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Digestibility of feed nutrients, nutrient excretion and nutrient retention in broilers under consumption of combined feed with sulfate and zinc-mixed ligand complex

A. Redka, V. Bomko, M. Slomchynskyi, O. Cherniavskyi, S. Babenko

Bila Tserkva National Agrarian University
E-mail: foodrada@ukr.net

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Digestibility of the feed nutrients and the chemical elements balance in broiler chickens were studied under use of mixed feed with sulfate and Zink-mixed ligand complex in the physiological experiment that was conducted in the vivarium of the Bila Tserkva National Agrarian University. A tendency to increase the level of feed nutrients digestibility in the experimental groups of broiler chickens consuming mixed fodders with Zinc-mixed ligand complex was revealed in the conducted experiment. The nutrients digestibility indices were the highest in the chickens of the experimental group 3 where Zink-mixed ligand complex was added to the mixed feed. 45, 37.5 and 30 g of the element was added per 1 ton of mixed feed, respectively, for the growing period of 5-21, 22-35 and 36-42 days. The protein digestibility in this group was 89.2, fat - 82.5, fiber - 12.9 and Nitrogen free extractive substances (NFES) - 83.8%. The lowest digestibility indices of the nutrients were in the control group chickens, which, depending on the age, consumed feeds added with Zinc sulfate at doses corresponding to the introduction of 60, 50, and 40 g of the element per 1 ton of feed - 60.8, 80.2, 11.27, and 82.2%, respectively. Indicators of Nitrogen, Calcium, Phosphorus, and Zinc deposits in the body were also higher in the chicks of the experimental group 3 consuming the feed with Zink-mixed ligand complex. Feeding the birds with Zinc-mixed ligand complex as a component of mixed feed, in comparison with sulfate, improves the nutrients digestibility and increases the amount of chemical elements deposited in the body, which makes it possible to reduce the dose of the additive.

Key words: broiler chickens; nutrients digestibility; Nitrogen balance; Calcium balance; Phosphorus balance; Zinc balance; Zinc-mixed ligand complex; Zinc sulfate

Introduction

Farming the poultry of modern meat breeds and crosses under intensive industrial production allows to achievethe highest level of profitability compared to production of other species of animals. Yet, further intensification demands for developing the ways of increasing the mixed feed nutrients conversion into the products (Akbaev, Malofeeva, 2003; Boroday et al., 2003; Kravtsiv et al., 2005; Medvid et al., 2017). A complete mineral nutrition is one of the main prerequisites for high productivity of poultry. The absence or lack of certain mineral elements, as well as the violation of the correlation of their content in mixed feed, leads to a decrease in the level of mixed feed nutrient utilization and, consequently, causes a decrease in poultry productivity of (Melnyk, 2003; Polishchuk, Bulavkina, 2010; Richards et al., 2011; Sychov, 2017; Vertiychuk, Hlyebova, 2012).

Mineral elements entering the poultry body with feed and feed additives, participate in the enzymatic processes of feed nutrients digestion, their absorption, synthesis, decomposition and metabolic products excretion create the necessary conditions for the normal functioning of enzymes, hormones, vitamins as well as stabilization of acid-base balance and osmotic pressure (Zhang et al., 2017; Yurchenko, 2013).

The experience gained and the studies conducted in the field of poultry feeding have made it possible to introduce significant changes in the poultry production technology. Due to this, the issue of ensuring the poultry rations supply with microelements has recently been paid more and more attention. The mineral element of Zinc metal-

biotic, which must be added to the mixed feed composition in the form of additives, is of vital importance (Brzóska, Moniuszko-Jakoniuk, 2001; Liu et al., 2015; Melnyk, 2015; Peluffo, Acarin, 2005; Yanovych, 2002).

Zinc is a necessary element in the animals' body as it activates various enzymes and hormones, affects the metabolism of proteins, fats and carbohydrates as well as strengthens the immune system and affects broiler chickens hatchability. Lack of Zinc in the poultry body, above all, leads to violations in protein synthesis. As a result, the growth is suppressed and poultry production period increases which negatively affects the efficiency of the industry (Jackson et al., 2008; Lemesheva, 2003; Palmiter, 2004; Vaizelin et al., 2004; Yastrebov, Chyhryn, 2003). If the parent birds consume mixed feed with low level of Zinc, they have a decreased level of the element in the blood plasma, in bone tissue, pancreas, liver, kidneys along with the decreased activity of blood phosphatase and carboanhydrase, of carboxypeptidase A and B of the pancreas, lactate dehydrogenase of the heart, skeletal muscles, kidney, alcohol dehydrogenase. This ultimately causes a decrease in hatchability due to poor fertility of the eggs (Jarosz et al., 2017; Laity, Andrews, 2007; Malyuha et al., 2008; Olukosi et al., 2018; Vaizelin, Levosko, 2011).

The aim of the research was to determine the effect of Zinc sulfate and Zinc-mixed ligand complex as a component of mixed fodder on the digestibility of mixed fodder nutrients and the balance of chemical elements.

Methods

A physiological experiment on the study of the effect of feeding sulfate and Zinc-mixed ligand complex as a component of mixed fodder on the digestibility and the balance of chemical elements in broiler chickens was carried out by the grouping method.

Three groups were formed according to the principle of analogues - one control and two experimental ones, 3 birds in each (2 males and 1 female). The experiment lasted from 35 to 42 days of age. The weight of birds at the beginning of the experiment was: in the 1st control group – 1799.9 g, in the 2nd experimental – 1872.5 g, in the 3rd experimental – 1933.5 g. Calcium and zinc contents were estimated by atomic absorption, phosphorus content by the colorimetric method, nitrogen content was determined using the Kjedhal method.

Chickens were obtained from a parent flock, they were raised and kept at a poultry farm of the Scientific Research Centre of Bila Tserkva National Agrarian University. The broiler chickens' age and live weight were taken into account when selecting the analogues. All the requirements on carrying out zootechnical experiments were met in the experiment (Ibatullin, Zhurovsky, 2017; Klitsenko et al., 2001).

Results and Discussion

The results of the physiological studies conducted on broiler chickens of 35-41 days age, indicate a high digestibility of the mixed fodder nutrients. However, the digestibility of some nutrients depended on the Zinc-mixed complex introduction into the mixed feed and its dosage (Table 1).

Table 1. Nutrients digestibility (%), (M ± m)

Group	Nutrients			
	crude protein	crude fat	crude fiber	NFES
Control 1	86.80±0.66	80.20±0.60	11.27±1.15	82.20±0.69
Experimental 2	87.50±0.42	81.60±1.07	12.10±1.40	83.10±0.77
Experimental 3	89.20±0.62	82.50±1.12	12.90±0.87	83.80±0.64

Table 1 data analysis reveals that introduction of Zink-mixed ligand complex into mixed feed caused the increase in digestibility level of virtually all nutrients, but the highest digestion was in the chicks of group 3 consuming mixed feed with the Zink-mixed ligand complex in a dose corresponding to introduction of 37.5 g of the element per 1 t of the feed. Thus, the digestibility of crude protein, crude fat, crude fiber and NFES was higher than the corresponding rates in the control group, respectively, by 2.8, 2.9, 14.4 and 1.9%. Somewhat lower digestibility of nutrients was in broiler chickens of the experimental group 2 consuming mixed feeds with Zink-mixed ligand complex at a dose corresponding to introduction of 50.0 g of the element into 1 ton of feed, and it also dominated the digestibility parameters in the control group, respectively by 0.8, 1.7, 7.3 and 1.9%, although the probable difference between these indicators was not established.

The study of Nitrogen balance in experimental broiler chickens was carried out in a physiological experiment simultaneously with the study of the balance of Calcium, Phosphorus and Zinc and the level of digestibility of nutrients in the feed. The results of studying the daily average balance of Nitrogen are shown in Table 2.

Table 2. Average daily balance of Nitrogen, (M ± m, n = 3)

Index	Group		
	Control 1	experimental	
		group 2	group 3
Consumed with feed, g	4.91±0.631	5.14±0.550	5.26±0.542
Excreted with litter, g	2.0±0.088	2.01±0.096	1.95±0.098
Deposited in the body, g	2.91±0.057	3.13±0.065	3.31±0.083*
Ratio of consumed and deposited, %	59.3±1.15	60.9±1.25	63.0±1.58
Relative to the control, %	–	102.7	106.3

* p <0.05 - in comparison with the control group.

Table 2 analysis shows that the balance of Nitrogen in the body of the experimental broiler chickens of all groups was positive, and its use was at a rather high level. It was established that the introduction of various doses of Zinc into the broiler chickens mixed feed had different effect on the use of nitrogen substances in the feed.

The chickens of the control and experimental group 2 excreted almost identical amounts of Nitrogen (2.00 and 2.01 g), while the chickens of experimental group 3 excreted the least amount of the element - 1.95 g, although no probable difference for this indicator was established.

The lowest amount of Nitrogen was deposited in the body in the control group chickens - 2.91 g. The birds were fed with the mixed feed with addition of Zinc sulfate in a dose, which corresponded to the introduction of 50.0 g of the element per 1 ton of feed. A slightly higher amount of Nitrogen - 3.13 g was deposited in the body of chicks of experimental group 2. They consumed mixed feed with addition of Zinc-mixed ligand complex in a dose, which corresponded to the introduction of 50.0 g of the element per 1 ton of mixed feed, but the difference was uncertain.

The largest amount of Nitrogen - 3.31 g - was deposited in the body of chicks of experimental group 3. They were fed with fed with the mixed feed with addition of Zinc-mixed ligand complex in a dose, which corresponded to the introduction of 37.5 g of the element per 1 ton of the feed, and this difference was probable - p <0 , 05.

The lowest level of the deposited Nitrogen - 63.0% - was observed in the broilers of experimental group 3 which exceeded the rate of the control group by 6.3%. A slightly lower level of deposited nitrogen content - 60.9% - was in the broilers of experimental group 2 though it surpassed this indicator in the control group by 2.7%. The lowest level of nitrogen deposited from the consumed feed was in the control group birds - 59.3%.

Thus, we can conclude that the introduction of Zinc-mixed ligand complex into mixed feed in a dose corresponding to the introduction of 37.5 g of the element per 1 ton of the feed led to a probable increase in the amount of deposited Nitrogen in the body and allowed to increase the level of deposited Nitrogen from consumed fodder from 59.3 to 63.0%.

The average daily balance of Calcium in broiler chickens body also depended on the introduction of Zinc into themixed feed and its dosage (Table 3).

Table 3. Average daily Calcium balance (M ± m, n = 3)

Index	Group		
	Control 1	experimental	
		group 2	group 3
Consumed with feed, g	1.390±0.081	1.420±0.042	1.450±0.036
Excreted with litter, g	0.690±0.027	0.70±0.034	0.710±0.041
Deposited in the body, g	0.660±0.027	0.710±0.033	0.740±0.042
Ratio of consumed and deposited, %	48.60±2.02	50.20±2.38	51.0±2.87
Relative to the control, %	–	103.3	104.9

According to the data of Table 3, the balance of calcium in the body of experimental broiler chickens of all groups was positive, and its use was at the level of 48.6-51.0%. In the physiological experiment, it was found that the introduction of various Zink compounds at various doses affected its use differently.

The chickens of all experimental groups excreted approximately the same amount of Calcium (0.69- 0.71 g), while the amount of the element deposited in the body of chickens of the experimental groups 2 and 3 exceeded the control by 0.05 and 0.08 g respectively, although no probable difference for this indicator was established.

The lowest amount of Calcium in the chicken body - 0.66 g, was deposited in the control group chicks fed with Zinc sulfate at a dose corresponding to the introduction of 50g of the element per 1 ton of mixed feed.
Regarding the amount of Calcium deposited after the fodder consuming, it was the highest in the broilers of experimental group 3 - 51.0%, which exceeded the same indicator in the control group by 4.9%. A slightly lower level of Calcium deposited after consuming mixed feed was in the experimental group 2 - 50.2%, but it also surpassed the rate of the control group by 3.3%. The lowest level of Calcium deposited from consumed mixed fodders was in the control group birds - 48.6%.
Thus, we can conclude that the introduction of Zinc-mixed ligand complex into mixed feed in a dose corresponding to the introduction of 37.5 g of the element per 1 ton of the feed proved the tendency to increase the amount of Calcium deposited in the body which increased the level of the deposited element from the consumed mixed fodder from 48.6 to 51.0%.
According to the results of the physiological experiment, we determined the way the introduction of various Zinc compounds and their doses into the mixed feed affects the daily average balance of Phosphorus (Table 4).

Table 4. Average daily balance of Phosphorus, (M ± m, n = 4)

Index	Group		
	Control 1	experimental	
		group 2	group 3
Phosphorus consumed with feed, g	1.050±0.056	1.110±0.042	1.130±0.057
Excreted with litter, g	0.50±0.013	0.470±0.042	0.460±0.027
Deposited in the body, g	0.570±0.015	0.640±0.041	0.680±0.027*
Ratio of consumed and deposited, %	54.30±1.450	57.90±3.76	59.0±2.41
Relative to the control, %	–	106.6	108.6

* p <0.05; ** p <0.01; *** p <0.001 compared with the control group.

Table 4 analysis shows that Phosphorus balance in the body of experimental broiler chickens of all groups was positive, and its deposits was at the level of 54.3 - 59.0%. In the physiological experiment, it was found that the introduction of various Zink compounds at various doses did not have the same effect on the use of Phosphorus in the mixed feed.
The lowest amount of Phosphorus was excreted by the chickens of the experimental group 3. Their mixed feed was enriched with Zinc-mixed ligand complex at the dose corresponding to the introduction of 37.5 g of the element per 1 ton of the feed, although no probable difference was found for this index.
The lowest amount of Phosphorus - 0.57 g - was deposited in the body of the control group chickens fed with Zinc sulfate at a dose corresponding to the introduction of 50g of the element per 1 ton of mixed feed. A slightly larger amount of Phosphorus was deposited in the body of chicks of experimental group 2 - 0.64 g. They consumed mixed feed with Zinc-mixed ligand complex at the dose, which corresponded to the introduction of 50.0 g of the element per 1 ton of feed, but this difference was not probable.
The largest amount of Phosphorus was deposited in the body of chicks of experimental group 3 - 0.68 g, fed with Zinc-mixed ligand complex at the dose, which corresponded to the introduction of 37.5 g of the element per 1 ton of feed,with the probable difference of p<0,05.
The highest level of deposited Phosphorus - 59.3%, consumed with mixed feed was in the broilers of experimental group 3. It exceeded the index of the control group by 8.6%. A slightly lower level of Phosphorus deposited from the consumed fodder was in the broilers of experimental group 2 – it was 57.9%, but it surpassed a similar index in the control group by 6.6%. The lowest level of deposited Phosphorus consumed with fodder was in the control group poultry - 54.3%.
Thus, we can conclude that the introduction of Zinc-mixed ligand complex at the dose, which corresponded to the introduction of 37.5 g of the element per 1 ton of mixed feed, resulted in probable increase in the amount of deposited Phosphorus in the body and allowed to increase the level of the deposited element from 54.3 to 59.0%.
Zinc balance was studied along with the studying Nitrogen, Calcium and Phosphorus balance in a physiological experiment, (Table 5).
According to the average daily balance of Zinc (Table 5), it was found out that broiler chickens of the control and experimental group 2 consumed almost the same amount of Zinc. A slightly smaller amount of Zinc was consumed by chicks of experimental group 3 due to the reduction of the mixed-ligand complex dose in the mixed feed.

Consumption of various doses of Zinc from mixed feed had different affect on its excretion with the litter. Thus, the poultry of experimental groups 2 and 3 excreted, respectively 27.4 and 52.9% less than the control group birds, and the difference was probable - p <0.001.

Table 5. Average daily balance of Zinc, (M ± m, n = 3)

	Group		
	Control 1	experimental	
		group 2	group 3
Zink consumed with feed, g	7.560±0.161	7.570±0.158	6.320±0.151*
Excreted with litter, g	4.750±0.028	3.450±0.024***	2.240±0.037***
Deposited in the body, g	2.810±0.132	4.120±0.135***	4.080±0.114***
Ratio of consumed and deposited, %	37.130±0.960	54.40±0.657***	64.50±0.282***
Relative to the control, %	–	146.5	173.7

* p <0.05; ** p <0.01; *** p <0.001 compared with the control group.

The lowest amount of Zinc was deposited in the body the control group chickens - 2.81 mg. They consumed mixed fodder with Zinc sulfate at a dose corresponding to the introduction of 50.0 g of the element per 1 ton of feed. Somewhat larger amount of Zinc - 4.08 mg, was deposited in the body of experimental group 3 chicks. The birds consumed Zink-mixed ligand complex as a component of mixed feed in a dose, which also corresponded to the introduction of 37.5 g of the element per 1 ton of the feed and this difference was probable - p <0.001.

The largest amount of Zinc - 4.12 mg - was deposited in the body of chicks of experimental group 2 which consumed Zink-mixed ligand complex at a dose corresponding to the introduction of 50.0 g of the element per 1 ton of feed, and this difference was probable - p < 0.001as well .

Regarding the level of Zinc deposited from consumed fodder, it was the highest in broilers of experimental group 3 and made 64.5% (p <0.001), which exceeded the index in the control group by 73.7%. A slightly lower level of deposited Zinc was in broilers of experimental group 2 – it made 54.5% (p <0.001), but it also exceeded a similar index in the control group by 46.5%. The lowest level of deposited Zinc consumed with feed was in the birds of the control group - 37.13%.

Thus, we can conclude that introduction of Zinc-mixed ligand complex results in a probable decrease in its excretion with litter due to its better digestibility. The highest level of Zinc deposits from the consumed feed - 64.50% - was in the experimental group 3 birds consuming mixed feed with the mixed ligand complex at a dose corresponding to the introduction of 37.5 g of the element to 1 ton of fodder.

Conclusions

Feeding the birds with Zinc-mixed ligand complex as a component of mixed feed, in comparison with sulfate, improves the nutrients digestibility and increases the amount of chemical elements deposited in the body, which makes it possible to reduce the dose of the additive.

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