OPEN ACCESS Potravinarstvo® Scientific Journal for Food Industry

Potravinarstvo, vol. 10, 2016, no. 1, p. 272-275
doi:10.5219/580
Received: 31 December 2015. Accepted: 27 May 2016.
Available online: 14 June 2016 at www.potravinarstvo.com

ISSN 1337-0960 (online)

THE EFFECT OF REDUCED ZINC LEVELS ON PERFORMANCE PARAMETERS OF BROILER CHICKENS

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ABSTRACT

The experiment was conducted to determine the effect of reduced supplemental zinc levels on broiler growth and carcass yield. A total of 160 male broiler chicks (Ross 308) divided into four groups were allotted to 16 cages with 10 birds per cage in each of group and kept in a temperature-controlled room. During the trial, chicks were ad libitum access to feed and water. The experiment started at 11 days of broiler age and chicks were fattened up to 35 days of age. It consisted of 4 dietary treatments with 4 replications per treatment. A corn-wheat-soybean meal basal diet containing 25.84 mg $Zn.kg^{-1}$ was formulated and zinc levels of 120, 40 or 20 $mg.kg^{-1}$ was supplied as zinc oxide to give four dietary treatments. At the end of the feeding trial, 24 birds from each group were randomly selected, slaughtered and carcass evaluation was performed. The results show that different levels of zinc had no significant effect on body weight of broilers or feed consumption ratio. These parameters increased by decreasing zinc levels from 120 to 20 mg $Zn.kg^{-1}$ similarly as the carcass yield, percentages of breast meat and leg meat, but differences between these groups were not significant. In case of relative liver weight and zinc concentration in liver there were significant difference (p <0.05) between group given supplemented zinc of 40 $mg.kg^{-1}$ and group without zinc supplementation and 120 $mg.kg^{-1}$ and 40 $mg.kg^{-1}$, respectively. No signs of disorders such as loss of appetite, growth depression or abnormalities of the skin was appeared in chicks. It seems that reduced supplemented zinc levels from 120 to 20 $mg.kg^{-1}$ (total Zn 153.13 $mg.kg^{-1}$ to 45.28 $mg.kg^{-1}$ respectively) not influenced growth performance parameters of broilers fed corn-wheat-soybean meal diet.

Keywords: broiler; zinc level; zinc oxide; carcass yield; liver

INTRODUCTION

Zinc (Zn) is an essential trace mineral, cofactor of more than 200 enzymes **(Nair and Choudhury, 2013)** involved in protein synthesis, carbohydrate metabolism and many other biochemical reactions, affects all cellular functions, especially growth and development of organism **(Ao et al., 2011)**. In all species, zinc is necessary for growth, immune system and disease resistance. Deprivation of zinc is characterized by loss of appetite, growth depression, abnormalities of the skin or outgrowths (hair, wool, feathers, hoof, horn) and reproductive disorders **(Suttle, 2010)**. Deficiency of zinc in chicks can cause decreased growth, frizzled feathers, shortened and thickened legs or enlarged hocks **(Nielsen, 2012)**.

The National Research Council (1994) estimates the dietary zinc requirement for broilers as 40 $mg.kg^{-1}$. The requirement of nutrients is usually defined as the minimum dietary concentration required for animal performance. A diet much higher in zinc (60 – 100 $mg.kg^{-1}$) apparently is needed to prevent disorders such as frizzled feathers in poultry **(Underwood and Suttle, 1999)**.

Feeds are routinely supplemented with zinc, because feed materials are either too low in zinc or availability of zinc is inadequate to cover the requirements. Zinc is added to the diets in inorganic sources (usually zinc oxide, zinc sulphate, zinc chloride) or in organic forms complexed to amino acids, proteins, or carbohydrates. The nutritional value of mineral sources depends on the composition of the diet, concentration in the feed, interactions with other mineral elements, and the bioavailability of the element to the chicks **(Star et al., 2012)**. The most commonly used sources of zinc are the oxide (ZnO). Fear of zinc deprivation causes exceed NRC (1994) recommendation, but if the requirement is markedly exceeded, additional zinc is not absorbed or endogenously secreted, but passes the gut and ends up in the manure **(EFSA, 2014)**. Manure from broilers fed high zinc levels spread on fields may enrich soil and drainage water with zinc and zinc contamination can affect quantity and quality of humus and lead to reduced crop yields.

The potential problem of high zinc in manure leaded to a recommendation by the Scientific Committee for Animal Nutrition (SCAN) to reduce zinc levels in feeds, followed by Regulation (EC) No 1334/2003 to decrease the maximum total zinc contents in complete feed for all animals. Maximum authorised total zinc content for poultry is 150 $mg.kg^{-1}$ complete feed. In 2014, EFSA posted a study „Scientific Opinion on the potential reduction of the currently authorised maximum zinc content in complete feed“ and the FEEDAP Panel proposed new maximum content of total zinc in complete feed for poultry (except turkeys for fattening) at the level of 100 mg $Zn.kg^{-1}$. EFSA expected that the reduction of maximum zinc contents in complete feed (from 150 to

100 mg Zn.kg^{-1} for broiler chickens) ensure health, welfare and productivity of food-producing animals as well as reduction of zinc emissions from animal production of about 20% in case of the application in feeding practices without affect consumer safety. The reduction of currently authorised maximum total zinc content in feeds would decrease the zinc load in the environment, but it is necessary to check the effect of reduced zinc levels on animal health and performance.

MATERIAL AND METHODOLOGY

Experimental birds, diets and treatments

A total of 160 7-d-old broiler chicks (Ross 308) were allotted to 16 balance cages with 10 birds per cage. The chicks had free access to feed and water throughout feeding trial. The lighting regime was 18 hours light and 6 hours dark. Birds were marked by wing tags and housed in a room that had a temperature set according to Management Handbook for broilers Ross 308. Temperature and relative humidity was recorded every day.

The experiment started at 11 days of broiler age and chicks were fattened up to 35 days of age. It consisted of 4 dietary treatments with 4 replications per treatment. As shown in Table 1, the basal diet was formulated to meet or exceed NRC (1994) nutritional requirements except zinc, with using Zn-low mineral premix containing minimum amount of zinc, so basal diet contained 25.84 mg Zn.kg^{-1} and it was added 120 mg of zinc.kg^{-1} (Zn 120) to achieve overall 153 mg Zn.kg^{-1}, (150 mg Zn.kg^{-1} is currently the maximum authorised total zinc contents for poultry). In other groups was added 40 (Zn 40) and 20 (Zn 20) mg of zinc.kg^{-1} and one group was without zinc supplementation. The source of added zinc was zinc oxide (ZnO). Total content of zinc in the diets were analysed (Table 2).

Feed consumption was noticed every day. Body weight of each chicks was measured on the digital scales at the start of experiment (11 d of age), then twice a week in the morning before feeding and at the final day (35 d of age) before slaughter.

Table 1 Composition of the basal diet fed from d 11 of age to 35 d of age.

Ingredients	%
Maize	34
Wheat	31.5
Soybean meal	26
Sunflower oil	4
Vitamin-mineral premix [1]	2
Experimental Zn-premix [2]	2
Chromium oxide	0.5
Nutrient composition	
ME_N (MJ.kg^{-1})	12.69
Crude protein	20.66
Ether extract	5.89
Crude fibre	3.14
Ash	5.53
Lysine	1.19
Methionine	0.58
Calcium	0.97
Non-phytate P	0.30
Zinc (mg)	25.84

[1]Supplied per kilogram of premix: lysine 101.65 g, methionine 135.63 g, threonine 51.22 g, calcium 200 g, phosphorus 98.19 g, natrium 62.89 g, sulphur 0.39 g, chlorine 119.69 g, copper 752.5 mg, iron 3768.6 mg, zinc 44.73 mg, manganese 6046.07 mg, cobalt 11 mg, iodine 47.95 mg, selenium 8.96 mg, vitamin A 680000 IU, vitamin D 250000 IU, vitamin E 2250 mg, K_3 74.8 mg, B_1 206.44 mg, B_2 344 mg, B_6 300.44 mg, B_{12} 1999.2 mg, biotin 11 mg, niacinamid 1793.4 mg, calcium pantothenate 676.2mg, folic acid 82.8 mg, cholinechlorid 9000 mg.

[2]Content different levels of Zn according to the dietary treatments.

Table 2 Dietary treatments.

Group	Supplement level of zinc (mg.kg^{-1})	Total content of zinc in the diet (mg.kg^{-1})
Zn 120	120	153.13
Zn 40	40	71.96
Zn 20	20	45.28
non-supplement	0	25.84

Evaluation of carcass quality

At the end of the experiment (35 d of age), 96 broilers (24 birds from each treatment) were selected, weighed and slaughtered by cervical cutting. Carcasses and livers were weighed, breast and leg meat were cut, skinned and percentages of live body weight were calculated.

Statistical analysis

Data has been processed by Microsoft Excel (USA) and STATISTICA.CZ, version 12.0 (CZ). The results were expressed as mean ±standard deviation (SD). It was used one-way analysis (ANOVA). Sheffe´s test was applied to defined statistical differences and differences between groups were considered significant at p <0.05.

RESULTS AND DISCUSSION

The correct environment and brooding conditions should be managed to meet all nutritional and physiological requirements to support body-weight gain throughout the growing period **(Nevrkla et al., 2015)**. Zinc oxide is commonly used source of zinc added as a supplement to poultry diets. The advantage of inorganic zinc sources is lower price, so inorganic zinc sources are still preferred than organic ones.

The effects of supplemental zinc level on slaughter weight and carcass yield are shown in Table 3.

Against non-supplement diet, slaughter weight was improved by Zn supplement of 20 mg.kg^{-1}, total dietary Zn of 45.28 mg.kg^{-1}. That agree with recommendation by **NRC (1994)** that a total dietary Zn concentration of about 40 mg.kg^{-1} is necessary to achieve normal growth in chicks. However, these parameters decreased by increasing zinc contents to 120 mg.kg^{-1} (total Zn 153.13 mg.kg^{-1}). **Mohanna and Nys (1999, In: Huang et al., 2007)**

Table 3 Effects of supplemental zinc levels on slaughter weight (g) and carcass weight (g).

Group	Slaughter weight	Carcass weight
Zn 120	2052.7 ±275.2	1505.1 ±229.5
Zn 40	2041.0 ±330.3	1499.4 ±253.2
Zn 20	2126.5 ±328.2	1573.8 ±263.2
non-supplement	1972.1 ±270.6	1438.5 ±213.7

No significant differences at a level of p <0.05.

reported that body weight gain increased with the dietary Zn supplementation of 25 mg.kg^{-1} (45 mg.kg^{-1} total dietary Zn), when chicks were fed a diet supplemented with Zn (added as Zn sulfate) at 0, 10 or 25 mg.kg^{-1}.

Jahanian et al., (2008) observed that this parameter was not affected by added zinc during wk 1 to 5, but in contrast with our results, in their trial taken 42 days, daily feed intake and weight gains decreased by decreasing Zn level from 120 to 40 mg.kg^{-1}. On the other hand, weight gain could be influenced by many other factors **(Nevrkla et al., 2014)**. **Haščík et al., (2010)** noted average saughter weight 2086 g at the age of 40 d of broiler cockerels fed commercial feed mixture and carcass weight 1475.20 g. **Liptaiová et al., (2010)** attained an average slaughter weight of unsexed broiler chickens 1651 g at 38 days of age and carcass weight 1124.17 g.

Carcass yield parameters are expressed as a percentages of live body weight measured at the day of slaughter (35 day of age). Breast meat and leg meat was weighed without skin. As shown in Table 4, the best efficiency of carcass (73.9%) and its parts, breast meat (21.3%) and leg meat (19.4%) was found in group Zn 20 and these parameters decreased with increasing Zn levels up to 120 mg Zn.kg^{-1}.

Nevertheless reduced zinc levels had no significant effect on carcass yield. Similar to our opinion, **Jahanian et al., (2008)** referred no influence of dietary zinc supplementation on carcass parameters. In their study, the highest percentage of carcass (68.64%) and breast meat (21.00%) was noticed in broilers given diet with added 80 mg Zn.kg^{-1} and relative carcass weight decreased by 120, followed 40 mg Zn.kg^{-1}, whereas breast yield decreased by 40, followed 120 mg Zn.kg^{-1}.

Our results show that zinc supplementation did not affect carcass yield, but affected relative weight of livers. Relative liver weights (see Table 5) is expressed as a percentage of live body weight measured at the day of slaughter (35 day of age). There was significant difference (p <0.05) between group Zn 40 and chicks fed non-supplemented diet.

Table 4 Effects of varying supplemental zinc levels on carcass yield (% of live body weight).

Group	Carcass	Breast meat	Leg meat
Zn 120	73.2 ±0.4	20.7 ±0.5	19.1 ±0.2
Zn 40	73.4 ±0.3	21.0 ±0.3	19.1 ±0.2
Zn 20	73.9 ±0.4	21.3 ±0.4	19.4 ±0.2
non-supplement	72.8 ±0.3	21.3 ±0.3	19.2 ±0.2

No significant differences at a level of p <0.05.

Table 5 Effect of dietary zinc on livers.

Group	Relative liver weights (% of live body weight)	Zinc concentration (mg) in 1000g of liver
Zn 120	2.13 ±0.19^{ab}	24.4 ±2.2^{a}
Zn 40	1.96 ±0.26^{a}	26.9 ±2.2^{b}
Zn 20	1.99 ±0.26^{ab}	25.8 ±2.3^{ab}
non-supplement	2.19 ±0.31^{b}	25.14 ±3.3^{ab}

Different letters ^{a,b} in the columns indicate significant differences at a level of p <0.05.

The heaviest livers were assigned to chicks fed on diet supplemented by 120 mg Zn.kg^{-1} (43.69), but relative to live body weight, non-supplemented group was the highest value (2.19), followed group Zn 120 (2.13).

Zinc concentration in liver calculated to 1000 g of liver is shown in Table 5. Dietary Reference Values have been established for zinc as 7 – 11 mg.day^{-1} for adult males and 6 – 9 mg.kg^{-1} for adult females. Tissues and products of animal origin participate in about 40 – 50% of total zinc intake. Based on collected data by **EFSA (2014)**, reduction in dietary zinc from 150 mg Zn.kg^{-1} to requirements do not affect zinc concentration in animal tissues so expect no concern about consumers' safety.

CONCLUSION

In this experiment, reduced zinc levels were evaluated for their effects on the growth performance of broiler chicks from 11 days up to 35 days of their age. Dietary zinc level had no significant effect on body weight or carcass yield. Only relative liver weight and zinc concentration in liver, there were significant differences (p <0.05). No signs of disorders such as loss of appetite, growth depression or abnormalities of the skin was appeared in chicks. It seems that reduced supplemented zinc levels from 120 to 20 mg.kg^{-1} (total Zn 153.13 mg.kg^{-1} to 45.28 mg.kg^{-1} respectively) not influenced growth performance parameters of broilers fed corn-wheat-soybean meal diet and incline to the proposal by EFSA to reduce total maximum zinc content in complete feed for broiler chicken, even so it will be necessary to examine interaction with other minerals before formulating feed with reduced zinc content.

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Acknowledgments:

The study was supported by IGA MENDELU 14/2015.

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