The Effects of Marbling Level, Electrical Stimulation and Post-Mortem Aging on the Cooking and Palatability Properties of Beef Rib Eye Steaks

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SUMMARY

A total of 456 beef rib eye steaks (longissimus thoracis) were used to evaluate the effects of marbling, electrical stimulation and post-mortem aging on the cooking and palatability properties of beef. Marbling had no effect on initial or overall tenderness, flavour intensity or desirability, but steaks with slight or greater levels of marbling were more juicy ($P<0.05$) than those with traces of marbling. However, the percentage of unacceptable ratings for steaks based on overall palatability declined from 38.5% for traces of marbling to 23.7% for modest marbling. Electrical stimulation had no effect ($P>0.05$) on any of the palatability traits. Post-mortem aging significantly ($P<0.05$) increased the tenderness and overall palatability of rib eye steaks while decreasing the frequency of unacceptable steaks from 38.8% in 4 day old steaks compared to 24.0% in 11 day old steaks. The results of this study confirmed the importance of post-mortem aging to beef tenderness and palatability and the importance of marbling to juiciness, but indicated that low voltage stimulation was ineffective in improving beef palatability.

INTRODUCTION

Survey information collected by the beef industry (McDonell 1988) has suggested that more than 30% of Canadian consumers believe that the quality of beef has declined over the last 10 years. The main reasons stated for this perceived decline in beef quality were reduced tenderness and inconsistent palatability. Although lack of consumer education in the preparation and selection of cuts may be partly responsible for this finding, it seems more likely that overall changes in industry practices such as the production of leaner carcasses (Jones 1986), shorter periods of post-mortem aging and the adoption of more rapid carcass chilling methods are likely to be the primary underlying factors.

The potential interactive effects of marbling, low voltage electrical stimulation and post-mortem aging have not been adequately explored. There is evidence with high voltage stimulation that palatability improvements are maximized with short aging periods (Savell et al. 1981) and disappear by the time it takes meat to be shipped and distributed from Western to Eastern Canada (Wood and Froehlich 1983). The present study was conducted to assess the effects of marbling level, low voltage electrical stimulation, post-mortem aging and their interactions on the cooking and palatability properties of beef rib-eye steaks.

MATERIAL AND METHODS

The steaks for this study were obtained from a commercial beef processing plant. A total of 456 beef rib eye steaks (longissimus thoracis) were obtained from 229 carcass sides representing four different marbling levels (58 traces, 58 slight, 56 small, 57 modest). These sides were selected over a period of two days and were either graded Canada A1 or A2 (fat thickness range of 5-15mm). On day 1, 28 sides from each marbling level (total 112 sides), which had previously received low voltage electrical stimulation, were identified and the section of the longissimus thoracis between the 10th and 12th ribs removed. On day 2, a group of 117 sides were selected with the following distribution of marbling levels: 30 traces, 30 slight, 28 small and 29 modest. The procedures were the same on both days except that the sides selected on day 2 had not received low voltage electrical stimulation.

Electrical stimulation was applied with a Jarvis stimulator (Model BV-80, Jarvis Products Corp., Middletown, CN) by a stationary bar making contact with the neck or brisket area of the hide-on carcass within 5 min of stunning. Carcasses were stimulated for 18 sec with a 21V rectangular wave and a stimulation current of 0.25 amps at a frequency of 60 Htz.

Two 19mm steaks were cut from each section using a bandsaw and vacuum packaged. One steak from each side, selected at random, was aged for 4 days, while the remaining steak was aged for 11 days. All steaks were frozen at -30°C for subsequent organoleptic evaluation (approximately 45 days). Following thawing, steaks were roasted to an internal temperature of 70°C in a conventional oven preheated to 177°C. Six cubes from each steak were then randomly assigned to a six member sensory panel, screened and trained according to established guidelines (American Meat Science Association 1978). Each sample was evaluated for: initial and overall tenderness, amount of perceptible connective tissue, juiciness and flavour intensity using nine-point descriptive scales (9 = extremely tender, no perceptible connective tissue, extremely juicy and extremely intense beef flavour; 1 = extremely tough, abundant connective tissue, extremely dry and extremely bland meat flavour). In addition, each sample was evaluated for flavour desirability and overall palatability using a nine-point hedonic scale (9 = extremely desirable, 1 = extremely undesirable). A least squares analysis of variance was used to determine the probability of treatment effects with marbling level, electrical stimulation and post-mortem aging as main effects and all two way and three way interactions. Means separation where necessary was performed using linear contrasts (Statistical Analysis System Institute 1985).

RESULTS AND DISCUSSION

On an overall basis, the small number of interactions found (no 3-way and three 3-way), and the relatively minor changes in the means suggest for this study that the main effects (marbling level, electrical stimulation and post-mortem aging) generally acted independently to each other on beef palatability.

Effect of Marbling Level. As marbling level changed from traces to modest there were significant changes in thaw drip loss, cooking time, amount of perceptible connective tissue and juiciness (Table 1). No differences were found for tenderness, flavour or overall palatability. Marbling level influenced juiciness (Table 1) with modest, small and slight levels having higher mean panel scores than the traces level. It

Table I. Least square means and standard errors for cooking and palatability properties of rib eye steaks with different degrees of marbling

Trait	Marbling Level							
	Modest		Small		Slight		Traces	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Initial tenderness	4.80	0.10	4.87	0.10	4.56	0.10	4.72	0.10
Overall tenderness	4.57	0.10	4.69	0.10	4.34	0.10	4.54	0.10
Juiciness	5.09^{c}	0.08	4.92^{b}	0.08	4.94^{bc}	0.08	4.73^{a}	0.08
Flavour desirability	5.37	0.04	5.30	0.04	5.31	0.04	5.29	0.04
Flavour intensity	5.55	0.03	5.51	0.03	5.50	0.03	5.47	0.03
Overall palatability	4.83	0.07	4.73	0.07	4.70	0.07	4.71	0.07

^{abc} Means in the same row without a superscript or bearing a common superscript do not differ significantly ($P<0.05$)

was of interest to note that unacceptable palatability occurred at a frequency of 23.7% for modest levels of marbling, whereas it was 38.5% for steaks with traces of marbling. This result does suggest a possible association between higher levels of marbling and consistency of overall palatability. These findings support previous research studies (Dryden and Marchello 1970; Jennings et al. 1978; Tatum et al. 1982) that increased levels of intramuscular fat improve meat juiciness in high quality cuts (loins and ribs), but fail to confirm

Table II. Least squares means and standard errors for cooking and palatability properties of rib eye steaks from electrically stimulated and non-stimulated sides

Trait	Stimulated		Non-stimulated	
	Mean	SE	Mean	SE
Initial tenderness	4.77	0.07	4.70	0.07
Overall tenderness	4.57	0.07	4.50	0.07
Juiciness	4.90	0.05	4.94	0.05
Flavour desirability	5.34	0.03	5.30	0.03
Flavour intensity	5.50	0.02	5.52	0.02
Overall palatability	4.78	0.05	4.71	0.05

improvements in other palatability attributes such as tenderness observed in other published reports (Dryden and Marchello 1970; Tatum et al. 1982; Smith et al. 1985, 1987).

Electrical Simulation. Low voltage electrical stimulation as used in the present study had no effect ($P > 0.05$) on the cooking or palatability properties of steaks (Table II). However, despite palatability traits having a similar frequency of unacceptable ratings, it should be noted for overall palatability that the frequency of unacceptable ratings for unstimulated steaks was 36.1%, whereas it was 26.5% for stimulated

Table III. Least squares means and standard errors for cooking and palatability properties of rib eye steaks aged for 4 or 11 days

Trait	4 days		11 days	
	Mean	SE	Mean	SE
Initial tenderness	4.29[a]	0.07	5.19[b]	0.07
Overall tenderness	4.07[a]	0.07	5.00[b]	0.07
Juiciness	4.94	0.05	4.89	0.05
Flavour desirability	5.36	0.03	5.28	0.03
Flavour intensity	5.49	0.02	5.52	0.02
Overall palatability	4.61[a]	0.05	4.87[b]	0.05

[ab] Means in the same row bearing a different superscript differ significantly ($P < 0.05$)

steaks. While there are several reports which have observed palatability improvements in beef as a result of low voltage electrical stimulation (Bouton et al. 1978; Villarreal and Will 1988; Makami et al. 1990), the results of the present study suggest little benefit of this process in relation to meat palatability, with the possible exception of when there is a high risk of cold toughening occurring during the chilling of carcasses. Post-mortem aging. Time for post-mortem aging had significant ($P < 0.05$) effects on tenderness (both initial and overall tenderness) and overall palatability (Table III). Samples aged for 11 days had close to a 1 panel unit higher score for overall

tenderness compared to those aged for 4 days. Over 60% of samples aged only 4 days were found to be unacceptable in overall tenderness whereas this declined to 26.2% in steaks aged for 11 days. Overall palatability showed a similar change falling from 38.8% in 4 day old steaks to 24.0% in steaks aged for 11 days. Results confirm the importance of post-mortem aging to the tenderness and palatability of beef rib eye steaks and indicate that 4 days of post-mortem aging is insufficient to insure consistency of tenderness and palatability. The results of this study are in agreement with others that indicate a period of at least 6 days through to 11 days post-mortem is required to improve the consistency of tenderness prior to retail sale (Martin et al. 1977; Smith et al. 1978).

CONCLUSIONS

The present study has shown that post-mortem periods longer than 4 days and up to 11 days are required to improve the tenderness and consistency of beef rib eye steaks. Low voltage electrical stimulation had no effect on any of the meat palatability traits evaluated. Marbling had a significant effect on meat juiciness, but there was little benefit to be gained once the slight level of marbling had been achieved. Of greater importance was the high level of steaks rated as unacceptable in overall palatability which exceeded 20% even for steaks which had been aged for 11 days. The reason for this relatively high level of unacceptable ratings is unknown, but should be the subject of further research to resolve palatability problems in beef.

REFERENCES

American Meat Science Association 1978. Guidelines for cookery and sensory evaluation of meat. American Meat Science Association, Chicago, Ill.

Bouton, P.E., Ford, A.L., Harris, P.V. and Shaw, F.D. 1978. Effect of low voltage stimulation of beef carcasses on muscle tenderness. J. Fd. Sci. 43:1392-1396.

Dryden, F.D. and Marchello, J.A. 1970. Influence of total lipid and fatty acid composition upon the palatability of three bovine muscles. J. Anim. Sci. 31: 36-41.

Jennings, T.G., Berry, B.W. and Joseph, A.L. 1978. Influence of fat thickness, marbling and length of aging on beef palatability and shelf life characteristics. J. Anim. Sci. 46: 654-665.

Jones, S.D.M. 1986. Changes in animal product composition and implications for animal production systems. Can. J. Anim. Sci. 66: 22-30.

Makami, M., Kudoh, T., Hayashi, A., Hiruta, E. and Miura, H. 1990. Effects of electrical stimulation on myofibrillar proteins and tenderness of beef muscle. Agric. Biol. Chem. 54: 531-532.

Martin, A.H., Jeremiah, L.E., Fredeen, H.T. and L'Hirondelle, P.J. 1977. Influence of pre- and post-rigor muscle changes on intrinsic toughness of beef muscle. Can. J. Anim. Sci. 57: 705-712.

McDonell, C. 1988. Consumer perceptions of quality. Proc. Can. Meat Council Annual Meeting p 14-1 - 14-4.

Savell, J.W., McKeith, F.K. and Smith, G.C. 1981. Reducing post-mortem aging time of beef with electrical stimulation. J. Fd. Sci. 46: 1777-1780.

Smith, G.C., Culp, G.R. and Carpenter, Z.L. 1978. Post-mortem aging of beef carcasses. J. Fd. Sci. 43: 823-826.

Smith, G.C., Carpenter, Z.L., Cross, H.R., Murphy, C.E., Abraham, H.C., Savell, J.W., Davis, G.W., Berry, B.W. and Parrish, F.C. 1985. Relationship of USDA marbling groups to palatability in cooked beef. J. Fd. Qual. 7: 289-308.

Smith, G.C., Savell, J.W., Cross, H.R., Carpenter, Z.L., Murphey, C.E., Davis, G.W., Abraham, H.C., Parrish, F.C. and Berry, B.W. 1987. Relationship of USDA quality grades to palatability of cooked beef. J. Fd. Qual. 10: 269-286.

Statistical Analysis System Institute. 1985. SAS User's Guide: Statistics, Version 5 Edition. Cary, NC.

Tatum, J.D., Smith, CG.C. and Carpenter, Z.L. 1982. Interrelationships between marbling, subcutaneous fat thickness and cooked beef palatability. J. Anim. Sci. 54: 777-784.

Villarreal, R. and Will, P.A. 1988. Effects of electrical stimulation on the bovine carcass. J. Fd. Qual. 11: 35-42.

Wood, D.F. and Froehlich, D.A. 1983. The effect of electrical stimulation on sensory and physical properties of steaks from three grades of Canadian beef after commercial handling. Can. Inst. Fd. Sci. Tech. J. 16: 52-56.