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Effect of Silver Nanoparticles on Performance, N Metabolism and Microbial Profile of Broiler Chicken

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Introduction

As a result of the European ban on in-feed growth-promotng antibiotics, the on-going search for alternatives has prompted interest in the use of silver nanoparticles (AgNano) as an antimicrobial agent (Monteiro et al 2009). Metallic silver compounds and its ions have long been known to have unique antibacterial properties; however, because ionic silver is toxic, its usage has been limited. The application of nanotechnology has enabled silver to be engineered to nanosize (1–100 nm) and to have large functional surface area (Luoma 2008). At the nano-scale, AgNano exhibits unique biological properties and broad-spectrum of antimicrobial activity. Furthermore, it has been hypothesized that because nanoparticles act in a physical rather than in chemical manner, they will not cause microbial resistant bacteria. These features makes AgNano a potent alternative feed supplement for animals and likely for medical applications (Chen and Schluesener 2008; Fondevila, 2010).

In poultry production, AgNano may function as an alternative to antibiotic based growth promoters. Silver is toxic to microorganisms (Percival et al. 2005), and may also, like other metal compounds such as zinc and copper that are used as growth promoters in animal nutrition, modulate the digestive microbiota.

Furthermore, silver has high affinity to nitrogen (N) molecules (Sebastian et al 2005) and the application of AgNano in poultry production could be a strategy in the future to minimize N pollution. As N excretion continues to be a major issue in the modern poultry production, we speculate that this affinity of silver to N will favor higher retention and in effect reduce N excretion.

The study evaluated the potential of adding AgNano to drinking water as a growth promoting supplement for broiler chicken and investigated the effects on the microbial profile of the ileum and caecum, immune status, utilization of N and growth performance in broiler chickens.

Experimental Treatments

Three concentrations of AgNano (0, 10, 20 mg/kg; i.e. Control group, Group AgNano10 and Group AgNano20, respectively) were provided via the drinking water to broiler chickens from day 7 to 36 post-hatching. The birds were fed ad libitum with commercial broiler diet (2914 kcal/kg ME, 17.6% crude protein, 3.3% crude fat, 3.8% crude fiber, 5.2% ash, 8.7 g/kg lysine, 4.1 g/kg methionine, 3.2 g/kg cystine). Body weight (BW) and feed consumption were measured weekly. Feed conversion ratio (FCR) was calculated as the feed consumption:weight gain ratio. At days 22 and 36, blood samples and intestinal content were collected to evaluate the effects of AgNano on plasma concentration of immunoglobulins and the intestinal microflora, respectively. Balance experiments were carried out to determine nitrogen (N) utilization. For detailed information cf Pineda et al, 2012a, 2012b.

Growth performance

The supplementation of AgNano at 10 and 20 mg/kg had no effect on feed intake, BW and FCR of broiler chickens (Table 1). The feed intake and the ability of the birds to retain N were the same in all the groups; and this explains the similarity in BW gain. Consequently, the ability of the birds to convert feed into body gain did not differ significantly among the treatments. The lack of effect of AgNano in this study could be due in part to the number of birds used and possibly influenced by the good state of health of the birds as a result of optimum environmental conditions. However, we may expect that AgNano would exhibit greatest benefits when birds are exposed to stressful conditions, for example when levels of pathogenic bacteria are high.

Nitrogen metabolism

Data on N balance indicated that broilers of Group AgNano10 and AgNano20 significantly increased N intake and retention, but did not result in a significant reduction of N excretion, probably due to the limited number of birds used. However, it should be noted that N excretion, when calculated relative to N intake, was 1% and 2% lower for Groups AgNano10 and AgNano20 than for the Control. Extrapolated to practical production conditions with high bird numbers, a 1–2% reduction in N excretion may contribute to a significant reduction of N pollution.

Microbial profile

The provision of AgNano via drinking water had no influence on the populations of bacteria in the intestinal samples. AgNano did not affect the most dominant ileal species in particular lactic acid bacteria. Furthermore, no effect of AgNano on caecal numbers of anaerobic bacteria, lactic acid bacteria, lactose-negative and coliform bacteria, as well as Enterococci and Clostridium perfringens was observed. Thus the antimicrobial activity under in vivo conditions was not confirmed in this study.

The results of the immune assay demonstrate that AgNano has a profound effect on the IgG concentration of broilers at a later age, indicating that AgNano may interact with the humoral immune system of the bird. However, additional studies should be conducted to provide further evidence.

Conclusion

AgNano did not elicit an improvement of growth performance of birds, and the antimicrobial activity of AgNano was not exerted under in vivo conditions, presumably because birds were kept under optimum environmental condition. However, the affinity of silver to N was exhibited in terms of N retention. Although the difference in absolute values was small, the provision of AgNano via the drinking water could be used to increase N retention and could reduce N pollution; however, its impact on growth performance, microbial profile and N excretion should be explored at the commercial scale of poultry production.

Table 1. Nitrogen metabolism and growth performance of broiler chickens after post-hatch treatment with increasing concentrations of AgNano

	Experimental group			
	Control	AgNano10	AgNano20	*SE*[#]
N metabolism[*]				
Intake [$g/kg^{0.75}$]	3.0^{b}	3.2^{a}	3.1^{ab}	0.09
Excretion [$g/kg^{0.75}$]	1.4	1.5	1.4	0.04
Retention [$g/kg^{0.75}$]	1.6^{b}	1.7^{a}	1.7^{b}	0.06
Utilization [RN/IN][+] [%]	53.0	53.7	54.1	0.42
Growth performance[*]				
Body weight [g]	563	609	600	6.66
Feed intake [g]	67.8	72.7	71.9	0.84
FCR[=]	1.8	1.8	1.9	0.02

[*]Values are pooled means of 6 cages, each containing 4 birds from balance periods 1 to 4; [#]SE, Pooled standard error; [ab]Within rows, means with different superscripts differ significantly ($P < 0.05$); [+]Nitrogen utilization (RN/IN);RN: retained nitrogen, IN:intake of nitrogen; [=]FCR: feed conversion ratio.

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