Efficacy of Sodium Bisulfate or Sodium Chloride for Reducing Broiler House Floor Microbial Populations

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Primary Audience: Live Production Managers, Researchers, Veterinarians

SUMMARY

Sodium bisulfate is often applied to acid shock poultry house dirt floors following litter removal. Some farms utilize sodium chloride (salt) as a floor treatment. A field study was conducted to compare the efficacy of sodium bisulfate or salt for reducing broiler house floor microbial populations following litter removal. Commercial broiler houses were chosen as the test sites. Floor plots were established under feed and water lines throughout the house. In trials 1 and 2, treatments consisted of (1) control; (2) sodium bisulfate, and (3) Farmer's Coop fine rock salt. Floor plots were aseptically swabbed using a sterile cellulose sponge pre-treatment and at 24 h and 72 h post-treatment. Samples were cultured to determine populations of total aerobic bacteria, *Escherichia coli*, total coliforms, yeast, mold and the presence of *Staphylococcus* spp. Floor plot surface pH was also measured. In both trials, salt had no effect on surface pH and populations of total aerobic bacteria and mold and limited to no impact on yeast populations. Sodium bisulfate showed significant reductions in floor pH and populations of total aerobic bacteria, yeast, and mold in both trials. *E. coli* and total coliform counts were reduced over time regardless of treatment. *Staphylococcus* spp. presence in samples was reduced from 100% pre-treatment to 80%, 60%, and 0% positive 72 h post-treatment in control, salt, and sodium bisulfate treatments, respectively. Sodium bisulfate proved effective for reducing microbial populations on a broiler house floor while salt showed limited to no effect.

Key words: bacteria, sodium bisulfate, pathogens, pad treatment

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DESCRIPTION OF PROBLEM

In the USA, commercial broilers and turkeys are commonly raised inside environmentally controlled houses built on soil pads. Bedding, such as wood shavings, sawdust, rice hulls, or peanut hulls, is added on top of the pad and serves as an absorbent manure carrier. Poultry litter, which consists of bedding, manure, feathers, spilled feedstuff, and soil, is periodically removed and replaced with fresh bedding material. Poultry house sanitation programs commonly consist of complete poultry litter removal followed by cleaning and disinfection of the facility. This practice is implemented as a disease control measure to help reduce pathogen loads and break disease cycles. In between flocks, disinfectants, sodium bisulfate [1] or sodium chloride (salt)

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are sometimes applied on poultry house floors following complete litter removal.

Disinfectant efficacy for controlling aerobic bacteria, yeast, mold, and *Salmonella* populations on a poultry house floor largely depends on disinfectant type, application rate and exposure time [2]. Some chemical disinfectants, such as chlorine, iodine, and quaternary ammonia have limited effectiveness when organic matter and soil are present [3]. Research has shown that sodium bisulfate can control poultry litter pathogens [4, 5]. However, research regarding the impact of sodium bisulfate on poultry house floor microbial populations following complete litter removal is lacking. The objective of this study was to determine the efficacy of sodium bisulfate or salt for reducing broiler house floor microbial populations.

MATERIALS AND METHODS

Two field trials were conducted on two separate commercial broiler farms. For each farm, one 40" × 400" poultry house was selected for bacterial sampling. Both houses were tunnel ventilated with solid sidewalls and contained clay-lined floors. One-year-old poultry litter, consisting of pine shavings, rice hulls, and broiler manure was completely removed from each house. Houses were sampled during the summer within 24 h of litter removal. Experimental test units were floor plots (0.6 m × 3 m) established under feed and water lines throughout the house. Treatments were assigned using a complete randomized block design. In trial 1, treatments consisted of (1) control; (2) sodium bisulfate at 45 kg/93 m^2 (100 lbs/1000 ft^2); (3) sodium bisulfate at 68 kg/93 m^2 (150 lbs/1000 ft^2); and (4) Farmer's Coop fine rock salt at 68 kg/93 m^2 (150 lbs/1000 ft^2). There were 4 replicate plots per treatment. In trial 2, treatments consisted of (1) control; (2) sodium bisulfate at 68 kg/93 m^2 (150 lbs/1000 ft^2); and (3) Farmer's Coop fine rock salt at 68 kg/93 m^2 (150 lbs/1000 ft^2). There were 5 replicate plots per treatment. Each treatment was evenly applied by hand to the surface of each respective plot. The control received no application.

Floor plots were swabbed pre-treatment and at 24 h and 72 h post-treatment. Surface samples were aseptically taken using cellulose drag sponges (2.54 cm × 5.08 cm) contained in sterile Whirl-pak® bags [6] that were hydrated with 20 mL of laboratory prepared sterile Butterfield's phosphate diluent (BPD) [7] prior to sampling. Sponges were then placed back into each bag and immediately transported to the laboratory.

Upon arrival at the laboratory, a 1:10 dilution was prepared by placing each sponge into sterile bottles containing 180 mL of BPD. All samples were shaken vigorously and then cultured to determine plate counts of total aerobic bacteria, *Escherichia coli*, total coliforms, yeast, and mold. Additionally, samples in trial 2 were sent to the University of Arkansas, Division of Agriculture, Veterinary Diagnostic Laboratory in Fayetteville and cultured for the presence of *Staphylococcus* spp. Petrifilm™ [8] was used in accordance with the manufacturer's instructions to determine total aerobic bacteria, *E. coli*, total coliform, yeast, and mold counts. Serial dilutions of BPD were made, and 1 mL was transferred onto the appropriate Petrifilm™. The yeast and mold Petrifilm™ samples were then incubated at 25°C for 3 d, and the aerobic plate count Petrifilm™ samples were incubated at 30°C for 48 h both as recommended by the manufacturer. Samples were cultured for the presence of *Staphylococcus* spp. by serially diluting in sterile saline. Using a 1-mL pipet, 0.1 mL of each diluted sample was spread plated onto Columbia CNA agar [9] and incubated at 37°C for 24 h. Following incubation, the plates were examined for growth.

Floor plot surface pH was measured pre-treatment and at 24 h and 72 h post-treatment. Approximately 10 g of soil was scraped from each of the surface of each plot, placed into a Whirl-pak® bag, and transported to the laboratory. Upon arrival, soil samples were ground using a Perten hammer mill grinder [10] and 4 g was mixed with 40 ml of deionized water. Samples were then placed on a rotating platform for 15 min, and then centrifuged using a Beckman Coulter Model TJ6 centrifuge [11] for 10 minutes. The pH of the supernatant was then read with a Fisher Scientific Accumet basic pH meter [12].

Table 1. The Effect of Poultry House Floor Treatments on Total Aerobic Bacteria Populations (Trial 1).

	Log^{10} aerobic bacteria cfu/mL		
Treatment	Pre	24 h	72 h
Control	$7.07^{a,b,c}$	7.77^{a}	7.90^{a}
Salt[1] (68 kg/93 m^2)	7.44^{a}	7.49^{a}	7.53^{a}
SBS[2] (45 kg/93 m^2)	$7.41^{a,b}$	5.46^{d}	$6.42^{b,c,d}$
SBS[3] (68 kg/93 m^2)	$7.14^{a,b,c}$	2.92^{e}	$6.16^{c,d}$
SEM	0.37		
P-value	0.0001		

[1]Farmer's Coop fine rock salt at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[2]Sodium bisulfate at 45 kg/93 m^2 (100 lbs/1000 ft^2).
[3]Sodium bisulfate at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[a–e]Values with different superscripts differ significantly ($P < 0.05$).

Table 2. The Effect of Poultry House Floor Treatments on Total Aerobic Bacteria Populations (Trial 2).

	Log^{10} aerobic bacteria cfu/mL		
Treatment	Pre	24 h	72 h
Control	7.18^{a}	7.17^{a}	7.08^{a}
Salt[1] (68 kg/93 m^2)	7.09^{a}	7.43^{a}	7.05^{a}
SBS[2] (68 kg/93 m^2)	7.12^{a}	0.62^{c}	3.80^{b}
SEM	0.189		
P-value	0.0001		

[1]Farmer's Coop fine rock salt at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[2]Sodium bisulfate at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[a–c]Values with different superscripts differ significantly ($P < 0.05$).

Table 3. The Effect of Poultry House Floor Treatments on Yeast Populations (Trial 1).

	Log^{10} yeast cfu/mL		
Treatment	Pre	24 h	72 h
Control	2.72^{b}	3.13^{a}	$3.67^{a,b}$
Salt[1] (68 kg/93 m^2)	$3.05^{a,b}$	$2.55^{b,c}$	2.83^{b}
SBS[2] (45 kg/93 m^2)	2.84^{b}	$1.35^{d,e}$	$2.9^{b,c}$
SBS[3] (68 kg/93 m^2)	2.98^{b}	1.05^{e}	$1.91^{c,d}$
SEM	0.237		
P-value	0.0003		

[1]Farmer's Coop fine rock salt at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[2]Sodium bisulfate at 45 kg/93 m^2 (100 lbs/1000 ft^2).
[3]Sodium bisulfate at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[a–e]Values with different superscripts differ significantly ($P < 0.05$).

Table 4. The Effect of Poultry House Floor Treatments on Yeast Populations (Trial 2).

	Log^{10} yeast cfu/mL		
Treatment	Pre	24 h	72 h
Control	$2.36^{a,b}$	2.74^{a}	$2.14^{a,b}$
Salt[1] (68 kg/93 m^2)	$2.33^{a,b}$	3.03^{a}	1.65^{b}
SBS[2] (68 kg/93 m^2)	$2.34^{a,b}$	0.45^{c}	t$2.12^{a,b}$
SEM	0.33		
P-value	0.0001		

[1]Farmer's Coop fine rock salt at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[2]Sodium bisulfate at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[a–c]Values with different superscripts differ significantly ($P < 0.05$).

Data were transformed to a base-10 logarithm prior to analysis. An ANOVA was carried out using the GLM procedure of SAS software [13]. Individual plots were the experimental units, and residual effects were used as the error term. Treatment group and exposure time were the main effects for factorial analysis. The main effects of treatment and time were both significant for total aerobic bacteria, yeast, and mold counts and pH ($P = 0.0001$). However, since the interaction of time and treatment was also highly significant, the discussion will focus on how treatments influenced the dependent variables over time. Variables having a significant *F*-test were compared using the least square means function of SAS and were considered to be significant at $P < 0.05$.

RESULTS AND DISCUSSION

For trials 1 and 2, poultry house floor aerobic plate counts were significantly reduced at 24 h and 72 h following sodium bisulfate treatments; however, salt showed no effect on aerobic plate counts (($P = 0.0001$); Tables 1 and 2). In Trial 1, the higher rate of sodium bisulfate resulted in the greatest reduction (4.85 log) of aerobic plate counts.

Yeast populations were significantly reduced at 24 h after treating with sodium bisulfate in both trials and at 72 h in trial 1 (($P = 0.0003$; $P = 0.0001$); Tables 3 and 4). Salt had limited impact on yeast populations with the only significant reduction occurring at 24 h in Trial 1.

Sodium bisulfate significantly reduced poultry house floor mold populations at 24 h and 72 h in both trials (($P = 0.0001$); Tables 5 and 6). Salt did not significantly reduce mold populations in either trial. Other researchers have reported no significant effects on aerobic plate

Table 5. The Effect of Poultry House Floor Treatments on Mold Populations (Trial 1).

	Log10 mold cfu/mL		
Treatment	Pre	24 h	72 h
Control	3.08[a,b]	3.41[a]	2.94[b,c]
Salt[1] (68 kg/93 m^2)	3.34[a,b]	3.24[a,b]	3.14[a,b]
SBS[2] (45 kg/93 m^2)	3.34[a,b]	2.30[d,e]	2.61[c,d]
SBS[3] (68 kg/93 m^2)	3.26[a,b]	1.97[e]	2.34[d]
SEM	0.15		
P-value	0.0001		

[1]Farmer's Coop fine rock salt at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[2]Sodium bisulfate at 45 kg/93 m^2 (100 lbs/1000 ft^2).
[3]Sodium bisulfate at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[a–e]Values with different superscripts differ significantly ($P < 0.05$).

Table 6. The Effect of Poultry House Floor Treatments on Mold Populations (Trial 2).

	Log10 mold cfu/mL		
Treatment	Pre	24 h	72 h
Control	2.30[a]	1.70[b]	1.93[a,b]
Salt[1] (68 kg/93 m^2)	2.25[a]	2.36[a]	1.55[b]
SBS[2] (68 kg/93 m^2)	2.32[a]	0.94[c]	1.01[c]
SEM	0.18		
P-value	0.0001		

[1]Farmer's Coop fine rock salt at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[2]Sodium bisulfate at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[a–c]Values with different superscripts differ significantly ($P < 0.05$).

Table 7. The Effect of Poultry House Floor Treatments on Surface pH (Trial 1).

	pH		
Treatment	Pre	24 h	72 h
Control	8.04[a]	6.86[a]	7.52[a]
Salt[1] (68 kg/93 m^2)	7.87[a]	7.46[a]	7.14[a]
SBS[2] (45 kg/93 m^2)	8.03[a]	3.87[b]	3.71[b]
SBS[3] (68 kg/93 m^2)	8.01[a]	3.24[b]	2.81[b]
SEM	0.56		
P-value	0.0003		

[1]Farmer's Coop fine rock salt at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[2]Sodium bisulfate at 45 kg/93 m^2 (100 lbs/1000 ft^2).
[3]Sodium bisulfate at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[a–b]Values with different superscripts differ significantly ($P < 0.05$).

Table 8. The Effect of Poultry House Floor Treatments on Surface pH (Trial 2).

	pH		
Treatment	Pre	24 h	72 h
Control	7.78[a]	7.57[c]	7.62[a,b,c]
Salt[1] (68 kg/93 m^2)	7.79[a]	7.65[a,b]	7.67[a,b]
SBS[2] (68 kg/93 m^2)	7.75[a]	2.18[d]	2.39[d]
SEM	0.15		
P-value	0.0001		

[1]Farmer's Coop fine rock salt at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[2]Sodium bisulfate at 68 kg/93 m^2 (150 lbs/1000 ft^2).
[a–d]Values with different superscripts differ significantly ($P < 0.05$).

counts and yeast and mold counts from chicken breasts dipped in a 10% salt solution for 10 min [14].

>In Trial 2, *Staphylococcus* spp. was present in 100% of the pre-treatment samples. At 24 h post treatment *Staphylococcus* spp. was present in 100%, 40%, and 20% of the control, salt and sodium bisulfate samples, respectively. However, by 72 h *Staphylococcus* spp. was present in 80%, 60%, and 0% positive in control, salt, and sodium bisulfate samples, respectively.

E. coli and total coliform counts were reduced over time regardless of treatment. Presence or absence was sporadic throughout the control and treatment groups at each time interval with no clear indication of a trend. Desiccation and the lack of a heavy organic matter load on the poultry house floor may explain the limited recovery.

Poultry house floor surface pH was significantly reduced by sodium bisulfate treatments in both trials (($P = 0.0003$; $P = 0.0001$); Tables 7 and 8). Salt did not impact surface pH. The higher sodium bisulfate rate resulted in the lowest surface pH (2.18). Surface pH following sodium bisulfate application at equivalent rates (45 kg/93 m^2) agrees with previous findings [4].

Microbial populations decreased 24 h post sodium bisulfate application but generally increased at 72 h. However, surface pH remained below 3 at 72 h for the higher sodium bisulfate rate and below 4 for the lower rate. Previous research illustrates that common litter pathogens are destroyed when pH is reduced below 4 [4, 5, 15, 16]. The increase in total aerobic plate counts at 72 h suggests proliferation of non-pathogenic acid thriving aerobic bacteria. Furthermore, yeast and mold populations favor an acidic environment [17] which may explain the observed increase in yeast populations (Trial 1 and 2) and mold populations (Trial 1) 72 h post sodium bisulfate treatment. Future research should focus on further characterizing the acid thriving bacteria that proliferate following sodium bisulfate application. Metagenomic analysis could help determine if these bacteria are strains that may be beneficial to bird gut health.

CONCLUSIONS AND APPLICATIONS

1. Salt application to a poultry house floor had no effect on populations of total aerobic bacteria and mold and showed limited to no impact on yeast populations.
2. Sodium bisulfate applied to a poultry house floor significantly reduced surface pH and populations of total aerobic bacteria, yeast, and mold.
3. Salt showed limited effects on reducing *Staphylococcus* spp. presence while sodium bisulfate eliminated *Staphylococcus* spp. by 72 h.
4. Sodium bisulfate applied at 45 and 65 kg/93 m^2 (100 and 150 lbs/1000 ft^2) proved effective for reducing microbial populations on a commercial broiler house floor following litter removal while salt applied at 65 kg/93 m^2 (150 lbs/1000 ft^2) showed limited to no effect.

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