BACTERIA ASSOCIATED WITH ELECTRICALLY STIMULATED AND HOT BONED MEAT

A. W. KOTULA

Meat Science Research Laboratory, SEA-AR, USDA, Beltsville, Maryland, U.S.A.

INTRODUCTION

The effectiveness of electrically stimulating carcasses of slaughter animals immediately after evisceration to enhance palatability appears to have been adequately documented, (Cross et al. 1979b, Cross 1979, Nilsson et al. 1979, McKeith et al. 1980). Coupling the practice of boning unchilled carcasses (hot boning) with that of electrical stimulation has been reported by Cross et al. (1979a) as a means of reaping the benefits of hot boning--which include savings in energy, labor and yield--without losses in tenderness. The potential exists for either or both of these technologies to influence not only the sensory characteristics and yield of the resultant meat but also its microbiological condition.

Electrical stimulation might be expected to have a beneficial effect by destroying spoilage and potentially pathogenic bacteria. The utilization of ATP and glycogen of the muscle lowers the pH to about 5.9; thus, the growth of some bacteria should not be extensive. Also, the treatment may release some proteolytic enzymes (Sorinmade et al. 1978, Dutson et al. 1980) that can destroy bacteria. Mrigarat et al. (1980) proposed that changes in E_h and presence of free radicals may destroy bacterial cells.

Before the mechanisms by which electrical stimulation destroys bacterial cells are evaluated, we must ascertain that microbial count is reduced and that the magnitude of the change is of importance. We must also be concerned about the ultimate microbial levels on electrically stimulated carcasses when hot boning is used in conjunction with the electrical treatment. The potential for microbial growth on unchilled carcasses, which provide the bacteria with near ideal growth temperatures and surface moisture, is much greater than on chilled carcasses.

The purpose of this research was to determine the influence of electrical stimulation and hot boning on the microbiological condition of the meat from those carcasses.

MATERIALS AND METHODS

Ten U.S. Choice, Yield Grade 3 carcasses were selected, immediately after slaughter and evisceration, for the study. One side from each carcass was electrically stimulated and hot boned within one hour post-mortem, whereas the other side was chilled for 24 hours at 3° C before boning. Electrodes were inserted into muscles in the neck and near the Achilles tendon. Sides were stimulated with 1.5 amp AC (60 Hz) current, 250-400 volts for 3 min, with four 10-sec duration shocks per min. Stimulated sides and chilled control sides were hung, and boneless cuts were removed. The cuts were the brisket, clod, chuck roll, ribeye, strip loin, tenderloin, top sirloin, knuckle, inside round and gooseneck (eye of round and outside round cuts).

Each primal cut was sampled for surface bacteria immediately after excision from the side and after 20 days' storage at 2° C in a vacuum packaged bag. A cotton tipped swab moistened in Butterfield's phosphate diluent (USDA 1974) was used to remove bacteria from 12.3 cm^2 of the surface of the primals. Three swabs, one for each 12.3 cm^2 area, were used for each primal and then dropped into 100 ml of Butterfield's phosphate diluent. The diluent bottle was shaken 15 times through a 12-in arc to remove the bacteria from the swabs. The diluent was then serially diluted and analyzed for: aerobic plate count 35° C (mesotrophic), on plate count agar (Difco), by the pour plate technique and 2 days incubation at 35° C; aerobic plate count 20° C (mesotrophic and psychrotrophic), on plate count agar (Difco), by the pour plate technique and 3 days' incubation at 20° C; aerobic plate count 5° C (psychrotrophic), on plate count agar (Difco) by the pour plate technique and 7 days incubation at 5° C; coliform count on Bacto violet red bile agar (Difco), by the pour plate with overlay technique and 24 hours' incubation at 37° C.

Twelve additional carcasses were used to show the effects of electrical stimulation of carcasses without hot boning. One side of each carcass was stimulated as described above and then chilled along with the opposite side at 3° C. Aerobic plate counts (APC 5°, 20°, 35° C) were determined as described above.
Four additional carcasses were utilized to show the effect of manufacturing ground beef from unchilled carcasses on the microbiological quality of the product. The ground beef was prepared under normal commercial conditions except that CO_2, at the rate of 0.1 kg of meat, was added to the hot trimmings after the coarse grind to lower the temperature prior to the final grind through a 0.32-cm plate. Bacterial counts were determined as described above.

Each count plus .1 per square centimeter was converted to its logarithm to the base 10, .1 being added to avoid logarithm of 0 counts. Analyses of variance of the log values were calculated (Snedecor and Cochran, 1972), and Duncan's multiple range test (Duncan 1955) at the 5% level was applied to the means which are presented in this paper.

RESULTS

Immediately after excision, the primals from the hot boned electrically stimulated beef sides tended to have higher aerobic plate counts for psychrotrophs ($APC_{5° C}$), mesotrophs ($APC_{35° C}$) and a combination of both ($APC_{20° C}$) than the primals from the chilled sides (Fig 1). The $APC_{5° C}$ values for top sirloin and the gooseneck from the treated sides were greater ($P<.05$) than those for the corresponding cuts from the controls; and the magnitude of the differences exceeded one logarithm (log), indicating that the differences due to treatment were important. Though the $APC_{5° C}$ for the chuck roll and strip loins from the treated side were more than one log higher than the control, the difference was not significant. The differences in $APC_{20° C}$ were significant ($P<.05$) and greater than one log for chuck roll, strip loin, tenderloin, top sirloin and gooseneck from the treated sides. The differences in $APC_{35° C}$ were significant for each primal except chuck roll, ribeye and strip loin, but the magnitude of the differences was less than one log and therefore may not be important.

After 20 days' storage at 2° C in vacuum packaged bags, $APC_{5° C}$ values were usually higher for primals from the chilled sides than for those from the treated sides (Fig 2). $APC_{5° C}$ was greater ($P<.05$) for brisket from the treated sides than for brisket from chilled sides by more than one log. On the other hand, $APC_{5° C}$ was greater ($P<.05$) for knuckle from the chilled sides than for knuckle from the treated sides by more than one log. There were no significant differences in the $APC_{5° C}$ due to treatment of the other primals. The knuckle was the only primal that showed lower $APC_{20° C}$ for the treatment than for the control, and in this instance the magnitude of the difference was small. The $APC_{20° C}$ values for clod and strip loin from the treated sides were greater, but by less than one log, than those for the corresponding primals for the chilled sides. For all other primals evaluated except the ribeye and tenderloin, $APC_{20° C}$ was greater ($P<.05$), by more than one log, for the treated meat than for the chilled meat. For those two primals the differences were significant ($P<.05$) but of questionable importance (<1 log). The differences in $APC_{35° C}$ values between treatment and control were greater than 1 log ($P<.05$) for Brisket, chuck roll, strip loin, top sirloin, inside round and gooseneck. The count difference between the chilled and treated tenderloins was significant but less than one log. The treated and chilled sides did not differ significantly in $APC_{35° C}$ values for clod, ribeye and knuckle.

There was no significant treatment effect ($P<.05$) on the coliform counts for the primals either immediately after excision from the sides or after 20 days' storage at 2° C in vacuum packaged bags.

The significant differences reported above are confounded by the effects of both hot boning and electrical stimulation. Data that were obtained from additional carcasses and that were not confounded by hot boning effects showed no differences ($P<.05$) in $APC_{5°}$, $20°$, or $35° C$ due to electrical stimulation (Table 1). These results agree with most of the previously published results as summarized by Kotula (1980).

Utilizing hot meat trimmings for the manufacture of ground beef need not adversely influence the microbial quality of the product. Before storage, $APC_{5°}$, $20°$, $35° C$ values were not significantly different ($P<.05$) between ground beef prepared from hot boned sides and that prepared from control sides (Table 2). After storage the $APC_{5°}$, $20° C$ values were higher for the control ground beef, although by less than one log.

In this research electrical stimulation did not influence the microbial counts on beef primals. As compared with conventional boning, hot boning in conjunction with electrical stimulation did result in significantly higher and important levels of bacteria on some primals. Immediately after excision the bacterial counts on the hot boned meat were greater than those on the chilled meat. This indicates that sanitation must be improved if hot boning is to be utilized. After storage the numbers of psychrotrophic bacteria on the hot boned primals usually were not as great as those on chill-boned primals; and this indicates that the psychrotrophic bacteria may have been injured by the hot boning temperature. The fact that ground beef could be prepared from hot boned sides without significantly greater bacterial levels than ground beef from chilled sides is important. I believe that hot boning in conjunction with electrical stimulation of carcasses should not be discouraged on the basis of increased bacterial numbers on hot boned primals. Rather, modifications in handling procedures need to be developed for handling hot primals more sanitarily.

REFERENCES

Cross, H. R. 1979. Effects of electrical stimulation on meat tissue and muscle properties - A review. J. Food Sci. 44(2)509-514, 523.

Cross, H. R., I. Tennent and D. A. Muse. 1979a. Storage properties of primal cuts of hot- and cold-boned beef. J. of Food Quality. (4)289-296.

Cross, H. R., G. C. Smith, A. W. Kotula and D. A. Muse. 1979b. Effects of electrical stimulation and shrouding method on quality and palatability of beef carcasses. J. Food Sci. 44(5)1560-1561, 1563.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics. 11:1.

Dutson, T. R., G. C. Smith and Z. L. Carpenter. 1980. Lysosomal enzyme distribution in electrically stimulated ovine muscle. J. Food Sci. (In press).

Kotula, A. W. 1980. Microbiology of hot-boned and electrostimulated meat. J. of Food Protection. (In press).

Mckeith, F. M., G. C. Smith, J. W. Savell, T. R. Dutson, Z. L. Carpenter and D. R. Hammons. 1980. Electrical stimulation of mature cow carcasses. J. of Anim. Sci. 50(4)694.

Mrigadat, B., G. C. Smith, T. R. Dutson, L. C. Hall, M. O. Hanna and C. Vanderzant. 1980. Bacteriology of electrically stimulated rabbit, pork, lamb and beef carcasses. J. of Food Protection. (In press).

Nilsson, H. H. Ruderus and S. Fabiansson. 1979. Meat Quality characteristics of very low voltage stimulated beef carcasses. Proc. 25th European Meeting of Meat Research Workers.

Snedecor, B. W. and Cochran, W. G. 1972. Statistical methods (6th ed). The Iowa State University Press, Ames.

Sorimnade, S. O., H. R. Cross and K. Ono. 1978. The effect of electrical stimulation on lysosomal enzyme activity, pH decline and beef tenderness. 24th European Meats Conference. Kulmbach, West Germany.

Table 1. Effect of electrical stimulation on the microbial count (log_{10}) of beef longissimus muscle before and after 20 days' storage at 2° C.

	Before Storage		After Storage	
	Control	Treated	Control	Treated
APC_5	1.50	1.40	3.54	3.63
APC_{20}	2.63	2.50	5.07	4.27
APC_{35}	2.68	2.61	3.91	3.65

n = 12; treatment effect was not significant (P<.95).

Table 2. Effect of hot boning on the microbial count (log_{10}) of ground beef before and after 20 days' storage at -2° C.

	Before Storage		After Storage	
	Control	Treated	Control	Treated
APC_5	3.94	4.30	5.06	4.27*
APC_{20}	4.96	5.05	5.36	4.78*
APC_{35}	5.13	5.13	5.34	4.93

n = 3; *significant (P<.05) treatment effect.

Figure 1. Effects of conventional and hot boning after electrical stimulation on bacterial counts of beef primal cuts upon excision (n = 10).

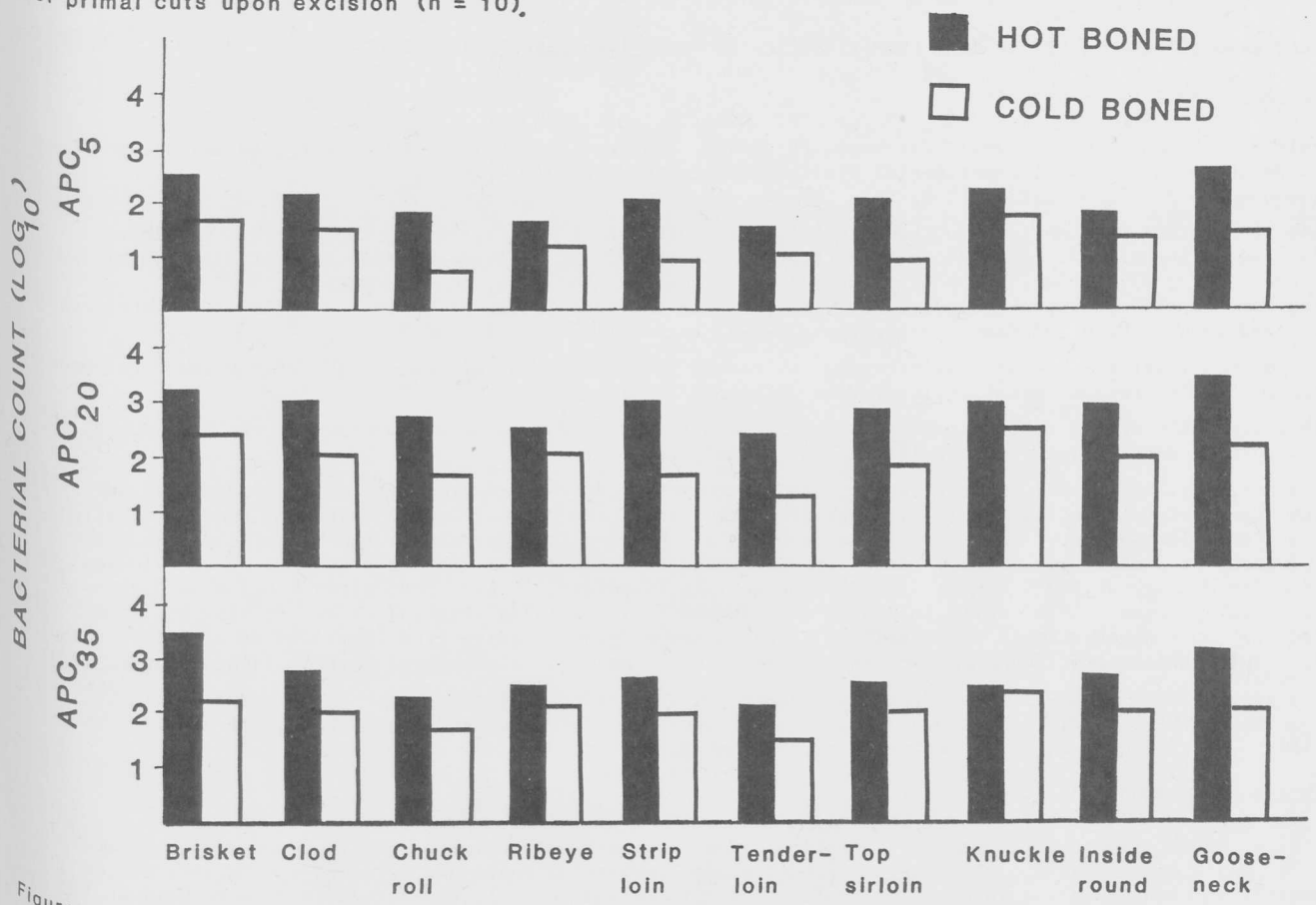

Figure 2. Effects of conventional and hot boning after electrical stimulation on bacterial counts of beef primal cuts at the end of 20 days' storage at 20° C (n = 10).