Effect of supplemental humic and butyric acid on performance and mortality in broilers raised under various environmental conditions

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Primary Audience: Live Production Managers, Nutritionists, Researchers

SUMMARY

Evaluating natural compounds as a way of enhancing performance and reducing mortality in broilers is important for the poultry industry. Four experiments, involving 1,668 male Ross 708 broilers, were conducted to determine the effect of humic acid (MFG) and protected butyric acid (PBA) on performance and death loss throughout the starter and grower-finisher periods. Experiments 1 and 2 (conducted in early summer and late summer and fall) had between 4 and 6 treatments with MFG and PBA fed alone or in combination with 10 (0.22 m^2/bird) to 12 (0.18 m^2/bird) broilers per pen. The combination of MFG and PBA significantly improved performance and livability in experiment 1, but had no effect in experiment 2. Experiments 3 (early summer) and 4 (middle of summer) had 20 broilers per pen (0.11 m^2/bird). Treatments for experiments 3 and 4 were (1) control, (2) control + MFG (4 and 2 lb/ton for starter and grower-finisher, respectively), (3) control + MFG (4 and 2 lb/ton) + PBA (0.66 and 0.33 lb/ton) for starter and grower-finisher, respectively, and (4) control + MFG (4 and 2 lb/ton) + PBA (1.1 and 0.55 lb/ton). No significant performance differences were observed in experiment 3. In contrast, broilers on treatment 4 in experiment 4 had significant responses in ADG and FCR, along with lower mortalities in extremely hot weather, compared with treatment 1, for the overall (d 0–45) period. Based on these data, especially during heat stress, broilers fed a mixture of MFG and PBA have improved growth and feed efficiency along with lower mortalities.

Key words: broiler, protected butyric acid, humic acid, heat stress, mortality

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DESCRIPTION OF PROBLEM

Evaluating newer technologies to enhance the production and health of poultry is vital for today's industry. Butyrate elicits potent effects on a variety of colonic mucosal functions, such as inhibition of inflammation and decreasing oxidative stress [1]. Added butyric acid has increased carcass weight and breast meat yield in broilers; likewise, in birds challenged with coccidiosis, growth has been improved when broilers were fed butyric acid before the challenge [2]. Further work in broilers subjected to stress via *Escherichia coli* lipopolysaccharide (**LPS**) revealed that supplemental butyric acid improved growth [3]. Supplementing sodium

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butyrate in broilers starting on d 1 resulted in decreased *Salmonella* Enteritidis infections by d 27 [4]. Improvements in intestinal morphology were observed in studies with both very young and finisher pigs from diets fortified with sodium butyrate [5, 6] or a coated calcium butyrate [7]. In other work with baby pigs, it was shown that postweaning performance and digestibility were improved when sodium butyrate was orally administered before weaning [8].

Humic substances, or humates, have been shown to transfer micronutrients from soil to plants, enhance water retention, increase seed germination rates, and improve microbial populations in soils [9] and are composed of humus, humic acid, fulvic acid, ulmic acid, and trace minerals [10]; further applications in animal feeds are still being found. In 2 studies with broilers [11, 12] and 1 study with turkeys [13], significant performance responses were noted from added humates; no significant response was observed in another broiler study [14]. In work with layers [15], supplemental humates improved performance. Moreover, an extensive review [16] showed beneficial results from supplemental humates on digestion, growth, and immunity in chickens, turkeys, pigs, dogs, and cats.

We are not aware of studies in poultry in which protected butyric acid and humates have been evaluated individually or in combination in poultry that are raised in nonstressful and stressful environments. Therefore, the objective of the current research was to determine whether these natural compounds would elicit synergistic effects in broilers raised in normal or under heat-stress conditions.

MATERIALS AND METHODS

General

Four experiments were conducted with Ross 708 male broilers that were obtained from Hoover's Hatchery [17]. The broilers were housed at the Kent Nutrition Group's Product Development Center in 1 solid-sided room that had 24 floor pens, with each pen measuring 1.52 × 1.52 m on a concrete pad. Our ventilation system produced 10,000 cubic feet per minute when operating at full capacity. During the first 2 wk, air was exchanged 2 out of every 10 min with a tunnel ventilation system. During wk 2 to 4, air was exchanged 6 out of every 10 min. After wk 4, air was exchanged continuously with 36 air exchanges per hour. The dimensions of the broiler house were 23 ft wide, 81 ft long, and 9 ft high. The pens were in 2 rows, with 3 ft of empty space behind each pen and 7 ft of empty space (aisle) in front of each pen. When entering the house, the initial 9 ft of the building was also empty. Therefore, because the building was not fully used (only 43% of this building had broilers), the air speed is not comparable to a commercial operation. The estimated air speed was 50 to 75 ft/min in this building. Temperatures were set at 31°C and gradually lowered until 21°C was achieved during the late finishing periods. Individual heat lamps were also placed in each pen for the first 2 wk of each trial. The lighting program throughout the studies consisted of 24 h of light. On d 0 posthatch, broilers were weighed and randomly allotted to treatments. A 20% CP commercial chick starter (crumble) containing amprolium [18] at 125 mg/kg was used during the first 14 d, followed by a 20% CP grower-finisher mash feed for the remaining 27 to 32 d. The 20% CP chick starter contained 1.1% Lys and 0.48% Met, whereas the 20% CP grower-finisher diet contained 1.07% Lys and 0.43% Met. Corn and soybean meal were the primary ingredients used in both diets, with other nutrients exceeding the requirements suggested for broilers [19]. Feed and water were provided on an ad libitum basis for all 4 experiments. Mortalities were recorded daily, and the weights of the dead birds were used to adjust ADG, ADFI, and FCR. All pens in experiments 1 to 3 were washed and disinfected and top-dressed with 10 cm of clean wood shavings. In experiment 4, 25% of the old litter from experiment 3 was left in each pen and then top-dressed with 10 cm of clean wood shavings. All research protocols followed guidelines stated in the *Guide for the Care and Use of Agricultural Animals in Research and Teaching* [20].

Experiment 1

This experiment was conducted to evaluate the effect of humates (**MFG**) [21] or a protected butyric acid (**PBA**) [22] on performance and mortality in 0- to 46-d-old commercial broilers.

The MFG is derived from Menefee Humate. The MFG is a natural occurring mined mineral material derived exclusively from the Menefee Geological Formation in New Mexico. It consists of highly compressed and biodegraded fresh water carbon (sub-bituminous coal), trace minerals, silicon dioxide, humic acid, and fulvic acid. Experiment 1 consisted of 4 treatments: (1) Control (**C**), (2) C + MFG (10 and 5 lb/ton) for starter and grower-finisher, respectively, (3) C + PBA (2 and 1 lb/ton) for starter and grower-finisher, respectively, and (4) C + MFG (5 and 2.5 lb/ton) and PBA (1 and 0.5 lb/ton) for starter and grower-finisher, respectively. The experiment had 12 broilers per pen with 6 replications (pens) per treatment. Average initial and final BW were 33 and 2,893 g, respectively. This trial was conducted from May 3 to June 18, 2007, which had an average high temperature of 81.5°F.

Experiment 2

In this experiment, additional levels of MFG or PBA were evaluated to determine the effect on performance and mortality in 0- to 41-d-old commercial broilers. Experiment 2 had 6 treatments: (1) C, (2) C + MFG (5 and 2.5 lb/ton) for starter and grower-finisher, respectively, (3) C + MFG (10 and 5 lb/ton) for starter and grower-finisher, respectively, (4) C + PBA (1 and 0.5 lb/ton) for starter and grower-finisher, respectively, (5) C + PBA (2 and 1 lb/ton) for starter and grower-finisher, respectively, and (6) C + MFG (5 and 2.5 lb/ton) and PBA (1 and 0.5 lb/ton) for starter and grower-finisher, respectively. Seven replications per treatment were used, with 10 broilers per pen. Average initial and final BW were 35 and 2,605 g, respectively. Four of the replications were conducted from August 16 to September 26, 2007 (average high temperature for this period was 82.3°F), with 3 of the replications conducted from October 3 to November 12, 2007 (average high temperature for this period was 65.5°F). A block analysis was conducted due to the replications being conducted at 2 different time periods.

Experiment 3

In this experiment, we used a constant level of MFG, with and without 2 levels of PBA, to evaluate the effect on performance and mortality in 0- to 44-d-old commercial broilers. Treatments were (1) C, (2) C + MFG (4 and 2 lb/ton) for starter and grower-finisher, respectively, (3) C + MFG (4 and 2 lb/ton) and PBA (0.66 and 0.33 lb/ton) for starter and grower-finisher, respectively, and (4) C + MFG (4 and 2 lb/ton) + PBA (1.1 and 0.55 lb/ton) for starter and grower-finisher, respectively. This experiment had 20 broilers per pen with 6 replications (pens) per treatment. Average initial and final BW were 33 and 2,798 g, respectively. This experiment was conducted from April 29 to June 12, 2008, which had an average high temperature of 73.7°F.

Experiment 4

This experiment was similar to experiment 3, except for 3 differences. The first difference was that we left about 25% of the old litter from experiment 3 in the pens and then added clean wood shavings over the old litter. The second difference was that we conducted this trial during a much hotter time of year (June 24–August 8, 2008), which had an average high temperature of 86.3°F. The third difference was the trial was conducted for 45 d. Average initial and final BW were 35 and 2,743 g, respectively.

Statistical Analysis

Each pen of chicks was the experimental unit for all statistical analyses. Data were analyzed as a completely randomized design using the LSD method for all-pairwise comparisons from Statistix 8 [23].

RESULTS AND DISCUSSION

Experiment 1

No significant performance and mortality differences were observed between broilers on the diets with MFG compared with those on the C diets. Broilers on diets with added PBA and those on diets with added MFG and PBA in combination had significantly greater ADG and ADFI than those on the diets without any supplementation during all periods (Table 1). In addition, significant improvements in FCR also occurred for those broilers fed diets with added PBA and those with both added MFG and PBA compared with those on the control diets during the starter phase. Mortality was decreased ($P \leq 0.05$) for broilers on the diets with supplemental PBA and those with supplemental MFG and PBA compared with those on the C diets without any supplementation. Gain and ADFI were significantly greater for broilers fed diets with both MFG and PBA added compared with those broilers fed diets with MFG or PBA added alone during the starter phase. During the overall period, ADG and ADFI were greater ($P \leq 0.05$) for broilers on MFG and PBA compared with those fed diets supplemented with only MFG.

Experiment 2

Chicks fed diets with MFG added at 5 and 2.5 lb/ton had similar performance for all 3 phases compared with those on the control diets. However, in the starter phase, ADG and ADFI were significantly decreased when broilers were fed diets containing 10 lb/ton of MFG as opposed to those without any supplementation. In the later 2 growth phases, added MFG at 5 lb/ton was without effect compared with those chicks fed the C diets. Chicks fed diets with PBA at 1 and 0.5 lb/ton had similar performance during all phases when compared with the chicks fed the C diets. Chicks fed diets with 2 and 1 lb/ton of PBA had significantly lower ADG during all 3 growth phases compared with those on the control diets. In addition, FCR (d 0–14 and 0–41) was also markedly worse ($P \leq 0.05$) for chicks fed the diets with 2 and 1 lb/ton of PBA compared with those on the C diets. During the 14- to 41-d and 0- to 41-d periods, broilers fed diets with the higher (2 and 1 lb/ton) levels of PBA had depressed ($P \leq 0.05$) ADG compared with those fed the lower (1 and 0.5 lb/ton) levels of PBA. The combination of MFG (5 lb/ton) and PBA (1 lb/ton) resulted in an improved ($P \leq 0.05$) FCR in the starter phase compared with diets containing 5 lb/ton of MFG and a PBA level of 2 lb/ton fed alone. However, the combination of MFG and PBA was statistically similar for ADG, ADFI, and FCR to the broilers on the C diet in the starter phase (Table 2).

Experiment 3

The supplementation of diets with MFG (4 and 2 lb/ton) and the combination of MFG (4 and 2 lb/ton) with added PBA (0.66 and 0.33 as well as 1.1 and 0.55 lb/ton) did not significantly

Table 1. Growth performance of broilers fed humic acid (MFG),[1] protected butyric acid (PBA),[2] or combinations of MFG and PBA (experiment 1)[3]

Item (g, unless otherwise noted)	Control	MFG (10/5 lb/ton[4])	PBA (2/1 lb/ton[4])	MFG (5/2.5 lb/ton[4]) and PBA (1/0.5 lb/ton[4])	SEM
Starter (d 0–14)					
ADG	24.28[c]	24.88[c]	26.41[b]	28.01[a]	0.498
ADFI	32.47[c]	32.98[bc]	34.45[b]	36.66[a]	0.552
FCR	1.34[a]	1.33[ab]	1.30[b]	1.31[b]	0.008
Grower-finisher (d 14–46)					
ADG	76.27[c]	78.12[bc]	82.57[a]	81.37[ab]	1.449
ADFI	143.10[b]	147.59[ab]	151.26[a]	151.90[a]	2.099
FCR	1.88	1.89	1.83	1.87	0.026
Overall (d 0–46)					
ADG	60.04[b]	61.33[b]	65.30[a]	64.89[a]	1.110
ADFI	108.55[c]	111.42[bc]	115.34[ab]	116.32[a]	1.653
FCR	1.81	1.82	1.77	1.79	0.022
Mortality (%)	11.11[A]	5.56[AB]	2.78[B]	2.78[B]	2.980

[a–c]Means within a row containing unlike superscripts are different ($P \leq 0.05$).

[A,B]Means within a row containing unlike superscripts are different ($P \leq 0.10$).

[1]Kent Nutrition Group, Muscatine, IA.

[2]Nutriad Inc., Elgin, IL.

[3]Data are means of 6 replicate pens with 12 males per pen. Trial was conducted from May 3 through June 18, 2007.

[4]The first level refers to the amount added to the starter diets, whereas the second level refers to the amount added to the grower-finisher diets.

Table 2. Growth performance of broilers fed humic acid (MFG),[1] protected butyric acid (PBA),[2] or combinations of MFG and PBA (experiment 2)[3]

Item (g, unless otherwise noted)	Control	MFG (5/2.5 lb/ton[4])	MFG (10/5 lb/ton[4])	PBA (1/0.5 lb/ton[4])	PBA (2/1 lb/ton[4])	MFG (5/2.5 lb/ton[4]) and PBA (1/0.5 lb/ton[4])	SEM
Starter (d 0–14)							
ADG	28.10[ab]	27.41[bc]	25.80[d]	27.60[abc]	26.40[cd]	28.81[a]	0.425
ADFI	36.46[a]	36.41[a]	34.16[b]	36.23[a]	36.53[a]	36.13[ab]	0.713
FCR	1.298[bc]	1.328[ab]	1.324[abc]	1.314[abc]	1.384[a]	1.251[c]	0.026
Grower-finisher (d 14–41)							
ADG	84.65[ab]	84.79[ab]	82.36[bc]	85.86[a]	81.24[c]	83.70[abc]	1.166
ADFI	154.30[abc]	154.96[abc]	150.82[c]	156.62[a]	151.50[bc]	156.52[ab]	1.776
FCR	1.823	1.829	1.831	1.824	1.867	1.872	0.019
Overall (d 0–41)							
ADG	64.35[a]	63.76[ab]	62.05[ab]	64.21[a]	61.53[b]	63.90[ab]	0.833
ADFI	112.01[ab]	111.59[ab]	108.93[b]	111.91[ab]	110.15[ab]	113.10[a]	1.364
FCR	1.741[b]	1.750[ab]	1.756[ab]	1.743[ab]	1.792[a]	1.771[ab]	0.017
Mortality (%)	2.73[bc]	6.89[ab]	0.00[c]	9.74[a]	1.30[c]	4.16[bc]	1.910

[a–d]Means within a row containing unlike superscript letters are different ($P \leq 0.05$).

[1]Kent Nutrition Group, Muscatine, IA.

[2]Nutriad Inc., Elgin, IL.

[3]Data are means of 7 replicate pens with 10 males per pen. Trial was conducted from August 16 through September 26, 2007 (4 replicate pens), and from October 3 through November 12, 2007 (3 replicate pens).

[4]The first level refers to the amount added to the starter diets, whereas the second level refers to the amount added to the grower-finisher diets.

improve ADG, ADFI, and FCR for any of the weigh periods. Mortality was reduced ($P \leq 0.05$) for broilers on MFG (4 and 2 lb/ton) and PBA (0.66 and 0.33 lb/ton) compared with those on diets with supplemental MFG alone. Nevertheless, mortality was not significantly different for any of the diets supplemented with MFG and the combinations of MFG and PBA when compared with broilers fed the diets without any supplementation (Table 3).

Experiment 4

The broilers fed diets supplemented with MFG had improved ($P \leq 0.05$) ADG and ADFI during the starter phase as opposed to those broilers fed the C diets. During d 14 to 45 and 0 to 45, no significant differences were observed between chicks fed the diets with MFG compared with those on the C diets. Mortality was numerically reduced (−36%) from broilers fed the diets supplemented with MFG compared with those on the C diets. Feeding broilers the diets with MFG and PBA (0.66 and 0.33 lb/ton) resulted in no differences in ADG. Supplemental MFG and PBA (0.66 and 0.33 lb/ton) in broiler diets improved ($P \leq 0.05$) overall FCR and numerically (−39%) reduced mortality as opposed to those broilers on the C diets. Broilers supplemented with MFG (4 and 2 lb/ton) and PBA (1.1 and 0.55 lb/ton) had significant responses in ADG (d 0–14, 14–45, and 0–45) and FCR (d 14–45 and 0–45) compared with those fed the C diets without supplementation. In addition, broilers fed diets containing the combination of MFG (4 and 2 lb/ton) and PBA (1.1 and 0.55 lb/ton) also had marked ($P < 0.05$) reductions (−57%) in mortality during extreme hot weather (d 42) as opposed to those on the C diets. During d 42, the heat index was 124.5, with a high temperature of 97°F and a humidity of 65%. Our ventilation systems were operating at maximum capacity, but substantial losses still occurred due to the extreme heat stress on this particular day. Under normal summer temperatures, our ventilation system was adequate in this building that only had birds in 43% of the space available. However, we also had more space per broiler (0.11 m^2/bird) compared with commercial poultry units (as low as 0.08 m^2/bird), which should have helped our birds during this period of extreme heat stress (Table 4).

Table 3. Growth performance of broilers fed humic acid (MFG),[1] protected butyric acid (PBA),[2] or combinations of MFG and PBA (experiment 3)[3]

Item (g, unless otherwise noted)	Control	MFG (4/2 lb/ton[4])	MFG (4/2 lb/ton[4]) and PBA (0.66/0.33 lb/ton[4])	MFG (4/2 lb/ton[4]) and PBA (1.1/0.55 lb/ton[4])	SEM
Starter (d 0–14)					
ADG	27.59	27.88	27.16	27.43	0.527
ADFI	36.74	36.74	35.45	36.53	0.863
FCR	1.33	1.32	1.31	1.33	0.015
Grower-finisher (d 14–44)					
ADG	80.04	80.81	80.25	81.10	0.893
ADFI	159.75	163.23	158.63	159.76	2.377
FCR	2.00	2.02	1.98	1.97	0.019
Overall (d 0–44)					
ADG	63.25	63.83	63.27	63.97	0.723
ADFI	120.37	122.63	119.21	120.43	1.794
FCR	1.90	1.92	1.88	1.88	0.017
Mortality (%)	10.00[ab]	13.33[a]	5.83[b]	10.83[ab]	2.780

[a,b]Means within a row containing unlike superscript letters are different ($P \leq 0.10$).

[1]Kent Nutrition Group, Muscatine, IA.

[2]Nutriad Inc., Elgin, IL.

[3]Data are means of 6 replicate pens with 20 males per pen. Trial was conducted from April 29 through June 12, 2008.

[4]The first level refers to the amount added to the starter diets, whereas the second level refers to the amount added to the grower-finisher diets.

Literature Review

Based on the results from our first trial, there was a possible synergistic effect from the combination of MFG and PBA during the starter phase, whereas overall we observed marked improvements in gain from PBA and the mixture of MFG and PBA. In the second trial, we elected to test a lower level of MFG as well as a lower level of PBA along with the same treatments from the first trial. In this trial we observed no response from any of the treatments.

In designing the third trial, we set the MFG level at 4 and 2 lb/ton for the starter and grower-finisher phases, respectively, and added to this MFG treatment either 0.66 and 0.33 or 1.1 and 0.55 lb/ton of PBA, respectively, to determine if we could obtain the synergistic effects observed in the first trial. The purpose for lowering the MFG, as well as the PBA from the 2 previous trials, was to determine if a response could occur with a more cost-effective mixture. In this third trial, a very small numerical advantage was observed for overall growth and FCR from the combination of MFG and the higher levels of PBA.

We elected to retest the treatments used in the third trial, but the fourth trial was conducted during the hottest time of year and left about 25% of the old litter in the pens from the third trial to create a greater health challenge compared with our previous 3 trials. In the fourth trial, we observed marked synergistic effects in growth and FCR in the grower-finisher period and overall from the combination of MFG and the 1.1 and 0.55 lb/ton levels of PBA added in the starter and grower-finisher phases, respectively. What was even more surprising was the large reduction in mortality (d 42) from MFG (36%), MFG and 0.66 and 0.33 lb/ton levels of PBA (39%), and the significant reduction (57%) in mortality from MFG and PBA levels of 1.1 and 0.55 lb/ton, respectively, for the starter and grower-finisher phases. We clearly observed both a dramatic improvement in performance and a reduction in mortality when broilers were raised under heat stress with a dirtier environment from the use of both supplemental MFG and PBA.

Supplemental (10 lb/ton) Menefee Humate (same source as MFG) in broilers [11] resulted in significant improvements in FCR at 35 d, whereas a level of 10 and 20 lb/ton of Menefee Humate also markedly improved FCR in turkeys fed for 140 d [13]. Further research in broilers [12] with another source of humates

Table 4. Growth performance of broilers fed humic acid (MFG),[1] protected butyric acid (PBA),[2] or combinations of MFG and PBA (experiment 4)[3]

Item (g, unless otherwise noted)	Control	MFG (4/2 lb/ton[4])	MFG (4/2 lb/ton[4]) and PBA (0.66/0.33 lb/ton[4])	MFG (4/2 lb/ton[4]) and PBA (1.1/0.55 lb/ton[4])	SEM
Starter (d 0–14)					
ADG	27.60^{b}	28.65^{a}	28.27^{ab}	28.76^{a}	0.269
ADFI	37.20^{b}	38.46^{a}	37.95^{ab}	38.15^{ab}	0.402
FCR	1.35	1.34	1.34	1.33	0.010
Grower-finisher (d 14–45)					
ADG	74.85^{b}	75.21^{b}	75.29^{ab}	79.35^{a}	1.398
ADFI	166.97^{ab}	165.07^{ab}	160.25^{b}	168.60^{a}	2.696
FCR	2.23^{a}	2.20^{ab}	2.13^{ab}	2.13^{b}	0.036
Overall (d 0–45)					
ADG	59.63^{b}	60.32^{b}	60.44^{ab}	63.39^{a}	1.040
ADFI	125.13^{ab}	124.58^{ab}	121.58^{b}	127.43^{a}	1.911
FCR	2.10^{a}	2.07^{ab}	2.01^{b}	2.01^{b}	0.029
Mortality (d 0–41, %)	4.17^{a}	4.17^{a}	2.50^{ab}	0.00^{b}	1.220
Mortality (d 42, %)	46.67^{a}	30.00^{ab}	28.33^{ab}	20.00^{b}	8.270

^{a,b}Means within a row containing unlike superscript letters are different ($P \leq 0.05$).

[1]Kent Nutrition Group, Muscatine, IA.

[2]Nutriad Inc., Elgin, IL.

[3]Data are means of 6 replicate pens with 20 males per pen. Trial was conducted from June 24 through August 8, 2008. The pens contained about 25% of the litter from experiment 3.

[4]The first level refers to the amount added to the starter diets, whereas the second level refers to the amount added to the grower-finisher diets.

(Farmagülatör DRY Humate [24]) resulted in FCR improvements in a 42-d study with a level of 5.5 lb/ton being added. In contrast, no significant performance and carcass traits occurred in other research [14] with broilers fed the Farmagülatör DRY Humate at 2, 4, and 6 lb/ton during a 49-d test period. In layer research [25] utilizing the Farmagülatör DRY Humate product, significant improvements in egg production and feed conversion efficiency occurred when layers (54 wk of age) were supplemented with 2 and 4 lb/ton of humates for 75 d. Other forms of humates consist of liquids. Broilers [26] fed for 42 d, with 300 ppm of humates added to the water had marked improvements in growth, FCR, and carcass weight compared with those without supplementation.

In a review article by Hamer et al. [1], many positive effects of butyric acid on improving gut function were observed, which included the inhibition of inflammation and decreasing oxidative stress. In broilers that were subjected to *E. coli* LPS, the addition of supplemental sodium butyrate at 1 or 2 lb/ton helped maintain growth performance and improved several key immunological factors in serum [3]. Furthermore, other research [4] in broilers infected with *Salmonella* Enteritidis showed that sodium butyrate (1.84 lb/ton), when partially protected with vegetable fats, provided a greater improvement in reducing infection in the crop, cecum, and liver compared with sodium butyrate without the fat covering. Thus, the coated butyric acid offers a unique balance of free and protected active substances along the entire gastrointestinal tract due to its slow release during digestion. Broilers subjected to coccidial oocyte challenge [2] had greater growth rates when they received butyric acid (4 lb/ton) before the challenge than those on feed without the butyric acid. Moreover, these same infected birds that had supplemental butyric acid in feed also had higher carcass weight and breast meat yield.

In research with weanling pigs [27], Weber and Kerr observed that coated butyric acid (4 lb/ton) helped regulate the response to inflammatory stimuli from pigs subjected to LPS, but that growth rate was unaffected. In rodent studies, an oral dose of butyrate helped protect mice that had been subjected to acute lung injuries via an injection of LPS [28]. Improving gut health in calves is critical to their survival and growth.

A study by Guilloteau et al. [29] concluded that the use of sodium butyrate (6 lb/ton of DM in milk replacer) had beneficial effects on the maturation of gastrointestinal function in milk-fed calves.

CONCLUSIONS AND APPLICATIONS

1. No significant performance responses to the various additives were observed in 2 of the 4 experiments.
2. Performance and mortality were markedly improved in broilers subjected to heat stress when fed diets supplemented with both a proprietary naturally occurring mined mineral (MFG) and a specific source of PBA.

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