1-1-1990

Interactive effects of sodium zeolite A (Ethacal) and monensin in uninfected and Eimeria acervulina-infected chicks.

T. L. Ward
LSU Agricultural Center

K. L. Watkins
LSU Agricultural Center

L. L. Southern
LSU Agricultural Center

Recommended Citation

Ward, T., Watkins, K., & Southern, L. (1990). Interactive effects of sodium zeolite A (Ethacal) and monensin in uninfected and Eimeria acervulina-infected chicks.. *Poultry science, 69* (2), 276-280. https://doi.org/10.3382/ps.0690276

Interactive Effects of Sodium Zeolite A (Ethacal®) and Monensin in Uninfected and *Eimeria acervulina*-Infected Chicks[1]

T. L. WARD, K. L. WATKINS,[2] and L. L. SOUTHERN[3]

Department of Animal Science, Louisiana Agricultural Experiment Station, Louisiana State University Agricultural Center, Baton Rouge, Louisiana 70803

(Received for publication May 2, 1989)

ABSTRACT An experiment was conducted with 5- to 18-day-old Arbor Acres broiler chicks to evaluate the interaction of sodium zeolite A (NZA) and monensin in uninfected and in coccidiosis-infected chicks. Sodium zeolite A (0 and .75%) or monensin (0 and 121 ppm), or both, were fed to uninfected chicks or to chicks infected with 4×10^5 sporulated, *Eimeria acervulina* oocysts, resulting in a 2-by-2-by-2 factorial arrangement of treatments. Coccidial infection reduced (P<.01) weight gain, feed intake, feed efficiency, percentage of bone ash and of bone calcium; but the infection increased (P<.05) bone Zn percentage. Monensin alleviated (or at least partially so) the adverse effects of the coccidial infection on weight gain, feed intake, feed efficiency and percentage of bone ash (coccidiosis by monensin, P<.01). In addition, monensin increased the bone-calcium (P<.06) and zinc content (P<.02) in uninfected chicks and in those infected with coccidiosis. Sodium zeolite A tended to reduce feed intake by coccidiosis-infected chicks (coccidiosis by NZA, P<.07), but increased (P<.01) the bone zinc and decreased (P<.01) serum inorganic phosphorus in uninfected chicks and in those infected with coccidiosis.

(*Key words*: chicks, zeolite, weight gain, bone minerals, monensin, coccidiosis)

1990 Poultry Science 69:276–280

INTRODUCTION

Ionophores are used extensively in the diets of ruminant animals to increase feed efficiency, and in poultry diets as anticoccidial agents (Edgar and Flanagan, 1974; Ruff *et al.*, 1976; Bergen and Bates, 1984). The biological activity of ionophores can be attributed to their ability to interact with metal ions and to transport them across biological membranes (Pressman, 1976; Ovchinnikov, 1979; Bergen and Bates, 1984). Elsasser (1984) observed a myriad of effects by ionophores on divalent-cation nutriture in ruminants and in nonruminants.

Sodium zeolite A (NZA) has been reported to improve weight gain and feed efficiency in broiler chicks (Willis *et al.*, 1982) and to increase the specific gravity of eggs (Roland *et al.*, 1985; Miles *et al.*, 1986; Roland, 1988). Watkins *et al.* (1989) reported that NZA increased the severity of excess calcium intake in chicks. However, beneficial effects from NZA on growth performance have not always been observed (Waldroup *et al.*, 1984; Ballard and Edwards, 1988; Watkins *et al.*, 1989). Although the mechanism by which NZA elicits effects in animals is not known, NZA selectively binds divalent cations (Breck, 1974) and has a high ion-exchange capacity (Cook *et al.*, 1982).

Both ionophores and NZA have ion-exchange capabilities and are likely to occur simultaneously in poultry diets. Therefore, the present investigation was conducted to determine the interactive effects of monensin and NZA in uninfected chicks and in those infected with *Eimeria acervulina*.

MATERIALS AND METHODS

An experiment consisting of two identical trials was conducted with unsexed, Arbor Acres broiler chicks, (Sanderson Farms, Laurel, MS). From hatching to Day 4 posthatching, the chicks received a corn-soybean meal diet (Table 1) formulated to meet or exceed the nutrient requirements for growing chicks (National Research Council, 1984). After an overnight fast with neither feed nor water, the chicks were weighed, wingbanded, and ran-

[1]Approved for publication by the Director of the Louisiana Agricultural Experiment Station as manuscript Number 89-11-3218.

[2]Present address: Lilly Research Laboratories, Greenfield, IN 46140.

[3]To whom reprint requests should be addressed.

TABLE 1. *Composition of the basal diet*[1]

Ingredient	Percentage
Silica flour	To 100.00
Ground yellow corn, 8.5% CP	46.27
Soybean meal, 44% CP	42.50
Corn oil	5.00
Defluorinated phosphate	2.10
Dehydrated alfalfa-leaf meal	2.00
Ground limestone	.40
Vitamin mix[2]	.25
DL-methionine	.15
$MnSO_4 \cdot H_2O$	.05
$ZnCO_3$	.01

[1]Calculated composition of the diet: CP, 23%; lysine, 1.37%; methionine, .52%; cystine, .37%; ME, 3,000 kcal/kg.

[2]Roche Chemical Division (Nutley, NJ) provided the following per kilogram of diet: vitamin A acetate, 6,614 IU; vitamin D_3 (D-activated animal sterol), 1,653 IU; dl-α-tocopheryl acetate, 6.6 IU; vitamin B_{12}, 11 μg; riboflavin, 6.6 mg; niacin, 33.1 mg; d-pantothenic acid, 11.0 mg; choline, 551 mg; menadione sodium bisulfite, 4.4 mg; folic acid, .7 mg; pyridoxine, 1.1 mg; thiamine, 1.1 mg; d-biotin, 55 μg.

domly assigned to treatment groups. They were provided with continuous light and were housed in heated, thermostatically controlled (35 C) starter batteries with raised, wire floors. For each trial, three pens with seven chicks each were assigned to each treatment. The average initial weight of the chicks was 84.8 and 86.5 g for Trials 1 and 2, respectively. Experimental diets and tap water were provided for consumption *ad libitum*.

The treatments consisted of two levels of NZA (0 and .75%), or two levels of monensin (0 and 121 ppm), or both, fed to control chicks or to those infected with *Eimeria acervulina*. These dietary additives and infection combinations resulted in a 2-by-2-by-2 factorial arrangement of treatments.

Coccidial infections were established by crop intubation of a 1-mL aqueous inoculum containing 4×10^5 sporulated, *Eimeria acervulina* oocysts on Days 2, 5, 8, and 11 of the trials. The uninfected, control chicks received inoculations of tap water.

Weight gain and feed intake were determined on Day 13 for both trials. In Trial 2, three chicks per pen were randomly selected and bled via cardiac puncture. Serum samples were frozen for subsequent analysis to determine inorganic phosphorus and calcium. The concentrations of serum inorganic phosphorus were determined by the modified method of Daly and Ertingshausen (1972) using a Gilford, inorganic-phosphorus reagent (Catalog Number S0284A, Ciba Corning Diagnostics Corporation, Oberlin, OH 44074). Serum calcium levels were measured using an automated, *o*-cresolphthalein procedure (Ciba Corning Diagnostics Corporation).

The three chicks selected at random for bleeding were subsequently killed by cervical dislocation. The right leg was removed and the tibia was cleaned of adhering tissue. The dry, fat-free tibias were dry-ashed at 600 C for 24 h and were analyzed for calcium and zinc content by atomic absorption spectrophotometry (Model 3030B, Perkin-Elmer Corporation, Norwalk, CT) and for inorganic phosphorus by molybdic-acid,a colorimetric procedure (Association of Official Analytical Chemists, 1984) with spectrophotometric analysis (Gilford, System 260).

Data were analyzed by analysis of variance procedures (Steel and Torrie, 1980) appropriate for factorially arranged treatments. For Trials 1 and 2, the data on weight gain, feed intake, and feed efficiency were pooled for statistical analysis.

RESULTS AND DISCUSSION

Coccidial infection reduced ($P<.01$) weight gain, feed intake, and feed efficiency (Table 2). In the uninfected chicks, monensin did not significantly affect weight gain, feed intake, or feed efficiency; but, as expected, monensin greatly improved these performance variables in the chicks infected with coccidiosis (coccidiosis-by-monensin interaction, $P<.01$). Sodium zeolite A had no effect ($P>.10$) on weight gain for the infected or uninfected chicks or on feed intake for the uninfected chicks. However, NZA tended to decrease feed intake by the chicks infected with *E. acervulina*, resulting in an NZA-by-coccidiosis interaction ($P<.07$). The reduction in feed intake did not result in a concomitant decrease in gain, which resulted in greater feed efficiency in the coccidiosis-infected chicks fed NZA. The effect of NZA and monensin on feed efficiency in the coccidiosis-infected chicks was not additive, resulting in a coccidiosis-by-monensin-by-NZA interaction ($P<.02$).

The percentage of bone ash (Table 3) was reduced ($P<.01$) by the coccidial infection and was restored to the level in uninfected chicks by monensin addition (coccidiosis-by-monen-

sin interaction, P<.01). Bone-ash percentage was not affected by NZA in uninfected or in infected chicks, or by monensin in uninfected chicks. Tibia calcium as a percentage of ash was reduced (P<.01) by the coccidial infection but was increased (P<.06) by monensin. In coccidiosis-infected chicks, NZA increased tibia calcium in the absence of monensin but decreased tibia calcium in the presence of monensin (coccidiosis-by-monensin-by-NZA interaction, P<.01). Tibia phosphorus was not affected (P>.10) by dietary treatment or by

TABLE 2. *Weight gain, feed intake, and gain:feed ratio for control (–) and* Eimeria acervulina*-infected (+) chicks fed sodium zeolite A (NZA), monensin (M), or both[1], with ANOVA summary*

Dietary additions	Weight gain		Feed intake		Gain:feed ratio	
	–	+	–	+	–	+
	(g)				(g/g)	
Basal (B)	412	346	589	573	.697	.604
B + .75% NZA	405	336	590	533	.685	.631
B + 121 ppm of M	397	404	581	581	.682	.694
B + NZA + M	403	396	582	579	.692	.683
	ANOVA summary					
Source of variation	Probability					
Coccidiosis (Cocc)	.001		.002		.001	
Monensin (M)	.001		NS		.001	
NZA	NS		.10		NS	
Cocc × M	.01		.01		.001	
NZA × M	NS		NS		NS	
Cocc × NZA	NS		.07		NS	
Cocc × M × NZA	NS		NS		.02	
Pooled SEM	5		8		.009	

[1]Data are the means of six replicates of seven chicks each from 5 to 18 days posthatching; combined average, initial weight was 85.7 g (Trial 1, 84.8 g; Trial 2, 86.5 g).

TABLE 3. *Tibia ash, calcium, inorganic phosphorus, and zinc for control (–) and* Eimeria acervulina*-infected (+) chicks fed sodium zeolite A (NZA), monensin (M), or both[1], with ANOVA summary*

Dietary additions	Ash		Calcium		Inorganic phosphorus		Zinc	
	–	+	–	+	–	+	–	+
	(%)		(% of tibia ash)				(μg/g of ash)	
Basal (B)	52.5	50.7	36.8	36.0	18.9	18.6	379	393
B + .75% NZA	52.6	49.3	37.2	37.1	18.6	18.9	421	428
B + 121 ppm of M	52.4	52.0	37.3	37.5	18.8	19.0	390	393
B + NZA + M	51.4	51.6	37.6	36.1	18.7	18.7	437	463
	ANOVA summary							
Source of variation	Probability							
Coccidiosis (Cocc)	.01		.01		NS		.05	
Monensin (M)	NS		.06		NS		.02	
NZA	NS		NS		NS		.01	
Cocc × M	.01		NS		NS		NS	
NZA × M	NS		.01		NS		.10	
Cocc × NZA	NS		NS		NS		NS	
Cocc × M × NZA	NS		.01		NS		NS	
Pooled SEM	.5		.2		.1		8	

[1]Data are means of three replicates of three chicks each on Day 13 of Trial 2.

TABLE 4. *Serum calcium and inorganic phosphorus, control (–) and* Eimeria acervulina*-infected (+) chicks fed .75% sodium zeolite A (NZA) or 121 ppm of monensin (M)*[1]

Dietary additions	Calcium		Inorganic phosphorus	
	–	+	–	+
	(mg/dL)			
Basal (B)	7.94	7.05	5.70	5.08
B + .75% NZA	7.04	8.73	4.58	4.45
B + 121 ppm of M	7.13	7.80	4.79	4.99
B + NZA + M	7.47	7.97	4.32	4.41
	Probability			
Source of variation				
Coccidiosis (Cocc)		NS		NS
Monensin (M)		NS		NS
NZA		NS		.01
Cocc × M		NS		NS
NZA × M		NS		NS
Cocc × NZA		NS		NS
Cocc × M × NZA		NS		NS
Pooled SEM		.54		.30

[1]Data are means of three replicates of three chicks each on Day 13 of Trial 2.

coccidial infection. This observation does not agree with previous results from the authors' laboratory in which an increase in tibia phosphorus content in coccidiosis-infected chicks was reported (Giraldo *et al.*, 1987; Watkins *et al.*, 1989).

Tibia zinc was increased by the coccidial infection ($P<.05$) and by the addition of NZA ($P<.01$) and monensin ($P<.02$) (Table 3). The interactive effects of monensin and NZA were not significant. Coccidial infections have been reported to reduce the concentrations of tibial zinc in chicks fed excess zinc (Southern and Baker, 1983). However, in coccidiosis-infected chicks fed dietary zinc levels near the requirement (as in this study) increases in tibia zinc have been observed (Southern and Baker, 1983). Sodium zeolite A has been shown to increase the concentration of tissue zinc in pigs (Pond and Yen, 1983). Sodium zeolite A has a high affinity for zinc (Breck, 1974), which may explain the increased concentrations of bone zinc in animals fed NZA.

Serum calcium was not affected by any of the treatments (Table 4). Serum inorganic phosphorus was reduced ($P<.01$) by NZA. This effect was consistent regardless of whether the chicks were fed monensin or were infected with coccidiosis. Edwards (1988) has reported that NZA reduces the availability of dietary phosphorus.

REFERENCES

Association of Official Analytical Chemists, 1984. Official Methods of Analysis. 14th ed. Assoc. Off. Anal. Chem., Arlington, VA.

Ballard, R., and H. M. Edwards, Jr., 1988. Effects of dietary zeolite and vitamin A on tibial dyschondroplasia in chickens. Poultry Sci. 67:113–119.

Bergen, W. G., and D. B. Bates, 1984. Ionophores: their effect on production efficiency and mode of action. J. Anim. Sci. 58:1465–1483.

Breck, D. W., 1974. Zeolites Molecular Sieves. Structure, Chemistry, and Use. John Wiley and Sons, New York, NY.

Cook, T. E., W. A. Cilley, A. C. Savitsky, and B. H. Wiers, 1982. Zeolite A hydrolysis and degradation. Environ. Sci. Technol. 16:344–350.

Daly, J. A., and G. Ertingshausen, 1972. Direct method for determining inorganic phosphorus in serum with the "Centrifichem." Clin. Chem. 18:263.

Edgar, S. A., and C. Flanagan, 1974. Efficacy of a new drug, lasalocid sodium, in the prevention of coccidiosis in chickens. Poultry Sci. 53:1637. (Abstr.)

Edwards, H. M., Jr., 1988. Effect of dietary calcium, phosphorus, chloride, and zeolite on the development of tibial dyschondroplasia. Poultry Sci. 67:1436–1446.

Elsasser, T. H., 1984. Potential interactions of ionophore drugs with divalent cations and their function in the animal body. J. Anim. Sci. 59:845–853.

Giraldo, C. A., D. R. Brown, K. L. Watkins, and L. L. Southern, 1987. Responses to excess dietary magnesium as affected by experimental *Eimeria acervulina* infection or by dietary ammonium chloride ingestion in the chick. J. Nutr. 117:1053–1059.

Miles, R. D., R. H. Harms, and S. M. Laurent, 1986. Influence of sodium zeolite A (Ethacal®) on laying hen performance. Nutr. Rep. Int. 34:1097–1103.

National Research Council, 1984. Nutrient Requirements of Poultry. National Academy Press, Washington, DC.

Ovchinnikov, Y. A., 1979. Physico-chemical basis of ion transport through biological membranes: ionophores and ion channels. Eur. J. Biochem. 94:321–336.

Pond, W. G., and J. T. Yen, 1983. Protection by clinoptilolite or zeolite NaA against cadmium-induced anemia in growing swine. Proc. Soc. Exp. Biol. Med. 173: 332–337.

Pressman, B. C., 1976. Biological applications of ionophores. Annu. Rev. Biochem. 45:501–530.

Roland, D. A., Sr., S. M. Laurent, and H. D. Orloff, 1985. Shell quality as influenced by zeolite with high ion-exchange capability. Poultry Sci. 64:1177–1187.

Roland, D. A., Sr., 1988. Further studies of effects of sodium aluminosilicate on egg shell quality. Poultry Sci. 67: 577–584.

Ruff, M. D., W. M. Reid, and A. P. Rahn, 1976. Efficacy of different feeding levels of monensin in the control of coccidiosis in broilers. Am. J. Vet. Res. 37:963–967.

Southern, L. L., and D. H. Baker, 1983. Zinc toxicity, zinc deficiency and zinc-copper interrelationship in *Eimeria acervulina*-infected chicks. J. Nutr. 113: 688–696.

Steel, R.G.D., and J. H. Torrie, 1980. Principles and Procedures of Statistics: A Biometrical Approach. McGraw-

Hill, Inc., New York, NY.
Waldroup, P. W., G. K. Spencer, and N. K. Smith, 1984. Evaluation of zeolites in the diet of broiler chickens. Poultry Sci. 63:1833–1836.
Watkins, K. L., D. B. Vagnoni, and L. L. Southern, 1989. Effect of dietary sodium zeolite A and excess calcium on gain, feed intake, gain/feed and tibia calcium and phosphorus of *Eimeria acervulina*-infected chicks. Poultry Sci. 68:1236–1240.
Willis, W. L., C. L. Quarles, and D. J. Fagerberg, 1982. Evaluation of zeolites fed to male broiler chickens. Poultry Sci. 61:438–442.