EFFECTS OF ELECTRICAL STIMULATION ON BEEF, PORK, LAMB AND GOAT MEAT

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INTRODUCTION

During the past five years, a series of studies has been conducted by researchers at the Texas Agricultural Experiment Station to determine effects of electrical stimulation on quality and palatability of beef, pork, lamb and goat meat. Of interest in these studies were advantages which might accrue to the packer, retailer, purveyor, restaurateur and/or consumer as a result of implementation of electrical stimulation technology by the slaughter-dressing industry. Improving the tenderness of beef, pork, lamb and goat meat has been a major goal of scientists at T.A.E.S. for more than a decade; during studies intended to quantitate the tenderizing effect of electrical stimulation it became apparent that the ES process also had quality enhancement capabilities. As a result, research studies ensued which had the objective of documenting response in quality indicators, as well as in palatability attributes, to the electrical stimulation of beef, pork, lamb and goat carcasses.

EXPERIMENTAL

Details of experimental procedures used in the studies summarized in this report are included in the individual papers that are cited. Most of these studies were conducted in commercial plants under conditions characteristic of those which exist in industry. Electrical stimulation equipment used included a commercially available hog stunning device modified for use in electrically stimulating carcasses and a test unit provided by the LeFiell Company, San Francisco, CA; the latter machine was the prototype of the LeFiell "Lectro-Tender" unit which is now used in beef packing plants throughout the U.S.A. For purposes of the present discussion, mean ratings, values or scores were used to compute percentages of improvement by dividing the difference between E.S. and control (not E.S.) carcasses or samples by the rating, value or score for the control carcasses or samples. Percentage improvement was the average (weighted according to the number of observations in each individual experiment) advantage for the electrically stimulated carcasses or samples. Since some of the differences between means were not statistically significantly different, this method of comparison may over-estimate the actual difference between E.S. and control (not E.S.) samples.

RESULTS AND DISCUSSION

A summary of the effects of electrical stimulation of beef carcasses on certain quality and palatability traits is presented in Table 1. Electrical stimulation increased tenderness by 26%, decreased shear force by 23% and enhanced flavor of cooked beef by 6%; evaluation of test results on an individual experiment basis suggests that E.S. is most effective in increasing tenderness of beef carcasses that would, if untreated, produce beef of unacceptable tenderness. Electrical stimulation apparently causes postmortem glycolysis and rigor mortis to proceed more rapidly than would be the case in untreated (not E.S.) carcasses, thereby resulting in brighter (14%) and more youthful (23%) lean, lessened development (23%) of "heat-ring" (a condition in which the longissimus dorsi muscle is coarse-textured and dark-colored and has a sunken appearance near the outermost edge of its surface), very slightly firmer (4%) lean, higher marbling (11%) scores (believed to be the result of faster "setting-up" of the marbling in the longissimus dorsi muscle) and an increase (8%) in USDA quality grade. Advantages for electrically stimulated, as opposed to control, sides or carcasses in lean color, firmness, marbling, freedom from "heat-ring" and U.S.D.A. quality grade are most evident when sides are ribbed 14 to 18, rather than 48 to 72, hours postmortem.

Two studies (25) have been conducted to determine the extent to which aging (periods of storage of meat at refrigerated temperatures) negates or complements tenderness differences effected by electrical stimulation. Results of one such study (data not presented in tabular form) revealed that aging of electrically stimulated beef for 14 days increased tenderness of loin steaks by 15% more (a total of 44%) than that (29%) achieved by electrical stimulation with only 2 days of aging while 14 days of aging of control (not E.S.) loin steaks increased tenderness by 26%. The latter results suggest that aging complements the tenderness of electrically stimulated beef. Results of the other aging study (data not presented in tabular form) reveal that loin steaks, from electrically stimulated carcasses, aged for 7 days were about 10% more tender than loin steaks, from unstimulated carcasses, aged for 21 days. These studies suggest that postmortem aging time can be substantially reduced by use of E.S., thus reducing costs associated with tie-up of capital in inventory, shrinkage, energy and space required for the aging of beef.

One study (4) has been conducted to determine effects of electrical stimulation on retail caselife of beef. Caselife of ground beef was not affected by electrical stimulation; ground beef made from electrically stimulated carcasses had the same pattern of discoloration as ground beef made from unstimulated carcasses. Round steaks that were from electrically stimulated carcasses remained brighter for an extra day, and had less surface discoloration and superior overall appearance on the third day of retail display as compared to round steaks from unstimulated carcasses. As a result, round steaks from electrically stimulated carcasses had 0.5 to 1.0 days of additional retail caselife as compared to round steaks from unstimulated carcasses.

For beef, electrical stimulation: (a) increases tenderness, (b) improves flavor, (c) brightens muscle color, (d) increases muscle firmness, (e) causes faster "setting up" of marbling, (f) reduces the need for aging to assure satisfactory palatability, and (g) improves retail cut appearance and caselife.

A summary of the effects of electrical stimulation of veal carcasses is presented in Table 2. For veal, electrical stimulation: (a) brightens muscle color, (b) improves lean texture, and (c) increases muscle firmness. Since color, texture and firmness are the most important value-determining characteristics in veal carcasses and cuts, electrical stimulation greatly improves quality and value in this commodity.

Effects of electrical stimulation of lamb carcasses are summarized in Table 3. Although lamb is not generally considered to be tough, electrical stimulation increased tenderness (12% for sensory panel ratings, 24% for shear force value). Electrical stimulation had little or no effect on lean maturity score (4%) or flavor (0%), but did improve lean color (36%) and U.S.D.A. quality grade (17%). The influence of electrical stimulation on storage-life and/or retail caselife of lamb cuts has been studied (9,10). In one of these studies (9), electrical stimulation improved muscle color, decreased surface discoloration and improved overall appearance of loin chops from old-crop lambs and, with one exception, electrical stimulation had no effect on weight losses of vacuum packaged wholesale cuts. In the other study (10), electrical stimulation brightened lean color and extended retail caselife of lamb loin chops.

For lamb, electrical stimulation: (a) increases tenderness, (b) brightens muscle color, (c) reduces the need for aging to assure satisfactory palatability, (d) increases U.S.D.A. quality grade, (e) improves retail cut appearance and caselife, and (f) does not effect weight loss of vacuum packaged wholesale cuts.

A summary of the effects of electrical stimulation of goat carcasses is presented in Table 4. Goat carcasses, because they usually have very little subcutaneous fat, should be very susceptible to "cold-shortening" toughness. Electrical stimulation increased tenderness of goat meat (32% for sensory panel ratings and 29% for shear force values), produced a slight increase (6%) in flavor and improved lean maturity score (16%). The improvement in lean maturity score in response to electrical stimulation was a result of brighter muscle color in electrically stimulated, as compared to unstimulated, goat carcasses. Data in one study (5) revealed that loin and leg muscles from electrically stimulated carcasses were more tender at one day postmortem than were comparable muscles from unstimulated carcasses at seven days postmortem.

For goats, electrical stimulation: (a) increases tenderness, (b) brightens muscle color, (c) enhances flavor, and (d) reduces the need for aging to assure satisfactory tenderness.

Effects of electrical stimulation of pork carcasses on certain quality and palatability traits are summarized in Table 5. Only one study (2) of effects of electrical stimulation of pork carcasses has been conducted by T.A.E.S. researchers; in that study it was concluded that electrical stimulation does not affect palatability traits or shear force values under normal chilling-processing conditions and that muscle color and firmness were affected more by chilling treatment (slow vs. rapid) than by electrical stimulation. Data in Table 5 suggest very minor effects of electrical stimulation on tenderness (3% for sensory panel ratings, 9% for shear force values), flavor (2%) and overall palatability (0%). When electrically stimulated and control (not E.S.) pork carcasses were fabricated at eight hours postmortem for evaluation of certain muscle quality-indicating characteristics (Table 5), electrical stimulation had undesirable effects on lean color (-7%), lean firmness (-11%) and muscle separation (-5%).

For pork, electrical stimulation does not appear to improve quality, quality-indicating or palatability traits of pork unless E.S. is combined with extremely rapid chilling treatments.

In conclusion, electrical stimulation equipment has been, or will soon be, incorporated into slaughter-dressing lines of approximately 100 beef plants in the U.S.A.; implementation of E.S. technology was prompted primarily by improvements in beef carcass quality-indicating characteristics and secondarily because of enhancement of cooked beef palatability. At present, electrical stimulation has not been implemented by pork, lamb or goat packers or processors in the U.S.A.; our research suggests that the process would be advantageous to packers who slaughter lambs and goats but that its use in pork slaughter-dressing cannot presently be recommended.

REFERENCES

(1) Calkins, C.R., J.W. Savell, G.C. Smith and C.E. Murphey. 1980. J. Food Sci. (In Press).
(2) Crenwelge, D.D. 1980. Ph.D. Dissertation. Texas A&M University, College Station, TX.
(3) Cross, H.R., G.C. Smith, A.W. Kotula and D.A. Muse. 1979. J. Food Sci. 44:1560.
(4) Hall, L.C., J.W. Savell and G.C. Smith. 1980. J. Food Sci. 45:171.
(5) McKeith, F.K., J.W. Savell, G.C. Smith, T.R. Dutson and M. Shelton. 1979. J. Anim. Sci. 49:972.
(6) McKeith, F.K., G.C. Smith, T.R. Dutson, J.W. Savell, R.L. Hostetler and Z.L. Carpenter. 1980. J. Food Protection (In Press).
(7) McKeith, F.K., G.C. Smith, J.W. Savell, T.R. Dutson, Z.L Carpenter and D.R. Hammons. 1980. J. Anim. Sci. 50:694.
(8) McKeith, F.K., G.C. Smith, J.W. Savell, T.R. Dutson, Z.L. Carpenter and D.R. Hammons. 1980. J. Food Sci. (Submitted).
(9) Riley, R.R., J.W. Savell and G.C. Smith. 1980. J. Food Sci. (In Press).
(10) Riley, R.R., J.W. Savell and G.C. Smith and M. Shelton. 1980. J. Food Sci. 45:119.
(11) Riley, R.R., J.W. Savell, G.C. Smith and M. Shelton. 1980. J. Anim. Sci. (Submitted).
(12) Savell, J.W., T.R. Dutson, G.C. Smith and Z.L. Carpenter. 1978. J. Food Sci. 43:1606.
(13) Savell, J.W., F.K. McKeith, D.B. Griffin, C.E. Murphey and G.C. Smith. 1980. Final Report to Delft Blue-Provimi, Incorporated. Texas Agr. Exp. Station, College Station, TX.
(14) Savell, J.W., F.K. McKeith, C.E. Murphey, G.C. Smith and Z.L. Carpenter. 1980. J. Anim. Sci. (Submitted).
(15) Savell, J.W., G.C. Smith and Z.L. Carpenter. 1978. J. Food Sci. 43:1666.
(16) Savell, J.W., G.C. Smith and Z.L. Carpenter. 1978. J. Anim. Sci. 46:1221.

(17) Savell, J.W., G.C. Smith, Z.L. Carpenter and F.C. Parrish, Jr. 1979. J. Food Sci. 44:911.
(18) Savell, J.W., G.C. Smith, T.R. Dutson, Z.L. Carpenter and D.A. Suter. 1977. J. Food Sci. 42:702.
(19) Seideman, S.C., G.C. Smith, T.R. Dutson and Z.L. Carpenter. 1979. J. Food Protection 42:651.
(20) Smith, G.C. 1979. Electrical stimulation of meat--tenderness. The National Provisioner. February 10, 1979, page 50.
(21) Smith, G.C., T.R. Dutson, Z.L. Carpenter and R.L. Hostetler. 1977. Proc. Meat Ind. Res. Conf. page 147.
(22) Smith, G.C., T.R. Dutson, H.R. Cross and Z.L. Carpenter. 1979. J. Food Sci. 44:335.
(23) Smith, G.C., T.G. Jambers, Z.L. Carpenter, T.R. Dutson, R.L. Hostetler and W.M. Oliver. 1979. J. Anim. Sci. 49:1207.
(24) Smith, G.C., F.K. McKeith, R.R. Riley and J.W. Savell. 1980. Final Report to PC-Development Corporation. Texas Agr. Exp. Station, College Station, TX.
(25) Smith, G.C. and J.W. Savell. 1980. Proc. International Stockmens School (Beef). B17:590.
(26) Smith, G.C. and J.W. Savell. 1980. Proc. International Stockmens School (Sheep) S1:167.

Table 1. Summary of effects of electrical stimulation of beef carcasses

Trait	Number of carcasses or samples	Percentage improvement	References
Tenderness rating	452	26%	3,6,8,12,15,16,17,18,19,21,22,23,25
Shear force value	656	23%	3,6,7,8,12,15,16,17,18,19,21,22,23,25
Flavor rating	349	6%	6,8,12,15,16,17,18,19,22,23,25
Lean maturity score	1261	23%	1,3,6,7,8,14,15,16,17,20,22,23,25
Lean color score	1261	14%	1,3,6,7,8,15,16,17,22,23,25
"Heat-ring" score	1177	23%	1,3,6,7,8,15,16,17,25
Firmness score	458	4%	1,3,15,16,17,23
Marbling score	1251	11%	1,3,6,7,8,14,15,16,17,20,22,23,25
USDA quality grade	1086	8%	1,3,8,14,15,16,17,20,22,23,25

Table 2. Summary of effects of electrical stimulation of veal carcasses

Trait	Number of carcasses or samples	Percentage improvement	Reference
Lean maturity score	40	3%	13
Lean color score	80	12%	13
Lean texture score	40	28%	13
Lean firmness score	40	36%	13

Table 3. Summary of effects of electrical stimulation of lamb carcasses

Trait	Number of carcasses or samples	Percentage improvement	References
Tenderness rating	109	12%	11,18,20,21,26
Shear force value	137	24%	10,11,18,20,21,26
Flavor rating	175	0%	11,18
Lean maturity score	151	4%	10,11,24
Lean color score	632	36%	9,10,11
USDA quality grade	510	17%	24

Table 4. Summary of effects of electrical stimulation of goat carcasses

Trait	Number of carcasses or samples	Percentage improvement	References
Tenderness rating	229	32%	5,18,20,21,26
Shear force value	731	29%	5,18,20,21,26
Flavor rating	118	6%	5,18
Lean maturity score	96	16%	5

Table 5. Summary of effects of electrical stimulation of pork carcasses

Trait	Number of carcasses or samples	Percentage improvement	Reference
Tenderness rating	180	3%	2
Shear force value	90	9%	2
Flavor rating	90	2%	2
Overall palatability rating	90	0%	2
Lean color score	90	-7%	2
Lean firmness score	90	-11%	2
Muscle separation score	90	-5%	2