EFFECT OF WATER AND ACETIC ACID SPRAYS ON CARCASS SHRINKAGE AND PORK MUSCLE QUALITY

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Key words: carcass spraying, acetic acid, pork, colour, drip loss

Background: Evaporative weight loss is an important problem during meat refrigeration in Mexico. Spray-chilling, a low cost method to reduce evaporative weight loss (Gigiel *et al.*, 1989), is used as intermittent spraying of cold water on carcasses during the few hours post mortem (Hippe *et al.*, 1991). Weight loss can be reduced by 0.56% in pork sides sprayed with water (Jones *et al.*, 1993; Strydom and Buys, 1995). Spray-chilling affects meat colour by accelerating the oxygenation of myoglobin to oxymyoglobin (Feldhusen *et al.*, 1995). Greer and Jones (1997) observed a linear relationship between spray-chilling duration and carcass weight loss, with exception of colour, carcass and meat quality measurements were unaffected by spray-chilling at any spray duration.
Water spraying can result in faster growth of spoilage bacteria and moulds (Gigiel *et al.*, 1989) but this can be minimized by good sanitation practices or "strict hygiene" during slaughter procedures (Dickson and Anderson, 1992). The commonly-used sanitizing agents include hot water, chlorine, hydrogen peroxide, trisodium phosphate and short-chain organic acids. Spraying carcasses with organic acids may inhibit both spoilage and pathogen microorganisms and decrease the surface microbial load on carcasses. In beef with added *Salmonella typhimurium*, 2% acetic acid was effective and independent of the initial bacterial load (Dickson, 1992) and acetic acid appears more effective than propionic, lactic or citric acids in inhibiting microbial growth (Ouattara *et al.*, 1997).
Objective: To evaluate the effect of water and/or acetic acid spray-chilling on pork carcass weight losses and meat quality.
Methods: 300 pigs from Pig Improvement Company, USA at approximately 110 kg live weight, were electrically stunned and dressed in a federally-inspected commercial abattoir in central Mexico. After evisceration, the carcasses were spray-washed with 15°C water and allowed to drain. At approximately 40 min *post mortem*, the carcasses in four equal groups were transferred to a chill room at 10°C, 95% RH, 0.5 m/s air velocity for 10 hours when the temperature was reduced to 0°C. One group received no treatment (C), the others were sprayed either with water and acetic acid (WA), acetic acid (Ac) or water (W). Water sprays were given every two hours from 25 nozzles spaced at 50 cm intervals along the rail where carcasses were hung. A total of 7 water sprays were given each lasting 60s and approximately 300 ml of water at 10°C were applied on each occasion. Acetic acid (1%) sprays were applied by hand at 4 and 12 h using a Jas Impala Model 425/501 sprayer (Swissmex, Mexico). Approximately 300 ml was applied on both occasions. The homogenous spraying mist ensured an even moistening of the surface.
Carcass cooling and pH: from of ten carcasses from each treatment were measured at the right leg in the M. Semimembranosus
Meat quality: Colour reflectance (CIE, 1976) L*, a* and b* coordinates were determined using a Minolta Model CM2002. The colour was measured in the *M. Semimembranosus* at 24 h *post mortem* after being cut and bloomed for 10 min. Water-holding capacity was evaluated using the drip losses technique (Honikel and Hamm, 1994) on the *Semimembranosus* muscle.
Bacteriology: Samples were obtained using hyssop technique (ICMSF, 1981a). One 20-cm^2 surface section was sampled using a sterile plaque and sterile cotton hyssop (Deshechables Quirurgicos e Industriales, S. A. de C. V. Mexico, D.F.) on the leg, loin, rib and neck. Hyssop were wet using 0.1% sterile peptone solution (Bioxon, Mexico) before samples were taken. One hyssop was utilized for each surface section. Five hyssops from each carcass were placed in sterile flasks containing 100 ml of 0.1% sterile peptone solution (ICMSF, 1981a). Following homogenization the homogenate was diluted by serial 10-fold dilution in 0.1% pepton water and 0.1 ml sample dilutions were surface plated on prepared bacteriological culture media.
Total aerobic bacterial counts were determined using Standard Plate Count Agar (Bioxon, Mexico) after incubation at 35°C for 48 h (ICMSF, 1981b). Total aerobic psychrotrophic counts were determined using red violet bile agar (Bioxon, Mexico) and incubated at 35°C for 24 h (ICMSF, 1981b). Skin pieces were excised from leg, loin, rib and neck on each carcass for *Salmonella* analysis. 25g of sample were placed in 225 ml Lactose Broth (Merck, Mexico) and incubated at 35°C for 24 h for non-selective enrichement (ICMSF, 1981b). Selective enrichment was made using selenite broth (Difco Laboratories, U.S.A.) and tetrathionate broth (J.T. Baker, Mexico) and incubated at 35°C for 24 h. Analysis on *Salmonella* suspicious colonies were made using lysin and iron agar and triple sugar iron agar (Bioxon, Mexico) (ICMSF, 1981b). Bacterial numbers are given as log colony forming, CFU/cm^2.
Results and Discussion: *Carcass cooling*: Carcasses chilled faster in the three spray-chill treatments than the control (Fig. 1). Initially, WA treatment had the fastest cooling. Temperatures at 24 h were 5.4, 4.4, 3.8 and 3.2°C for C, WA, A and W treatments.
Carcass pH: All 4 groups had similar pH_{45} (6.04 to 6.39) prior to spray-chilling treatment. Water and/or acetic acid spray-chilling had affected pH_{24} and an interaction was observed. Following acetic acid spraying, pH_{24} was reduced to 5.44. The pH, recorded from 45 min to 24 h post mortem from each treatment, showed typical rate of pH decline (Fig. 2) with a logarithmic decline (r =0.96, 0.95, 0.91 and 0.97 for C, WA, Ac and W treatment respectively). pH decline rate was similar between treatments, however, the lowest pH_{24} value (5.44) was observed in the acid sprayed carcasses.
Weight losses: All carcass treated with spray chilling had less weight losses (Table 1) than those with no spray or treated conventionally (C). Carcasses sprayed with water and acetic acid (WA) received a total of nine sprays and had the lowest weight losses (2.0%) and the carcass sprayed only with water (7 sprays) had a weight loss of 2.2%. Weight losses were reduced by 0.59% when the carcasses were sprayed with water and acetic acid, and 0.45% when they were sprayed only with water.

Meat quality: Acid acetic spray-chilling had effect ($p < 0.05$) on meat L* values (Table 1). Meat treated with water spray-chill was the lightest followed by the acid spray-chill and the conventional chilling treatments. The meat had a good appearance and there were no differences between treatments in a* and b* values.

TABLE 1 Effect of Water and Acetic Acid Spray-chill on Weight Losses and Meat Quality (mean and sd, n=75)

Treatment	Conventional	1% Acetic acid	Water spray	Water, 1% Acetic acid
No. of sprays	0	2	7	9
Weight loss (%)	2.6 (0.3)^{c}	2.4 (0.4)^{d}	2.2 (0.5)^{d}	2.0 (0.3)^{d}
pH_{45}	6.4 (0.3)^{c}	6.04 (0.2)^{c}	6.1 (0.2)^{c}	6.4 (0.4)^{c}
pH_{24}	5.6 (0.2)^{c}	5.4 (0.1)^{d}	5.5 (0.2)^{c}	5.6 (0.2)^{c}
L*	45 (6)^{c}	46 (5)^{c}	47 (6)^{c}	42 (6)^{d}
a*	10 (2)^{c}	10 (2)^{c}	10 (2)^{c}	9 (2)^{c}
b*	11 (4)^{c}	10 (4)^{c}	11(3)^{c}	10 (3)^{c}
Drip loss (%)	2.2 (0.6)^{d}	2.8 (1.1)^{c}	2.1 (0.5)^{d}	2.3 (0.9)^{d}

^{cd} Means in the same row with different superscripts are significantly different at $p < 0.05$.

Carcasses treated with acetic acid spray-chilling had the highest drip losses (Table 1). Water spray-chilling did not affect drip loss.
Bacteriology: Water and/or acetic acid spray-chill had no effect ($p > 0.05$) on the pre- and post-chill aerobic plate counts, coliforms and aerobic psychrotrophic counts and Salmonella were absent (Table 2).

TABLE 2 Effect of Water and Acetic Acid Spray-chill on Carcass Microbial Counts (mean and sd, n=40)

	Total Aerobic Bacteria Count (log_{10} CFU/cm^2)		Total Coliforms (log_{10} CFU/cm^2)		Aerobic Psychrotrophic Count (log_{10} CFU/cm^2)		Salmonella (in 25g of meat)
Treatment	Initial (SD)	Final (SD)	Initial (SD)	Final (SD)	Initial (SD)	Final (SD)	
Conventional	2.74 (.27)	2.70 (.39)	2.00 (.48)	1.11 (.07)	2.14 (.27)	2.20 (.48)	Negative
Water, 1% Acetic acid	2.59 (.42)	2.63 (.25)	1.67 (.42)	1.69 (.76)	0.53 (.62)	1.25 (.43)	Negative
1% Acetic acid	2.79 (.49)	2.44 (.61)	1.24 (.73)	1.14 (.86)	1.04 (.69)	1.58 (.39)	Negative
Water spray	3.16 (.40)	2.68 (.70)	2.20 (.63)	2.18 (.52)	1.57 (.40)	2.14 (.60)	Negative

Conclusions

Water and/or acetic acid (1%) spray chilling during the first 12 hours after slaughter decreased evaporative loss by up to 0.6% in pig carcasses without affecting meat quality or bacterial numbers.

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Fig 1. pH decline in conventional and sprayed chilled carcasses

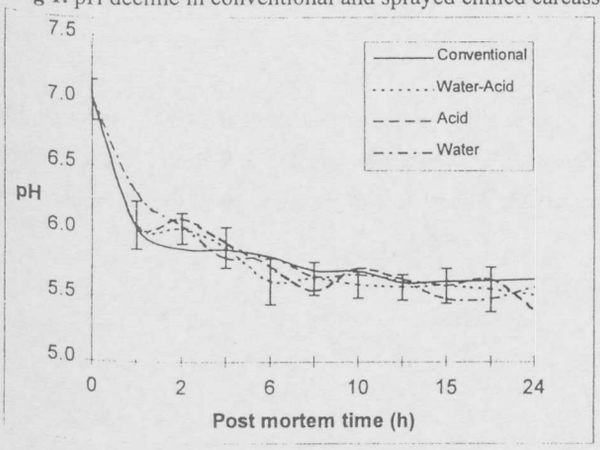

Fig 2. Temperatures in conventional and sprayed chilled carcasses