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EVALUATION OF DIFFERENT SOURCES OF PHOSHORUS IN BROILER DIETS

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The condition of the locomotor apparatus is very often unsatisfactory in broiler production. One frequent factor is inadequate mineralization of feed mixtures. The present study was undertaken to determine the possibility of use the two mineral feedstuffs - monoammonium phosphate (MAP, NH_4PO_4) and sodium tripolyphosphate (STPP, $Na_5P_3O_{10}$), as selective sources of phosphorus. The use of these feedstuffs has great nutritive importance due to the relatively easy supply of adequate amounts of phosphorus, and achievement of an optimal Ca:P ratio in the diet.

The control group of chickens (DCP group) exhibited satisfactory performance, adequate for Hybro broilers. The finishing body weight was 1,648 kg, average daily gain 34,59 g, food intake 0,065 kg/day and food conversion 1,862 kg. Compared with group DCP, groups MAP and STPP achieved similar results. Group MAP had 0,06% greater body weight, 0,96% smaller daily gain, 1,56% smaller food intake and 1,64% smaller food conversion ratio. At the same time, group STPP had 1,46% greater body weight, 1,68% greater daily gain, 3,13% greater food intake and 0,43% greater food conversion ratio.

Serum calcium levels were almost equal for all groups, in the range 2,48 - 2,99 mmol/l. Differences between the groups were not statistically significant. On the other hand, concentrations of phosphorus in groups MAP and STPP were significantly higher than in group DCP.

Calcium levels in the bones were similar for all groups. Tibia phosphorus levels in groups MAP and STPP, and femur calcium level in group STPP were significantly higher than in group DCP.

According to our results, we can conclude that usage of certain mineral feedstuffs can support good, or even better production results than standard feedstuffs such as limestone and dicalcium phosphate alone. Ammonia phosphate, as well as sodium tripolyphosphate, are suitable supplements in diets for broiler chickens.

Key words: Chickens, monoammonium phosphate, sodium tripolyphosphate, performance, health, ossification.

INTRODUCTION

The condition of the locomotor apparatus is very often unsatisfactory in broiler production (Antonijević et all., 1986). The most common factors that can influence development of the bone system are genetic (Morch, 1985; El Boushy, 1974; Mandor et al., 1976), management (Mayer and Sunde, 1974; Biewner et all., 1976) and nutrition (Ruff and Huges, 1989; Merkley, 1989), with significant interaction among those factors (Boren, 1992). One frequent factor is inadequate mineralization of the feed mixtures. Due to the great number of feedstuffs available and synthetic additives, it is relatively easy to provide adequate amounts of nutrients in the organic part of the diet. The problem of how to supply adequate amounts of the macro elements (calcium, phosphorus), with an optimal relation between them remains, because the selection of mineral feedstuffs is mainly limited to limestone and dicalcium phosphate. An insufficient supply of calcium (Mathur et all., 1983), and, especially of phosphorus (Tortuero and Diez Tardon, 1983; Blair and Stivens, 1983; Bar and Hurwitz, 1984), in recommended amounts and relation (NCR, 1977; AEC, 1988), can provoke poor development of the bones with disturbed locomotion.

The present study was undertaken to determine the possibility of using two mineral feedstuffs - monoammonium phosphate (MAP, NH_4PO_4) and sodium tripolyphosphate (STPP, $Na_5P_3O_{10}$), as selective sources of phosphorus. The use of these feedstuffs has great nutritive importance due to the relatively easy supply of adequate amounts of phosphorus, and the achievement of an optimal Ca: Patio in the diet.

MATERIALS AND METHODS

The 42 day long experiment was initiated with 150 day old Hybro broilers, divided into three groups. The technology of management and nutrition usual for the farm was used in the trial.

Three different diets, detailed in table 1, were applied. The first group received dicalcium phosphate (DCP) as the phosphorus source. In the diets for the second and the third group DCP was replaced with monoammonium phosphate (group MAP) and sodium tripolyphosphate (group STPP), respectively. The level of limestone was increased to retain the same levels and relations of calcium and phosphorus in all diets.

During the trial performance (body weight, feed intake, food conversion and average daily gain), health, and, especially, status of the locomotor apparatus were observed. At the end of the starting phase (28th day of trial), six birds from each group were sacrificed. The femur and tibia of the right leg and blood sera were taken as samples for further analyses. The concentration of calcium and phosphorus in the diets, bones and sera were determined, and X-ray diagnostics of femur and tibia (bone osification and pneumatization, bone structure) was done. The results are shown as means $\pm$ SEM. The significance of differences was calculated using Student's t-test.

Table 1. Percentage diet composition, %

	Starter (1-28th day)			Finisher (28-42th day)		
Feedstuffs	DCP	MAP	STPP	DCP	MAP	STPP
1. Maize	56,9	56,3	56,3	62,1	61,6	61,6
2. Soybean meal	22,0	22,0	22,0	18,0	18,0	18,0
3. Sunflower meal	9,0	9,0	9,0	9,0	9,0	9,0
4. Yeast	3,0	3,0	3,0	2,0	2,0	2,0
5. Fish meal	4,0	4,0	4,0	4,0	4,0	4,0
6. Fat	2,0	2,0	2,0	2,0	2,0	2,0
7. Limestone	0,9	1,8	1,8	0,9	1,7	1,7
8. Dicalcium phosphate	1,4	—	—	1,2	—	—
9. Monoammonium phosphate	—	1,1	—	—	0,9	—
10. Sodium tripolyphosphate	—	—	1,1	—	—	0,9
11. Salt	0,3	0,3	0,3	0,3	0,3	0,3
12. Vitamin-mineral premix	0,5	0,5	0,5	0,5	0,5	0,5
Nutrient content						
Crude protein, %	22,03	21,98	21,98	20,57	20,54	20,54
ME, MJ/kg	12,42	12,33	12,33	12,67	12,61	12,61
Calcium, %	1,08	1,08	1,08	1,00	1,02	1,02
Phosphorus, %	0,85	0,86	0,86	0,76	0,76	0,76
Ca : P ratio	1,27:1	1,26:1	1,26:1	1,31:1	1,34:1	1,34:1

RESULTS

Chemical analyses showed that calcium and phosphorus concentrations in the feed mixtures used in the trial were the same for all groups (1,08% Ca and 0,85% P in the starter; 1,00% Ca and 0,76%P in the finisher). During the trial mortality was about 2,5%, which was within the range of normal values for farm conditions.

The control group of chickens (DCP group) had a satisfactory performance, adequate for Hybro broilers. The finishing body weight was 1,648 kg, average daily gain 34,59 g, food intake 0,065 kg/day and food conversion 1,862 kg. Comparing with group DCP, groups MAP and STPP achieved similar results (table 2). Group MAP had 0,06% greater body weight, 0,96% smaller daily gain, 1,56% smaller food intake and 1,64% smaller food conversion ratio. At the same time, group STPP had 1,46% greater body weight, 1,68% greater daily gain, 3,13% greater food intake and 0,43% greater food conversion radio.

Serum calcium levels were almost equal for all groups, within the range 2,48 - 2,99 mmol/l. Differences between the groups were not statistically significant. On the other hand, concentrations of phosphorus in groups MAP and STPP were significantly higher than in group DCP (table 3). It is interesting to note that the concentrations of phosphorus were higher than concentrations of calcium in groups MAP and STPP.

Calcium levels in bones (femur and tibia) were similar for all groups. Groups DCP and MAP had higher levels of calcium in the femur than in the tibia, while this relation was inverse in group STPP (table 3). Tibia phosphorus levels in groups MAP and STPP, and femur calcium level in group STPP were significantly higher than in group DCP.

Table 2. Performance of broilers in the trial

Parameters	Group		
	DCP	MAP	STPP
Number of chickens			
1. day	50	50	50
28. day	49	48	49
42. day	43	42	43
Body weight, kg			
1. day	0,039	0,040	0,040
28. day	0,934	**1,017	0,936
42. day	1,648	1,649	1,672
Weight gain, g/day			
1 - 28. day	31,53	34,04	31,65
28 - 42. day	50,96	45,14	52,16
1 - 42. day	34,59	34,25	35,17
Feed intake, g/day			
1 - 28. day	0,055	0,059	0,056
28 - 42. day	0,082	0,071	0,086
1 - 42. day	0,064	0,063	0,066
Feed conversion, kg			
1 - 28. day	1,735	1,746	1,755
28 - 42. day	2,084	2,089	2,063
1 - 42. day	1,862	1,850	1,870

* -p<0,05 ** -p<0,01

Table 3. Bone and serum concentration of calcium and phosphorus

Group	Calcium		Phosphorus	
	— X + SEM		— $\bar{X} \pm$ SEM	
		Serum, mmol/l		
DCP	2,95	0,18	2,89	0,10
MAP	2,99	0,35	*3,36	0,05
STPP	2,53	0,17	*3,32	0,09
		Femur, %		
DCP	29,12	2,28	12,64	0,87
MAP	30,80	1,79	13,32	0,99
STPP	*33,41	1,72	13,51	0,61
		Tibia,%		
DCP	29,82	1,74	15,49	0,64
MAP	31,93	2,49	**17,13	0,96
STPP	31,52	2,75	*16,84	1,21

* -p<0,05 ** -p<0,01

X-ray analyses (femur) showed that ossification was normal in all groups. No changes, which might suggest disturbances in mineral deposition, were detected. Bone pneumatization was well developed in groups MAP and STPP, and very well developed in group DCP. Bone structure was within physiological limits in all groups. The average thickness of compacta for all groups was 0,1 cm.

DISCUSSION

The standard feed mixtures (starter and finisher) for group DCP were sufficient in all nutrients (AEC, 1989; NCR, 1987), resulting in optimal performance, according to technical normatives (Euribrid, 1989). Differences in diet composition for groups MAP and STPP had no influence on the nutritive values of the feed mixtures used leading to similar results (body weight, average daily gain, food intake, food conversion), with no significant differences. The performance achieved excluded the possible influence of intensive growth on bone quality and states of the locomotor apparatus, which are related (Mašić et al., 1985).

It is interesting to emphasize that the presence of inorganic nitrogen as ammonium ion (NH_4^+) in MAP did not have negative effects on performance and health. On the contrary, in the first phase of the trial, the body weight of group MAP was significantly greater than for group DCP. Similar results were reported by Küskinen (1983), who found that urea phosphates can be used as a replacement for dicalcium phosphate, without any negative effect on health and production. Moreover, Küskinen cited that the average body weight during the third week was greater than in the group of chickens fed with dicalcium phosphate. Addition of 0,5% urea or 1,1% diammonium phosphate in commercial feed mixtures for broiler chickens had no influence on weight gain and food conversion (El Boushy, 1980). Mono- and diammonium phosphate in diets with suboptimal levels of phosphorus, produced even greater amounts of ash in the tibia than dicalcium phosphate, without negative effects on performance (Filev and Šokarovski, 1985).

The presence of sodium ion (Na^+) in STPP increased water intake, be cause of the mechanism of its elimination. Although there were no clinical health disorders, increased moisture of droppings can alter ambient conditions (Damron and Johnson, 1985).

The concentrations of calcium and phosphorus in blood sera showed an intensive mineral supply. The realtively high blood concentrations of these two minerals, especially phosphorus, were a good base for intensive mineral deposition. Also, they offer a proof that monoammonium phosphate and sodium tripolyphosphate can be characterized as good sources of phosphorus, especially because of the greater digestibility than dicalcium phosphate.

Greater bioavailability of phosphorus from monoammonium phosphate and sodium tripolyphosphate than from dicalcium phosphate, reported by many authors (Jensen and Edwards, 1980; Huyghebaert et all., 1980; Han et all., 1986; Damron et all., 1985), can be a possible reason for better bone ossification

and mineral deposition in groups MAP and STPP, than in group DCP. Our results led to the same conclusions: the significantly higher bone concentrations of calcium and phosphorus and more massive bones of chickens from groups MAP and STPP could be the result of a more adequate mineral supply. The greater digestibility and bioavailability of the examined mineral feedstuffs resulted in greater mineral deposition only during the first phase of the trial, without altering other monitored parameters (production results, health).

During the trial mortality was about 2,5% which can be accepted as normal for farm conditions. No relation between mortality and the examined mineral feedstuffs was noticed, because mortality was almost equal in all groups. Chickens of all groups were active and dynamic, showed normal appetite and gained within physiological limits. The states of the locomotor apparatus was normal for all groups.

According to our results, we can conclude that usage of certain mineral feedstuffs can provide good, or even better production results than only usage of standard feedstuffs: limestone and dicalcium phosphate. Ammonium phosphates (monoammonium phosphate in our study, and diammonium phosphate in studies of other authors), as well as sodium tripolyphosphate, are good choices in diets for broiler chickens. Adequate performance and good health of the experimental birds are the best recommendation for these feedstuffs. Further research should display the possibility of their usage in diets for other monogastric animals, especially when ammonium phosphates are in question.

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RAZLIČITI IZVORI FOSFORA U OBROCIMA ZA BROJLERE

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SADRŽAJ

Nezadovoljavajuće stanje lokomotornog aparata veoma je često prisutno u brojlerskoj proizvodnji. Jedan od najčešćih razloga je neadekvatna mineralizacija kompletnih krmnih smeša. Cilj ovog rada bio je da ispita mogućnost korišćenja monomonijum fosfata (MAP) i natrijum tripolifosfata (STPP) kao isključivih izvora fosfora, na proizvodne rezultate, zdravstveno stanje i osifikaciju skeleta pilića u tovu.

Kontrolna grupa pilića (DCP grupa), ostvarila je zadovoljavajuće proizvodne rezultate. Završna telesna masa bile je 1,648 kg, prosečan dnevni prirast 34,59 g, konzumacija 0,065 kg/dan a konverzija hrane 1,862 kg. U poređenju sa DCP grupom, MAP i STPP grupa ostvarile su slične rezultate. MAP grupa imala je 0,06% veću telesnu masu, 0,96% manji dnevni prirast, 1,56% manju konzumaciju i 1,64% manju konverziju hrane. Istovremeno, STPP grupa imala je 1,46% veću telesnu masu, 1,68% veći dnevni prirast, 3,13% veću konzumaciju i 0,43% veću konverziju hrane.

Koncentracija kalcijuma u serumu bila je gotovo ista za sve grupe, i to od 2,48 - 2,99 mmol/l. Razlike između grupa nisu bile statistički značajne. Sa druge strane, koncentracija fosfora u MAP i STPP grupama bila je značajno više nego kod DCP grupe.

Količina kalcijuma u kostima bila je slična u svim grupama. Količina fosfora u kostima pilića MAP STPP grupe, kao i količina kalcijuma u femuru pilića STPP grupe bili su signifikantno viši nego u kostima pilića DCP grupe.

U skladu sa dobijenim rezultatima možemo zaključiti da primena ispitivanih mineralnih hraniva može obezbediti dobre proizvodne rezultate i solidno zdravstveno stanje. Amonijum fosfati, kao i natrijum tripolifosfat, dobar su izbor prilikom sastavljanja obroka za ishranu pilića u tovu.