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The New Progresses in Zn Requirements of Poultry

Review Article

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ABSTRACT

There were no considerable up to date on the trace element requirements of commercial poultry in recent years in despite of the progress in their performance traits. One of the more prevalent problems in modern broiler production system which could be attributed to the trace mineral inadequacy is skeletal disorders. Zinc, is an essential trace element which acts as a co-factor in several metaloenzymes and plays an important role in different metabolic pathways. Zinc deficiency in poultry affect the protein and carbohydrate metabolism and have negative effects on feed intake, growth rate, feed conversion ratio and also is associated with immunological, reproductive, skeletal and skin disorders. The commercial poultry producers often use a considerable safety margin for trace minerals including Zn in feed formulation, which will resulted in trace mineral excretion into environment. There are differences in the recommended dietary Zn requirement between commercial strains of broiler chickens and all of them are differ from NRC (1994) recommendations.

KEY WORDS dietary requirements, NRC, poultry, zinc.

INTRODUCTION

Zinc, a vital trace element for human and animals, acts as a co-factor in more than 300 metaloenzymes and plays an essential role in many metabolic pathways, such as protein synthesis (Salim *et al.* 2008). The zinc readily available stored pools in animal body are limited, then there is a need to daily Zn supply via diet (Bao *et al.* 2009). A considerable progress has been achieved in commercial poultry performance in recent decades. Both excess and inadequate zinc consumption negatively affects feed intake, growth rate and feed conversion ratio (FCR), defects protein and carbohydrate metabolism and cause abnormalities in immune responses, reproductive performance and skeletal and skin disorders (Underwood and Suttle, 1999). A comparison between NRC (1994) recommendation and modern commercial strains of broiler chickens indicates that the industry often use a big safety margin for Zn in broiler feed formulation. An adverse outcome of this safety margin is more mineral excretion into environment. In a recent survey on the previous efforts to determine Zn requirements of broiler chickens, Zaghari *et al.* (2015) reported a wide range from 10.6 to 105 mg/kg diet.

On the other hand, differences in Zn requirement estimates are probably related to factors such as dietary fiber and protein source, dietary ascorbic acid, source of dietary Zn and interactions with other minerals in the diet (Ammerman *et al.* 1995).

This review is trying to summarize new finding in Zn supplements applications in poultry nutrition and its outcome on birds' performance, health, immune system function and reproductive traits.

Zinc importance in poultry nutrition

Introducing the organic Zn supplements, allowed the modern broilers to intake their required dietary levels with a lower dietary Zn supplementation. The nanoparticles of Zn are a more recent generations of supplements which are under investigations. The source of Zn influences the dietary requirement of it in poultry. Huang *et al.* (2009) reported the relative bioavailability of Zn in three organic zinc compound and ZnSO and concluded that the bioavailability of organic Zn compounds was highly related to their chelation strength. Lina *et al.* (2009) reported that both protein-bound zinc and nano-ZnO improved antioxidant capacity in the body, increased the activities of the antioxidant enzymes and reduced the concentrations of free radicals in poultry. They recommendation was 40-80 mg nano-zinc/kg of diet in broilers.

In the study of El-Wahab *et al.* (2013) a blend supplement of biotin and 150 ppm organic Zn-methionine, reduced the severity of foot pad dermatitis in broilers reared under high litter moisture condition. Saenmahayak *et al.* (2010) also reported an improved skin quality and decreased in the severity and occurrence of foot pad dermatitis in broilers when dietary inorganic Zn supplement was partially replaced with organic Zn. El-Samee *et al.* (2012) fed laying quails with diets supplemented up to 40 ppm of organic Zn and observed an improvement in weight, fertility and hatchability of eggs. Zhao *et al.* (2016) reported that zinc oxide nanoparticles affected egg quality and in particular lipids metabolism in hens by modifying the function of hen's ovary and liver.

Soni *et al.* (2013) reported that Zn-methionine at 80 ppm dietary inclusion rate improved cellular immune response to phaseolus vulgaris lectin P (PHA-P) and enhanced antibody titres against sheep red blood cells (SRBC) in broiler breeder hens. Ao *et al.* (2007) found that 12 mg/kg dietary Zn or 7.4 mg/kg dietary Zn plus phytase are required for normal growth of broiler chickens. Many authors recommend that in heat stress conditions, dietary zinc supplementation could have antioxidant and anti-stress effects (Nollet *et al.* 2008; Kucuk, 2008). Lin *et al.* (2006) also observed a lower corticosterone in birds under heat stress following zinc and vitamin C supplements administration and attributed it to its antioxidant and antistress properties.

Zinc is necessary as a cofactor of vital antioxidant enzymes. Cu/Zn superoxide dismutase, moderates the unnecessary high level secretion of corticosterone and reduce NADP dependent lipid peroxidation (Kucuk, 2008). Sahin *et al.* (2002) found that 30 mg Zn/kg in the diet of laying hens exposed to cold stress (6.8 ˚C) reduced serum corticosterone, glucose and cholesterol. These authors also reported that 30 or 60 mg dietary Zn fed to quails under heat stress decreased serum corticosterone concentrations. Comparable data has been reported by other authors with regard to the antioxidant and antistress properties of zinc and vitamin C in controlling excessive corticosterone secretion and corticosterone-induced systemic biochemical alterations (Sahin *et al.* 2002; Kucuk *et al.* 2003). Yardibi and Turkay (2008) reported a decreased egg production in layer hens under heat stress. However, the dietary inclusion of 35 mg/kg Zn as Zinteral 35 and 250 mg vitamin C during stress improved egg production in hens.

In another study, Gerzilov *et al.* (2015), reported that a blend of zinc and vitamin C in the diet of layer hens decreased the negative effects of both cold and heat stress. Hens fed diets containing 35 mg Zn/kg or 35 mg Zn + 250 mg vitamin C/kg showed an improvement in egg production by 2.22% and 4.60% compared to the control group, respectively. There is apparently a synergism between zinc and vitamin C in reducing the impact of both cold and heat stress on egg production in hens. Consistent with these results, Kucuk *et al.* (2003) reported that 30 mg/kg dietary zinc plus 8 mg/kg pyridoxine increased productive performance of the laying hens. Sperm metabolism also improved in layer hens fed 100 ppm Zn supplement (Shanmugam *et al.* 2014). Saenmahayak *et al.* (2012) studied the effect of an organic Zn supplement (40 ppm) on the quality of broilers' meat and found an improvement.

Yang *et al.* (2016) showed that ZnPal inclusion altered muscular mineral content, improved meat quality and increased the muscular antioxidant capacity of broilers. They concluded that dietary Zn supplementation in the form of ZnPal at the level of 20 mg/kg would be enough in enhancing meat quality and meat oxidative status. Rao *et al.* (2016) reported that organic form of Zn supplementation at 40 mg/kg of diet significantly improved the growth performance and antioxidant properties of broiler chickens exposed to heat stress during 1-21 days of age.

An improvement in lipid metabolism and reduction in skin's fat was also reported by Refaie and Eisa (2014) using nanoparticle of zinc oxid (ZnO) at 80 mg/kg in broiler diet. Ebrahimnezhad *et al.* (2013) reported that 60 or 90 ppm dietary supplementation of nano ZnO in broiler chicks significantly increased the relative weights of breast and thigh compared to the control group. Kim and Patterson (2005) did not find any unfavorable effect for overdose of zinc (1000 mg/kg of diet) on body weight, feed intake, egg production and egg weight in the laying hens. Zhang *et al.* (2012) reported that dietary Zn supplementation up to 120 mg/kg improved the intestinal mucosal damage induced by *Salmonella typhimurium* challenge.

Zn requirement of broiler chickens

Zinc is a vital trace element for avian growth, bone development, feathering and feed intake regulation (Batal *et al.*

2001). The dietary inclusion of zinc at 120-180 mg/kg of diet is as usual in poultry diets (Park *et al.* 2004). The chemical structure of zinc source is a key factor to dietary Zn supplement inclusion. Zinc oxide (ZnO:72% Zn) and zinc sulfate monohydrate ($ZnSO_4$,H_2O:36% Zn) are two usual sources of zinc in poultry diets. However, the availability of ZnO is less than $ZnSO_4$ (Sandoval *et al.* 1997).

$ZnSO_4$ is very soluble in water and enhances free-radical formation by reactive metal ions, which leads to oxidation of vitamins and degradation of fats and oils that decrease the nutrient value of the feed (Batal *et al.* 2001). On the other hand, ZnO is less reactive, but also less bioavailable (Park *et al.* 2004).

Although animals usually are highly tolerant to zinc overdose (Fosmire, 1990), there are reports on the hazardous effect of high dietary zinc on growth performance, mortality, feed intake, gizzard and pancreas in laying hens (Dewar *et al.* 1983).

There are interactions between zinc and other elements which could anfluence the Zn requirement of birds. There are reports that, high dietary Cu decrease Zn bioavailability through competing for absorption sites. Oestreicher and Cousins (1985); Bremner and Beattie (1995) and Zhao *et al.* (2016) reported that, dietary 250 mg/kg Cu reduced feed intake and weight gain in birds fed $ZnSO_4H_2O$, but had less impact in birds fed Zn(HMTBa). These authors also found that FCR was reduced and tibia Zn was increased with increasing Zn levels from 30 to 75 mg/kg and broiler chickens fed Zn(HMTBa) had superior feed intake and growth rate compared to birds fed $ZnSO_4$, especially at lower dietary Zn levels.

They concluded that chelated organic Zn was better utilized than inorganic zinc in the diets containing high Cu levels. In another study Ognik *et al.* (2016) in an *in vitro* study reported that Cu over dose in the intestines reduces absorption of calcium and zinc, but does not affect iron absorption.

The optimal mineral requirements for broilers are also affected by performance, meat quality, and immune status (Yang *et al.* 2011). A level of 40 mg/kg Zn dry matter has been recommended by NRC for broiler chickens.

The Zn requirement suggested by NRC is based on findings using semi-purified diets (O'Dell and Savage, 1957; Roberson and Schaible, 1958).

For Leghorn laying hens and chicks in different intake units and different ages NRC recommended levels are given in Table 1.

Zn requirements of two commercial strains (Ross 308 and Cobb 500) are represented in Table 2. It can be noted that supplementary levels of NRC are higher than commercial catalogues which means NRC has a higher marginal level than both catalogues. In another report, Rosatgno *et al.* (2011) in the Brazilian tables for poultry and swine: Composition of feedstuffs and nutritional requirements, suggested Zn requirement in broiler chickens at 1-7, 8-21, 22-33, 34-42 and 43-49 days of age as follow: 81.3, 71.5, 65.5, 48.8 and 42.3 mg/kg, respectively.

Zaghari *et al.* (2015) reported that the best growth rate was achieved in broiler chickens (Ross 308) fed 60.1 and 57.4 mg/kg dietary zinc, which were more than NRC (1994) recommendation and less than Ross 308 broiler recommendation (100 mg/kg).

After 1994 there is no update for NRC requirements. It is thus reasonable to consider the current NRC recommendation as unsuitable for the needs of the modern bird. But commercial companies are updating their data. For example requirements of Zn for Ross 308 have been increased since June-2007.

In that year the recommended supplementary level was 100 mg/kg for starter, grower and finisher broiler chicks but in recent publication (2014) it has increased to 110 mg/kg for this strain. Comparison of Cobb 500 requirements shows no differences in supplementary levels between May-2008 and October-2013 for all growing periods.

Table 1 NRC (1994) recommendations for Zn requirements (mg/kg)

	0-3 week			3-6 week			6-8 week
Broiler chicken	40			40			40
	Leghorn laying hen, mg/kg			Leghorn laying chick, mg/kg			
Leghorn	80 Unit intake	100 Unit intake	120 Unit intake	0-6	6-12	12-18	18- first wk. of lying
	44	35	29	40	35	35	35

Table 2 The recommended levels of Zn requirements for Cobb and Ross broiler strains

Broiler chicken	Cobb 500 (mg/kg)					Ross 308 (mg/kg)			
	Year	Starter 0-10	Grower 11-22	Finisher 1 23-42	Finisher 2 43 day	Year	Starter 0-10	Grower 11-24	Finisher 24-market
	2008	100	100	100	100	2007	100	100	100
	2013	100	100	100	100	2014	110	110	110

CONCLUSION

This review article showed that there is a rend to find new aspects of zinc roles in poultry nutrition. Especially, the progress in genetic improvment of commercial poultry in recent years has increased the importance of re-newing the dietary nutrients including zinc requirments.

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