Reprinted from *J. Food Sci.*
55(2): 573–574
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A Research Note

Effect of Freezing of Beef on Subsequent Postmortem Aging and Shear Force

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ABSTRACT

Seventy-two steaks were used to determine effects of freezing postrigor muscle on aging of meat and shear force. Steaks were removed from each carcass 24 hr postmortem and aged at 2°C for 2 or 6 days; or frozen at −30°C for 27 days, thawed 24 hr and aged 2 or 6 days at 2°C. After aging, steaks were cooked and shear force determinations made. Aging of meat reduced shear force values; however, meat aged after freezing had lower ($P < 0.03$) shear force values than meat aged before freezing. Meat cooked after freezing had greater ($P < 0.05$) cooking losses. Freezing enhances the aging process and improves shear values of meat.

INTRODUCTION

POSTMORTEM STORAGE at refrigerated temperatures has been clearly demonstrated to improve meat tenderness. Proteolysis of myofibrillar proteins has also been generally accepted to play an important role in the process (Penny, 1980; Goll et al., 1983; Dutson, 1983; Koohmaraie, 1988). Research indicates calcium-dependent proteases (CDP) and their inhibitor are important in postmortem proteolysis of meat and tenderness as associated with aging (Koohmaraie et al., 1986). Recent data from Koohmaraie (1989) indicate the inhibitor of CDP loses activity with time while meat is frozen at temperatures as low as −70°C. However, CDP within muscle does not lose activity while frozen (Koohmaraie, 1989). Also, results indicate the aging process may be more highly regulated by the inhibitor than by CDP activity. Based on these results, we hypothesized that freezing meat before aging to preserve CDP activity while depleting the inhibitor, would improve proteolytic activity of CDP upon thawing and enhance aging and tenderness. Meat that is frozen, is generally aged first. The aging process is cost prohibitive for major meat processors because of the need to store large quantities of meat for extended periods. If our hypothesis holds true, the packer could freeze meat after rigor (about 24 hr postmortem), sell frozen retail cuts, and retail outlets or the consumer could age the product before cooking. Our objective was to determine the effect of freezing of fresh meat on tenderness determined by shear force.

MATERIALS & METHODS

SEVENTY-TWO 2.5-cm steaks were obtained from the loins (12 steaks per side) of two Angus cows and one Brown Swiss cow that had been fed a corn-corn silage diet and were about 20 months of age. Cattle were transported about 10 km and slaughtered at the laboratory at the U.S. Meat Animal Research Center. After slaughter, the carcasses were moved to a 0°C room and aged for one day. After one day of aging, carcasses were evaluated, and steaks from the Longissimus dorsi muscle (11th rib through third lumbar vertebra) of each side were stratified and assigned to treatments so that steaks from each of the 12 locations were equally represented within each treatment. Carcasses averaged USDA (1976) Choice grade, 336 kg in weight, 0.9 cm fat cover at the 12th rib, and 90 cm^2 Longissimus dorsi muscle area at the 12th rib.

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The following treatments were imposed: 1A = 24 hr at 0°C; 3A = 24 hr at 0°C, followed by 48 hr at 2°C; 7A = 24 hr at 0°C, followed by 144 hr at 2°C; 1FA = 24 hr at 0°C, followed by 27 days storage at −30°C, and thawing 24 hr at 2°C; 3FA = 24 hr at 0°C, followed by 27 days storage at −30°C, thawing 24 hr, and 48 hr at 2°C; 7FA = 24 hr at 0°C, followed by 27 days storage at −30°C, thawing 24 hr, and 144 hr at 2°C.

Shear force observations were made after each aging period (AMSA, 1978). Steaks were broiled on a Farberware "Open-Hearth" broiler (Model 450N; Farberware, Bronx, NY). Internal temperatures were monitored with iron constantan wire thermocouples attached to a potentiometer. Steaks were turned at 40°C and removed from the broiler at 70°C. Steaks were stored in ventilated polyethylene bags for 24 hr at 2°C before coring. Six 1.3-cm cores were removed so muscle fibers were parallel to the length of the core. Cores were sheared with an Instron 1132/Microcon II Universal Testing Instrument (Instron Corp., Caton, MA) equipped with a Warner-Bratzler shear blade. The crosshead operated at 5 cm/min.

Data were analyzed by least-squares procedures using the program by SAS (1982). The model included main effects for carcasses (2 df) and treatments (5 df). Residual variation was used as an error term. Linear contrasts and least-significant differences were used to test differences among means.

RESULTS & DISCUSSION

MEAT AGED after freezing had lower ($P < 0.03$) shear force values than meat aged before freezing. Cooking traits and shear force results are presented in Table 1. Significant ($P < 0.01$) reductions in shear force were observed over the aging period of fresh (1.88 kg) or frozen (2.45 kg) meat. The additional ($P < 0.01$) reduction in shear value of 0.67 kg (7A-7FA) of aged meat that had been frozen compared to the additional reduction of 0.34 kg (3A-3FA) indicates that freezing meat before the aging period may enhance postmortem proteolysis. Since only 0.10 kg reduction in shear force could have been attributed to the freezing process, the enhancement in tenderness was likely due to increased proteolysis during aging. The increased aging was probably due to the loss of inhibitor for calcium-dependent proteases. Winger and Fennema (1976) had previously observed a linear reduction in shear values up to 2.3 kg in meat from the Sternomandibularis muscle that had been stored at −3°C up to 28 days. Cohen (1984) observed meat soaked in salt solution will age after being frozen. Variation in shear force within treatments, as measured by the standard deviation, was not statistically tested among the treatments, but appeared similar for all treatments (Table 1).

Meat cooked after freezing had greater ($P < 0.05$) cooking loss than meat cooked before freezing (Table 1). Cooking losses were computed based on weights of steaks immediately prior to cooking, and losses did not directly reflect losses in weight associated with lyophilization or thaw purge. However, Winger and Fennema (1976) observed that meat frozen postrigor did not appreciably release an exudate during thawing. Also, cooking losses were less ($P < 0.05$) with meat aged 7 days as compared to meat aged 1 day. Part of the reduced cooking losses may have been associated indirectly with increased

Table 1—Means and standard deviations for cooking and shear force characteristics by treatments

	Treatments						
	Fresh			Frozen			
Trait	1A	3A	7A	1FA	3FA	7FA	Probability[a]
Shear force, kg, $\bar{x}$	7.60	6.68	5.72	7.50	6.34	5.05	$P < 0.01$
Shear force, kg, SD[b]	1.20	1.53	1.12	1.19	0.94	0.93	Not tested
Cooking loss, %[c]	27.8	28.0	26.8	33.8	31.9	30.7	$P < 0.01$
Cooking rate, g/min[d]	10.8	9.9	12.2	9.5	10.6	10.9	$P < 0.09$
Cooking time, min	30.8	33.6	26.7	33.6	29.7	28.1	$P < 0.01$

[a] Probability of means being equal.
[b] Analysis of variance was not computed.
[c] Cooking loss, % = [(uncooked weight − cooked weight) ÷ cooked weight] × 100.
[d] Cooking rate, g/m = uncooked weight divided by cooking time.

shrinkage which was not measured. Cohen (1984) and Parrish et al. (1969) observed no differences in moist heat cooking losses of meat associated with length of aging. However, Parrish et al. (1969) observed aging of meat improves water-holding capacity before cooking. Cooking time was less ($P < 0.01$) for the aged meat, which was reflected in a tendency for faster ($P < 0.09$) cooking rates (g of uncooked meat/min). No differences in cooking time or rate were observed due to freezing (Table 1).

Our results indicate freezing postrigor muscle reduces shear force values as compared to meat aged prior to freezing. Freezing before aging has the potential of significant savings to the packing industry reducing losses due to shrinkage and storage costs for fresh meat.

REFERENCES

AMSA. 1978. Guidelines for cookery and sensory evaluation of meat. American Meat Science Association and the National Live Stock and Meat Board.
Cohen, T. 1984. Aging of frozen parts of beef. J. Food Sci. 49: 1174.
Dutson, T.R. 1983. Relationship of pH and temperature to distribution of specific muscle proteins and activity of lysosomal proteinases. J. Food Biochem. 7: 223.
Goll, D.E., Otsuka, Y., Nagainis, P.A., Shannon, J.D., Sathe, S.K., Muguruma, M. 1983. Role of muscle proteinases in maintenance of muscle integrity and mass. J. Food Biochem. 7: 137.
Koohmaraie, M. 1988. The role of endogenous proteases in meat tenderness. Recip. Meat Conf. Proc. 41: 89.
Koohmaraie, M. 1989. Quantification of Ca^{2+} −dependent protease activities by hydrophobic and ion-exchange chromatography. J. Anim. Sci. (In press).
Koohmaraie, M., Schollmeyer, J.E., and Dutson, T.R. 1986. Effect of low-calcium-requiring calcium activated factor on myofibrils under varing pH and temperature conditions. J. Food Sci. 51: 28.
Parrish, F.C., Jr. Rust, R.E., Popenhagen, G.R., and Minor, B.E. 1969. Effect of postmortem aging time and temperature on beef muscle attributes. J. Anim. Sci. 29: 398.
Penny, I.F. 1980. The enzymology of conditioning. In "Developments in Meat Science-1," R. Lawrie (Ed.), p. 115. Applied Science Publishers Ltd., London.
SAS Institute, Inc. 1982. "SAS User's Guide: Statistics" (1982 ed.). SAS Inst. Cary, NC.
USDA. 1976. Official United States standards for grades of carcass beef. Title 7, Ch. 28, Pt. 2853, Sections 102-107. Code of Federal Regulations, U.S. Department of Agriculture, Washington, DC.
Winger, R.J. and Fennema, O. 1976. Tenderness and water holding properties of beef muscle as influenced by freezing and subsequent storage at −3 or 15°C. J. Food Sci. 41: 1433.
Ms received 10/10/89; accepted 12/18/89.

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