, hyperemia with severe fatty change. In the third treatment (12 ppm), increased connective tissue (fibroplasia) and focal necrosis of hepatocytes. Lesions and apoptotic cells in groups 3 (8 ppm) and 4 (12 ppm) were more severe than in group 2 (4 ppm). They concluded that higher concentrations of nanosilver (8 and 12 ppm) can induce sever lesions in chickens liver. This study provided that, its (more than 4 ppm) harmful effect on the liver cells, especially in broilers, and recommended the use of nanosilver as anti microbial agent in poultry industry with caution and that the necessary conditions should be observed.

Relative Organ Weight:

Andi *et al*. (2011) Showed that silver (especially in the form of nano-particles) had negative effects on relative liver weight to live body weight. Absorbed silver ions from gastrointestinal tract enter liver through the portal vein and might have impact on the liver since the liver serves as the first checkpoint for everything absorbed before becoming systemic. Also, they recorded bigger bursa and spleen that are contrary with investigations of Ahmadi and Kurdestani (2010).

Blood Parameters

Silver nano-particles had negative effects on serum uric acid but no effects on SGOT an SGPT This is a sign of kidney destruction since uric acid is a metabolite that synthesized in kidney (Drake and Hazelwood, 2005; Andi *et al*. 2011).

The nanoparticles had no effect on activity of enzymes; ASP, ALT and AP, and on concentrations of glucose, TG and cholesterol. (Sawosz *et al*., 2009)

Nanoparticles of silver in chicken embryos

Chicken embryo is a unique biological model because it is independent from mother organism and there is no external nutrient supply.

Sawosz *et al*. (2009) concluded that, administration in ovo of 50 ppm hydrocolloids of nanoparticles of Ag and alloys of Ag with Cu and Pd did not influence mortality, growth and development of 48 h and 20 days old embryos. This treatment did not increase oxidative damage of liver DNA and had no effect on biochemical indices of blood serum and activity of liver enzymes

Nano-Ag deposited in embryo's bone but did not affect structure and mechanical properties of the bone. There was a tendency of increasing mineral content, indicating that nanoparticles may influence bone mineralization (Sikorska *et al*., 2010).

Conclusion

Metallic silver and silver salts have currently been applied as antimicrobial agents in many aspects of medical industries with a minimal risk of toxicity in humans. However, their uses in animal feeding as prebiotics have remained minimized, mostly because of the low cost antibiotics used as growth promoters.The use of nanosilver as anti microbial agent in poultry industry is recommended with caution. So, it needs further work in the future.

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