# LIDIA (FIGHTING BULL) BOVINE BREED USED AS A PRODUCER OF QUALITY MEAT. OPTIMIZATION OF CHILLING RATE AND AGEING TIME

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**Abstract –Lidia breed is selected by behavior characteristics but studies related to this breed as beef producer are scarce. Because is characterized by poor conformation and very thin subcutaneous fat cover, it is necessary to optimize the chilling regime at slaughterhouse to minimize the risk to suffer cold shortening. Twelve carcasses were subjected to two chilling treatments (Conventional -2ºC for 24 h, and delayed chilling 12ºC for 6 h then 2ºC until 24 h). Microbial counts and pH and temperature changes were measured during 24 hours post mortem. *Longissimus thoracis* muscles were used to measure sarcomere length and meat quality (instrumental texture, cooking loses and sensorial analyses) after 3 and 10 days of ageing.  The pH and temperature that makes them susceptible to cold shortening were just observed (10.9ºC when pH=6.2.). Carcasses microbial counts were not affected. Conventional chilling treatments resulted in significantly lower cooking losses. Sarcomere length and Warner-Bratzler shear force was unaffected by chilling regime. However, in sensory analysis, conventional chilling showed a higher toughness than delayed chilling carcasses. Although both chilling regimes improved Warner-Bratzler shear force and some sensory attributes with ageing, a longer period than 10 days should be necessary to reach a desirable tenderness. Objective: to study the effect of chilling treatment and ageing applied to Lidia breed carcasses on meat quality**

**Key Words –**Beef tenderness, cold shortening, sarcomere length.

## I. INTRODUCTION

The Lidia bovine breed (otherwise known as the fighting bull) has similar zootechnical characteristics than other native beef breeds living in the Mediterranean forest ecosystem traditionally known as La Dehesa. Two years old females are subject to a tienta (trials, to test the behavior characteristics) and then are select to use as breeding female animals or are sold at low prices, because these animals are selected for genetic, morphology and behavior but the carcass have low value.

Commercial chilling procedure applied in Spanish slaughterhouses entails to transfer the carcasses immediately after slaughter to a cooling chamber at 0-2ºC.  It is generally accepted that when the internal temperature of carcasses drops below 10ºC and the pH is high (pH>6.2), within 10 hours post slaughter, cold shortening occurs and this is related to meat toughening. The particular characteristics of carcasses from Lidia females (poor conformation and very thin subcutaneous fat cover), made them susceptible to suffer cold shortening under commercial practices in Spanish abattoirs. Delaying the chilling of carcasses has been proposed as an alternative to prevent cold shortening and improve meat tenderness [1]; [2]. On the other hand, the effect of ageing to solve the toughness arising from cold shortening is discussed. Whereas authors indicate that ageing improves tenderness of shortened meat in the same extent of non-shortened [3]; others [4] reported a reduction in protein degradation and subsequent tenderness. Owing to the controversial opinions in relation to how the chilling process and ageing time applied to carcasses with particular characteristics affect meat quality, a study is necessary.

## II. MATERIALS AND METHODS

### Animals and experimental design

Twelve Lidia breed females were used. Carcasses were weighed at the end of slaughter line immediately before chilling. After slaughter, the carcasses were randomly assigned to two post mortem chilling treatments: conventional (C), and delayed (D), 6 carcasses each. Conventional chilling carcasses were immediately stored in a chilling room

(2±2ºC) with air movement of 2 m/s for 24 h post mortem. Delayed chilling carcasses were stored at 12±2ºC for the first 6 h and transferred to the conventional chilling room (2±2ºC) until 24 h post mortem.

**Analysis of carcass and meat quality**

Just after dressing and also 24 h post mortem, total viable counts (TVC), Enterobacteriaceae counts and Salmonella on carcass surface were measured. Carcass pH and temperature were measured at 0, 2, 4, 6 and 24 after slaughter. The *longissimus thoracis* section between 7–11th were removed from each carcass side, and then were packed under vacuum. The sections from left carcass side were aged for 3 days and the portions from right carcass side were aged for 10 days. The sections were divided in portions for different analysis: sarcomere length, instrumental texture, water holding capacity measured as cooking losses and sensorial analyses. Thenn the postions were vacuum packaged, blast frozen and stored at -20ºC until further analysis.

**Statistical analysis**

The data were subjected to two-ways analysis of variance using GLM procedure, including chilling treatment and post-mortem ageing and the corresponding interactions. Hot carcass weight was included in the model as a co-variant, but was finally excluded owing to the fact no statistical effect was found. When statistical differences were detected, Duncan's test was used to measure differences between means. Differences were considered significant at the $p \leq 0.05$ level. The statistical package used was SPSS 15.0.

III. RESULTS AND DISCUSSION

Average carcass weight (103.6 kg), dressing percentage (50.6%), conformation (O+) and fatness (2) scores rated on EUROP and fatness 5-point scale allow considering the animals suitable for meat production. No differences were found in microbial counts in carcasses under different chilling conditions. It is interesting to note that the numbers of bacteria in conventional and slow chilled carcasses 24 hours post mortem did not exceed numbers generally regarded as acceptable for lamb carcasses before chilling by [5].

Post mortem temperature decline is presented in Fig. 1 and pH decline is showed in Fig. 2.

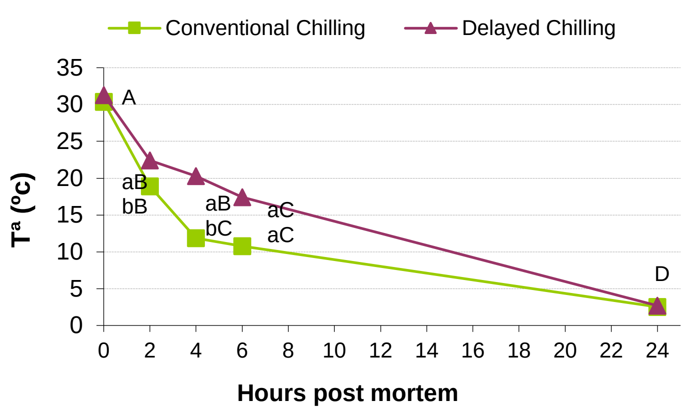


Figure 1: temperature (ºC) changes during the first 24 post mortem for conventional and delayed chilling carcasses. Different small letters mean significant differences ($P < 0.05$) between treatments within time and capital letters mean significant differences ($P < 0.05$) between times within treatment.

As expected, conventional chilling carcasses showed significantly faster temperature fall than delayed chilling carcasses, since values at 2, 4 and 6 hours post mortem were significantly higher ($p<0.001$) in delayed chilling carcasses. Likewise, no differences were found in temperatures recorded after 24 hours post mortem.

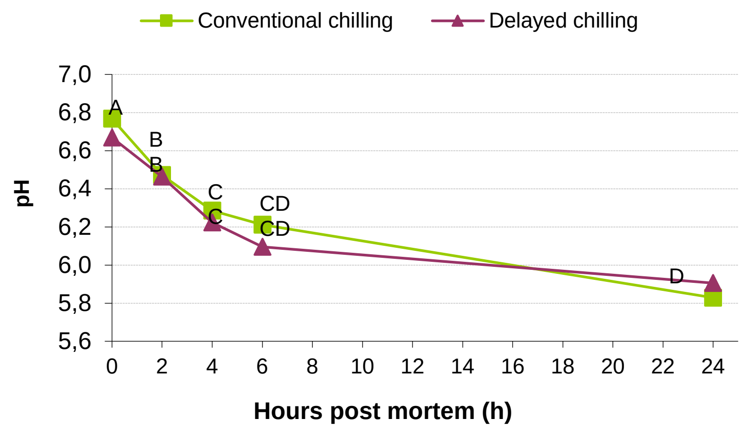


Figure 2: pH changes during the first 24 post mortem for conventional and delayed chilling carcasses. Different capital letters mean significant differences ($P < 0.05$) between times within treatment.

The behaviour of pH drop was similar in both chilling regimes, showing significant differences between sampling times ($p<0.05$). However, no significant effect of chilling regime was found in pH decline, since no differences were observed between values recorded at any times of measurement ($p>0.05$). In relation to the effect of chilling that carcasses are subjected to, it is generally accepted that when the internal temperature of carcasses drops below 10ºC and the pH is high (pH>6.2), within 10 hours post slaughter, cold shortening occurs and this is related to meat toughening [6]. The faster pH fall which occurs in delayed chilling muscles may be due to enzyme activity is temperature-dependent being lower at low temperatures [7]. According to the data obtained in our study, the conditions of pH and temperature that make the carcasses susceptible to suffer cold shortening were just the mentioned conditions, since a temperature of 10.9ºC was achieved at 6 hours post mortem when pH = 6.2. Sarcomere length was unaffected by chilling regime ($p>0.05$), showing conventional and delayed chilling carcasses values of 1.64 and 1.78 µm respectively, being the percentage of difference between chilling regimes just 15%. This is in accordance with studies that have found a relationship between the percentage of sarcomere shortening and muscle toughening. As has been reported [8], a percentage of muscle shortening below 20%, causes little or no toughening. The absence of cold shortening in carcass studied in the present work, with poor conformation and subcutaneous fat, could be partially explained because Lidia breed tends to show more aggressive behavior than beef-specialized breeds, so that its glycogen reserves at slaughter could have been low. Therefore, the decrease in post-mortem pH may have been slower in this breed regardless of the chilling rate. Instrumental texture (Warner-Braztler shear force) and sensory analysis results are shown in Table 1.

Table 1: Effect of chilling regime and ageing time on Warner-Braztler shear force (kg) and sensory parameters (1-7 linear scale).

| | Ag. | Chilling | | SED | P-value | | |
|---|---|---|---|---|---|---|---|
| | | Conventional | Delayed | | C | A | CxA |
| Warner-Braztler | 3 | 8.6x | 9.6x | 0.61 | ns | * | ns |
| | 10 | 7.3y | 7.1y | | | | |
| Toughness | 3 | 4.3a | 5.0b | 0.80 | * | ns | * |
| | 10 | 5.0 | 4.1 | | | | |
| Fibrosity | 3 | 4.9x | 5.3x | 0.81 | ns | * | ns |
| | 10 | 4.1y | 4.6y | | | | |
| Chewiness | 3 | 5.4 | 5.8 | 0.80 | ns | ns | ns |
| | 10 | 5.0 | 5.1 | | | | |
| Overall liking | 3 | 4.6 | 4.7 | 0.72 | ns | ns | ns |
| | 10 | 4.7 | 4.2 | | | | |

a, b: Means with different superscripts within the same ageing time represent significant differences between chilling treatments.
y, z: Means with different superscripts within the same chilling treatment represent significant differences as a result of ageing.
ns: no significant differences ($p>0.05$). * $p<0.05$

Regarding the effect of chilling regime on Warner-Braztler shear force values, no differences were found between conventional and delayed chilling carcasses ($p>0.05$). Taking into account the results of pH and temperature decline and sarcomere length, the absence of significant effect of chilling in Warner-Braztler shear force ($p>0.05$) was expected.

On the other hand, the relatively high Warner-Braztler shear force values recorded in Lidia breed meat after 3 days post mortem, allow classified as tough meat, because meat with values over 6 kg is classified as tough [9]. Although meat aged for 10 d had lower Warner-Braztler shear force values than did meat aged for 3 d ($p<0.05$), the trained sensory panel did not report differences in toughness. Likewise, no significant effect of ageing was observed in other sensorial parameters, chewiness, and overall liking, which theoretically should improve as the length of the ageing period increases. Taking into account low tenderness scores together with higher Warner-Braztler shear force values, it seems that meat from Lidia breed females might need ageing periods longer than 10 days to achieve a desirable tenderness.

Cooking losses were affected by chilling rate ($p<0.01$), and also by ageing time ($p<0.01$), giving values of 28.8% and 22.0% in conventional chilling for 3 and 10 days-aged meat respectively and 30.4% and 25.8%, in delayed chilling for 3 and 10 days-aged meat, respectively. The differences in WHC are usually associated with final pH [10]. However, in our work, despite the lack of differences in pH at 24 h, conventional chilling presented lower cooking losses than delayed chilling, suggesting that other effects may have influenced cooking losses. In reference to the effect of ageing in cooking loss, numerous studies, have reported an increase in water losses after ageing, although this depends on the ageing period, considering that this effect is usually observe because of longer ageing periods than used in this work [11].

## IV. CONCLUSION

Our results suggest that keeping female lidia breed carcasses at about 12ºC of air temperature (until 6 hours post mortem) before cooling at conventional temperatures (0-2ºC) allows to obtain meat with better characteristics without affecting hygienic quality. However, an ageing time longer than 10 days could be necessary to obtain meat with desirable tenderness.


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## REFERENCES


1. Hwang, I. H., Park, B.Y., Cho, S.H. & Lee, J.M. (2004). Effects of muscle shortening and proteolysis on Warner-Bratzler shear force in beef longissimus and semitendinosus. Meat Science 68(3), 497-505.
2. Vieira, C., Fernández, A.M. (2012). Effect of chilling applied to suckling lamb carcasses on hygienic, physicochemical and sensory meat quality. Meat Science 92, 569–574
3. Redmond, G. A., McGeehin, B., Sheridan, J. J., & Butler, F. (2000). Ultra-rapid chilling: chilling rate effects on the appearance of lamb carcasses and tenderness of lamb chops. Journal of Muscle Foods 11, 69–84.
4. Weaver, A.D., Bowker, B.C, Gerrard, D.E. (2009). Sarcomere length influences calpain mediated proteolysis of bovine myofibrils. Journal of Animal Science 87, 2096-2103.
5. Commission Regulation (EC) 1441/2007.
6. Bendall, J.R. (1972). The influence of rate of chilling and the development of rigor and "cold-shortening". In Meat Chilling—Why & How? Pp. 3.1-3.6, Meat Research Institute, Langford, Bristol.
7. Dransfield, E. & Roncalés, P. (1998). Very fast chilling in beef. 2. Muscle to Meat. University of Bristol Press.
8. Marsh, B.B. & Leet, N.G. (1966). Studies in meat tenderness III: The effects of cold shortening on tenderness. Journal of Food Science 31, 450-459.
9. Bruce, H., Stark, S.L. & Beilken, J.L. (2004). The effects of finishing diet and postmortem ageing on the eating quality of the M. Longissimus thoracis of electrically stimulated Brahman steer carcasses. Meat Science 67(2), 261-268 ·
10. Jacob, R., Rosenvold, K., North, M., Kemp, R., Warner, R., & Geesink, G. (2012). Rapid tenderisation of lamb M. longissimus with very fast chilling depends on rapidly achieving sub-zero temperatures. Meat Science 92 (1), 16–23.
11. Purslow, P.P. Oiseth, S. Hughes, J. Warner, R.D. (2016). The structural basis of cooking loss in beef: Variations with temperature and ageing Food Research International 89 (1), 739-748.