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FACT SHEET

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TENDERIZING BEEF WITH ELECTRICITY

J. W. Savell, G. C. Smith, T. R. Dutson and Z. L. Carpenter*

Electrical Stimulation Not New

The use of electrical stimulation for increasing meat tenderness is not a new idea. Benjamin Franklin is credited with having remarked in 1749 that "killing turkeys electrically, with the pleasant side effect that it made them uncommonly tender, was the first practical application that had been found for electricity." In 1951, more than two centuries after Franklin's discovery, patents were obtained by Harsham and Deatherage (U.S. Patent No. 2,544,681) and Rentschler (U.S. Patent No. 2,544,724) for their processes of tenderizing carcasses by use of electrical stimulation.

Most of the research on electrical stimulation has been reported since 1976. Experiments conducted on electrical stimulation by researchers in New Zealand, England and the United States have delineated effects of using electrical stimulation to tenderize meat. Other benefits of electrical stimulation include increased firmness of lean, brighter lean color, earlier development of marbling and more complete bleeding (facilitating blood removal in areas of the plant designed to handle such wastes). Although the methods and sources of electrical stimulation vary among studies, it is evident from all studies that electrical stimulation can be an excellent method for faster processing of carcasses and that it can produce a more palatable product.

Stimulation Improves Tenderness

Studies at Texas A&M University involving both sensory panel tenderness studies and shear force measurements of cooked steaks from stimulated and non-stimulated carcasses (Table 1) have demonstrated sizable tenderness improvements resulting from use of electrical stimulation. On the average, tenderness is increased about 21 percent (19.7 percent for sensory ratings, 21.6 percent for shear force measurements) when carcasses are electrically stimulated. The amount of tenderization achieved (from as little as 11 percent to as much as 55 percent) is usually associated with the initial tenderness of the unstimulated meat. If the initial tenderness is acceptable, the electrical stimulation will not appreciably change the ratings; if the initial tenderness is unacceptable, electrical stimulation will be very effective in increasing tenderness.

Table 1. Summary of electrical stimulation effects on tenderness

Description of animals	Percent of Change in Tenderness Values[a]	
	Sensory Rating[b]	Shear force[b]
29 forage-fed steers	+24	−25
30 grain-fed heifers	+21	−13
9 grain-fed steers	—	−46
6 forage-fed steers	+55	−41
30 hot-skinned calves	+16	−22
30 cold-skinned calves	+18	−17
5 grain-fed steers	+27	−24
30 grain-fed heifers	+11	−15
12 grain-fed steers	+27	−20
60 calves	+21	−20
50 grain-fed heifers	—	−24
40 aged cows	—	−26
331 cattle (Percent Average Net Effect)	+19.7	−21.6

[a] Calculated by comparing stimulated and non-stimulated sides of the same animal.

[b] An increase in sensory panel ratings and a decrease in shear force values indicate more tender meat.

*Meats specialist, Texas Agricultural Extension Service; professor and associate professor, Texas Agricultural Experiment Station; and head, Department of Animal Science; The Texas A&M University System.

Texas Agricultural Extension Service • The Texas A&M University System • Daniel C. Pfannstiel, Director • College Station, Texas

There are three theories regarding the mechanism by which electrical stimulation tenderizes meat. First, because of the rapid decline in the amount of available ATP (an energy compound necessary for muscle contraction) caused by electrical stimulation, the muscles of the carcass will "lock" into rigor mortis before the temperatures achieved during normal cooling can cause "cold-shortening" to take place. "Cold-shortening" of muscle causes the meat to be tough because of the contraction of the muscle fibers before rigor mortis is complete.

Second, because of rapid reduction in pH (caused by the build-up of lactic acid) in the muscle while carcass temperatures are still high, conditions are favorable for the naturally occurring (lysosomal) enzymes responsible for tenderization during aging to degrade muscle proteins and cause more rapid tenderization. Studies have shown that the lysosomal enzymes in electrically stimulated carcasses are released sooner and work at a faster rate than lysosomal enzymes in unstimulated carcasses.

Third, light and electron micrographs of beef from electrically stimulated and unstimulated carcasses reveal that structural damage has occurred in the muscle fibers of the electrically stimulated samples. Contracture bands, which may be caused by physical disturbance associated with stimulation-induced contractions, are observed within some of the electrically stimulated muscle fibers. The disarray of the protein filaments in the contracture bands of the electrically stimulated muscle fibers suggests that structural damage may result in tenderization. Also, tenderization may result from the stretching of areas of the fiber on either side of the contracture band, which would result in less overlap of the muscle filaments and cause less resistance to chewing.

It is possible that these three mechanisms are singularly or collectively responsible for the observed improvement in tenderness. The method of stimulation may dictate the relative importance of each of the three mechanisms in tenderizing muscle since various voltages, amperages, cycles and modes of administration of electricity have been used by researchers with varying effects. However, all types of stimulation treatments have increased tenderness.

Prevents "Heat-ring" Formation

A problem associated with attempts to move beef through the sequence of slaughter, chilling, grading and fabrication too rapidly is that of "heat-ring" formation. If severe enough, this can delay or preclude federal grading of carcasses. "Heat-ring" usually occurs in beef that has been chilled too rapidly and not held for the proper length of time. "Heat-ring" usually is prevalent in carcasses with limited outside fat covering over the ribeye. Biochemical data suggests that "heat-ring" results from a slowed rate of postmortem reactions near the surface caused by a cold environment.

The severity of "heat-ring" ranges from slightly dark, slightly coarse, slightly depressed lean in the ribeye extending inward about one-half inch from the outside portion of the ribeye to dark, coarse, depressed lean in the ribeye extending inward about 1 inch. Usually, if the side of a carcass ribbed first (in normal grading practice) has a severe "heat-ring", the other side will be stored for a longer period of time, ribbed and presented for grading — lessening the incidence of "heat-ring" formation. Delayed ribbing creates problems for some packers because of delays in moving beef and increased space requirements for holding beef to insure proper rigor mortis development before grading and processing.

Research has shown that "heat-ring" can be significantly reduced or alleviated by the use of electrical stimulation (Table 2). Studies on paired sides of carcasses by Texas A&M University scientists have revealed that, with the use of electrical stimulation, "heat-ring" formation in carcasses ribbed 18 hours postmortem was substantially reduced in electrically stimulated sides as compared to control sides.

Improves Lean Color

Lean color can be substantially improved by the use of electrical stimulation (Table 2). When lean color tends to be dark, electrical stimulation causes postmortem glycolysis to be more nearly complete at the time of carcass ribbing. This insures brighter, more youthful lean color if carcasses are ribbed within 18 hours postmortem. In most instances, slight cases of "dark-cutting" beef have been eliminated by electrical stimulation. However, severe cases of "dark-cutting" beef may not be improved by electrical stimulation.

Increases Marbling Scores

Tests have shown that marbling scores can be increased by electrical stimulation when carcasses are ribbed and evaluated at 24 hours. This probably results from faster "setting-up" of the fat in the ribeye, caused by improved firmness of the ribeye muscle. Present evidence suggests that differences in marbling between electrically stimulated and unstimulated sides would be minimal or nonexistent after additional chilling (greater than 48 hours).

Stimulation Methods Modified

In early tests of electrical stimulation, a commercially-available, electrical stunning machine was utilized for carcass stimulation. The stunner was modified for providing electrical stimulation by attaching two cables to the lamb stunning unit to extend the stunning probes to the extremes of the carcass. A metal pin was attached at the end of each cable. These pins were placed in the muscles of the round near the hock and in the muscles between the blade bone (scapula) and the vertebrae in the chuck

region. Electrical stimulation was administered in pulses of .5 to 1 second duration with intervals between pulses of approximately 1 second. Carcasses were stimulated with 50 pulses within 1 hour of slaughter and then processed according to normal procedures.

Later tests of electrical stimulation before plant implementation involved a unit having variable voltage, pulse duration and pulse intervals. From this unit, one cable was inserted into the neck region of the carcass and electricity was administered automatically. Voltages used in these experiments ranged from 150 to 550; amperage ranged from 0.5 to 5; and 20 impulses were administered in 45 to 70 seconds. Response in terms of tenderness increase was not closely associated with the level of voltage. However, lean color, "heat-ring" and marbling scores appeared to be greatly improved by the use of the higher voltages.

NOTE: Persons who use electrical stimulation must be aware of the dangers involved in using high voltage electricity and must exercise extreme caution in providing proper safety for packing plant personnel.

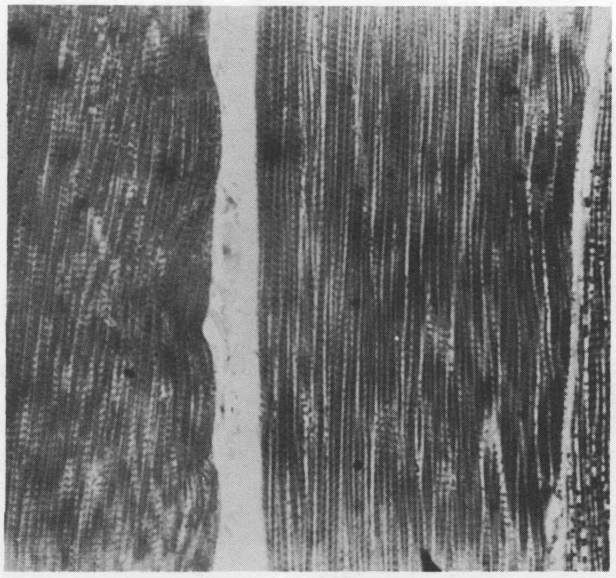
Commercial Stimulators Available

Commercial, in-line application of electrical stimulation has begun. At the present time, a com-

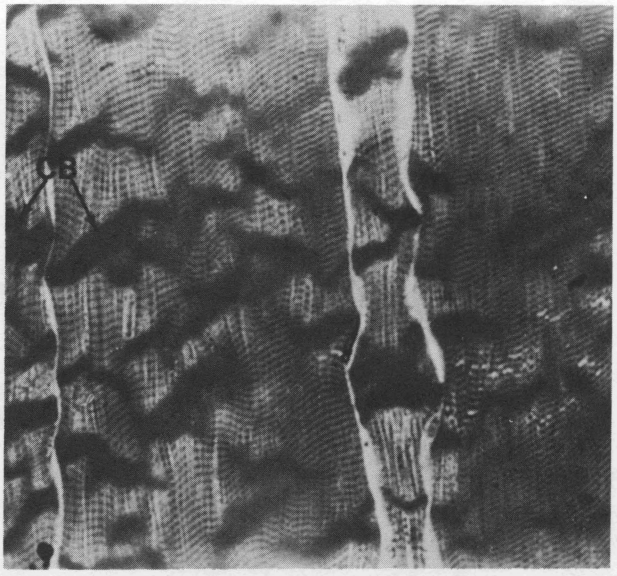
Table 2. Summary of electrical stimulation effects on lean color, marbling and "heat-ring"

Description of animals	Lean maturity[a] (Percent)	Color score[b] (Percent)	Marbling score[c] (Percent)	Heat-ring[d] (Percent)
30 grain-fed heifers	−30	−16	+15	−37
30 hot-skinned calves	+16	—	—	—
30 cold-skinned calves	+4	—	—	—
8 grain-fed steers	−18	—	—	−100
30 grain-fed heifers	−17	−11	+5	−53
12 grain-fed steers	+5	−24	+30	−43
60 calves	+8	+10	+5	—
50 grain-fed heifers	−31	−21	+14	−54
40 aged cows	−39	−17	+15	−6
109 grain-fed cattle	−6	−6	+20	−20
57 grain-fed cattle	−4	−4	+18	−38
347 cattle (Percent Average Net Effect)	−10	−8	+15	−34

[a] Using USDA standards for maturity.
[b] Eight-point scale: 8 = light grayish-red, 1 = very dark purple.
[c] Using USDA standards for marbling.
[d] Five-point scale: 5 = none, 1 = extremely severe.

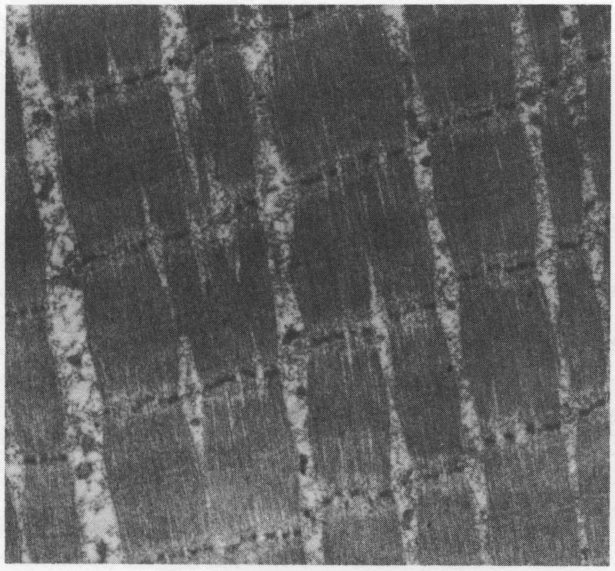


Light micrograph of muscle fibers from a non-stimulated side of a carcass.

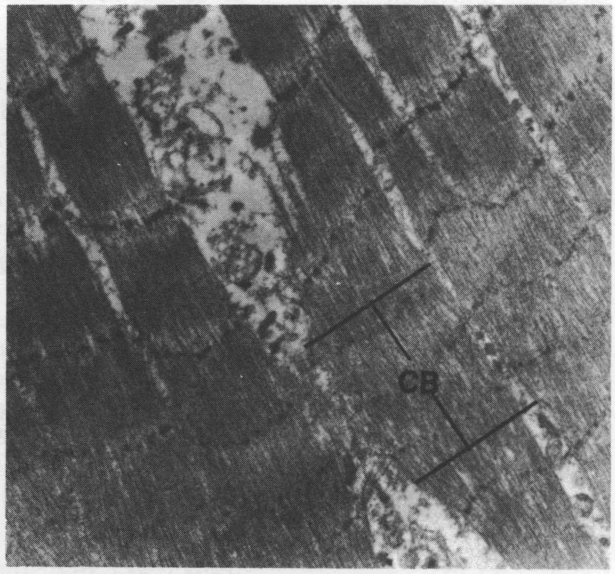


Light micrograph of muscle fibers from an electrically stimulated side of a carcass. CB = contracture band. Disruption of proteins in contracture bands may be responsible for increases in tenderness.

mercial electrical stimulation unit is being produced and is available for purchase. Other companies have also shown interest in distributing electrical stimulation equipment to large and small slaughter plants. If the present trend continues, all beef sold in the future likely will be tenderized with electricity, thereby helping to insure acceptable meat quality.



Electron micrograph of a muscle fiber from a non-stimulated side of a carcass.



Electron micrograph of a muscle fiber from an electrically stimulated side of a carcass. CB = contracture band. Disruption of proteins in contracture bands may be responsible for increases in tenderness.

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