Effect of grazing production system with different forage and supplementation allowances on Hereford steers performance and meat quality in Uruguay

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Abstract
Uruguayan meat production systems are based mainly on grazing pastures. More intensive systems have been growing by adding concentrate to grazing animals to improve performance and beef carcass and meat quality. Thirty two Hereford steers of 20 months of age, were randomly assigned to 4 treatments as a result of combining 2 levels of forage allowance (LFA: 2% and 4% of live weight LW) and supplementation (S: 0.8 and 1.6 % of ground sorghum), where: T1 = 4 % LFA + 0 % S; T2 = 2 % LFA + 0 % S; T3 = 2 % LFA + 0.8 % S and T4 = 2 % LFA + 1.6 % S. Steers from T1 and T4 produced heavier carcasses (HCW) and higher back fat thickness (BFT). When HCW is adjusted by final live weight (FLW) the differences disappeared, showing that differences were due basically for different final weight. Same tendency was observed for the weight of the most valuable meat cuts. Treatments did no affect (P>0.05) ultimate pH, intramuscular fat, meat color at 48 hours after slaughter, tenderness of meat aged for 7 and 20 days. No treatment differences on PUFA concentration and PUFA/SFA and n6/n3 ratio were found. However, meat of T4 animals presented the higher concentration of MUFA, particularly oleic fatty acid. Meat of treatments based only on pasture (T1 and T2) presented the higher concentration of linolenic and stearic fatty acids. Meat produced on grass-fed or combined with low supplement levels, could promote human health.

Introduction
In recent years, human health concern in relation to consumption of fats from red meats has been increased. In this regard, a lot of information about the effect of diet on the composition of intramuscular fat of meat from ruminants has been generated, associated to its potential impact on human health. Some trials have compared grass based production systems against feedlot systems (Enser *et al*., 1998; Realini *et al*., 2004; Raes *et al*., 2004; Purchas *et al*., 2005). The inclusion of grain or concentrate allows an intensification of the extensive grazing systems of meat production by improving individual animal performance, productivity per unit of area, and in many cases economical benefits. It is also important to know the effect of including different levels of grain in the diet of the animals on the fatty acid composition of the meat produced. However, there are just a few trials that have studied the effect of the inclusion of different grain or concentrate levels in the diet of grazing animals (French *et al*., 2000; French, *et al*., 2003; Alvarez *et al*., 2007; del Campo *et al.* 2007). The main objective of this study was to evaluate the effect of different levels of forage allowance and supplementation on the animal performance, carcass quality, meat quality and fatty acid composition, of Hereford steers.

Materials and methods
This experiment was carried out at the Basaltic region of Uruguay, using improved pastures, with a mixture of *Trifolium repens*, *Lotus corniculatus* and natural *Lolium multiflorum*, grazed by 32 Hereford steers (2 months of age and 303.5 ± 15.3 kg). Four treatments, as a result of combining 2 levels of forage allowance (LFA: 2% and 4% of live weight LW) and supplementation (S: 0.8 and 1.6 % of ground sorghum), were evaluated, where: T1 = 4% LFA + 0% S; T2 = 2 % LFA + 0% S; T3 = 2% LFA + 0.8% S and T4 = 2% LFA + 1.6% S. The concentrate was a sorghum grounded grain. The duration of the experiment was 104 days. All animals were slaughtered at a commercial slaughterhouse. The variables measured *in vivo* were: empty live weigh gain (LWG), empty final live weight (FLW), rib eye area (REA) and back fat thickness (BFT) by ultrasound scanning. The following carcass and meat quality parameters were measured: hot carcass weight (HCW), pistola cut weight (PCW) and the weight of the most valuable meat cuts, meat color, tenderness, and ultimate pH (pH) at 48 hours *pos mortem*. The proportion of the different tissues was measured by the dissection of the 12^{th} and 13^{th} ribs. Color measurements were taken using a Minolta Colorimeter (model C-10). They were recorded from the approximate geometric center of the *Longissimus dorsi* muscle at the 10^{th} rib, after 48 hours *pos mortem*, recording L*, a* and b* parameters on the muscle, according to the Hunter system. A portion of *Longissimus dorsi* was vacuum-packaged and aged for 7 and 20 days at 2-4°C. Tenderness was obtained from six cores (1.27 cm) removed from each sample using a WBSF

machine (G-R Electric Manufacturing Co, Manhattan, KS). Individual shear force (SF) values were averaged to assign a mean WBSF value to each sample. Samples of the *Longissimus dorsi* were obtained 48 h after slaughter to determine the composition of fatty acids. Total lipid was measured by solvent extraction based on Folch *et al*. (1957) method and fatty acids were quantified by gas chromatography. Fatty acids are expressed as percentages of the sum of all fatty acids measured. The information was analysed using the statistical package GLM procedure of SAS, with an analysis of variance in a model including block and treatment as main effects. Mean of the treatments were compared by test lsmeans test (P<0.05). Also, some variables were adjusted by co-variants.

Results and discussion

Table 1 shows animal performance and carcass quality traits results. Animal performance was affected by the level of supplementation. Animals from T4 (higher supplementation level) and T1 (higher LFA) obtained the best results (P<0.05). Animals from T2 presented the worst results in animal performance and carcass quality parameters.

Table 2 reports meat quality parameters. Neither tenderness of the meat aged for 7 and 20 days, nor ultimate pH, or meat color, were affected (P>0.05) by the treatments. None of the meat quality parameters was affected by treatments (P>0.05), probably because it would take higher levels of supplementation in order to affect those characteristics.

Table 1. Mean values of animal performance characteristics and carcass quality traits

Variable	Treatments				P	Block	Treatment x Block
	4 % LFA + 0 % S	2 % LFA + 0 % S	2 % LFA + 0.8 % S	2 % LFA + 1.6 % S			
LWG (g/d)	1.217^{ab}	0.753^{c}	1.115^{b}	1.297^{a}	**	ns	ns
FLW (kg)	422.9^{ab}	369.1^{c}	411.1^{b}	432.3^{a}	**	ns	ns
REA (cm^2) [1]	51.2^{a}	43.6^{b}	45.8^{b}	47.6^{b}	*	ns	**
BFT (mm) [1]	5.21^{a}	2.80^{b}	3.51^{b}	4.99^{a}	**	ns	**
HCW (kg)	217.3^{a}	183.0^{b}	208.3^{a}	219.2^{a}	**	ns	ns
PCW (kg)	47.3^{a}	41.3^{b}	48.0^{a}	48.5^{a}	**	ns	ns
Tenderloin (kg) [2]	1.606	1.586	1.728	1.708	ns	ns	ns
Striploin (kg) [2]	3.856^{a}	3.349^{b}	3.680^{a}	3.695^{a}	*	ns	ns
Rump (kg) [2]	3.832	3.691	4.000	3.803	ns	ns	ns

References: ns: not significant (P>0.05), *: P<0.05 and **: P<0.01.
$^{a, b, c}$: means with different letters among columns are significant different at P<0.05.
[1]: adjusted by FLW. [2]: adjusted by HCW.

Table 2. Mean values of meat quality parameters

Variable	CF	Treatments				P	Block	Treatment x Block
		4 % LFA + 0 % S	2 % LFA + 0 % S	2 % LFA + 0.8 % S	2 % LFA + 1.6 % S			
SF (kgF) 7 days	--	5.14	4.53	5.47	4.55	ns	ns	ns
SF (kgF) 20 days	$\sqrt[3]{}$	3.65	3.38	3.51	3.80	ns	ns	ns
pH 48	1/Ln	5.62	5.52	5.68	5.64	ns	ns	ns
L*	--	37.1	38.0	37.8	38.5	ns	ns	ns
a*	Ln	12.9	14.6	13.8	15.9	ns	ns	ns
b*	Ln	10.3	11.3	11.3	12.3	ns	ns	ns

References: ns: not significant (P>0.05).
$^{a, b, c}$: means with different letters among columns are significant different at P<0.05.

In **Table 3** is reported the content of intramuscular fat and fatty acid composition of the meat from animals of different treatments studied. The IMF was not affected (P>0.05) by the treatments. However, differences in the concentration of some fatty acids were found. Oleic concentration increased as S level increased. On the other hand, stearic and linolenic fatty acids concentration was reduced as S increased. These results are in agreement with others of Alvarez *et al*. (2007), where the highest concentration of linolenic fatty acid was found in the meat of animals of pure pastoral systems. No differences on PUFA concentration and PUFA/SFA and Ω6/Ω3 ratio (P>0.05) were found. However, meat of T4 animals presented the higher concentration of MUFA (P<0.05), explained by the oleic fatty acid response described above.

Table 3. Mean values of intramuscular fat (g/100g muscle) and fatty acid composition (g/100g of FA)

Variable	Treatments				P
	4 % LFA + 0 % S	2 % LFA + 0 % S	2 % LFA + 0.8 % S	2 % LFA + 1.6 % S	
IMF (g/100g)	2.50	2.47	2.41	2.46	ns
Fatty acids (g/100g FA)					
C 16:0	28.85	26.69	27.56	28.11	ns
C 18:0	16.53[a]	17.89[a]	16.49[a]	14.38[b]	*
C 18:1	37.50[bc]	36.36[c]	39.35[ab]	41.64[a]	**
C 18:2	3.62	4.12	3.66	2.89	ns
C 18:3	1.45a	1.46a	1.25ab	1.06b	*
CLA	0.53	0.55	0.54	0.54	ns
SFA	48.47	47.53	46.96	45.30	ns
MUFA	41.33[b]	40.79[b]	43.33[b]	45.26[a]	*
PUFA	9.25	10.13	9.07	10.72	ns
PUFA/SFA	0.20	0.22	0.20	0.26	ns
Ω6: Ω3	1.67	1.68	1.84	1.88	ns

References: ns: not significant (P>0.05), *: P<0.05 and **: P<0.01.
[a, b, c]: means with different letters among columns are significant different at P<0.05.

Conclusions

For the conditions imposed in this study, the production system affected the animal performance and carcass quality, improving them as the level of supplementation was increased. Meat quality characteristics (tenderness, ultimate pH, meat color and IMF) were not affected by either the LFA or by the S. The linolenic acid concentration was higher in pure pastoral systems. Finally, it can be stated that meat produced on grass-fed combined with low supplement levels, would not have any undesirable effect on human health.

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