COULD RESTRICTED GRAIN SUPPLEMENTATION MODIFY FATTY ACID COMPOSITION IN BEEF MEAT UNDER GRAZING CONDITIONS?

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Abstract— Restricted grain supplementation effects on animal performance, carcass weight, meat quality and fatty acids profile were investigated on finnishing steers under grazing conditions, focused on their influences on human health. During 194 days (from June to December 2008), 24 Uruguayan Hereford steers were assigned to different treatments (T) considering herbage allowance (HA) and level of grain (ground sorghum) supplementation (G) according to the liveweight (LW) of the animals. Treatments were a combination of pastures (P) and G levels, where T1 (P at 4% HA of LW); T2 (P at 2% HA of LW + G at 0.8% of LW); T3 (P at 2% HA of LW + G at 1.6% of LW) were applied. It was proven that increasing levels of G supplementation improved animal peformance and carcass weight, having minor influences on meat quality traits (pH, meat colour, tenderness). Intramuscular fat was not affected by T. 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. The long chain arachidonic (20:4 n-6), eicosapentaenoic-EPA (20:5 n-3) and docosapentaenoic-DPA (22:5 n-3) fatty acids were significant lower for T3 in comparison with T2. 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 0.22 to 0.36, while Ω6:Ω3 ratio was always below 0.4. However, T2 had better PUFA:SFA ratio than the rest of the treatments, while T1 produced the best Ω6:Ω3 ratio. It is highlighted the potential utilization of restricted amounts of grain supplementation G in beef finishing system under grazing conditions for increasing productivity as well as promoting healthy meat. This proposal could have productive and economical benefits for livestock farmers in extensive regions of Uruguay and for the beef industry.

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

I. INTRODUCTION

Several research studies carried out by INIA Uruguay and other international research organizations showed the potential benefits for human health of producing lamb and beef meat under grazing conditions (Montossi and Sañudo, 2007). On the other hand, the increasing competition for high valuable land in Uruguay and other countries in South America between cropping and livestock industries forced beef farmers to intensify their production systems to be more competitive in comparison with high profitable soybean cropping. As a result, land price and rent have dramatically risen. Other additional effect of this trend in the use and price/rent of the land is the need of intensification of the extensive livestock regions. The main components of this intensification have been pasture improvement, best management practises, and increasing grain supplementation. In this new business environment, one of the challenge for livestock farmers is to increase beef production with using more grain supplementation under grazing conditions without losing the positive effects of grass-fed beef on human health. In the context of intensifying beef fishing pastoral production systems, the objective of this study was to evaluate if restricted grain supplementation could produce similar fatty acid composition on meat compared with grass-fed steers.

II. MATERIALS 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 194 days (from 6th June to 17th December 2008). The twenty four Hereford steers backgrounded on pasture were finished on one of the following diets with increasing levels of grain supplementation: T1) pasture at allowance of 4% of liveweight (LW), T2) pasture at allowance of 2% of LW plus grain supplementation at 0.8% of LW, and T3) pasture at allowance of 2% of LW plus grain supplementation at 1.6% of LW. The grain used was ground sorghum, distributed daily to the steers into equally rations at 7:30 AM and 5:30 PM. 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 4 and 14 days posmortem. The rate of pH and temperature decline was measured at 4 and 14 h 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<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.

III. 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). This difference in individual performance and the effect of the grazing allowance, resulted in important changes in production levels per unit of area during the 194 days of experiment (459, 349 and 534 kgLW/ha for T1, T2 and T3, respectively). There were no differences in pH values between treatments, being all of them 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 14 days of aging, treatments had similar values for L*. However, a* and b* values were higher for T3 than for T1 and T2. 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 14 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; Brito *et al*., 2010, unpublished), 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 not 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 main fatty acids concentrations found in the IMF for all treatments were oleic (18:1), palmitic (16:0) and stearic (18:0), which accounted for 77.07% to 82.72% of the total fatty acids analyzed. The values fell into the ranges reported by Brito et al. (2008) and Brito et al. (2009). The percentage of oleic (18:1) was higher for T3 compared with T2, being T1 in an intermediate position. The contrary was the case of palmitic (16:0), being stearic (18:0) concentration similar between treatments. 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, as linoleic acid (18:2 n-6) is in grain lipid. 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 was significantly lower for T3 in comparison with T2. In general, T1 was in an intermediate position. 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; Brito *et al*., 2010, unpublished). In the present study, the same pattern was observed between T1 and T2, despite that T2 includes a restricted grain contribution in the total diet. 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;

Brito *et al*., 2010, unpublished). 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 MUFA, SFA and PUFA. The meat from animals of T2 had better concentration of PUFA than T1 and T3. T1 had the higher concentration of SFA than T2 and T3. With MUFA concentration, T2 and T3 differed between them, in favor of T3. T1 had an intermediate position. 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 0.22 to 0.36, while Ω6:Ω3 ratio was always below 0.4. However, T2 had better PUFA:SFA ratio than the rests of the treatments applied, while T1 produced the best Ω6:Ω3 ratio.

IV. CONCLUSION

Beef performance and carcass weight were improved by including grain supplementation under grazing conditions. Compared with pure grazing system, the restricted range of grain supplementation used in this study showed minor effects on the main meat quality traits evaluated, which achieved high standards for natural lean meat markets. It is highlighted the potential utilization of restricted amounts of grain supplementation in beef finishing system under grazing conditions for increasing productivity as well as promoting healthy meat. This proposal could have biological and economical benefits especially for livestock farmers located in the extensive regions of Uruguay and for the whole beef industry.

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

Traits	T1	T2	T3	P
Initial fasted LW (kg)	299.4	299.5	299.5	ns
Final fasted LW (kg)	437.0[b]	399.5[c]	462.7[a]	<0.01
Fasted LW gain (kg)	0.783[b]	0.595[c]	0.912[a]	<0.01
HCW (kg)	210.1[b]	185.8[c]	225.5[a]	<0.01
pHu 24 h	5.57	5.45	5.35	ns
WBSF 14 d (KgF)	3.22	3.40	3.90	ns
L* muscle 14 d	37.5	40.5	39.5	ns
a* muscle 14 d	14.4[b]	14.6[b]	17.2[a]	<0.05
b* muscle 14 d	8.3[b]	8.7[b]	10.4[a]	<0.05

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

Table 2 - Intramuscular fatty acid composition

Fatty Acid %	T1	T2	T3	P
Intramuscular fat	2.45	1.72	2.37	ns
14:0 *myristic*	2.30	2.13	2.19	ns
16:0 *palmitic*	26.50	25.06	25.81	ns
18:0 *stearic*	18.15[b]	16.29[ab]	15.86[a]	<0.05
14:1 *myristoleic*	0.54[a]	0.52[a]	0.38[b]	<0.01
16:1 *palmitoleic*	3.24	3.18	3.66	ns
18:1 *oleic*	38.08[ab]	35.72[b]	40.46[a]	<0.01
18:2 *n-6 linoleic*	3.86[b]	6.42[a]	4.80[b]	<0.01
18:3 *n-6 linolenic*	0.23	0.24	0.23	ns
18:3 *n-3 linoleic*	1.35[a]	1.10[a]	0.70[b]	<0.01
20:3 *n-3*	0.44[b]	0.83[a]	0.57[b]	<0.01
20:4 *n-6 arachidonic*	1.54[b]	3.17[a]	2.16[b]	<0.01
20:5 *n-3 EPA*[*]	0.91[ab]	1.29[a]	0.64[b]	<0.01
22:5 *n-3 DPA*[*]	1.11[ab]	1.52[a]	0.87[b]	<0.05
CLA	0.60	0.62	0.53	ns
MUFA	41.91[ab]	39.48[b]	44.52[a]	<0.01
PUFA	10.51[b]	15.93[a]	10.82[b]	<0.01
SFA	47.37[a]	44.47[b]	44.28[b]	<0.01
PUFA:SFA	0.22[b]	0.36[a]	0.25[b]	<0.01
n6:n3	1,42[c]	1.98[b]	2.44[a]	<0.01

[a.b.c]Means within the same column with uncommon superscripts differ (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.

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