DIETARY SODIUM BICARBONATE, MONENSIN, OR COCCIDIAL INOCULATION AND PRODUCTIVE PERFORMANCE OF MARKET TURKEYS ON BUILT-UP LITTER

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Primary Audience: Feed Manufacturers, Live Production Managers, Nutritionists, Researchers, Veterinarians

SUMMARY

Nicholas Large White male turkey poults, 1536 at placement and 1280 at 3 wk, were used in a pen trial on built-up litter during summer 1994 in Maryland to evaluate dietary sodium bicarbonate (SBC; 0 or 0.25%), monensin (MON; 0 or 99 ppm), or coccidial inoculation (COC; 0 or 2 *Eimeria* species), singly and in various combinations. Per treatment, there were eight replicate pens (5'×15') of 24 poults each at placement and 20 poults each retained at 3 wk. All feeds had bacitracin MD at 55 ppm.

Significant COC×SBC×MON interactions were found at 3 wk, and some two-variable interactions (COC×SBC, COC×MON, or SBC×MON) were observed at each age. Coccidial-inoculated tom turkeys fed dietary SBC and MON had significantly improved 3-wk weight (+0.122 lb) and mortality (-5.36% actual) compared to inoculated but unsupplemented birds. At 3 wk, inoculated turkeys without SBC or MON had 5.95% mortality, compared to 4.17% with SBC, 3.57% with MON, and 0.59% with SBC and MON (highest and lowest significantly different).

Poults inoculated with coccidia at 2 wk of age via drinking water had significantly poorer performance in all parameters measured at 3, 6, and 18 wk of age than uninoculated birds, validating the coccidial stressor model. Dietary MON significantly enhanced most or all performance parameters at each age. Dietary SBC significantly improved 3-wk and 6-wk body weights and feed conversions, and 18-wk mortality ($P<.054$; 8.64 vs. 6.07%), compared to diets with no SBC.

Key words: Coccidial lesion score, coccidiosis, electrolyte, ionophore coccidiostat, monensin, mortality, sodium bicarbonate, turkey

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Description of Problem

Seven *Eimeria* species have been described in turkeys, but only four are of major concern to the turkey industry: *E. adenoeides* (affecting the ceca), *E. meleagrimitis* (affecting the upper gut), *E. galopavonis* (affecting the lower gut), and *E. dispersa*. Coccidial immunity naturally develops toward each species of *Eimeria* to which the poult has been exposed, but protection against one species does not assure protection against all or other species. Oocyst shedding and fecal oocyst counts in turkeys usually peak between 3 and 6 wk of age. Larger flock size per house (for example, 25,000 poults vs. 15,000 poults) and crowding tend to increase the number of coccidia and severity of infection.

Turkeys appear to get exposed to one dominant species of *Eimeria* early and develop immunity but are then challenged with one after another of the other kinds during the growout. Because turkey coccidiosis lesions are generally less specific and discrete than those observed in broilers, it is considerably more difficult to diagnose coccidiosis in turkeys than in chickens [1]. Turkey coccidiosis has been called a "subtle embezzler" [2].

Dr. Patricia C. Augustine, USDA-ARS avian coccidiosis researcher, reported at the 1989 Arkansas Nutrition Conference that the reactions to mixed cultures of *E. adenoeides* and *E. meleagrimitis* were more severe in day-old poults than in older poults. One-day-old poults were found to be capable of developing an immune response against coccidia that was only slightly less protective than that elicited in 1- or 2-wk-old poults. When multiple immunizing doses were given, beginning when the poults were 1 day old, subsequent challenge with pathogenic coccidia had little effect on weight gain or feed efficiency [3, 4].

Ionophore coccidiostats are the primary antimicrobial agents used for prevention and treatment of coccidiosis, which can lead to malnutrition and lowered performance in market turkeys. Ionophores utilize cations to explode (monensin) or implode (lasalocid) coccidia and kill them. Increased effectiveness of several ionophore coccidiostats has been shown with dietary sodium bicarbonate (SBC; 0.20 to 0.30%) for broiler chickens on built-up litter with or without a coccidial inoculation (COC) through their drinking water at 2 wk of age [5, 6]. Improvements have been observed in body weight (BW), feed efficiency, coccidial lesion scores, mortality, litter quality, and carcass and breast yields. Because the intestine is such a dynamic organ metabolically, a healthier intestine can support more rapid growth (resulting in higher carcass and breast meat yields) with less nutritional waste.

Augustine [7] found that dietary SBC, when fed alone or in combination with monensin (MON), enhances the invasion of two species of coccidia (*E. acervulina* and *E. maxima*) into broiler chick epithelium. This was hypothesized to provide rapid, early immunity and later resistance to coccidial challenges. There appears to be a dissociation of the localized immune response and the systemic or whole body fever response so that immunity is obtained while the fever response is minimized, thus improving productive and processing performance. Augustine [8] reported that *in vitro* incubating freshly excysted sporozoites of turkey *E. meleagrimitis* and *E. adenoeides* in concentrations of MON from 0.01 to 1.0 mcg/mL, washing them free of the drug, and inoculating turkey kidney cells caused inhibition of invasion (due to rounding and protrusions) that was concentration- and time-dependent.

Lillehoj [9], in reviewing avian intestinal parasitism by coccidia and host immunity, indicated that intestinal T cells are the primary mediators of immunity to *Eimeria* (and critical for protection against reinfection); antibodies in circulation, gut secretions, and bile also play a minor role in protecting against coccidiosis. Coccidia damage the intestine and increase severity of other enteric diseases, so prophylaxis against coccidia helps promote better intestinal health and nutrition.

Synthetic zeolite A (Ethacal, Ethyl Corporation, Baton Rouge, LA), containing about 12.6% sodium, at 0.75% of the diet, in combination with MON at 121 ppm, was found by Ward *et al.* [10] to significantly increase bone zinc and decrease serum inorganic phosphorus in *E. acervulina*-infected and in uninoculated broiler chicks from 5 to 18 days of age. Zeolite supplementation was associated with a reduction in feed intake by coccidial-inoculated chicks ($P < .07$).

In research work at the Roslin Institute in Edinburgh, Scotland [11], turkey poults were found to differ from chicks in their response to varying anion to cation ratios in the diet. In chicks fed semi-purified diets, Mongin [12] reported a dietary electrolyte balance (Na + K–Cl) of 250 mEq/kg to be optimum, whereas in poults Scottish researchers found 250 mEq/kg to be maximum. A depression in 3-wk BW occurred at mEq/kg concentrations of 250 or more.

The present research was performed to evaluate the efficacy of 0.25% dietary SBC [13] with the ionophore monensin (Coban) [14] in practical-type diets of turkeys grown on built-up litter and given a COC (*E. adenoeides* and *E. meleagrimitis*) through the drinking water.

Materials and Methods

A pen trial involving 1536 male Nicholas Large White turkey poults to 3 wk, and 1280 retained thereafter, was conducted at PARC Institute, Inc. in Queen Anne, MD, from June 1 to September 7, 1994 (18 wk). Pens were 5'×15' (1.5×4.5 m), and each pen contained one tube feeder and one bell-type waterer. Two inches (5 cm) of new litter was placed on top of built-up (old, used) litter for the trial. Beneath the litter was a dirt floor. Stocking density at placement was 3.75 ft^2 (0.348 m^2) per bird. Poults were weighed at placement, and the top 10% and bottom 10% were discarded, leaving 1536 birds to begin. There were 24 poults/pen initially and 20/pen retained at 3 wk. Poults that died during the first 7 days of the test were replaced with birds of the same sex.

The building was wood and cinder block construction with a metal roof and low ceiling insulated to an R value of 19 overhead and 12 in the sidewalls, except curtains. Warm-room brooding and positive pressure (across house) ventilation by forced-air heaters were used. Temperatures at bird level were maintained at about 85–90°F (29.4–32.2°C) during the 1st wk, and reduced 1°F (0.55°C) per day thereafter until 70°F was reached. Lighting was natural in the daytime and continuous incandescent at about 5 to 10 lux at night.

There were eight replicate pens per treatment (total poults/treatment was 192 initially and 160 at 3 wk). A 2×2×2 factorial arrangement was utilized, and split-plot ANOVA was conducted, with significant interaction means being separated by Tukey's (HSD) Test. Arc sin transformations of the square root of each proportion (*i.e.*, numbers ranging 0 to 1) obtained from mortality percentages (proportion = %/100) or composite coccidial lesion scores (proportion = 0 to 4/100) were performed as necessary. Statistix for Windows software was used for all statistical procedures [15]. There were two levels of COC (0 or 2 *Eimeria* species), two levels of dietary SBC (0 or 0.25%), and two levels of MON (Coban; 0 or 99 ppm).

Basal diets were practical-type corn-soy-meat (4 to 2% animal by-product blend) formulas that met or exceeded NRC 1994 nutrient requirements [16]. For testing purposes, some diets were supplemented with MON, SBC, or both by adding them on top of regular formulas, thus adding slightly to the batch weight and diluting the basal feed. Mixing was done using a uniform basal diet for each phase of feeding. All feeds were changed at the same age throughout the replicate pens. Starter 1 feed crumbles were fed 0 to 3 wk, followed by Starter 2 crumbles from 3 to 6 wk of age. Pelleted feeds were fed as Grower 1 from 6 to 10 wk, Grower 2 from 10 to 14 wk, and finisher feed 14 to 18 wk. Steam conditioning of mash feed prior to pelleting was at about 178°F (81.1°C). Bacitracin MD was added to all diets throughout the study at 55 ppm.

Added SBC (0.25%) provided 0.068% sodium, 0.18% bicarbonate, and +29.6 mEq/kg (Na + K–Cl). The five diets, starter to finisher, contained the following calculated levels of Na, K, Cl, and mEq: % Na = 0.20, 0.20, 0.18, 0.18, 0.18; % K = 1.05, 0.99, 0.96, 0.93, 0.93; % Cl = 0.21, 0.25, 0.23, 0.23, 0.24; and mEq/kg = 296.3, 269.7, 258.9, 225.7, 192.2.

A sample of each experimental feed was analyzed for crude protein, Ca, phosphorus, sodium, and MON prior to use. For each sample, these nutrients were found to be in compliance within acceptable ranges around the target levels according to standards in the AOAC Official Methods of Analysis, 15th Edition [17], developed using t values with 90% confidence intervals for infinity. Using approved lab techniques, the acceptable analytical variation ranges were: crude protein (AOAC 954.01), ±(2/target + 2%); Ca (AOAC 968.08), ±10%; phosphorus (AOAC 965.17), ±(3/target + 8%); and sodium by atomic absorption, ±20% or by ICP method, ±15%. MON assays were also performed prior to use of experimental diets, and MON levels were found to be within the assigned tolerance limits of ±25%.

When poults were 2 wk of age, a mixture of two coccidial species was administered via drinking water to specific treatment groups to simulate a commercial coccidiosis challenge (*E. meleagrimitis*, about 200,000 sporulated oocysts, and *E. adenoeides*, about 100,000 sporulated oocysts per poult). At 22 days of age, four males from each replicate pen were necropsied and scored for coccidiosis at the upper small intestine, lower small intestine, large intestine, and ceca using the 0 to 4 (5-point) system, with 4 being the most severe. The visual scores for the four locations were added together to get a single composite coccidial lesion score per bird [18].

Results and Discussion

3-WK PERFORMANCE

Nicholas tom turkey poults on built-up litter, but uninoculated with coccidia through the water, and fed diets with 0.25% SBC and 99 ppm MON had significantly ($P < .05$) improved 3-wk BW compared to uninoculated poults receiving no SBC or MON (Table 1, COC×SBC×MON interactions). Coccidial-inoculated poults fed diets containing MON or SBC and MON had significantly ($P < .05$) heavier BW than inoculated poults given no SBC or MON in their diets. Inoculated poults receiving diets supplemented with SBC and MON had significantly ($P < .05$) lower mortality than inoculated poults given diets with no SBC or MON.

Regarding COC×SBC interaction effects, coccidial-inoculated birds with no dietary SBC had a significantly ($P < .05$) higher feed conversion ratio than either of the uninoculated treatments or the SBC treatment. Mortality was significantly ($P < .05$) higher in coccidial-inoculated poults receiving no SBC than in uninoculated poults that received and did not receive SBC. Coccidial-inoculated birds fed diets with and without SBC had significantly ($P < .05$) higher coccidial lesion scores than either of the uninoculated groups (*i.e.*, 0 or 0.25% SBC).

There were significant COC×MON interactions. Poult BWs were lowest for the COC birds receiving no MON, and feeding dietary MON to inoculated poults significantly ($P < .05$) increased weights. Regular and mortality-adjusted feed conversion ratios were similarly improved ($P < .05$) by MON. Inoculated poults receiving MON were in the same statistical weight group as the two uninoculated treatments (0 or 99 ppm MON). Coccidial lesion scores at 22 days were lowest for uninoculated poults and significantly ($P < .05$) increased due to COC via the drinking water. Coccidial-inoculated birds fed MON had a significantly ($P < .05$) lower lesion score than those fed diets with no MON.

SBC×MON effects were significant for BW. Poults fed diets supplemented with both 0.25% SBC and 99 ppm MON had significantly ($P < .05$) higher BW than either uninoculated treatment (unsupplemented control or 0.25% SBC and no MON) or the dietary treatment with 99 ppm MON alone (no SBC).

Based on main effect means, COC of turkeys grown on built-up litter significantly ($P < .05$) depressed 3-wk BW, impaired feed efficiency and mortality-adjusted feed efficiency, and increased coccidial lesion score and mortality, compared to results of uninoculated birds (Table 1). Dietary SBC at 0.25% significantly ($P < .05$) improved BW, feed conversion ratio, and mortality-adjusted feed conversion ratio compared to diets containing no SBC. Dietary MON significantly ($P < .05$) improved BW, feed efficiency, and mortality-adjusted feed efficiency compared to diets without the ionophore coccidiostat.

6-WK PERFORMANCE

There were no significant ($P < .05$) differences between interaction means, involving either three variables or two variables, except for BW means within the COC×MON category (Table 2). In this category, lowest BW occurred in treatments receiving COC and no MON, and uninoculated treatment groups were significantly ($P < .05$) higher in BW, whereas the COC and MON treatment group was intermediate and in a separate statistical grouping from all other means.

Considering 6-wk main effects (Table 2), COC of poults on built-up litter significantly ($P < .05$) worsened all parameters measured, including BW, feed efficiency, mortality-adjusted feed efficiency, and mortality, compared to uninoculated poults, indicating that the coccidial stressor model was effective. Use of 0.25% dietary SBC signif-

TABLE 1. Productive performance and coccidial lesion scores of Nicholas male turkey poults at 3 wk

TREATMENT[A] COC	SBC	MON	BODY WEIGHT	FEED/BODY WEIGHT	MORTALITY ADJUSTED FEED/BODY WEIGHT	MORTALITY	COCCIDIAL LESION SCORE
	%	ppm	lb	lb/lb	lb/lb	%	0 – 4[B]
COC×SBC×MON INTERACTIONS							
No	0	0	1.267[b]	1.316[a]	1.305[a]	1.786[ab]	0.031[a]
No	0.25	0	1.289[ab]	1.298[a]	1.288[a]	1.786[ab]	0.000[a]
No	0	99	1.279[ab]	1.293[a]	1.284[a]	1.190[b]	0.094[a]
No	0.25	99	1.309[a]	1.285[a]	1.275[a]	1.786[ab]	0.063[a]
Yes	0	0	1.170[d]	1.400[a]	1.352[a]	5.952[a]	2.813[a]
Yes	0.25	0	1.180[d]	1.357[a]	1.327[a]	4.167[ab]	2.344[a]
Yes	0	99	1.225[c]	1.339[a]	1.314[a]	3.571[ab]	1.563[a]
Yes	0.25	99	1.292[ab]	1.278[a]	1.274[a]	0.595[b]	0.938[a]
COC×SBC INTERACTIONS							
No	0		1.273[a]	1.304[b]	1.294[a]	1.488[b]	0.062[b]
No	0.25		1.299[a]	1.291[b]	1.281[a]	1.786[b]	0.031[b]
Yes	0		1.197[a]	1.369[a]	1.333[a]	4.761[a]	2.188[a]
Yes	0.25		1.236[a]	1.317[b]	1.300[a]	2.381[ab]	1.641[a]
COC×MON INTERACTIONS							
No		0	1.278[ab]	1.307[b]	1.296[b]	1.786[a]	0.015[c]
No		99	1.294[a]	1.289[b]	1.279[b]	1.488[a]	0.078[c]
Yes		0	1.175[c]	1.378[a]	1.339[a]	5.059[a]	2.578[a]
Yes		99	1.258[b]	1.308[b]	1.294[b]	2.083[a]	1.250[b]
SBC×MON INTERACTIONS							
	0	0	1.218[b]	1.358[a]	1.328[a]	3.869[a]	1.422[a]
	0.25	0	1.234[b]	1.327[a]	1.307[a]	2.976[a]	1.172[a]
	0	99	1.252[b]	1.316[a]	1.299[a]	2.380[a]	0.828[a]
	0.25	99	1.300[a]	1.281[a]	1.274[a]	1.190[a]	0.500[a]
COC, SBC, MON MAIN EFFECTS							
No			1.286[a]	1.298[b]	1.288[b]	1.637[b]	0.047[b]
Yes			1.217[b]	1.344[a]	1.317[a]	3.571[a]	1.914[a]
	0		1.235[b]	1.337[a]	1.314[a]	3.125[a]	1.125[a]
	0.25		1.267[a]	1.305[b]	1.291[b]	2.083[a]	0.836[a]
		0	1.226[b]	1.343[a]	1.318[a]	3.423[a]	1.297[a]
		99	1.276[a]	1.299[b]	1.287[b]	1.786[a]	0.664[a]

[A]COC = Coccidial inoculation; SBC = dietary sodium bicarbonate; MON = monensin. Each treatment (COC×SBC×MON) had eight replicate pens with 24 poults each at placement and with 20 poults each per treatment at 21 days of age.

[B]Visual scoring, 0 to 4 (least to most severe), was done for upper small intestine, lower small intestine, large intestine, and cecum, then the four sites were summed to determine a single composite coccidial lesion score per bird. Table contains averages by treatment.

[a–d]Means within a column and group and with no common superscript letter differ significantly at $P < .05$ (Split-Plot Analysis; Tukey's [HSD] Test when interactions were significant).

TABLE 2. Productive performance and coccidial lesion scores of Nicholas male turkey poults at 6 wk

TREATMENT[A]			BODY WEIGHT	FEED/BODY WEIGHT	MORTALITY ADJUSTED FEED/BODY WEIGHT	MORTALITY
COC	SBC	MON				
	%	ppm	lb	lb/lb	lb/lb	%
COC×SBC×MON INTERACTIONS						
No	0	0	4.772[a]	1.535[a]	1.526[a]	3.68[a]
No	0.25	0	4.821[a]	1.524[a]	1.516[a]	3.68[a]
No	0	99	4.787[a]	1.524[a]	1.516[a]	2.94[a]
No	0.25	99	4.825[a]	1.497[a]	1.488[a]	3.68[a]
Yes	0	0	4.350[a]	1.630[a]	1.584[a]	14.71[a]
Yes	0.25	0	4.435[a]	1.590[a]	1.560[a]	10.29[a]
Yes	0	99	4.582[a]	1.564[a]	1.541[a]	8.09[a]
Yes	0.25	99	4.753[a]	1.538[a]	1.523[a]	5.15[a]
COC×SBC INTERACTIONS						
No	0		4.779[a]	1.529[a]	1.521[a]	3.31[a]
No	0.25		4.823[a]	1.510[a]	1.502[a]	3.68[a]
Yes	0		4.466[a]	1.597[a]	1.562[a]	11.40[a]
Yes	0.25		4.594[a]	1.564[a]	1.541[a]	7.72[a]
COC×MON INTERACTIONS						
No		0	4.796[a]	1.510[a]	1.521[a]	3.68[a]
No		99	4.806[a]	1.510[a]	1.502[a]	3.31[a]
Yes		0	4.392[c]	1.610[a]	1.572[a]	6.00[a]
Yes		99	4.667[b]	1.551[a]	1.532[a]	2.65[a]
SBC×MON INTERACTIONS						
	0	0	4.561[a]	1.582[a]	1.555[a]	9.19[a]
	0.25	0	4.628[a]	1.557[a]	1.538[a]	6.98[a]
	0	99	4.684[a]	1.544[a]	1.528[a]	5.51[a]
	0.25	99	4.789[a]	1.517[a]	1.505[a]	4.41[a]
COC, SBC, MON MAIN EFFECTS						
No			4.801[a]	1.520[b]	1.512[b]	3.49[b]
Yes			4.530[b]	1.580[a]	1.552[a]	9.56[a]
	0		4.623[b]	1.563[a]	1.542[a]	7.35[a]
	0.25		4.708[a]	1.537[b]	1.522[a]	5.70[a]
		0	4.595[b]	1.570[a]	1.546[a]	8.09[a]
		99	4.737[a]	1.531[b]	1.517[b]	4.96[b]

[A]COC = Coccidial inoculation; SBC = dietary sodium bicarbonate; MON = monensin. There were eight replicate pens with 24 poults each per treatment at placement and with 20 poults each per treatment at 21 days of age.

[a,b]Means within a column and group and with no common superscript letter differ significantly at $P < .05$ (Split-Plot Analysis; Tukey's [HSD] Test after significant COC×SBC×MON interactions).

icantly ($P < .05$) improved BW and feed efficiency compared to no SBC supplementation. Dietary MON (99 ppm) significantly ($P < .05$) improved BW and feed efficiency compared to diets with no MON.

18-WK PERFORMANCE

Nicholas toms with no COC but grown on built-up litter were not significantly affected at 18 wk of age by three-variable (COC×SBC×MON) or two-variable (COC ×SBC, COC×MON, and SBC×MON) interactions (Table 3). Significant differences were detected among COC×MON interaction means for feed efficiency and mortality-adjusted feed efficiency. Feed efficiency and mortality-adjusted feed efficiency means of inoculated tom turkeys given no MON were separated statistically ($P < .05$) from uninoculated birds fed MON or no MON or inoculated toms fed MON.

Considering main effects (Table 3), COC at 14 days of age significantly worsened 18-wk BW, feed efficiency, mortality-adjusted feed efficiency, and mortality compared to uninoculated bird performance. Dietary SBC significantly ($P < .054$) decreased mortality from 8.64 to 6.07%, a 29.7% improvement, when averaging across inoculation and MON levels. The significant ($P < .05$) improvements in BW at 3 and 6 wk of age with dietary SBC did not carry through to 18 wk of age (*i.e.,* nonsignificant). However, mortality differences nonsignificant at younger ages became significant at 18 wk. Dietary MON significantly ($P < .05$) improved all measurements compared to diets with no MON. Although not shown in Table 3, the cost of SBC at 0.25% of the diets was approximately 17% of the cost of MON addition in the United States during this trial.

The 3-wk and 6-wk responses for male turkey poults fed dietary SBC and MON are similar in magnitude to previously reported broiler chicken live performance production improvements when broilers were grown on built-up litter and received a COC at 2 wk of age [5, 6]. Although the first turkey basal diet contained Na + K–Cl electrolyte balance of 296.3, higher than the maximum of 250 mEq/kg recommended by Roslin Institute, Edinburgh, Scotland [11], turkey performance was typical of commercial performance at the time of the study in 1994. Today (5 yr later), the electrolyte balance used commercially is lower than that used in these tests, and more in line with the Scottish recommendations, due to starting sodium levels of about 0.14 or 0.15% utilized by many companies.

The mode of action of dietary SBC was not determined in this test, but from interaction means it was apparent that the SBC and MON combination was acting in some manner to protect the birds from the effects of coccidiosis. Lillehoj [9] stated that intestinal T cells are the primary mediators of immunity to *Eimeria*. Augustine [8] discovered that dietary SBC enhanced invasion of two species of chicken coccidia, with or without MON. It is hypothesized that chicks or poults on built-up litter, especially in the presence of a coccidial challenge, would be assisted by the enhanced coccidial invasion to obtain early and rapid immunity and later resistance to coccidial challenge, resulting in improved productive and processing performance. For some reason, these events appear to favor a localized immune response without the normal large systemic response and its associated depression in performance. Coccidia that remain to invade, or to be facilitated in invading, the gut may include some of those resistant to the ionophore. Also, the ionophore may provide a metering effect by lowering the coccidial population, possibly to a point similar in numbers to a live coccidial vaccine, and this metering may work in sync with facilitated invasion of the surviving viable coccidia.

TABLE 3. Productive performance and coccidial lesion scores of Nicholas male turkey poults at 18 wk

TREATMENT[A]			BODY WEIGHT	FEED/BODY WEIGHT	MORTALITY ADJUSTED FEED/BODY WEIGHT	MORTALITY
COC	SBC	MON				
	%	ppm	lb	lb/lb	lb/lb	%
COC×SBC×MON INTERACTIONS						
No	0	0	33.97^{a}	2.736^{a}	2.730^{a}	4.41^{a}
No	0.25	0	34.07^{a}	2.739^{a}	2.737^{a}	3.68^{a}
No	0	99	34.26^{a}	2.709^{a}	2.700^{a}	3.68^{a}
No	0.25	99	34.32^{a}	2.703^{a}	2.701^{a}	3.68^{a}
Yes	0	0	33.42^{a}	2.929^{a}	2.890^{a}	16.91^{a}
Yes	0.25	0	33.59^{a}	2.814^{a}	2.788^{a}	11.76^{a}
Yes	0	99	34.07^{a}	2.762^{a}	2.740^{a}	9.56^{a}
Yes	0.25	99	33.83^{a}	2.729^{a}	2.725^{a}	5.15^{a}
COC×SBC INTERACTIONS						
No	0		34.12^{a}	2.722^{a}	2.715^{a}	4.04^{a}
No	0.25		34.20^{a}	2.721^{a}	2.719^{a}	3.68^{a}
Yes	0		33.75^{a}	2.845^{a}	2.815^{a}	13.24^{a}
Yes	0.25		33.71^{a}	2.771^{a}	2.756^{a}	8.46^{a}
COC×MON INTERACTIONS						
No		0	34.02^{a}	2.737^{b}	2.733^{b}	4.04^{a}
No		99	34.29^{a}	2.706^{b}	2.700^{b}	3.68^{a}
Yes		0	33.51^{a}	2.871^{a}	2.839^{a}	14.34^{a}
Yes		99	33.95^{a}	2.745^{b}	2.732^{b}	7.35^{a}
SBC×MON INTERACTIONS						
	0	0	33.70^{a}	2.832^{a}	2.810^{a}	10.66^{a}
	0.25	0	33.83^{a}	2.776^{a}	2.762^{a}	7.72^{a}
	0	99	34.16^{a}	2.735^{a}	2.720^{a}	6.62^{a}
	0.25	99	34.07^{a}	2.716^{a}	2.713^{a}	4.41^{a}
COC, SBC, MON MAIN EFFECTS						
No			34.16^{a}	2.722^{b}	2.717^{b}	3.86^{b}
Yes			33.73^{b}	2.809^{a}	2.738^{a}	10.85^{a}
	0		33.93^{a}	2.784^{a}	2.765^{a}	8.64^{a}
	0.25		33.95^{a}	2.747^{a}	2.738^{a}	6.07^{b}
		0	33.76^{b}	2.805^{a}	2.786^{a}	9.19^{a}
		99	34.12^{a}	2.726^{b}	2.717^{b}	5.51^{b}

[A]COC = Coccidial inoculation; SBC = dietary sodium bicarbonate; MON = monensin. There were eight replicate pens with 24 poults each per treatment (COC×SBC×MON) at placement and with 20 poults each per treatment at 21 days of age.

[a,b]Means within a column and group and with no common superscript letter differ significantly at $P < .05$ (Split-Plot Analysis; Tukey's [HSD] Test when interactions were significant), except that the SBC main effect means for mortality were considered significantly different at $P = .054$.

Conclusions and Applications

1. Nicholas Large White male poults grown on built-up litter and inoculated with two kinds of turkey coccidia through the drinking water at 14 days of age had a significantly ($P < .05$) higher coccidial lesion score at 22 days of age and poorer productive performance in all parameters measured at 3, 6, and 18 wk of age than uninoculated birds, indicating an effective coccidial stressor model.
2. Dietary monensin (MON; 99 ppm) significantly ($P < .05$) improved all turkey live performance criteria measured at 3, 6, and 18 wk of age, with the exception of 3-wk mortality and 22-day coccidial lesion score. The ionophore MON was used in conjunction with bacitracin MD at 55 ppm in all feeds.
3. Dietary sodium bicarbonate (SBC; 0.25%) significantly ($P < .05$) improved 3-wk and 6-wk turkey body weights and feed efficiencies, and 18-wk mortality ($P < .054$; 8.64 vs. 6.07%). Added SBC contributed 0.068% sodium and 0.180% bicarbonate, and increased dietary electrolyte balance of each treated feed by +29.6 mEq/kg. Dietary SBC interacted significantly ($P < .05$) with MON to improve 3-wk body weight and mortality.
4. Nicholas male turkey poults on built-up litter, exposed to a coccidial challenge and fed practical diets containing MON, significantly benefited in early growth, feed conversion, and mortality from supplementation with SBC. Therefore, dietary SBC (0.25%) is recommended for use in market turkey feeds containing MON to improve live performance.

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