The hot water spray cabinet used on lamb carcasses had water leaving the nozzles at 95°C, but the temperature of the water reaching the carcass could not be raised above 74°C (165°F). They were able to obtain a 99 percent decrease in inoculated *E. coli* at all sites when sheep carcasses were immersed in 80°C (176°F) water for 10 seconds. Immersion for 30 seconds gave little extra kill of inoculated bacteria. In-plant immersion tests on carcasses that had not been inoculated showed a 98 percent reduction in bacterial numbers.

Researchers have found that pouring hot water at 169°F (77°C) on beef (tissue slices) and mutton (carcass) samples for 10 seconds destroyed more than 99 percent of *E. coli* and *Salmonella* inoculated ($10^{6.5}$/cm²) onto the samples. Tissues surfaces were not permanently discolored. When beef slices (2.5 cm thick) swabbed with bacterial culture were exposed to hot water (60°, 65°, 70°, 80°, 90°C) for intervals of 10, 30, 60, and 120 seconds, it was found that the time of exposure was not a factor, but a progressive decrease in *E. coli* counts from $>10^1$ at 60°C to $>10^4$ at 90°C was noted. Coliform and aerobic mesophilic bacteria counts on six naturally contaminated sheep carcasses were reduced from 100 cells/cm² to below detectable limits and 8,500 to 310 cells/cm² respectively.

A 1979 study applied cold water (16°C, 60°F)(<14 kg/cm²), hot water 76°C–80°C [168°C–176°F])(14 kg/cm²), and steam (95°C) to previously frozen beef plate strips. Treatment with cold water alone reduced the counts by about one log. Steam alone only reduced the count by 0.06 log. Initial reduction in counts by hot water alone was 2.0 log. Samples held at 3.3°C were cultured for several days after treatment. After an initial lag phase of less than a day for samples treated with cold water or steam, the rates of bacterial growth were greater on the treated samples than on untreated controls. By the fifth day the aerobic plate counts for steam and cold water treated samples exceeded the aerobic plate count on the control samples. Presumably this was due to the greater surface moisture from the treatment. The rate of bacterial growth on samples treated with hot water was similar to that on controls, but the initial 2-log difference was maintained through 12 days of storage resulting in nearly 5 additional days for counts to reach 10^8/cm².

A 1981 study reported that lamb carcasses sprayed with hot water at temperatures >169°F (77°C) caused significant decreases (1.0 $\log_{10}$/cm²) in APC. As temperature was increased the reduction in bacterial numbers observed by spray washing was increased.

Another researcher used a deluge method instead of conventional pressure spraying. Advantages cited include: construction simplicity, cheaper running cost, and greater reduction in bacteria. However, unlike spray decontamination, coverage of the abdominal and thoracic cavities was only about 65 percent. He found a significant (<0.05) linear relation between the log reduction in inoculated *E. coli* and average water film temperature which varied with exposure time immediately after treatment. Longer exposure (20 sec vs 10 sec) produced significantly greater reduction at higher temperatures (44.5°, 66.0°, 74.2°, 83.5°C). There was no significant growth of *E. coli* between 24 and 48 hours, which is consistent with the findings of several other researchers. After chilling for 48 hours, sides exposed to 83.5°C had a slight and apparently permanent bleaching of the fat and meat tissue in the area of the upper thoracic cavity.

In a 1993 study, carcasses were sprayed with 2 liters of hot (95°C) water for 40 seconds with the intent of raising the meat surface temperature to 82°C for 10 seconds before final wash and after final wash. The apparatus was designed to raise the temperature within 30 seconds and maintain it at 82°C for 10 seconds. Culture samples taken from hot water-treated carcasses before final wash had a mean $\log_{10}$/cm² of 1.1 while controls had $\log_{10}$/cm² of 2.4. Culture samples taken from hot water-treated carcasses after the final wash had a mean $\log_{10}$/cm² of 1.5 while controls had $\log_{10}$/cm² of 2.3. It was unclear why a greater reduction in bacterial numbers occurred when carcasses were sprayed with hot water before the final carcass rinse. A 15–20 minute elapsed time between hot water and final wash may have allowed more bacterial attachment to take place. The volume of the spray and the size of droplets were found to have a profound effect on the temperature of the water contacting the carcass surface.

In view of this research, FSIS is proposing that hot water treatments used to meet the intent of this regulation be applied such that the temperature of the water at the surface of the carcass is ≥ 165°F (≥ 74°C) for ≥ 10 seconds. If applied by a spray, this is likely to require that the water be heated to a somewhat higher temperature. The hot water would have to contact all carcass surfaces. Other combinations of time and temperature of hot water also may be effective. FSIS would like comments on this point.

FSIS considers the final beef carcass wash to be an appropriate point at which to apply hot water as an antimicrobial treatment. The final carcass wash occurs at the end of the slaughter and dressing process, after trimming and FSIS postmortem inspection is completed. The final carcass wash is usually the last step in the dressing process before the carcass enters the cooler for chilling. The final carcass wash removes blood, bone dust, hair, dirt, and other accidental contamination. On November 1, 1994, FSIS announced that hot water rinses will be allowed at the final beef carcass wash without prior approval. An establishment wishing to apply hot water to beef carcasses at the final wash no longer must obtain prior approval by FSIS. However, FSIS notes that a hot water wash used pre-evisceration might also meet the intent of this regulation and therefore has the potential advantage of removing/destroying bacteria before they have had time to become tightly attached to carcass tissues. FSIS invites comments on whether the use of hot water wash to satisfy the proposed requirement of an antimicrobial treatment should be limited to the final carcass wash or should be permitted at other stages of the slaughter and dressing process.

A list of studies on various methods of applying hot water to meat and poultry carcasses is on file in the FSIS Docket Clerk's office, and is available from the Director, Slaughter Inspection Standards and Procedures Division, FSIS, U.S. Department of Agriculture, Washington, DC 20250. FSIS welcomes additional data on the effectiveness of hot water as an antimicrobial treatment, especially regarding the effectiveness of varying temperatures and times of exposure.

(b) *Lactic, acetic, and citric acid solution sprays.*

Lactic, acetic and citric acids are weak acids that have long been consumed by humans in a variety of foods. They occur naturally (e.g., citric acid in limes), have been added in the processing of a broad variety of foods (e.g. acetic acid in mayonnaise), and develop in the fermentation of foods (e.g., lactic acid in cheese).

FDA lists acetic acid as Generally Recognized As Safe (GRAS) as a direct food substance in 21 CFR 184.1005 if used at levels not exceeding current good manufacturing practice (CGMP). The acetic acid listing specifies that the CGMP results in a maximum level in meat of 0.6 percent as served. While the use of acetic acid on fresh meat was not reviewed by the Select Committee on GRAS Substances in reaching its