MEAT QUALITY FROM BEEF CATTLE OF DIFFERENT GENETIC GROUPS FINISHED ON FEEDLOT OR PASTURE

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Abstract – A practice to improve tenderness is ageing. Steaks from young bulls and heifers crossbred from Angus or Limousin bulls and ½ Angus + ½ Nellore or ½ Simmental + ½ Nellore cows were vacuum-packed and aged for 0, 7, or 14 days. Warner Bratzler shear forces, pH, water holding capacity, cooking loss and objective colour were determined. Cooking loss was not affected (*p>0.01*) by any of the studied effects. A triple interaction among sex, production system and ageing was found for water holding capacity. Significant interactions (*p<0.01*) for sex and production system, sex and ageing, and production system and ageing were found. Meat colour L* parameters was higher in heifers finished in feedlot (39.86) than in heifers finished on pasture (38.33) and bulls finished in both production systems (37.58). The values for pH were higher for bulls (5.81) than for heifers (5.58). The ageing meat for 14 days improved tenderness of beef from animals of different genetic groups. Ageing for 14 days of the meat of heifers and young bulls can be considered tender, according to international standards. The meat from animals finished on feedlot or pasture, aged for 14 days was considered tender.

Key Words – Ageing, Crossbreed, Tenderness

• INTRODUCTION

The use of specialized breeds in the production of meat is a strategy that can be used to increase the productivity of production systems and improve meat quality. The use of crossbreeding in a more efficient production system, associated to technologies such as ageing, may become an alternative to improve the production system and produce more tender meat. The mechanism of tenderization is complex and affected by a number of variables [1]. A correct ageing strategy would be more effective in controlling beef tenderness than manipulating *in vivo* factors, such as production system [2]. The aim of this study was to evaluate the effects of crossbreeding and ageing on meat quality of beef cattle finished on feedlot or pasture.

• MATERIALS AND METHODS

Beef from two hundred and twenty five young bulls and heifers from crosses of Angus or Limousin bulls and ½ Angus + ½ Nellore or ½ Simmental + ½ Nellore cows from Embrapa Southeast Livestock, São Carlos, Brazil were evaluated. After weaning at 8 months, half of the animals, in 2010 and 2011, were maintained at feedlot in 30 m^2 individual pens for 4.5 months and slaughtered with 419 kg; another half was raised on pasture for 10 months and slaughtered with 450 kg. The diet at feedlot was changed from D1 to D2 when heifers and young bulls reached 330 kg and 380 kg respectively (Table 1).

Table 1 Diet composition (% dry matter)

	D1	D2	S1	S2
Corn silage	68.0	50.0		

Ground corn grain	12.0	32.8	48.0	65.0
Wheat meal	3.5	8.0	20.0	
Soybean meal	15.0	7.0	20.0	13.0
Limestone	0.5	0.7	4.0	
Mineral supplement	1.0	1.0	5.0	2.0
Urea		0.5	3.0	
Corn gluten				10.0
Protected fat				10.0

D1=diet 1; D2=diet 2; S1=supplement in dry period; S2= supplement in wet period.

In the pasture, animals received 5-8 kg corn silage plus 1 kg supplement (S1) in the dry season, and 3 kg supplement (S2) in the wet season. Animals were slaughtered when reached 5 mm backfat thickness estimated by ultrasound measurements. Animals were shipped the day before slaughter to a commercial abattoir and held overnight with access to water. Carcasses were chilled at 2°C overnight for 24 h. At 24 h after slaughter, the left half-carcass was cut between the 12th and 13th rib where rib-eye area and fat thickness were measured and 2.5 cm steaks were removed for quality analysis (pH, water holding capacity, cooking loss, objective colour and shear force) at the Embrapa's Meat Analysis Laboratory and for ageing. Steaks for ageing were vacuum-packed and maintained at 1-2°C for 7 and 14 days and analyzed for the same parameters. For objective colour, steaks were exposed to atmospheric air for thirty minutes prior to the analyses, and CIE L*, a* and b* parameters were measured at three locations across the surface of the steaks using a HunterLab colorimeter model MiniScan XE with Universal Software v. 4.10 (Hunter Associates Laboratory, Inc., Reston, VA, USA), illuminant D65 and observer 10°. pH was then measured also at three locations across the surface using a Testo pH measuring instrument, model 230 (Testo AG, Lenzkirch, Germany). Fat colour was measured only in the zero time. Water holding capacity was obtained by the difference between the weights of a meat sample of approximately 2g, before and after it was submitted to a pressure of 10 kgf for 5 minutes as described by Hamm [3] with modifications. Briefly, water holding capacity was obtained by formula = 100 – {[(loss in compression x 100)/ % moisture sample] x 100}. For cooking loss and shear force measurements, the same steak of 2.5 cm thickness was weighed and cooked in a Tedesco combined oven, model TC 06 (Tedesco, Caixas do Sul, RS, Brazil), at 170°C until the temperature at the centre of the sample reached 70°C, controlled by thermocouples linked to the FE-MUX software (Flyever, São Carlos, SP, Brazil). The samples were then cooled at room temperature and weighed again. Cooking loss was calculated by the difference between the weights before and after cooking, expressed as percentage.

These steaks were transferred to a cooler and held for 24 hours, after which, eight cores, 1.27 cm in diameter, were removed per steak, parallel to the fiber grain. Peak shear force was determined on each core perpendicular to the fiber grain using a 1.016 mm Warner Bratzler probe in a TA.XT Plus Texture Analyzer (crosshead speed 200 mm.min^{-1} and a 50 kg load cell, 40 mm distance, calibration weight 10kg - Stable Micro Systems Ltd., Surrey, UK). Full peak shear force was recorded and maximum shear force was calculated as the average of the eight cores. Statistical analyses for all the studied traits were developed using the GLM procedure of SAS [4], whose statistic model considered the effects of genetic group of bull and cow, sex, production system, year, ageing, and interactions. As genetic group of cow and year were not significant, they were taken off from the statistical model. Means were compared of the Student Newman-Keuls (SNK) test with 1% significant level when the F test was significant.

- RESULTS AND DISCUSSION

Results of statistical analysis are shown in Table 2.

Table 2 Results of statistical analysis for meat quality, considering the effects of sex (S), genetic group of bulls (B), production system (Sy), ageing (A), and interactions (Pr>F)

	P values					
	L*	a*	b*	pH	WHC	WBSF
S	<.01	<.01	<.01	<.01	<.01	0.43
B	<.01	0.99	0.04	<.01	0.04	0.05
Sy	0.02	0.30	<.01	0.49	<.01	<.01
A	<.01	<.01	<.01	0.49	<.01	<.01
S*B	<.01	0.02	<.01	<.01	0.25	0.11
S*Sy	<.01	<.01	<.01	<.01	0.06	0.24
S*A	0.02	<.01	<.01	0.37	<.01	<.01
B*Sy	0.27	0.45	0.07	0.06	0.92	0.03
B*A	0.67	0.88	0.82	0.87	0.85	0.10
Sy*A	<.01	0.02	0.11	0.29	<.01	<.01
S*B*Sy	0. 90	0.49	0.48	0.91	0.69	0.40
S*B*A	0.72	0.38	0.79	0.97	0.11	0.07
S*Sy*A	0.16	0.65	0.61	0.84	<.01	0.8
B*Sy*A	0.91	0.21	0.66	0.95	0.35	0.78
S*B*Sy*A	0.98	0.71	0.94	0.97	0.98	0.96
R^2	0.25	0.27	0.37	0.23	0.63	0.63
CV	7.79	12.46	14.07	4.24	7.02	31.76

WHC= Water holding capacity; WBSF= Warner Bratzler shear force; CV= coefficient of variation.

Cooking loss was not affected *(p>0.01)* by any of the studied effects. Significant interactions for sex and production system, sex and ageing, and production system and ageing were found (*p <0.01*) for selected parameters. Results for meat and fat colour for the Sex*Production system interaction are shown in Table 3.

Table 3 Meat and fat colour and pH for the Sex*Production System interaction

		Effects			
		Heifer		Bull	
		Feedlot	Pasture	Feedlot	Pasture
Meat	L*	39.86[a]	38.33[b]	37.42[b]	37.74[b]
	a*	16.10[a]	15.83[a]	14.36[c]	14.95[b]
	b*	14.63[a]	13.34[b]	12.25[c]	12.56[c]
Fat	L*	77.80[ab]	77.51[b]	77.04[b]	78.78[a]
	a*	6.25[b]	7.92[a]	6.58[b]	5.99[b]
	b*	16.27[c]	22.49[a]	15.04[d]	18.07[b]
pH		5.56[b]	5.60[b]	5.85[a]	5.78[a]

[a,b,c]Means in the same line with different superscripts are significantly different (*P<0.01*).

L* was higher in heifers finished in feedlot (39.86) than the heifers finished on pasture (38.33) and young bulls finished in both production systems (37.58). Likewise, parameter b* was higher in heifers finished in feedlot (14.63) than the heifers finished on pasture (13.34) and bulls finished in both system production (12.41). Parameter a* was similar for heifers finished in feedlot (16.10) and on pasture (15.83) and higher than for bulls on both systems. Bulls finished on pasture presented higher a* (14.95) than the bulls finished in feedlot (14.36). Although these differences have been statistically different, these differences will hardly be perceived by consumers. Huuskonen *et al.* [5] found higher L* values for animals finished on feedlot if compared to animals finished on pasture. Differences in carcass fatness have been reflected in different fat content in the muscle, and this might influence muscle lightness [5]. Fat colour parameter b* was higher in animals finished on pasture than the animals finished on feedlot. This difference can be explained by the higher concentration of carotenoids in the pasture than feedlot diets. The values for pH were higher for bulls (5.81) than for heifers (5.58), whilst production system had no effect on pH. This difference was expected once that bulls are more stressed animals than heifers. The results for the Sex*Ageing interaction are shown in Table 4. Meat of bulls (15.02) and heifers (16.90) aged for 14 days showed higher a* than non-aged meat (14.15).

Table 4 Meat colour and Warner Bratzler shear force (WBSF) for the Sex*Ageing interaction

Effects		Meat Colour		WBSF
Sex	Ageing	a*	b*	(kgf)
Heifer	0	14.49^{bc}	12.28^{bc}	9.35^{a}
Heifer	7	16.55^{a}	14.66^{a}	4.60^{c}
Heifer	14	16.90^{a}	15.15^{a}	3.53^{d}
Bull	0	13.84^{c}	11.53^{c}	8.35^{b}
Bull	7	15.10^{b}	12.83^{b}	5.13^{c}
Bull	14	15.02^{b}	12.86^{b}	3.66^{d}

^{a,b,c}Means in the same column with different superscripts are significantly different (*P<0.01*).

The ageing for 14 days increased meat tenderness from 8.35 to 3.66 kgf and from 9.35 to 3.53 kgf, for bulls and heifers, respectively. In the same way, the ageing for 7 days increased meat tenderness, but not to such an extent of to be considered tender (<4.5 kgf). It has been well accepted that postmortem ageing can increase meat tenderness [6]. Production System*Ageing interaction values for meat colour and WBSF are shown in Table 5. The lightness (L*) was higher for the meat of animals aged for 14 days finished on pasture. Again, although these differences have been statistically different, these differences will hardly be perceived by consumers The Warner Bratzler shear force was reduced from 8.61 to 3.23 kgf in the meat of animals finished in feedlot and from 9.07 to 4.00 kgf in the meat of animals finished on pasture when aged for 14 days. These values were below 4.5 kgf which is considered the parameter for tender meats.

Table 5 Meat colour and Warner Bratzler shear force (WBSF) for the Production System*Ageing interaction

Effects		Meat Colour	WBSF
System	Ageing	L*	(kgf)
Feedlot	0	37.67^{c}	8.61^{a}
Feedlot	7	38.60^{bc}	4.00^{c}
Feedlot	14	39.58^{ab}	3.23^{d}
Pasture	0	36.03^{d}	9.07^{a}
Pasture	7	38.23^{c}	5.81^{b}
Pasture	14	39.81^{a}	4.00^{c}

^{a,b,c}Means in the same column with different superscripts are significantly different (*P<0.01*).

Water holding capacity was affected by sex, production system, and ageing, showing a triple interaction. The high water holding capacity was present by meat of bulls finished on pasture and no aged (80.73%), whilst bulls' steaks finished on feedlot and aged for 7 days showed a value of 62.28% (Fig. 1).

Figure 1. Water holding capacity (%) in the Sex*Production System*Ageing interaction (H=heifer; B=bulls; Feed= feedlot; Past= pasture; 0, 7, and 14=days of ageing).

A number of intrinsic and extrinsic factors affects the development of WHC of meat and the water content of the end products. Among the intrinsic factors, genotype and feeding of animals are the most important ones, which affect directly the muscle characteristics. Moreover, post-slaughter treatments like ageing have been shown to affect the WHC of meat [7].

- CONCLUSION

The cooking loss was not affect by genetic group of bull or cow, sex, production system, year, or ageing.

Ageing produced heifers' meat with higher yellow than in young bulls.

The meat of heifers and young bulls finished on feed lot or pasture aged for 14 days can be considered tender, according to international standards.

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REFERENCES

- Koohmaraie, M. (1994). Muscle proteinases and meat aging. Meat Science 36: 93-104.
- Juárez, M., Basarab, J. A., Baron, V. S. Valera, M. Larsen, I. L. & Aalhus, J. L. (2012). Quantifying the relative contribution of *ante*- and *post-mortem* factors to the variability in beef texture. Animal 6: 1878-1887.
- Hamm, R. (1986). Functional properties of the myofibrilar system and their measurement. In: Bechtel, P.J. (Ed.) Muscle as food (pp. 135-199). Orlando: Academic Press.
- SAS INSTITUTE. (2004). Statistical analysis systems user’s guide. Version 9.0. Cary: SAS Institute Inc.
- Huuskonen, A., Jansson, S., Honkavaara, M., Tuomisto, L., Kauppinen, R. & Joki-Tokola, E. (2010). Meat colour, fatty acid profile and carcass characteristics of Hereford bulls finished on grazed pasture or grass silage-based diets with similar concentrate allowance. Livestock Science 131: 125-129.
- Jiang, T., Busboom, J. R., Nelson, M. L., O’Fallon, J., Ringkob, T. P., Rogers-Klette, K. R., Joos, D. & Piper, K. (2010). The influence of forage diets and aging beef palatability. Meat Science 86: 642-650.

- Cheng, Q. & Sun, D. (2008). Factors affecting the water holding capacity of red meat products: A review of recent research advances. Critical Reviews in Food Science and Nutrition 48: 137-159.