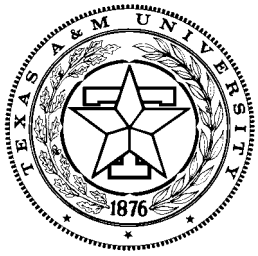

DEVELOPMENT OF A CARCASS SANITIZING SPRAYING SYSTEM FOR SMALL AND VERY SMALL SLAUGHTERHOUSES

Final Report to FSIS/TPDS

By

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Introduction

Although the meat industry has new tools to fight bacteria at all levels from farm to table, contamination of carcasses can still occur. With the implementation of United States regulations requiring plant operation under the HACCP system, meat processing plants employ various technologies for improving the microbiological quality of carcasses. Antimicrobial intervention methods are designed to reduce microbial contamination on the carcasses.

Carcass decontamination utilizing organic acids is a sanitation process that is widely used in the industry, and has been studied deeply. Spraying with organic acid solutions and/or hot or cold water is increasingly applied as sequential interventions for meat decontamination (Stopforth et al, 2003). Lactic acid cabinets are available on the national market, but they represent a significant investment and are available only for large establishments, which usually have higher financial resources in comparison to small and very small establishments.

Small and very small establishments represent approximately the 70% of the total slaughter plants in the U.S. (FSIS, 2003), and this large amount of establishments represents an important field of work where implementation of affordable technologies is needed to ensure the national public health. These establishments, if thjey apply organic acid sprays, usually achieve this treatment using a hand sprayer, which represents an economic tool. However, this method make the process time-consuming and unreliable, since an even spray is not achieved, leaving some areas of the carcass untreated. Our Sanitizing Halo, a carcass spraying system, was designed having in consideration three main parameters. The first parameter was cost effectiveness; small and very small slaughterhouses do not have the same investment capacity as the large establishments do. Therefore an inexpensive design is very important. The second parameter was convenience; small slaughterhouses are located generally out of the urban perimeter. Searching and purchasing materials can become a time consuming and discouraging task. To overcome this problem the system was designed so that it casn be built from materials purchased from any home improvement retail store. The third parameter was simplicity. The Sanitizing Halo can be assembled in a house garage or small shop utilizing common and basic tools available in the market.

The sanitizing spraying system has three main components. A PVC square frame (Picture 1) where the nozzles are located, serves to help the lactic acid solution to get to the nozzles. A large handle (Picture 2), which is attached to the square permits the displacement of the equipment from bottom to top of the carcass reaching the easily the highest and furthest points of the carcass. Finally a water pump is included for conveying the lactic acid solution from an insulated tank to its final destination on the surface of the carcass.

This project is aimed to help small and very small beef and pork slaughterhouses to comply with food safety regulations through the development of a sanitizing system with high performance of spray distribution at low cost.

Background

The contamination of beef during the slaughter and processing of carcasses is a major risk for subsequent food-borne infection in humans. It's estimated that food borne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the United States each year (Mead et al, 1999). Modern Meat, reported that it is estimated that at least one third of the 5,000 deaths each year from food-borne illness can be attributed to meat and poultry (Frontline, 2002).

Beef carcasses, which are initially sterile, become contaminated with bacterial pathogens via transmission of organisms from the exterior of the live animal, and/or from the environment to the product surface (Belk, 2001). Microbial contamination of beef carcasses occurs during the conversion of live animals to meat. After killing and evisceration, most of the microbial characteristics of the carcass remain unaltered. In a healthy animal it is expected that that inner layers of muscle tissue are free of any contamination from air, soil and water. However a large number of microorganisms find their way to the carcass surface during the cleaning operations from the intestine and by contact with knives, hooks, walls, floors as well as by human contact (Guerrero and Taylor, 1994). Main sources of bacterial contamination include feces from the hide, hair, and hooves of the animals (Mies et al 1999). During processing workers and equipment may spread bacterial contamination from the hide to the product. Integration of sanitizing methods, such as knife trimming in combination with other antimicrobial decontamination methods such as steam vacuuming, hot water and acid sprays systems and steam pasteurization can help to improve the microbial safety of carcasses after slaughter (Gorman et al 1995, Castillo et al, 1998, Castillo et al 1999, Pipek et al 2004). Medynsky, Pospiech,and Kniat (2000) found that an increase of the lactic acid concentration in meat above the level of 0.5% enhanced water holding capacity and reduced thermal loss. In other study Jimenez-Villarreal et al (2003) found that lactic acid treatments on beef trimmings before grinding could improve or maintain the same sensory and instrumental color, sensory odor, lipid oxidation, sensory taste, shear characteristics and cooking characteristics as traditionally processed ground beef patties. Therefore the use of these antimicrobial treatments could be used in industry as a measure of safety improvement without negatively impacting the fresh product. Carcass decontamination utilizing organic acids is a sanitation process that is widely used in the industry, and has been studied deeply. In 1995 (Netten, Mossel and Veld, 1995), found that lactic acid decontamination was capable of eliminating salmonellae from pork, veal and beef carcasses, and that this compound is also likely to be effective against *C jejuni*. This bacterium is at least 10-fold more sensitive to lactic acid than *Salmonella*. Furthermore, counts of *C. jejuni* on freshly slaughtered veal, pork and beef carcasses are also up to l00-fold lower than those of *Salmonella*. Castillo et al., (1998) compared the effect of different decontamination interventions on *E. coli* O157:H7 inoculated on beef carcasses. Lactic acid rinses in combination with water wash, trimming and hot water reached reductions from 4.2 to 5.0 log CFU/cm^2. Lactic acid is frequently used for beef carcass decontamination. Its ability to reduce pathogens or other organism of fecal origin has been studied extensively showing that lactic acid have a strong antibacterial effect. Besides the antimicrobial effect, the studies reviewed show

that the use of lactic acid as a meat sanitizer does not have a significant impact on sensory and/or physic-chemical characteristics.

Components and characteristics of the Sanitizing spraying system

Square frame: The sanitizing spraying system has two squares frames; one square frame is for spraying beef carcasses, and the second and smallest square frame is used for spraying the pork carcasses. Difference in size of the square frames is due to the fact that beef carcasses are much wider than pork carcasses. Delivery of the solution is made through a series of nozzles that are arranged in such a way that all regions of the carcass will receive the same amount of solution. The square frame used to spray the pork carcasses has total number of eight nozzles and the square frame used for spraying beef carcasses has 12 nozzles.
The square frame is attached to a **large handle**. This handle permits the displacement of the square frame from bottom to top of the carcass. The large handle permits the operator to reach easily the furthest points of the carcass. The handle is attached to a pumping system, which impels the lactic acid solution from an isolated Rubbermaid cooler.

System adjustment:

Temperature. The lactic acid solution should be heated to 55°C and then transferred to an insulated tank. In this study a Rubbermaid® water container was used. This container was used to hold the lactic acid solution. Since it is insulated, it was able to keep the temperature for about 1 ½ hour. After that, a decrease of 3 to 5°C was detected. It is recommendable to prepare the lactic acid minutes before the system is to be used.

Spraying Pressure. The pumping system utilized in the Sanitizing Halo system delivers the lactic acid solution at a maximum pressure of 40 psi. FSIS has no current requirements concerning the minimum and maximum pressure for organic acids (i.e., lactic acid, acetic, and citric acid) when they are applied onto livestock carcasses. However, the rescinded FSIS Directive 6340.1—Acceptance and Monitoring of Pre-Evisceration Carcass Spray (PECS) Systems, dated 1/24/92, stated that the spray pressures should be limited to 50 psi.

Spraying time and amount of solution delivered: Each carcass was sprayed for a total time period of 20 seconds. Starting from the bottom, to the Highest point for 10 seconds, and coming down and spraying for 10 more seconds. During the spraying time the system delivers 1.5 gal of lactic acid solution on each carcass side.

System testing:

Methods. The system was tested at the Texas A&M University Rosenthal Meat Science and Technology Center (RMSTC). The testing objective was to compare the effectiveness of the spray system to routine hand spraying on bacterial reduction of beef carcasses. Lactic spraying at RMSTC is done utilizing a pressure washer gun, which is attached to a pumping system.

Carcass sampling. After spraying, each carcass side was sampled using a sponge to collect 100-cm^2 samples each from the rump, brisket and clod regions following FSIS procedure (FSIS, 1996). The sponge was placed in a plastic bag and added with 25 ml of sterile 0.1-peptone water and transported to the food Microbiology laboratory located in 313 Kleberg building at Texas A&M University.

Plating. Each sample was plated on *E. coli* and Aerobic Plate Count Petrifilm^{TM} plates for counts of coliforms and *E. coli* as well as counts of mesophilic aerobes.

System Validation

Methods. The sanitizing halo was validated for carcass decontamination at two selected small slaughter plants producing beef carcasses and pork carcasses. The system was taken to the slaughter floor and used for treating 24 carcass halves. A set of 24 untreated carcass halves were used as a control.

Sampling. After application of the lactic acid solution both, treated and untreated carcasses were sampled following FSIS sampling requirements (FSIS 1996) as it was done at the implementation stage. A total of 300 cm^2 per carcass were collected from the rump, brisket and clod regions of the beef carcasses, and jowl, bacon and ham regions of the pork carcasses. The sponges were placed in a refrigerated container and transported to the laboratory 313 at Kleberg building in Texas A&M University for analysis within one day.

Plating. Each sample was plated on E. coli and Aerobic Plate Count Petrifilm^{TM} plates for counts of coliform and *E .coli* as well as counts of mesophilic bacteria. Each sample was tested for counts of *E. coli*, coliforms and mesophilic aerobic bacteria.

Statistical analysis:

Microbiological data were transformed logarithmically before statistical analysis. Means for each treatment were analyzed by analysis of variance (ANOVA) procedure of SPSS 11.5 for Windows. Least square means were separated when treatment effect was significant in the ANOVA table ($p<0.05$).

Results

Temperature and pH. Data in Table 1 show that the pH was reduced on the carcass surface from 7.1-7.6 to 2.8-3.2. Since the lactic acid solution was applied at 55°C, the temperature at the carcass surface increased by approximately 3°C; but the temperature was rapidly lowered at the subsequent chilling step.

System implementation. The counts of aerobic and mesophilic bacteria obtained from the carcasses sprayed with the sanitizing spraying system were significantly lower than the counts on the carcasses sprayed with the hand spraying method (Table 2). Bacterial counts for coliforms were below to the detectable limit for both treatments. The bacterial counts for coliforms obtained the control were between 1.0 logCFU/100cm^2.and 1.5 0 log CFU/100cm^2. These results confirm the efficacy of the sanitizing spraying system on reducing coliforms, aerobic and mesophilic bacteria.

System Validation. All bacterial counts obtained from sprayed carcasses were significantly lower than the bacterial counts on the non-sprayed carcasses, with overall reductions of mesophilic bacteria by 2.9 log cycles for beef carcasses and 1.9 log cycles on pork carcasses (Tables 2 and 3, Fig 1 and 2). A relevant finding in this study was the usefulness of our spraying system for meeting the bacterial counts required in the FSIS standard for *E. coli*. This was true for beef carcasses. As shown in Table 4, 16 of 24 non-sprayed beef carcasses produced *E. coli* counts above the acceptance limit set in the FSIS rule, whereas only 1 of 24 carcasses subjected to lactic acid spray produced unacceptable *E. coli* counts. For pig slaughter, neither control nor sprayed carcasses produced unacceptable *E. coli* counts. This indicates that our spraying system can help small processors in meeting current food safety standards. However, care must be taken to encourage good hygiene before using the sanitizing halo, which should be a complement and not a substitute for good manufacturing practices.

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Table 1. Surface pH and temperature for beef and pork carcasses with or without lactic acid spray

Type of carcass	Determination	Treatment	
		Control	Sprayed
Beef	Surface temperature (°C)	30.9	33.7
	Surface pH	7.1	2.8
Pork	Surface temperature (°C)	27.0	29.3
	Surface pH	7.6	3.2

Table 2. Comparison between the sanitizing spraying system and traditional hand spraying method

	Count[a]	Log cfu/100 cm^2 ± SD (N = 13)		
		Control[1]	RMSTC[2]	Sanitation Halo[2]
Rump	Mesophilic[b]	2.1 ±0.40A[c]	1.7 ± 0.83B	1.2 ± 0.66C
	APC*	2.3 ± 0.40A	2.0 ± 0.66	1.4 ± 0.68C
	Coliforms	1.0 ± 0.92	0.6 ± 0.23	0.5 ± 0.14
Clod	Mesophilic	2.4 ± 0.36A	2.1 ± 0.81	1.2 ± 0.77C
	APC	2.7 ± 0.20A	2.3 ± 0.53	1.5 ± 0.69C
	Coliforms	0.5 ± 0.00	0.5 ± 0.00	0.6 ± 0.40
Brisket	Mesophilic	2.8 ± 1.00A	2.1 ± 0.71	1.5 ± 0.66C
	APC	2.9 ± 0.85A	2.4 ± 0.61	1.5 ± 1.18C
	Coliforms	1.5 ± 0.96	0.6 ± 0.31	0.5 ± 0.00

1 Control: Samples taken after trimming and hot water wash before application of 2% lactic acid solution at 55 °C.

2 RMSTC: Samples taken after applying the lactic solution using the traditional spray method in Rosenthal Meat Science and Technology Center.

3 Sanitation Halo: Samples taken after applying the lactic acid solution using the proposed spray system.

a Mesophilic aerobes: Aerobic Plate Count Petrifilm™ plates incubated at 37 °C/24 hr; Total Coliforms: Total lactose-fermenting colonies on *E. coli* Petrifilm™ incubated at 37 °C for 24 h; E. coli: Glucuronidase-positive on *E. coli* Petrifilm™ incubated at 37 °C for 24 h.

b Values within rows with same letter are not different (P>0.05)

Table 3. In-plant validation of the Sanitizing spraying system for reducing bacterial numbers on beef carcasses[a]

	Count[b]	Log cfu/100 cm^2 ± SD (N = 24)		Log reduction
		Control	Sanitizing Halo	
Rump	Mesophilic aerobes[b]	4.9 ± 0.9A[c]	2.2 ± 1.0B	2.7
	Total Coliforms	3.6 ± 1.2A	1.1 ± 1.1B	2.5
	E. *coli*	3.0 ± 1.4A	<1.0 ± 0.8B	>2.0
Clod	Mesophilic aerobes	4.3 ± 0.8A	2.2 ± 0.8B	2.1
	Total Coliforms	3.0 ± 1.1A	<1.0 ± 0.5B	>2.0
	E. *coli*	2.2 ± 1.3A	<1.0 ± 0.3B	>1.1
Brisket	Mesophilic aerobes	5.1 ± 0.7A	1.9 ± 0.9B	3.2
	Total Coliforms	3.7± 1.2A	<1.0 ± 0.5B	>2.7
	E. *coli*	3.2 ± 1.1A	<1.0 ± 0.0B	>2.2
Overall	Mesophilic aerobes	4.8 ± 0.8A	1.9 ± 0.9B	2.9
	Total Coliforms	3.4± 1.2A	<1.0 ± 0.7B	>2.4
	E. *coli*	2.8 ± 1.3A	<1.0 ± 0.4B	>1.8

[a] Beef carcasses sampled by the FSIS sponge method at the end of the processing line, before chilling

[b] Mesophilic aerobes: Aerobic Plate Count Petrifilm™ plates incubated at 37 °C/24 hr; Total Coliforms: Total lactose-fermenting colonies on *E. coli* Petrifilm™ incubated at 37 °C for 24 h; E. coli: Glucuronidase-positive on *E. coli* Petrifilm™ incubated at 37 °C for 24 h.

[c] Mean values within rows followed by same letter are not significantly different (P > 0.05)

Table 4. In-plant validation of the Sanitizing spraying system for reducing bacterial numbers on pork carcasses[a]

	Count[b]	Log cfu/100 cm^2 ± SD (N = 24)		
		Control	Sanitizing Halo	Log reduction
Jowl	Mesophilic aerobes[b]	4.8 ± 0.3A[c]	2.8 ± 0.7B	2.0
	Total Coliforms	2.0 ± 0.8A	<1.0 ± 0.4B	>1.0
	E. *coli*	1.7 ± 0.8A	<1.0 ± 0.2B	>0.7
Ham	Mesophilic aerobes	4.1 ± 0.3A	2.4 ± 0.6B	1.7
	Total Coliforms	1.9 ± 0.9A	<1.0 ± 0.6B	>0.9
	E. *coli*	1.5 ± 0.7A	<1.0 ± 0.4B	>0.5
Bacon	Mesophilic aerobes	4.3 ± 0.5A	2.3 ± 0.6B	2.0
	Total Coliforms	2.2 ± 1.0A	<1.0 ± 0.3B	>1.1
	E. *coli*	2.0 ± 0.9A	<1.0 ± 0.2B	>1.0
Overall	Mesophilic aerobes	4.4 ± 0.4A	2.5 ± 0.6B	1.9
	Total Coliforms	2.0 ± 0.9A	<1.0 ± 0.4B	>1.0
	E. *coli*	1.7 ± 0.8A	<1.0 ± 0.3B	>0.7

[a] Pork carcasses sampled by the FSIS sponge method at the end of the processing line, before chilling

[b] Mesophilic aerobes: Aerobic Plate Count Petrifilm™ plates incubated at 37 °C for 24 hr; Total Coliforms: Total lactose-fermenting colonies on *E. coli* Petrifilm™ incubated at 37 °C for 24 h; E. coli: Glucuronidase-positive on *E. coli* Petrifilm™ incubated at 37 °C for 24 h.

[c] Mean values within rows followed by same letter are not significantly different (P > 0.05)

Table 4. Effect of lactic acid spray using the Sanitizing spraying system on the ability of a small beef and a small pork slaughterhouse to meet current *E. coli* FSIS standards

	No. carcasses sampled	Mean *E. coli* cfu/cm^{2a}		No. carcasses between m and M^{b}	
		Control^{c}	Sprayed	Control^{c}	Sprayed
Beef	24	150	0.5	16	1
Pork	24	3	<0.2	0	0

[a] For each carcass, the *E. coli* count represents the average count from the rump, clod and brisket regions in beef or the jowl, ham and belly regions in pork, an area of 100 cm^2 from each region was sampled using a sponge to follow the FSIS method.

[b] The FSIS standards stipulates N = 13, c = 3, m = not detectable, M = 100 cfu/cm^2 for beef carcasses and N = 13, c = 3, m = 10 cfu/cm^2, M = 10,000 cfu/cm^2 for pork carcasses.

[c] Control carcasses were sampled after trimming and washing, immediately before chilling

Figure 1. Effect of the sanitazing spraying system on microbial loads on beef carcasses

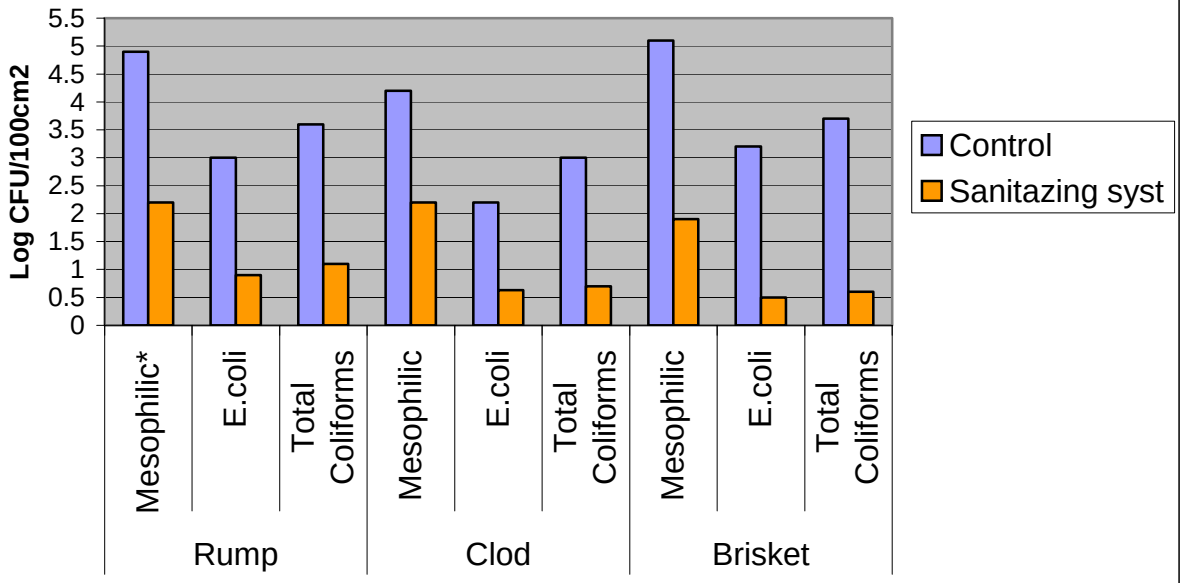
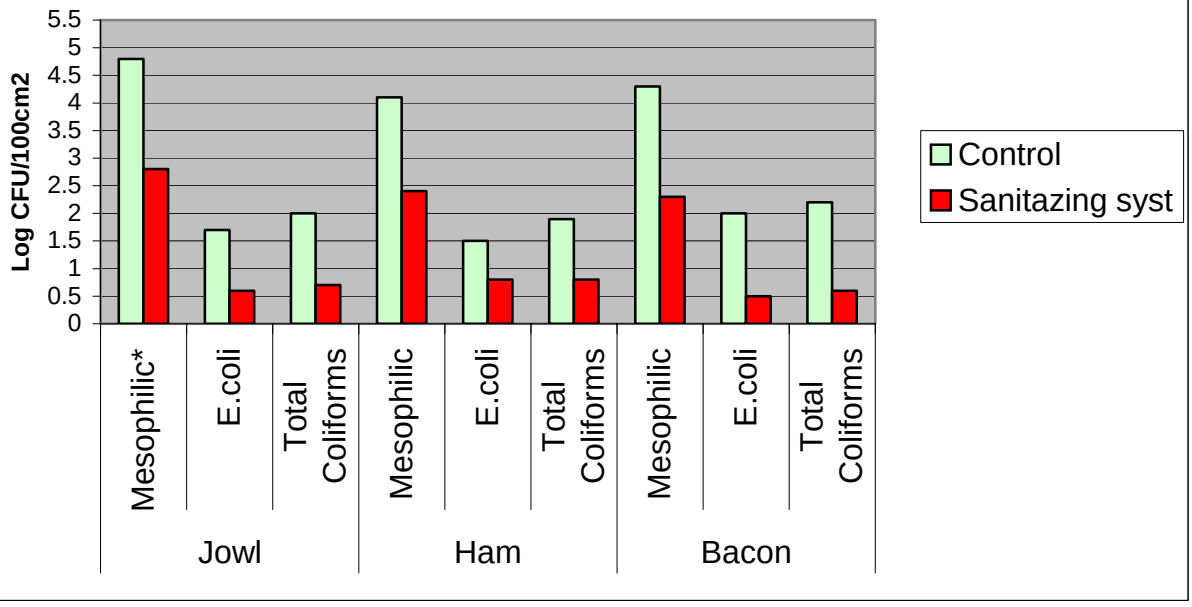
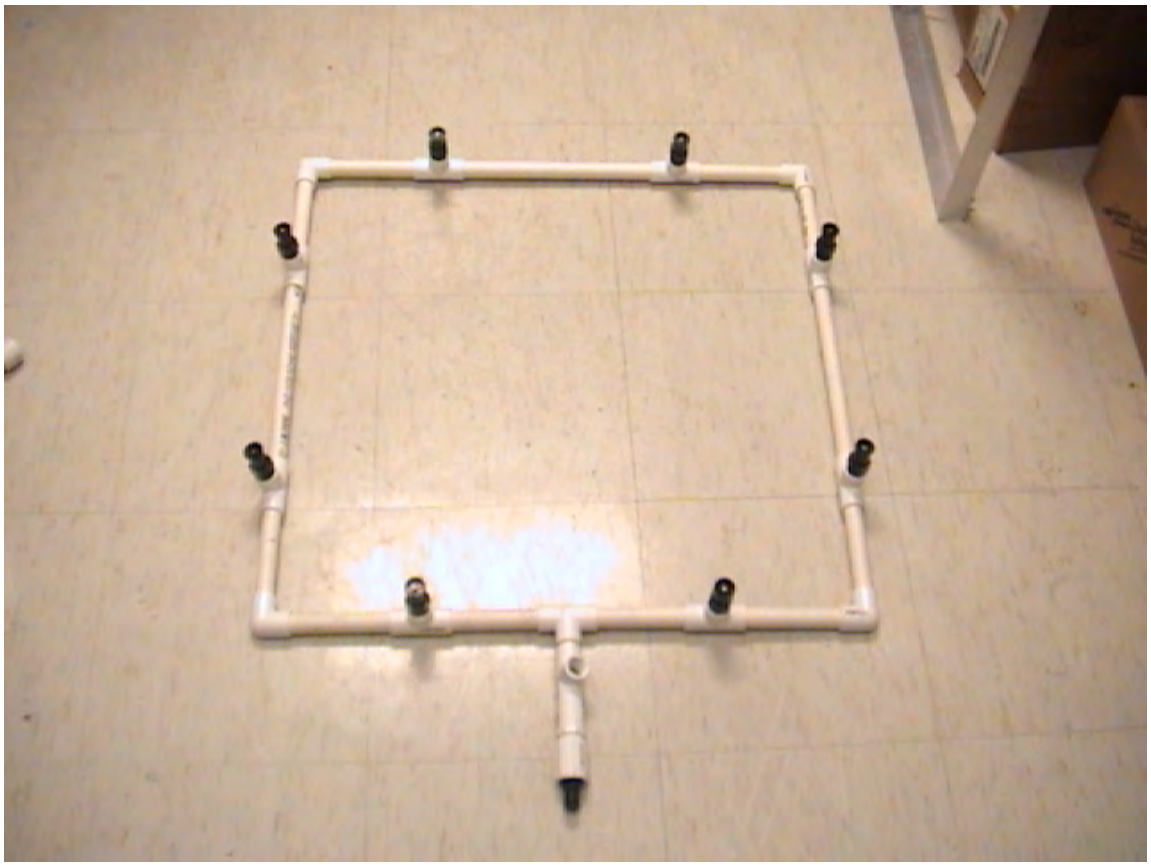


Figure 2. Effect of the sanitazing sprying system on microbial loads on pork carcasses



Picture 1. Square frame



Picture 2. Large handle

Picture 3. Pumping system components

Conclusions and recommendations

The sanitizing halo reduced considerably the bacterial loads on the surface of beef and pork carcasses. It is an important tool that can help small and very small slaughterhouses to comply with government regulations and at the same time to assure the safety of their products.

The use of a wheel cart to move the sanitizing spraying system to different areas of the plant is complicated. Kill floors at small and very small establishments have no space for a wheel cart. Hoses, water, fat and meat pieces are other obstacles that make difficult the use of the wheel cart. Instead of setting the sanitizing spraying system in a wheel cart a larger hose (large of the hose depends on the area of the killing floor) connecting the sanitizing spraying system to the pumping system can be used, and system can be hung from a hook located strategically in one of the walls, so it would not contact the floor and become contaminated.