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# Effects of Ultraviolet Light, Organic Acids, and Bacteriophage Interventions on *Salmonella* Populations in Ground Beef

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## Objectives

*Salmonella* is an emerging beef industry challenge. To reduce pathogen contamination of ground beef, major processing companies apply organic acids to beef trim before grinding. The objectives of this study were (1) to evaluate the efficacy of individual applications of lactic acid (LA), peroxyacetic acid (PAA), ultraviolet light (UVC) and bacteriophages (BA), and (2) to determine which combination provides the optimal control of *Salmonella* in ground beef.

## Materials and Methods

A total of 96 ($n$ = 96) samples containing 100 g of 80% lean trim were randomly assigned to 1 of 12 treatments: Control not inoculated (CO), Control Inoculated (COI), LA, PAA, UVC, BA, LA+PAA, LA+UVC, LA+BA, PAA+UVC, PAA+BA, and UVC+BA. Samples were inoculated with a cocktail comprising 4 *Salmonella* strains to yield approximately 3 log CFU/g (COI = 3.52 log CFU/g). Strains used in this study included: S. enterica (ATCC 51741), S. Heidelberg (ATCC 8326), S. Newport (ATCC 27869), and S. Enteritidis C (Se 13, streptomycin resistant). After inoculation samples were treated with LA at 5%, PAA at 400 ppm, UVC at 254 nm, and BA solution including S16 and FO1a phages at 109 PFU/ml. LA, PAA, and BA solutions (5 mL) were uniformly pipetted onto trim surfaces whereas UVC was applied during tumbling for 2 min. Samples were ground and a 25-g aliquot stomached for 2 min in 225ml of sterile 0.1% BPW. The homogenate was centrifuged and the supernatant was discarded to avoid plating phages. Pellets were resuspended in BPW, vortexed, serially diluted in BPW, and plated onto XLD plates to evaluate *Salmonella* counts. Data were analyzed as a CRD by using the PROC GLIMMIX procedure of SAS (SAS Inst. Inc., Cary, NC).

## Results

No *Salmonella* growth was observed in plates from CO samples. Fixed effect of treatment was significant at $P < 0.0001$. Individual applications of organic acids (LA and PAA) as well the combination of both (LA+PAA) did not significantly decrease *Salmonella* counts when compared to COI samples (COI = $3.52^{A}$, LA = $3.13^{A}$, PAA = $3.13^{A}$, and LA+PAA = $3.07^{A}$ log CFU/g). When combined with UVC and BA, LA significantly reduced *Salmonella* loads in ground samples when compared to COI and organic acids-only treatments (LA+UVC = $2.28^{B}$ and LA+BA = $2.46^{B}$ log CFU/g). Similar results were observed for UVC and for the combination of PAA and UVC (UVC = $2.37^{B}$ and PAA+UVC = $2.20^{B}$ log CFU/g). Bacteriophage application (BA = $2.29^{B}$ log CFU/g) and its combination with PAA (PAA+BA $2.07^{B}$ log CFU/g) led to similar *Salmonella* decrease when compared to UVC, UVC and organic acids, LA, and LA+BA. Combined application of UVC and BA provided the optimal reduction when compared to all other treatments. (UVC+BA = 1.55C log CFU/g).

## Conclusion

Application of lactic and peroxyacetic acids on trim prior to grinding did not affect populations of 4 different *Salmonella* strains in ground beef. When applied to beef trim, exposure of ultraviolet light at 254 nm combined with bacteriophage application led to lowest values of *Salmonella* loads in ground beef.

 