The use of restricted grain supplementation to promote simultaneously beef production and healthy meat under grazing conditions

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Abstract— **The use of restricted grain supplementation effects on animal performance, carcass weight, meat quality traits and fatty acids profile of intramuscular fat was researched on finnishing steers under grazing conditions. The experiment lasted for 150 days, from 11th June to 9th December 2007, where twenty four Uruguayan Hereford steers were assigned to different treatments (T) considering herbage allowance (HA) on pasture (P) and grain (ground sorghum) supplementation (G) according to the liveweight (LW) of the animals. The treatments applied were a combination of P allowances and unique G supplementation level, being T1 (P at 4% HA of LW); T2 (P at 2% HA of LW without G) and T3 (P at 2% HA of LW + G at 0.8% of LW). The increase in HA and G increased animal performance, ribeye area, carcass weight and fatness, and pistola cuts and had limited influences on meat quality traits (marbling, pH, meat colour, tenderness). Intramuscular fat was affected by T (T3>T1>T2; P<0.01). The concentrations of linolenic (18:3 n-3) was higher for P treatments (T1=T2>T3; P<00.1). However, linoleic acid (18:2 n-6) concentration followed the pattern of T2>T1=T3 (P<0.01). The trend in the long chain arachidonic (20:4 n-6), eicosapentaenoic-EPA (20:5 n-3) and docosapentaenoic-DPA (22:5 n-3) was similar between treatments, where the concentration was significantly higher for T2 in comparison with T1 and T3 (P<0.01), being, in general, T1 higher than T3. The CLA, SFA, MUFA concentrations did not vary between T. However, levels of PUFA were T2>T1>T3 (P<0.01). Human health recommendations for PUFA:SFA and Ω6:Ω3 ratios are over 0.45 and below 4.0, respectively. The PUFA:SFA ration fell into the range of 0.11 to 0.25 (T2>T1>T3; P<0.01), while Ω6:Ω3 ratio was always below 4.0, ranged between 1.28 and 1.79, being T3>T1=T2 (P<0.01). This research group showed the benefits of using limited G levels in promoting animal performance, productivity and carcass and meat quality traits under grazing conditions without affecting sustantially the wellknow advantage of grass-fed beef for human health.**

Keywords—**pasture, grain, beef, meat quality, fatty acid composition.**

INTRODUCTION

In a changing world, where consumers are preoccupied by food safety and health, INIA Uruguay in joint work with other international research organizations have proven the potential benefits for human health of producing lamb and beef meat under grazing conditions or with the restricted use of supplements on those situations (Montossi and Sañudo, 2007). On the other hand, the previous studies also showed the preferences of British, German, Spanish and French consumers for lamb and beef meats produced with supplements compared to those obtained only on grass-fed animals. Additionally, in Uruguay and other South American countries, important increases in land prices and rents, living costs, etc., have pushed farmers to improve productivity, mainly by the utilization of supplementation and improved pastures. This study addresses the investigation of different pasture and grain diet combinations to look for opportunities for enhancing animal productivity by the use of supplements under grazing situations without jeopardizing the benefits of pasture grass-fed animals on human health.

I. MATERIAL AND METHODS

This experiment was carried out at the Experimental Unit "Glencoe"-INIA Tacuarembó, situated in the Basaltic region of Uruguay, using a two years old pasture, composed by *Lolium multiflorum* cv. LE 284, *Trifolium repens* cv. LE Zapican and *Lotus corniculatus* cv. San Gabriel sward and grazed by 24 steers (20-22 months of age). The experiment lasted for 150 days (from 11th June to 9th December 2007). The twenty four Hereford steers backgrounded on pasture were assigned to different treatments (T) considering herbage allowance (HA) on pasture (P) and grain (ground sorghum) supplementation (G) according to the liveweight (LW) of the animals. The treatments applied were a combination of P allowances and unique G supplementation level, being T1 (P at 4% HA of LW); T2 (P at 2% HA of LW without G) and T3 (P at 2% HA of LW + G at 0.8% of LW).

During the whole experiments animals had free access to fesh water and mineral blocks. The steers were slaughtered in a commercial abattoir. Carcasses data was recorded (HCW) and cutted between the 10-11th ribs at 36 h postmortem. Steaks for Warner Braztler shear force (WBSF), meat color and fatty acid analyses were individually vacuum packaged and frozen for subsequent analysis. WBSF and meat color were measured at 7 and 20 days posmortem. The rate of pH and temperature decline was measured postmortem in the *Longissimus thoracis* (LT) muscle between 12-13th rib using a thermometer (Barnant 115) with type E thermocouple and pHmeter (Orion 210A) with gel device. L*, a*, b* colour parameters were calculated by using a colorimeter (Minolta C10) with an 8 mm diameter measurement area after 1 h of blooming. For lipid analysis, steaks were submerged in liquid nitrogen (-196°C), pulverized and stored at -20°C. Total lipid was determined following the chloroform-methanol procedure of Folch *et al*. (1957) modified by using a 10:1 ratio of chloroform-methanol to sample. Extract containing approximately 25 mg of lipid was converted to fatty acid methyl esters (FAME) following the method of Park and Goins (1994). The FAME was analyzed using a Konik HRGC 4000B gas chromatograph and separated using a 100-m SP 2560 capillary column (0.25 mm i.d. and 0.20 μm film thickness, Supelco, Bellefonte. PA). Column oven temperature was programmed at 140 to 165°C at 3°C/min. 165 to 220°C at 5°C/min for 10 min and held at 220°C for 50 min with a split ratio of 0.42. The injector was maintained at 230°C and detector at 240°C. Nitrogen was the gas carrier at a flow rate of 1 mL/min. Individual fatty acids were identified by comparison of retention times with standards (Sigma. St. Louis. MO, Supelco, Bellefonte, PA). Results were analyzed by analysis of variance using the GLM procedure of SAS (SAS Inst. Inc., Cary. NC). LSM means and differences among treatments were estimated (0.05 or 0.01<P). All data were initially tested for normality and homogeneity of variance and some variables were normalized previously to be analyzed. Also, some variables were adjusted by their corresponding co-variates.

II. RESULTS AND DISCUSSION

The effect of feeding treatments on animal performance, carcass traits and meat quality attributes is shown in Table 1. The response in fasted LW gain and final fasted LW probably reflected the energy consumptions of the steers in the different treatments applied, where T3=T1>T2. This trend also was observed for HCW. The animals consumed all the grain daily offered. In a similar experiment, carried out by this research team comparable tendencies were found (Luzardo *et al.,* 2008). There were no differences in marbling and pH values between treatments, being all of them equal or below 5.8. Similar findings are suggested by Luzardo *et al.* (2008). Under more intensive steer finishing regimes, including the comparison of grass-fed versus grain-fed animals in Uruguay, in general, the ultimate pH are normally lower when the diet has more energy density and it is lower than 5.8 (Realini *et al*. 2004; del Campo *et al.,* 2008). Muscle colour is an important criteria used by consumers for purchasing decisions. With 20 days of aging, treatments had similar values for L*, a* and b* values. These results do not agree with those found by Realini et al. (2004) and del Campo et al. (2008), which showed that the muscle colour of grain-fed beef had higher values for L* and lower values for a* and b* than grass-fed steers. These previous studies compared more contrasting productions systems and different energy source (maize *vs*. sorghum) than of the present experiment. WBSF values for 20 days of aging were similar between treatments and tender (lower than 4 KgF.). Luzardo et al. (2008) with similar experimental design obtained similar tendencies. With 21 of days of aging, other previous research with Uruguayan Hereford steers, where grain and grass-fed steers were compared, grain-fed animals presented higher values of WBSF (Realini *et al*., 2003; del Campo *et al*., 2008), differing from the results reported in international studies (Brito *et al.*, 2008). The fatty acid composition of *longissimus* IMF for all treatments is presented in Table 2. The IMF percentage did differ between treatments and fell into the range of values reported in Uruguayan literature, particularly for on grass-fed steers (Realini *et al*., 2004; Brito *et al*., 2008; Luzardo *et al*., 2008; Brito *et al.* 2009), being much lower when they are compared with those of more intensive systems, which included feedlot finishing systems during 100 to 120 days and similar to those generated by Luzardo *et al*. (2008). The percentage of oleic (18:1) and stearic (18:0) was similar between T. In the case of palmitic (16:0), T3>T2, being T1 in an intermediate position. The concentrations of linolenic (18:3 n-3) followed the pattern of T1=T2>T3. In the case of linoleic acid (18:2 n-6), T2 had higher concentrations than T1 and T3. These differences obtained are probably mainly due to fatty acid composition of the diet, where α-linolenic acid (18:3 n-3) is the major fatty acid in grass lipids. The trend in the long chain arachidonic (20:4 n-6), eicosapentaenoic-EPA (20:5 n-3) and docosapentaenoic-DPA (22:5 n-3) fatty acids was similar between treatments, where the concentration followed the pattern T2>T1>T3. In general, these results are in agreement with those reported by Luzardo *et al*. (2008). Several national research studies showed a general trend in demonstrating greater concentrations of stearic, linolenic, EPA, DPA and arachidonic fatty acids in the IMF of the beef meat produced on grass-fed animals compared with those of grain-fed (Realini *et al*., 2004; Brito *et al*., 2008; Brito *et al*. 2009). Total CLA did not vary between treatments and it is situated in the higher concentration reported in the research studies performed by INIA (Realini *et al*., 2004; Brito *et al*., 2008; Luzardo *et al*., 2008; Brito *et al*. 2009). In Uruguay,

previous research studies have shown that including grain supplementation in beef finishing systems under grazing reduced the CLA concentration in IMF (Brito *et al*. 2008). Treatments affected significantly the concentration of PUFA, but not MUFA and SFA concentrations. The meat from animals of T2 had better concentration of PUFA than T1 and T3. The UK Department of Health (1994) recommends that PUFA:SFA and Ω6:Ω3 ratios should over 0.45 and below 4.0, respectively. In the present investigation, PUFA:SFA ratio fell into the range of 0.11 to 0.25, while Ω6:Ω3 ratio was always below 0.4. However, T2 had better or similar PUFA:SFA ratio than T1, which was in turn better than T3.

III. CONCLUSIONS

Beef performance, carcass weight and stocking rate carrying capacity can be substantially improved by the use of supplements under grazing conditions. Compared with grazing treatments, the restricted grain supplementation allowed to animals in this study showed minor effects on the main meat quality traits evaluated, which achieved high standards for natural lean meat markets. Also, this experiment like others performed by this group of researchers showed consistency the potential benefits of using restricted amounts of grain supplementation in beef finishing systems to promote animal productivity and healthy meat.

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Table 1 - Mean animal performance, carcass weight and meat quality traits of steers.

Traits	T1	T2	T3	P
Initial fasted LW (kg)	245.8	241.9	242.4	Ns
Final fasted LW (kg)	445.5[a]	401.1[b]	454.8[a]	**
Fasted LW gain (kg)	1.108[a]	0.886[b]	1.173[a]	**
HCW (kg)	220.9[a]	187.4[b]	228.8[a]	**
pHu 24 h	5.8	5.8	5.6	Ns
WBSF 20d (KgF)	3.1	3.3	3.0	Ns
L* muscle (20d)	34.9	31.5	34.0	Ns
Marbling	228	201	232	Ns
a* muscle (20d)	10.8	11.7	11.8	Ns
b* muscle (20d)	4.5	3.9	5.0	Ns

[abc] Means within the same row with uncommon uperscripts differ (**; P<0.01) and (*; P<0.05).

Table 2 - Intramuscular fatty acid composition

Fatty Acid %	T1	T2	T3	P
Intramuscular fat	3.08[b]	2.05[c]	4.60 [a]	**
14:0 *myristic*	1.97	1.88	2.14	ns
16:0 *palmitic*	27.9[ab]	26.7[b]	31.0[a]	*
18:0 *stearic*	21.7	21.0	21.1	ns
14:1 *myristoleic*	0.50[b]	0.59[a]	0.41[c]	**
16:1 *palmitoleic*	3.16	3.00	3.16	ns
18:1 *oleic*	35.8	34.0	35.9	ns
18:2 *n-6 linoleic*	3.27[b]	4.4 [a]	2.49[b]	**
18:3 *n-6 linolenic*	0.21	0.19	0.18	Ns
18:3 *n-3 linoleic*	1.58[a]	1.64[a]	0.77[b]	**
20:3 *n-3*	0.30[b]	0.48[a]	0.25[b]	**
20:4 *n-6 arachidonic*	0.95[b]	1.92[a]	0.77[b]	**
20:5 *n-3 EPA*[*]	0.73[b]	1.32[a]	0.39[c]	**
22:5 *n-3 DPA*[*]	0.80[b]	1.28[a]	0.48[c]	**
CLA	0.60	0.59	0.52	ns
MUFA	39.47	37.56	39.48	ns
PUFA	8.76[b]	12.38[a]	6.05[b]	**
SFA	51.77	49.75	54.46	ns
PUFA:SFA	0.17[b]	0.25[a]	0.11[b]	**
n6:n3	1.28[b]	1.38[b]	1.79[a]	**

[a.b.c] Means within the same row with uncommon uperscripts differ (**; P<0.01) and (*; P<0.05). [*]CLA: conjugated linoleic acid;
EPA: eicosapentaenoic acid; DPA: docosapentaenoic acid; SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.