TIME-INTENSITY, ELECTROMYOGRAPHY AND MECHANICAL MEASUREMENTS OF ROAST BEEF TOUGHNESS INFLUENCED BY COOKING RATE AND DEGREE OF DONENESS

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INTRODUCTION

Methods used to investigate toughness in meat include traditional methods such as Warner Bratzler shear and compression. Such me provide useful information about the overall toughness of a meat sample, but do not measure the temporal aspects of toughness. The adva of the use of temporal methods such as electromyography (Duizer *et al.*, 1994) and time-intensity sensory evaluation (TI) is their potent reflect changes in texture properties in a continuous way during mastication rather than a single point measure. TI sensory evaluation has shown to be successful in separating beef muscles on the basis of tenderness (Duizer *et al.*, 1993, 1994; Butler *et al.*, 1996). In cooked consumer preference is usually associated with up to five degrees or categories of doneness. These categories are traditionally defined temperature attained at the geometric centre of the meat during heat processing. The objective of the present study was to use a combinat time-averaged and temporal methods to investigate the toughness of beef *Semitendinous* roasts cooked at a variety of oven temperatur three degrees of doneness.

METHODS

Beef *Semitendinous* roasts were obtained from a local meat processing plant and wet aged for three weeks. Roasts were prepared (3 repli of nine treatment combinations) and assigned to days using a balanced incomplete block design. The nine treatments were, roasts cook three oven temperatures (160, 170 and 180°C), to three internal temperatures (60 (rare), 70 (medium) and 80°C (well done)). All temper were monitored using multiple PT100 thermocouples (Tracker 3000 Data Logging System, Data Track Technology LTD, Dorset, Engl Mechanical measurements, (TI) sensory evaluation and electromyography (EMG) were used to analyse the toughness of each roast. W Bratzler shear and compression values were obtained using the Instron Universal Testing Machine (Instron Corporation, Canton, MA 02 Ten subjects were trained in the use of TI over a two week period. During the first part of training, assessors were familiarised with computerised method of TI scaling on a one to one basis. During the next three training sessions, assessors participated in focus gr designed to familiarise them with muscle fibre orientation, definition of meat tenderness (AMSA, 1978) and the technique of TI scaling (Bu *et al.*, 1996). TI data (1 point sec^{-1}) were collected using the PSA system (Oliemans, Punter and Partners, BV, The Netherla Electromyographic data were recorded using a Grass Polyview model P511 instrument (Astro-Med Inc., West Warwick, England). Su electrodes were placed on the left and right masseter muscles and subjects were asked to chew naturally. TI curves were analysed by Prin Component Analysis (Dijksterhuis *et al.*, 1994). Results obtained from EMG and Instron data were subjected to Analysis of vari (ANOVA) using SPSS statistical software (SPSS Inc., Chicago). Correlation coefficients were calculated between average perce toughness (Principal Curve measurements) and Instron data (SPSS Inc., Chicago).

RESULTS AND DISCUSSION

Oven temperature did not significantly effect shear or compression values (Table 1). Significant differences in shear values were found betw rare and well done roasts cooked at 170°C. A significant increase in compression values between rare, medium and well done roasts was observed in roasts cooked at 160 and 180°C. The TI Principal Curve (Figure 1) provided a simple and rapid means of viewing ov differences in beef toughness between treatments. The curves show the time course of perceived toughness throughout the complete chew sequence. As the final internal temperature increased, the meat became tougher. Rare meat was toughest when cooked slowly (160 Medium and well done roasts were toughest when cooked rapidly (170 and 180°C). Shear and compression measurements were correla with toughness intensity at the start (0.793 and 0.752), in the middle (0.809 and 0.774) and at the end of the chewing sequence (0.799 0.725). Analysis of variance of the EMG data for the three subjects (Table 2) show that different EMG parameters discriminated betw treatments for different subjects. Rare and medium cooked roasts took significantly less time to chew and needed a smaller number of chew reach the end of the chewing sequence than well done roasts. Subjects 2 and 3 did not differentiate between the treatments in terms of eit chew time or number.

CONCLUSIONS

Our results show that toughness of beef *Semitendinous* roasts was more influenced by final internal temperature than cooking temperatu Rare roasts were less tough than medium or well done roasts. A better understanding of the changes in beef toughness as it occurs throughout mastication was provided by the combined use of mechanical time-averaged methods (Instron), TI sensory evaluation and EM measurements.

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REFERENCES

AMSA, (1978). Guidelines for the Cookery and Sensory Evaluation of Meat. American Meat Science Association and National Livestock a Meat Board. Chicago, Il.

Butler, G., Poste, L. M., Mackie, D. A. & Jones, A. (1996). Time-intensity as a tool for the measurement of meat tenderness. *Food Qual. a Pref.* **7**, 193-204.

Dijksterhuis, G., Flipsen, M. & Punter, P. (1994). Principal component analysis of TI curves: three methods compared. *Food Qual. and Pr* **5**, 121-127

Duizer, L. M., Gullet, E. A. & Finlay, C. J. (1993). Time-Intensity methology for beef tenderness perception. *J. Food Sci.* **58**, 943-947.

Duizer, L. M., Gullett, E. A. & Findlay, C. J. (1994). The effect of masticatory patterns as measured by time-intensity and electromyograph on the perception of bovine muscle tenderness. *J. Sens. Stud.* **9**, 33-46.

Table 1 Effect of cooking temperature and degree of doneness on Warner Bratzler shear and compression values

	Treatment*									Duncan test (p = 0.05)
	160/60 Mean (SE)[1]	160/70 Mean (SE)[1]	160/80 Mean (SE)[1]	170/60 Mean (SE)[1]	170/70 Mean (SE)[1]	170/80 Mean (SE)[1]	180/60 Mean (SE)[1]	180/70 Mean (SE)[1]	180/80 Mean (SE)[1]	
Warner Bratzler shear (Kgf)	2.6 (0.1)	2.9 (0.2)	2.8 (01)	2.7 (0.3)	3.5 (0.1)	4.0 (0.6)	2.5 (0.2)	2.9 (0.2)	3.6 (0.5)	1.3
Compression (Kgf)	0.7 (0.1)	1.1 (0.4)	1.6 (0.2)	0.6 (0.1)	0.8 (0.1)	1.3 (0.3)	0.5 (0.2)	1.4 (0.2)	1.6 (0.2)	0.9

*Treatment: oven temperature (°C) / meat internal temperature (°C).
mean value with standard error of 3 roasts, each analysed 5 times.

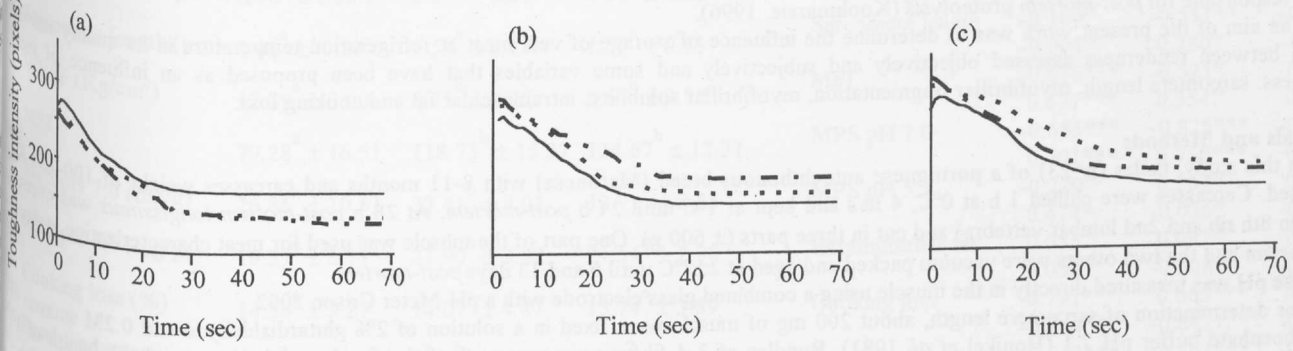

Figure 1 Average Principal Curves for toughness. Roasts cooked to internal temperatures: (a) 60; (b) 70; (c) 80 °C at three oven temperatures: ——— 160; · · · · 170; — · — 180 °C.

Table 2 Effect of cooking temperature and degree of doneness on EMG parameters for the three subjects

	Treatment*									Duncan test (p = 0.05)
	160/60 Mean (SE)[1]	160/70 Mean (SE)[1]	160/80 Mean (SE)[1]	170/60 Mean (SE)[1]	170/70 Mean (SE)[1]	170/80 Mean (SE)[1]	180/60 Mean (SE)[1]	180/70 Mean (SE)[1]	180/80 Mean (SE)[1]	
SUBJECT 1										
Chew time	7.96 (0.50)	8.28 (0.64)	12.1 (0.47)	8.18 (1.85)	13.3 (0.90)	14.3 (0.97)	7.44 (1.31)	7.99 (0.97)	12.5 (0.52)	3.73
Chew number	11.7 (1.75)	12.7 (0.75)	18.5 (1.00)	12.2 (2.25)	20.3 (1.45)	21.0 (1.00)	11.7 (2.03)	13.0 (1.50)	19.2 (0.83)	5.71
Chew rate[2]	1.47 (0.13)	1.54 (0.03)	1.53 (0.04)	1.51 (0.07)	1.53 (0.05)	1.48 (0.03)	1.57 (0.02)	1.63 (0.01)	1.53 (0.02)	0.18
AUC[3]	280 (29.7)	362 (12.1)	434 (106)	230 (49.1)	512 (72.2)	461 (145)	305 (47.5)	343 (2.87)	434 (56.8)	289
SUBJECT 2										
Chew time	27.6 (1.29)	27.3 (1.83)	26.9 (3.95)	25.8 (1.31)	29.2 (3.29)	30.4 (1.85)	27.0 (1.74)	23.4 (4.48)	29.1 (1.21)	10.8
Chew number	41.7 (1.07)	42.2 (1.75)	42.3 (4.53)	41.4 (0.58)	47.3 (5.29)	47.8 (1.17)	42.6 (3.08)	35.1 (5.97)	48.1 (1.74)	14.0
Chew rate[2]	1.52 (0.08)	1.55 (0.04)	1.59 (0.10)	1.61 (0.07)	1.61 (0.02)	1.58 (0.05)	1.58 (0.05)	1.52 (0.05)	1.65 (0.01)	0.24
AUC[3]	952 (163)	1039 (143)	1029 (201)	899 (178)	903 (82.1)	991 (182)	785 (76.5)	907 (165.9)	1069 (78.1)	618
SUBJECT 3										
Chew time	16.5 (0.66)	17.2 (1.36)	18.4 (2.44)	15.3 (0.94)	19.0 (0.54)	21.3 (1.02)	18.4 (1.58)	18.9 (1.28)	15.7 (3.28)	6.99
Chew number	22.7 (1.20)	25.1 (1.11)	26.2 (2.52)	23.3 (1.58)	27.2 (0.44)	28.2 (0.44)	26.4 (2.09)	26.7 (0.88)	26.2 (0.17)	5.75
Chew rate[2]	1.37 (0.05)	1.47 (0.08)	1.44 (0.10)	1.51 (0.02)	1.43 (0.07)	1.33 (0.08)	1.44 (0.03)	1.41 (0.12)	1.85 (0.77)	0.64
AUC[3]	460 (139)	623 (73.7)	645 (141)	448 (137)	463 (70.9)	617 (247)	440 (40.9)	709 (99.2)	370 (129)	450

*Treatment: oven temperature (°C) / meat internal temperature (°C).
[1] mean value with standard error of 3 roasts, each analysed 5 time.
[2] numbers of chews per second.
[3] area under the integrated EMG curve.