PE1.66 Diet, Lairage Time and Temperament Effects on Carcass and Meat Quality Traits in Uruguayan Steers 415.00

Marcia del Campo Gigena (1) *mdelcampo@tb.inia.org.uy, Gustavo Brito( ), Pilar Hernández , Fabio Montossi*
(1)INIA Uruguay
ICTA UPV

Abstract- Intensification in Uruguay leaded to cattle with different carcass and meat quality attributes that need to be studied, and adequate scientific data are lacking on stress-inducing factors in cattle lairage Sixty Hereford and Braford steers were assigned to: D1) native pasture plus corn grain; and D2) high quality pasture, for finishing purposes. Animals were slaughtered the same day in two groups (50 % of animals from D1 and 50 % from D2 in each group) subjected to 15 and 3 hours in lairage pens, respectively, in order to study the effect of diet, lairage time and temperament on carcass and meat quality. Average daily gain (ADG) and temperament did not differ between diets. Calmer steers had higher ADG within both breeds and also showed lower meat shear force values. Animals from D1 had higher hot carcass weight (HCW), pistola cut weight (PCW) and valuable cuts weight than D2, with no differences in meat yield. Pistola cut (PC) from D1 had higher fat percentage and higher fat thickness than those from D2. Steers from the long lairage group had a better rate of pH decline, better meat colour and more tender meat. It seems that more than 3 hours pre-slaughter is necessary to allow rest and recovery in cattle. Temperament appears to be an important factor regarding its effect on productivity and on meat quality. Braford animals were more excitable than Hereford, and also had higher HCW, PCW, and valuable cuts weight but meat was less tender.

Index Terms - diet, lairage time, meat quality, steers, temperament

I. INTRODUCTION

Uruguayan meat production systems are mainly based on native pasture but the use of high quality pastures and supplement for finishing purposes is becoming common, resulting in cattle with different carcass and meat quality attributes. In many European countries, it is common to slaughter animals on the day of arrival to he slaughterhouse, whereas in others like Uruguay, animals are slaughtered the day after arrival, following safety regulations. Several authors sustain that lairage time potentially allows cattle to replenish muscle glycogen concentrations and to rest and recover from some of the effects of transport. Others support that the lairage environment itself may inhibit the ability of cattle to rest or recover from the effects of feed and water restriction (8). Excitable cattle have been reported to be more susceptible to stress, to have increased incidence of dark cutting lean and increased Warner-Bratzler shear force values than their calmer pen mates (18). The objective of this experiment was to evaluate the effect of the diet, lairage time and temperament, on carcass and meat quality in Uruguayan steers.

II. MATERIALS AND METHODS

Sixty Hereford and Braford steers 2.5 years old were finished on: D1) rangeland plus corn grain (1 % LW, Hereford n=15, Braford n=15) and D2) high quality pasture composed mainly by lotus (Lotus corniculatus) and a small proportion of white clover (Trifolium repens) (Hereford n=15, Braford n=15). They were weighed without previous fasting every 14 days.

Temperament was individually assessed each 14 days by the following tests:

1) Crush score (CS), which is the behaviour of the animal when put into a crush using a 1 (calm) to 5 (combative) scale,

2) Flight-time (FT): which is the amount of time (in seconds) that takes an animal to cover a fixed distance (5 meters) after it leaves the restraining device and

3) Exit speed (ES): which evaluates the speed for leaving the squeeze chute and was ranked as 1 = walked, 2 = trotted, and 3 if the animal ran out of it. Animals were slaughtered in the same day in a commercial abattoir when they reached an average of 470 kg of LW in each diet. Each slaughter group was composed of 50% of animals from D1 and

50% from D2. They remained in lairage pens for 3 and 15 hours respectively. Steers from different diets (and slaughter groups) were not mixed either in the truck or in the abattoir. Hot carcass weight (HCW) was registered. Carcass pH was measured at 1, 3, 6, 12 and 24 hours post mortem (pm) at the Longissimus dorsi (LD) muscle between 12-13th rib, using a pHmeter (Orion 210A) with gel device. Subcutaneous fat thickness (SFT) and instrumental fat colour were recorded at 48 hours pm, the last based on L*, a* and b* colour space, using a colorimeter (Minolta C10). At 36 hours pm carcasses were ribbed between 10-11th rib, obtaining primal cuts (United Kingdom commercial standard). From the pistola cut, 7 boneless cuts were obtained (Striploin, Tenderloin, Rump, Topside, Silverside, Knuckle, Tail of Rump). Retail cuts were weighed and retail yields were calculated. Muscle, fat and bone percentages were calculated from the pistola cut (UK commercial standard). A steak per animal (2.54 cm thickness) was vaccum packaged and aged for 7 days at 2-4 oC. After this period, muscle colour and shear force were determined. Color was measured on the LD at the L*, a* and b* colour space, using a Minolta C10 colorimeter after one hour of blooming. For toughness, the LD steak was placed inside a polyethylene bag and cooked in a water bath until an internal temperature of 70oC was achieved, using a Barnant 115 thermometer with type E thermocouple. Six cores, 1.27 cm diameter, were removed from each steak parallel to the muscle fiber orientation. Shear force measurement (WBSF) was obtained for each core using Warner Bratzler (Model D 2000) and an average value was calculated for each steak. Statistical analysis. A general linear model (SAS, 2007) was used to evaluate the effect of diet, breed and temperament on ADG. A multicriterial temperament index (Average Tindex) was built with FT, CS and ES using the Analytic Hierarchy Process (AHP) (14). A higher Tindex implied a calmer animal. A general linear model (SAS, 2007) was used to evaluate the effect of diet, lairage time, breed and temperament on carcass and meat quality traits with initial and final LW as covariates. In order to study the direct relationship between tenderness and temperament, shear force values were adjusted by all factors and variables that could have an effect on it. Residuals from this regression were plotted with temperament and a regression analysis was performed with these two variables. Several correlation analyses were performed. Means were compared by the LSMEANS procedure (SAS, 2007).

III. RESULTS AND DISCUSSION

Productivity and temperament. ADG did not differ between diets (0.63 ± 0.02 in D1 and 0.64 ± 0.02 in D2) but due to differences in initial LW, animals from D1 showed lower final LW than those from D2. Considering the experiment main objectives, all animals were slaughtered on the same day. Average Tindex did not differ between diets but Braford steers were more excitable than Hereford (62.10 ± 4.10 in Hereford and 50.90 ± 4.00 in Braford, $p<0.05$). Genetic differences in tameness are well known and many authors have reported that, Bos indicus and Bos indicus cross breeds (17) were more excitable than Bos taurus cattle. Calmer animals had higher ADG within both breeds ($p<0.05$) and these results are also consistent with other authors (17), who reported higher ADG in calmer Bos indicus-cross and Bos taurus. However, Braford steers had higher ADG than Hereford ones (0.73 ± 0.05 and 0.53 ± 0.05, respectively; $p<0.05$).

Carcass traits. Animals from D1 had higher HCW and PCW than D2 (Table 1). Striploin, tenderloin and rump (R&L) represent most of the commercial value of the carcass. In this experiment, the heaviest carcasses also had the highest seven boneless cuts (7C) weight and R&L weight. However, pistola cut yield (PC/half carcass weight; PCY), valuable cuts yield (7C weight/PC; 7CY) and R&L yield (R&Lweight/PC, RLY) did not differ between diets ($p<0.05$). Table 1 Braford animals had higher HCW, 7C R&L weight and meat yield than Hereford steers ($p<0.05$). They also had higher muscle percentage and lower bone percentage than Hereford in the PC ($p<0.05$). Animals with a high growing potential like Braford, have later maturity and consequently they have more protein than fat deposition (4). SFT was higher in carcass from D2 (7.26 ± 0.45 in D1 vs 4.51 ± 0.47 in D2; $p< 0.05$). In general, higher carcass weight produces higher muscle thickness and fat deposits (15). Braford and Hereford steers did not differ either in subcutaneous fat thickness (SFT) or in PC fat percentage. Muscle percentage did not show differences between diets when PC composition was evaluated. Similar results were found by (3) who compared steers finished on pastures vs. supplemented with grain at 1.2% LW. On the contrary, many studies had reported that a higher grain or concentrate level during finishing periods leads to a lower proportion of muscle and bone in the carcass, along with a higher percentage of fat (9). Meat quality. No differences in pH decline were obtained between diets nor between breeds ($p<0.05$). Carcasses from the short lairage group had higher pH values at 1, 3, 6, and 24 hours pm (Table 2). Preslaughter stress is likely to reduce muscle glycogen level in vivo because of energy expenditure due to physical exercise or pshycological stress, which may in turn increase ultimate pH of muscles (7). Stressors appear to be additive and multiple stressors in the preslaughter period will result in a greater elevation of ultimate muscle pH than a single stressor alone. Table 2 In this study, overnight animals were probably allowed to replenish muscle glycogen concentrations and to recover from some of the previous stressors. Glycogen resources can be restored at lairage, and cattle can recover from physical exhaustion even if they are not fed (19). Inconsistencies with other authors who sustain that the environment itself may inhibit the ability of cattle to rest or recover from the effects of feed and water restriction (16), could be explained not only by the lairage duration evaluated in each experiment but also by differences in animal temperament, breed, handling procedures, transport, weather conditions, and/or cumulative effects of the different factors. In our study, 55% of animals from the short lairage group showed pH values higher than 5.8. Fat colour was not affected by diet, breed or lairage time. Cattle produced on pastures generally have yellower carcass fat than their intensively-reared, concentrate-fed counterparts, probably caused by carotenoids from green forage (6). In our study, the grain level used in D2 was not enough to diminish fat yellowness. Muscle colour was not affected either by diet or breed ($p<0.05$). Other researchers did not find significant effects of different forage/concentrate ratio diets during finishing on muscle colour (3). In our experiment, redness and b* values were higher in the long lairage group (Table 3). Lower pH values (long lairage group) were linked to more red (higher *a) and yellow (higher *b) meat. It has been established by several authors that muscle colour is highly correlated with muscle pH. Some authors reported that a* and b* values were more highly correlated with muscle pH ($r= -0.58$ and -0.56, respectively) than L* values ($r= -0.40$) (13). In our experiment a* and b* values were also more significantly ($p<0.05$) correlated to pH3 ($r= -0.33$, a*), pH6 ($r= -0.59$ and -0.48, a* and b*, respectively) and pH24 (-0.40, b*). Table 3 Shear force. Diet did not have an effect on WBSF vlaues, being consistent with other authors results evaluating pastures vs. supplement-fed steers (1 % LW) (3). Meat from animals in the long lairage group showed lower WBSF values than steers from the short one (Table 3). Depletion of muscular glycogen reserves because of greater pre slaughter stress without the opportunity to rest and restore energy reserves probably had a considerable influence on pH values. Glycolytic rate in the first few hours post slaughter is a major determinant of quality. The effects of calpains and their inhibitors immediately post mortem, depend on pH and temperature and have an important influence on tenderness (5). In our experiment, differences in pH rate decline (1, 3 and 6 hours) had already probably determined tenderness differences between the two slaugther groups. Correlations between WBSF and pH values partially confirm this (pH1=0.56, pH3=0.55, pH6=0.47; $p<0.05$). In this experiment, Braford steers had higher WBSF values than Hereford (5.93 ± 0.32 vs. 4.78 ± 0.32, respectively). Meat from Bos indicus breeds of cattle is often less tender than meat from Bos taurus. Genetic differences are partly due to a reduced post-mortem proteolysis of myofibrillar proteins in Bos indicus associated with a higher activity of calcium dependent protease inhibitor. Breed differences in tenderness in our study were probably mainly explained by the known genetic factors, that means differences in calpastatin activity in the meat (11). Calmer animals had lower shear force values with 7 aging days (Figure 1). It is well known that stress impairs the meat aging process, generally leading to toughter meat (12). Temperament and pH were not associated suggesting that temperament did have an effect on tenderness, independently of its effect through the rate of pH decline. When animals are under intense stress, the cells receive the apoptosis-inducing signals via the receptors of cellular death. If the stress is not as severe, cells prepare their defense by synthesis of heat shock proteins for helping in the protection of intracellular components and structures against hazards associated with loss of their biological functions (1), being accentuated in more temperamental animals. Consequently, the process of cellular death will be slowed down, being an impediment to good meat ageing (12). In addition, the altered metabolism associated with greater stress responsiveness in the more stressed and excitable cattle may have created conditions that were less favorable to calpain-mediated proteolysis (10). Figure 1

IV. CONCLUSION

The addition of low level of grain in a pasture finishing diet appears to improve carcass weight with no deleterious effect on fat and meat quality. Special consideration should be paid to lairage time with regard to pH and temperature decline and consequently shear force values, especially under stressful pre-slaughter conditions. The first few hours post-slaughter are critical in determining glycoliytic rate, with the subsequent impact on meat quality attributes such as tenderness. Temperament appears to be an important tool regarding its effect on productivity and also on meat quality.

ACKNOWLEDGEMENT

M. del Campo wishes to thank AECID (Spain) for the financial support of her Doctoral studies, and J Soares de Lima (INIA Uruguay) and A. Blasco (UPV) for statistical assistance. The authors are grateful to the R&D&I Linguistic Assistance Office at UPV for help in revising this paper.

REFERENCES

[1] Beere, H. M. (2004). The stress of dying: the role of heat shock proteins in the regulation of apoptosis. Journal of Cell Science, 117: 2641-2651.

[2] Brito, G., Lagomarsino, X., Olivera, J., Trindade, G., Arrieta, G., Pittaluga, O., del Campo, M., Soares de Lima, J.M., San Julián, R., Luzardo, S., & Montossi, F. (2008). Effect of different feeding systems on carcass and meat quality of Hereford and Braford steers in Uruguay. In: Proceedings of the 54th ICOMST. South Africa.

[3] del Campo, M., Brito, G., Soares de Lima, J.M., Vaz Martins, D., Sañudo, C., San Julián, R., Hernández, P., & Montossi, F. (2008). Effects of feeding strategies including different proportion of pasture and concentrate, on carcass and meat quality traits in Uruguayan steers. Meat Science, 80: 753-760.

[4] Di Marco, O. N. (1994). Crecimiento y respuesta animal. Asociación Argentina de Producción Animal, 129 p.

[5] Dransfield, E. (1994). Optimisation of tenderisation, ageing and tenderness. Meat Science, 36: 105-121.

[6] Dunne, P.G., Monahan, F.J., O'Mara, F.P., & Moloney, A.P. (2009). Colour of bovine subcutaneous adipose tissue: A review of contributory factors, associations with carcass and meat quality and its potential utility in authentication of dietary history. Meat Science, 81: 28-45.

[7] Gregory, N.G., & Grandin, T. (1998). Animal Welfare and Meat Science, CAB International, Wallingford, UK.

[8] Jarvis, A.M., Harrington D.W.J., & Cockram M.S. (1996). Effect of source and lairage on some behavioural and biochemical measurements of feed restriction and dehydration in cattle at a slaughterhouse. Applied Animal Behaviour Science, 50: 83-94.

[9] Keane, M. G., O´Ferrall, G. J., & Connolly, J. (1989). Growth and carcass composition of Friesian, Limousin *Friesian and Blonde D´Aquitaine * Friesian steers. Animal Production, 48: 353-365.

[10] King D.A., Schuehle Pfeiffer, C.E., Randel , R.D., Welsh Jr., T.H, Oliphint, R.A., Baird, B.E., Curley Jr., K.O., Vann, R.C., Hale, D.S., & Savell, J.W. (2006). Influence of animal temperament and stress responsiveness on the carcass quality and beef tenderness of feedlot cattle. Meat Science, 74: 546-556.

[11] Koohmaraie, M. (1995). The biological basis of meat tenderness and potential genetic approaches for its control and prediction. In: Proceedings of 48th annual reciprocal meat conference. pp. 69-75.

[12] Ouali, A., Herrera-Mendez, C.H., Coulis, G., Becila, S., Boudjellal, A.C., Aubry, L., & Sentandreu, M.A. (2006). Revisiting the conversion of muscle into meat and the underlying mechanisms. Meat Science, 74(1): 44-58.

[13] Page, J.K., Wulf, D.M., & Schwotzer, T.R. (2001). A survey of beef muscle colour and pH. Journal of Animal Science, 79: 678

[14] Saaty, Thomas L. (1980). Analytic Hierarchy Pocess. New York: Ed. McGrawHill.

[15] Sañudo, C. (1997). Análisis sensorial de la carne de vacuno. In: II Jornadas de Análisis Sensorial. Septiembre, Villaviciosa, España.

[16] Van de Water, G., Verjans, F., & Geers, R. (2003). T he effect of short distance transport under commercial conditions on the physiology of slaughter calves; pH and colour profiles of veal. Livestock Production Science, 82: 171-179.

[17] Voisinet, B.D., Grandin, T., Tatum, J.D., O´Connor, S.F., & Struthers, J.J. (1997) a. Feedlot Cattle with Calm Temperaments have higher average daily gain than cattle with Excitable Temperaments. Journal of Animal Science, 75: 892-896.

[18] Voisinet, B.D., Grandin, T., O´Connor, S.F., Tatum, J.D., & Deesing, M.J. (1997) b. Bos Indicus-Cross Feedlot Cattle with Excitable Temperaments have Tougher Meat and a Higher Incidence of Borderline Dark Cutters. Meat Science, 46(4): 367-377.

[19] Warriss, P.D., Kestin, S.C., Brown, S. N, & Wilkins. L. J. (1984). The time required for recovery from mixing stress in young bulls and the prevention of dark cutting beef. Meat Science, 10: 53-68.

Table 1. Effect of diet, lairage time and breed, on hot carcass weight, pistola cut weight, seven boneless cuts weight and Rump&Loin weight. Least square means ± Standard error.

	Diet 1	*Diet 2*	*Long lairage 15 hours*	*Short lairage 3 hours*	*Diet effect*	*Lairage effect*	*Breed*
HCW, (Kg)	227.05± 1.26	214.30±1.31	218.31± 1.23	223.00 ± 1.23	<0.05	<0.05	< 0.05
PC wt, (Kg)	50.20 ± 0.37	47.70 ± 0.38	48.08 ± 0.36	49.76 ± 0.36	<0.05	<0.05	ns
7C wt, (Kg)	29.19 ± 0.33	27.51 ± 0.34	27.93 ± 0.32	28.77 ± 0.32	<0.05	Ns	<0.05
R&L wt, (Kg)	10.04 ± 0.08	9.44 ± 0.09	9.67± 0.08	9.82 ± 0.08	<0.05	Ns	<0.05

Diet 1: Pasture + grain, Diet 2: High quality pasture.
HCW: hot carcass weight, PC: pistola cut, 7C: seven boneless cuts, R&L: rump and loin.

Table 2. Effect of lairage time on the rate of pH decline.
Least square means ± Standard error.

	Long lairage	*Short lairage*	*Significance*
pH1	6.56 ± 0.06	6.82 ± 0.06	<0.05
pH3	6.24 ± 0.06	6.74 ± 0.06	<0.05
pH6	6.02 ± 0.05	6.30 ± 0.05	<0.05
pH24	5.67 ± 0.03	5.83 ± 0.03	<0.05

Diet 1: Pasture + grain, Diet 2: High quality pasture.

Table 3. Effect of diet and lairage time on muscle colour and beef shear force.
Least square means ± Standard error.

	Long lairage	*Short lairage*	*Significance*
a*	10.20 ± 0.26	9.40 ± 0.26	<0.05
b*	10.40 ± 0.14	9.90 ± 0.14	<0.05
WBSF (Kg F)	4.30 ± 0.38	6.40 ± 0.38	<0.05

Diet 1: Pasture + grain, Diet 2: High quality pasture, WBSF: Warner Bratzler shear force.

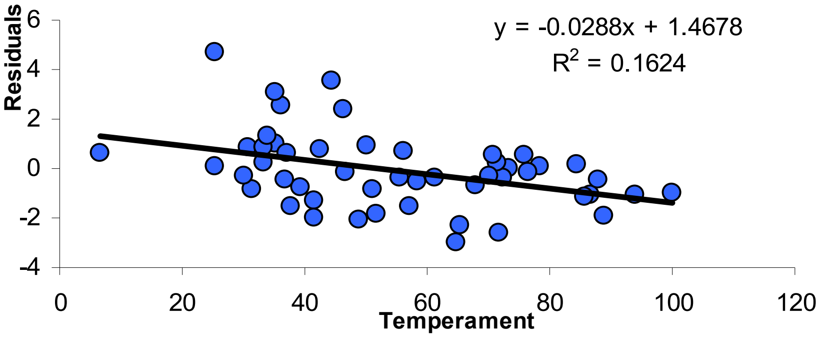

Figure 1. Temperament and shear force.