EFFECTS OF ELECTRICAL STIMULATION, BONING TEMPERATURE, FORMULATION, AND RATE OF FREEZING ON SENSORY, COOKING, CHEMICAL, AND PHYSICAL PROPERTIES OF BEEF PATTIES

B. W. BERRY[1] and D. M. STIFFLER[2]

[1]Meat Science Research Laboratory, SEA-AR, USDA, Beltsville, Maryland, U.S.A
[2]Department of Animal and Range Sciences, New Mexico State University, Las Cruces, New Mexico, U.S.A.

INTRODUCTION

IF HOT processing of primal cuts for steaks and roasts becomes commonplace in the meat industry, it is likely that the carcasses providing those primals will be electrically stimulated. Ground beef processed from prerigor hot-boned beef has been shown to be superior to cold boned beef in palatability (Cross et al., 1979; Cross and Tennent, 1980; Wells et al., 1980). Electrical stimulation has been shown to yield no negative effects on chemical, physical, sensory and cooking characteristics of resultant ground beef patties (Cross and Tennent, 1980). Prerigor hot-boned muscle may react differently than chilled beef to various processing methods. Mechanical desinewing has effectively improved tenderness and removed connective tissue with chilled beef (Cross et al., 1978a; Wells et al., 1980), but not hot-boned beef (Wells et al., 1980).

Ground beef made from a hot-boned fat source has not been evaluated. The effects of electrical stimulation, temperature of boning, formulation and rate of freezing on sensory, cooking and chemical properties of ground beef have not been studied concurrently. In this study, we evaluated these four factors concurrently in beef patties.

EXPERIMENTAL

SIXTEEN USDA Choice carcasses were sources of lean and fat for ground beef. The left sides of all carcasses were boned 2 hr after exsanguination and the right sides were boned after 48 hr of chilling at 2° C. Both right and left sides of eight carcasses were subjected to electrical stimulation at 1 hr after exsanguination, while both sides of the remaining eight carcasses received no stimulation. Stimulation was accomplished by inserting metal pins in the round muscle near the Achilles tendon and in the muscles between the scapula and the thoracic vertebrae. Each treated side received 1.5 A of AC (60 Hz; 250-400 V) through the carcass for 2 min with 30 1-sec shocks per min.

Formulations. Within all electrical stimulation and temperature of boning treatments, formulations consisted of either boneless chuck meat (lean source) with boneless USDA Choice plates (fat source) or boneless frozen, imported cow lean with boneless USDA Choice plates. The frozen cow lean was equivalent to USDA Cutter in grade. When hot-boned Choice chuck lean was used, boneless chilled Choice plates were used from additional carcasses to the 16 described above. Boneless frozen cow meat was always used as the source of lean when hot-boned Choice plates were used as the fat source.

Grinding. The frozen cow meat blocks were passed through a Rietz grinder using a 0.95-cm plate. The nonfrozen, boneless Choice chucks and plates were initially ground through a Weiler grinder (0.95-cm plate). Raw material samples were randomly removed after 2 min of mixing and fat contents were determined with an Anyl Ray Instrument before formulation. Depending on the carcasses and formulations, the percentage of fat for the various raw materials ranged from: 17.2-20.1% for Choice chucks; 42.4-46.0% for Choice plates; and 10.5-12.0% for cow lean. Fat was adjusted to 24% in the formulations. CO_2 pellets were added to formulations contained hot boned meat during the first mixing step. One part CO_2 was used to five parts beef. After a second mixing step of 3 min, the formulations were passed through the 0.32-cm plate. Formulation temperatures after final grinding before to patty formulation ranged from -2° C to 3° C.

Patty formulation and freezing. The ground beef was passed through a Formax 24 patty machine. The average pressure during patty formulation was 34 to 36 kg/sq cm. After the patties were made, one-half of the patties were subjected to fast freezing, while the remaining half were slow frozen. For the fast freezing procedure, patties were passed through a Northfield Spiroblast ammonia freezer (-50° C) tunnel on a conveyor belt. The internal temperature of the patties after 12 min in the tunnel was -7° C. The patties subjected to slow freezing were placed in 10-patty stacks in polyethylene lined boxes and frozen at -20° C in a blast air freezer. Patties were shipped 2000 km to Beltsville, MD, by truck at -10° C and stored at -20° C for 4 weeks before sensory, cooking, physical and chemical evaluation.

Cookery and presentation to the panel. Frozen patties were broiled on electric Farberware broilers (model 450-A) to an internal temperature of 65° C. Temperature was monitored during cooking using Teflon-coated iron/constantan thermocouples. Patties required 6 min cooking on one side and 5 min cooking on the other side. Total cooking losses were calculated from frozen and cooked weights. Each patty was sectioned into 6 pieces and two of the 24 pieces (4 patties) were randomly assigned to each panelist. The samples were served as warm as possible to panelists as described in AMSA guidelines (1978).

Sensory Panel Evaluation. A 10-member descriptive attribute panel was selected and trained according to AMSA procedures (1978). The panel evaluated patties for differences in (a) initial and final tenderness, with 8 = extremely tender and 1 = extremely tough; (b) juiciness, with 8 = extremely juicy and 1 = extremely dry; (c) initial and final connective tissue amount, with 8 = none and 1 = abundant; and (d) ground beef flavor intensity with 8 = extremely intense and 1 = extremely bland. Initial tenderness was scored after five chews and final tenderness and initial connective tissue amount were rated after 15 chews. Final connective tissue amount was scored after complete mastication.

Shear force and physical measurements. Ten patties for each treatment were broiled as described above and measured for shear force and shear energy. The single blade shear as described by Cross et al., (1978b) was used to determine maximum shear force (kilogram) and shear energy (centimeters-kilograms) by shearing four 2.54 cm squares per patty on an Universal Instron Shear machine. Shear energy measured total work or energy required during the shearing of the sample. Patty height and diameter were measured on the ten patties used for the Instron shear values before and after cooking.

Chemical analyses. Fat and moisture contents of raw and broiled patties were determined according to AOAC (1975) procedures. Moisture content was based on weight loss of two 3-g samples dried in an oven at 102° C for 24 hours. Fat content was based on weight loss of the dried samples after 16 hr of extraction with diethyl ether. Differences in fat and moisture content between raw and cooked patties were calculated. Also the percentage of the cooking losses comprised of fat and moisture were determined.

Statistical analysis. Data were analyzed as a four-way factorial design with the four factors being electrical stimulation, temperature of boning, formulation and rate of freezing. Analysis of variance procedures (Snedecor and Cochran, 1972) were employed. Duncan's new multiple range test (1955) was used to test main effects and interactions when they were statistically noted through analyses of variance.

RESULTS AND DISCUSSION

A SUMMARIZATION of the significant ($P<0.05$) sources of variation affecting sensory, physical, cooking and chemical traits of beef patties is given in Table 1. Final tenderness scores and initial and final connective tissue scores were higher in patties made from nonstimulated beef, hot boned beef, and formulations of Choice chucks and plates than patties made from the alternate treatments. Cross and Tennent (1980) found similar tenderness differences in patties made from nonstimulated (NS) beef compared to electrically stimulated (ES) beef. Improvements in tenderness associated with hot boning have been previously reported (Cross et al., 1979; Wells et al., 1980; Cross and Tennent, 1980, Jacobs and Sebranek, 1980), although Nusbaum et al., (1979) found greater tenderness in patties processed from postrigor beef compared to prerigor beef. The improved tenderness of hot boned ground beef patties is probably due to the rapid cooking of frozen prerigor patties, which means that panelists evaluated prerigor beef.

Scores for initial tenderness reflected improvements associated with hot boning only for ES beef. No interaction of stimulation and boning temperature was noted in the study of Cross and Tennent (1980). Patties made from NS Choice chucks and plates had ratings indicative of less connective tissue compared to patties made from the other treatment combinations involving ES and formulation materials. Cross and Tennent (1980) found ES to have no influence on the ratings for connective tissue. Sensory panels in previous studies have shown high levels of sensory panel determined connective tissue in ground beef formulations containing cow lean (Cross et al., 1976, Cross et al., 1978a, Berry et al., 1980). However, in our study patties processed with cow lean were found to have higher levels of sensory panel determined connective tissue compared to Choice beef only when the beef was hot-boned.

Juiciness scores were significantly higher in hot-boned beef than in cold-boned beef only for ES carcasses. Higher juiciness scores have been reported for hot boned beef patties than cold-boned beef patties (Cross et al., 1979; Wells et al., 1980; Cross and Tennent, 1980).

Instron maximum single blade shear and energy data produced significant differences ($P<0.01$) only in the four-way interaction. The major differences were essentially that patties from ES hot-boned beef subjected to slow freezing had lower shear and energy values than patties from ES cold-boned Choice chucks and plates. Patties from both ES hot boned Choice or cow beef subjected to slow freezing had lower shear and energy values than patties derived from NS cold-boned cow beef formulations subjected to fast freezing.

Interactions involving ES, boning temperature and formulation as well as ES, boning temperature and rate of freezing influenced total cooking losses. With the exception of ES hot-boned beef, formulations made of all Choice beef had higher cooking losses than formulations made from cow lean and Choice plates. The higher protein to moisture ratios usually associated with cow lean compared to Choice lean may have been responsible for the lower cooking losses for patties of the cow lean formulations. Regardless of the rate of freezing, patties made from ES hot-boned beef had lower ($P<0.01$) cooking losses than patties from ES cold-boned beef. This is in agreement with the results of Cross and Tennent (1980). However, for NS beef, rate of freezing, rather than temperature of boning exerted more of an influence on cooking loss. Similar to the results of our study, Nusbaum et al. (1979) reported lower cooking losses with fast than with slow frozen beef patties. Nusbaum et al. (1979), Cross et al. (1979) and Jacobs and Sebranek (1980) found that patties from hot-boned beef had lower cooking losses than patties from cold-boned beef.

Patties from treatments that had less cooking loss or more of their cooking loss as moisture tended to show less reduction in height during cooking. In the interaction involving temperature of boning, formulation and rate of freezing, the lowest reduction in patty height during cooking was found in three of the four hot-boned formulations. Cross et al. (1979) and Cross and Tennent (1980) also found that hot boning reduced the amount of change in patty height during cooking.

For NS beef, patties made from Choice chucks and plates had a greater reduction in moisture content from the raw to the cooked state than patties made from cow lean and Choice plates. This is in agreement with moisture reduction data previously found between Choice and Cutter-Canner cow beef formulations (Berry et al., 1980). Within NS beef formulations, all treatments underwent an increase in fat content between the raw and cooked state with the exception of the hot-boned cow formulation. Patties made from hot-boned beef had greater moisture loss during cooking when they were slow frozen than when they were fast frozen. NS beef patties subjected to slow freezing displayed less increase in fat content as a result of cooking than did patties subjected to fast freezing. Likewise, under the fast frozen category, ES resulted in a decrease in fat level between the raw and cooked state, whereas NS produced an increase in fat content as a result of cooking.

Composition data of the cooking losses indicated that, with the exception of ES cold-boned beef, fat losses made up a higher percentage of the cooking losses for the all Choice beef formulations than for the cow lean and Choice plate formulations. More of the cooking loss was fat for patties from cold-boned beef that were fast frozen than with slow frozen patties. The opposite was true for hot-boned beef, especially with patties processed from NS beef.

In conclusion, if the meat industry were to use electrical stimulation either with or without hot boning, resultant lean sources (boneless chucks) and fat sources (boneless plates) can be suitably used in the manufacture of ground beef. Patties processed from ES beef seemed to lose more fat during cooking, while patties from NS beef lost more moisture during cooking. Substituting boneless cow lean for boneless Choice chucks resulted in less fat loss in cooking, lower cooking losses and less reduction in patty height during cooking.

LITERATURE CITED

American Meat Science Association. 1978. Guidelines for Cookery and Sensory Evaluation of Meat. Published by AMSA and the National Live Stock and Meat Board, Chicago, IL.

AOAC. 1975. "Official Methods of Analysis" 12 ed. Association of Official Analytical Chemists, Washington, D.C.

Berry, B. W., Marshall, W. H. and E. J. Koch. 1980. Cooking and chemical properties of raw and precooked flaked and ground beef patties. J. Food Sci. (Submitted).

Cross, H. R., Green, E. C., Stanfield, Marilyn S. and Franks. W. J., Jr. 1976. Effect of quality grade and cut formulation on the palatability of ground beef patties. J. Food Sci. 41: 9.

Cross, H. R., Berry, B. W., Nichols, J. E., Elder, R. E., and Quick, J. A. 1978a. Effect of desinewing versus grinding on textural properties of beef. J. Food Sci. 43: 1057.

Cross, H. R., Stanfield, M. S. and Franks. W. J. Jr. 1978b. Objective measurements of texture in ground beef patties. J. Food Sci. 43: 1510.

Cross, H. R., Berry, B. W. and Muse, D. 1979. Sensory and cooking properties of ground beef prepared from hot and chilled beef carcasses. J. Food Sci. 44: 1432.

Cross, H. R. and Tennent, I. 1980. The effect of electrical stimultion and postmortem boning time on sensory and cookery properties of ground beef. J. Food Sci. (In press).

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

Jacobs, D. K. and Sebranek, J. G. 1980. Use of prerigor beef and frozen ground beef patties. J. Food Sci. 45: 648.

Nusbaum, R. P., Topel, D. G. and Sebranek, J. G. 1979. The effect of freezing rate on the microstructure and quality of pre- and postrigor ground beef patties. J. Anim Sci. Suppl. 1 ASAS 216 (Abstr).

Snedecor, G. W. and Cochran, W. G. 1972. "Statistical Methods", 6th ed., Iowa State University Press, Ames, Iowa.

Wells, L. H., Berry, B. W. and Douglass, L. W. 1980. Effects of grinding and mechanical desinewing in the manufacture of beef patties using conventionally chilled and hot boned and rapidly chilled mature beef. J. Food Sci. 45: 163.

The authors wish to thank Monfort of Colorado for assisting in this project. This project was supported in part by the Natick Army Research and Development Command, Natick, Mass.

Mention of brand names does not imply endorsement by the U.S. Government.

Table 1. Significant sources of variation affecting sensory, physical, cooking and chemical traits of beef patties.

Sensory, physical, cooking or chemical trait.	Significant (P<0.05) sources of variation--main effects, first, second or third order interactions.[a]
Initial tenderness score	S x B, B x F
Final tenderness score	S, B, F
Initial connective tissue amount score	S, B, F
Final connective tissue amount score	S, B, F
Juiciness score	F, S x B
Instron single blade maximum shear force	S x B x F x R
Instron shear energy	S x B x F x R
Total cooking loss, %	S x B x F, S x B x R
Reduction in patty height, %	S x B x F, S x B x R, B x F x R
Difference in water between raw and cooked, %	S x B x F, S x B x R, B x F x R
Difference in fat between raw and cooked, %	S x B x F, S x B x R, B x F x R
Amount of water in cooking loss, %	S x B x F, S x B x R, B x F x R
Amount of fat in cooking loss, %	S x B x F, S x B x R, B x F x R

[a]S = electrical stimulation vs nonstimulation, B = prerigor hot-boning vs postrigor cold-boning, F = formulations of USDA Choice chucks and plates vs imported cow lean with USDA Choice plates and R = fast freezing rate of -50° C vs slow freezing rate of -20° C.