EFFECT OF TRANSPORT TIME AND SEASON ON INSTRUMENTAL MEAT QUALITY OF BEEF MEAT

Villarroel, M., María, G., Sañudo, C., Olleta, J.L., Sierra, I., and Gebresenbet G[1]
Dept. Producción Animal, Universidad de Zaragoza, 50013-Zaragoza, Spain
[1]Dept Agricultural Engineering, Swedish University of Agricultural Sciences, P.O. Box 7033, SE-75007 Uppsala, Sweden

Background

Stress shortly before slaughter can affect several aspects of meat quality (Mitchell et al. 1988). Short-haul trips do not normally affect ultimate pH in cattle (Tarrant 1989; Grandin 2000) but the quantitative time limits in terms of animal welfare or meat quality remains unclear. Ultimate pH is the most commonly measured factor in studies that consider pre-slaughter effects on beef quality. While it is clear that even travelling short distances can reduce live weight (shrinkage), decrease glycogen reserves and increase meat temperature (Agnes et al. 1990), this is not always reflected in ultimate pH. Apart from ultimate pH, some studies have considered in more detail the changes in meat colour and tenderness with transport time. However, this effect is normally grouped with other confounding factors that may mask the final results, such as breed, production system, animal feed, etc.

Objectives

To measure the effect of transport time and season while maintaining other factors constant such as the source farm, breed type, lorry and driver and abattoir. In Spain, transport is typically less than 3 hours but this may vary depending on the region (Villarroel et al. 2001). We analysed the most common range of transport times to measure its effect on meat pH, colour and texture. It is hoped that the results may be useful to the commercial sector and to further understand which aspects of normal commercial transports may put avoidable or unnecessary stress on the animals.

Methods

Forty-eight non-castrated male yearlings were transported in groups of eight for exactly 38 min, 212 min and 375 min in winter and 35 min, 210 min and 398 min in summer. Animals were kept in large partially shaded pens (approximately 24 animals in 220 m^2) with a diet of concentrate and cereal straw *ad libitum* and slaughtered between 13-15 months of age (yearling or *añojo* type). The animals we used were meat aptitude cross-breeds imported from Ireland. In each season we took the experimental animals (n=24) from one pen where they had been bred together and never mixed with unfamiliar animals. Before loading, eight animals were selected at random from the group pen and led to the truck. The cattle were slaughtered at local abattoir after an overnight lairage. Carcasses were chilled under commercial conditions at 4ºC for 24 h. The next day we measured pH at 24 h post-mortem on the lumbar region with a Crison 507 electrode. The *M. longissimus thoracis* (between T5 and T11) was removed from the left side and sliced into 3,5-cm thick steaks. Chops were vacuum packaged and kept at 4ºC for 7 or 14 days before being frozen and stored at -18ºC until instrumental analysis. Textural meat analysis (Warner-Bratzler and compression) was performed on sample steaks as in Campo et al. (1999). Water holding capacity (WHC) and colour values were measured in unfrozen meat. WHC at 7 days post mortem was measured by the Grau and Hamm method (Cañeque & Sañudo, 2001) and colour by spectrophotometry (L*a*b* systems- Minolta 2002) at 24 h. The data were analysed using the least square methodology of the GLM procedure of SAS, fitting a two-way model with a fixed effect of transport time (3 levels) and season (2 levels).

Results and Discussion

No significant differences were observed for pH24, except for the short winter trip which was significantly higher than the short summer trip. There was a trend for the pH to be higher in winter (5.70 ± 0.05) than in summer (5.56 ± 0.04) (Table 1). WHC was significantly higher for the short winter trip than all the other trips. Since lower values of WHC represent higher capacity to retain water, the short winter trip was apparently the most dry in correspondence with its pH values.

There was no significant effect of either transport time or season on WB values of texture (Table 1). The only significant difference was with the ageing time between 7 and 14 d, but this was not included in the model. In general the average values at these ageing times were similar to other studies (e.g. Campo et al. 1999).

Meat texture was also measured by a compression cell (Table 2). Transport and season had little effect on these variables. The only exception was at 20% compression (7 d of ageing) in terms of transport time with a slight interaction between the two main effects. This finding is explained by the high pH24 of the short trip in winter. Small differences in pH can affect meat tenderness. The tenderness of beef tends to decrease with an increase in pH24 from 5.5 to 6.1, after which it increases. The reasons for this are still obscure but seem to be directly affected by the change in sarcomere length which is intensified by cold shortening (Purchas & Aungsupakorn, 1993), which may have occurred in some of the carcasses analysed.

As opposed to the WB test, the compression cell did not reveal differences between ageing times except for compression at 20% (7 d ageing) which represents the tenderness of the myofibrillar structure (Eikelenboom et al. 1998). In general, our results suggest that transport time of up to six hours does not negatively affect the instrumental measure of texture.

Like texture, colour is also associated with the pH24 and the ageing time (Wulf & Wise 1988). Antemortem stress can alter the pH24 and thereby affect meat colour. The transport stress in our study had a little effect on colour indices at 24h post mortem except for a slight season effect (Table 3). L* was slightly higher in winter and there were no large differences between ageing times. Values of a* were statistically different between the short winter trip and the middle summer trip. The b* index varied little but was higher for the middle winter trip than the short and middle summer trips. In general the values agree with the literature.

The average values in Abril et al. (2001) for meat less than pH 6.1 were in the range of 41-43 for L*, 10-13 for a* and 6-10 for b*. Animals with higher pH had slightly lower values. Schaefer et al. (1990) analyse the effect of adding electrolytes to the animals before slaughter. The values of L*a*b* were within the range of our study. Jones et al. (1988) also analyse the effect of transport on the quality of met in yearling males. It varied between L* from 38 to 35, and 18.50 to 17 and 14.25 to 12.88. They conclude that transport time only has a slight effect on meat, making it slightly more dark.

Conclusions

1. In the conditions of this study, transport times from 30 min to 6 hours had very little effect on instrumental measurements of meat quality

2. Improvements in the transport conditions in these time frames are probably more related to improving animal welfare than meat quality, which leads us to a new concept of quality that involves ethical aspects.

Acknowledgements

We would like to thank Antonio Miranda, Hermanos Escanilla and Mercazaragoza for their help and co-operation in this study. Our thanks also to J.L. Blasco and Carne de Vacuno de Aragón and especially J.J. Pardos and B. Panea for technical support. This research was funded by the European Project CATRA (Project PL1507) on cattle transport.

Pertinent literature

■ Abril, M., Campo, M.M., Onenc, A., Sañudo, C. Alberti, P., Negueruela, A.I. (2001). Meat Science 58: 69-78. ■Agnes, F., Sartorelli, P., Borrow, H.A., & Locatelli, A. (1990). Am. J. Vet. Res. 51: 1679-1681. ■ Campo, M.M., Sañudo, C., Panea, B., Alberti, P., & Santolaria, P. (1999). Meat Science 51, 383-390. ■ Cañeque, C. & Sañudo, C. (2001). Metodología para el estudio de la calidad de la canal y de la carne en rumiantes. Monografías INIA, Ganadera Nº1. Ministerio de Ciencia y Tecnología. ■ Eikelenboom, G., Barrier, V.M.H., Hoving-Boloink, A.H., Smulders, F.J.M. & Culioli, J. (1998). Meat Science 49: 89-99. ■Grandin, T. (2000). *Livestock handling and transport*. Oxon, UK: CABI Publishing, Oxon. ■ Jones, S.D.M., Schaefer, A.L., Robertson, W.M., Vincent, B.C. (1990). Meat Science 28: 131-139. ■ Purchas, R.W. & Aungsupakorn, R. 1993. *Meat Science* 34: 163-178. ■ Mitchell, G., Hattingh, J. & Ganhao, M. (1988). Veterinary Record 123: 201-205. ■ Schaefer, A.I. Jones, S.D.M., Tong, A.K.W., Young, B.A. (1990). Canadian Journal of Animal Science 70: 107-119. ■Tarrant, P.V. (1989). *Irish Journal of Food Science and Technology. 13*, 1-21. ■Villarroel, M., Maria, G., Sañudo, C., Sierra, I., García-Belenguer, S. & Gebrehemsbert, G. (2001). *Veterinary Record 149,* 173-176. ■ Wulf, M.D. & Wise, J.W. (1999). Journal of Animal Science 77: 2418-2427.

Table 1. Least square means (± s.e.) of pH 24h, WHC and Warner-Bratzler parameters in winter and summer in terms of the three different transport times. No significant differences ($P \leq 0.05$) were found between seasons or transport times for WB.

Item	Winter						Summer					
	30 min		3 h		6h		30 min		3h		6h	
pH 24h	5.78^{x}	± 0.08	5.71^{xy}	± 0.07	5.63^{xy}	± 0.07	5.52^{y}	± 0.06	5.57^{xy}	± 0.07	5.58^{xy}	± 0.08
WHC	17.93^{x}	± 0.92	23.82^{y}	± 0.81	21.24^{y}	± 0.97	22.09^{y}	± 0.82	21.06^{y}	± 0.79	21.05^{y}	± 0.98
Max load 7d	5.59	± 0.47	5.51	± 0.47	5.36	± 0.07	5.02	± 0.39	4.63	± 0.39	5.12	± 0.47
Toughness 7d	1.76	± 0.13	1.79	± 0.13	1.74	± 0.90	1.76	± 0.11	1.65	± 0.11	1.85	± 0.13
Max load 14d	5.02	± 0.47	4.46	± 0.52	4.28	± 0.69	3.75	± 0.41	3.90	± 0.41	4.26	± 0.49
Toughness 14d	1.74	± 0.15	1.69	± 0.17	1.58	± 1.00	1.49	± 0.13	1.47	± 0.13	1.59	± 0.16

*Different letters in the same column represent significant differences ($p < 0.05$).

Table 2. Least square means (± s.e.) of results from the compression of meat from the different treatments. Means lacking a common superscript letter are significantly different ($P < 0.5$).

Item	Winter						Summer					
	30 min		3 h		6h		30 min		3h		6h	
Maximum stress 7d	49.40^{x}	± 4.48	49.41^{x}	± 4.60	54.90^{x}	± 3.74	51.59^{x}	± 3.76	49.91^{x}	± 3.81	58.14^{x}	± 4.52
Compression 20% 7d	10.83^{x}	± 1.24	5.19^{y}	± 1.28	6.84^{y}	± 1.04	5.31^{y}	± 1.04	4.81^{y}	± 1.06	5.45^{y}	± 1.26
Compression 80% 7d	37.82^{xy}	± 3.12	34.83^{xy}	± 3.21	38.56^{xy}	± 2.61	36.83^{xy}	± 2.62	34.87^{x}	± 2.66	41.73^{y}	± 3.15
Maximum stress 14d	56.51^{x}	± 5.84	47.72^{x}	± 6.19	58.22^{x}	± 5.04	57.92^{x}	± 5.15	56.45^{x}	± 5.22	60.81^{x}	± 6.21
Compression 20% 14d	6.10^{x}	± 0.55	5.45^{xy}	± 0.58	4.88^{xy}	± 0.48	4.68^{xy}	± 0.48	4.18^{y}	± 0.49	4.30^{xy}	± 0.58
Compression 80% 14d	39.58^{x}	± 3.91	36.06^{x}	± 4.15	42.34^{y}	± 3.38	40.70^{x}	± 3.45	37.97^{x}	± 3.50	43.54^{x}	± 4.16

*Different letters in the same column represent significant differences ($p < 0.05$).

Table 3. Least square means (± s.e.) of colour meat quality parameters in winter and summer in terms of the three different transport times. Different letters in the same row represent a significant ($p<0.05$) difference.

Item	Winter						Summer					
	30 min		3 h		6h		30 min		3h		6h	
L 24h*	37.80^{x}	± 1.05	37.46^{x}	± 1.11	36.93^{x}	± 0.90	33.33^{y}	± 0.92	31.28^{y}	± 0.94	32.93^{y}	± 1.11
a 24h*	20.50^{x}	± 0.81	22.06^{xy}	± 0.86	21.78^{xy}	± 0.69	22.29^{xy}	± 0.71	23.12^{y}	± 0.72	22.80^{xy}	± 0.86
b 24h*	11.47^{x}	± 0.60	12.10^{x}	± 0.64	11.45^{x}	± 0.52	11.20^{x}	± 0.54	12.50^{x}	± 0.54	11.50^{x}	± 0.65

*Different letters in the same column represent significant differences ($p < 0.05$).