

**Anti-Salmonella and Anti-Campylobacter Properties of Sodium
Metasilicate on Commercially Available Ready-to-Cook Broiler Breast
Meat Stored at $4 \pm 1^{\circ}\text{C}$ for 7 Days**

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INTRODUCTION

Food-borne Diseases Active Surveillance Network (FoodNet, 2009) reported a total of 17,468 laboratory-confirmed cases (CDC, 2010) that included infections by *Salmonella* (7,039 cases), *Campylobacter* (6,033 cases) and *Shigella* (1,849 cases). Prevalence of *Campylobacter* and *Salmonella* was reported as 49.9% and 11.5% in retail chicken breast samples, respectively (NARMS, 2007). Sodium metasilicate (SMS) is approved as a processing aid and can be used as an antimicrobial component of marinades for meat and poultry products up to 2% by weight of the marinades (USDA FSIS, 2010). SMS is a white anhydrous fast dissolving, fine granular chemical with pH values ranging from 12.5 to 13.0 in 1% solutions.

Limited research has been conducted for sodium metasilicate applications in poultry. The major research that has been conducted is in beef. Weber et al. (2004) reported that exposure of *E. coli* O157:H7 to SMS (5 to 10 s) at a concentration as low as 0.6% (pH 12.1) solutions at room temperature resulted in 100% inhibition with no recoverable *E. coli* O157:H7. Carlson et al. (2008) reduced levels of *E. coli* O157:H7 and *Salmonella* on cattle hides using a 4% SMS solution (at 23°C) as a spray. Pohlman et al. (2009) inoculated beef trimmings prior to grinding with *E. coli* and *S. Typhimurium* followed by treatment with a 4% SMS solution and reported significant reduction in *S. Typhimurium* of more than 1.5 logs. The objectives of this study were to determine the antimicrobial properties of sodium metasilicate (SMS, U.S. Food and Drug Administration approved food additive, USDA FSIS, 2010) against *Salmonella* and *Campylobacter* in fresh ready to cook chicken breast meat, and to ascertain the effects of the SMS treatment on pH.

Materials and Methods

The study was divided into two experiments: Experiment One (Antimicrobial effects of sodium metasilicate against *Salmonella* and *Campylobacter* on inoculated skinless and boneless chicken breasts) and Experiment Two (Antimicrobial effects of SMS against *Salmonella* and *Campylobacter* on inoculated skin-on chicken breasts). For both experiments, chicken breasts were purchased from a local supplier and utilized in the study as outlined below:

Experiment One:

Skinless and boneless chicken breasts were inoculated with *Salmonella* Typhimurium (ATCC 14028, Part A) and *Campylobacter jejuni* (Part B), allowed to set at room temperature for 20 minutes to allow for attachment to the meat. The chicken meat was treated in the following manner using either 1 or 2% SMS based on marinade concentration:

A. *Salmonella* Typhimurium

- Negative control (no treatment, no inoculum)
- Positive control (no treatment, inoculated with *S. Typhimurium*)
- Chicken breast samples inoculated and treated with 1% SMS solution
- Chicken breast samples inoculated and treated with 2% SMS solution

B. *Campylobacter jejuni* inoculum

- Negative control (Non-inoculated chicken breast samples)
- Positive control (Chicken breast samples inoculated with *Campylobacter jejuni*)
- Chicken breast samples inoculated with *Campylobacter jejuni* and treated with 1% SMS solution
- Chicken breast samples inoculated with *Campylobacter jejuni* and treated with 2% SMS solution

Experiment Two

Boneless and skin-on chicken breasts were inoculated with *Salmonella* Typhimurium (ATCC 14028, Part A) and *Campylobacter jejuni* (Part B), allowed to set at room temperature for 20 minutes to allow for attachment to the meat. The chicken was treated in the same manner as in Experiment One, except for concentration of SMS. In Experiment 2, the usage level of SMS was based on the weight of the meat instead of the weight of the marinade.

All samples in Experiments One and Two were packaged stored at $4 \pm 1^\circ\text{C}$ and analyzed in duplicate on 0, 1, 3, 5 and 7 d for *Campylobacter*, *Salmonella* and pH. Three replications (trials) were conducted. Initially, samples were stored for 12 d, but after 6 days, all samples, regardless of treatment were spoiled. Therefore, 7 d was used in this study instead of the 12 d proposed.

Microbiological Analyses

Sample homogenate was prepared and serial dilutions were aseptically transferred onto duplicate sterile disposable 100 x 20 mm Petri plates that contained pre-poured hardened XLT-4 Agar for *Salmonella* and Campy agar with horse blood and antibiotics for *Campylobacter jejuni*. The plates were incubated aerobically 24 ± 2 h at $37 \pm 1^\circ\text{C}$ for *Salmonella* and at 42°C for 48 h under micro-aerophilic conditions for *Campylobacter jejuni*. The resulting colonies were expressed as logarithmic Colony Forming Units per gram (log cfu/g).

pH Analysis

Prior to analysis of pH for each treatment, the pH meter was calibrated. The pH measurements were determined using the sample homogenate immediately after completing the microbiology analysis. The probe was placed into the sample

homogenate and allowed to equilibrate for one minute before the pH readings were recorded. All pH readings were performed in duplicate.

Results and Discussion

Experiment One: Boneless and skinless chicken breasts treated with SMS as part of the marinade.

pH and *Campylobacter jejuni*. The pH values were similar ($P > 0.05$) for the positive and negative control and were higher for the 2% SMS treatment ($P < 0.05$) when compared to all treatments on all days except for Day 7. (Table 1). *Campylobacter jejuni* counts were similar ($P > 0.05$) for all treatments, which suggested that the 1 and 2% SMS treatments exhibited no antimicrobial properties in this study.

***Salmonella Typhimurium*.** Chicken breasts marinated with 1% and 2% SMS had lower ($P < 0.05$) *Salmonella* counts when compared to the positive control at days 3 through 7 of storage. Samples treated with 1% and 2% SMS marinade resulted in 0.83 to 0.91 and 1.04 to 1.16 log cfu/g reductions in *S. Typhimurium*, respectively, 3 through 7 days storage when compared to the positive controls. The data suggested that SMS could function to control *Salmonella*, but had no effect on reducing *Campylobacter*.

Experiment Two - Boneless skin - on chicken breasts treated with sodium meatsilicate as part of the meat block.

pH and *Salmonella Typhimurium*. The pH values were higher ($P < 0.05$) for all SMS treatments when compared to the negative and positive controls (Table 2). *Salmonella Typhimurium* counts decreased as the concentration of SMS increased from 1% (w/w) to 2% (w/w) (Table 2). Treating breast meat with 1 and 2% SMS (w/w) resulted in 1 and 2 log cfu/g reductions ($P < 0.05$) in *Salmonella*, respectively, when compared to the positive control. The results of the present study indicate that SMS has significant antimicrobial potential against gram negative foodborne pathogens, such as *Salmonella Typhimurium*, in chicken meat and can play a role in safeguarding the health of consumers in terms of food safety.

***Campylobacter jejuni*.** *Campylobacter* counts decreased as the concentration of SMS increased from 1% (w/w) to 2% (w/w) (Table 2). Treating breast meat with 1 and 2% SMS (w/w) resulted in 1.21 (Day 0) to 3.23 (Day 0) log cfu/g reductions ($P < 0.05$) in *Campylobacter*, respectively, when compared to the positive control.

Implications for the Poultry Industry

The results of this study will have significant economic impact on poultry processors as well as retailers and consumers. An additional antimicrobial agent will be available to control *Salmonella* and/or *Campylobacter* in poultry. All findings determined in this study for broilers will also be applicable to turkey carcasses and cut-up turkey retail portions.

Conclusions

Experiment One:

- ❖ The 2% SMS marinade treatment, which is the maximum approved level for poultry, resulted in reduction in *Salmonella* on the chicken breast samples.
- ❖ The data revealed that 2% SMS was effective in controlling the growth of *Salmonella* in ready-to-cook skinless and boneless chicken breasts, which could result in enhancing microbiological safety of raw poultry.
- ❖ The SMS treatments were not effective in controlling *Campylobacter*, which suggested the need for usage levels greater than the 2% approved by USDA FSIS in poultry marinades and the need for additional research.

Experiment 2

- ❖ The 1 and 2% concentrations of SMS were effective in controlling the growth of *Salmonella* and *Campylobacter* in the boneless and skin-on chicken breast meat samples evaluated in this study.
- ❖ The level of sodium metasilicate used in Experiment Two was above the USDA FSIS approved level, and, therefore, could not be used in food products, but might have application for use in postharvest environments of food animals to control pathogens. However, additional research is essential.

References

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Table 1. pH measurements and *Salmonella* Typhimurium counts for inoculated ready to cook boneless and skinless chicken breast meat, treated with sodium metasilicate and stored at 4 ±1°C for 7 d

Treatments*	Storage day				
	0	1	3	5	7
pH					
Negative control	6.31 ^{c,x}	6.32 ^{c,x}	6.36 ^{b,x}	6.36 ^{b,x}	6.56 ^{b,y}
Positive control	6.31 ^{c,x}	6.29 ^{c,x}	6.39 ^{b,x}	6.31 ^{b,x}	6.45 ^{b,x}
1% SMS	6.61 ^{b,x}	6.56 ^{b,x}	6.57 ^{b,x}	6.53 ^{a,b,x}	6.63 ^{a,b,x}
2% SMS	6.92 ^{a,x}	6.80 ^{a,x}	6.86 ^{a,x}	6.73 ^{a,x}	6.83 ^{a,x}
Salmonella Typhimurium (log cfu/g)					
Negative Control	NGD ^{a, x}	NGD ^{a, x}	NGD ^{a, x}	NGD ^{a, y}	NGD ^{a, z}
Positive control	6.33 ^{a, w}	6.05 ^{ab, x}	5.97 ^{b, y}	5.59 ^{b, y}	5.01 ^{b, z}
1% SMS	5.97 ^{a, w}	5.57 ^{b, x}	5.06 ^{b, x}	4.76 ^{b, y}	4.15 ^{b, z}
2% SMS	5.76	5.25	4.93	4.43	3.88

pH Measurements:

^{a-c} means in same column with different superscripts are significantly different (P < 0.05).

^{x-y} means in same row with different superscripts are significantly different (P < 0.05).

* SMS = Sodium metasilicate; NGD = No growth detected

Salmonella Typhimurium Counts:

^{a-b} means in same column with different superscripts are significantly different (P < 0.05).

^{w-z} means in same row with different superscripts are significantly different (P < 0.05).

*SMS = Sodium metasilicate. NGD = No growth detected (<100 cfu/g).

Table 2. pH, *Salmonella* Typhimurium and *Campylobacter jejuni* in ready to cook chicken breast with skin on inoculated with *Salmonella* Typhimurium or *Campylobacter jejuni*, treated with sodium metasilicate and stored at $4 \pm 1^\circ\text{C}$ for 7 d

Treatments*	Storage day				
	0	1	3	5	7
pH					
Negative control	6.54 ^c	6.50 ^b	6.49 ^c	6.52 ^c	6.80 ^c
Positive control	6.47 ^c	6.38 ^b	6.37 ^c	6.44 ^c	6.64 ^c
1% SMS (w/w)	9.40 ^b	9.11 ^a	8.84 ^b	8.93 ^b	8.79 ^b
2% SMS (w/w)	10.20 ^a	9.84 ^a	9.90 ^a	9.82 ^a	9.92 ^a
<i>Salmonella</i> Typhimurium (log cfu/g)					
Negative control	NGD	NGD	NGD	NGD	NGD
Positive control	6.09 ^{a, x}	5.48 ^{a, y}	5.19 ^{a, y}	4.88 ^{a, y}	4.35 ^{a, z}
1% SMS (w/w)	4.66 ^{b, x}	4.12 ^{b, y}	3.93 ^{b, y}	3.76 ^{b, y}	3.24 ^{b, z}
2% SMS (w/w)	3.19 ^{c, x}	3.00 ^{c, x}	1.65 ^{c, y}	0.77 ^{c, z}	0.77 ^{c, z}
<i>Campylobacter jejuni</i> (log cfu/g)					
Negative control	NGD	NGD	NGD	NGD	NGD
Positive control	4.75 ^a	4.73 ^a	4.65 ^a	4.63 ^a	4.57 ^a
1% SMS (w/w)	3.54 ^b	3.59 ^b	3.48 ^b	3.24 ^b	3.29 ^b
2% SMS (w/w)	1.52 ^c	1.55 ^c	1.48 ^c	1.00 ^c	1.00 ^c

pH Measurements:

^{a-c} means in same column with different superscripts are significantly different ($P < 0.05$)

* SMS = Sodium metasilicate

Salmonella Typhimurium:

^{a-c} means in same column with different superscripts are significantly different ($P < 0.05$)

^{x-z} means in same row with different superscripts are significantly different ($P < 0.05$)

* SMS = Sodium metasilicate. NGD = No growth detected (< 100 cfu/g).

Campylobacter jejuni:

^{a-c} means in same column with different superscripts are significantly different ($P < 0.05$).

* SMS = Sodium metasilicate. NGD = No growth detected (< 100 cfu/g).