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# MOISTURE UPTAKE DURING WASHING AND SPRAY CHILLING OF HOLSTEIN AND BEEF-TYPE STEER CARCASSES<sup>1</sup>

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## ABSTRACT

This study was conducted at a commercial beef slaughter plant to determine the effects of carcass washing, intermittent spray chilling and carcass fatness on carcass weight yields and on moisture content of cutaneous trunci muscle and s.c. adipose tissue (AT) samples excised from two carcass locations. Beef steer carcasses ( $n = 36$ ) initially had 12.8% moisture in AT. Immediately following washing, AT from the sirloin region had more ( $P < .01$ ) moisture (24.5%) than AT from the fifth-rib region (15.6%). Fat ( $n = 20$ ) and lean ( $n = 20$ ) carcasses were selected, and their right and left sides were allotted alternately to either a non-spray chill cycle or to an intermittent cold water spray-chilling cycle lasting either 3 or 6 h. After 20 h of chilling, carcasses subjected to the 6-h spray had 12.9% more ( $P < .01$ ) AT moisture and possessed 2.6% more moisture in the cutaneous trunci muscle than similar samples from the non-spray chilled counterparts. In comparison, AT samples that were subjected to the 3-h spray had 3.9% more ( $P < .05$ ) moisture, and the cutaneous trunci muscle had 2.0% more moisture, than their dry-chilled counterparts. After chilling, the spray-chilled AT had substantially higher ( $P < .01$ ) moisture in the fifth-rib region (26.1%) than in the sirloin (14.8%). Spray-chilled sides in the 6-h cycle gained .3% of their hot carcass weight, whereas the corresponding non-spray sides shrank 1.2%. Spray-chilled sides subjected to the 3-h cycle shrank .4%, and their dry counterparts shrank 1.1%. Carcass washing and length of spray cycle had a greater influence than carcass fatness on surface tissue moisture retention. Modulation of these factors will help control post-chilling fluctuation of carcass weights in excess of USDA regulations and yet maximize carcass weight yields.

(Key Words: Beef, Adipose Tissues, Carcass Weight, Chilling, Shrinkage.)

## Introduction

Intermittent spraying of cold water on beef carcasses for 3 to 8 h during chilling has become the norm in commercial beef slaughter plants. The primary benefit of this practice is to reduce evaporative losses during the initial chill period. Yet under USDA regulations, the weight of carcasses after chilling cannot exceed their pre-wash, hot carcass weight. Carcass chilling is accomplished to a large extent by surface moisture evaporation, which occurs at a faster rate when the temperature differential

between the carcass surface and the drip cooler is the greatest. Furthermore, as carcass surface tissue becomes drier, moisture migrates toward the surface, where it evaporates. Eventually, an equilibrium is reached as the temperature differential narrows and reduces the evaporative loss (Locker et al., 1975; Heitter, 1975; Vallort, 1986).

When carcasses were shrouded, once a popular method for reducing weight loss (shrink), typical evaporative losses ranged from .75 to 2.0% for an overnight chill (Kastner, 1981; Vallort, 1986). Heitter (1975) reported that the Chlor-chill system reduced shrink by .5 to 1.25%, depending on carcass type and individual plant. Allen et al. (1987) found that spray chilled beef sides shrank .3% compared with 1.5% for non-sprayed, chilled sides. Those authors stated that, although variation in

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carcass shrink of spray-chilled sides was influenced by carcass spacing, other factors, especially those affecting the dynamics of surface tissue moisture, may be involved. Carcass washing, length of spray cycle, and carcass fatness also influence the variation in shrink. Hence, the objectives of this study were to examine the effects of carcass washing, spray cycle length, and carcass fatness on moisture content of carcass surface tissue and to relate these to carcass shrink during chilling.

#### Experimental Procedures

**Carcass Wash Analysis.** In part 1 of this study, conducted at a large commercial beef packing plant, 10 to 12 g of s.c. adipose tissue (AT) were removed from both the sirloin and fifth-rib regions of 36 steer carcasses having a fat thickness of approximately 1.3 cm. Samples (5 × 5 × .3 cm) were excised 7.5 cm laterally from the carcass midline immediately before and immediately after they entered the carcass wash cabinet. Carcasses were washed with 18°C water at 8.8 kg/cm<sup>2</sup> (125 psi) for 25 s and then with 32°C water at 4.2 kg/cm<sup>2</sup> (60 psi) for 25 s. The post-wash samples were initially blotted with a paper towel to remove excessive residual surface moisture. These and all subsequent samples were placed in individual plastic bags, quick-frozen and stored at -20°C until analyzed for moisture.

**Spray-Chill Analysis.** In part 2 of this study, beef steer (n = 20) and Holstein steer (n = 20) carcasses were selected to represent fat and trim carcass groups, respectively. The average fat thicknesses and hot carcass weights for the fat and trim groups were 1.6 and .5 cm and 344 and 346 kg, respectively. All carcasses were electrically stimulated at 15 min postmortem for 20 s using a stimulator<sup>3</sup> set at 240 V. Left and right sides were assigned alternately to a non-spray or a spray-chill treatment, in which the carcasses were sprayed 60 s every 8 min over either a 3-h or a 6-h period with 1°C water at 4.2 kg/cm<sup>2</sup>. Ten beef-type and 10 Holstein-type sides were designated to both the 3-h and 6-h spray cycles. Their counterpart sides were chilled without spraying. Both sprayed and non-sprayed sides were chilled at 3.3°C for either 7 h (3-h cycle) or 10 h (6-h cycle), and

then at -5.6°C for the remainder of the chill time. Subcutaneous AT samples were excised after 20 h of chilling. Cutaneous trunci muscle samples were removed at 24 h postmortem and handled in a manner similar to AT samples. Side weights were measured immediately before and 20 s after carcass washing and after chilling (20 h). Carcass percentage shrink or gain was calculated for each side.

**Moisture Analysis.** Tissue samples were kept frozen (-20°C) and initially prepared for analysis by pulverization in liquid N. Moisture analysis was conducted in duplicate, using procedures of the vacuum-oven drying method (AOAC, 1984). The differential moisture content of AT tissue was expressed as the moisture content of the sample from each spray-chilled side minus the moisture content of its non-sprayed counterpart.

**Statistical Analysis.** Data were subjected to analysis of variance and means were separated by the least significant difference (LSD) procedure of SAS (1982). Means presented were from 36 observations for the carcass wash data and from either 10, 20 or 40 observations for non-spray and spray-chill data, depending on the treatment combination.

#### Results and Discussion

**Carcass Washing.** The carcass washing procedure added 4.2 kg of water per carcass, resulting in a 1.2% weight gain. These data are typical of those reported by Vallort (1986). There were no differences in AT moisture between the two sampling locations before carcass washing (Figure 1), but the AT from the sirloin region had more ( $P < .01$ ) moisture (24.5%) than AT from the fifth-rib region (15.6%) after washing. This difference may be related to the orientation of spray nozzles in the wash cabinet, which may vary from one cabinet to another. Thus, certain regions may have received more wash water than others, which may have affected AT moisture distribution at the end of the spray-chill cycle.

**Spray Cycle and Carcass Fatness.** Because moisture contents of AT from spray-chilled carcasses are not commonly reported in the literature, we have included them in Table 1. Generally, these means show that AT from both trim and fat carcasses that were spray-chilled had more moisture than AT from non-sprayed carcasses after an overnight chill. Furthermore, AT from the fifth-rib region had more moisture than AT from the sirloin region.

<sup>3</sup>LeFiell Model No. 4055, LeFiell Company, San Francisco, CA.

TABLE 1. MOISTURE CONTENT OF CHILLED (20 H) SUBCUTANEOUS ADIPOSE TISSUE FROM NON-SPRAYED AND SPRAY-CHILLED BEEF SIDES

Trait	Non-sprayed	Spray chill cycle	
		3-h	6-h
Carcass fatness			
Trim	13.1 <sup>ab</sup>	16.1 <sup>b</sup>	27.5 <sup>c</sup>
Fat	11.0 <sup>a</sup>	14.8 <sup>ab</sup>	23.5 <sup>c</sup>
Carcass location			
Fifth rib	13.4 <sup>a</sup>	20.2 <sup>b</sup>	32.0 <sup>c</sup>
Sirloin	10.7 <sup>a</sup>	10.7 <sup>a</sup>	19.0 <sup>b</sup>

<sup>a,b,c</sup>Means in the same row or in each column within a fatness and position group with different superscripts differ ( $P < .05$ ). Average standard error of means for chill cycle, carcass fatness and location was 1.17.

The length of the spray cycle influenced the amount of moisture retained (differential moisture content) in surface AT after chilling (Figure 2). Spray-chilled sides in the 6-h cycle had about three times more ( $P < .01$ ) AT moisture than the spray-chilled sides in the 3-h cycle (12.9 vs 3.9%), when each was compared with its non-sprayed counterpart. No differences ( $P > .05$ ) were found in moisture of the outer layer of AT between the fat (beef-type) and the trim (Holstein-type) steer carcasses. However, the trimmer carcasses in the 6-h cycle appeared

to be wet, and they had a less attractive appearance than trimmer carcasses in the 3-h cycle.

The effects of sampling position on AT moisture are shown in Figure 3. For spray-chilled sides in both cycles, the fifth-rib region AT had more moisture ( $P < .01$ ) than AT from the sirloin region. Sirloin AT moisture was higher than that of the fifth-rib region after the carcass wash, yet it was lower after chilling. Hence, there appears to have been some downward movement of sprayed-on water from the

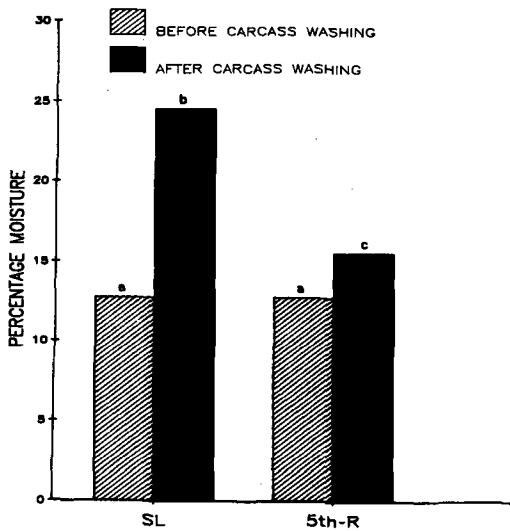


Figure 1. Moisture content in beef s.c. adipose tissue from two carcass locations (SL = sirloin area, 5th-R = fifth-rib area) immediately before and after carcass washing. <sup>a,b,c</sup>Means with different superscripts differ ( $P < .05$ ). Standard error of means for carcass washing and location were .41 and .45, respectively.

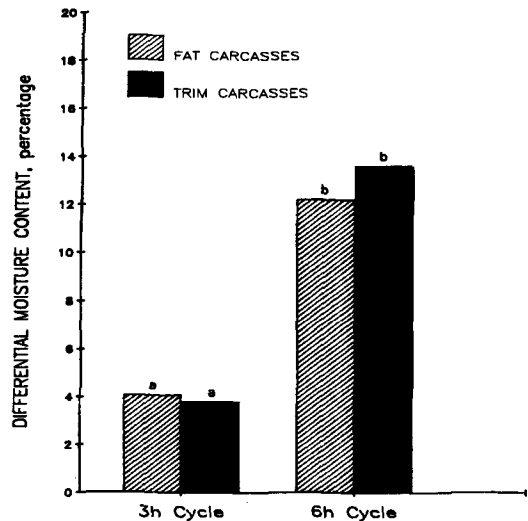


Figure 2. The differential moisture content (sprayed-chilled side minus non-sprayed side) after chilling (20 h) in s.c. adipose tissue from fat (beef-type) and trim (Holstein-type) steer carcasses subjected to 3 or 6 h of intermittent cold water spray during chilling. <sup>a,b</sup>Means with different superscripts differ ( $P < .01$ ). Standard error of means for both cycle and carcass fatness was 1.3.

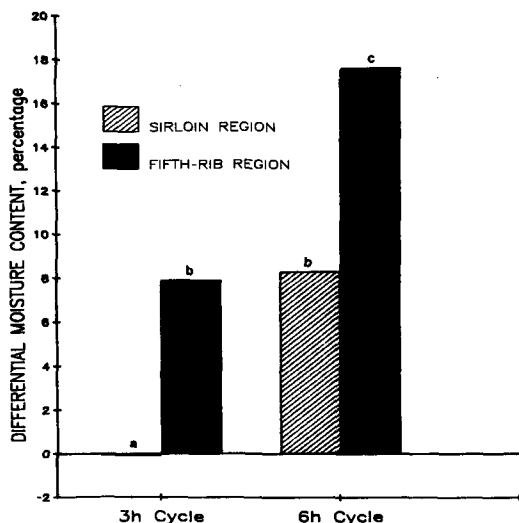


Figure 3. The differential moisture content after chilling (20 h) in s.c. adipose tissue from two carcass locations subjected to 3 or 6 h of intermittent cold water spray during chilling. a,b,cMeans with different superscripts differ ( $P < .01$ ). Standard error of means for carcass location and cycle length were 1.30 and 1.32, respectively.

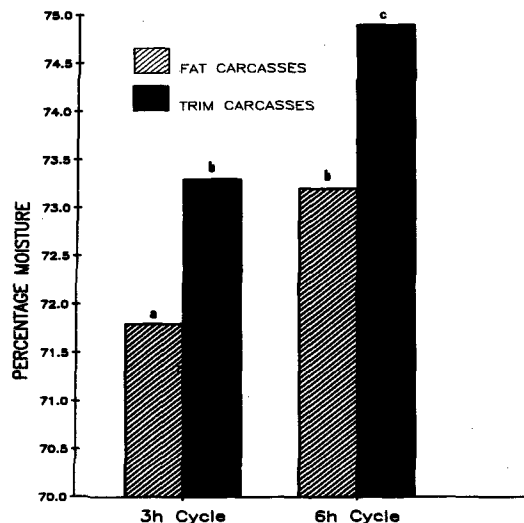


Figure 4. Moisture content in cutaneous trunci muscle after chilling (20 h) of fat (beef-type) and trim (Holstein-type) steer carcasses subjected to 3 to 6 h of intermittent cold water spray during chilling. a,b,cMeans with different superscripts differ ( $P < .08$ ). Standard error of means for both carcass fatness and cycle length was .58.

round to the chuck. Air movement distribution also may influence differences in surface tissue moisture. The air velocity, although not measured in this study, was estimated to be less for the lower portion than for the higher region of the carcasses. These trends are in agreement with those reported by Locker et al. (1975), who stated that faster cooling rates in the thinner carcass regions usually result in less moisture evaporation because the AT in the thinner areas chill quicker and achieve a temperature equilibrium sooner, thus reducing the initial moisture loss from AT during evaporative chilling of thinner as compared to thicker regions.

Following an overnight chill, cutaneous trunci samples excised from the non-sprayed sides had less ( $P < .01$ ) moisture than similar samples from spray-chilled sides. Sides in the 6-h spray cycle (Figure 4) had more ( $P < .02$ ) moisture (74%) than similar samples from the 3-h spray cycle (72.6%). Additionally, the trimmer carcasses (74.1%) had wetter cutaneous trunci muscle than the fatter carcasses (72.5;  $P < .02$ ).

**Carcass Yields.** The amount of moisture retained in surface tissues directly influenced carcass yields following an overnight chill

(Figure 5). Hot side weights of spray-chilled and non-spray chilled carcasses were nearly

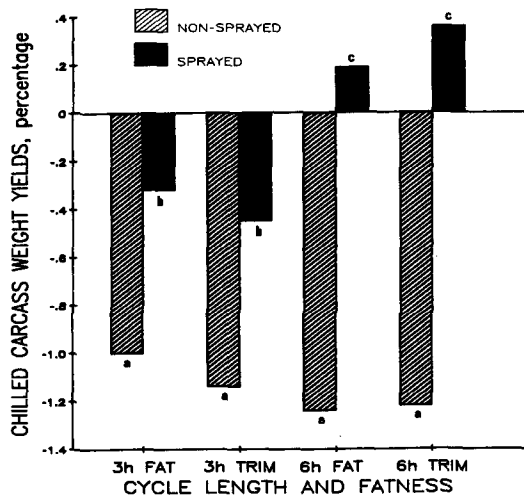


Figure 5. Chilled carcass weight yields of fat (beef-type) and trim (Holstein-type) steer carcasses subjected to either a non-spray or a 3 to 6 h intermittent cold water spray cycle during chilling. a,b,cMeans with different superscripts differ ( $P < .01$ ). Average standard error for spray treatment, cycle length and carcass fatness was .08.

identical because of the method of assigning alternate right and left sides to each treatment. However, after chilling, those sides (fat and trim) subjected to the 6-h cycle gained about .3%, whereas similar sides in the 3-h cycle shrank about .4%, compared with shrinkage of about 1.1% in the non-sprayed sides. The optimum spray cycle length for this slaughter plant is between 3 and 6 h in order to minimize shrinkage and still comply with USDA regulations; however, other plants would have to adjust to their own unique conditions. Although no differences ( $P > .05$ ) in percentage carcass shrink existed between fat and trim sides in the 6-h spray-chill cycle (Figure 2), the surface of the trimmer carcasses appeared overly wet. The yield improvement of 6-h sprayed-chilled sides surpassed yield advantages reported by Heitter (1975) and Allen et al. (1987), but the yields of 3-h spray-chilled sides are in agreement with results reported by those authors. The benefits of spray-chilled sides are in agreement with results reported by those authors. The benefits of spray-chilling to enhance carcass weight yields can amount to tremendous savings in shrink, particularly for a large-volume, low-margin business such as the meat packing industry, if excessive variation in carcass weight gains can be avoided. The additional moisture in trimmable AT from spray-chilled carcasses, however, may necessitate greater energy utilization to drive off moisture during rendering operations.

The purpose of this study was to evaluate factors that might help explain variations in chilled weight yields of beef carcasses that were sprayed chilled. Apparently, any factor that affects moisture uptake or delays moisture evaporation from s.c. AT and surface lean tissue has a significant effect on the ultimate, chilled

carcass weight. Previously, Allen et al. (1987) found that carcass spacing during chilling influenced surface moisture losses and carcass weight yields. The present data indicate that hot-carcass washing and spray-cycle conditions also affect weight yields. Additionally, because s.c. AT is prone to trimming knife cuts and hide pulls, defects in the dressing procedures that entrap water in or below the AT also may affect the moisture dynamics of AT. Thus, several factors, either singly or combined, must be controlled to maximize spray-chilled carcass weight without exceeding USDA weight regulations for chilled carcasses. The effects of spray chilling on tissue moisture retention and weight yields of subprimal and retail cuts at various stages of processing and distribution merit further investigation.

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